SciMedCentral

JSM Atherosclerosis

Review Article

Computed Tomography Imaging of the Acute Aorta - Pictorial Essay

Alexandre Semionov* and John Kosiuk

Department of Radiology, McGill University Health Center, Montreal, Canada

***Corresponding author**

Alexandre Semionov, Department of Radiology, McGill University Health Center, Montreal General Hospital, 1650 Cedar Avenue, Montreal, Quebec, Canada H3G 1A4, Tel: 514-934-8084; Fax: 514-934-8263; Email: alexandre.semionov@mail.mcgill.ca

Submitted: 05 January 2017

Accepted: 03 February 2017

Published: 04 February 2017

Keywords

- Acute aortic syndrome
- Acute aortic traumatic injury
- Aortitis

Abstract

This is a pictorial essay reviewing typical computed tomography findings of acute aortic syndrome, traumatic aortic injury, aortitis and some common diagnostic pitfalls.

ABBREVIATIONS

AAS: Acute Aortic Syndrome; ATAI: Acute Traumatic Aortic Injury; CT: Computed Tomography; ECG: Electrocardiogram; PAU: Penetrating Atherosclerotic Ulcer; TA: Takayasu's Arteritis

INTRODUCTION

Acute aortic syndrome (AAS) refers to several conditions that result in acute disruption of the aortic wall, which in turn can lead to exsanguination or various organs hypo-perfusion or ischemia. These conditions comprise aortic dissection, aortic intramural hematoma, penetrating atherosclerotic ulcer, and aortic aneurysm rupture. Additionally, aortic wall can be disrupted as a result of acute trauma, commonly manifesting as acute intimal injury, traumatic dissection or contained aortic rupture/pseudo aneurysm. Some of the conditions above may co-exist or arise from each other. For example, penetrating atherosclerotic ulcer can result in dissection or pseudo aneurysm formation, blunt trauma to the chest can lead to an intramural hematoma, and an intramural hematoma may progress to dissection. Finally, acute aortitis of inflammatory or infectious etiology may present with symptoms and clinical signs indistinguishable from AAS. Radiological imaging plays a key role in diagnosis of AAS and related conditions.

Aortic dissection

Dissection results from the flowing blood within the lumen of the vessel entering the substance of the arterial wall (media) through an intimal defect, causing separation of a layer of the vessel wall (the intima and portion of the media) from the rest of it. This in turn leads to creation of two channels of flowing blood - true and false lumens. Arterial hypertension, connective tissue disorders, bicuspid aortic valve, large vessel vasculitides and atherosclerosis are considered predisposing factors to spontaneous aortic dissection [1]. Depending on its location, aortic dissection is classified as type A - if either the ascending aorta or the aortic arch are involved, or as type B - if only the descending aorta is involved (Stanford classification) [2]. Whereas type B aortic dissection is usually treated conservatively with aggressive blood pressure control, type Aaortic dissection is considered a surgical emergency, as if left untreated; it can lead to occlusion of the coronary or carotid arteries, or cardiac tamponade secondary to hemopericardium.

On contrast-enhanced computed tomography (CT), the aortic dissection appears as a linear filling defect in the lumen of the vessel, the so-called "intimal flap", which can extend over variable length along the course of the aorta, dividing the aortic lumen into two, usually unequal, parts (Figure 1). The true lumen, the one surrounded by the intima, is usually smaller. The degree of perfusion of the true and false lumens can be different (Figure 2), and occasionally one of the lumens may thrombose. Aortic dissections commonly extend into the branches of the aorta - coronary arteries, branches of the arch, visceral branches of the abdominal aorta, iliac and femoral arteries (Figure 1,2).

Long term complications of untreated dissection include aneurysmal dilatation of the affected portion of the vessel and occlusion of the branch vessels.

Aortic intramural hematoma

Intramural hematoma is a condition similar to dissection. It results from acute bleed into the media from disrupted vasa vasorum - small arteries which feed the aortic wall, in the absence of intimal defect [1]. Similar to dissection, intramural hematomas are classified as type A or type B, depending on their location - proximal or distal to the take-off of the left subclavian artery. The former is considered a surgical emergency, whereas the latter is usually treated conservatively.

