

Spectrum of Abdominal Aortic Disease in a Tertiary Health Care Setup: MDCT Based Observational Study

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ABSTRACT

Introduction: Abdominal aortic disease is an important cause of clinical disability that requires early detection by imaging methods for prompt and effective management. Understanding regional disease pattern and prevalence has a bearing on healthcare management and resource planning. Non-invasive, conclusive imaging strategy plays an important role in the detection of disease. Multi-Detector Computed Tomography (MDCT) with its technological developments provides affordable, accurate and comprehensive imaging solution.

Aim: To evaluate regional demography of abdominal aortic disease spectrum detected using MDCT imaging data in a tertiary hospital.

Materials and Methods: A descriptive study was conducted based on MDCT imaging data of patients who were investigated with clinical diagnosis of abdominal aortic disease, from March 2008-2010, over a period of 24 months. Patients were examined with the contrast-enhanced MDCT examination. Morphological diagnosis of the aortic disease was based on changes in relative aortic caliber, luminal irregularity, presence of wall calcification, dissection or thrombus and evidence of major branch occlusion. Patients were categorized into four groups based on imaging findings. MDCT information and associated clinical parameters

were examined and correlated to management of patient. Descriptive statistical data, namely mean, standard deviation and frequency of disease were evaluated.

Results: A total of 90 out of 210 patients (43%) were detected with the abdominal aortic abnormality defined by imaging criteria. Group I, comprising of patients with atherosclerosis –including those with complications, constituted 65.5% of the patients. Group II represented patients with aneurysms (45.5%). Group III, consisting of 32.2% of the patients, contained those with dissections. The rest of the patients, including patients with aorto-arteritis, were classified as group IV. Eight patients with aneurysm and one patient with aorto-arteritis were considered for surgical treatment. Ten patients with dissection underwent endovascular procedure. Rest of the patients was managed conservatively.

Conclusion: Aortic disease was observed in 43% of investigated patients. Atherosclerosis with and without aortic aneurysm constituted the largest group. MDCT provided comprehensive information about the lesion and associated complications. In view of the wider availability and desired imaging qualities, MDCT provided optimal information for diagnosis and management of aortic pathology. Majority of our patients (90%) were treated conservatively.

Keywords: Abdominal aortic aneurysm, Aorto-arteritis, Atherosclerosis, CT angiography

INTRODUCTION

The abdominal aorta is a major vascular structure, integrity of which ensures the viability and function of vital abdominal organs and caudal half of the body. Subtle abnormality in the abdominal aorta and its branches can be reflected in the end organs, can present as either acute or chronic condition. Wide spectrum of diseases can be seen in abdominal aorta; some commonly encountered entities include atherosclerosis, aneurysm, dissection and aorto-arteritis [1-7]. Aetiology and classification of abdominal aortic disease confirms to pattern of disease in rest of vascular tree. Often classification of thoracic and abdominal aortic disease is grouped together in view of similarity of disease spectrum [8]. List of entities are presented in [Table/Fig-1], based on the recommendation of European society of Cardiology publication on aortic disease [8]. In the present study grouping of patients was based on the classification, minimally modified to suit regional disease spectrum. Imaging information helps to stratify disease for management purpose and identify lesions that lead to complication. Imaging also plays an important role in early detection (screening) and follows up of these conditions. Essentially anatomic imaging is required for abdominal aorta, either needed as a screening tool for screening aneurysm in high-risk patients or as a definitive procedure for diagnosing aortic disease.

Invasive contrast study of aorta is the gold standard for anatomic imaging technique. High-spatial (0.1–0.2 mm) and temporal (10 mSc) resolution provided by the technique is not yet achieved by noninvasive techniques [9]. Invasive angiography becomes necessary for guiding proper management. New technical developments of Multi-Detector Computed Tomography (MDCT) scanners have made non-invasive computed tomography a comprehensive, affordable, practical, technology [10-13]. State of the art MDCT provides major advantages over earlier CT techniques and conventional angiography, by allowing acquisition of large volume of thin-sections within a short breath hold during contrast injection [14-18]. MDCT utility has been further supplemented by versatile, fast volumetric post-processing techniques, like Maximum-Intensity Projection (MIP), Curvilinear Reformation (CVR), Volume Rendering (VR), Surface Shaded Display (SSD) and Virtual Intravascular Endoscopy (VIE) [14,16,19].

