TEE for Aortic surgery, Epiaortic imaging

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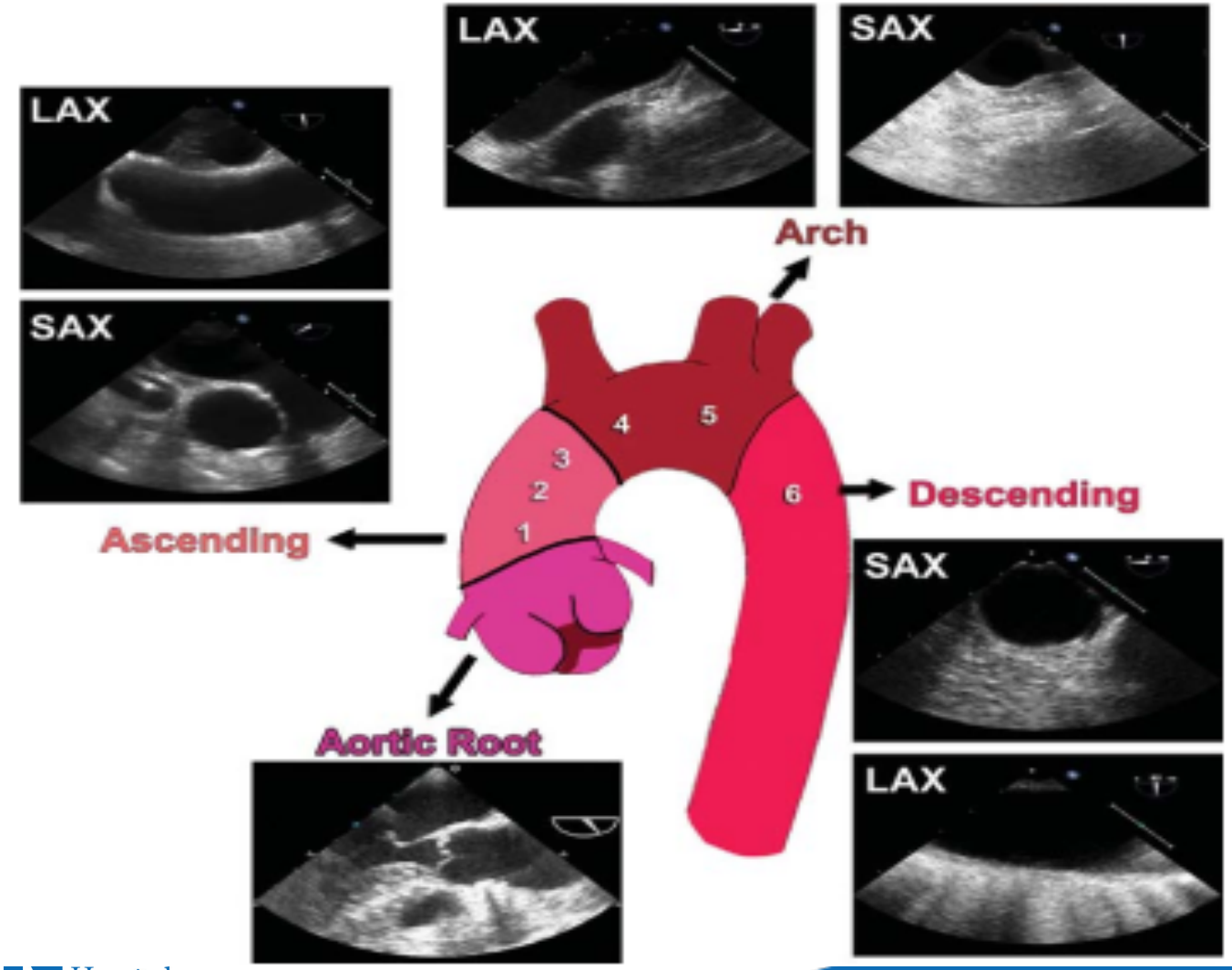
Outline

- Normal anatomy
- Aortic aneurysms (Root and AA)
- Aortic Dissection
- Intramural hematoma and Penetrating atherosclerotic ulcer
- TAA and TEVAR
- Epi aortic scanning

References

- Multimodality imaging of the diseases of the thoracic aorta in adults; Goldstein et al; JASE 2015;28:119-82
- Guidelines for the performance of comprehensive epiaortic ultrasonographic examination: Glas et al; JASE 2007; 20; 1227-35
- Perrino's textbook : A practical approach to transesophageal echocardiography 3rd edition
- Kaplan's textbook of Cardiac Anesthesia

Aorta


LAX
SAX
LAX
SAX
Arch
4
5
3
2
1
6
Descending
Ascending
SAX
Aortic Root
LAX

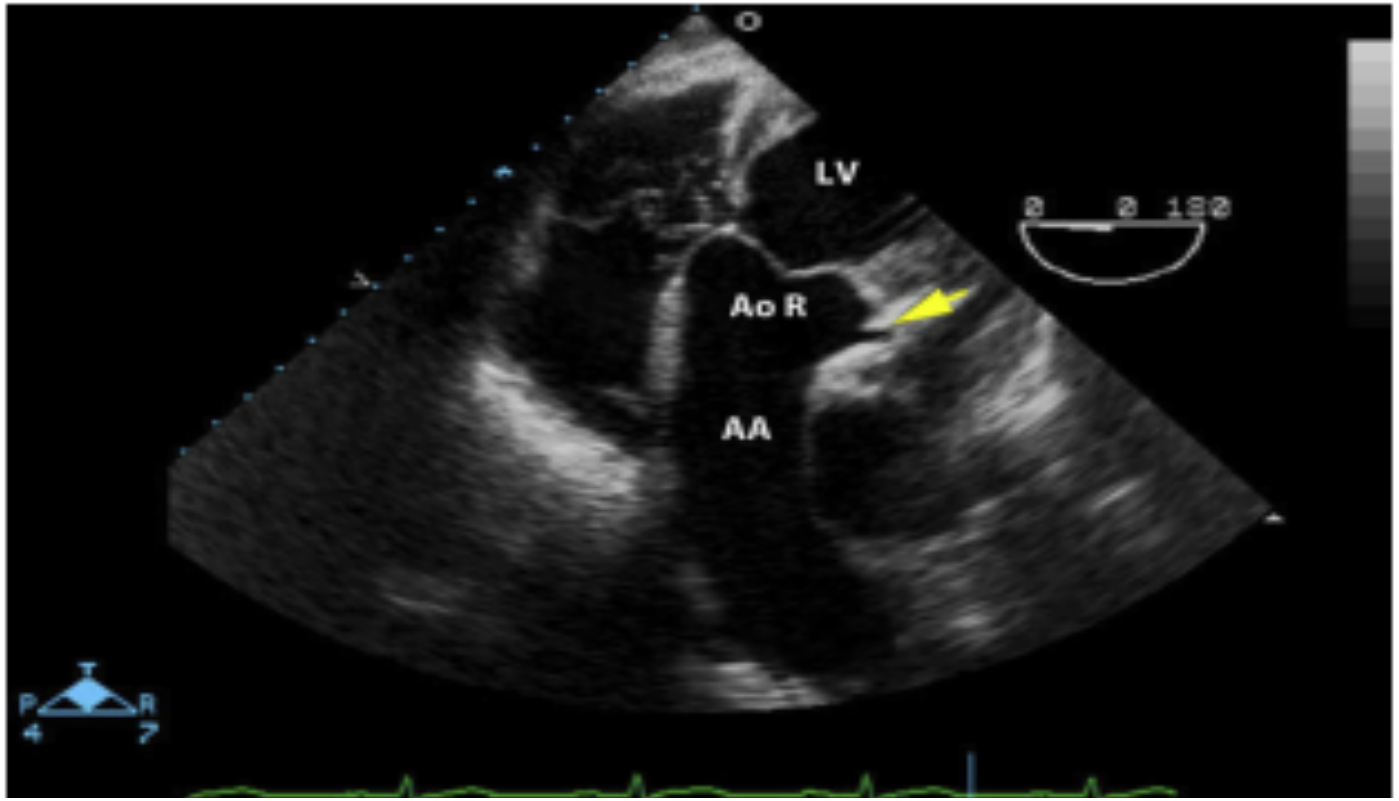


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TABLE 17.2 Normal Aortic Parameters based upon BSA of ~2 m^2

Diameter measurement	Mean ± SD
Subaortic (annulus)	21 ± 3 mm
Maximum sinus	32 ± 4 mm
STJ	27 ± 4 mm
Ascending aorta	33 ± 4 mm
Descending aorta	24 ± 4 mm

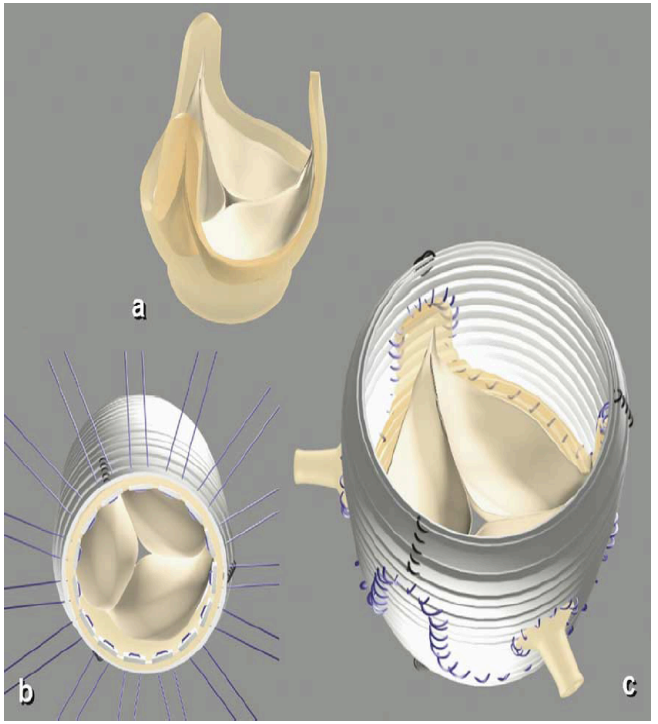
Aortic Root Aneurysm

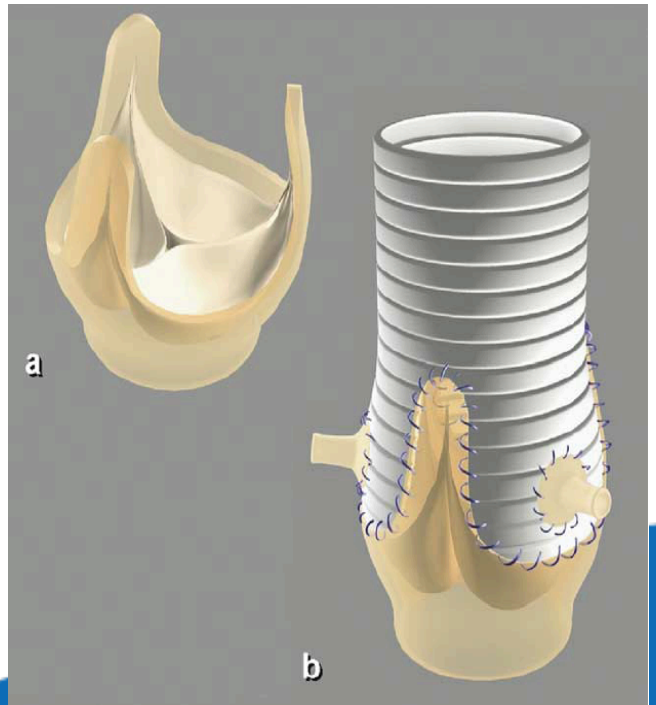
- Valve sparing Root repair
- Composite Valve graft (Bentall)

