Journal Club

Distinguishing Acute from Chronic Aortic Dissections using CT Imaging Features

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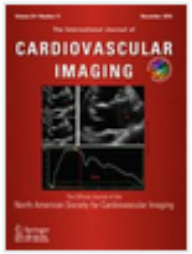

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Distinguishing acute from chronic aortic dissections using CT imaging features

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Original Paper
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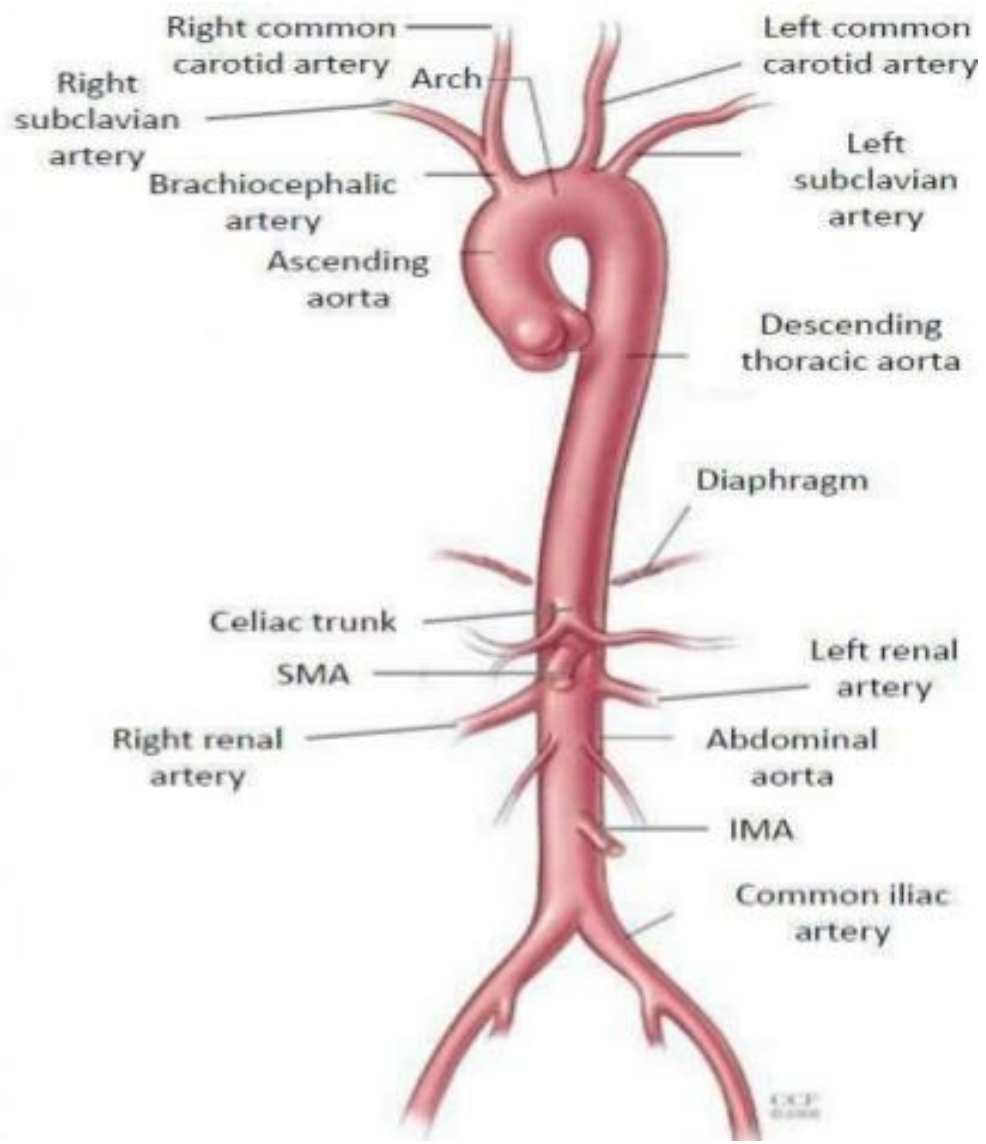
Abstract

The aim was to compare computed tomography (CT) features in acute and chronic aortic dissections (AADs and CADs) and determine if a certain combination of imaging features was reliably predictive of the acute versus chronic nature of disease in individual patients. Consecutive patients with aortic dissection and a chest CT scan were identified, and 120 CT scans corresponding to 105 patients were reviewed for a variety of imaging features. Statistical tests assessed for differences in the frequency of these features. A predictive model was created and tested on an additional 120 CT scans from 115 patients. Statistically significant features of

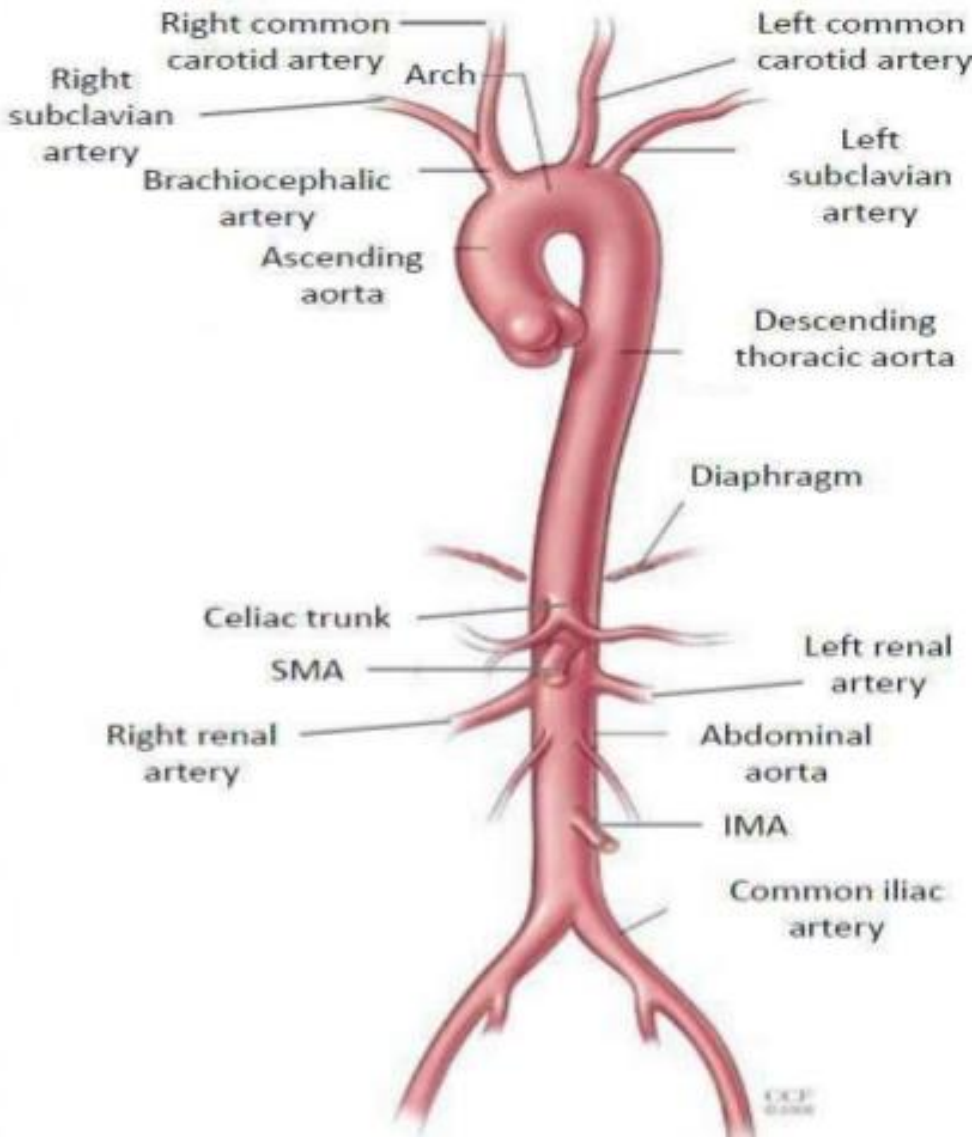
Introduction

- Anatomy
- Aortic Dissection
- Epidemiology
- Clinical Presentation
- Type of Aortic Dissection
- Diagnostics

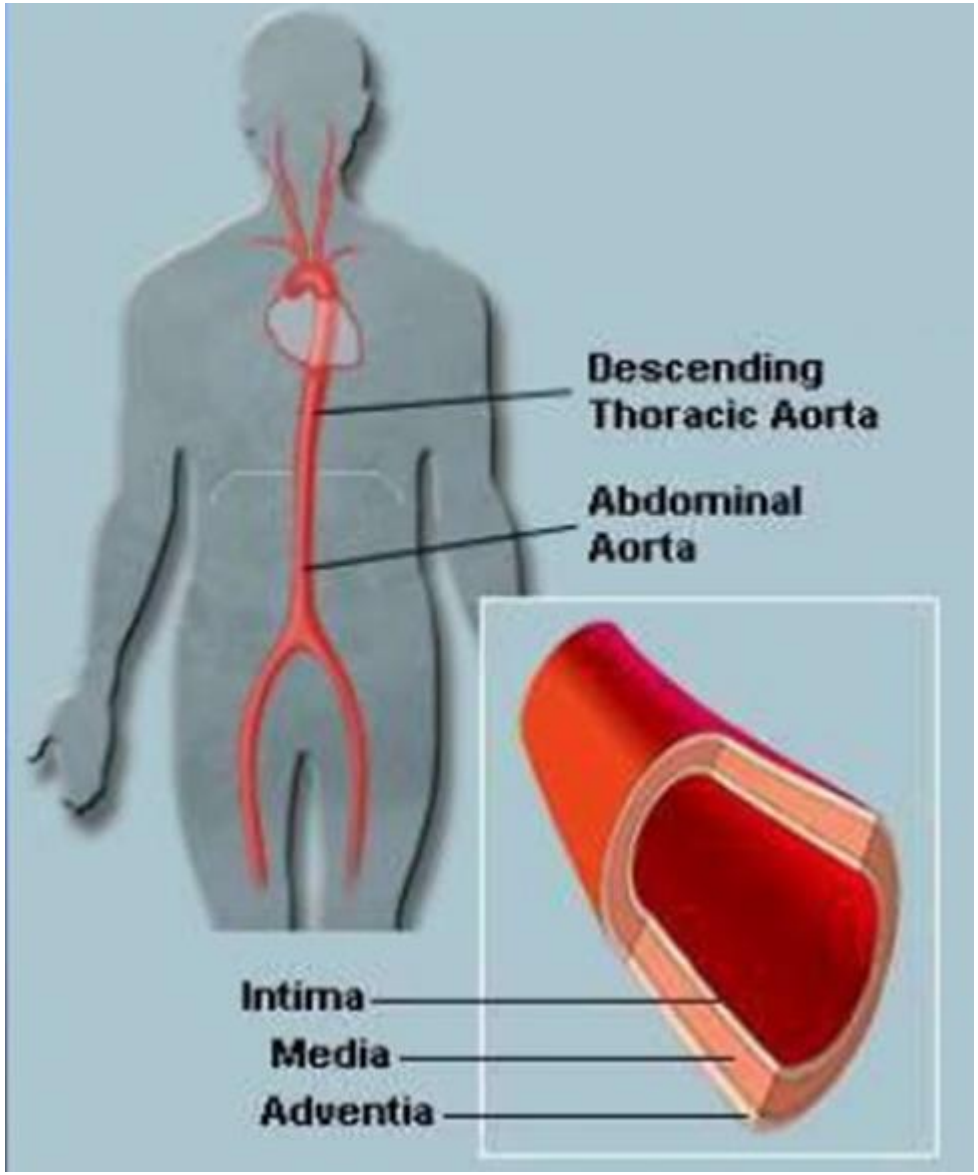
Review of Aortic Anatomy



- Largest blood vessel in the body
- Transporting oxygen rich blood from heart to the rest of the body.
- Divided into:
  - ✓ Thoracic aorta
    - ascending aorta
    - aortic arch
    - descending aorta
  - ✓ Abdominal aorta