MDCT generally serves as one-stop shop from diagnostic standpoint. Small number of patients may need additional catheter angiography, when a specific issue like small vessel occlusion has to be sorted out. This presentation presents a spectrum of diseases of the abdominal aorta at a tertiary hospital setup evaluated by MDCT angiography. MDCT angiography is preferred over MRA for anatomic imaging of abdominal aorta, although

MRA has definite advantage in young women to avoid radiation exposure, in patients with renal impairment and postoperative/poststent imaging. Generally MRI technique includes gated or non-gated free-breathing 3D volume acquisition. High-field MR, 16-32-channel coils with high parallel imaging decrease image acquisition time. T1/T2 spin/gradient preparations and different pulsed sequences to increase signal/contrast-to-noise ratios. High-resolution non-contrast bright- blood techniques provide high contrast diagnostic images without the need for potentially nephrotoxic contrast agents [9]. Contrast enhanced MRA is an additional tool for global vascular assessment when there are no contraindication for contrast.

AIM

The present study was carried out to evaluate regional demographic assessment of abdominal aortic disease spectrum, in a tertiary hospital setting using MDCT imaging data.

MATERIALS AND METHODS

A descriptive study was performed from March 2008-March 2010 over a period of 24 months. MDCT imaging data of patients were analysed for imaging diagnosis of abdominal aortic disease. The study was approved by the institutional review board.

CT was performed with GE Light speed, VCT. (GE Medical systems Milwaukee, Wisconsin, USA). Technical parameters were as follows: KV-120, effective mAs 250–790, time-0.35sec, detector collimation - 0.625mm, Slice Thickness-0.625-5mm, Matrix size 512 x 512. Examination was performed without oral contrast. Iohexol 350mg/ml or low osmolar (visipaque) contrast medium was used. A total of 1.2ml/kg body weight, of contrast was injected at the rate of 3.5-4.5 ml/second using Mallinckrodt optistat pressure injector. An 18-gauge intravenous canula was used for contrast injection, preferably in the left antecubital vein. Data was processed on GE advanced workstation, Advantage Windows 4.2 P. Conventional axial images, 3-Dimensional (3D), Multi-Planar Reformations (MPR) sagittal, oblique views, coronal, thick and thin Maximum Intensity Projection (MIP), volume rendered images and vessel analysis techniques were utilized. Patients who had contraindication for contrast CT examination or radiation procedure were excluded. Morphological diagnosis of the aortic disease was based on changes in relative aortic caliber, luminal irregularity and presence of wall calcification, dissection or thrombus and evidence of major branch occlusion. Patients were categorized into four groups based on imaging findings:

Group I - Showing changes of atherosclerosis.

Group II - Patients with aortic aneurysm.

Group III - Consisting of aortic dissection.

Group IV- Consisting of patients with aorto-arteritis, other aortic disease and postoperative patients.

The non-imaging data, which consisted of the diabetic status, blood pressure correlation and lipid profile, were obtained for all patients. Patients who were considered for surgical management and needed additional information underwent conventional angiography.

RESULTS

Total of 210 patients were investigated for abdominal aortic disease. Patients with normal abdominal aorta or those with minor plaques, calcification or reduction of aortic lumen less than 30% were excluded from the study. A total of 90 patients were diagnosed with significant abdominal aortic abnormality based on predefined imaging criteria [Table/Fig-2,3].

In the study, cohort 80% were males and 20% were female. Age range was 40-80yrs, 34.7% in 61-70 years and 26% in 41-50 years group. Rest as nearly equal number of cases in 31-40,

Category	Entities
Genetic diseases affecting the aorta	Marfans syndrome
	Ehlers Danlas Syndrome
	Turner syndrome
	Arterial Tortuosity Syndrome
	Coarctation of aorta
Atherosclerotic lesions of the aorta	Thromboembolic aortic disease
	Mobile aortic thrombosis
	Atherosclerotic aortic occlusion
	Calcified aorta
Acute thoracic aortic syndrome	Acute aortic dissection
	Intramural haematoma
	Penetrating aortic ulcer
	Aortic pseudoaneurysm
	Traumatic aortic injury
	Iatrogenic aortic dissection
Aortic aneurysms	
Aortitis	Takayasu Disease
	Becet's Disease
	Giant cell arteritis
	Buerger disease, Kawasaki disease,
Aortic tumours	Angiosarcoma, Leiomyosarcoma

