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Original Research Paper

Radio-Diagnosis

MDCT EVALUATION OF AORTIC ROOT AND ASCENDING AORTIC PATHOLOGIES: PICTORIAL ESSAY

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ABSTRACT **Objective;** The purpose of this pictorial essay is to review the MDCT appearance of aortic root and ascending aortic pathologies. Familiarity with atypical anatomy and pathologies of the aortic root, ascending aorta and their clinical presentation may facilitate appropriate diagnosis and management.This can be of immense help to the clinician planning interventional procedures such as stenting, balloon dilatation, or graft surgery. **Conclusion;** Increasing use of MDCT for cardiac imaging has helped in the detection of many benign aortic root anomalies, but a small number are associated with myocardial ischemia and sudden death. Increasing the use of MDCT in cardiac imaging may yield diagnostic information on pathologies of the aortic root and ascending aorta not obtained with invasive coronary angiography. Axial sections, multiplanar reconstructions, virtual angioscopy, and 3D volume-rendered images should aid in the detection and improve the interpretation of such pathologies.

KEYWORDS : Aortic root aneurysm, Aortic dissection, Aortic stenosis, Ascending aorta, Bicuspid aortic valve, Sinus of Valsalva aneurysm.

INTRODUCTION

Multidetector computed tomography (MDCT) cardiac imaging is an important tool in the assessment of coronary artery anatomy and coronary stenosis and is also helpful in assessing the aortic root pathologies which can mimic coronary artery diseases which are sometimes fatal [1].The aortic root is the proximal-most segment of the aorta from the aortic annulus to the sinotubular junction. Components of the aortic root include the aortic annulus, aortic leaflets with their attachments and trigones, the sinuses of Valsalva (SOV), and the sinotubular junction (STJ).

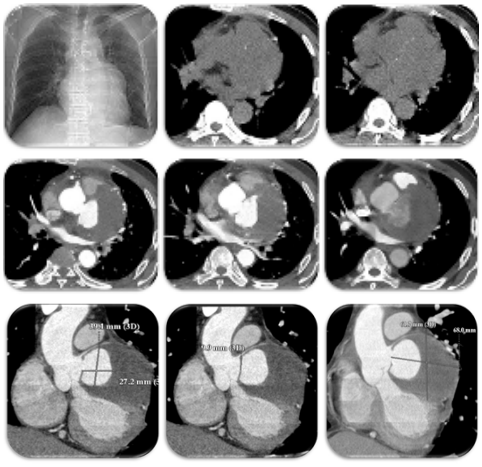
The aortic root bulges outwards to form three dilatations, the aortic sinuses or sinuses of Valsalva (SOV). The SOVs lie within the pericardial sac and at the centre of the heart. The superior border of SOV is the sino-tubular junction. The right coronary sinus locates anteriorly and gives origin to the right coronary artery, while the left coronary sinus locates posteriorly to the left, giving origin to the left coronary artery. The right posterior SOV does not give rise to the coronary artery and is called the non-coronary sinus. The aortic annulus is defined as a virtual ring at the aortic root where the nadirs of the basal attachment of the valvular leaflets locate. The ascending aorta rises to a point above the pulmonary arteries where the aortic arch begins with the innominate artery origin.

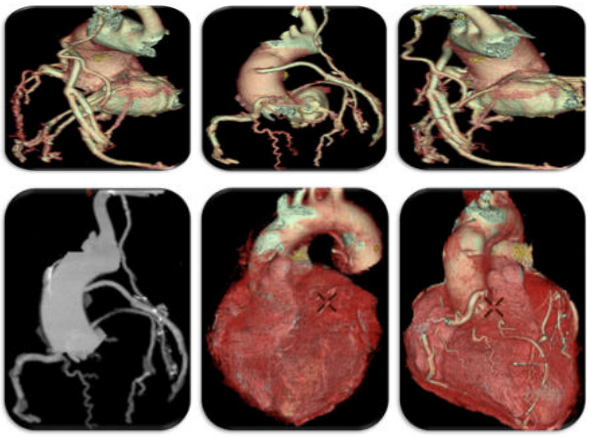
Aortic root and ascending aortic pathologies can be incidentally seen in patients getting a CT for non-aortic indications. Knowledge of the pathologies specific to this part of the aorta and their imaging appearance is useful for diagnosis and early treatment.

