

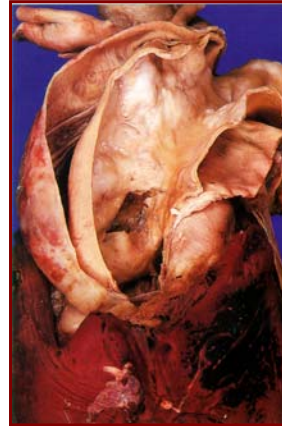
ASCeXAM/ReASCE  
REVIEW COURSE

The most comprehensive review to help you prepare for the NBE certification examinations.



THE UNIVERSITY OF  
**CHICAGO**  
CARDIAC IMAGING CENTER

**Diseases of the Aorta:  
Dissection, Hematoma  
and Trauma**

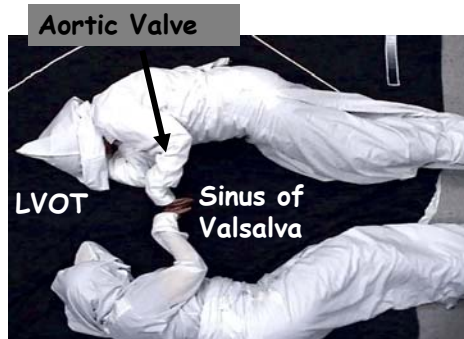
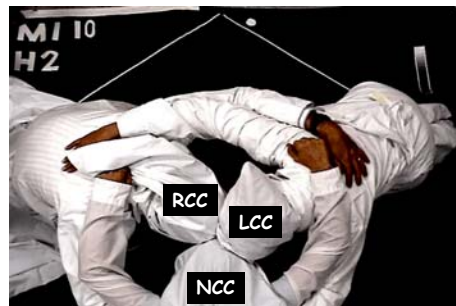


**Roberto M. Lang M.D., FASE**

**SAX**

**Normal  
Ao Valve**

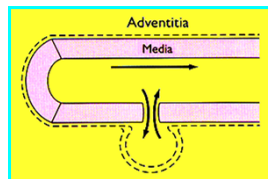
**Long Axis**



## Identify the Reason for this Emergency TEE

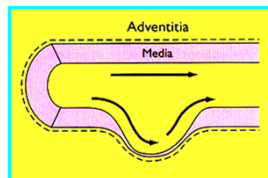


## Type of Aneurysm : Causes



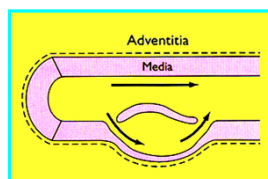
**False saccular aneurysm**

**Trauma**



**True diffuse and saccular aneurysms**

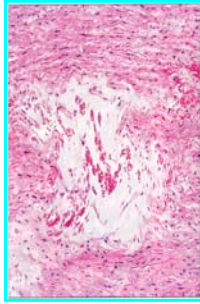
**Connective tissue generic disorders**  
**Non-inflammatory medial disease**  
**Aortitis**  
**Atherosclerosis**



**Dissecting aneurysms**

**Connective tissue disorders: Hypertension, Marfan's**

## PATHOPHYSIOLOGY



- Deterioration of medial collagen and elastin

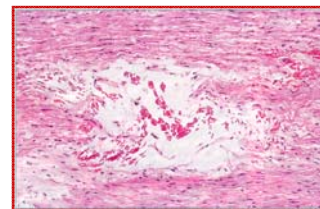
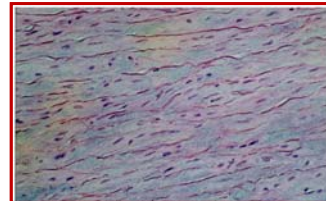
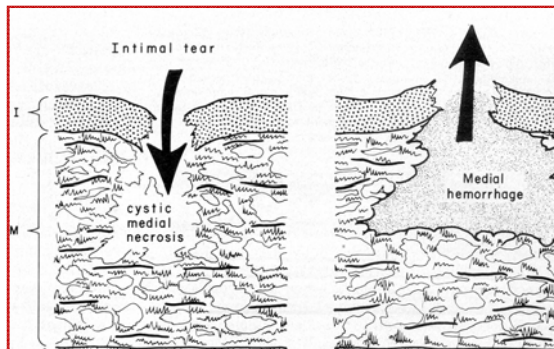


- A tear in the intimal layer allows blood to enter the intima-media space



- Blood then propagates down this new space creating a “true” and a “false” lumen

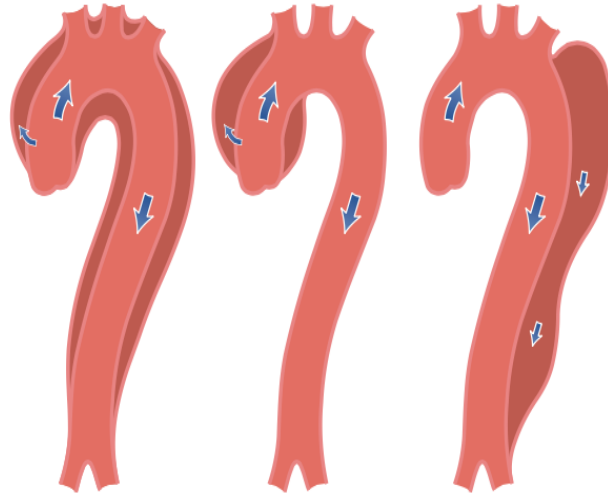
## Cystic Medial Change



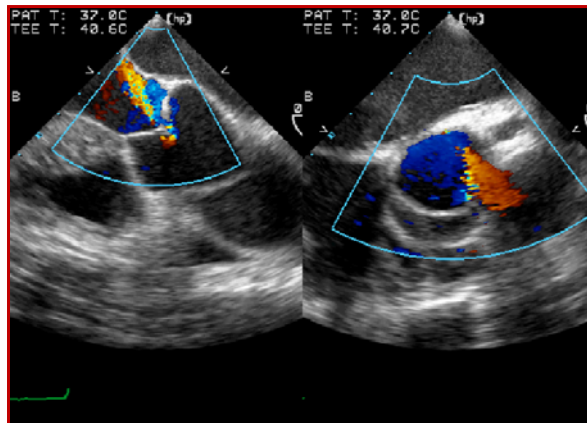
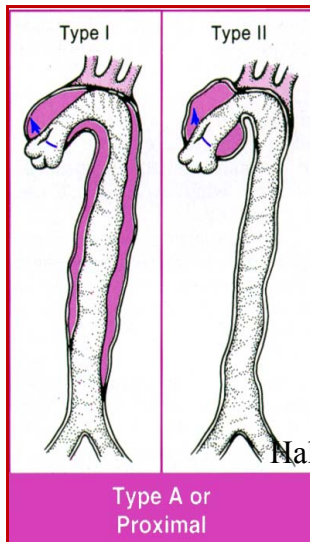
- Hypertension
- Marfan's and Ehler-Danlos
- Coarctation and bicuspid aortic valve
- Pregnancy
- Trauma
- Perforation through an intimal atheromatous plaque

# Types of Aortic Dissection

De Baakey	Type I	Type II	Type III
Stanford	Type A	Type A	Type B



## Proximal or Ascending Type A

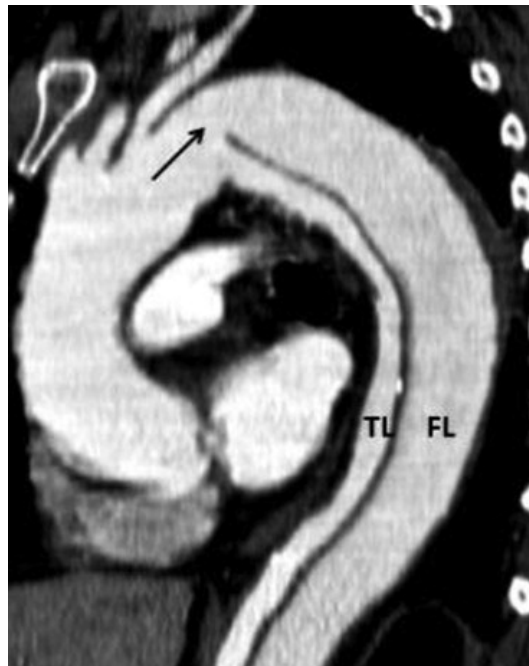
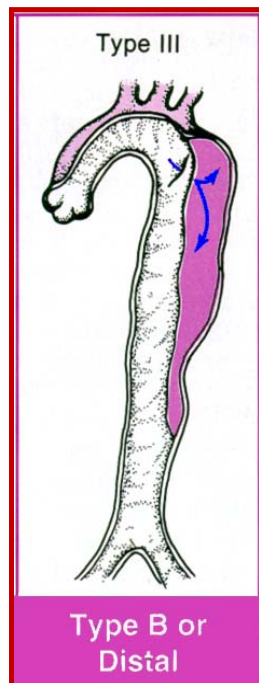