On non-contrast enhanced CT, the intramural hematoma appears as a crescent of hyper-attenuation along the aortic wall (Figure 3,4). On contrast-enhanced CT, the intramural hematoma appears as aortic wall thickening which is hypo-dense compared to the intraluminal contrast material (Figure 4). In type A aortic intramural hematoma, the blood can extend along the wall of the

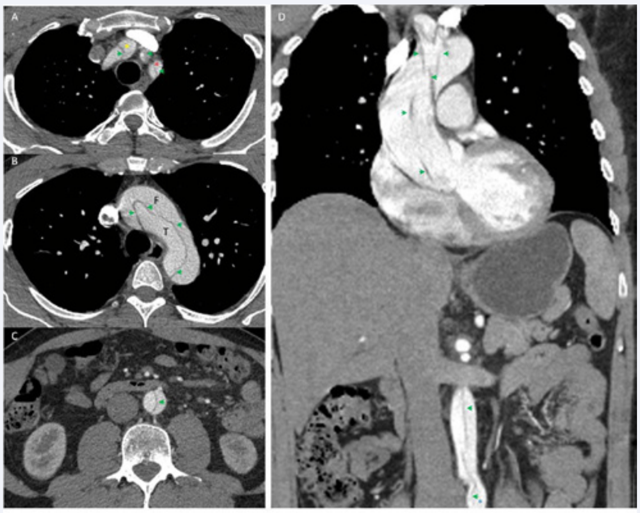

Figure 1 Type A acute aortic dissection in a 58-year-old male presenting with acute chest pain. Contrast-enhanced axial CT images at the level of branches of the arch (A), at the aortic arch (B), and infrarenal aorta (C), and coronal reformation (D) show intimal flap (green arrows) extending from the aortic root to the brachiocephalic artery (yellow *), into the left common carotid artery, left sublclavian artery (red *), into the abdominal aorta and left common iliac artery (blue * in D). The true (T) and false (F) lumens are perfused to a similar degree.

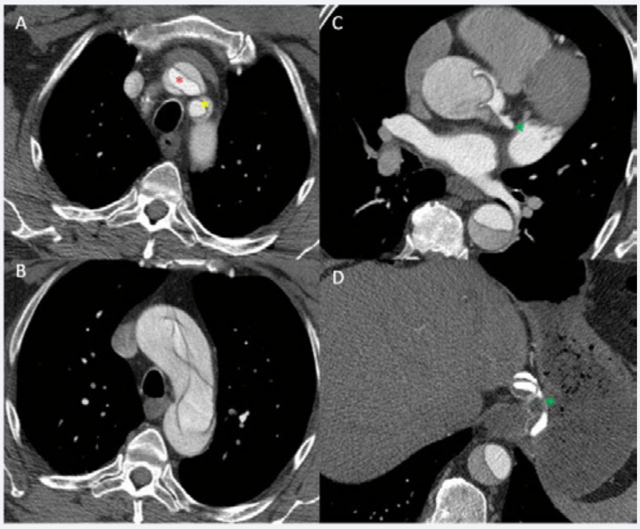

Figure 2 Type A acute aortic dissection in a 64-year-old male. Contrast-enhanced axial CT images at the level of branches of the aortic arch (A), aortic arch (B), aortic root (C), and suprarenal abdominal aorta(D) show intimal flap extending into the left main coronary artery (green arrow in c), into the brachiocephalic artery (red *), left common carotid artery (yellow *), into the abdominal aorta and celiac trunk (green arrow in D). Note differential intravascular contrast opacification of the two lumens.

central pulmonary arteries and result in their luminal narrowing [3] (Figure 4).