ILLUSTRATIVE CASES

Fig.1. (A-O). Chest X-Ray (A) - Shows focal bulge in left cardiac border &evidence of post-thoracotomy. Plain CT (B, C) – Shows an oval iso-density merging with cardia showing medial curvilinear partial rim calcification abutting the aortic root.Computed Tomography Coronary Angiography (CTCA) axial images (D-F) reveal a saccular aneurysm arising from the left sinus of Valsalva with surrounding large intramural thrombus, posterior-inferiorly compressing on the pulmonary veins & left atrium, anterior-superiorly indenting RVOT.CTCA coronal images (G-I) reveal a saccular aneurysm arising from the left sinus of Valsalva measuring about 39.1 x 27.2 mm & neck diameter of 9.9 mm, surrounded by a large intramural thrombus, superiorly elevating & compressing LMCA, LAD & LCX. Coronary tree images (J-L) reveal a saccular aneurysm arising from the left sinus of Valsalva, antero-superiorly elevating & indenting LMCA, LCX & LAD.MIP Coronarytree (M) & 3D volume-rendered images (N, O) reveals saccular Aneurysm arising from the Left Sinus of Valsalva , antero -superiorly elevating & indenting LMCA, LCX & LAD.

CASE- 1.51years old male patient with a history of Coronary artery bypass graft (CABG) surgery came with complaints of Chest Pain & discomfort.





CASE-2.2. 4-year-old patient with a history of aortic valve replacement presented with shortness of breath & Chest Pain.

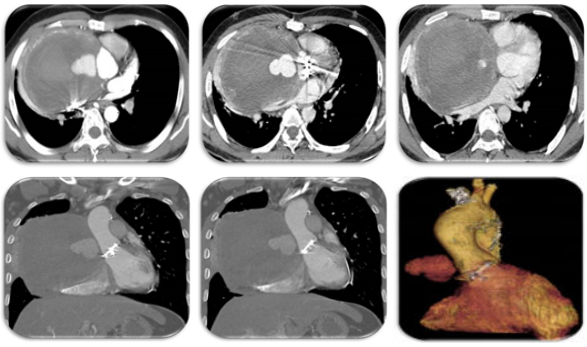


FIG.2 (A-F).CTCA Axial images (A-C) reveal a saccular aneurysm arising from the Right sinus of Valsalva surrounded by a large intramural thrombus, antero-superiorly abutting the chest wall, postero-inferiorly compressing & displacing RCA, pulmonary veins & left Atrium. Coronal (D, E) & 3D volume-rendered images (F) reveal a saccular aneurysm arising from the Right sinus of the Valsalva surrounded by a large intramural thrombus, laterally abutting chest wall & inferiorly compressing on the Right Ventricle

CASE-3.60 years old male referred for CT aortic angiography for abnormalities.

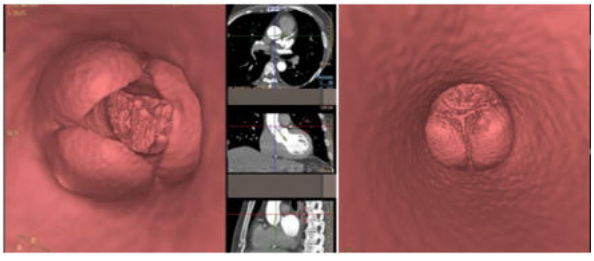
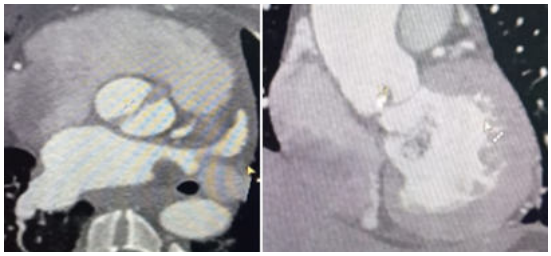


FIG.3. (A, B). CT Aortic angiography and Virtual angioscopy images show normal open (A) and closed (B) tricuspid aortic valves.

CASE-4. 40 years old woman presenting with nonspecific chest pain.