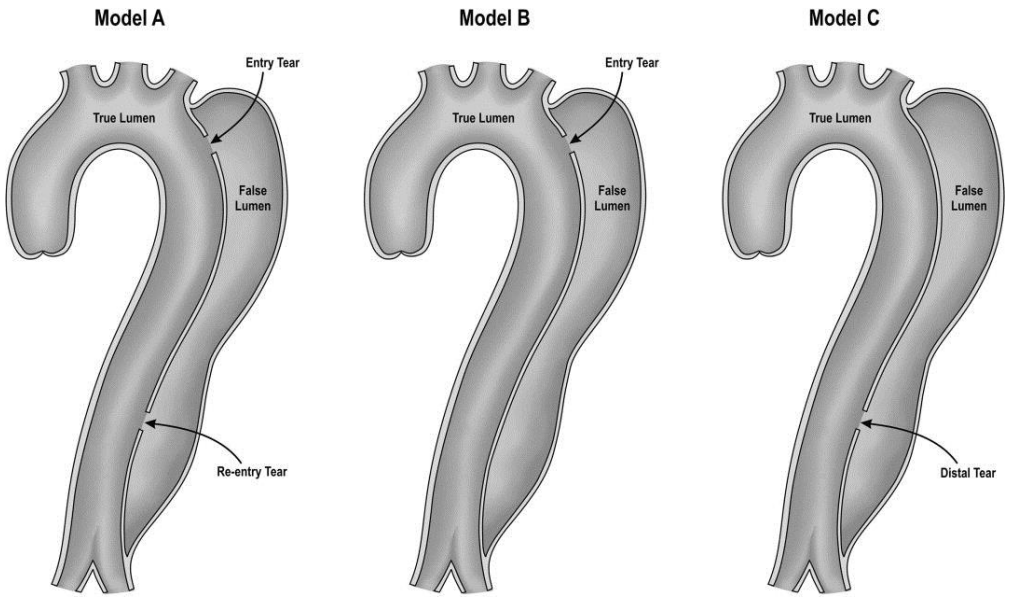
- Ascending aorta – arises from aortic orifice from left ventricle and ascends to become ascending aorta. 2 inches long in length
- Aortic arch – begins at level of 2nd sternocostal joint, ends at level T4 vertebra, 3 major branches
- Descending aorta – from level T4 until T12. leaves thorax via aortic hiatus in the diaphragm.
- Abdominal aorta – from T12, terminates at level L4 by bifurcating into left and right common iliac arteries, approximately 13cm

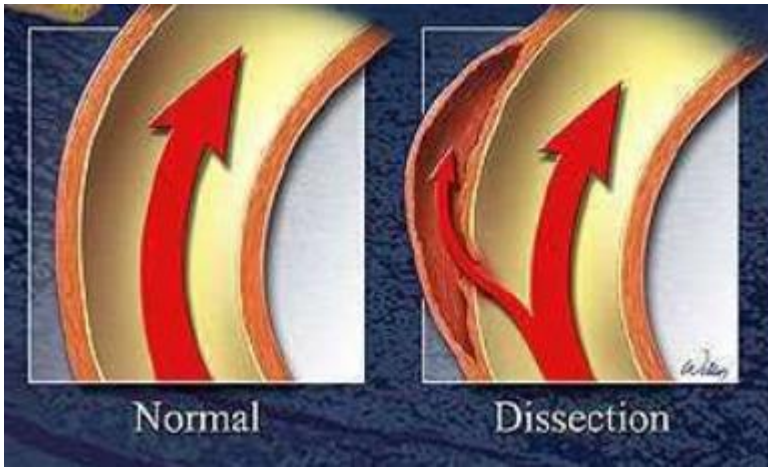

Descending
Thoracic Aorta
Abdominal
Aorta
Intima
Media
Adventia

Aortic Dissection

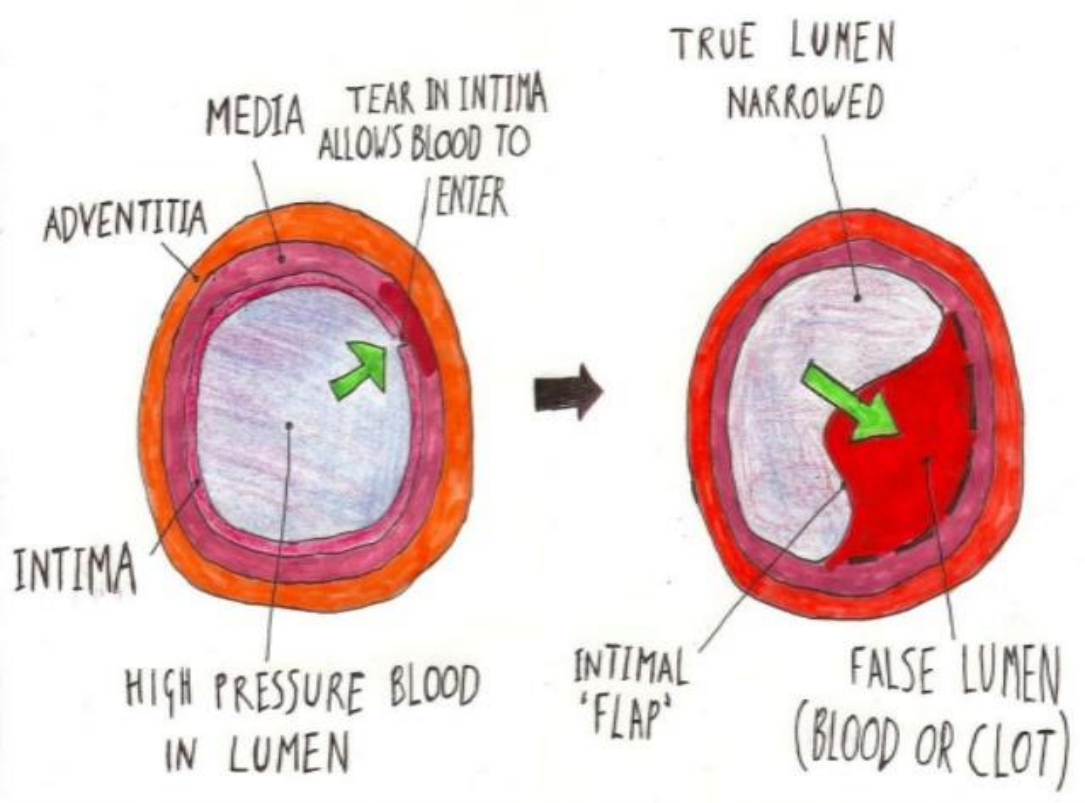
- Most common form of the acute aortic syndromes
- A type of arterial dissection
- Occurs when blood enters the medial layer of the aortic wall through a tear or penetrating ulcer in the intima and tracks along the media, forming a second blood-filled channel within the wall.
- Driven by persistent intraluminal pressure, the dissection process extends a variable length along the aortic wall, typically antegrade but sometimes retrograde from the site of the intimal tear.

- The blood-filled space between the dissected layers of the aortic wall becomes the false lumen.
- Shear forces may lead to further tears in the intimal flap (the inner portion of the dissected aortic wall) and produce exit sites or additional entry sites for blood flow into the false lumen.





- Distension of the false lumen with blood may cause the intimal flap to bow into the true lumen and thereby narrow its caliber and distort its shape.



Following dissection, blood flow into the media may cause:

- extension up or down
- rupture
- vessel branch occlusion
- aortic regurgitation
- pericardial effusion / tamponade

Epidemiology

- Rare but fatal
- 1 for every 12 200 visits in ED (US) [1]
- Peak incidence at 50-60 years old
- Mortality rate as high as [2]
  - 33 % within first 24 hours
  - 50 % within 48 hours
  - 75% within 2 weeks
- Overall global death rate increased from 2.49% to 2.78% per 100,000 people between the years 1990 and 2010 [3]
- Male : female = 3: 1

1. Gaul, C, Dietrich, W, Erbguth, FJ. Neurological symptoms in aortic dissection: a challenge for neurologists. Cerebrovasc Dis 2008; 26: 1–8.

2. Collins JS, Evangelista A, Nienaber CA, Bossone E, Fang J, et al. (2004) - Differences in clinical presentation, management, and outcomes of acutetype a aortic dissection in patients with and without previous cardiacsurgery. Circulation 110: II237-242

3. Gerald Tan Jack Soon, Paul Khoo Li Zhi, Sailesh Mohana Krishnan, Chan Kok Meng John (2019) - A review of aortic disease research in Malaysia; Med Malaysia Vol 74 No 1 .

Risk Factors

- Elderly
- Chronic smoker
- Atherosclerosis
- Uncontrolled hypertension
- Blunt trauma to the chest

Abdullah NS, Saad FFA (2015) Acute Thoracic Aortic Dissection (Stanford B): Challenges in Early Detection and Management. OMICSJ Radiol 4: 200.

Acquired	Congenital
• Hypertension (most common) • Trauma (e.g., deceleration injury in a motor vehicle accident, iatrogenic injury and during valve replacements or graft surgery) • Vasculitis with aortic involvement (e.g., syphilis) • Use of amphetamines and cocaine • Third-trimester pregnancy (or early postpartum period) • Atherosclerosis	• Connective tissue disease (Marfan syndrome, Ehlers-Danlos syndrome) • Bicuspid aortic valve • Coarctation of the aorta

1. *Khan AN, Cho KJ. Aortic Dissection Imaging. In: Aortic Dissection Imaging. New York, NY: WebMD. http://emedicine.medscape.com/article/416776-overview#showall. Updated May 13, 2016. Accessed December 4, 2016.*
2. *Black JH III, Manning WJ. Clinical Features and Diagnosis of Acute Aortic Dissection. In: Post TW, ed. UpToDate. Waltham, MA: UpToDate. https://www.uptodate.com/contents/clinical-features-and-diagnosis-of-acute-aortic-dissection. Last updated September 6, 2018. Accessed November 12, 2018.*

Clinical Presentation

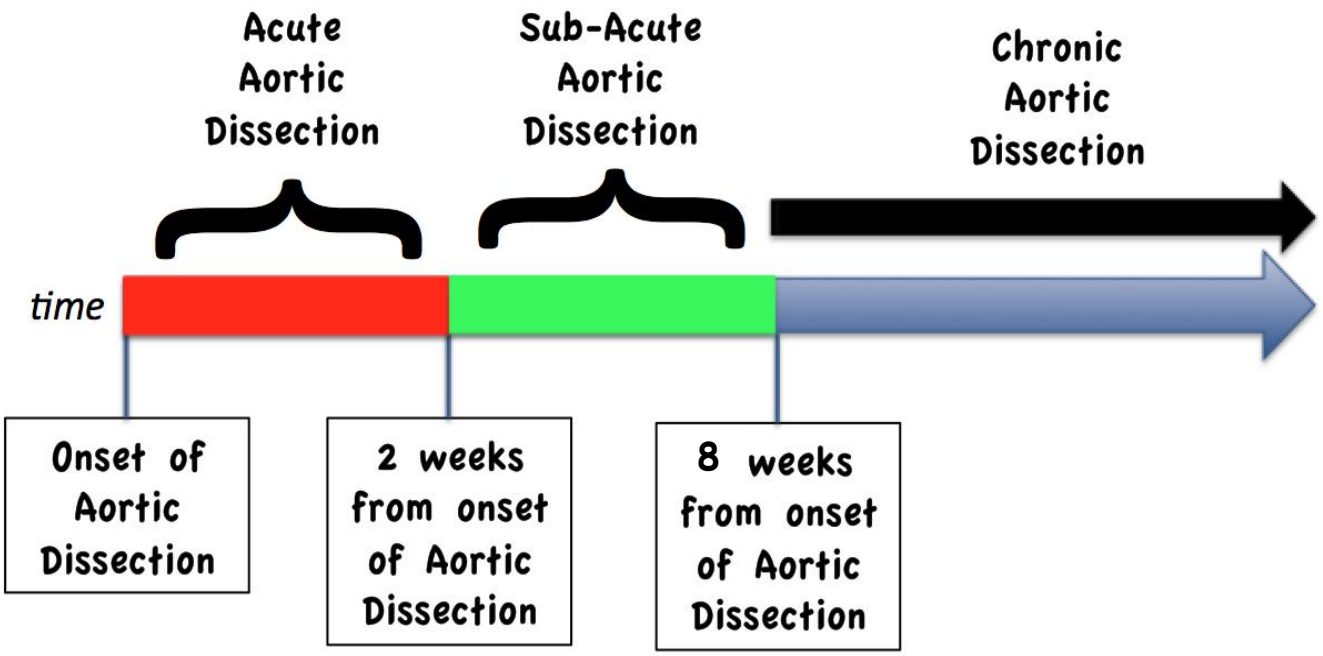
- Sudden onset of chest pain radiating to the back [1]
- Painless dissection may occur between 5% and 15% of the cases [1]
- Often present with cardiac failure [2]