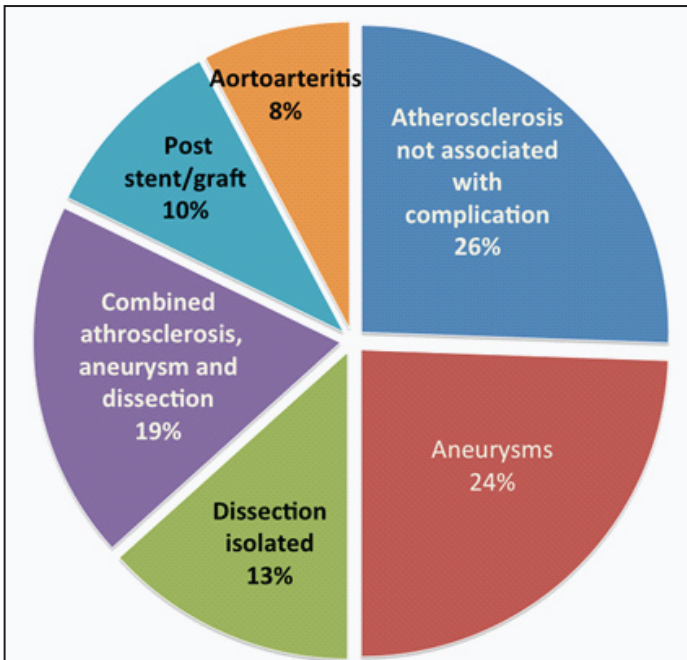
[Table/Fig-1]: Classification of abdominal aortic disease. (Adapted from the ESC 2014 guidelines on aortic disease [8]).

Type of disease	Number	Percentage %
Group I: Atherosclerosis (Total)	59	65.5%
Atherosclerosis not associated with complications	23	25.5%
Atherosclerosis associated with complications	36	40.0%
Group II Aneurysms (Total)	41	45.5%
Aneurysms	22	24%
Aneurysm associated with dissection	17	18.8%
Aneurysm with aorto-arteritis	2	2.2%
Group III: Dissection(Total)	29	32.2%
Dissection isolated	12	13.3%
Dissection associated with aneurysm	17	18.8%
Combined aneurysm and dissection	17	18.8%
Group IV: Post stent/graft	9	10.0%
Aortoarteritis	7	7.7%
Total	90	100%

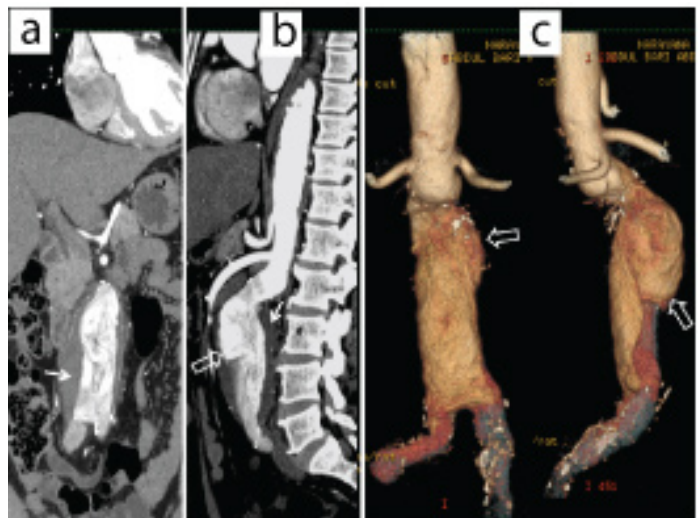
[Table/Fig-2]: Shows relative incidence of abdominal aortic disease.

51-60 and 71-80 years age group. Overall 56/90(57.7%) patient had history of DM. HTN and smoking history was seen in 46/90 (51.1%) and 42/90(46.6%), respectively. Dyslipidemia was seen in 32/90(35.5%).