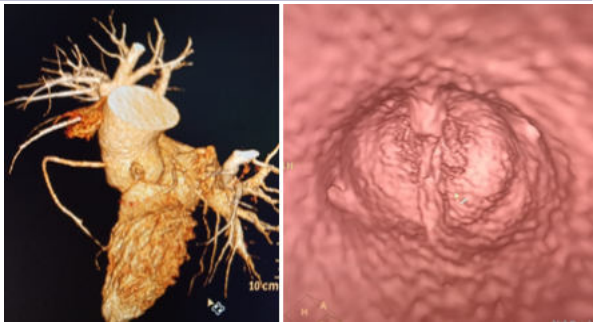


FIG.4 (A-D). CTCA 2 D-Axial (A), reconstructed coronal (B) , 3 D-volume rendered (C) and virtual angioscopy (D) image shows a closed, thickened, partially calcified bicuspid aortic valve.

CASE-5. 50 Years old female with vague chest pain.

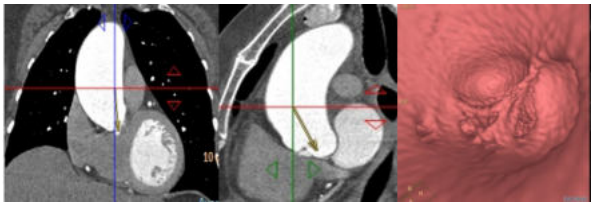


FIG.5 (A-C). CT Aortic angiogram reformatted coronal (A), sagittal (B) and virtual angioscopy (C) images reveal a thickened aortic valve causing mild aortic stenosis.

CASE-6. 55 years old male with rheumatic fever referred for CT of Thoracic aorta

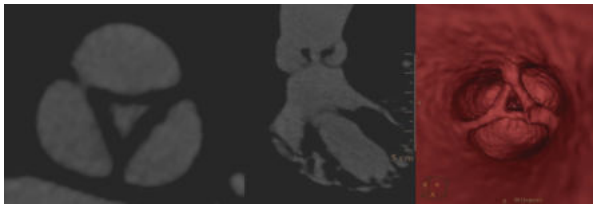


FIG.6 (A-C). CT Aortic angiogram (A, B) and virtual angioscopy (C) images reveal thickened tricuspid aortic valve leaflets causing mild aortic stenosis.

CASE-7. A 28-year-old woman with Aortic stenosis presented for evaluation of prosthetic aortic valve status after undergoing aortic valve replacement.

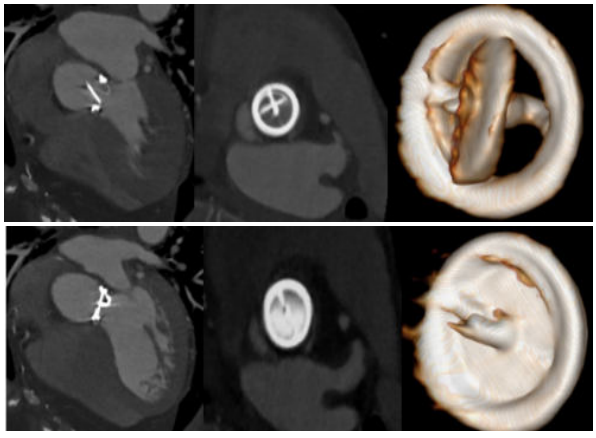
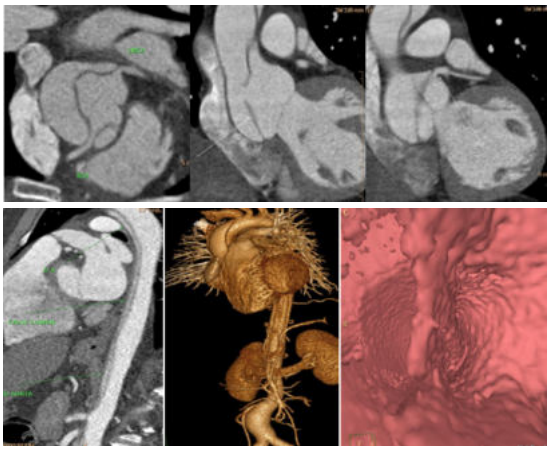


FIG.7. Cardiac CT of aortic valve shows open (A-C) and closed (D-F) prosthetic aortic valve.