AV Sparing root repair

- Reimplantation (David procedure) during which the native valve is resuspended within the Dacron graft

- Remodelling (Yacoub procedure) in which the native valve is sutured to a sculpted Dacron graft





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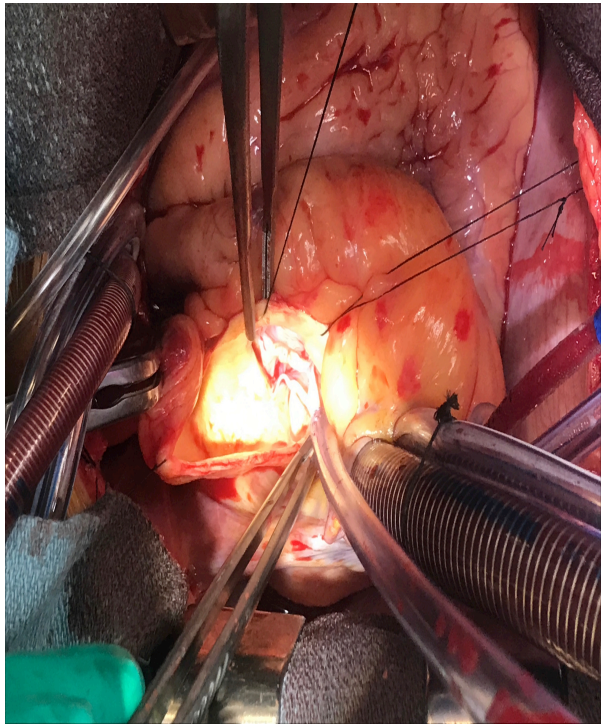
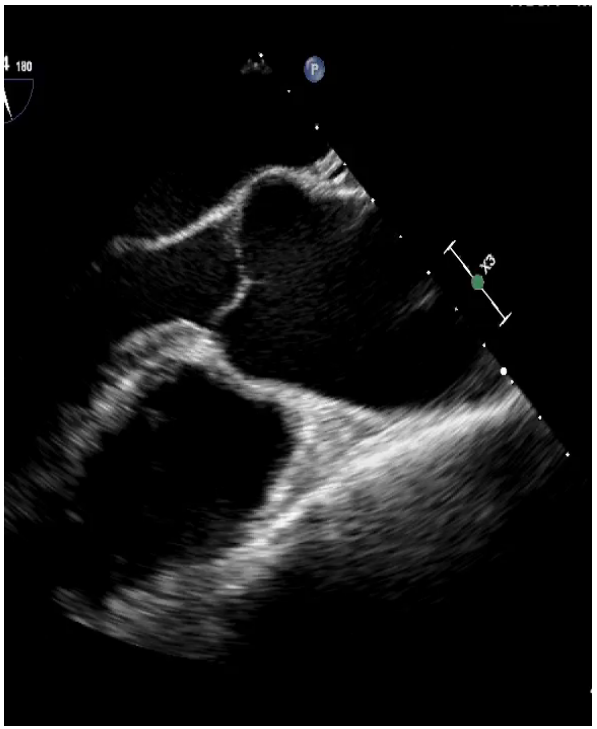
AV sparing root surgery

Single most important criterion for patient selection is morphological appearance of aortic valve.