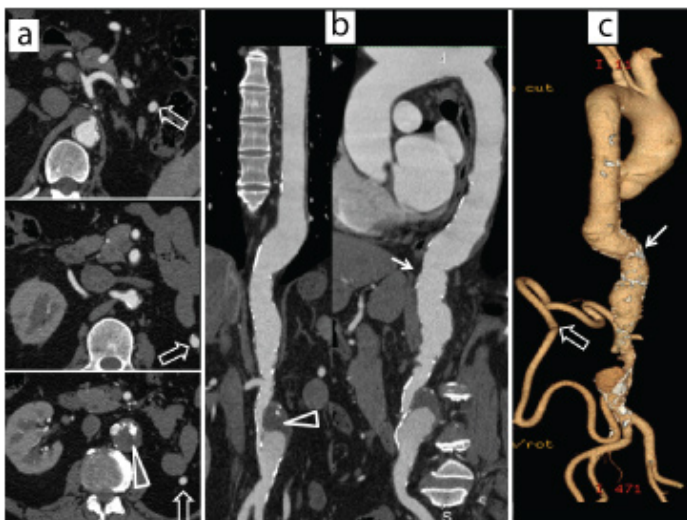
Diffuse atherosclerosis was seen in 59/90(65.5%) patients in association with aneurysms, dissections and in poststent-graft patients. A total of 57 patients (96.6%) showed involvement of infra-renal segment [Table/Fig-4] with renal and suprarenal segmental involvement in 55 (93.2%) and 52 (88.1%) patients respectively. Penetrating atherosclerotic ulcers were seen in 9 cases, located at infra-renal segment (77.7%), renal (55.5%) and suprarenal segmental (33.3%) respectively [Table/Fig-5]. Fusiform aneurysms were most frequent (90.24%) [Table/Fig-6] and saccular aneurysms were seen in 9.7% cases [Table/Fig-7]. Infra-renal aorta was the most common segment involved Mural thrombus was seen in 58.5%. Wall calcifications were seen in 65.8% patients. Impending and contained ruptures were seen in 2 patients each (4.8%). Rupture was seen in only 1 patient (2.4%). Dissection was seen in 29/90 (32.2%), predominantly in male



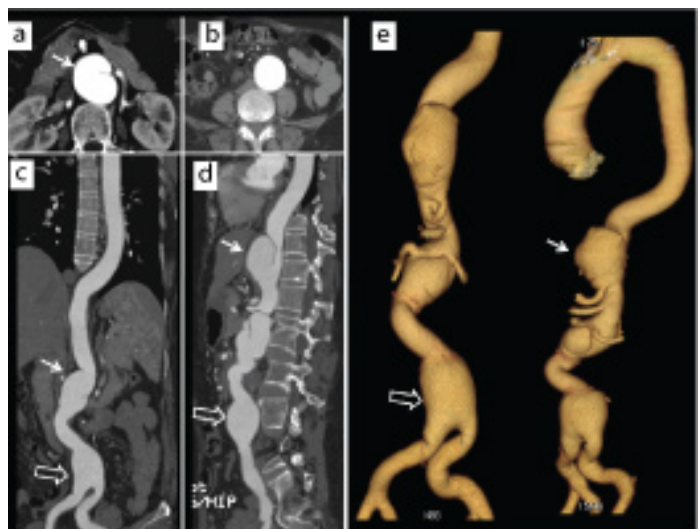
[Table/Fig-3]: Pie chart showing distribution of aortic disease spectrum.



[Table/Fig-6]: Contrast enhanced coronal & sagittal images (a,b) and VR images(c) show extensive atheromatous changes in the abdominal aorta. There is fusiform aneurysm of the infrarenal abdominal aorta (open arrows) with concentric mural thrombus. (arrows) Also note ectatic bilateral common iliac arteries.



[Table/Fig-4]: Axial contrast enhanced (a) axial, (b) curved coronal and sagittal, (c) VR images show atheromatous aorta (arrow) with significant luminal stenosis due to a thrombus (triangle) of the infrarenal segment. Also, note a large collateral between the supra and infrarenal segments (open arrow).



[Table/Fig-7]: Axial contrast enhanced images (a,b), curved coronal, sagittal images(c,d) and VR images (e) show saccular aneurysm of the suprarenal abdominal aorta (arrows) and fusiform aneurysm at the level of renal arteries with a focal dissection. Also note fusiform aneurysm of the infrarenal aorta (open arrows) and extensive atheromatous changes in the abdominal aorta extending into bilateral common iliac arteries.