FIG.8(A-F). CTCA- 2D reformatted volume-rendered (E) and virtual angioscopy (F) revealed ostioproximal narrowed main coronary arteries with aortic root dissection involving the right coronary sinus and extending to descending thoracic aorta till

the celiac axis (Debakey Type 1/ Stanford Type A).

CASE-8.34 years old college lecturer presenting with acute chest pain to the emergency department.



CASE- 9. 52 years old male patient with symptoms of acute coronary syndrome

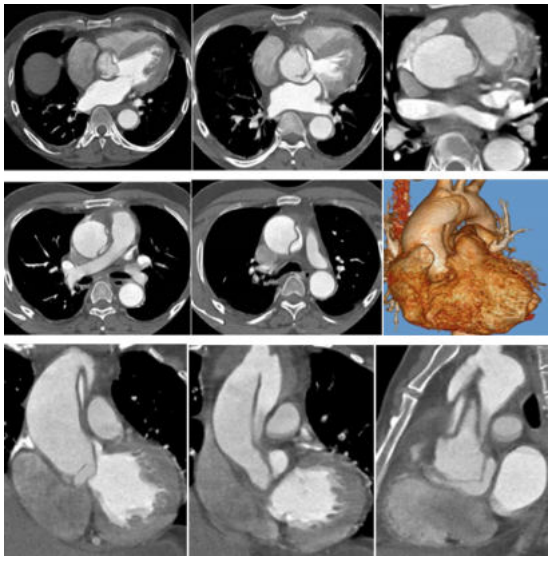


FIG.9 (A-I). CTCA- 2D axial images (A-E), 3-D volume-rendered (F) and reformatted coronal (G-I) images revealed aortic root and ascending aorta dissection(Debakey Type 2/ Stanford Type A). Right coronary artery arising from false lumen with severe reduced blood flow.

CASE.10. 48 years old man presenting with atypical chest pain

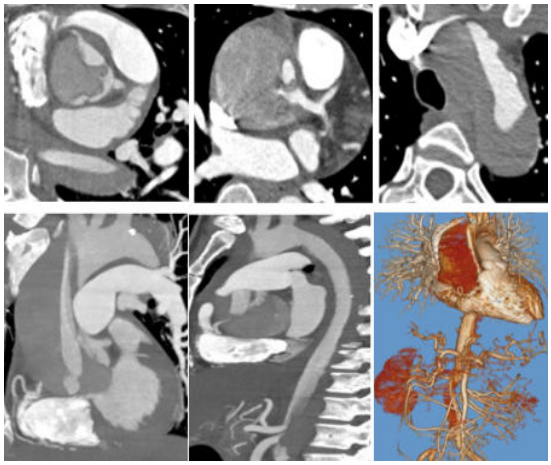


FIG. 10 (A-F). CT Aortic angiogram showing dissection of aortic root, ascending and descending thoracic aorta(Debakey Type 1/ Stanford Type A).Normal origin of right and left coronary arteries from true lumen seen.

CASE.11. 50 Years old male presented with sudden chest pain to emergency medicine.

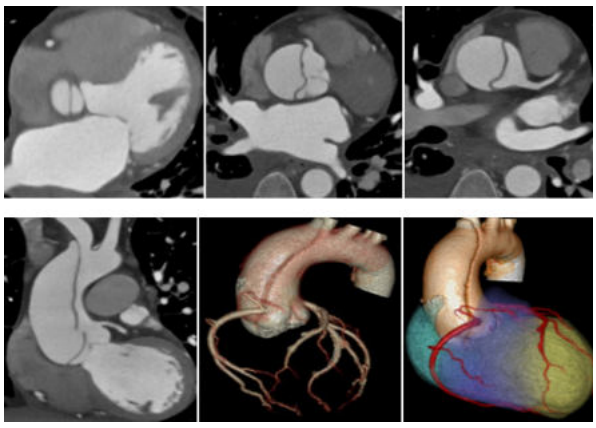


FIG.11(A-F).Computed tomography coronary angiography (CTCA).Axial (A-C), reformated Coronal (D), coronary tree and 3 D volume rendered images reveal aortic root & ascending aortic dissection (Debakey Type 2 / Stanford Type A). Normal origin of right and left coronary arteries from true lumen seen.

