State-of-the-Art CT and MR Imaging of Aortic Diseases

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Overview
- Aortic aneurysm
- Acute Aortic Syndrome
  1. Aortic Dissection
  2. Intramural Hematoma
  3. Penetrating Aortic Ulcer
- Aortic trauma

Aorta – anatomy
- Thoracic branches -
  - Intercostal
  - Bronchial
- Subdiaphragmatic branches
  - Celiac
  - SMA
  - Renal arteries
  - IMA
  - Lumbar arteries

Aorta – normal diameter
- Ascending aorta normally has greater diameter than descending
  - Ascending: 4.0 cm
  - Descending: 3.0 cm
  - Abdominal: 2.0 cm
Aorta – “normal” variants

- Aortic spindle
- Aortic Isthmus — narrowing of aorta between the left subclavian artery and the ductus arteriosum. Resolves up to 2 months of age
- Ductus diverticulum
- Pseudocoarctation

Mediastinal “Mass”

Pseudocoarctation – Extremely tortuous aorta

True Coarctation

Aorta - Imaging modalities

- CXR
- US
- Angiography
- CT
- MRI
Atherosclerotic Vascular Disease (ASVD)

- Smooth intimal plaques
- Ulcerated plaques
- Calcified plaques
- Mobile thrombi
- "Protruding" atheromas

Atherosclerotic Vascular Disease

- Plaques thicker than 4 mm - an increased risk of stroke
- Calcified plaque may be relatively stable
- Uncalcified or ulcerated plaque may pose an increased risk for embolization
- Thrombi may be superimposed on atherosclerotic plaques
- Protruding atheromas are prone to embolize
- Such thrombi may resolve with anticoagulation

Aortic aneurysm

- How do we define aneurysm?
- What are the types?
- Epidemiology?
- Imaging modalities and appearance?
- Treatment?

What constitutes an aneurysm?

- Dilation of the aorta involving all three wall layers equaling or exceeding 1.5 /twice the expected normal diameter
- Fusiform vs. saccular
- Rule of thumb:
  - Ascending: 5 cm
  - Descending: 4 cm
  - Abdominal: 3 cm

Aortic aneurysms – risk factors

- Atherosclerotic disease
- Family history
- Cystic medial necrosis (incl. Htn, Pregnancy, Marfan)
- Syphilis, TB, Takayasu, Giant cell arteritis
- RA, posttraumatic
- Congenital (primary or secondary to bicuspid aortic valve or coarctation)
Aortic Aneurysm: Natural history
- 80% infrarenal
- Abdominal aorta and Descending thoracic aorta - most often due to atherosclerosis
- Ascending aorta - most often due to cystic medial necrosis
- Most are asymptomatic
- Can thrombose with distal embolization, leak or rupture

Risk of aneurysmal rupture
- Abdominal aorta
  - <4 cm: 0% yearly risk of rupture
  - 4-5 cm: 0.5 – 5% yearly risk
  - 5-6 cm: 10 - 20% yearly risk
  - 8+ cm: 30 – 50% yearly risk
- Thoracic aorta
  - >5 cm – abnormal
  - >6 cm – operate

Aortic Aneurysm – Risk of Rupture
- Thoracic aortic aneurysms - growth rate of 0.42 cm/year
- Abdominal aortic aneurysms - growth rate of 0.25 cm/ year
- 25% of thoracic aortic aneurysms are accompanied by infrarenal abdominal aortic aneurysms

Aortic Aneurysm – Risk of Rupture
- Ruptured ascending aortic aneurysms often >6 cm in diameter
- Frequency of rupture varies from 40% to 70%
- Elective vs emergent repair mortality - 9% versus 22% respectively
- Intervention for thoracic aortic aneurysms when aneurysm size exceeds 5.5 cm for ascending and 6.5 cm for descending thoracic aortic aneurysms

Aortic aneurysm
- How do we define aneurysm?
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Aneurysm evaluation
- CXR
- Angiography – rarely
- MRI – rarely
- Ultrasound
- CTA
- Cross-sectional imaging – diagnosis and mapping for treatment
Aneurysm on CR

*CR (about 75% of aneurysms are calcified)

Ascending aortic aneurysm

Aneurysm on US

CT - Ascending aortic aneurysm

Thoracic Aorta Aneurism

Descending Aortic Aneurysm with bronchial narrowing

Descending aorta aneurysm – bronchial narrowing (arrow)
Aortic aneurysm rupture

Rupture of Descending Aortic Aneurysm
- Enlarged aneurysm (now 8.1 x 7.0) with active bleeding
- 35 HU left pleural effusion – hemothorax!