Atherosclerosis (Group I)			
Observations	No	%	Additional Features
Total cases	59	65.50%	Atherosclerosis 23 (18:5)
Age between 61-70yr	8	34.70%	Luminal stenosis (>50%) 17 (28.8%)
Male	52	88.10%	
Female	7	11.90%	
Risk factors			
Hypertension	14	60.80%	
Diabetic mellitus	19	82.60%	
Smoking	15	65.20%	
Dyslipidemia	13	56.40%	
Segmental involvement			
			Penetrating ulcers 9 (15.2%)
Suprarenal	52	88.10%	Suprarenal 3 (33.3%)
Renal	55	93.20%	Renal 5 (55.5%)
Infrarenal	57	96.60%	Infrarenal 7 (77.7%)

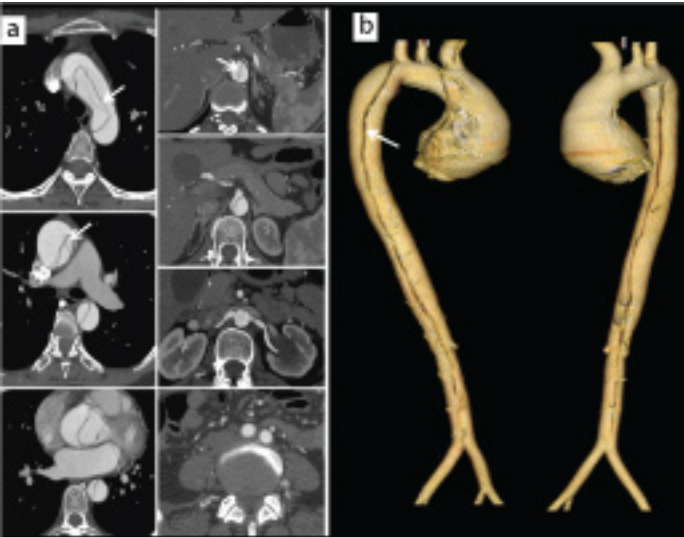
[Table/Fig-5]: Group I: Table illustrating clinical associations, disease location and special imaging features of Group I of aortic disease observed in our study.

Aneurysm (Group II and III)			
Observations	No	%	Associated Features
Total cases			Type of aneurysm
Age between 61-70yr	14	34.20%	Fusiform 37 (90.2%)
Male	39	95.10%	Saccular 4 (9.8%)
Female	2	4.90%	
Risk factors			Other complications
Hypertension	29	70.20%	Mural thrombus 24 (58.5%)
Diabetic mellitus	28	68.20%	Wall calcification 27 (65.8%)
Smoking	26	63.40%	
Dyslipidemia	15	36.50%	Dissection 7 (17.1%)
Segmental involvement			Contained leak 2 (4.8%)
Suprarenal	18	43.90%	Impending rupture 2 (4.8%)
Renal	24	58.30%	Rupture 1 (2.4%)
Infrarenal	31	75.60%	

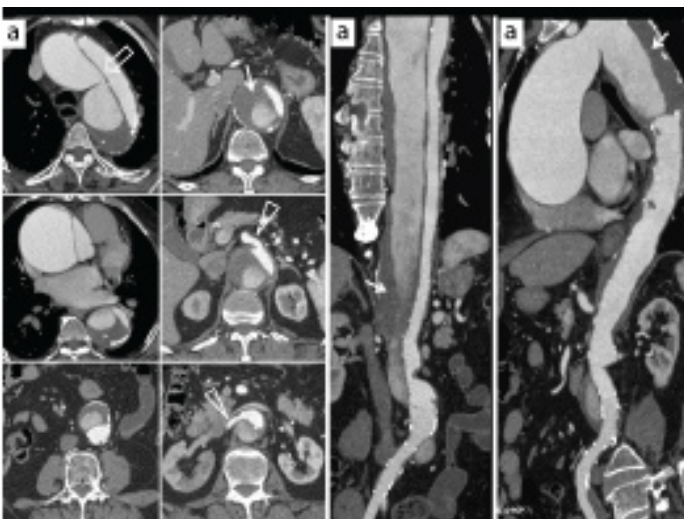
[Table/Fig-8]: Group II and III a: Table illustrating clinical associations, disease location and special imaging features of Group II of aortic disease.