CASE 12.45 years old male presented with acute chest pain and abdominal pain to the ER

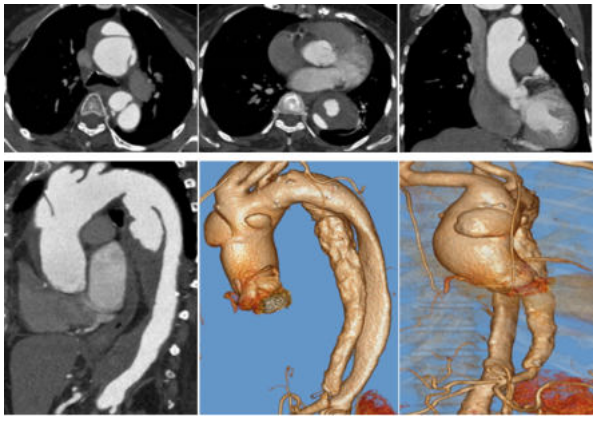


FIG.12(A-F). CT Aortic angiogram Axial (A,B), Coronal (C,D) and 3 D volume rendered images (E,F) showing 2 small focal ascending aortic aneurysmal fissuring, a larger descending thoracic and abdominal aortic fissured aneurysm.

CASE-13. 9 years old boy with vague chest pain.

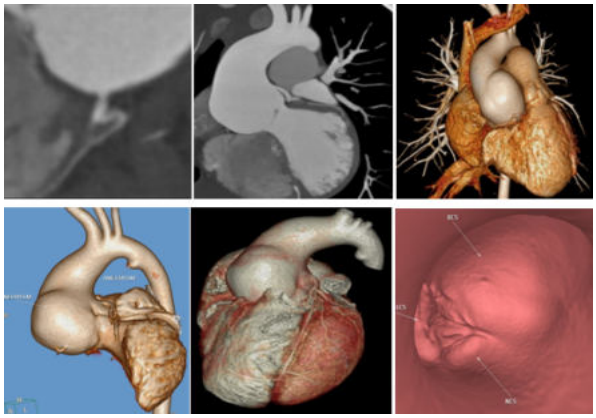


FIG.13(A-F).CTCA 2-dimensional (A, B), 3-dimensional volume-rendered (C-E), and virtual angioscopy images (F) of thoracic aorta show aortic root saccular aneurysm involving the right coronary sinus and another small aneurysm in the proximal descending thoracic aorta.

CASE .14. 42 years old female with atypical chest pain

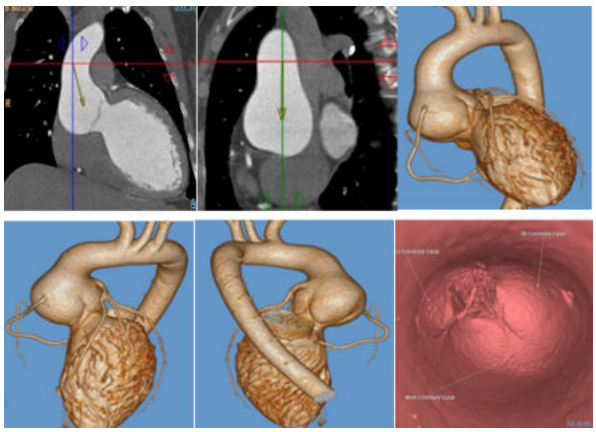


FIG.14 (A-F). CTCA Reformatted coronal (A) and sagittal (B) 2D images, 3-dimensional volume-rendered (C-E), and virtual angioscopy images (F) of the thoracic aorta show an aortic root saccular aneurysm involving the right coronary sinus.

CASE-15. 48 years male for referred for CTCA.