Best done by visual inspection by the surgeon aided by Peri op TEE

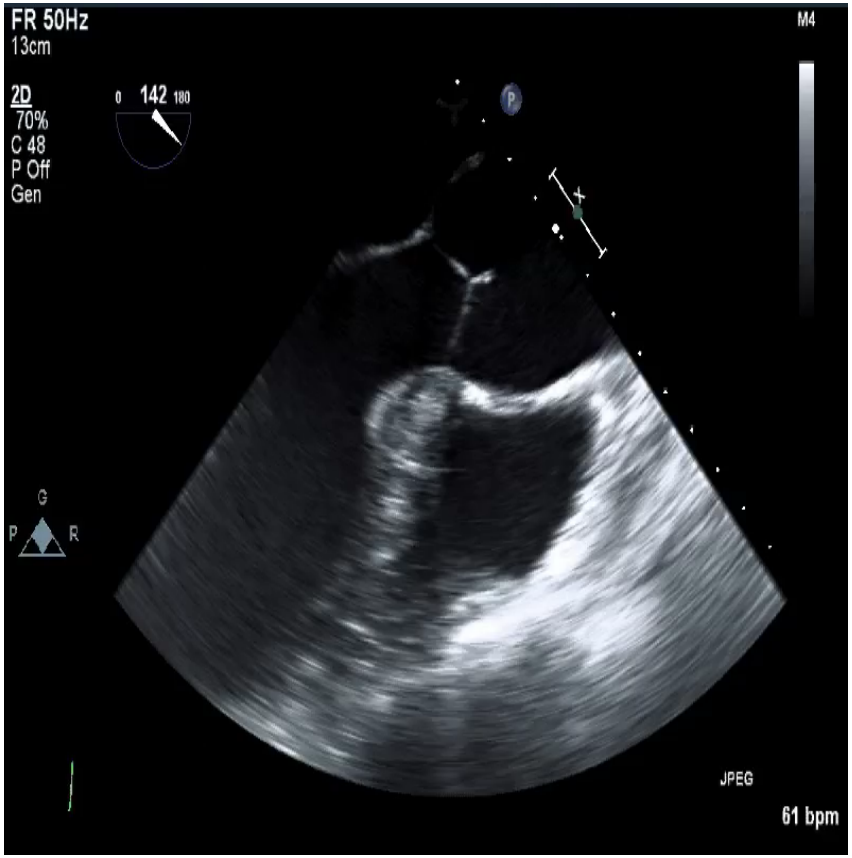


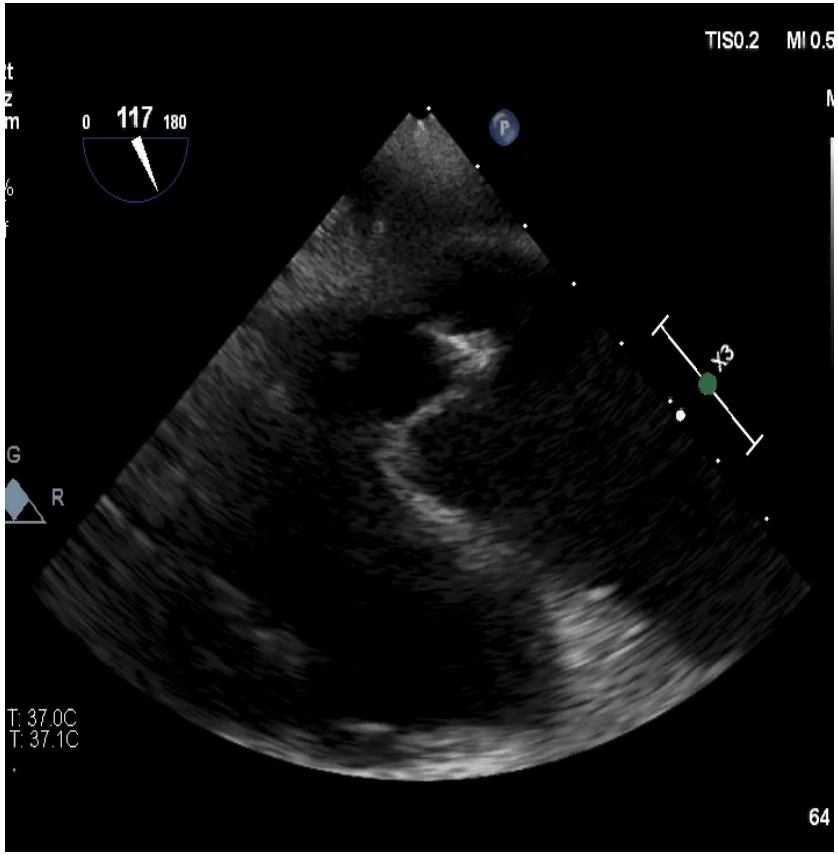


Pre CPB TEE

- Aortic cusp abnormalities
- Severity and direction of AI
- Root dimensions

Aortic cusp abnormalities





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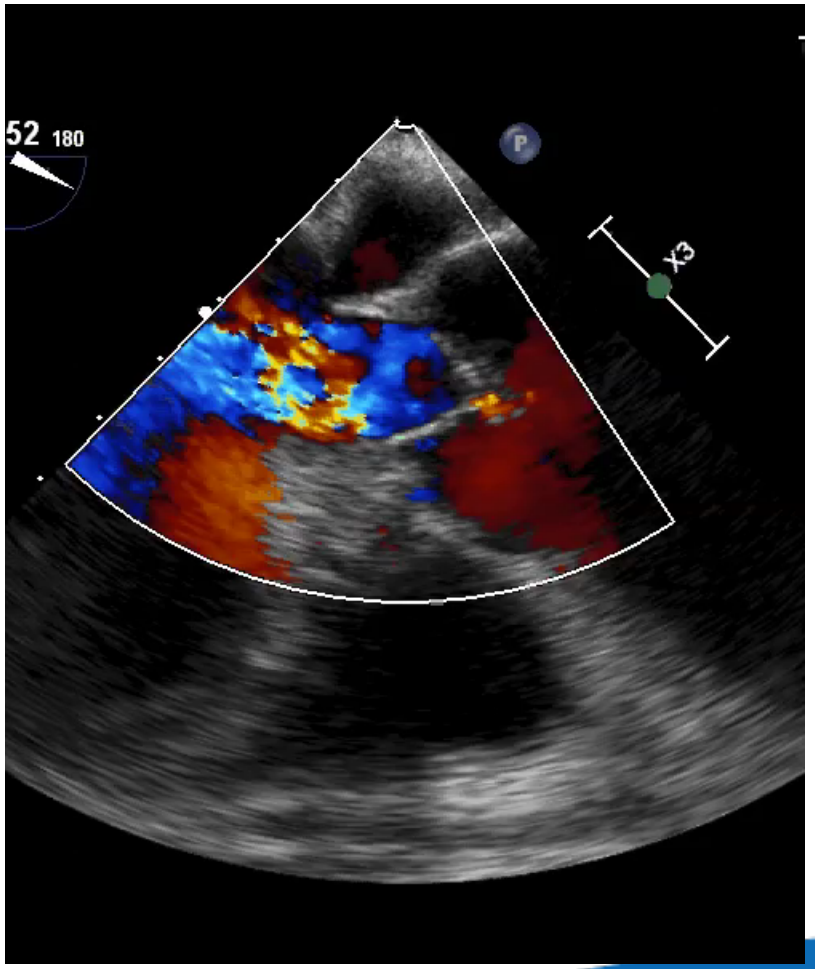
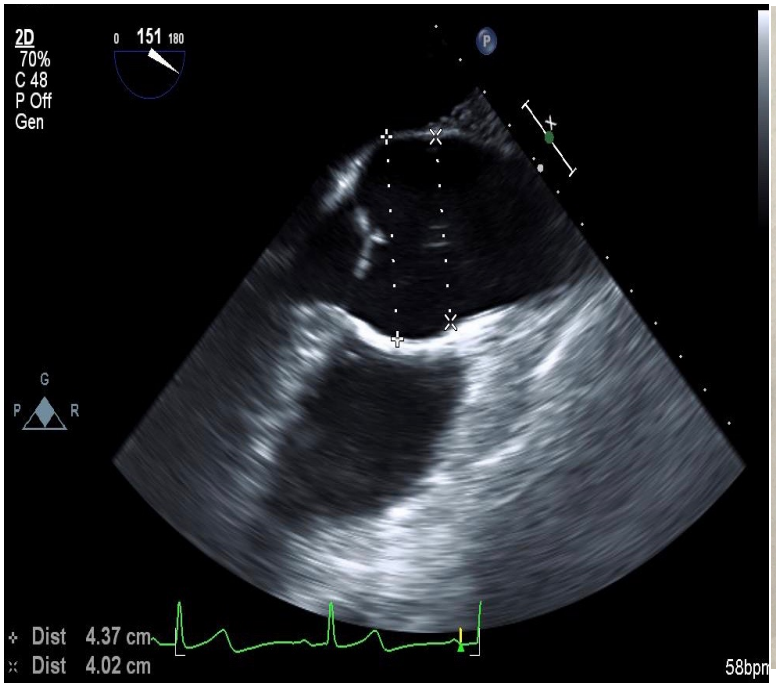
Assessing AI

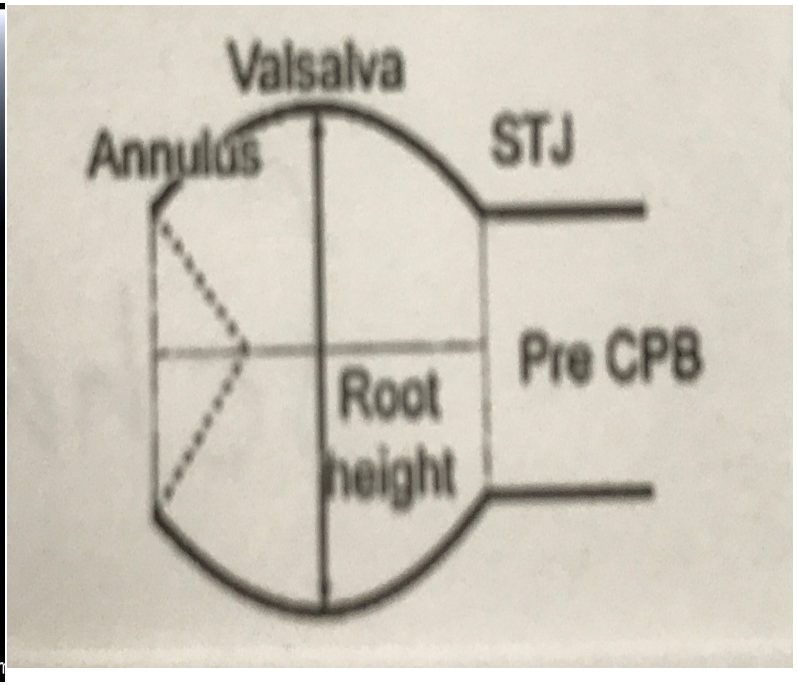
- Central AI jet results from symmetric dilatation of aortic root
- Eccentric jets imply additional cusp pathology further complicating valve sparing procedures



Root dimensions

- Dilated annulus > 28 mm requires aortic annuloplasty
- STJ may be severely dilated making it difficult to identify and measure





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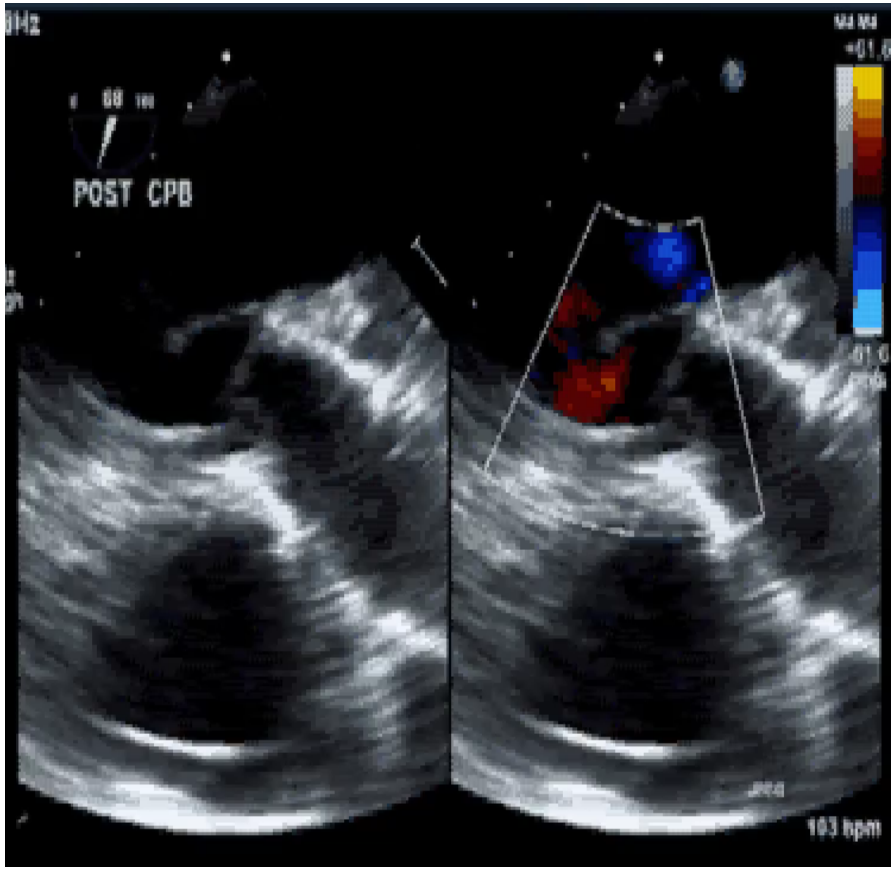
TEE assessment Post CPB

- Evaluation of cusp morphology and co aptation
- Residual AI
- Root dimensions
- LV function

TEE assessment post AV surgery



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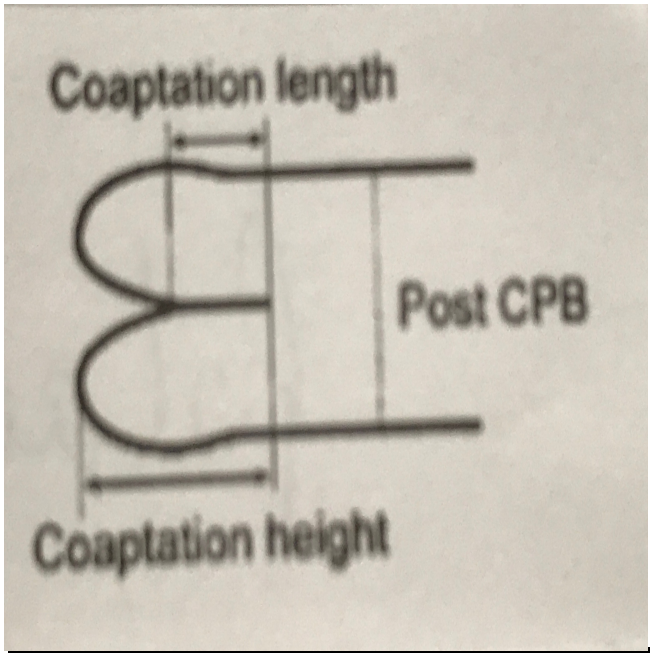
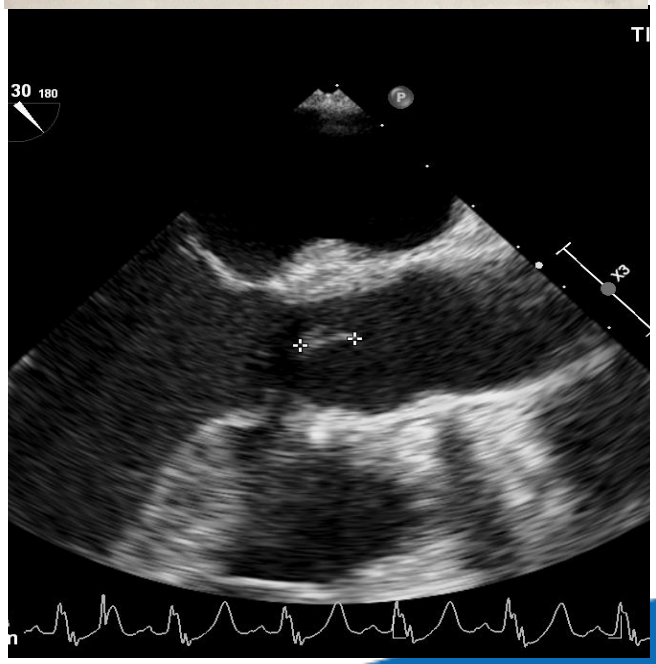
Successful repair