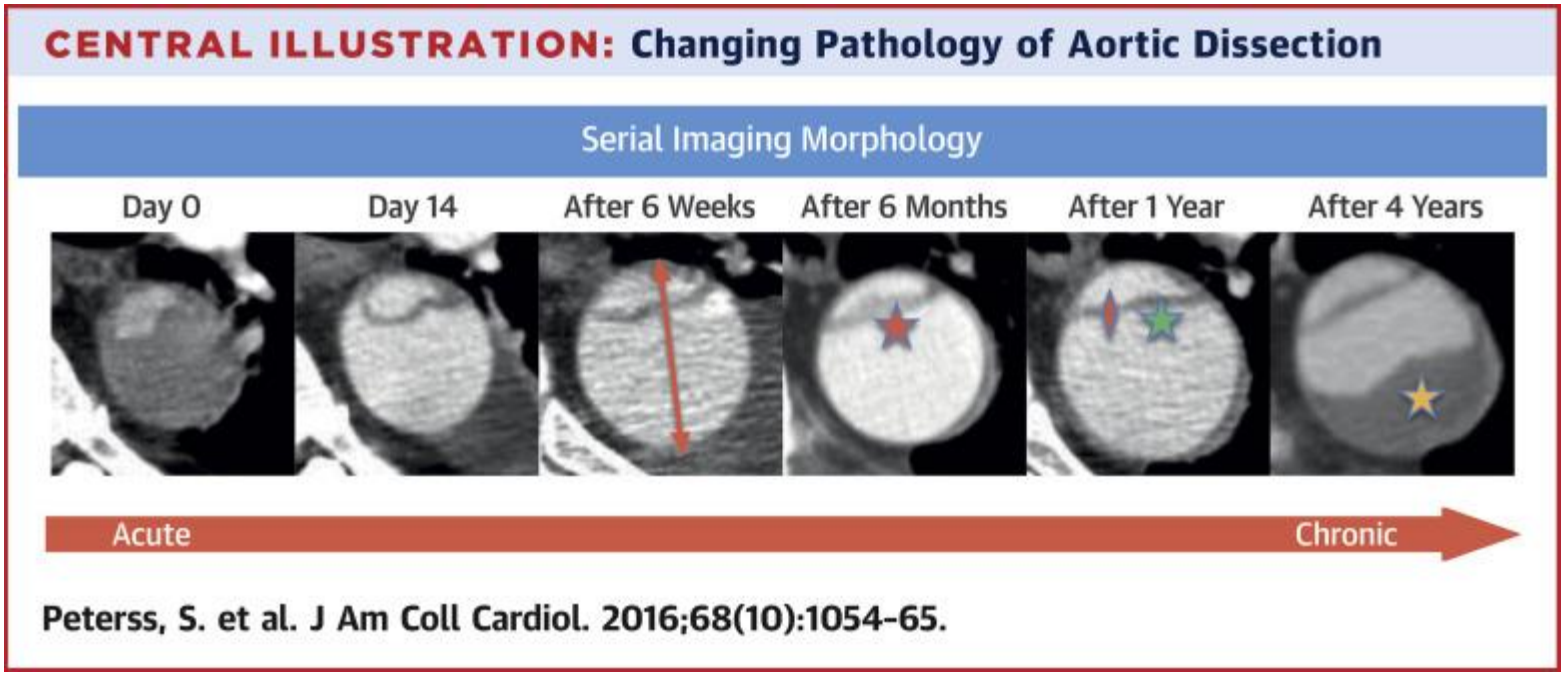
- Usually hypertensive but can be normotensive or hypotensive
- Asymmetrical peripheral pulse
- End organ ischemia may also be present (up to 27% of the cases) [3]

1. *Meszaros, I, Morocz, J, Szlavi, J. Epidemiology and clinicopathology of aortic dissection. Chest 2000; 117: 1271–1278.*
2. *Abdullah NS, Saad FFA (2015) Acute Thoracic Aortic Dissection (Stanford B): Challenges in Early Detection and Management. OMICSJ Radiol 4: 200.*
3. *Macura KJ, Corl FM, Fishman EK et-al. Pathogenesis in acute aortic syndromes: aortic dissection, intramural hematoma, and penetrating atherosclerotic aortic ulcer. AJR Am J Roentgenol. 2003;181 (2): 309-16*

Types

- Chronicity
  - ✓ Acute – onset of symptoms until < 2 weeks
  - ✓ Subacute – 2 weeks until 2 months
  - ✓ Chronic - > 2 months after onset





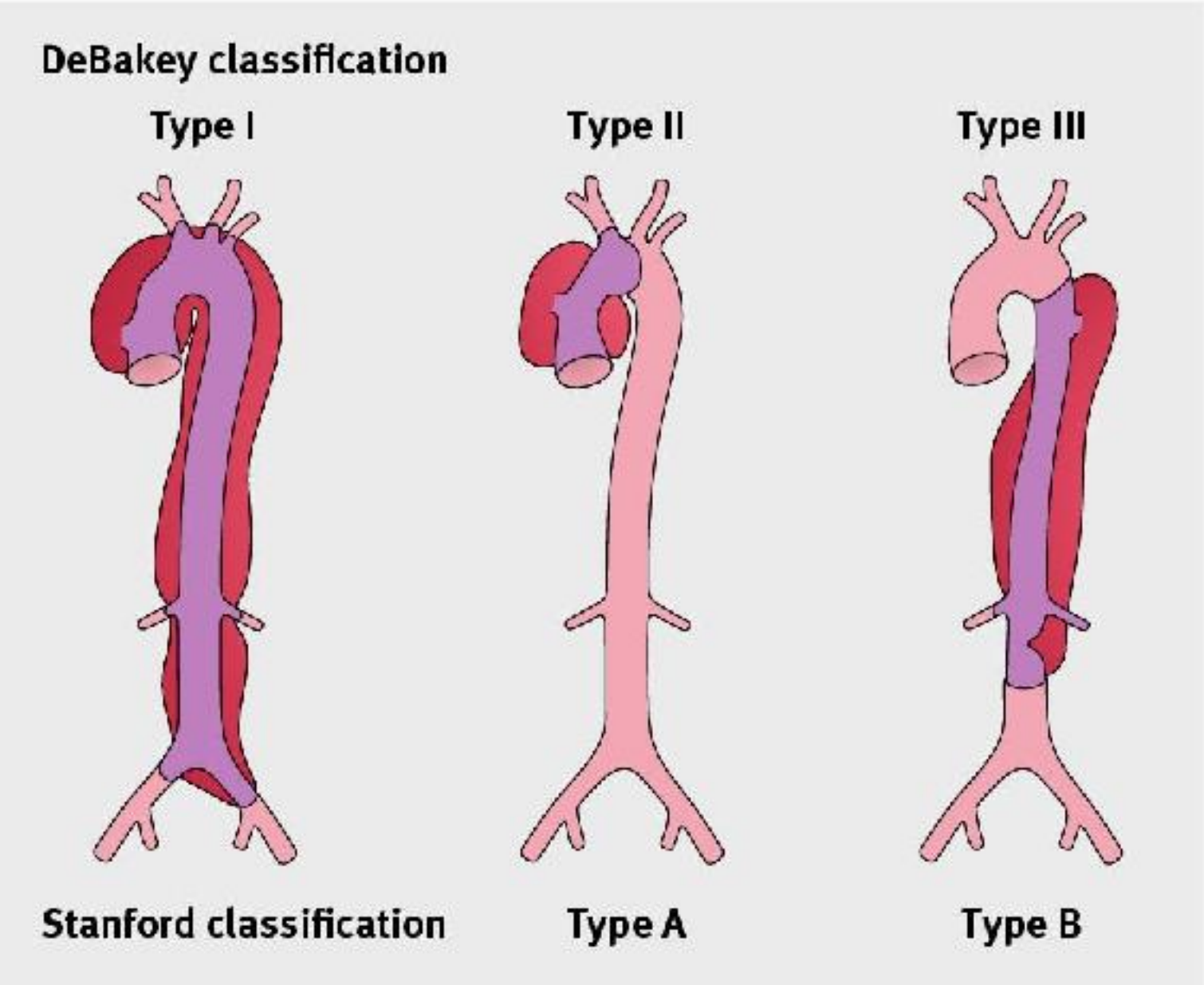
Changing morphology of a type B dissection over time by computed tomography in a single illustrative patient with multiple good quality images at the same aortic level. Please note:

1) marked early increase in aortic diameter **(orange arrow)**;
2) intimal thickening over time **(orange star)**
3) decreased flap motion over time **(orange triangles)**
4) flap straightening over time **(green star)**
5) increased false lumen thrombosis over time **(yellow star)**.

Sven Peterss, Ahmed M.Mansour, Julia A.Ross, Irena Vaitkeviciute, Paris Charilaou, Julia Dumfarth, Hai Fang, Bulat A. Ziganshin, John A. Rizzo, Adebowale J. Adeniran, John A. Elefteriades. Changing Pathology of the Thoracic Aorta From Acute to Chronic Dissection: Literature Review and Insights. Journal of the American College of Cardiology, Volume 68, Issue 10, 6 September 2016, Pages 1054-1065.

Types

- DeBakey
  - ✓ Type I - Originates in the ascending aorta; propagates at least to the aortic arch and often beyond it distally
  - ✓ Type II - Originates in and is confined to the ascending aorta
  - ✓ Type III - Originates in the descending aorta and extends distally down the aorta or (rarely) retrograde into the aortic arch and ascending aorta
- Standford
  - ✓ Type A - All dissections that affect the ascending aorta, regardless of the site of the origin
  - ✓ Type B - All dissections that do not affect the ascending aorta

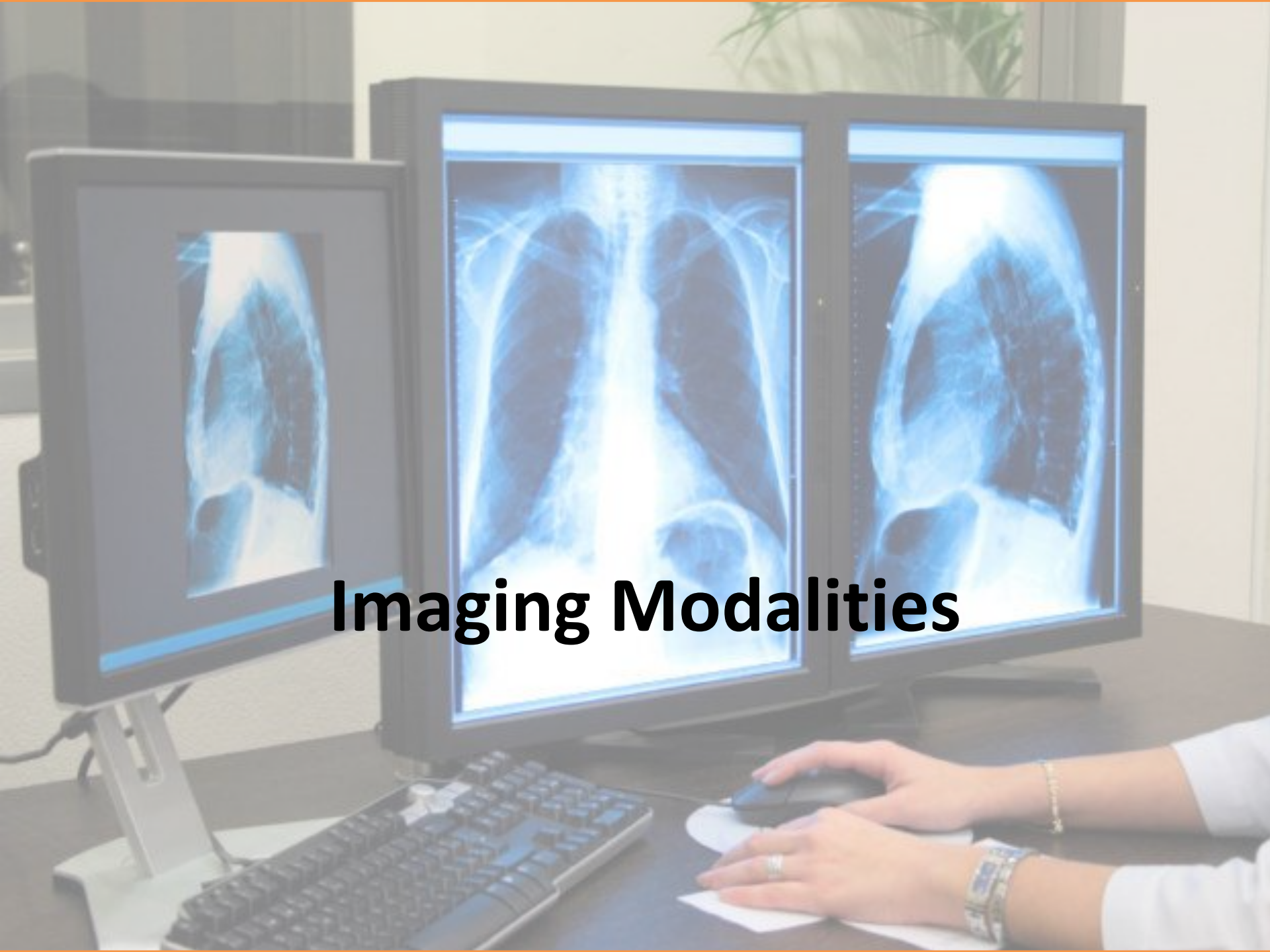


Thrumurthy, Sri Ganeshamurthy et al. "The diagnosis and management of aortic dissection." BMJ 344 (2011): d8290 .