Hallmark is visualization of mobile dissection flap  
 Motion that is independent of the Aorta  
 Visualization on more than one view  
 Clear distinction from reverberations

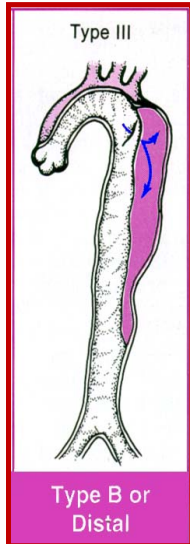
## Predicting Death in Patients with Acute Type A Aortic Dissection

- 547 pts; IRAD; Jan 96-Dec 99
- In hospital mortality 32.5%
  - Age  $\geq$  70 years
  - Abrupt onset of Cx pain
  - Hypotension, shock, tamponade
  - Kidney failure
  - Pulse deficit
  - ECG abnormalities

Circulation 2002;105:200-206



## Distal or descending – Type III Aortic Dissection



Iatrogenic (intra-arterial catheterization) – Type IV

## Management of Aortic Dissection

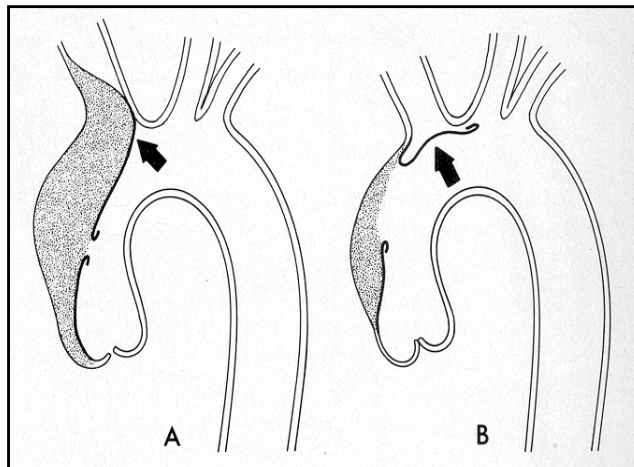
Depends not only on the type but also also on time elapsed between onset and presentation

- Acute < 2 weeks
  - 24 Hour hyper-acute period (Risk of rupture approaching 1% per hour)
  - 75% of AD related deaths occur in first two weeks
- Subacute > 2 weeks - 2 months
- Chronic > 2 months

## Clinical Presentation: Physical Exam

	A + B	Type A	Type B	P =
AI on exam	32%	44%	12%	<.001
Pulse deficit	15%	19%	9.2%	.006
CVA	4.7%	6.1%	2.3%	.07
CHF	6.6%	8.8%	3.0%	.02

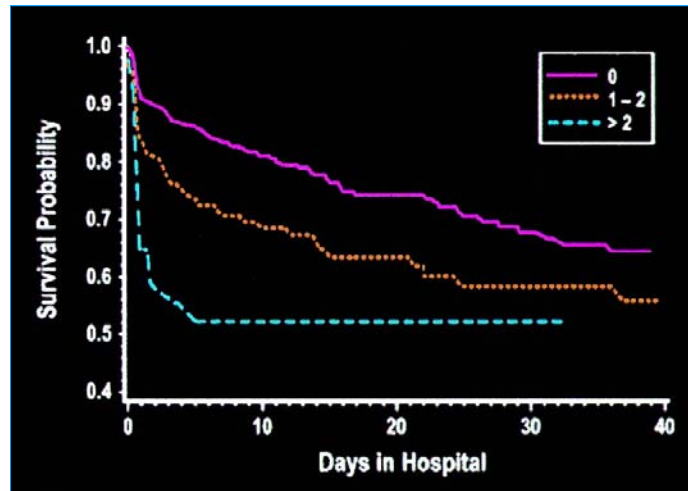
## Aortic Dissection: Pulse Loss



Due to direct  
compression

Blockade due to  
flap of intima

## Survival Curves for Type A Dissection By Number of Pulse Deficits on Presentation



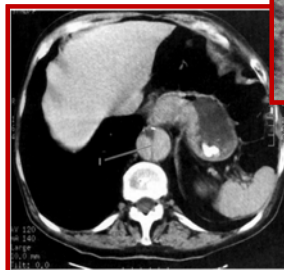
Circulation 2003;108:628-635

## GOALS OF DIAGNOSTIC IMAGING

- Confirm the diagnosis
- Classify the dissection and determine extent
- Detect extravasation
- Detect and Grade AI



- Aortography
- Spiral CT
- MRI
- TTE / TEE





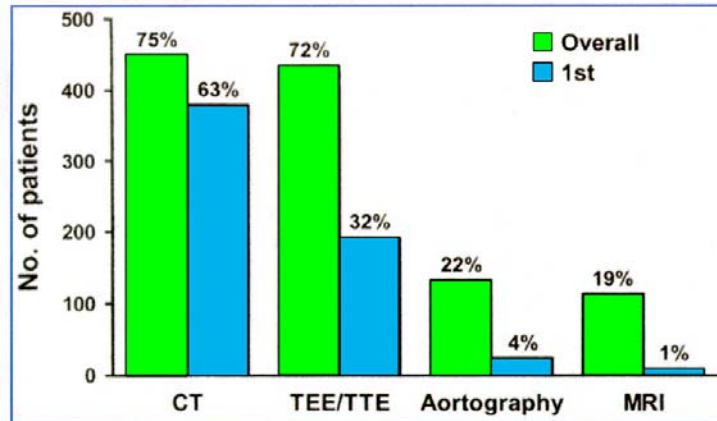
## **Aortic Dissection: Choice of Imaging Technique**

- Fine tradeoff in sensitivity and specificity
- Availability of technique
- Experience and expertise at a given institution
- Degree of urgency
- Stability of the patient

## **Aortic Dissection: Why Multiple Studies?**

- **Initial study often done at referral site**  
Confirmation needed or desired
- **If CT first**  
Still need cardiac anatomy, valve status etc
- **If echocardiography first**  
Still need assessment of abdominal aorta in many instances

## Procedure Used for the Diagnosis of Aortic Dissection



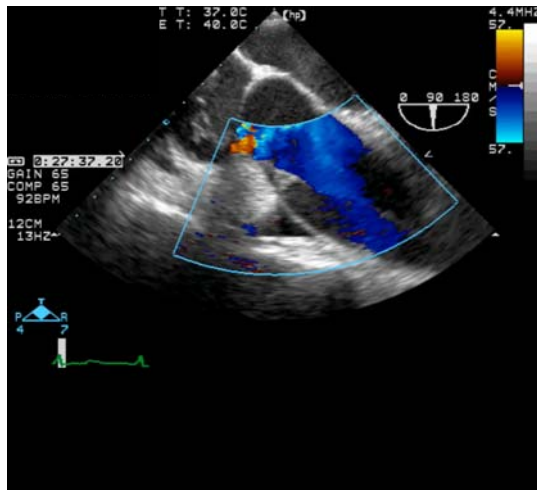
Moore, A. *et al.* Am J Cardiology, 89:1235-1238, 2002

## Diagnostic value of different imaging modalities in acute aortic syndromes

Lesion	TTE	TEE	CT	MRI
Ascending aortic dissection	++	+++	+++	+++
Aortic arch dissection	+	+	+++	+++
Descending aortic dissection	+	+++	+++	+++
Size	++	+++	+++	+++
Mural thrombus	+	+++	+++	+++
Intramural hematoma	+	+++	+++	+++
Penetrating aortic ulcer	++	++	+++	+++
Involvement of aortic branches	+ <sup>2</sup>	(+)	+++	+++

<sup>2</sup>Can be improved when combined by vascular ultrasound (carotid, subclavian, vertebral, celiac, mesenteric, and renal arteries).  
 +++=excellent; ++=moderate; +=poor,(+)=poor and inconstant; CT=computed tomography; MRI=magnetic resonance imaging.  
 TOE=transesophageal echocardiography; TTE=transthoracic echocardiography.