- Cusp coaptation length > 5mm
- Cusp coaptation height > 8-9 mm
- Mild or No AI





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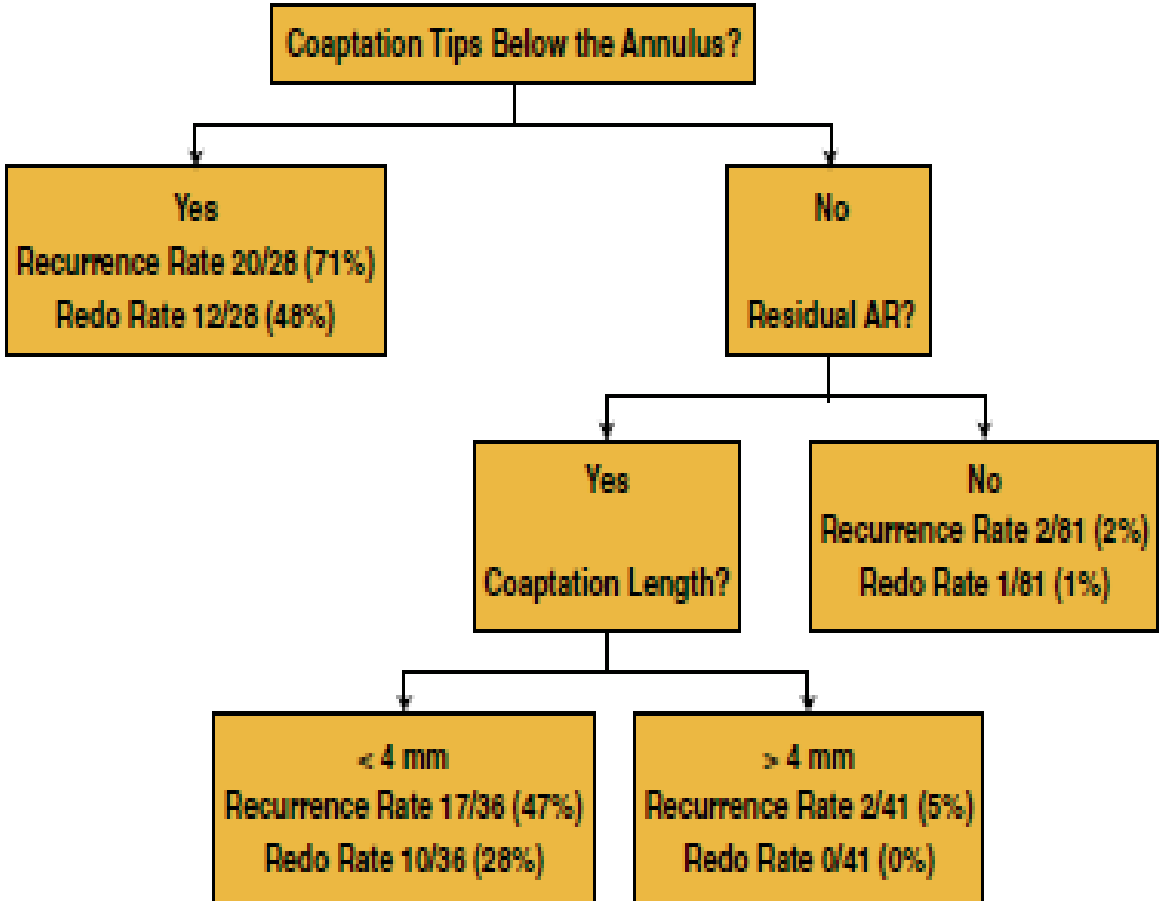

Polain de Waroux et al. JACC: CARDIOVASCULAR IMAGING, VOL. 2, NO . 8, 2009

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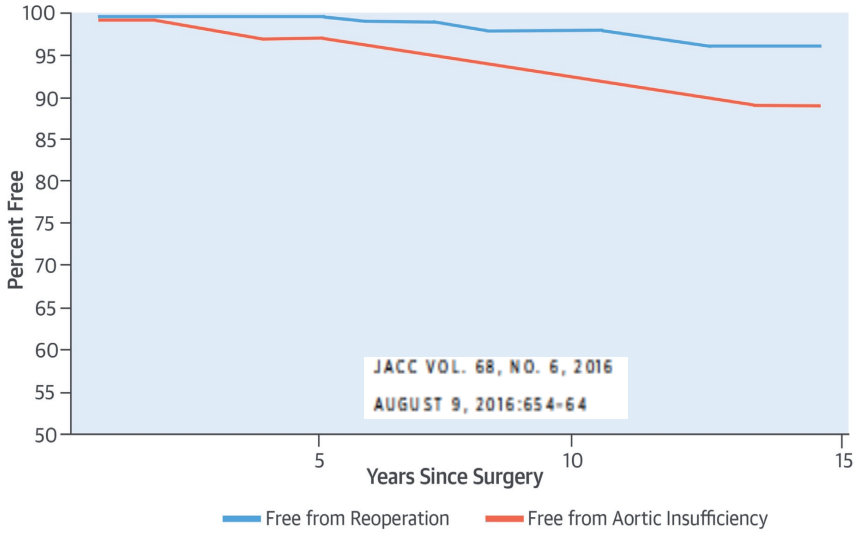
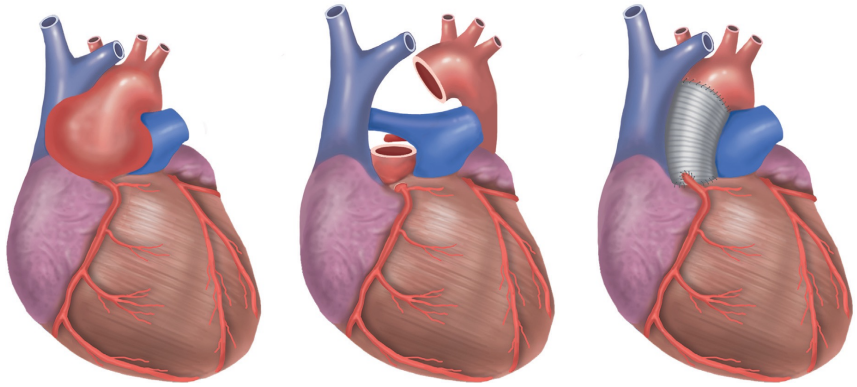
AV sparing (David procedure)





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Comparison data for AV repair techniques

TABLE 2 Freedom From Reoperation in the Aortic Valve and Freedom From Moderate or Severe Aortic Insufficiency After Aortic Valve-Sparing Operations

First Author (Ref. #)	n	Mean Age (yrs)	Marfan Syndrome	BAV	Mean Follow-Up (yrs)	Freedom From Adverse Events			
						Time	Reoperation	AI	No. at Risk
Reimplantation of the aortic valve									
David et al. (47)	296	46	36%	11%	6.9	5-yr	99.7%	98.3%	171
						10-yr	97.8%	92.9%	62
						15-yr	97.8%	89.4%	21
Liebrich et al. (48)	236	56	12%	15%	4.5			94%	78
						10-yr	87%	91%	3
Shrestha et al. (49)	126	57	21%	4%	10	5-yr	91%	N/A	97
						10-yr	86%	N/A	39
Kvitting et al. (50)	233	~38	40%	27%	4.7	5-yr	98%	97.4%	~99
						10-yr	92.2%	95.3%	18
De Paulis et al. (51)	124	53	17%	N/A	5.2	5-yr	95.4%	94.1%	56
						10-yr	90.1%	87.1%	23
Remodeling of the aortic root									
Yacoub et al. (52)	158	46	43%	N/A	5.5	5-yr	89%	N/A	N/A
						10-yr	89%	N/A	N/A
Aicher et al. (53)	193*	62	N/A	0	4.0			88%	63
						10-yr	95%	87%	5
	81†	52	N/A	100%	4.0	5-yr	97%	96%	36
						10-yr	97%	96%	1

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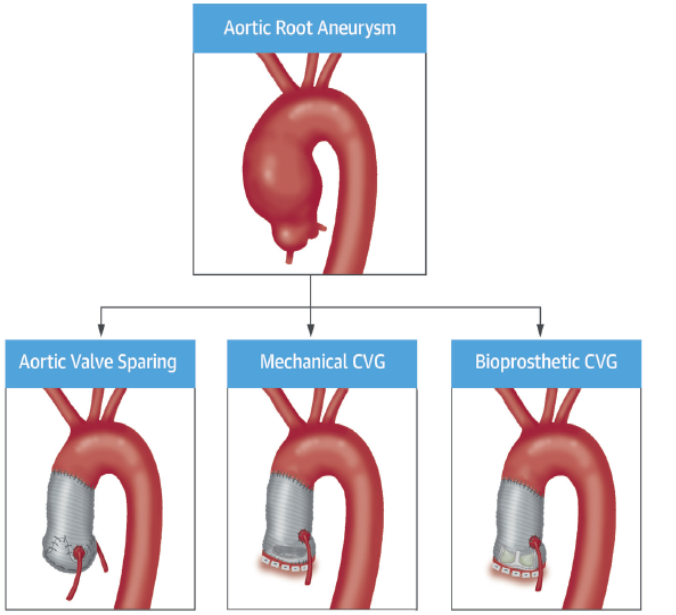
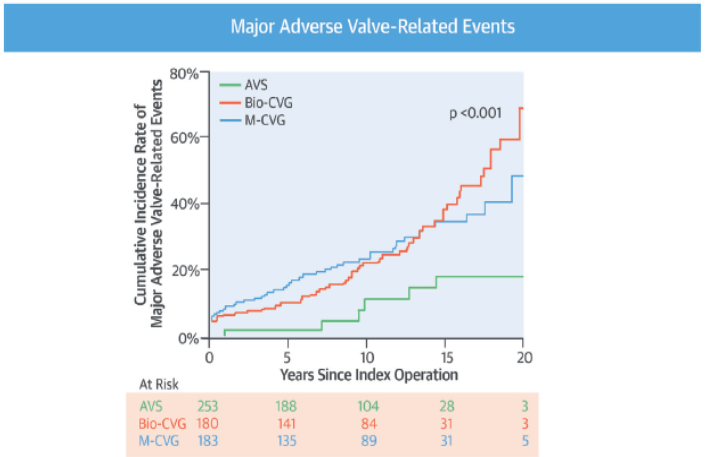
AUGUST 9, 2016:654-64