(75.8%) [Table/Fig-8]. Type A dissection was found in 20/29 (69%) [Table/Fig-9], Type B dissection was seen in 9/29 (31%) cases.

Enhancement of the false lumen was seen in 27 (93.1%) and true lumen in 24 (82.7%). Continuity of false lumen with true lumen was established in 21 (72.4%) cases. Displacement intimal calcification



[Table/Fig-9]: Axial post contrast images at multiple levels (a) and VR images of thoracic and abdominal aorta (b) up to common iliac arteries showing acute type of aortic dissection. Intimal flaps are demonstrated with arrows.



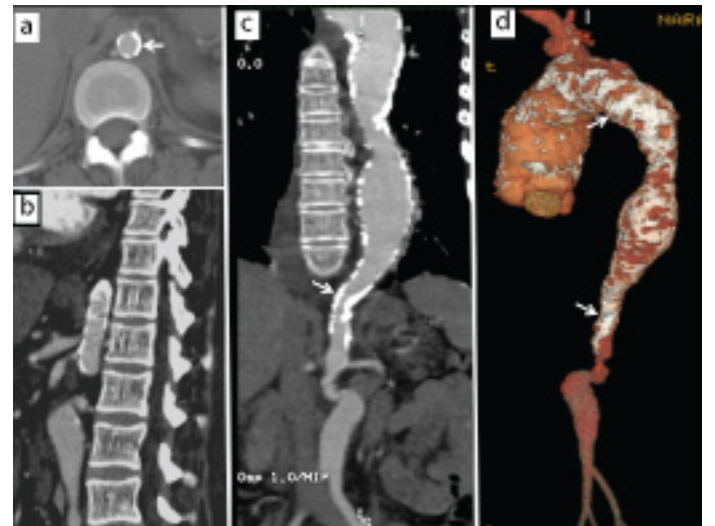
[Table/Fig-10a]: Multiple contrast enhanced axial images (a), sagittal (b) and coronal curved reconstruction (c) of thoracic and abdominal aorta up to common iliac arteries showing type an aortic dissection (open arrow). Note partial thrombosis of the false lumen (arrow). Celiac artery and right renal arteries are arising from the true lumen. (triangle).



[Table/Fig-10b]: VR images of thoracic and abdominal aorta illustrate extent of dissection in different color. There is aneurysm of ascending aorta.

Aorto-arteritis was seen in 7/90 (7.7%). Imaging features consisted of wall thickening and wall calcifications, seen in all patients (100%) [Table/Fig-11]. Significant luminal stenosis was seen in 6/7 cases (85.7%) and luminal dilatation in 4 cases (57.1%). In association with aorto-arteritis, celiac trunk occlusion was seen in 4 cases (57.1%). SMA and RCIA (42.8%) and RRA, LRA and LCIA occlusions in (28.5%) [Table/Fig-12].

Positive angiography confirmation was available in 12/59 patients with atherosclerosis, mostly examination were done along with coronary angiography. Angiography confirmation was also available in 7/41 patients with aneurysm/dissection and 2/7 patients with complicated aorto-arteritis. Surgical/Interventional correlation was present in 13/41 patients with aneurysm/dissection, 4/59 with atherosclerosis with complication and 2/7 patients with aorto-arteritis with vessel occlusion.



[Table/Fig-11]: Axial post contrast image (a), sagittal (b), coronal curved reconstruction (c) and VR reformations (d) show irregular narrowing and aneurysmal segments involving the entire aorta. There is extensive wall calcification (arrows) and thickening in a case of aorto-arteritis.