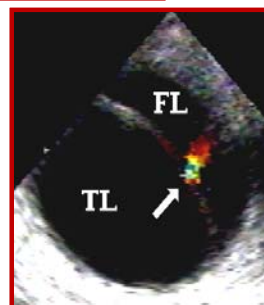
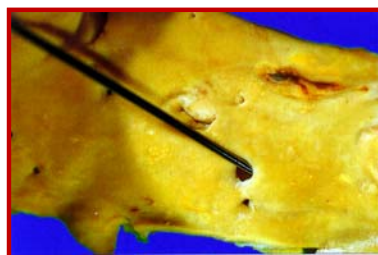
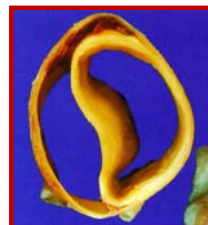
## TEE in Aortic Dissection



- Hallmark is visualization of mobile dissection flap
- Motion that is independent of the Aorta
- Visualization on more than one view
- Clear distinction from reverberations

Systolic expansion of the true lumen  
Diastolic expansion of the false lumen

## Aortic Dissection: Intimal Flap and Entry Site



## Advantages of TEE in Aortic Dissection

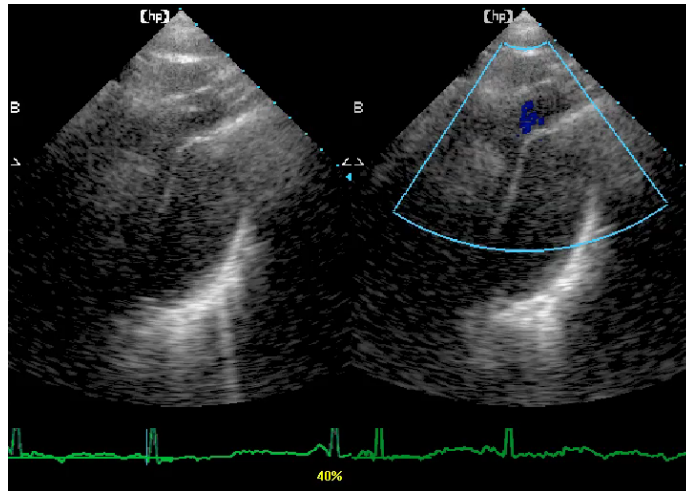
- **Origin and proximal extent of the dissection flap**
- **Dimension of the aorta**
- **Severity of Aortic Insufficiency**
- **Pericardial effusion**
- **Coronary involvement**

## TEE in AD: Disadvantages



- **Interposition of the trachea between the ascending aorta and the esophagus impeding visualization of distal ascending aorta and proximal arch**
- **Brachiocephalic and LCC artery difficult to visualize**
- **Celiac trunk and superior mesenteric artery cannot be consistently imaged**
- **Reverberation artifacts**

## TTE Echo in Aortic Dissection Suprasternal Approach



## 3D Epicardial Echo in Aortic Dissection



## **Advantages of CT in Aortic Dissection**

- ***CT first time imaging modality***
- **In 62% of Type A Ad, CT is the first imaging modality**
- **Diagnostic accuracy near 100% to exclude Ad**
- **Evaluation of the entire aorta and branches**
- **Shortest time to diagnosis**
- **Disadvantage: Need for iodinated contrast and radiation**

## **Information required from imaging in acute aortic dissection**

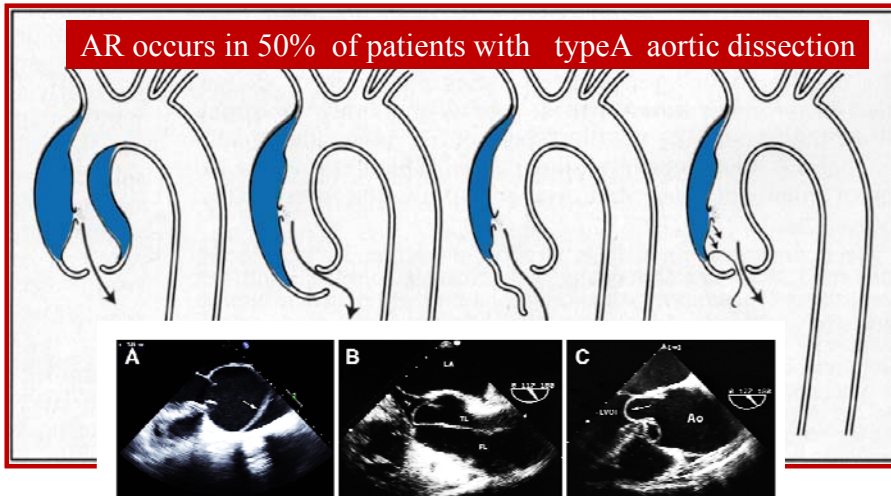
- **Visualization of intimal flap**
- **Extent of the disease (aortic segmentation)**
- **Identification of the false and true lumens (if present)**
- **Localization of entry and re-entry tears (if present)**
- **Identification of severity and mechanism of aortic valve regurgitation**
- **Involvement of side branches**
- **Detection of pericardial effusion**
- **Detection and extent of pleural effusion**
- **Detection of peri-aortic and mediastinal bleeding**

## Aortic Dissection: Complications

- **Aortic regurgitation**
- **Pericardial effusion (rupture of the false lumen into the pericardium) Echo best for pericardial effusion; CT for pleural effusion and peri- aortic hematoma**
- **Coronary artery involvement (invagination of intimal flap into the coronary)**
- **Other branch vessel involvement**

## Aortic Dissection: Mechanism of AR

AR occurs in 50% of patients with typeA aortic dissection

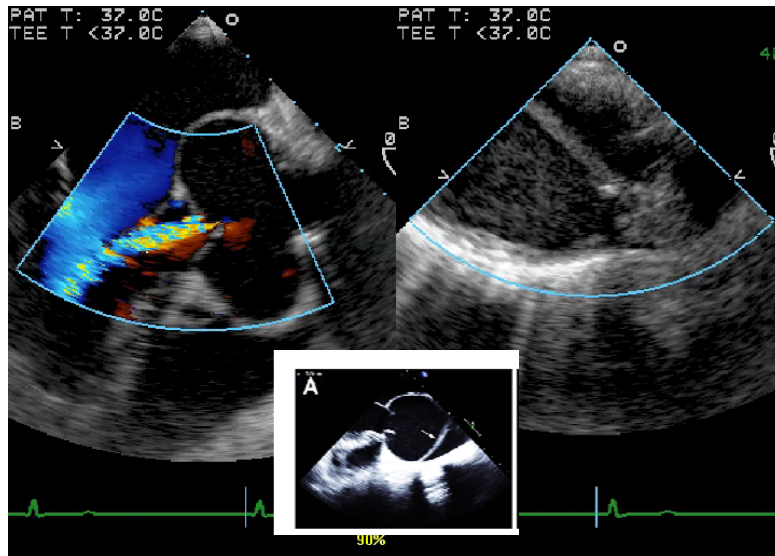


**Dilatation of aortic root.**

**Pressure from dissecting hematoma may depress one leaflet below line of closure. Prolapse or flail**

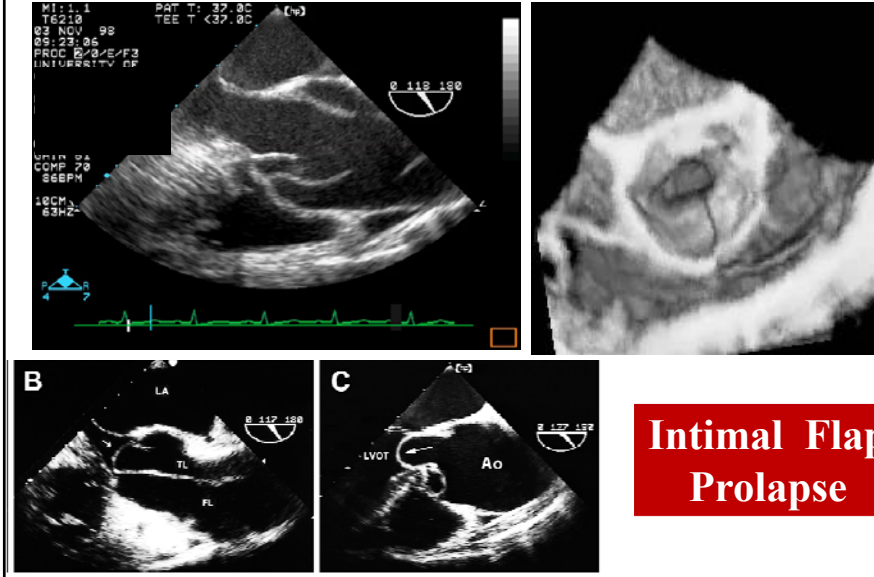
**–Torn annular support of the leaflets.**