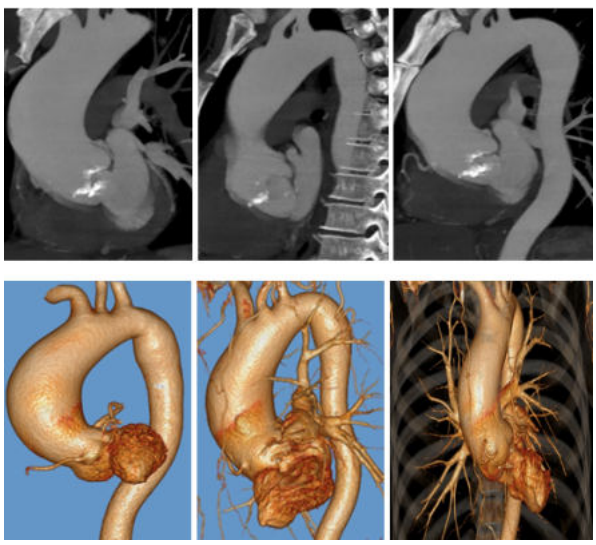


FIG.15 (A-F). CTCA Reformatted sagittal 2D images (A-C), and 3-dimensional volume-rendered (D-F), images of the thoracic aorta show ascending aortic fusiform aneurysm.

CASE-16.38 years old female referred for CT aortic angiogram for thoracic aortic pathologies.

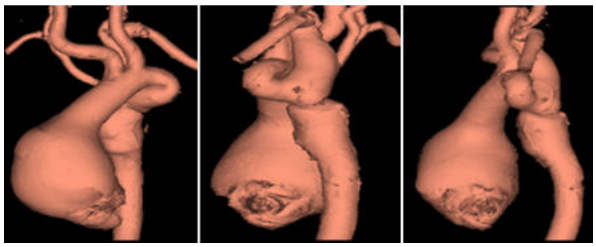


FIG.16(A-C) CT aortic angiography, 3-D volume rendered images show proximal ascending aortic fusiform aneurysm with corctation of descending thoracic aorta.

DISCUSSION;

AORTIC ROOT PATHOLOGY

Sinus of Valsalva Aneurysm (SVA)

SVA was first described by Hopeet al in 1839 as a relatively rare cardiac anomaly & can be congenital or acquired [2,3].More commonly seen in Asian men than in other ethnic groups. Male to Female ratio = 4;1.; Mean age 35.4 years, Age Range; 4 - 96 years.

SVA arises from Right Coronary Sinus (FIG.2) in 65-85%, Non-Coronary Sinus in 10- 30% and Left Coronary Sinus (FIG.1) in < 5%. Congenital causes are due to localized weakness of the elastic lamina or an underlying deficiency of normal elastic tissue (Marfan's, EDS).Acquired causes include infectious diseases (bacterial endocarditis, syphilis, TB), degenerative (atherosclerosis , cystic medial necrosis) , deceleration Trauma & 0.15% - 3.5% of all open-heart surgical procedures [3,4,5].

Although both ruptured & non-ruptured SVA may have potentially fatal complications, after treatment the prognosis is excellent. Thus, prompt & accurate diagnosis is critical [3]. Most SVA is diagnosed on the basis of Echocardiography with or without angiography. However, both ECG gated CT & MR imaging can provide excellent anatomic depiction [3].

Iatrogenic pseudo-Aneurysms of the sinus of Valsalva can occur due to hematoma formation after aortic valve replacement or removal of aortic valve calcifications [6].

Unruptured SVA is asymptomatic & incidentally discovered or symptomatic & manifests acutely with mass effect on adjacent cardiac structures [6]. Unruptured SVA may cause impaired mitral valve/tricuspid valve insufficiency, myocardial infarction, or ischemia due to coronary artery compression [3]. SVA may rupture into the right ventricle, right atrium, right ventricular outflow tract, left ventricle, interventricular septum & left atrium. Ruptured SVA results in Aorto-Cardiac shunt & manifests as insidiously progressive CCF, severe acute chest pain with dyspnea or cardiac arrest [3] & rupture into extracardiac space leads to cardiac tamponade [7]. Aortic regurgitation (30-50%) is a common complication of both ruptured & non-ruptured SVA [8].

At imaging, the criteria for diagnosing an SVA include an origin above the aortic annulus, a saccular shape & normal dimensions of the adjacent aortic root & ascending aorta [9].