Penetrating atherosclerotic ulcer (PAU)

Atherosclerotic disease is a common condition affecting the aorta of older individuals. Atherosclerotic plaques may occasionally ulcerate. When the ulcer extends through significant

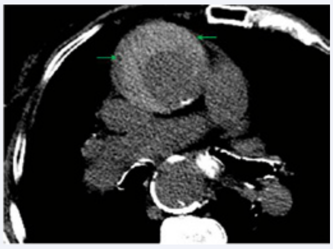

Figure 3 Type A aortic intramural hematoma in a 99-year-old female. Non-contrast CT chest demonstrates a crescent of hyperdensity in the thickened wall of the tubular ascending aorta (green arrows).

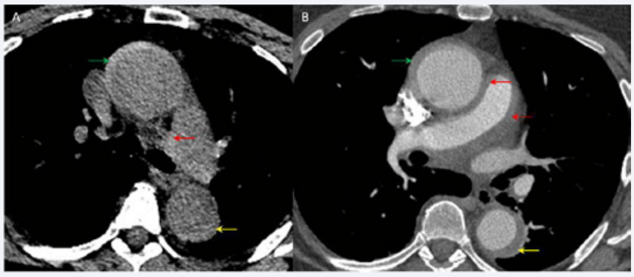

Figure 4 Type A aortic intramural hematoma in a 61-year-old female, extending into the wall of the main pulmonary artery. Non-contrast (A)and contrast-enhanced(B) CT chest demonstrate wall thickening of the ascending (green arrows) and descending (yellow arrows) aorta, and of the pulmonary trunk (red arrows), which is hyper-attenuating on the non-contrast study and hypodense to the endoluminal contrast on the infused scan.

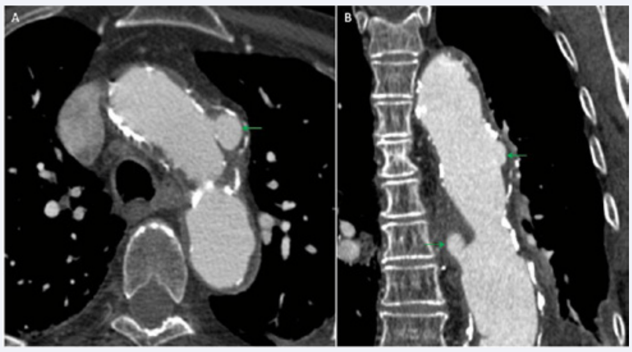

Figure 5 Axial contrast-enhanced CT chest (A) and its coronal reformation (B) in a 83-year-old male demonstrating extensive atherosclerosis of the thoracic aorta and multiple penetrating atherosclerotic ulcers (green arrows). The lesion in (A) has resulted in formation of a small pseudoaneurysm.

thickness of the aortic wall media, symptoms related to pain and bleeding may arise. On cross-sectional imaging, PAU appears as a focal excavating defect in the wall of the atheromatous vessel (Figure 5). Most of the PAUs arise in the descending thoracic aorta [4].

PAUs may regress spontaneously, remain stable or progress to dissection or pseudoaneurysm.

Aneurysmal rupture

Aortic aneurysms, and consequently their rupture, occur more commonly in the abdominal aorta. The aneurysmal rupture happens when the intra-arterial pressure exceeds the tensile strength of the aneurysmal wall. Thus the risk of rupture is proportional to the size of the aneurysm [5].

On imaging of aneurysmal rupture, one usually finds irregular contour of the aneurysm, peri-aneurysmal hematoma plus/minus areas of active contrast extravasation (Figure 6).

Aneurysmal rupture is a surgical emergency and is associated with high mortality rate.

Acute traumatic aortic injury (ATAI)

Of all cases of ATAI, motor vehicle collisions account for majority, followed by falls from height, and crush injuries [6]. The aortic isthmus is the most common location of ATAI. This is thought to be due to relatively immobile position of the isthmus, being tethered by the ligamentum arteriosum. The severity of ATAI may range from minimal intimal injury to frank aortic rupture.

In the context of blunt or acute deceleration trauma to the chest, minute tears of the aortic intima may occur. The intimal defects themselves are usually occult on CT imaging of the chest. Acute intimal injury is usually inferred from the presence of an endoluminal filling defect, thought to represent a mural thrombus forming at the site of injury (Figure 7,8). If aortic injury is more extensive, traumatic dissection with an intimal flap may be seen.