Location

- Ascending aorta – 65%
- Descending aorta – 20%
- Aortic arch – 10%
- Abdominal aorta – 5%

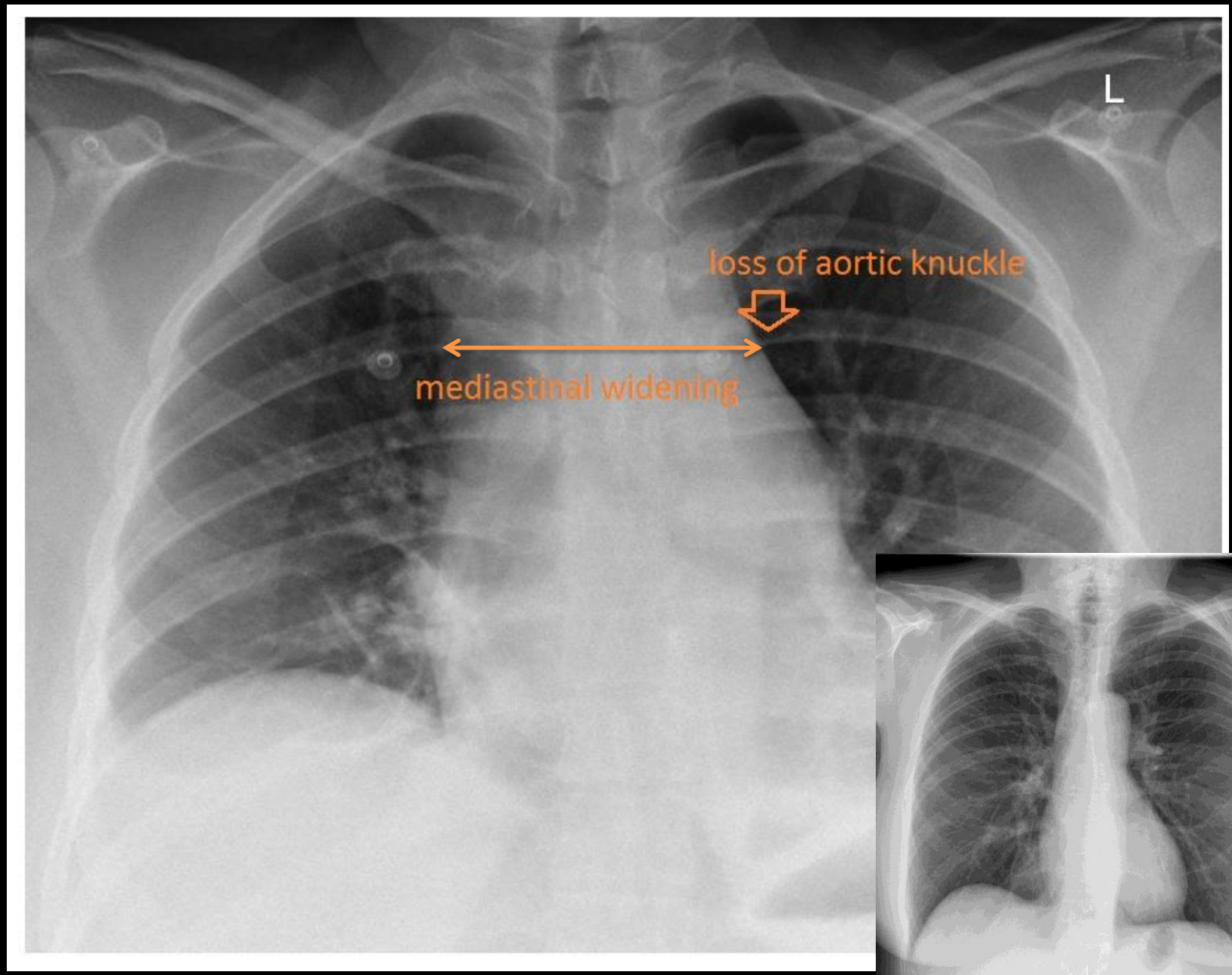
Black JH III, Manning WJ. Clinical Features and Diagnosis of Acute Aortic Dissection. In: Post TW, ed. UpToDate. Waltham, MA: UpToDate. https://www.uptodate.com/contents/clinical-features-and-diagnosis-of-acute-aortic-dissection. Last updated September 6, 2018. Accessed November 12, 2018


Imaging Modalities

Chest Radiograph

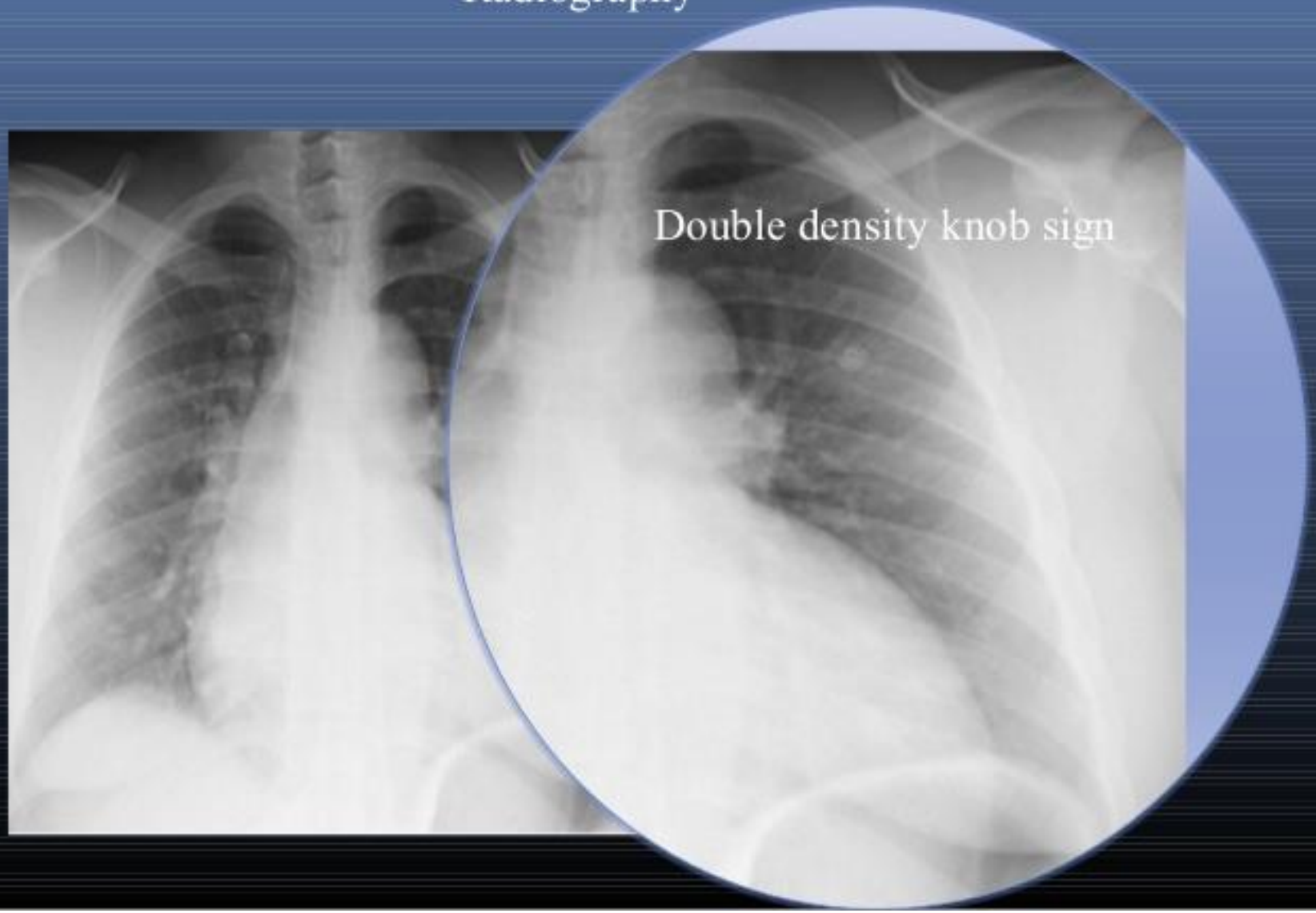
May be normal or demonstrate a number of suggestive findings, including:

- widened mediastinum : >8.0-8.8 cm at the level of the aortic knob on portable AP chest radiographs
- double aortic contour
- irregular aortic contour
- inward displacement of atherosclerotic calcification (>1 cm from the aortic margin)


L
loss of aortic knuckle
mediastinal widening

Inward displacement of aortic wall calcification by more than 10 mm

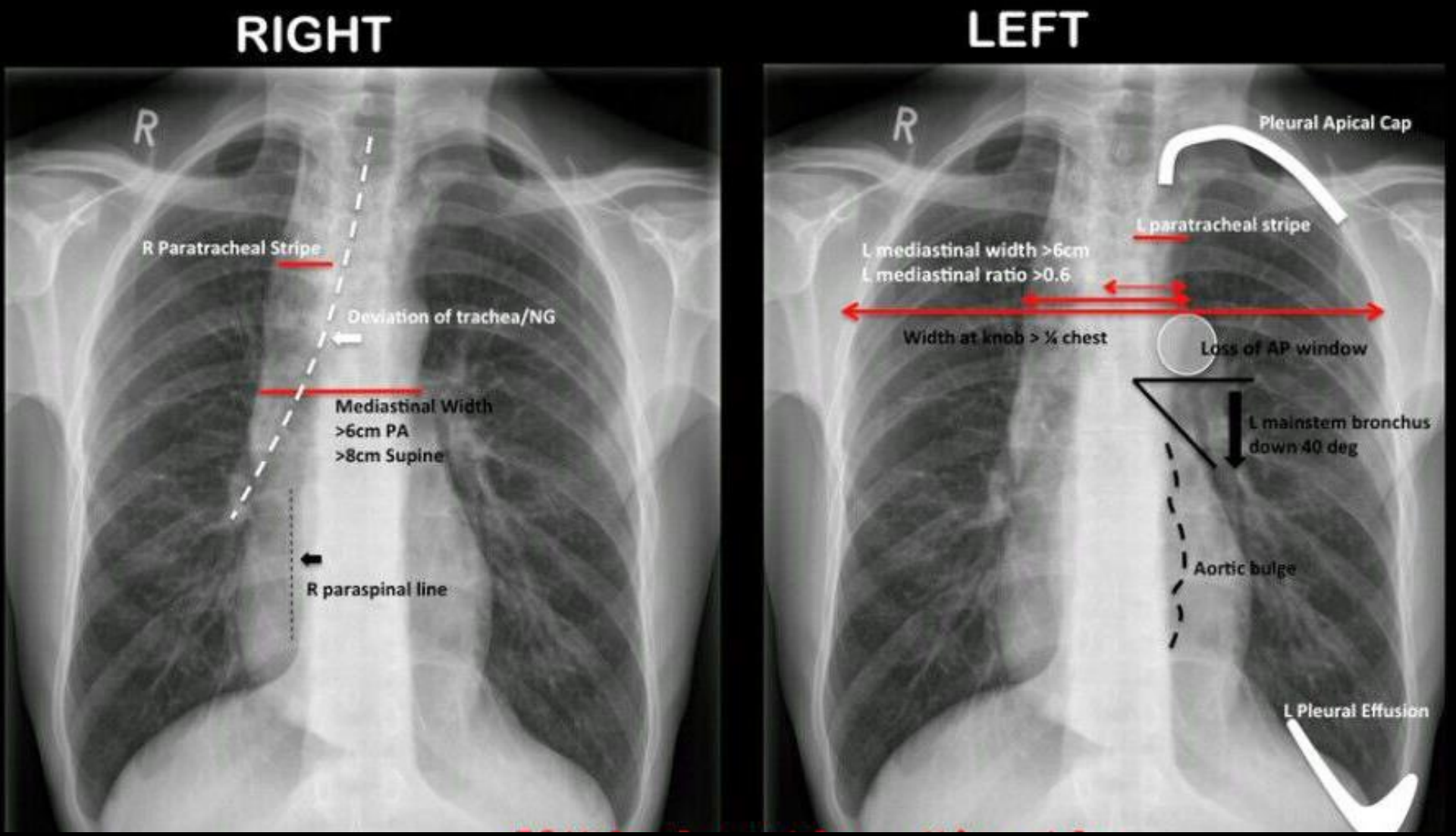
Radiography



Chest Radiograph

There may be signs of periaortic or mediastinal hematoma which include:

- obscuration of the aortic knob
- opacification of the AP window
- deviation of mediastinal structures
  - esophagus or NGT to the right
  - trachea to the right
  - left main bronchus inferiorly (decreased angle from the horizontal)
- increased thickness of the left and/or right paratracheal stripe
- apical capping, particularly on the left


RIGHT
LEFT
R
R Paratracheal Stripe
Deviation of trachea/NG
Mediastinal Width
>6cm PA
>8cm Supine
R paraspinal line
R
Pleural Apical Cap
L paratracheal stripe
L mediastinal width >6cm
L mediastinal ratio >0.6
Width at knob > ⅓ chest
Loss of AP window
L mainstem bronchus
down 40 deg
Aortic bulge
L Pleural Effusion

CT

- Is the investigation of choice, especially with arterial contrast enhancement (CTA)
- Sensitivity = 87 – 94%

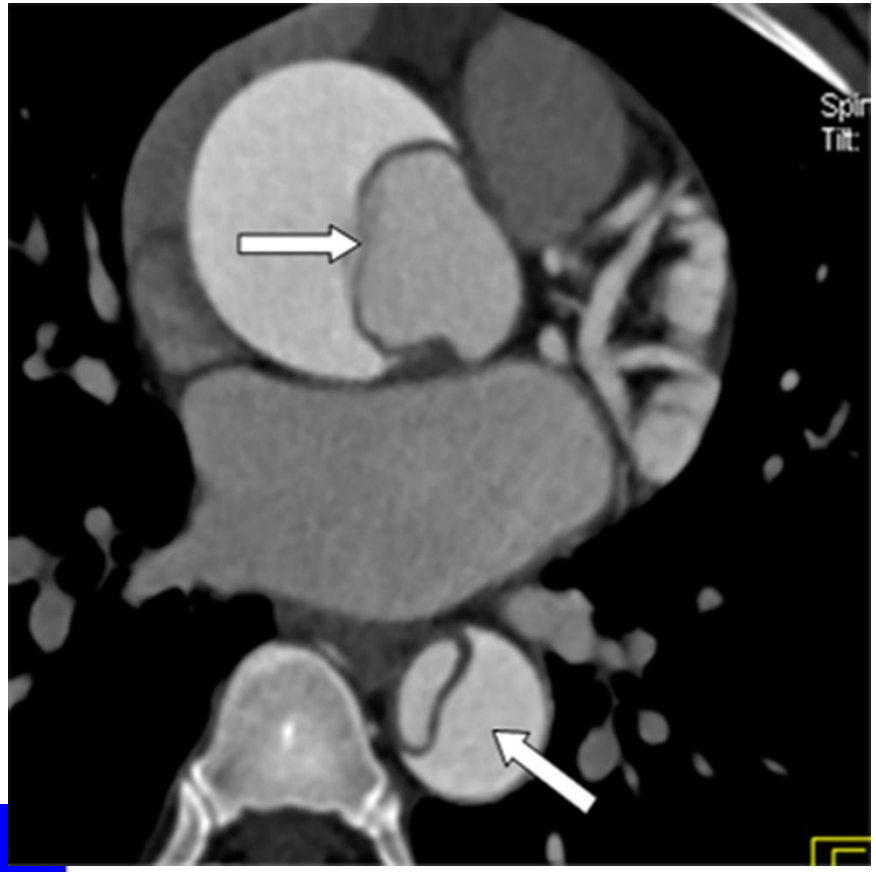
  Specificity = 92-100%
- Able to :
  - diagnose the dissection
  - classify the dissection
  - evaluate for distal complications

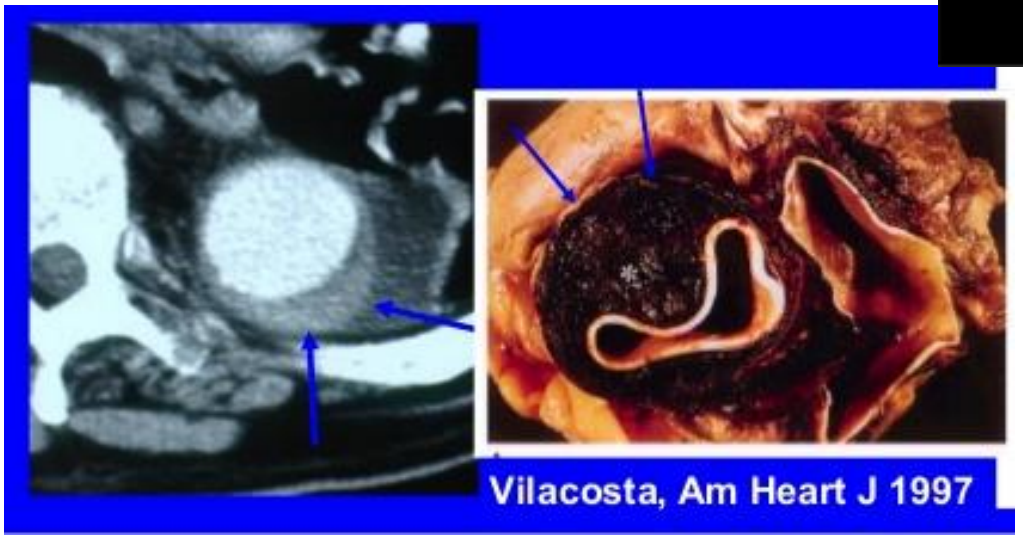
- Multidetector CT performed with 1-2.5mm collimation
- Approximately 25-30 sec after the injection of contrast material.
- LOCM is power injected via a peripheral IV line at a rate of 3-4 mL/sec

- Usually scanning done from thoracic inlet to common femoral arteries.
- Delayed images may be performed to obtain delayed images of the false lumen and aortic branches.
- MPR images obtained in sagittal, coronal and oblique view.

Findings include :

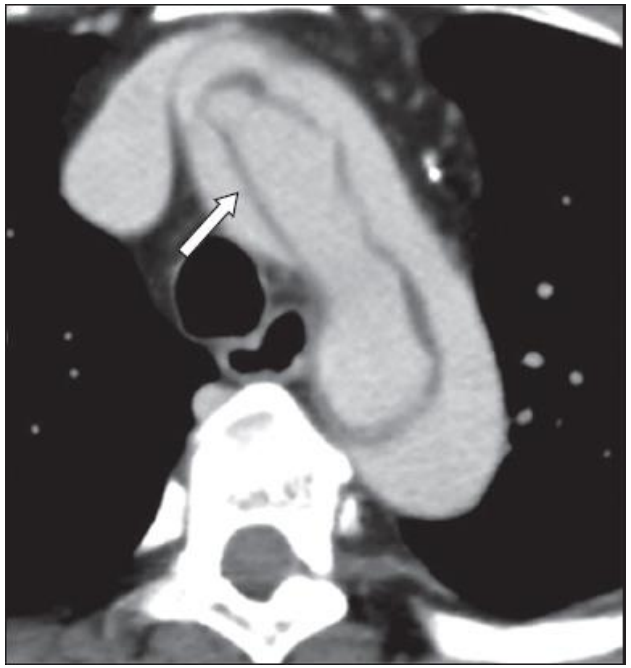
- intimal flap
- double lumen
- dilatation of the aorta
- aortic intramural hematoma





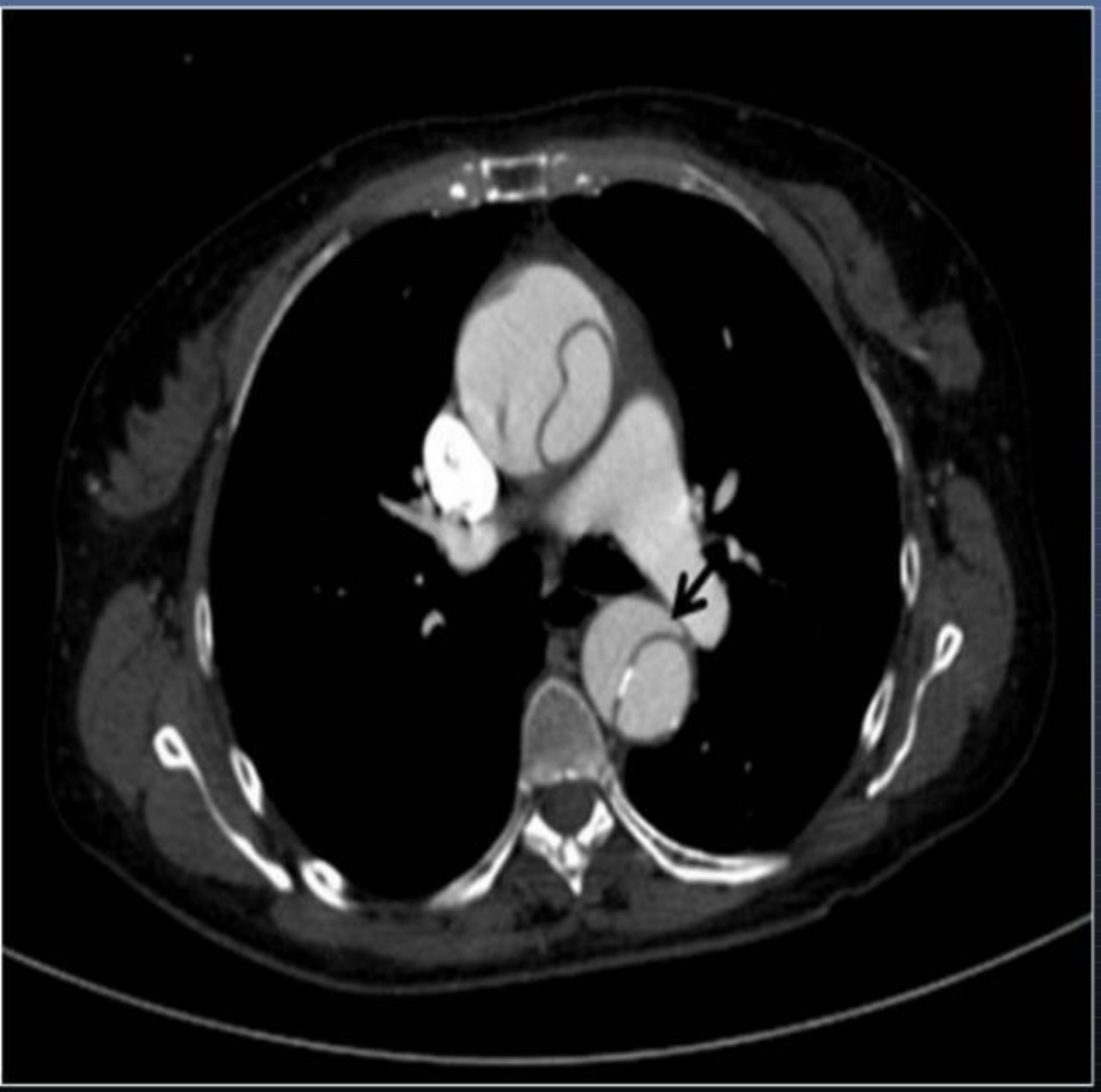
- Mercedes-Benz sign in the case of a "triple-barreled" dissection

