Aortic dissection: Aspects on computed tomography

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Learning objectives

To review the pathogenesis and classification systems for aortic dissection (AD).

To illustrate the typical computed tomography (CT) findings based on our department clinical database.

To discuss the best imaging methods to study the aforementioned findings along with its advantages and limitations.
Background

AD is a potentially medical emergency that requires early and accurate diagnosis to initiate appropriate surgical or medical treatment [1].

It is characterized by an intimal tear, which allows blood to access and split the medial layers of the aortic wall, generating a longitudinal division of the intima and adventitia. This results in two lumina - a true and a false one - separated by a layer of intimal tissue known as the intimal flap[2].

The false lumen lies within the external half of the media so that the outer wall of the false lumen is composed by the split media and adventitia and is very thin, explaining its tendency to rupture. Usually the false lumen includes a larger cross-sectional area with less velocity flow and turbulence having pressures greater than or equal to those in the true lumen which may generate compression or occlusion of the true lumen. This way organs supplied solely by the false lumen are rarely compromised [2,3].

Although the cause of spontaneous aortic dissection is unknown and most likely multifactorial, most patients have a history of systemic hypertension, which occurs in 60%-90% of cases. Drugs (cocaine for instance) have been documented as contributing agents in patients with no history of hypertension. Collagen vascular disorders like Marfan syndrome are also considered a cause of aortic dissection, particularly in young patients. Other conditions associated with an increased risk of aortic dissection are Turner syndrome, previous cardiac surgery/endovascular instrumentation, aortic coarctation, pregnancy and trauma.

For therapeutic and prognostic reasons, the Stanford classification system divides AD into two types on the basis of anatomic involvement and regardless of the site of the intimal tear. Type A dissections involve the ascending aorta and may extend distally and type B dissections are distal to the left subclavian artery. Approximately 60% of dissections are Type A and are considered surgical emergencies with higher mortality rates due to the risk of aortic insufficiency, rupture to the pericardium and dissection into the coronary or brachiocephalic arteries. These percentage is distinct from those previously noted in radiologic examinations, in which dissections involving the descending aorta are more common, because these studies mostly include the survivors of AD. Advances in surgical and medical treatment of dissection, including surgical repair and antihypertensive medication, have markedly improved survival. Type B dissections have a more benign course and are often managed conservatively, unless there are complications due to aortic rupture or extension [2,4] of the dissection with visceral vascular compromise.

The typical symptom of aortic dissection is severe pain located initially in the chest and subsequently in the back, radiating anteriorly into the neck or to the back between the scapulae, whereas some patients may present with cardiac insufficiency, abdominal pain,
cerebrovascular manifestations or syncope from marked hypotension. Regarding the time elapsed since the onset of the symptoms one considers acute AD to be defined by the presence of symptoms for less than 14 days, and chronic AD for longer periods.

Outcome depends on type and extent of dissection and the presence of associated complications [5] including:

- pleural or pericardial rupture
- aortic insufficiency
- cardiac tamponade
- loss of peripheral pulses
- abnormal hepatic and pancreatic enzymes
- stroke, shock, paraplegia
- visceral arterial compromise as acute oliguria/anuria
The variety of clinical presentation may predispose to misdiagnosis so imaging modalities play a crucial role.

The chest radiograph is widely used as a screening tool [7], however its specificity and sensitivity are very low, and up to 40% of examinations may be unremarkable. It may show a widened mediastinum with bilateral pleural effusion, an increased cardiothoracic ratio and inward displacement of calcification from the ascending or descending aorta contour.

At our hospital CT angiography has classically been the primary diagnostic imaging technique used to evaluate these patients, because of its wide availability, and high diagnostic accuracy. The study should include the entire aorta to determine the proximal aspects of the carotid and vertebral arteries and the distal extent of the dissection apart from including three phases [1,2,7]:

1- Unenhanced CT

2 - Enhanced arterial phase of the aorta with bolus triggering

3 - Venous phase scan.

Additionally, multiplanar and three-dimensional reconstructions will provide easier visualization of critical anatomic relationships for surgical repair or endovascular graft planning.

Unenhanced CT

Imaging features of unenhanced CT include information that can be covered by the presence of contrast material such as:

- Central displacement of intimal calcification (fig.1,2)
- Prosthetic aortic valves and grafts are easier to recognize
- In case of rupture, the high attenuation of blood is promptly perceptible within the mediastinum, pericardial sac, or pleural space
- Aortic wall with increased attenuation by an expanding intramural haematoma or acutely thrombosed false lumen.

Contrast-enhanced CT
On enhanced CT, the hallmark is the intimal flap, separating the true and false lumen, and seen in the vast majority of CT studies (70%) depicted as a hypodense band with a linear or S shape (figs. 3,4).

Identification of the true and false lumen is important in the interventional planning so the origin of coronary, carotid, renal, and mesenteric vessels from either the true or false lumen should be expressly addressed (fig.5). In most cases, the true lumen can be distinguished by tracing the continuity with the uninvolved portion of the aorta. However there might be multiple channels or destruction of the intimal membrane preventing this task. In such cases, it is possible to differentiate between these lumina by enhancement characteristics, morphologic features, relationship between them and presence of thrombosis and calcifications.

Le Page et al [8] found that the most reliable signs in identifying a false channel usually include a larger cross-sectional area containing a thrombus and presenting a beak or cobweb signs. The beak sign (fig.6), solely observed in the false lumen, is formed by an acute angle at the junction between intimal membrane and the outer wall. Similarly, aortic cobwebs were also only present in these situations, approximately in 80% of acute dissections and 74% of chronic dissections, and represent strands of fibrous tissue that have been incompletely sheared from the aortic wall.