How does AV sparing compare with CVG

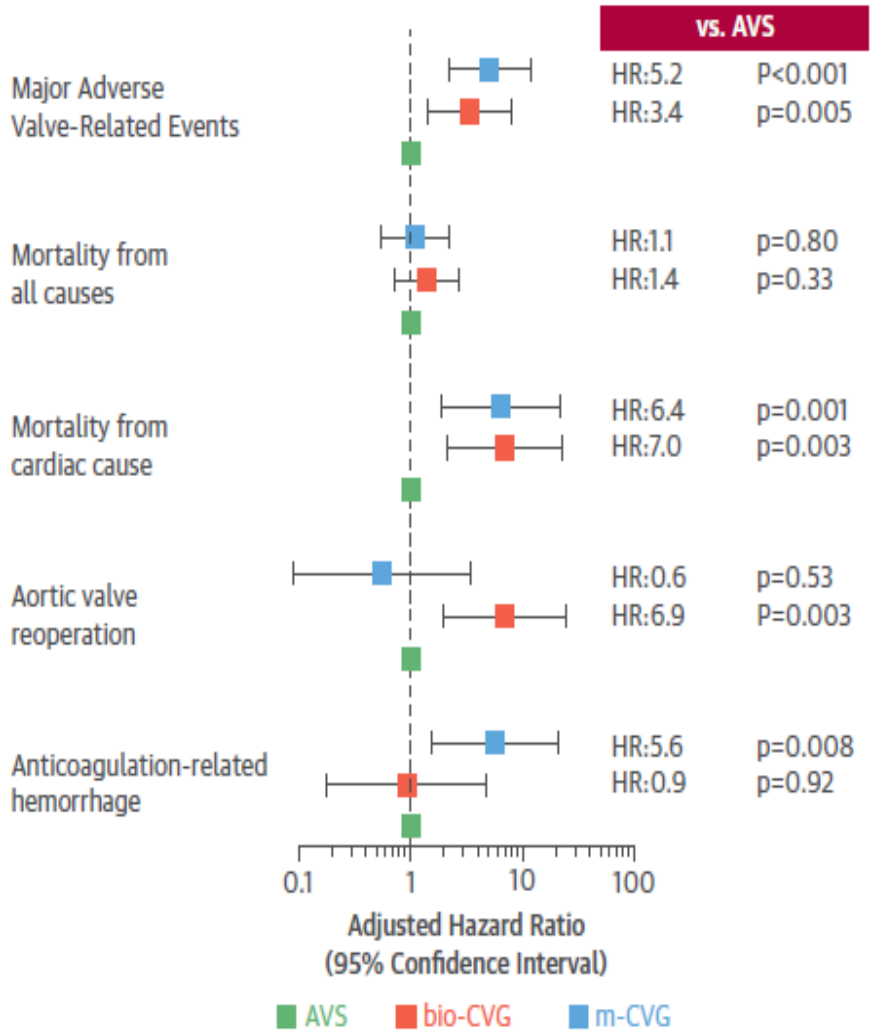
CENTRAL ILLUSTRATION Major Adverse Valve-Related Events After Aortic Root Replacement According to Surgical Strategy





Ouzounian, M. et al. J Am Coll Cardiol. 2016;68(17):1838-47.

FIGURE 5 Association Between Surgical Strategy and the Outcomes of Interest Following Multivariate Analysis

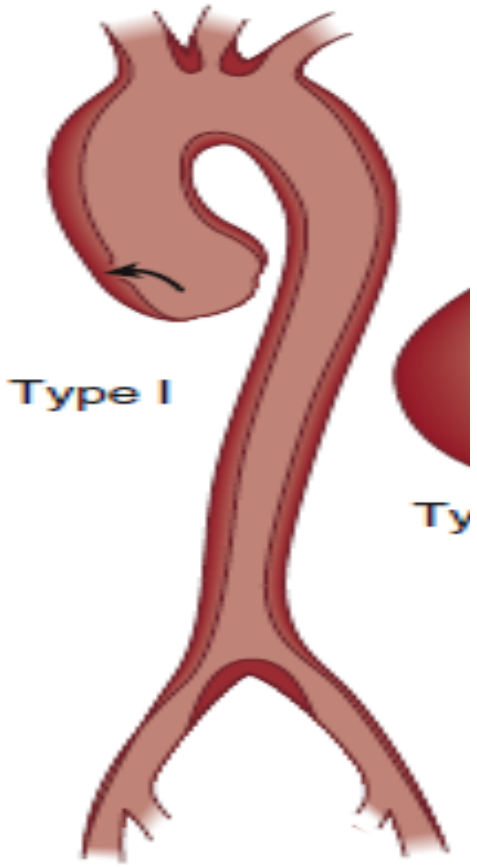


Summary

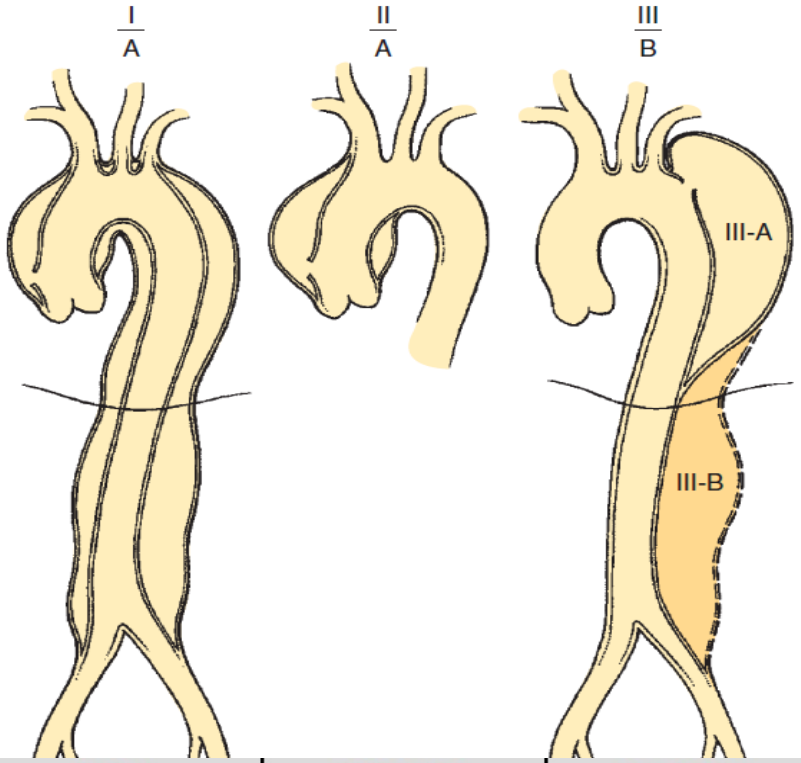
- Reimplantation technique - younger patients with aortic dilatation in the setting of genetic syndromes, and those with larger aortic annular (>28 mm) diameters.
- Remodeling - older patients whose aortic dilatation is not part of a genetic syndrome and whose aortic annulus is not dilated.
- With good patient selection, AV repair has shown excellent durability and a low risk of AI recurrence and reoperation over time

Acute Aortic Syndromes (AAS)

- Aortic dissection
- Aortic aneurysm rupture (contained or non contained)
- IMH (Intramural hematoma)
- PAU (Penetrating aortic ulcer)



Aortic Dissection



60%	10–15%	25–30%
DeBakey I	DeBakey II	DeBakey III
Stanford A (Proximal)		Stanford B (Distal)

Aortic dissection

- Acute ascending aortic dissection (Type A)
  - medical emergency
  - Initial 14-day mortality 50-75%
  - Risk of rupture increases by 1% per hour in first 24 hours of presentation
- Acute Type B dissections - Medically managed unless ischemic complications occur

Table 4 Comparison of five imaging modalities for diagnostic features of AAS

Diagnostic performance	CTA	TTE	TEE	MRA	Angiography
Sensitivity	+++	++	+++	+++	++
Specificity	+++	++	+++	+++	+++
Ability to detect IMH	+++	+	++	+++	–
Site of intimal tear	+++	–	++	+++	++
Presence of AR	–	+++	+++	++	+++
Coronary artery involvement	+	–	++	+	+++
Presence of pericardial effusion	++	+++	+++	++	–
Branch vessel involvement	++	–	+	++	+++

Table 5 Practical assessment of five imaging modalities in the evaluation of suspected AAS

Advantages of modality	CTA	TTE	TEE	MRA	Angiography
Readily available	+++	+++	++	+	+
Quickly performed	+++	+++	++	+	+
Performed at bedside	–	+++	+++	–	–
Noninvasive	+++	+++	+	+++	–
No iodinated contrast	–	+++	+++	+++	–
No ionizing radiation	–	+++	+++	+++	–
Cost	++	+	++	++	+++

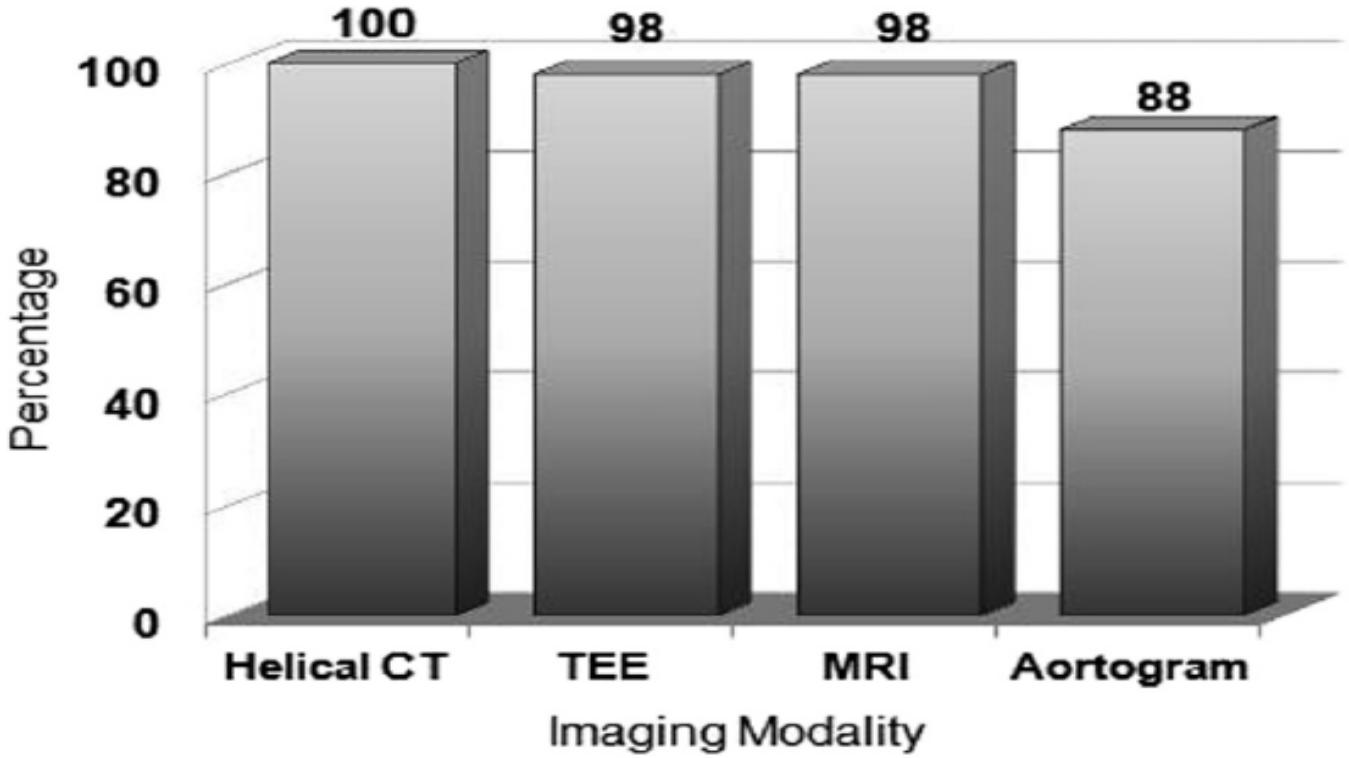


Figure 23 Sensitivity of imaging modalities in evaluating suspected aortic dissection in a meta-analysis of 1,139 patients. © Massachusetts General Hospital Thoracic Aortic Center; reproduced with permission.