In cases of even more severe injury to the aorta, abnormal aortic contour and traumatic pseudo aneurysm/contained rupture can occur (Figure 9,10). Active extravasation of intravenous contrast material is sometimes observed, indicative of impending exsanguination.

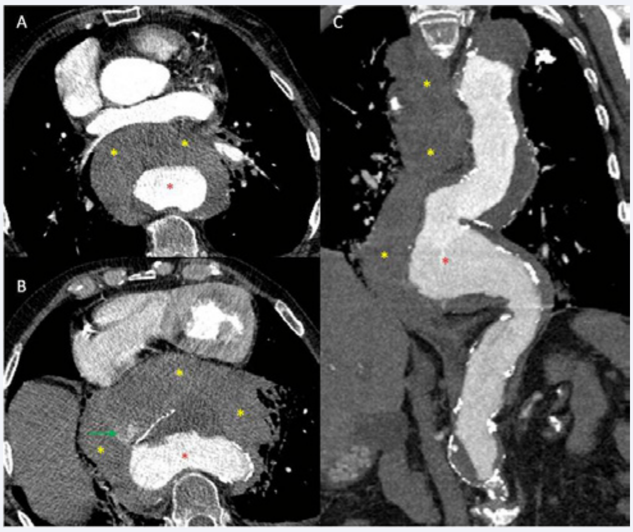

Figure 6 Contrast-enhanced CT chest in an 88-year-old male with acute aneurysmal rupture. Axial images at the level of the left atrium (A) and diaphragm (B), and coronal reformation (C)demonstrate a large aneurysm of the distal thoracic aorta (red *), which has irregular contour and is surrounded by a large hematoma (yellow *). The latter compresses the left atrium (A) and extends cranially to the level of the arch (C). Note the area of active contrast extravasation (green arrow in B).

Figure 7 Acute intimal injury in a 22-year-old male with blunt trauma to the chest. Axial (A), coronal (B) and sagittal (C) images of contrast-enhanced CT chest demonstrate a small endoluminal filling defect in the aortic isthmus (green arrows), corresponding to a small mural thrombus at the site of acute intimal injury. Follow-up postero-anterior chest radiograph (D) demonstrates placement of an endovascular stent-graft (red arrows) into the proximal descending aorta.

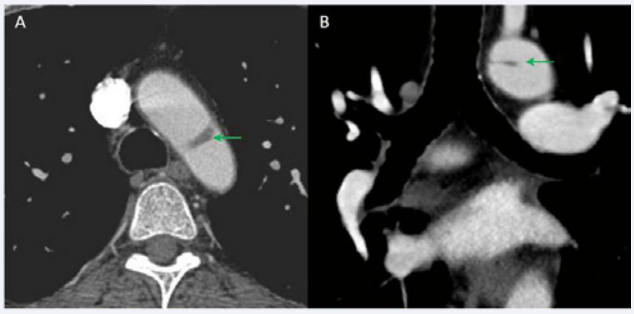

Figure 8 Axial (A) and coronal reformation (B) images of contrast-enhanced CT chest in a 50-year-old male with acute blunt trauma to the chest demonstrate a linear endoluminal filling defect in the aortic isthmus (green arrows), postulated to represent a floating mural thrombus at the site of acute intimal injury.

Indirect findings of ATAI generally consist of mediastinal hematoma and hemothorax (Figure 9,10).

Aortic pseudoaneurysm/contained rupture can also be seen secondary to surgical procedures, such as aortic valve replacement or aorto-coronary bypass grafts (Figure 11,12).

Mycotic aneurysm

The term “mycotic aneurysm” refers to an aneurysm which results from an infection, most commonly bacterial. Mycotic aneurysms are estimated to account for roughly 1% of all aortic aneurysms [7]. Approximately a quarter of aortic mycotic aneurysms result in rupture. The infra-renal abdominal aorta is the most frequently involved.