- windsock sign

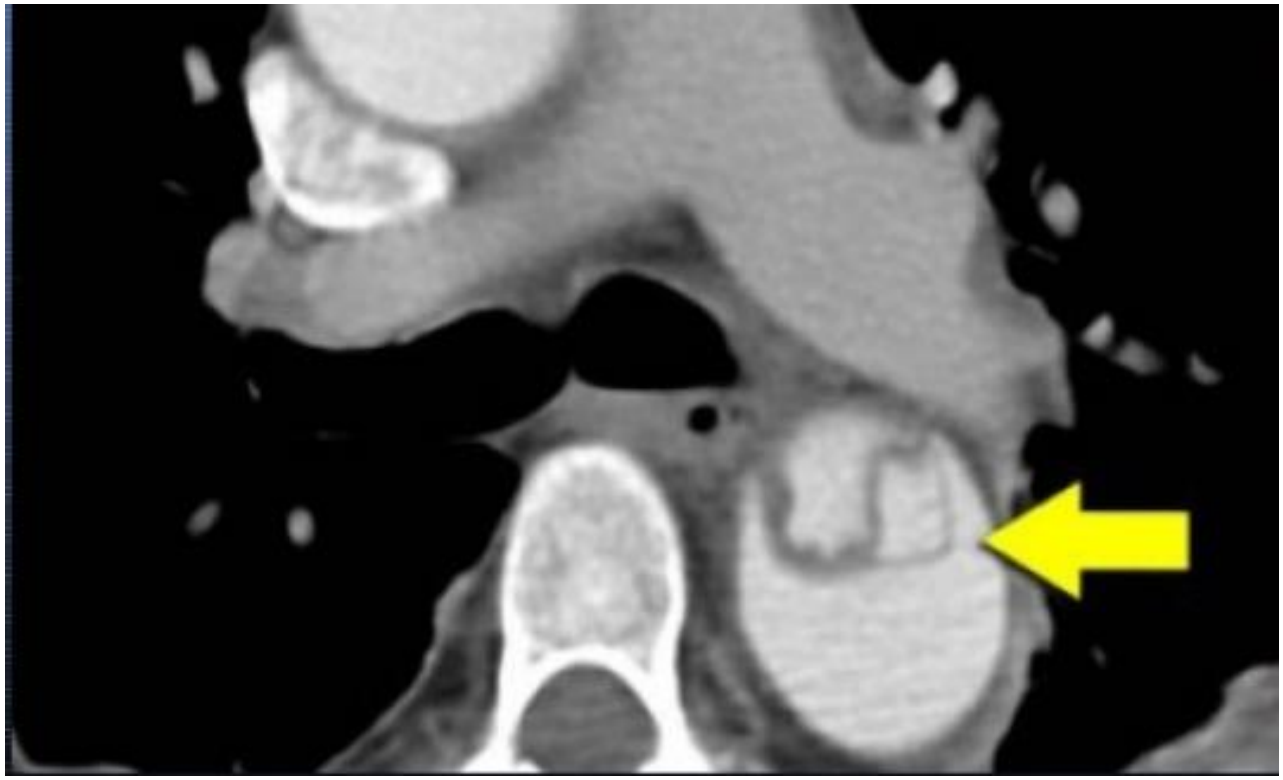


True vs. False Lumen

True Lumen	False Lumen
• often compressed by the false lumen and the smaller of the two • outer wall calcifications (if present) • origin of celiac trunk, SMA and right renal artery usually from true lumen	• often larger lumen size due to higher false luminal pressures • at risk for rupture due to reduced elastic recoil and dilation • beak sign • cobweb sign • often of lower contrast density due to delayed opacification • maybe thrombosed and seen as mural low density only (more common in chronic dissections) • origin of left renal artery usually from false lumen • surrounds true lumen in Stanford type A



Stanford type A typical aortic dissection. Sequential contrast-enhanced CT scans show a the beak sign (arrow), a wedge of hematoma is thought to create a space for the development of the false lumen



Cobweb sign

Other modalities

Echocardiography

- Transthoracic
  - 75% diagnostic Type A (ascending), 40% descending (Type B)
  - can identify complications (e.g. aortic regurgitation, regional wall abnormalities in cardiac ischaemia, cardiac tamponade)
- Transoesophageal (TOE)
  - Much higher sensitivity/specificity, though operator-dependent, need sedation, and is less available
  - Useful in ICU / perioperative
  - Upper ascending aorta and arch not well visualised

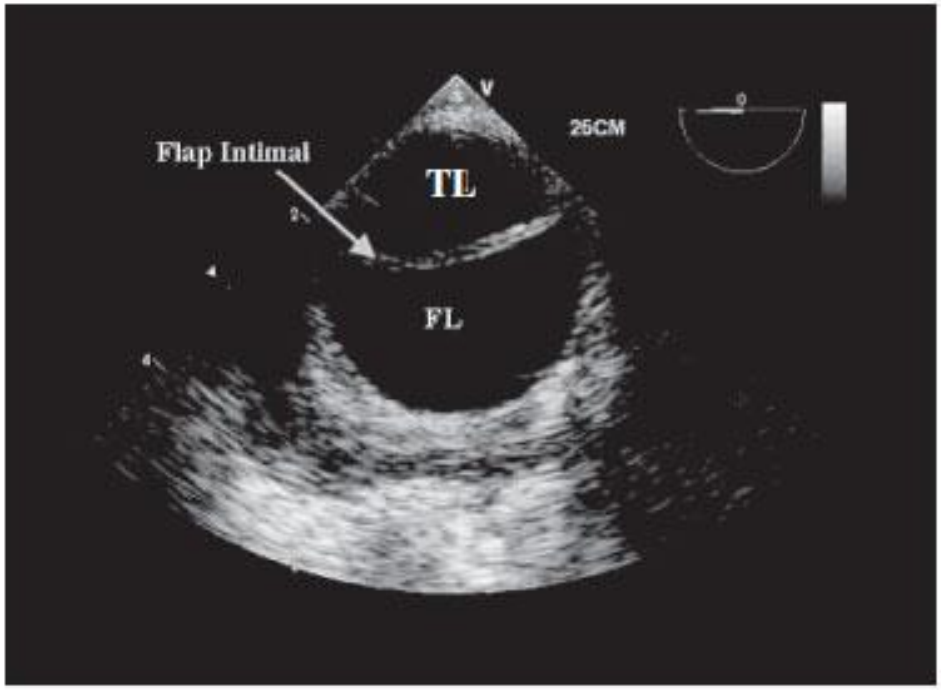
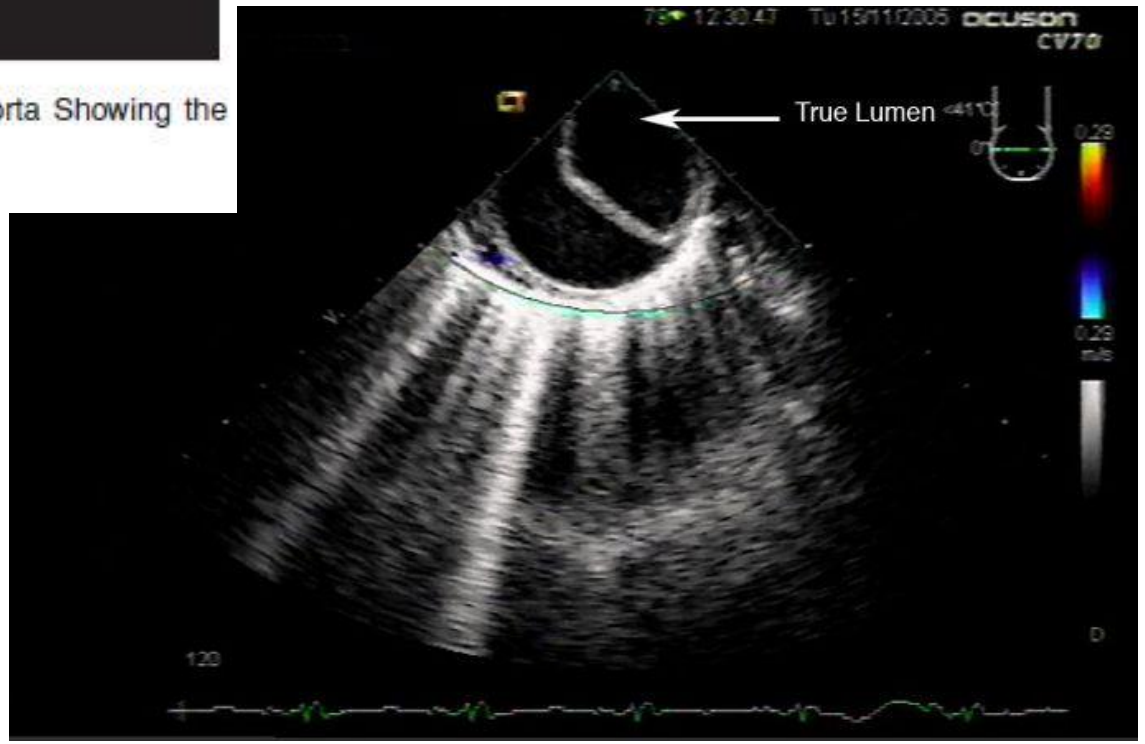
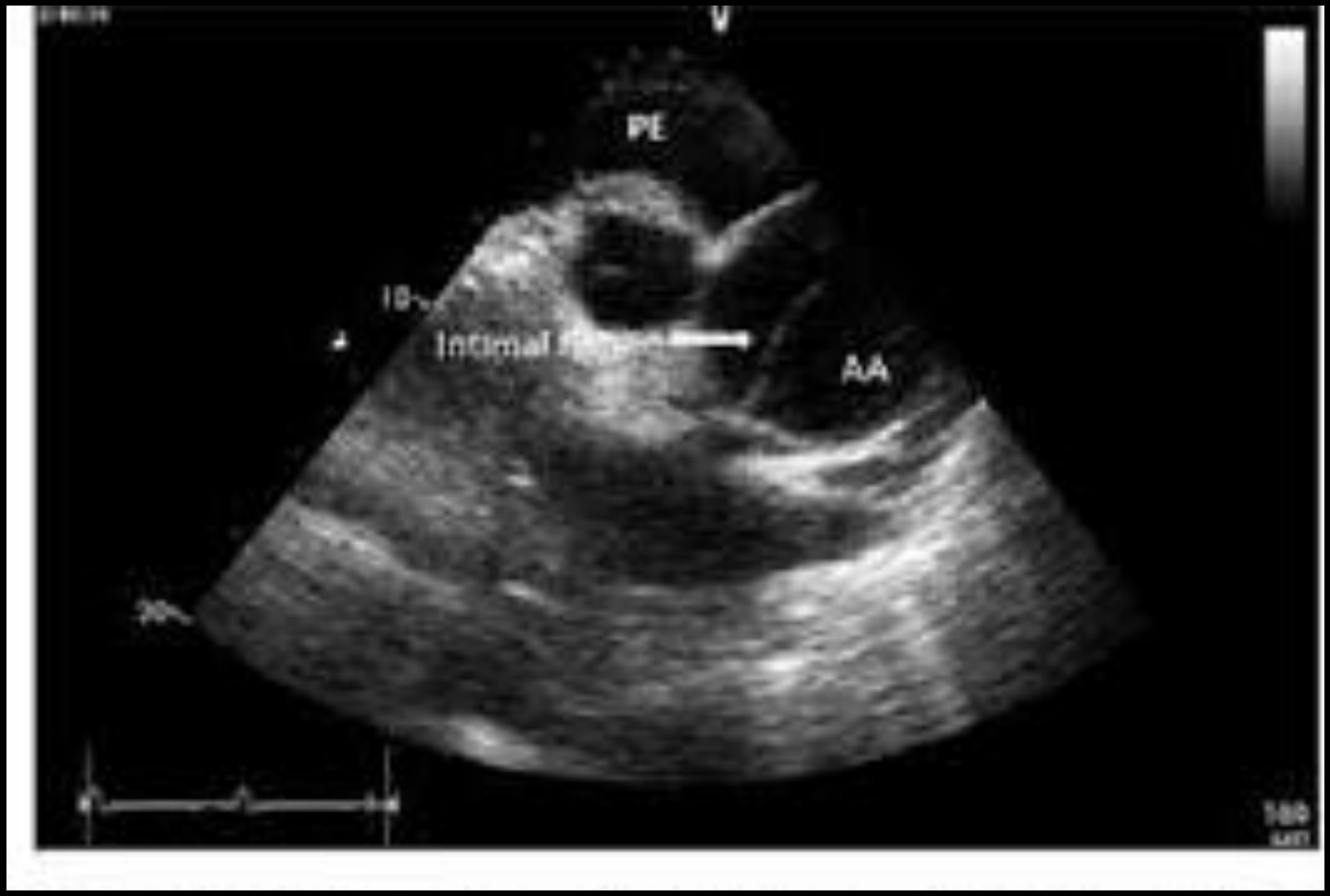


Figure 8 – Transversal Cut of the Descending Aorta Showing the Dissection Line with an Intimal Flap.
TL: True lumen, FL: False lumen.