## Aortic Dissection: Mechanism of AR

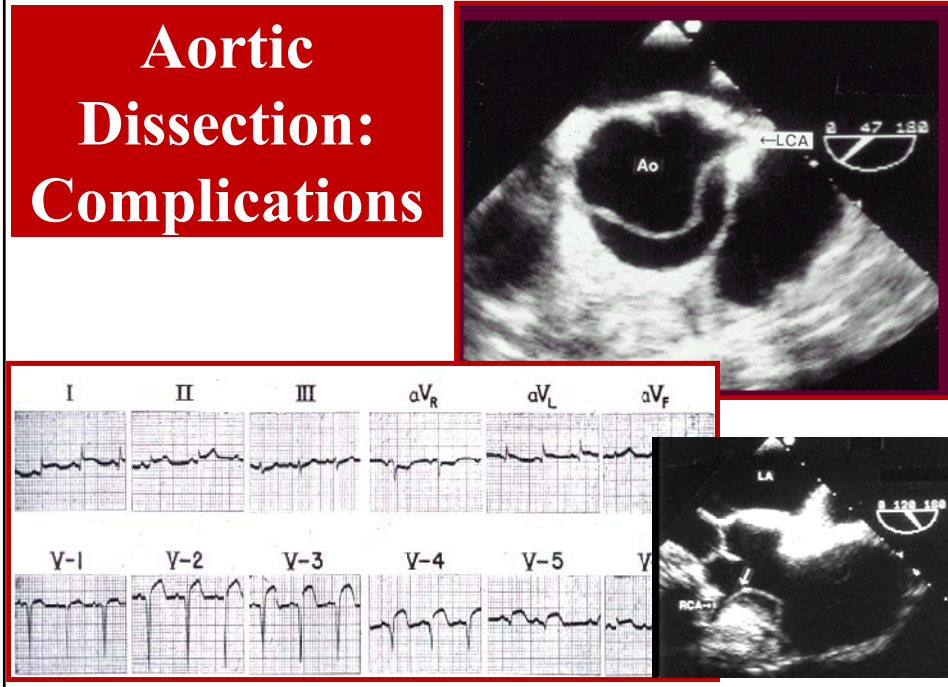




## Aortic Dissection: Mechanism of AR



## Aortic Dissection: Complications



## Aortic Dissection: Endovascular Repair

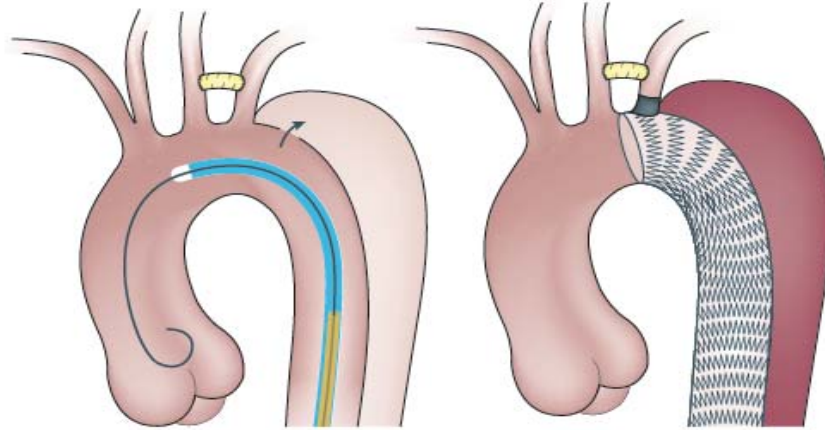
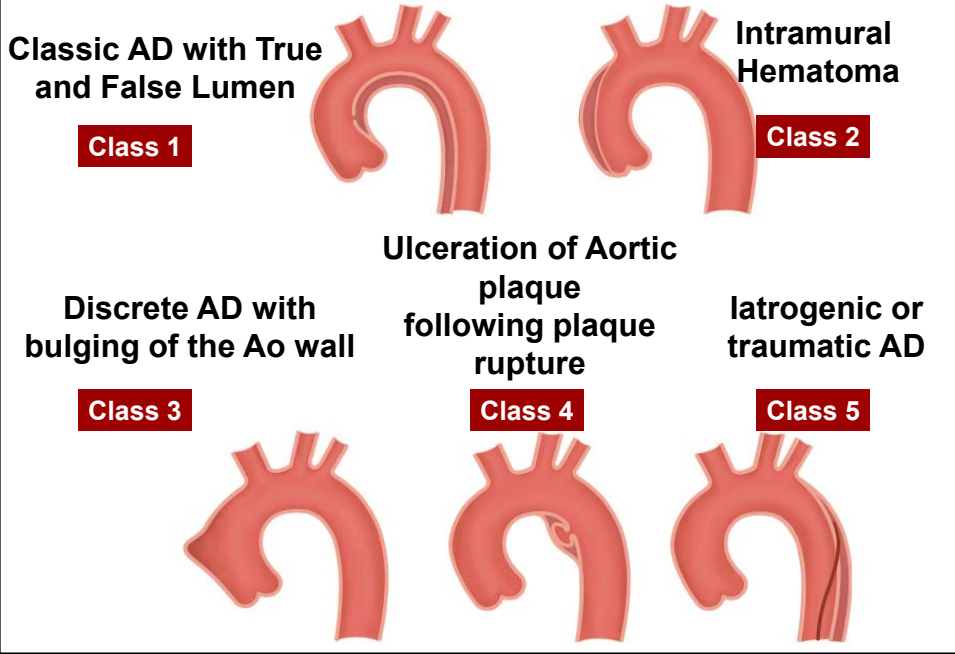


Figure 9 | Endovascular repair of Stanford type B aortic dissection. A catheter is used to insert an expandable stent graft into the aorta to cover the site of the intimal tear. In cases in which the stent graft occludes a branching artery, pre-emptive surgery is required (hybrid intervention) to vascularize the occluded artery. The covered stent graft excludes the false lumen, which collapses. Bleeding from the false lumen rupture is prevented by thrombosis within the false lumen and the covered stent graft. The endovascular approach may induce re-approximation and remodelling of the dissected

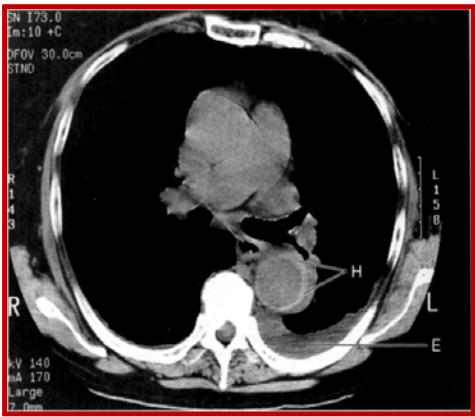
## Aortic Dissection: Follow-Up

- 1,3,6 and 12 months then yearly
- ***Ao diameter and status of the false lumen***
  - ***(thrombosed or patent)***
- Dilatation of the Ao is predictor of rupture
  - (Diameter > 60 or annual growth > 5 mm)
- Completely thrombosed false lumen (improved outcomes)
- Patent false lumen (risk for expansion and death)
  - Entry tear size
- Flap confined to ascending Ao (improved outcomes)

**Classification of Acute Aortic Syndrome in Aortic Dissection**



**Atypical Aortic Dissection**

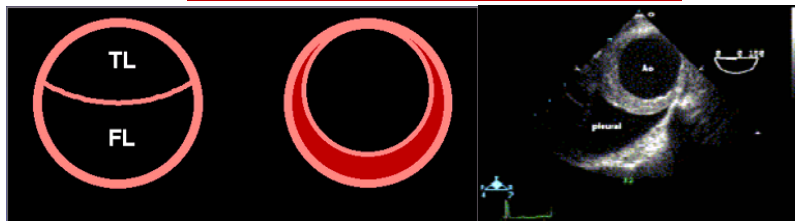


**Intramural Hematoma**



**Penetrating Atherosclerotic Ulcer**

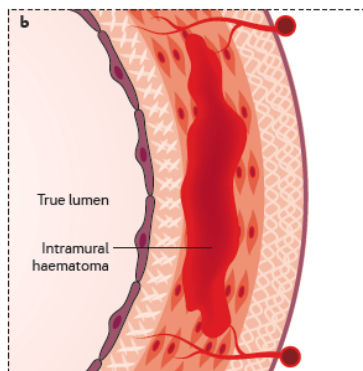
## Intramural Hematoma



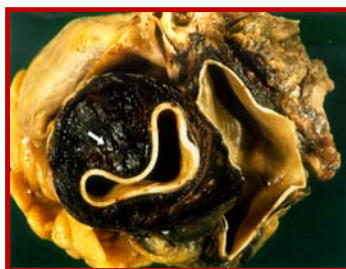
- Rupture of the VASA vasorum

Discrete hematoma

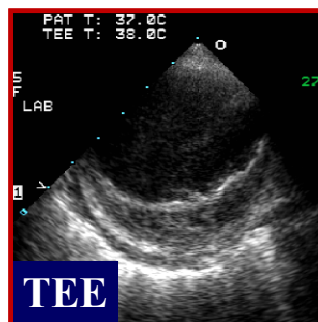
Extends for a variable distance by dissecting along the outer media beneath the adventitia