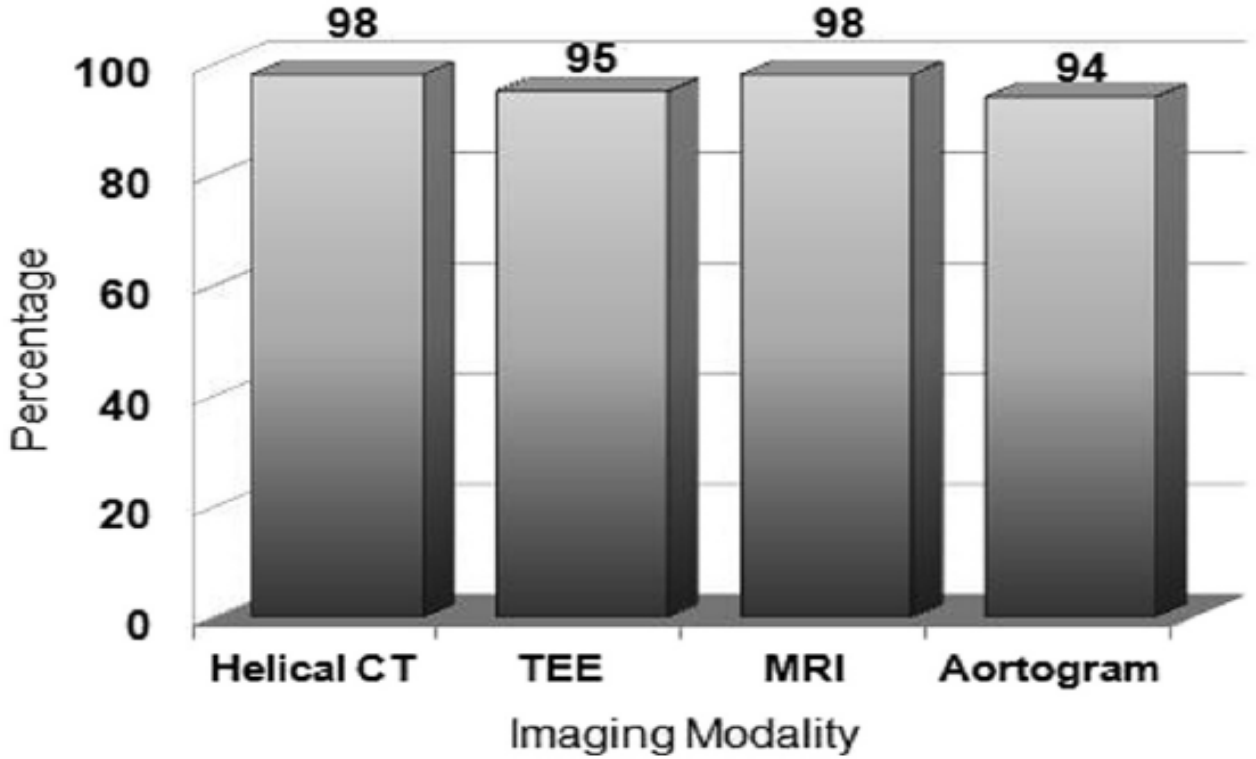


Figure 24 Specificity of imaging modalities in evaluating suspected aortic dissection in a meta-analysis of 1,139 patients. © Massachusetts General Hospital Thoracic Aortic Center; reproduced with permission.

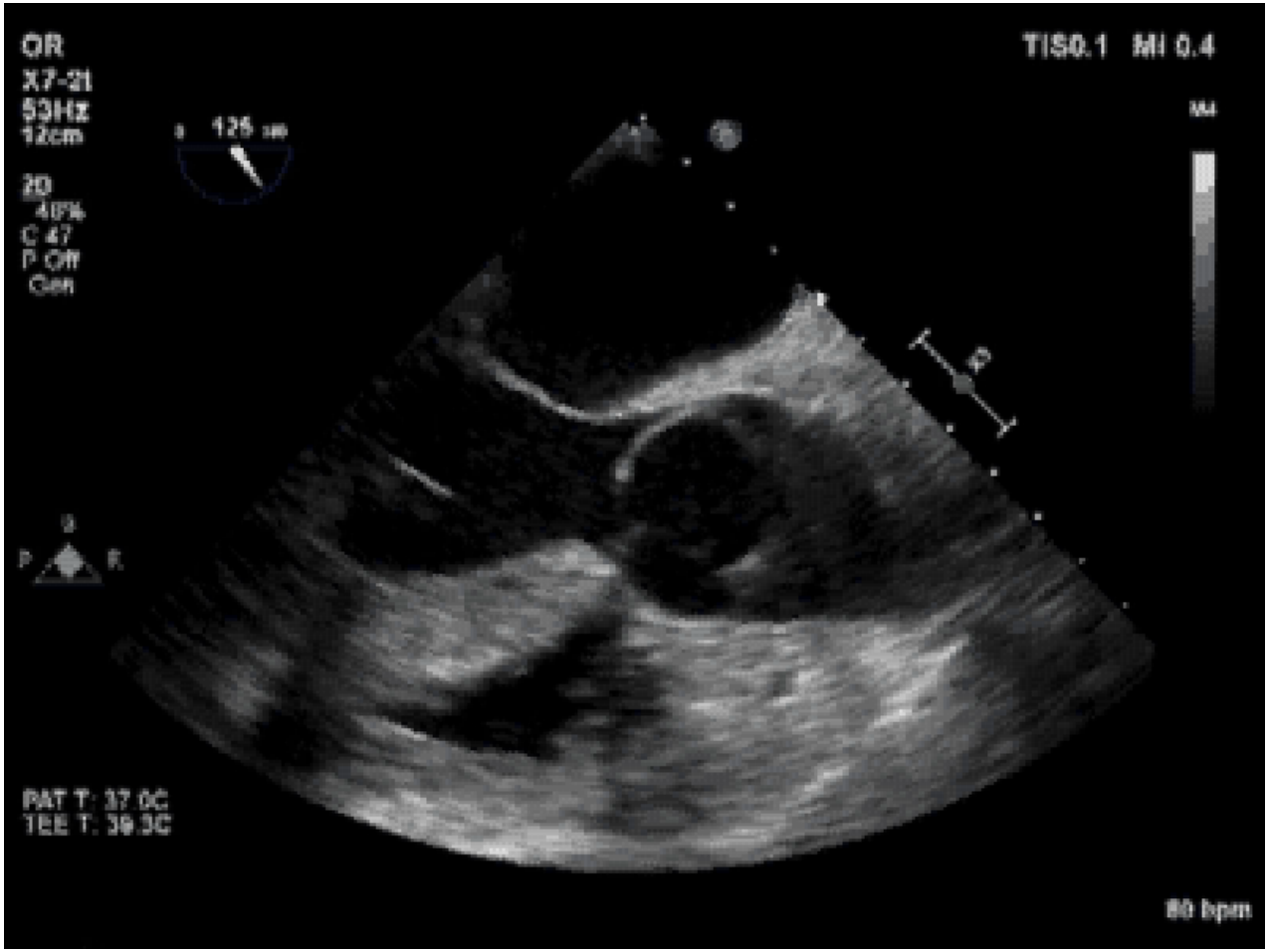


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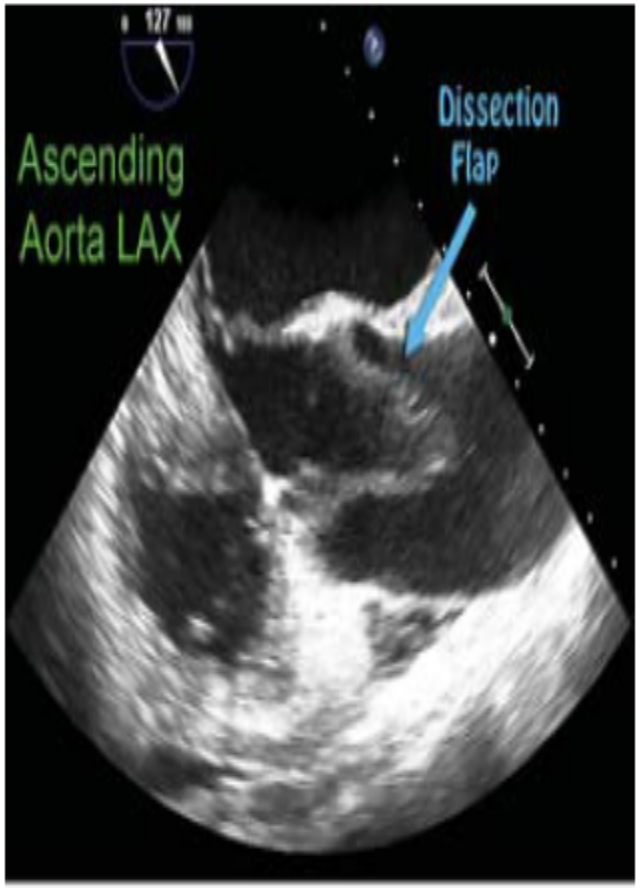
TABLE 17.1 Role of Intraoperative TEE in Acute Ascending Aortic Dissection

(1) Confirm the diagnosis	• Visualize the intimal flap in two separate imaging planes • Determine the proximal extent of the flap
(2) Identify the entry points	• Color flow Doppler to see flow from true to false lumen • There may be multiple tears
(3) Determine coronary involvement	• Look for flap extending into aortic root and coronary ostia • Look for regional wall motion abnormalities • Assess ventricular function
(4) Assess aortic valve	• Grade severity of any aortic regurgitation • Determine if aortic valve may be repairable
(5) Look for effusions	• Pericardial and pleural effusions are common
(6) Rule out additional cardiac pathology	• Preoperative workup is often minimal due to the urgency of the surgery—a complete examination is essential