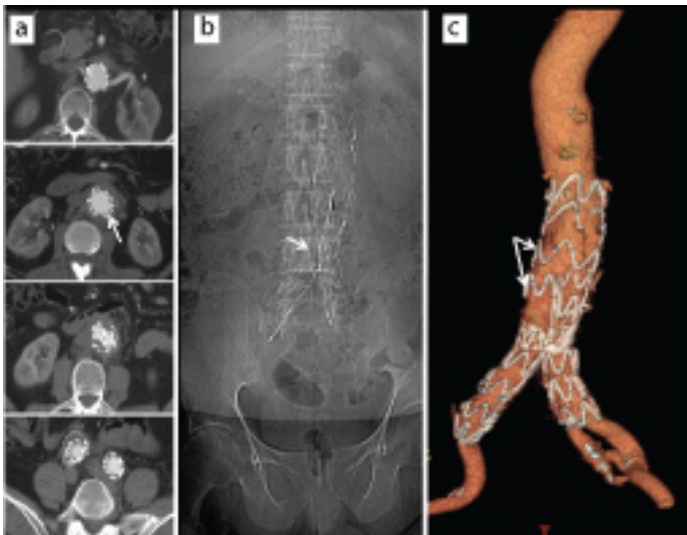
Aorto-arteritis (Group IV)				
Observations	No	%	Associated Features	
Total cases	7	7.70%	Wall thickening	7 (100%)
Mean age		57 yrs	Wall calcification	7 (100%)
Male	2	24.60%	Luminal stenosis	6 (85.7%)
Female	5	71.40%	Luminal dilatation	4 (57.1%)
Risk factors				
Hypertension	2	28.50%	Occlusion of major vessels	
Diabetic mellitus	2	28.50%	Celiac A	4 (57.1%)
Smoking	1	14.20%	Superior mesenteric A	3 (42.8%)
Dyslipidemia	1	14.20%	Inferior mesenteric A	1 (14.2%)
Segmental involvement			Right common Iliac A	3 (42.8%)
Suprarenal		Variable	Left common Iliac	2 (28.5%)
Renal			Right Renal A	2 (28.5%)
Infrarenal			Left Renal A	2(28.5%)

[Table/Fig-12]: Group IV: Table illustrating clinical associations, disease location and special imaging features of Group III of aortic disease.

DISCUSSION

Multidetector CT is an accurate, comprehensive modality for vascular imaging, suited for evaluation of medium and large vessels [6]. Abdominal aortic diseases like atherosclerosis, aneurysm and dissection occur frequently in adult, often elderly age group [10,20-23]. On the other hand, aorto-arteritis has a higher prevalence in younger age groups [7]. Our patients with atherosclerosis, in conformity with the reported incidence in other studies, showed male predominance and higher incidence (65.5%) in age group

was observed in 17/29 (58.6%) cases. Thrombosis of false lumen was seen 31% and true lumen was seen 20.6% [Table/Fig-10a]. Cobwebs were seen in only 13.7% cases. Right renal artery was the most common occluded vessel [Table/Fig-10b], involved in 37.9% cases; followed by 27.5% occlusion of left renal artery.



[Table/Fig-13]: Multiple axial post contrast images (a), scan gram of abdomen (b) and VR image (c) illustrate a stent in the infrarenal abdominal aorta (arrows) extending into bilateral common iliac arteries in an aneurysm patient. Stent is patent with no evidence of leak.

between 61-70 years [22,24]. Relatively younger patient with slightly higher female incidence were noted in aorto-arteritis group (1:3). Similar observations were noted in a study by RG Salkar et al., [7]. We also noted a slightly higher incidence of aneurysms (45%) in comparison with dissection (32.2%) in conformity with literature [25]. Reported incidence of infrarenal aneurysm was 88% in a series [26]. We noted infrarenal aneurysm in 75.6% of cases. Most (85%) of the patients with aneurysm were male. We also found association of smoking, diabetes and hypertension with abdominal aortic diseases, as observed in other larger studies [18,22,24].

Aortic aneurysms are known to be associated with complications like acute aortic dissections, aneurysmal rupture and branch vessel occlusions [10,26-29]. These patients may present with an acute condition necessitating prompt diagnosis and management. We found acute aortic dissection as a most common cause of admission to emergency services, similar to an earlier report [30]. Types of dissection in association with aneurysm vary [20,31]. Carmen Sebastià et al., reported 60% Stanford type A and 40% were type B dissections in association with aneurysm [20]. Classical imaging signs like beak sign, cobwebs were present in both acute and chronic dissections. Intraluminal thrombus was more common in the false lumen (more frequent in chronic dissection, 86% vs. 46%) compared with the true lumen (4-6%). We found type A dissection in 69% and type B dissection in 31% cases. Beak sign was seen in all patients (100%) and cobwebs were seen only in 13.7% cases. Thrombosis of false lumen was noted in 31% and relatively higher (20.6%) number of patients showed thrombosis of the true lumen. Diagnostic accuracy with helical CT ranges from 88% to 100% in detecting the dissections and classifying the true and false lumen [31,32]. Comparison of MDCT observations with catheter angiography data and surgical correlation, in available cases, showed 100% correlation.