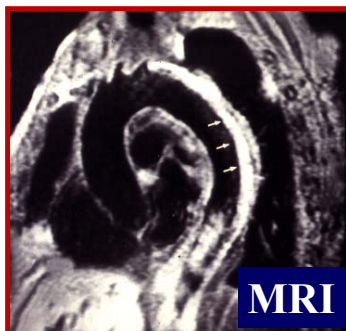
## Intramural Hematoma: Diagnosis



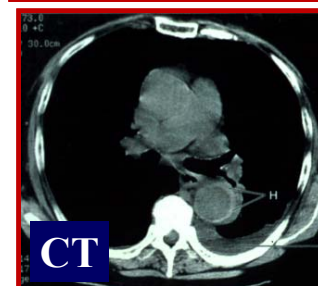
Contained hemorrhage within the medial layer of the aortic wall



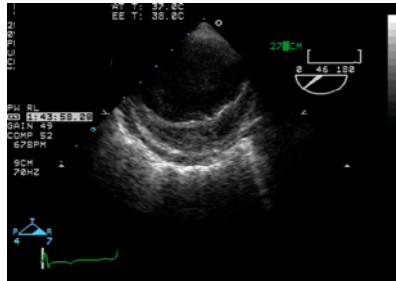
TEE



Crescentic area along the aortic wall

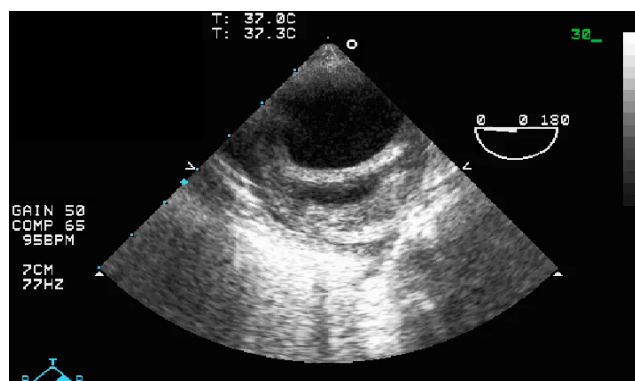


## Imaging features of IMH



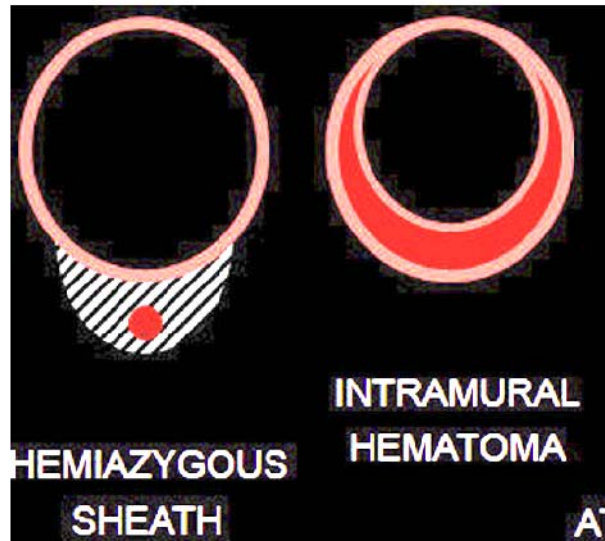
- IMH represents hemorrhage into medial layer of aorta with absence of dissection flap and false lumen
- Focal aortic wall thickening (crescentic > concentric)
- Preserved luminal shape with smooth luminal border
- Echolucent regions may be present in the aortic wall
- Central displacement of intimal calcium

## Significance of Echo-Free Space Detected by TEE in Type B AIH

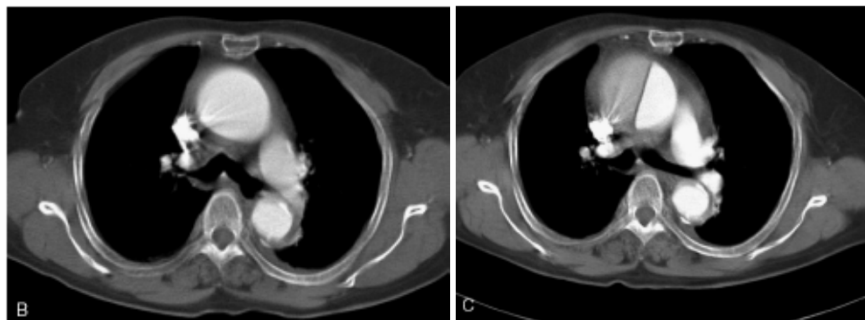


- Prevalence 60%
- Not a poor prognostic factor
- Not associated with the development of AD

## Differential Diagnosis



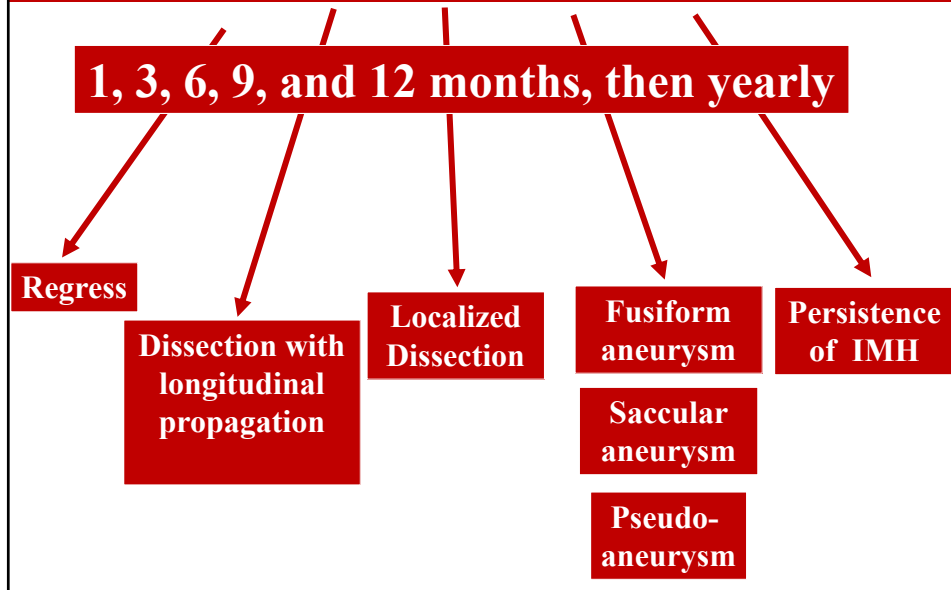
## Acute and Chronic Complications of IMH