A mycotic aortic aneurysm appears as a focal, contrast-enhancing dilatation that is usually saccular (Figure 13). Ruptured infected aortic aneurysms may show active extravasation of intravascular contrast, and hematoma formation adjacent to the aneurysm can occur.

Noninfectious aortitis

Noninfectious aortitis can be seen in patients with large-vessel vasculitides, of which Takayasu's arteritis (TA) and giant cell arteritis are the most common [8].

TA is an idiopathic large-vessel granulomatous inflammation. It is more commonly encountered in younger Asians females [9]. The aortic arch and its major vessels are most commonly affected. TA has three recognized clinical phases: a pre-pulse less phase characterized by constitutional symptoms, an acute inflammatory phase where arterial wall thickening develops, and a chronic occlusive phase. Since the disease is often recurrent, different phases may coexist.

CT findings in the acute phase of TA include arterial wall thickening, which is hyper-attenuating on non-infused studies, and features delayed post intravenous contrast enhancement, and surrounding fat stranding (Figure 14). In the chronic phase one may find arterial stenosis, occlusion, post-stenotic dilatation, pseudo aneurysms, mural ulcerations, dissection, thrombosis, and mural calcifications.

Pitfalls

Respiratory and cardiac motion during chest imaging can result in artifactual images of aortic wall irregularities and intraluminal filling defects simulating dissection, intimal injury or pseudo aneurysm (Figure 15). Usually motion artifacts can be identified as such by carefully assessing adjacent anatomical

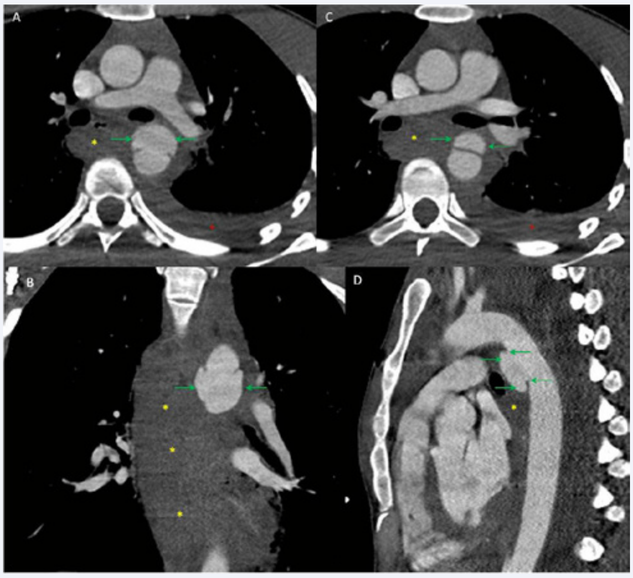

Figure 9 Axial (A,C), coronal (B) and sagittal (D) images of a contrast-enhanced CT chest in a 26-year-old male with acute aortic traumatic injury demonstrate irregularcontour of the aortic isthmus, in keeping with a pseudoaneurysm/ contained rupture (green arrows). A large mediastinal hematoma (yellow *) and a left hemothorax (red *) are present.