Bicuspid Aortic Valve and Aortic stenosis

The aortic valvular disease may be congenital in origin or secondary to another disease process (FIG.6) .Bicuspid aortic valve (BAV) is the most common congenital anomaly of the aortic valve (FIG.4 & FIG.5), resulting from complex abnormal cusp formation during vasculogenesis [10,11]. Since BAV causes premature fibrosis and calcification of the aortic valves (FIG.4), aortic stenosis is the most common complication [12].Aortic stenosis of the bicuspid valve presents at an age range of 30 to 50 years, earlier than those caused by degeneration (FIG.5). The bicuspid aortic valve is associated with an increased incidence of stenosis, regurgitation, endocarditis, and aneurysmal dilatation of the aorta. Surgery is generally recommended for patients with severe stenosis who are symptomatic or who have significant ventricular dysfunction (FIG.7). Transcatheter aortic valve implantation (TAVI) is an emerging therapeutic option for patients who are not eligible for surgical treatment.

Aortic dissection (AD)

An AD is characterized by an intimo-medial tear of the aortic wall with subsequent separation of the layers (FIG.8). Dissections most commonly arise in the ascending aorta (FIG. 10 & FIG.11)1 cm distal to the sino-tubular junction or in the descending thoracic aorta at or just beyond the isthmus of the thoracic aorta because of maximum wall shear stress [13].

Most AD with aortic root involvement (FIG.8-11) is due to retrograde dissection from the ascending aorta which increases the chances of rupture into the pericardial space causing cardiac tamponade, dissecting into coronary artery origin (FIG.9), or creating aortic valvular regurgitation [14]. These complications are life-threatening and therefore warrant urgent surgical repair. The involvement of the origin of coronary arteries can lead to ischemia from extension of the dissection into the Ostia or by narrowing from the intimo-medial flap within the aorta without extension into the coronary artery. The right coronary artery (FIG.9), is most commonly affected [13].The term 'acute aortic syndrome' is used to indicate the trilogy of acute aortic dissection, intramural hematoma, and penetrating atherosclerotic ulceration as aortic-based causes of acute chest pain.

Aortic Aneurysm

Of all thoracic aortic aneurysms, 60% involve the aortic root (FIG.13 & FIG.14), ascending aorta (FIG.15 & FIG 16), or both [15], and there is a cumulative yearly risk of rupture or dissection of up to 6.9% per year with a maximal diameter of larger than 60 mm [16-18]. True aneurysms involve all the layers of vessel wall, while a false aneurysm / Pseudoaneurysm represent disruption of layers of wall of aorta with containment of extravasated blood by surrounding tissues forming a pseudo-capsule [19]. Based on the normal variation in the size of the proximal aorta, the American college of radiology (ACR) white paper on management of incidentals on thoracic CT suggest a size of 5 centimeter as the cut off for a proximal aortic aneurysm [20]. Blunt thoracic trauma, post surgical & infection are the most common cause of the pseudoaneurysms of heart or the thoracic aorta [21]. Pseudoaneurysms can be complicated with fatal rupture, fistula formation, and compression of surrounding structures. Aortic dilatation may be related to connective tissue disorders like Marfans syndrome, Loeys-Dietz syndrome, Ehlers-Danlos syndromes and Turner syndrome. Many genetic mutations are known to predispose individuals to aortic aneurysms, aortic dissection, or both [22]. A classic appearance of Marfan syndrome is annulo-aortic ectasia with dilatation of the annulus, uniform dilatation of the sinuses, and effaced sino-tubular junction [23].

Aortic aneurysmal Thrombus fissuration (FIG.11) is a sign of impending rupture of an aortic aneurysm. It reflects blood dissecting into the intramural thrombus. This sign is observed on contrast-enhanced CT as a linear contrast infiltration from the aneurysm lumen through the intramural thrombus [24].

CONCLUSION

Increasing use of MDCT for cardiac imaging has helped in the detection of many benign aortic root anomalies, but a small number are associated with myocardial ischemia and sudden death. Increasing the use of MDCT in cardiac imaging may yield diagnostic information on pathologies of the aortic root and ascending aorta not obtained with invasive coronary angiography. Axial sections, multiplanar reconstructions, virtual angioscopy, and 3D volume-rendered images should aid in the detection and improve the interpretation of such pathologies.

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