Day 1

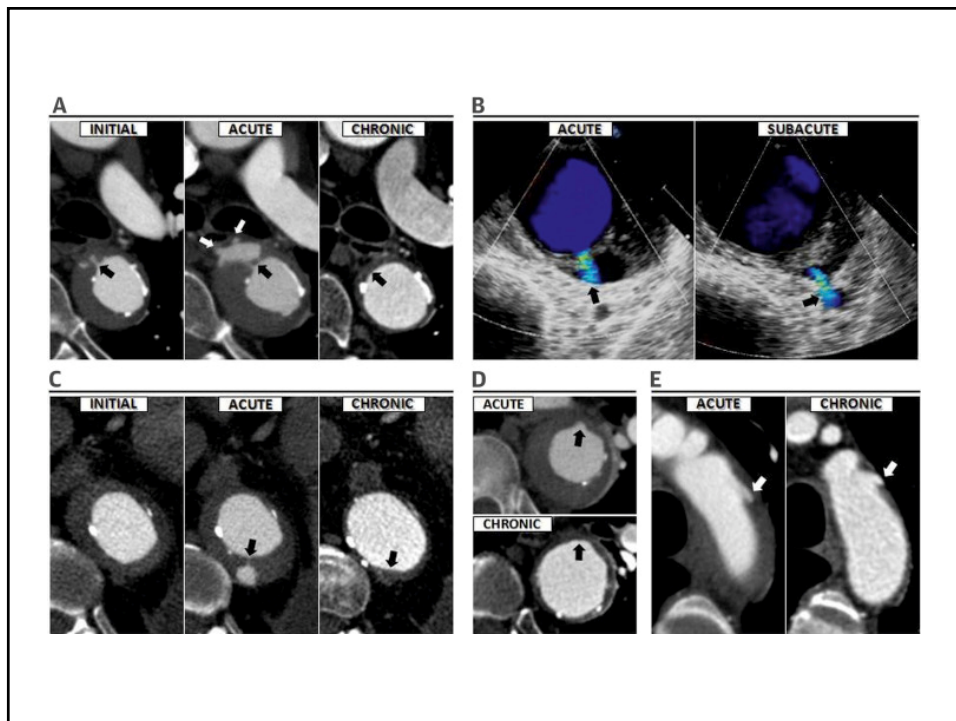
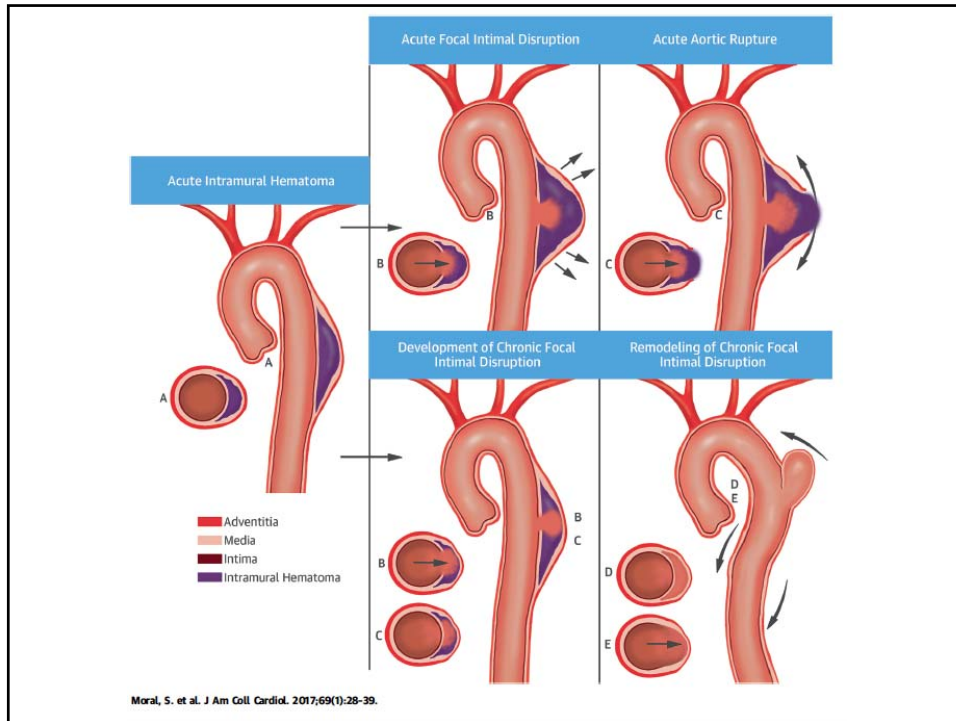
Day 7

## Intramural Hematoma: Natural History



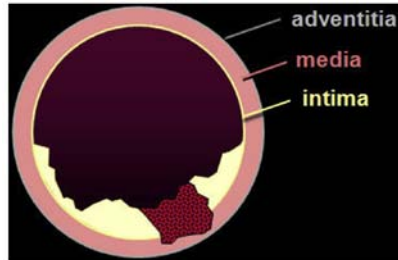
## IMH: Predictors

- Can progress to localized or frank dissection or rupture
- IMH thickness (>10 mm) and maximal aortic diameter (4cm) predict risk for progression
- Peri-aortic hemorrhage or pleural effusion (microperforations or inflammatory exudate)
- Penetrating ulcer or ulcer-like projection secondary to localized dissections in the involved segment





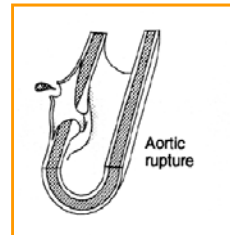
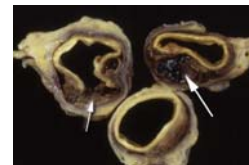
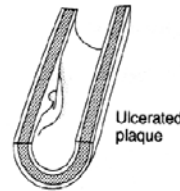
# Penetrating Aortic Ulcer



- Ulceration of an atherosclerotic lesion penetrates the aortic internal elastic lamina into the aortic media
- Disease of the intima
- Mid and distal descending thoracic aorta

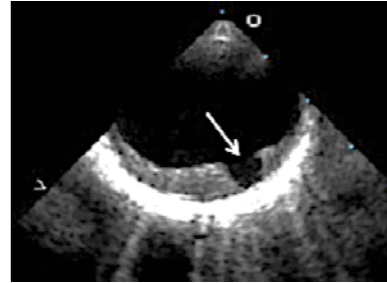
## Penetrating Atherosclerotic Ulcer

- Almost exclusively in the descending Ao
- Usually remains localized
- Chest and back pain without associated AR or neurological deficits



## Details required from imaging in Penetrating Aortic Ulcer

- Localization of the lesion (length and depth)
- Co-existence of intramural hematoma
- Peri-aortic tissue and bleeding
- Thickness of the residual wall
- CT, MRI and TEE

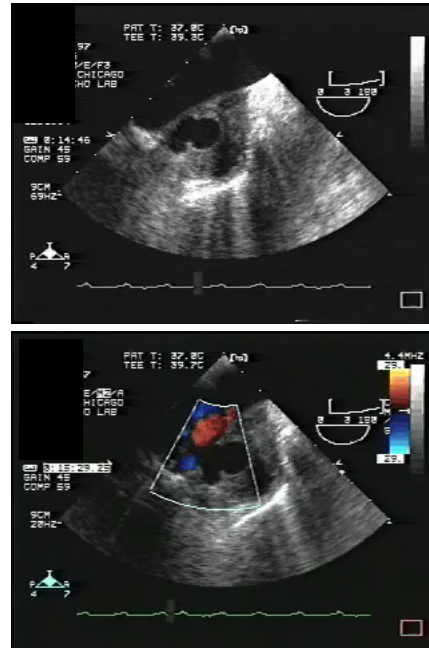


## PAU's: imaging parameters to report

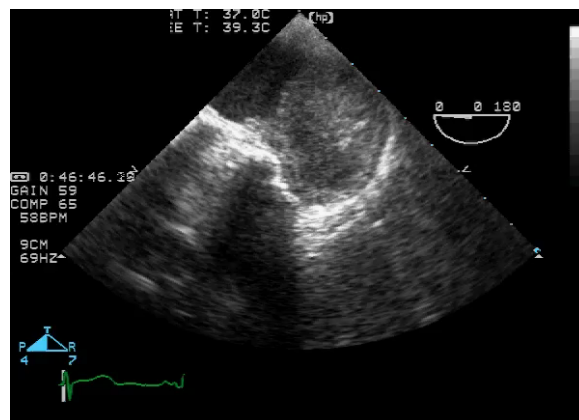
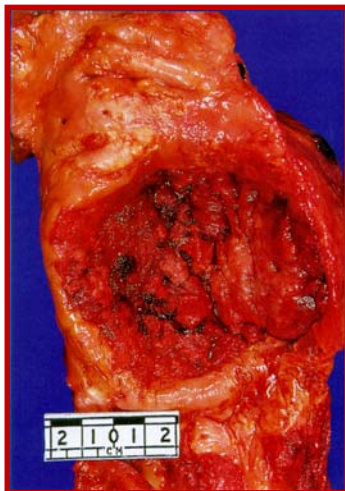
- Lesion location
- Lesion depth of penetration
- Width at entry site
- Axial length of associated intramural hematoma

## Penetrating Atherosclerotic Ulcer

- Natural history is unclear
- No defined strategy
- Surgical repair for
  - Pseudoaneurysm
  - Transmural rupture
  - Hemodynamic instability
  - Continued pain
  - Distal embolization
  - Aneurysmal dilatation