Transthoracic echo

Other modalities

MRI/MRA

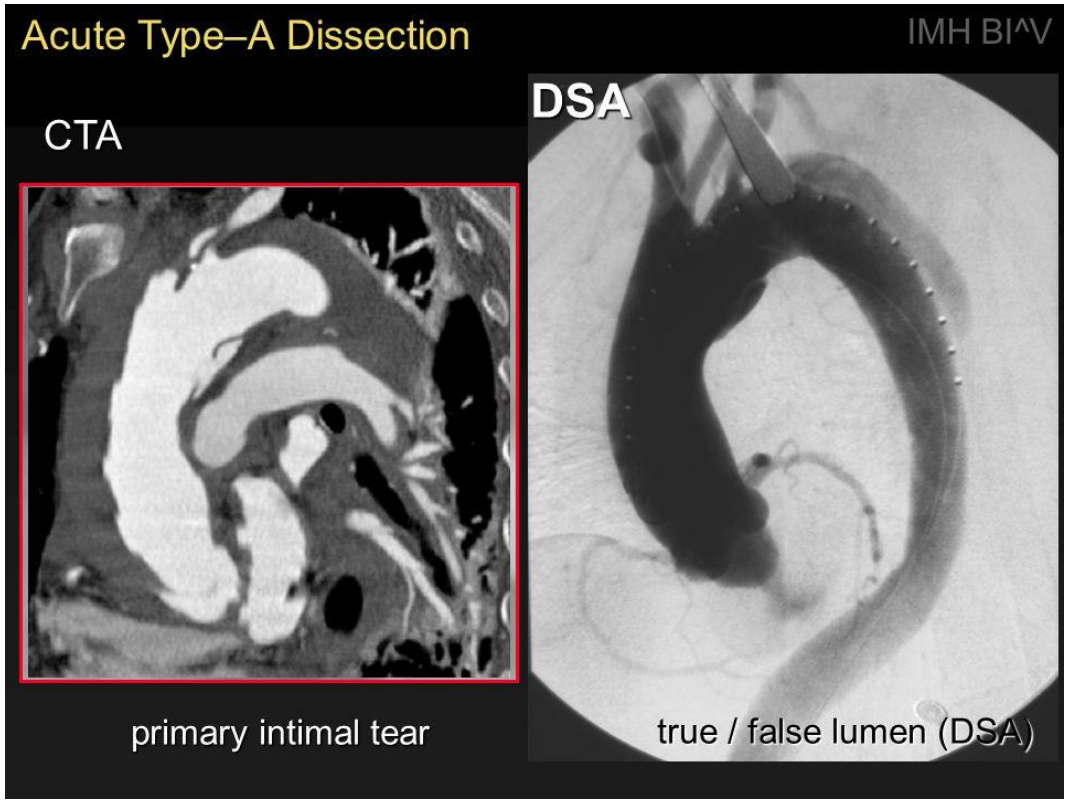
- Similar sensitivity and specificity to CTA and TOE
- Limited availability

  Difficulties inherent in performing MRI on acutely unwell patients.

Other modalities

Angiography

- Historically been the gold standard investigation – now replaced by CTA as the first line investigation
- still is required for endoluminal repair.



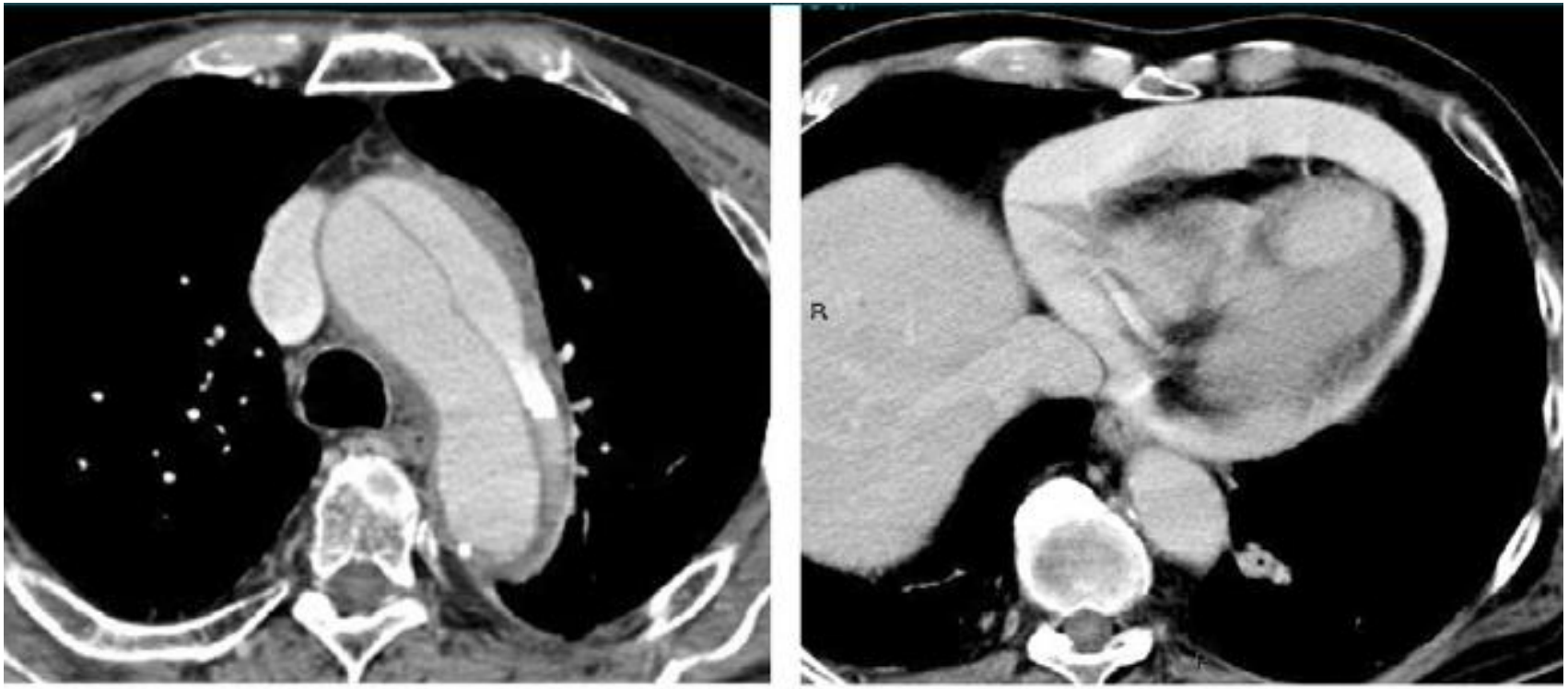
CT vs TOE vs MRI vs Aortogram

	Advantages	Disadvantages
CT	- easy availability in emergencies - high sensitivity and specificity - assess complications (ischaemic gut, tamponade, dissection or aorta) - easier to monitor vs MRI - quicker than MRI	- remote location - iodinated contrast - can't assess AR, LVF or coronaries - radiation exposure
TOE	- bedside - can detect intimal flap, true and false lumen, AR, tamponade - can assess LV function - no contrast needed	- semi-invasive - may need anaesthesia/intubation - may cause hypertension - not widely available - special expertise required - oesophageal trauma - doesn't quantify distal complicat.
MRI	- high sensitivity and specificity - Gadolinium contrast better safety profile - can detect AR - no radiation exposure - cardiac MRI could also be performed	- not readily available - inconvenient (> 30 min) - limited access and monitoring - limited applic. (claustrophobia, pacemakers)
Aortography	- detection of intimal flap and AR - assess LV function, tamponade, blocked coronaries)	- not readily available - invasive - contrast load - remote location

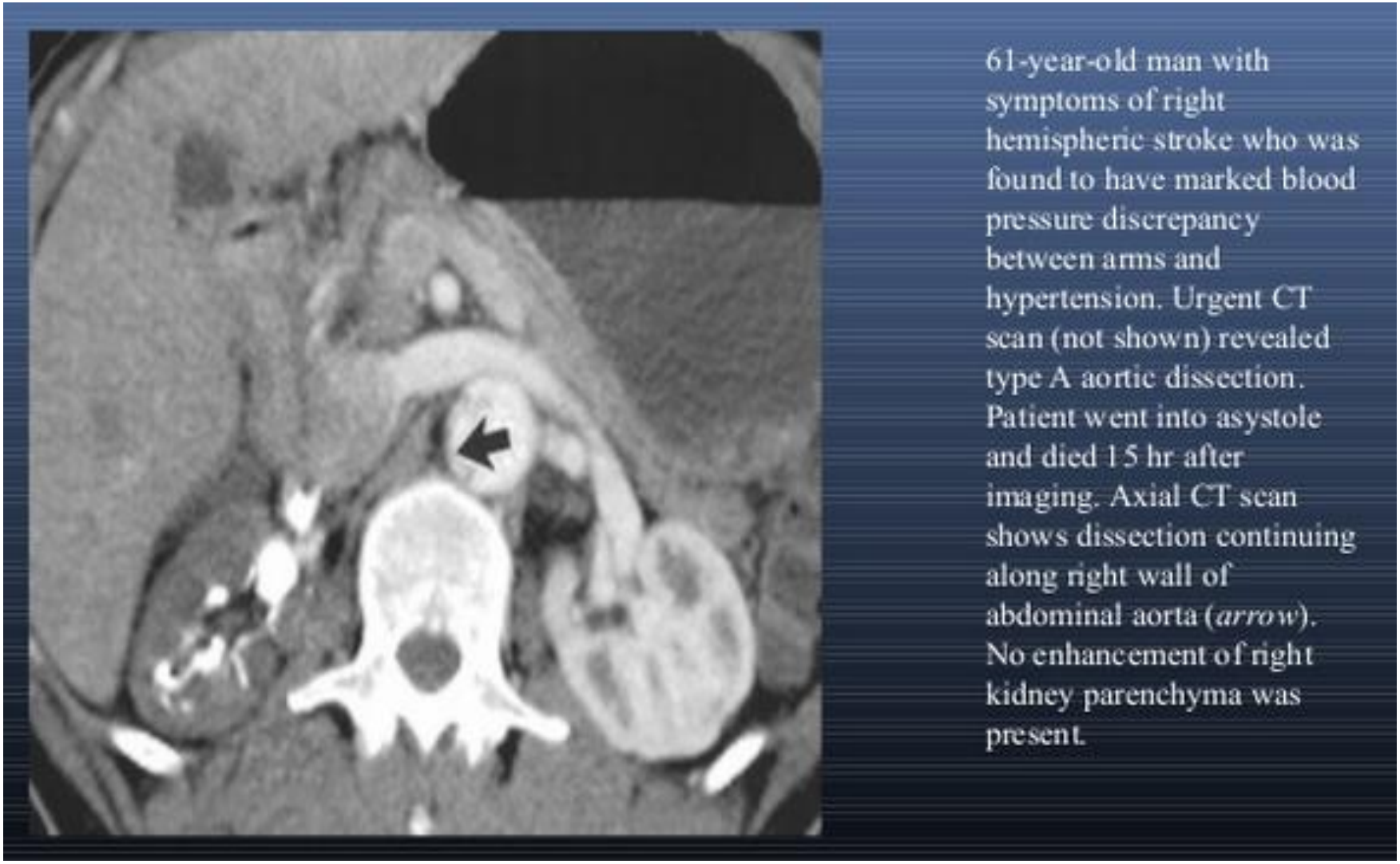
Complications

- dissection and occlusion of branch vessels
  - abdominal organ ischemia
  - limb ischemia
  - ischemic stroke
  - paraplegia: involvement of artery of Adamkiewicz
- distal thromboembolism
- aneurysmal dilatation - an indication for endovascular or surgical intervention
- aortic rupture