CT imaging has more important role to play in imaging aorto-arteritis by virtue of providing information regarding vessel wall and perivascular structures [32,33]. Yamada et al., showed that sensitivity and specificity of the helical CT was 95% and 100% in conformity with our own observations [34]. CT and MR imaging are equally effective in postoperative aorta [35]. In a study on post-operative endovascular stent-graft patients with both conventional and CT angiography, authors found that sensitivity and specificity of conventional and CT angiography in detecting the post stent-graft complications were 63% and 77% for conventional angiography and 92% and 90% for CT angiography, respectively [35]. CT angiography is the preferred method for establishing the presence

of peri-graft leakage following treatment of aorto-iliac aneurysms with stent-grafts. We had a single patient with the peri-graft leak. In view of the technique without involving ionizing radiation, MR imaging with the bright blood technique has important role play in luminal assessment of postoperative aorta.

In patients with intravascular stent/graft, MDCT angiography observations can be utilized as a surrogate parameter in assessing the surgical outcome, lumen of stents and complications related to stents [Table/Fig-13]. Endoleaks is the most common complication of associated with endovascular stenting of aneurysm, Type 1 endoleaks occurring most frequently. Thin section imaging with 1 mm slice thickness provides better detection rates of endovascular leak [36,37]. Volumetric data acquisition with thin partitioning (0.625 mm) as performed in our study provides greater advantage for detection of endoleaks. In conclusion, CT angiogram proves to be best choice in preoperative assessment of the abdominal aortic disease and related complications. Measurements obtained by CT angiogram guide the vascular interventionists to decide on type and size of endovascular stents to be used.

We have used standardized CT and contrast delivery techniques with automated bolus triggering technique in all patients. Varying techniques are described in the literature, some examinations intended to demonstrate contrast enhancement of the aortic wall. We had satisfactory results for evaluating vessel wall enhancement with the bolus technique. Careful matching of duration of the contrast injection and scan acquisition time was needed with the earlier generation scanners [12,13]. Generally, contrast volume of 120-170 ml is used, calculated on the patient weight. (Max 2ml/kg) [18]. Rubin et al., demonstrated that substantial reductions in contrast medium dose were possible with multi-detector row CT compared with single-detector row CT. In their study of the thoraco-abdominal aorta, the dose was determined by calculating a bolus duration that was equivalent to the scanning duration at an injection rate of 4 mL/sec. For example, for a scanning duration of 31 seconds, the total contrast medium dose administered was 124 mL [18,19].

Evaluation with the catheter angiography can additionally demonstrate subtle signs of vessel irregularity or occlusion. Slight advantage of DSA is found in some studies improving sensitivity as well as specificity [38]. State of the art MDCT evaluation is the nearly capable of the demonstrating most of medium-size vessel occlusion, along with the global assessment of the lesion as confirmed in our study.

LIMITATION

There are few limitations in our study. Our study was conducted at a private, tertiary hospital; hence there can be referral bias, leading to inaccurate inference on the incidence/prevalence of disease. Other limitation of the study is that we had a small number of patients with surgical/interventional confirmation and follow-up. Multiple factors were responsible for drawback that included financial considerations and limited management options.

CONCLUSION

Predominant abdominal aortic disease in our study was atherosclerosis with or without an abdominal aortic aneurysm. The aorto-arteritis contributed to significant number of patients in relatively younger age range. Overall incidence and pattern of disease confirm to incidence, described in literature. MDCT angiography with automated pressure injection of contrast provides optimal method for non-invasive evaluation of diseases of the abdominal aorta and its major branches. MDCT accurately delineated and differentiated various pathologies of the abdominal aorta. MDCT is the investigation of choice in the abdominal aortic emergencies and an integral tool in pre-operative evaluation of the abdominal aorta. MDCT angiography is very useful in post-

operative evaluation of the intravascular repair stent/graft and its complications.

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