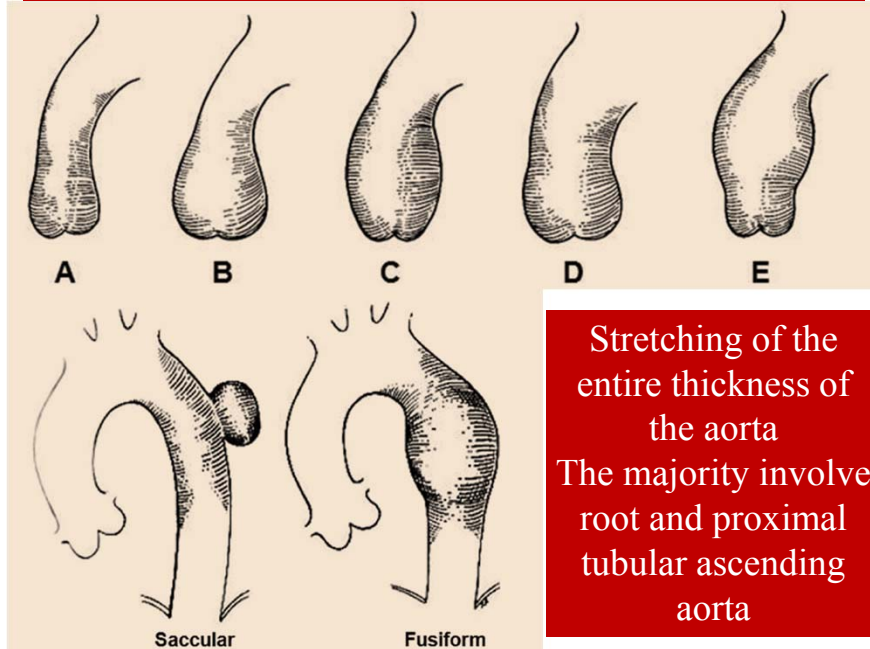


## Differential Diagnosis



- Ao Dissection
- Thrombosed False Lumen
- Ao atherosclerotic aneurysm
- Pseudoaneurysm
- IAH

## Aortic Root and Ascending Aortic Aneurysm



- Confirm diagnosis
- Maximal diameter
- Define longitudinal extent
- Involvement of the aortic valve
- Involvement of arch vessels
- Mural thrombus, dissection, periaortic hematoma

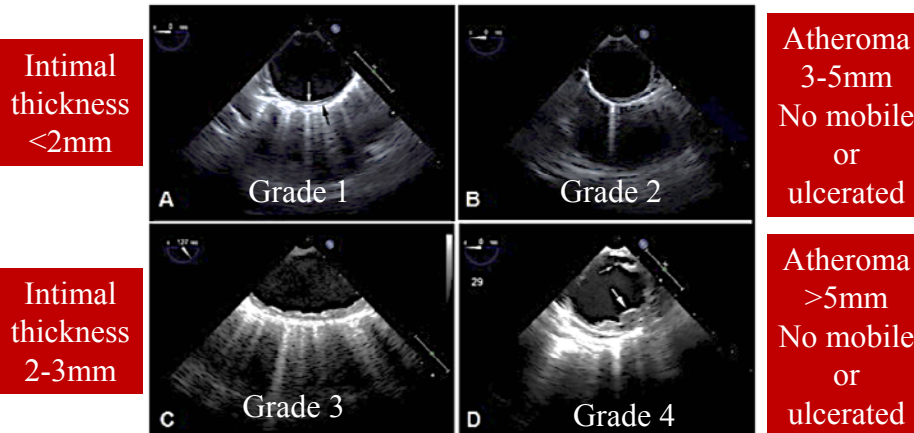
***Aortic diameter principal predictor of rupture  
increases significantly >6 cm***

CT first line  
MRI second line  
TTE second line  
TEE third line

## Grading system for severity of aortic atherosclerosis

Grade	Severity (atheroma thickness)	Description
1	Normal	Intimal thickness <2mm
2	Mild	Mild(focal or diffuse) intimal thickening of 2-3 mm
3	Moderate	Atheroma >3-5mm (no mobile/ulcerated components)
4	Severe	Atheroma >5mm (no mobile/ulcerated components)
5	Complex	Grade 2,3, or 4 atheroma plus mobile or ulcerated components

## Grading system for severity of aortic atherosclerosis



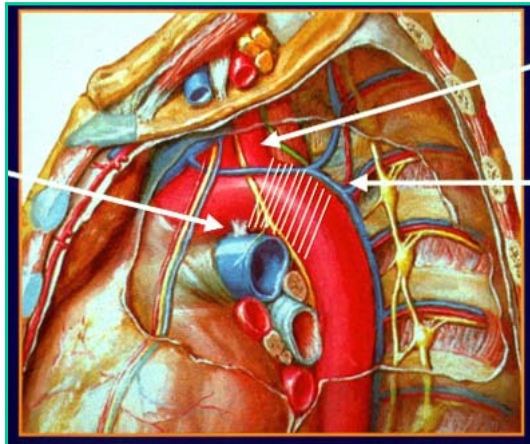
Complex: Grade 2,3, or 4 atheroma plus mobile or ulcerated components

## High-Speed Deceleration Accident



- Cardiac contusion
- Aortic injury
- Myocardial valve injury

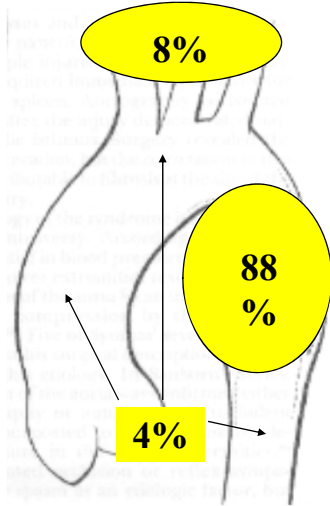
## Blunt Chest Trauma



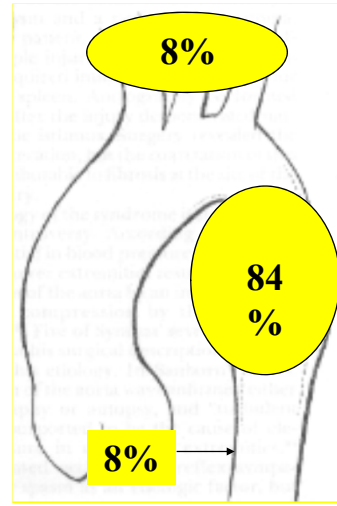
Generates shearing forces that act maximally on the aortic isthmus

# Blunt Aortic-Brachiocephalic Trauma

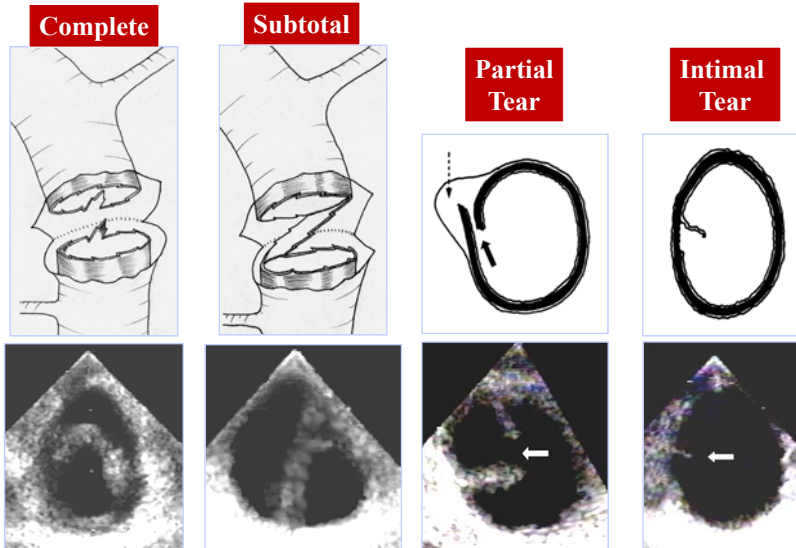
Fisher *et al*, 1981  
(n=510)



Vignon *et al*, 1998  
(n=25)



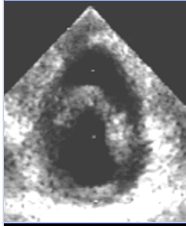
# Aortic Disruption: Anatomical Types



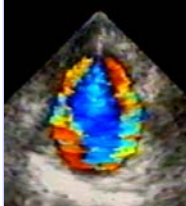
## Complete Transection



**Circular flap, separation of media from adventitia along entire circumference of the aorta**



**Elongation of the aorta consistent with pseudoaneurysm formation**



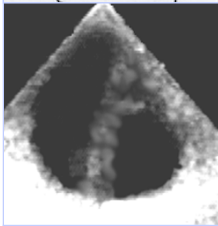
**Increased distance from the sector consistent with hemomediastinum**

**Turbulent color flow at the site of the tear**

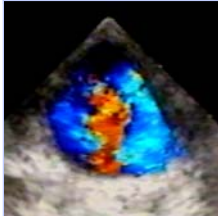
## Subtotal Transection



**Media flap involves at least 2/3 of aortic circumference**



**Spiral effect, small section of intact media and adventitia**




**Flap is vertically oriented**

**Turbulent color flow Doppler on both sides of the flap**

**Oblong shape of the aorta**



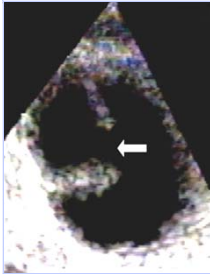
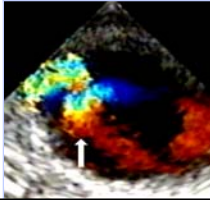