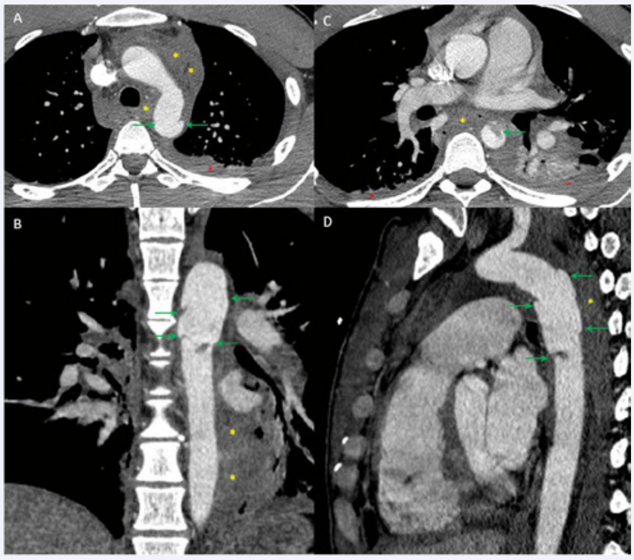

Figure 10 Case of acute traumatic aortic injury very similar to the one in Figure 9. Axial (A,C), coronal (B) and sagittal (D) images of a contrast-enhanced CT chest in a 25-year-old male with acute blunt thoracic trauma demonstrate contour irregularities and endoluminal filling defects in the proximal descending aorta (green arrows), a large mediastinal hematoma (yellow *) and bilateral hemothorax (red *).

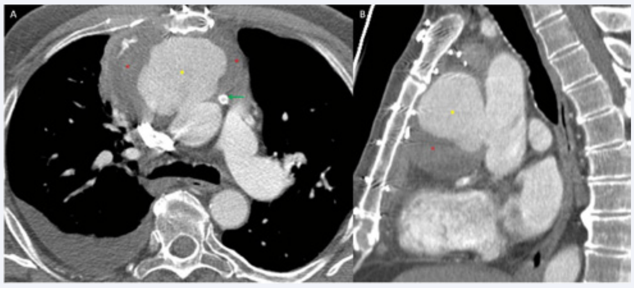

Figure 11 Axial (A) and sagittal reformation (B) images of a contrast-enhanced CT chest in a 75-year-old male status post median sternotomy and aorto-coronary bypass grafts, demonstrate a large pseudoaneurysm (yellow *) arising from the anterior wall of the tubular ascending aorta, close to the origin of the aorto-coronary bypass graft (green arrow), and an associated hematoma (red *).

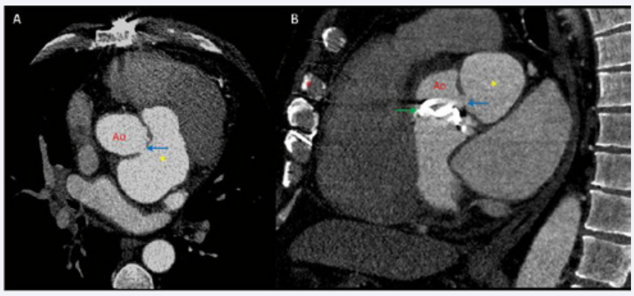

Figure 12 Axial (A) and sagittal reformation (B) images of a contrast-enhanced, ECG-gated cardiac CT in a 58-year-old male status post median sternotomy and aortic valve replacement, demonstrate a large pseudoaneurysm (yellow *) arising from the posterior wall of the proximal ascending aorta (Ao), just above the level of the artificial aortic valve (green arrow in B). Note very narrow neck of the pseudoaneurysm (blue arrows).

structures, such as pulmonary airways and vessels, which will appear ill-defined and blurred when motion is present. When doubt remains whether an abnormality represents a motion artifact, the study can be repeated and ECG gating can be performed (Figure 15).

Small out pouching of the aortic wall at the origin of small vessels, such as bronchial and intercostal arteries, can simulate (pseudo)aneurysms (Figure 16). These can be recognized as such by tracing the corresponding vessels to the suspected abnormality (Figure 16).