5.9 cm AAA with mural thrombus

7 cm AAA with mural thrombus

Pseudoaneurysm
- Pseudoaneurysm: intima and media disrupted; adventitia distends
- Associated with blunt chest trauma or penetrating atherosclerotic ulcers
- Less commonly, with infection or cardiovascular surgery

Pseudoaneurysm
- Acute Aortic Syndrome: 1. Aortic dissection

- What is aortic dissection?
- Classification systems
- Epidemiology
- Imaging modalities and appearance
- Treatment

Aortic dissection

- Blood enters the media of the aortic wall and splits it in a longitudinal fashion
- An intimal flap is created
- True lumen and false lumen
- Spontaneous dissections almost always originate in thoracic aorta and extend to involve the abdominal aorta

Aortic dissection

- Blood may propagate proximally and/or distally within the media, creating a false lumen
- False lumen may or may not re-enter the true aortic lumen at a point removed from the primary intimal tear
- Intimal tear itself may be a primary inciting factor in aortic dissection
- OR it may be the result of primary weakening of the aortic media due to a spontaneous intramural hematoma
Aortic dissection – Risk Factors

- Hypertension (70% of patients)
- Aortic valve disease - bicuspid/unicuspid valve
- Coarctation of the aorta
- Cystic medial necrosis: Connective tissue disorders (e.g., Marfan’s syndrome, Ehlers-Danlos syndrome), Pregnancy
- Aortic aneurysm
- Cardiovascular surgery
- Infections (syphilis and bacterial), and non-infectious causes of arteritis

Dissection: Classification systems

- Stanford classification:
  - Type A: Involves ascending aorta (with or without involving the descending aorta)
  - Type B: Descending only
- DeBakey classification:
  - Type I: Involves ascending and descending
  - Type II: Ascending only
  - Type III: Descending only

Imaging of dissection

- CT
- MRI
- Aortography
- CR (Often will not be apparent on CR)

MDCT diagnosis of aortic dissection

- Findings on both unenhanced and enhanced scans. Sensitivity and Specificity – about 100%.
- Single best criterion - demonstration of an intimal flap separating the true and false lumens (contrast study)
- Unenhanced scans - aortic intramural hematomas, displacement of aortic intimal calcifications
- Contrast enhanced studies - patency of branch vessels
- Differential flow rates between the true and false lumens

Intramural Hematoma and Displaced intimal calcifications

2 patients with Type A Aortic Dissection
MDCT diagnosis of aortic dissection

- Occasionally, it can be difficult to distinguish true from false lumen
- Most specific indicator for the false lumen - irregular strands within the lumen, "cobwebs."
- Cobwebs represent residual fragments of aortic media separated during the dissection

MDCT diagnosis of aortic dissection

- Frequently, the true lumen is located anteriorly in the descending thoracic aorta
- Often the true lumen is smaller than the false lumen due to compression by the latter
- True lumen may assume a concave orientation with respect to the false lumen (increased likelihood of impaired end-organ perfusion)

Aortic dissection with aortic aneurysm

Stanford type A typical aortic dissection – Coronary Arteries involvement

Stanford type B dissection
Celiac trunk originates from the false lumen

Subclavian artery dissection after minor trauma in a patient with Marfan syndrome

Extension of a dissection into common iliac arteries

Approach to Aortic Dissection evaluation
- Identify the intimal flap
- Identify any branch vessel involvement (great vessels, mesenteric and renal arteries)
- Identify the presence of pericardial fluid (intrapericardial rupture) or periaortic hematoma (aortic rupture)
- Identify extent of dissection
- Evaluate size of the aorta
- Evaluate the patency of the false lumen and degree of true lumen compression

2. Intramural Hematoma

Intramural Hematoma
- Bleeding of vaso vasorum
- Propagation along media
- May resolve or progress to conventional dissection
- No flow in false channel
- CT – precontrast scan critical
Intramural Hematoma

Several methods for the formation:
1) rupture of the vasa vasorum resulting in weakening of the aortic wall
2) spontaneous thrombosis of the false lumen of an aortic dissection
3) penetrating atherosclerotic ulcer induced by rupture of an intimal atherosclerotic plaque, allowing blood to gain access to the aortic media

Expanding Hematoma

Post-surgery appearance

3. Penetrating Atherosclerotic Ulcer
Penetrating Atherosclerotic Ulcer (PAU)

- CT/MRI – deep ulceration of the aortic wall
- Most common: descending thoracic aorta
- PAU - atherosclerotic plaque penetrates through the intima and internal elastic membrane of the aorta
- Blood gains access to the aortic media - PAU results in IMH
- OR can progress to dissection, saccular aneurysm, pseudo-aneurysm or frank aortic rupture
- Symptoms often mimic aortic dissection