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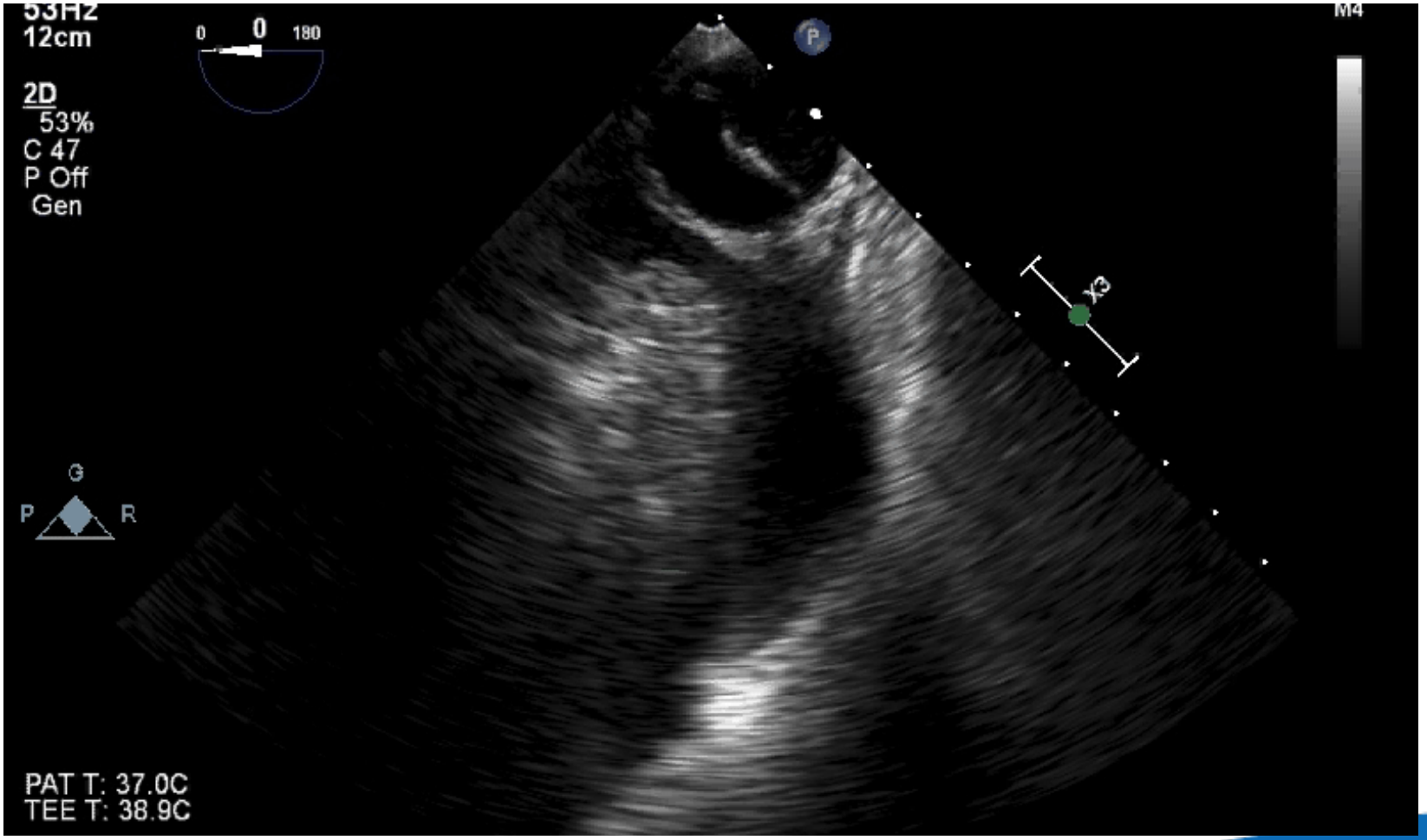
True lumen vs False lumen

- True lumen
  - expands during systole
  - Diastolic collapse
  - Forward systolic flow
  - Absence of SEC/ thrombus
- False lumen
  - Often larger
  - Diastolic diameter increases
  - May have SEC/ Thrombus
  - Reverse/ delayed or absent flow



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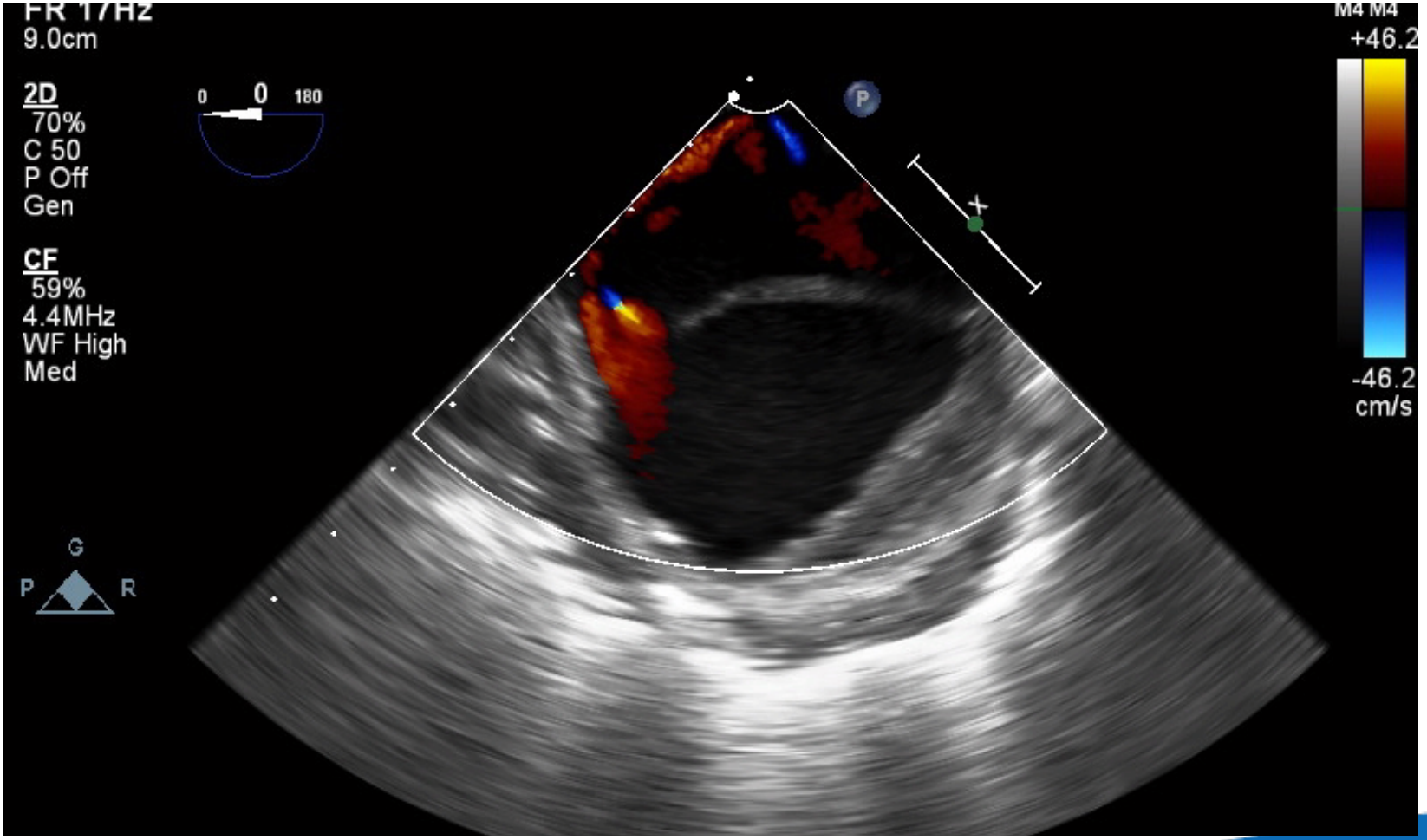

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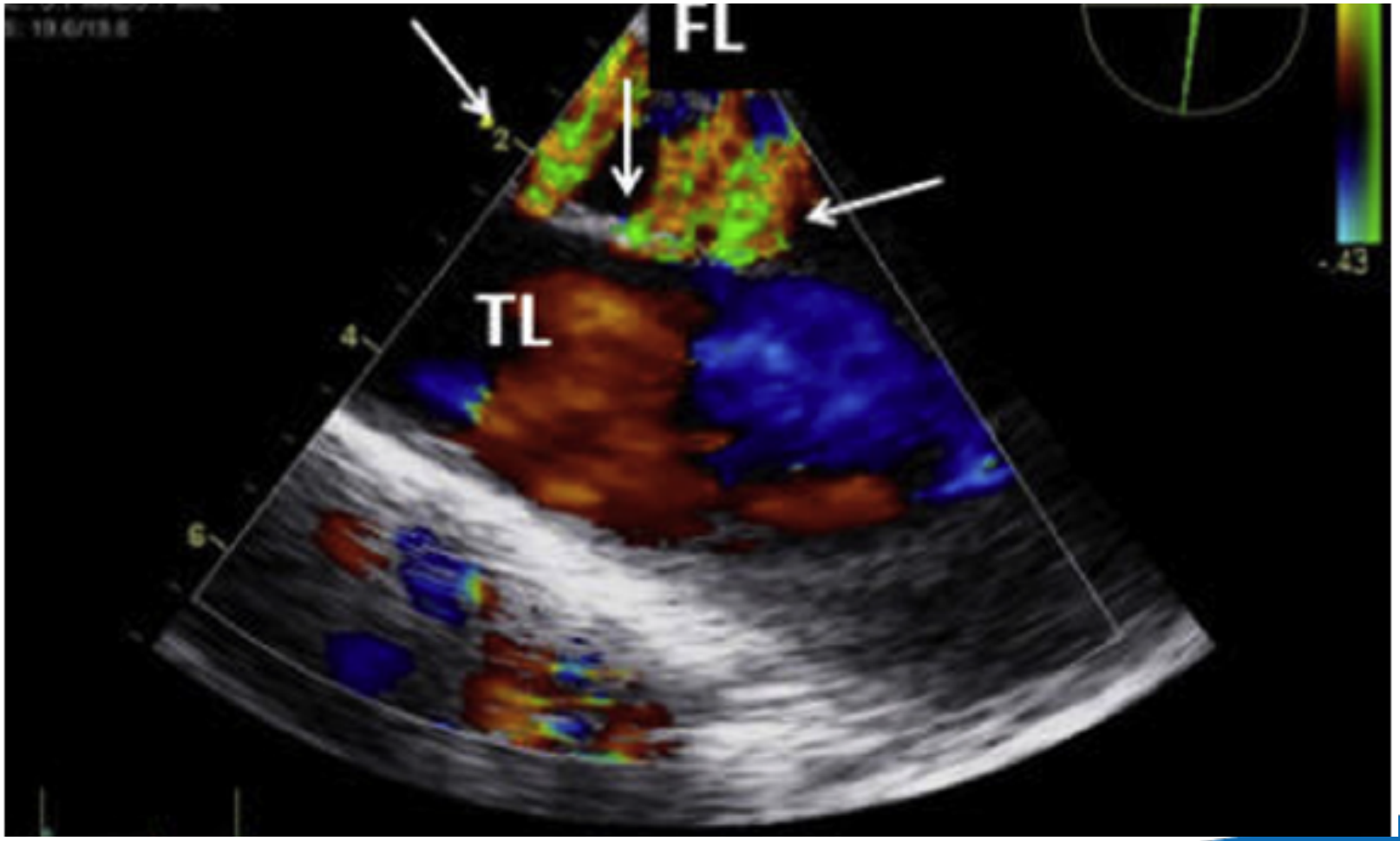