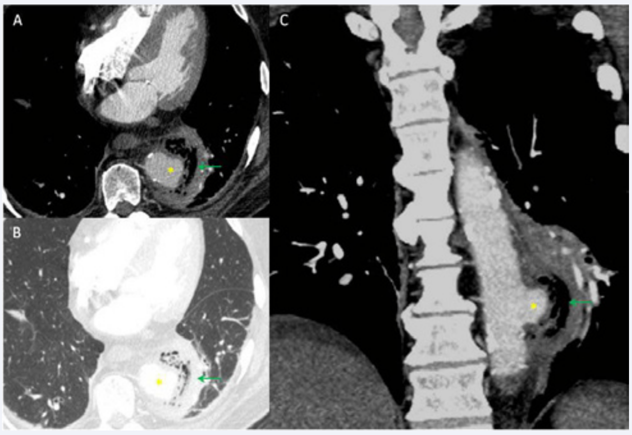

Figure 13 Mycotic aneurysm of the descending thoracic aorta in an 85-year-old male, presumed to be secondary to left lower lobe pneumonia. Axial images of the contrast-enhanced CT chest in mediastinal (A) and lung (B) windows, and coronal reformation image in mediastinal window (C), demonstrate a saccular aneurysm arising from the lateral wall of the distal descending thoracic aorta (yellow *). The aneurysm abuts an area of consolidation with central necrosis in the left lower lobe, compatible with necrotizing pneumonia (green arrows).

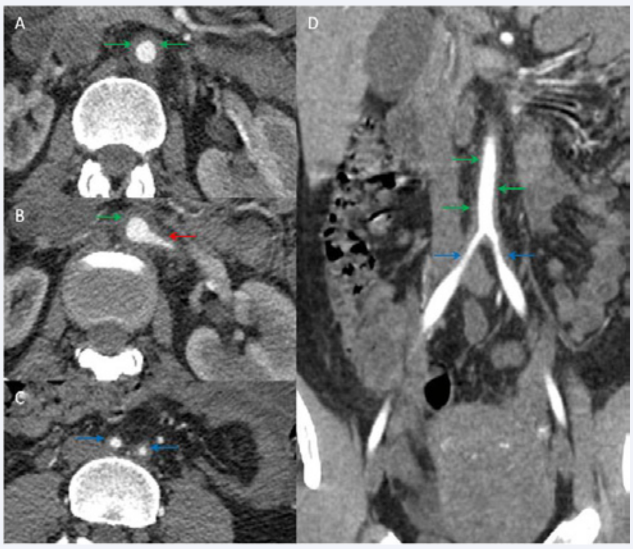

Figure 14 Contrast-enhanced CT abdomen in a 37-year-old female with Takayasu's arteritis. Axial (A-C) and coronal (D) images demonstrate marked circumferential wall thickening with associated luminal narrowing of the abdominal aorta (green arrows), left renal artery (red arrow) and bilateral common iliac arteries (blue arrows).

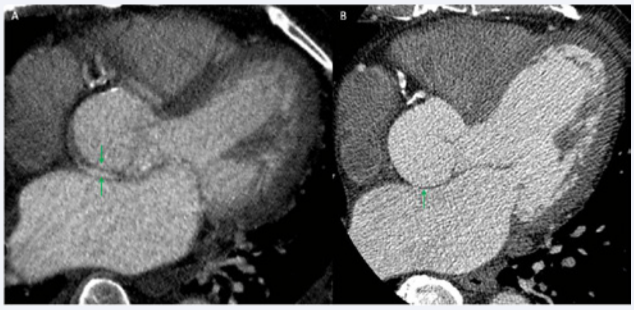

Figure 15 Non ECG-gated contrast enhanced CT chest (A) in a 72-year-old male investigated for acute chest pain, demonstrates cardiac motion artifact at the level of the aortic root, which simulates aortic dissection (arrows). The follow-up cardiac CT with ECG-gating from the same day (B) shows normal aortic root (arrow).

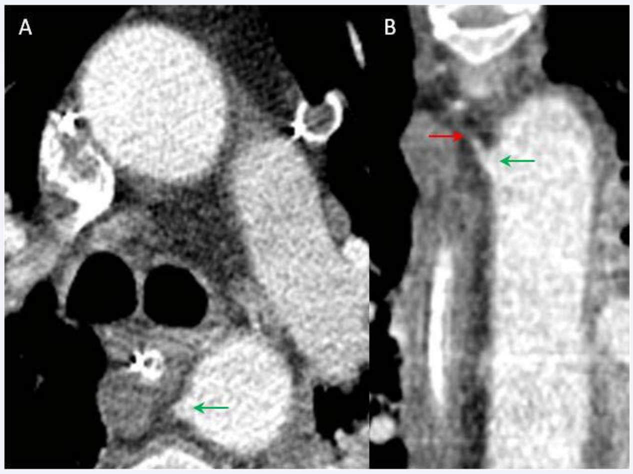

Figure 16 Axial (A) contrast-enhanced CT chest of a 60 year-old male trauma patient shows a small out pouching of the medial wall of the proximal descending aorta (green arrow), simulating an aortic aneurysm. However, the coronal reformation image (B) shows that the out pouching (green arrow) is in continuity with a bronchial artery (red arrow), in keeping with an infundibulum of that vessel.