Ruptured aortic dissection into right thorax

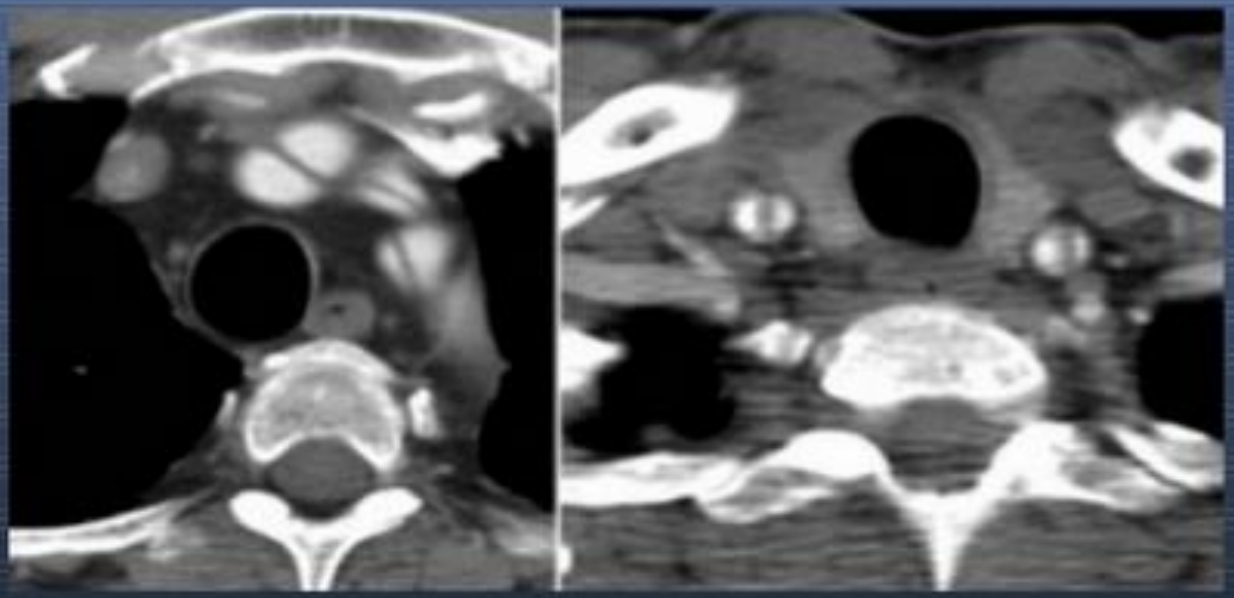


Acute cardiac tamponade due to ruptured aortic dissection. (a) Axial non–ECG-gated arterial phase CT image shows intimal flap in the ascending aorta extending into the aortic arch, corresponding to Stanford type A aortic dissection. No pericardial effusion is present. (b) Axial CT image acquired 60 seconds after contrast agent administration shows large high-attenuation pericardial effusion corresponding to massive hemopericardium. Weakening of aortic wall with subsequent rupture has led to massive extravasation of iodinated contrast agent to the pericardial sac. The patient died immediately after CT angiography. (Image courtesy of G. F. Gualdi, MD, and C. Valentini, MD, DEA Policlinico Umberto I, Rome, Italy.)

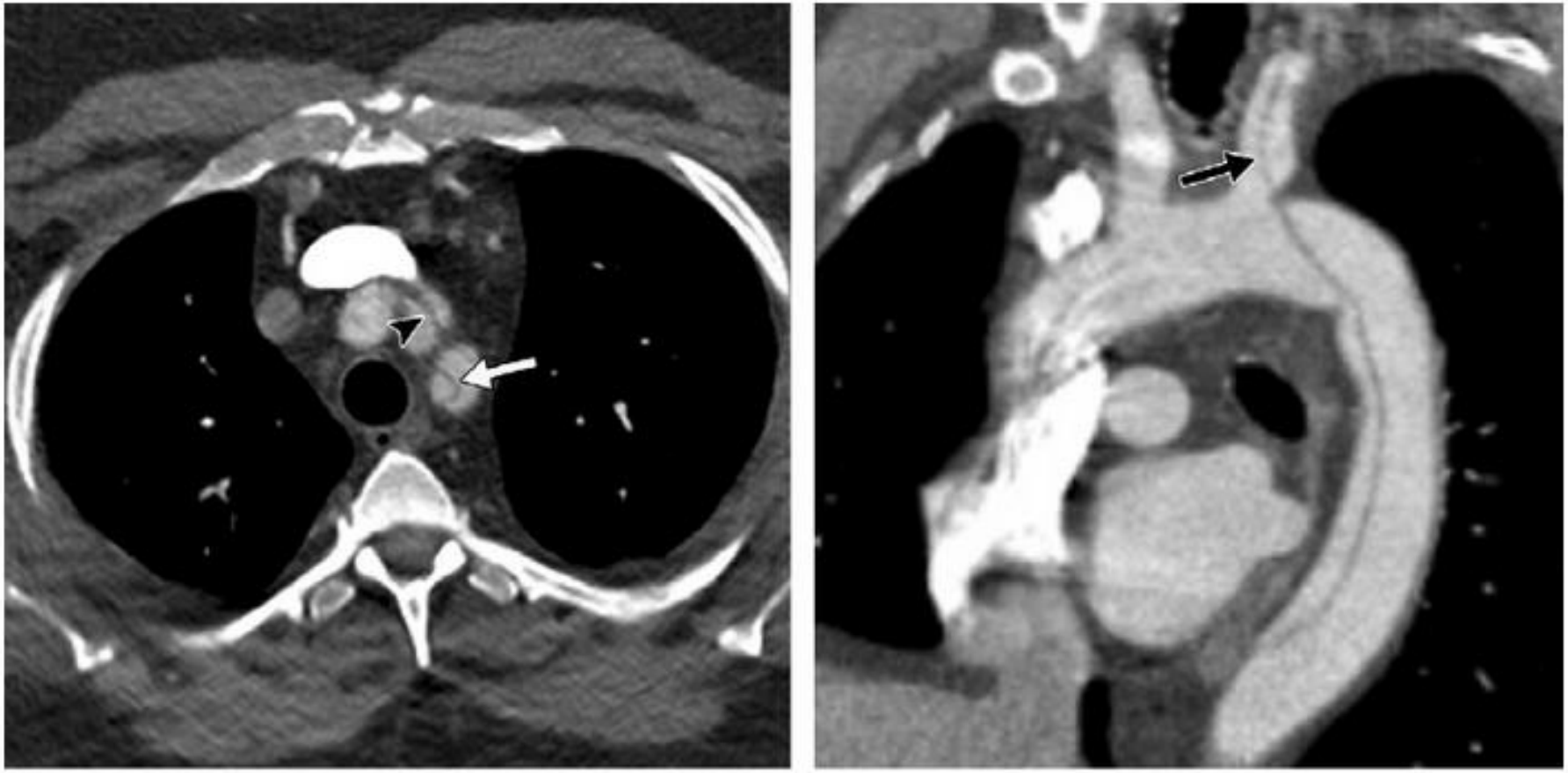


Dissection into abdominal aorta

Dissection into brachiocephalic arteries

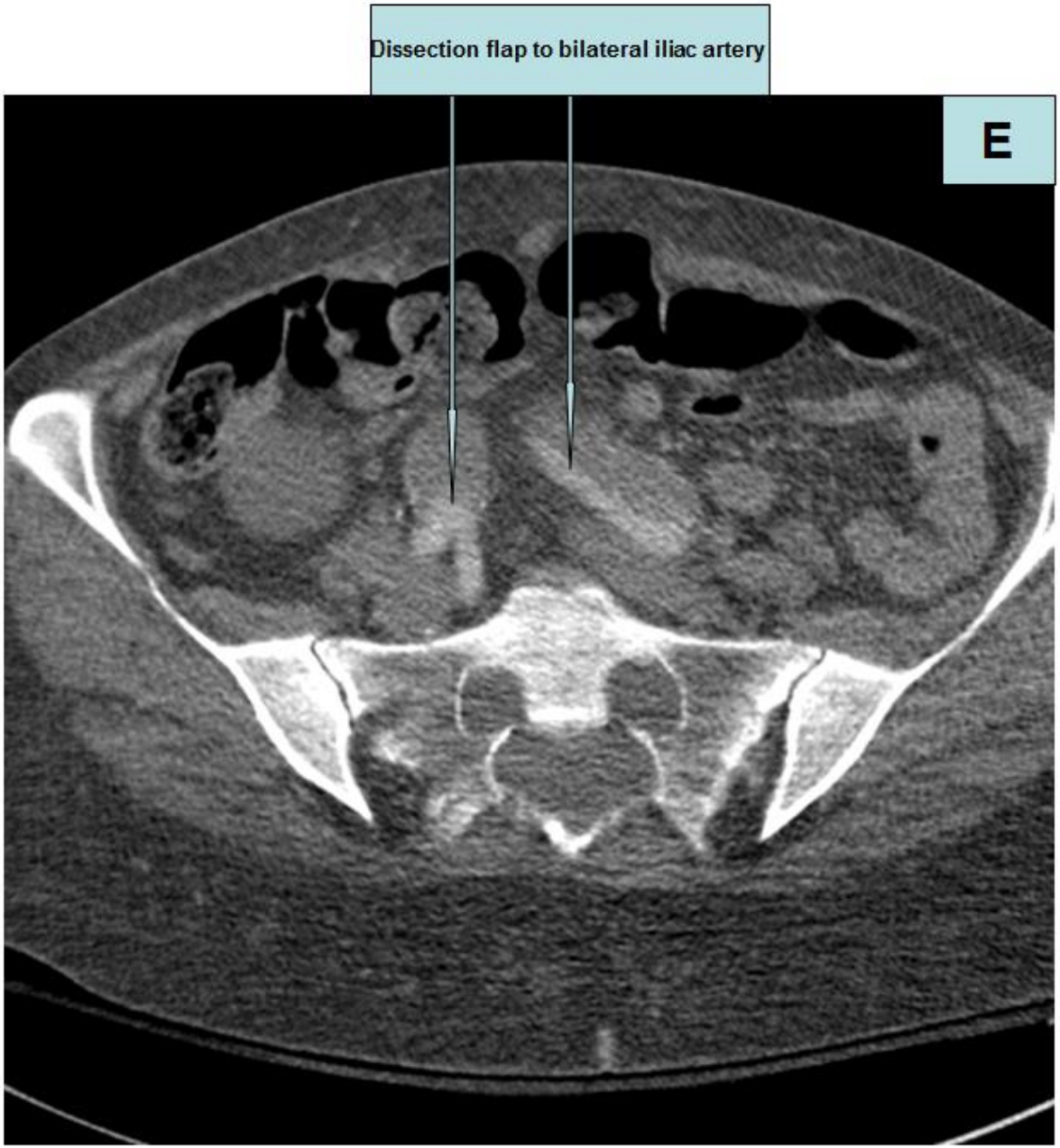


Aortic dissection involving brachiocephalic branches.



a. b.

Aortic arch dissection with arch vessel involvement. (a) Axial and (b) sagittal oblique CT angiographic images of the chest show a thoracic aortic dissection flap with extension into the left common carotid artery (arrowhead) and left subclavian artery (arrow).


Dissection flap to bilateral iliac artery
E

Management decisions are based on the following information :

- Type A or Type B
- Place of entry & re-entry
- Side branches involved, originating from true/false lumen
- Organs at risk
- Complications – rupture, coronary occlusion, aortic insufficiency, neurological
- Diameters of true and false lumens at proximal and distal landing zones, at entry and at minimum iliac vessel tortuosity.

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- *Collins JS, Evangelista A, Nienaber CA, Bossone E, Fang J, et al. (2004) - Differences in clinical presentation, management, and outcomes of acutetype a aortic dissection in patients with and without previous cardiacsurgery. Circulation 110: II237-242*
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