The two channels may be parallel to each other, the false lumen may wrap around the true lumen, or the true lumen may seem to flat in the false lumen.

The true lumen is usually smaller, appearing compressed in about 80% of cases and containing high velocity flow, compared with slower blood flow in a larger false lumen (fig.7). These different rates of blood flow translate as distinct rates of contrast enhancement. Therefore, the false lumen has delayed enhancement in the arterial phase and prolonged opacification towards the later phases. It also presents a higher propensity to thrombosis [1-5, 8].

Atherosclerotic calcifications are mainly located in the intima layer, so outer wall calcifications of an aortic lumen are indicative of the true lumen in acute aortic dissection (figs.1,2). On the other hand in chronic conditions, the outer wall of the false lumen may endothelialize and present calcifications and in those circumstances this sign is not valid.

Confident diagnosis and correct classification of aortic dissection may be hampered by several pitfalls. These might be due to technical factors such as improper timing of enhanced arterial phase; streak artifacts generated by high-attenuation material like surgical staples; periaortic structures (mediastinal veins, pericardial recess, atelectasis, pleural thickening); aortic wall motion.

Aortic motion artifact (figs.8,9) is seen during cardiac systole and diastole as curvilinear artifacts most pronounced in the proximal ascending aorta. In most cases they take place at the left anterior and right posterior margins of the aortic circumference and are restricted to few adjacent sections. When the findings on axial images are uncertain, a
serrated appearance of the anterior ascending aorta on reconstruction images provides unambiguous evidence of a motion artifact.

Awareness of these mimics is vital for preventing a false-positive diagnosis. At CT, ECG gating techniques are used to reduce artifacts caused by cardiac motion, significantly improving image quality. It helps minimizing false positive results by enabling a more precise delineation of the aortic root and coronary arteries [8].

However CT requires the use of nephrotoxic iodinated contrast agent, implies exposure to ionizing radiation and is not appropriate for patients with renal insufficiency).

In fact both CT angiography and contrast-enhanced magnetic resonance angiography [10] can accurately evaluate aortic dissection, with MR covering some of above mentioned disadvantages: it does not employ ionizing radiation, makes use of non-nephrotoxic contrast material, multiplanar evaluation and allows much faster postprocessing imaging.

Nevertheless, it also has limitations: calcification of the aortic wall may not be depicted, less equipment availability, and cannot be performed in unstable patients and / or those with implanted electronic devices. These studies may have a limited value in the follow-up of patients with a previously endovascular treatment, due to the occurrence of artifacts related to the metallic composition of the material.
Fig. 1: 43 year-old man with Stanford type A aortic dissection. a: Unenhanced axial CT demonstrated displaced intimal calcification (arrow) probably caused by aortic dissection. b: the diagnosis was confirmed in axial contrast-enhanced CT that exhibited a dissection flap separating the two lumina. (T - true; F - false)

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Fig. 2: Type A aortic dissection in the same patient. CT images, a: axial. b: maximum intensity projection (MIP). Dissection flap presented in the ascending and descending aorta.

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Fig. 3: Stanford type B aortic dissection. In a male with 77 years-old. (a-d) Axial images obtained at different levels demonstrate a type B aortic dissection that involves the descending thoracic aorta immediately distal to the left subclavian artery (arrows) - intimal flap.

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Fig. 4: Same patient as in previous figure. On a reconstructed image, the dissection arises just distal to the left subclavian artery (arrow.)

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**Fig. 5:** a,b: axial CT images. The right kidney is supplied by the false lumen (curved arrow, b) whereas the left renal artery arises from the true lumen (arrow, a). This finding emphasizes the need to include the entire aorta and pelvic vessels in the study.

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**Fig. 6:** Beak sign. Axial CT image demonstrates the beak sign (arrow). F - false lumen.

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Fig. 7: Stanford type A aortic dissection in a 58-year-old woman. a: axial image demonstrates a dissection flap in the ascending aorta with a partial thrombus in the false lumen (arrow) (c) and shows extension to the brachiocephalic artery (circle) (b) and right common carotid (circle) (c). d: coronal reformatted image reveals compression of the true aortic lumen by a false channel with a larger sectional area. (F). Secondary it was depicted an increase of attenuation values of pericardial effusion.

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**Fig. 8:** Aortic motion artifact. a: Enhanced axial CT image shows an artifactual rim of low attenuation (arrows) in the left anterior and right posterior wall of the ascending aorta. b: volume-rendered image reconstruction (VRT) obtained a waving contour due to pulsatile motion.

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**Fig. 9:** Non-gated axial CT image shows "dissection-like" intimal flap (arrow) due to motion of the aorta. B. Oblique sagital maximum intensity projection (MIP) reconstruction reveals a serrated appearance of the anterior wall of the ascending aorta (open arrow).

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Conclusion

In conclusion, the critical steps in the evaluation of a suspected aortic dissection are to confirm or rule out the suspicion, to identify the type of dissection (Stanford Type A or Type B) and the involvement of aortic branches.

CT is a widely available imaging modality with high diagnostic accuracy. The radiologist must be able to optimize the technique (electrocardiogram-gated CT), and provide an accurate report for adequate treatment planning that must contain:

- Accurate classification as type A or B
- Identification of signs of rupture, compression or thrombosis
- Assessment of the relationship of the branch vessels to the true and false lumen
- Identification of impaired perfusion of abdominal organs
- Assessment of other relevant thoraco-abdominal pathology.
References

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