**Partial Tear**

**Localized medial flap involving a relatively small section of the aorta**

**Extravasation of blood between the media and adventitia**

**Usually can define an entry site into a pseudoaneurysm**

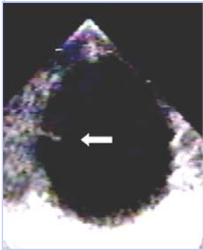
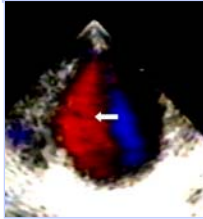
**Intimal Tear**

**Intima is lifted off of the media**

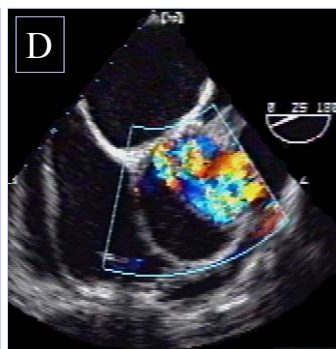
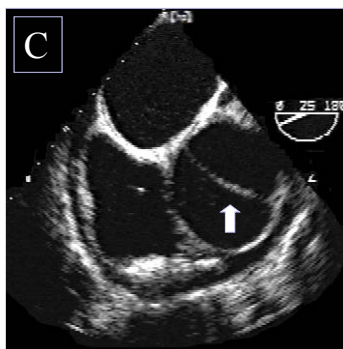
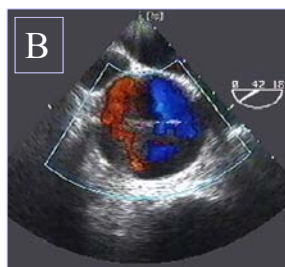
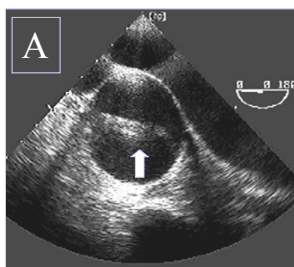
**Free, highly mobile**

**No color flow disturbance on Doppler**

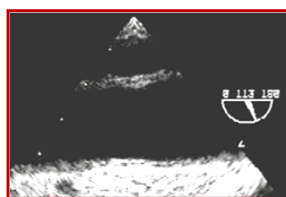
**Unclear prognostic importance**

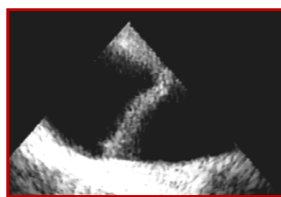
## Dissection vs. Disruption



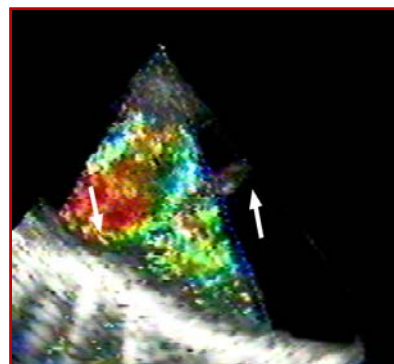
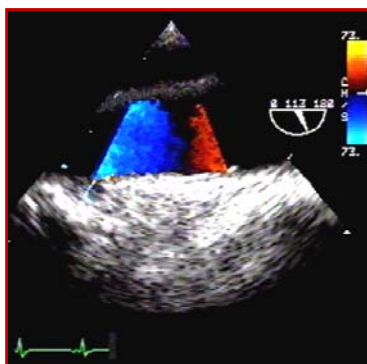
## TEE Longitudinal View

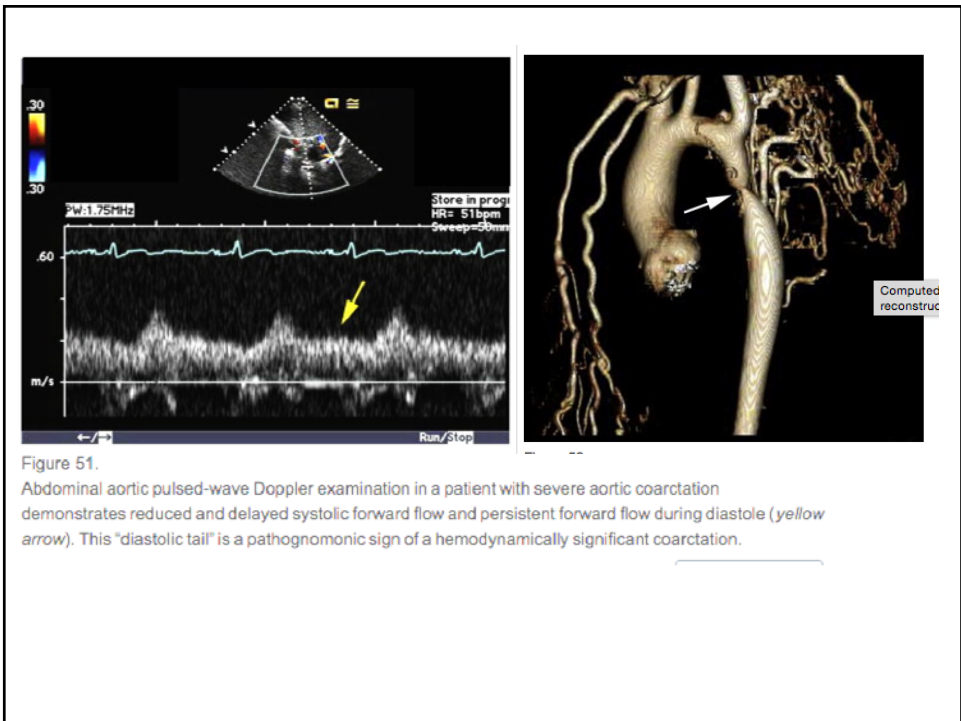


Dissection



Disruption





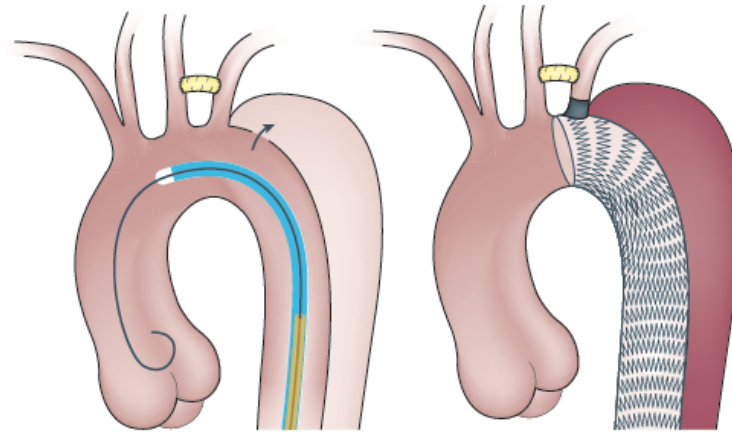


Figure 9 | Endovascular repair of Stanford type B aortic dissection. A catheter is used to insert an expandable stent graft into the aorta to cover the site of the intimal tear. In cases in which the stent graft occludes a branching artery, pre-emptive surgery is required (hybrid intervention) to vascularize the occluded artery. The covered stent graft excludes the false lumen, which collapses. Bleeding from the false lumen rupture is prevented by thrombosis within the false lumen and the covered stent graft. The endovascular approach may induce re-approximation and remodelling of the dissected segment. In the figure on the left, the arrow indicates blood flow out of the true lumen and into the false lumen.

**Table 5** Laboratory tests required for patients with acute aortic dissection

Laboratory tests	To detect signs of:
Red blood cell count	Blood loss, bleeding, anaemia
White blood cell count	Infection, inflammation (SIRS)
C-reactive protein	Inflammatory response
ProCalcitonin	Differential diagnosis between SIRS and sepsis
Creatine kinase	Reperfusion injury, rhabdomyolysis
Troponin I or T	Myocardial ischaemia, myocardial infarction
D-dimer	Aortic dissection, pulmonary embolism, thrombosis
Creatinine	Renal failure (existing or developing)
Aspartate transaminase/alanine aminotransferase	Liver ischaemia, liver disease
Lactate	Bowel ischaemia, metabolic disorder
Glucose	Diabetes mellitus
Blood gases	Metabolic disorder, oxygenation

SIRS = systemic inflammatory response syndrome.

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