Figure 17 Sagittal reformation of a contrast-enhanced CT chest in a trauma patient demonstrates an out pouching of the inferioraortic wall at the isthmus (green arrow), that can be misinterpreted as aneurysm or pseudoaneurysm. This is however a classical appearance of ductus diverticulum.

SciMedCentral

Another common pitfall is the ductus diverticulum - a developmental out pouching of the undersurface of the distal arch at the site of ligamentum arteriosum (Figure 17). This is also the site of most of traumatic aortic injuries; therefore, differentiation of ductus diverticulum from a pseudoaneurysm is crucial. In contrast to pseudoaneurysm, which usually forms sharp margins with the aorta, ductus diverticulum usually appears as a smooth focal bulge forming gentle obtuse angles with the aortic wall [10] (Figure17).

CONCLUSION

CT plays critical role in assessment of patients with suspected acute aortic abnormalities. Knowledge of typical radiological appearances of these conditions is important as many of them are potentially life threatening and require prompt diagnosis and management.

REFERENCES

1. Maddu KK, Shuaib W, Telleria J, Johnson JO, Khosa F. Nontraumatic acute aortic emergencies: Part 1, Acute aortic syndrome. AJR Am J Roentgenol. 2014; 202: 656-665.
2. Daily PO, Trueblood HW, Stinson EB, Wuerflein RD, Shumway NE. Management of acute aortic dissections. Ann Thorac Surg. 1970; 10: 237-247.
3. Guilmette J, Semionov A, Dennie C, Gahide G, Pressacco J, Fraser R, et al. Hemorrhagic infiltration of the aortopulmonary adventitia: A complication of acute aortic dissection. Eur J Radiol. 2016; 85: 239-247.
4. Hayashi H, Matsuoka Y, Sakamoto, Sueyoshi E, Okimoto T, Hayashi K, I et-al. Penetrating atherosclerotic ulcer of the aorta: imaging features and disease concept. Radiographics. 2000; 20: 995-1005.
5. Schwartz SA, Taljanovic MS, Smyth S, O'Brien MJ, Rogers LF. CT findings of rupture, impending rupture, and contained rupture of abdominal aortic aneurysms. AJR Am J Roentgenol. 2007; 188: W57-62.
6. Steenburg SD, Ravenel JG, Ikonomidis JS, Schönholz C, Reeves S. Acute traumatic aortic injury: imaging evaluation and management. Radiology. 2008; 248: 748-762.
7. Lee WK, Mossop PJ, Little AF, Fitt GJ, Vrazas JI, Hoang JK, et al. Infected (mycotic) aneurysms: spectrum of imaging appearances and management. Radiographics. 2008; 28: 1853-1868.
8. Restrepo CS, Ocazionez D, Suri R, Vargas D. Aortitis: imaging spectrum of the infectious and inflammatory conditions of the aorta. Radiographics. 2011; 31: 435-451.
9. Gotway MB, Araoz PA, Macedo TA, Stanson AW, Higgins CB, Ring EJ, et al. Imaging findings in Takayasu's arteritis. AJR Am J Roentgenol. 2005; 184: 1945-1950.
10. Agarwal PP, Chughtai A, Matzinger FRK, Kazerooni EA. Multidetector CT of Thoracic Aortic Aneurysms. Radiographics. 2009; 29: 537-552.

Cite this article

Semionov A, Kosiuk J (2017) Computed Tomography Imaging of the Acute Aorta - Pictorial Essay. JSM Atheroscler 2(2): 1024.