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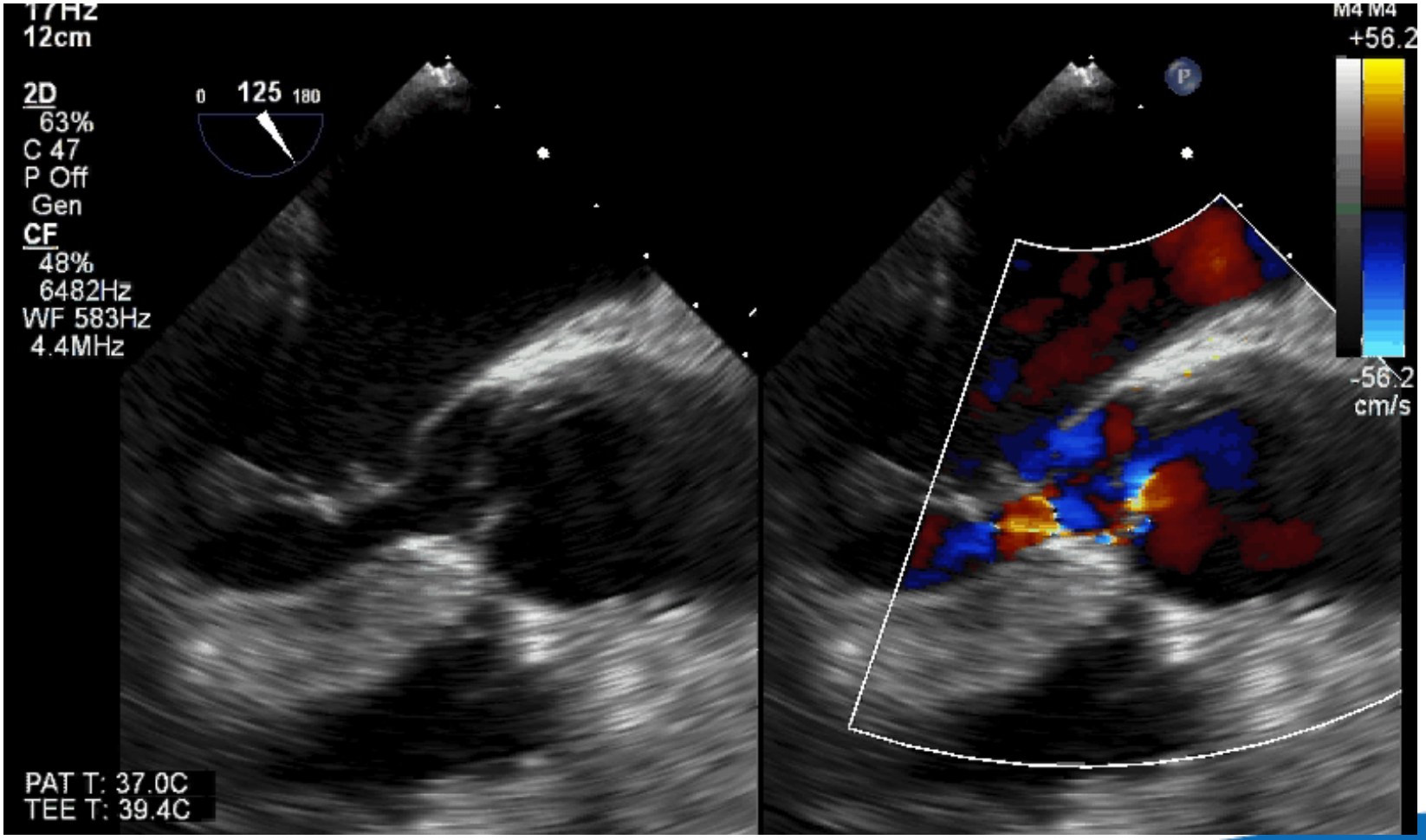
Table 8 Mechanisms of AR in type A aortic dissection

1. Dilatation of the aortic root leading to incomplete aortic leaflet coaptation
2. Cusp prolapse (asymmetric dissection depressing cusp[s] below annulus)
3. Disruption of aortic annular support resulting in flail leaflet
4. Invagination/prolapse of dissection flap through the aortic valve in diastole
5. Preexisting aortic valve disease (e.g., bicuspid valve)



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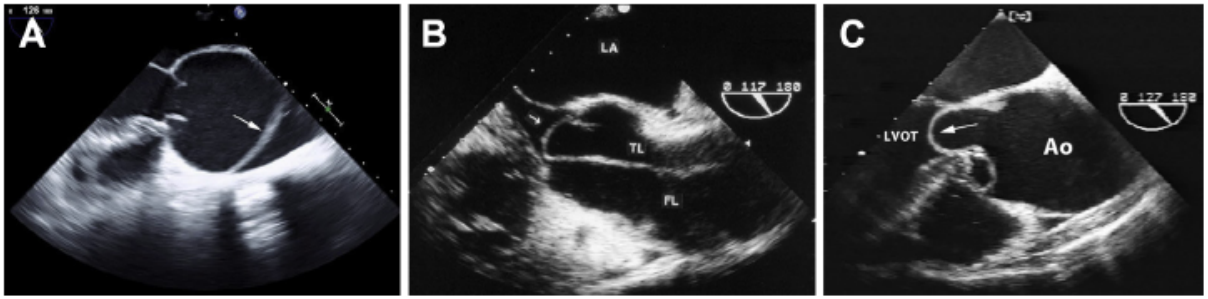
Mechanisms of AI in Type A dissection



Malcoaptation | Cusp prolapse | Dissection flap extending into LVOT

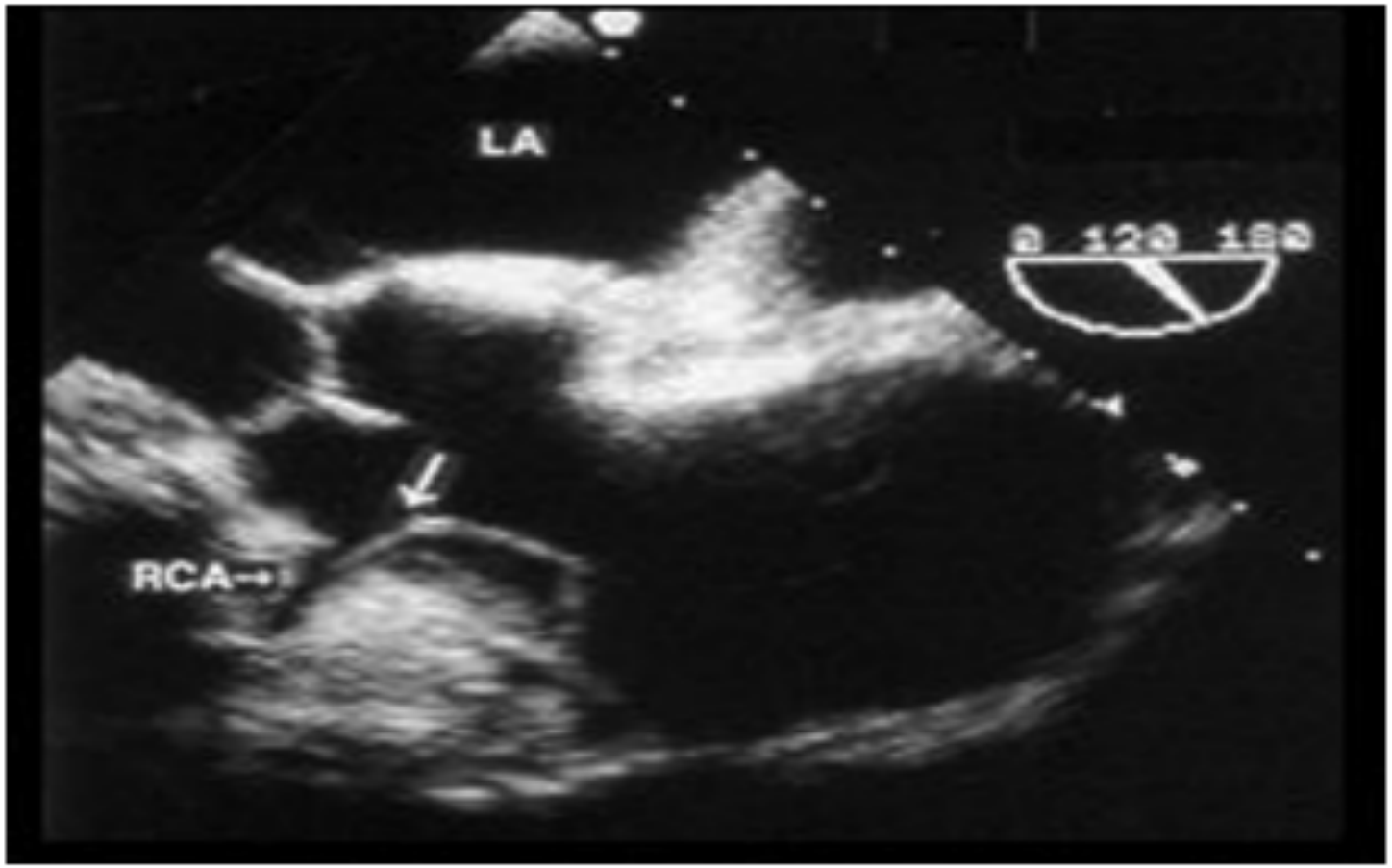


Figure 37 Transesophageal echocardiogram from a patient with type A aortic dissection that illustrates the dissection flap (*arrow*) entering the ostium of the right coronary artery (RCA). *LA*, Left atrium.

Question

- Which of the following is true regarding the true lumen (please choose all correct option/s)

A. May have reversed/ delayed or absent flow
B. Diastolic collapse
C. Often larger
D. Systolic expansion
E. Diastolic expansion

Question

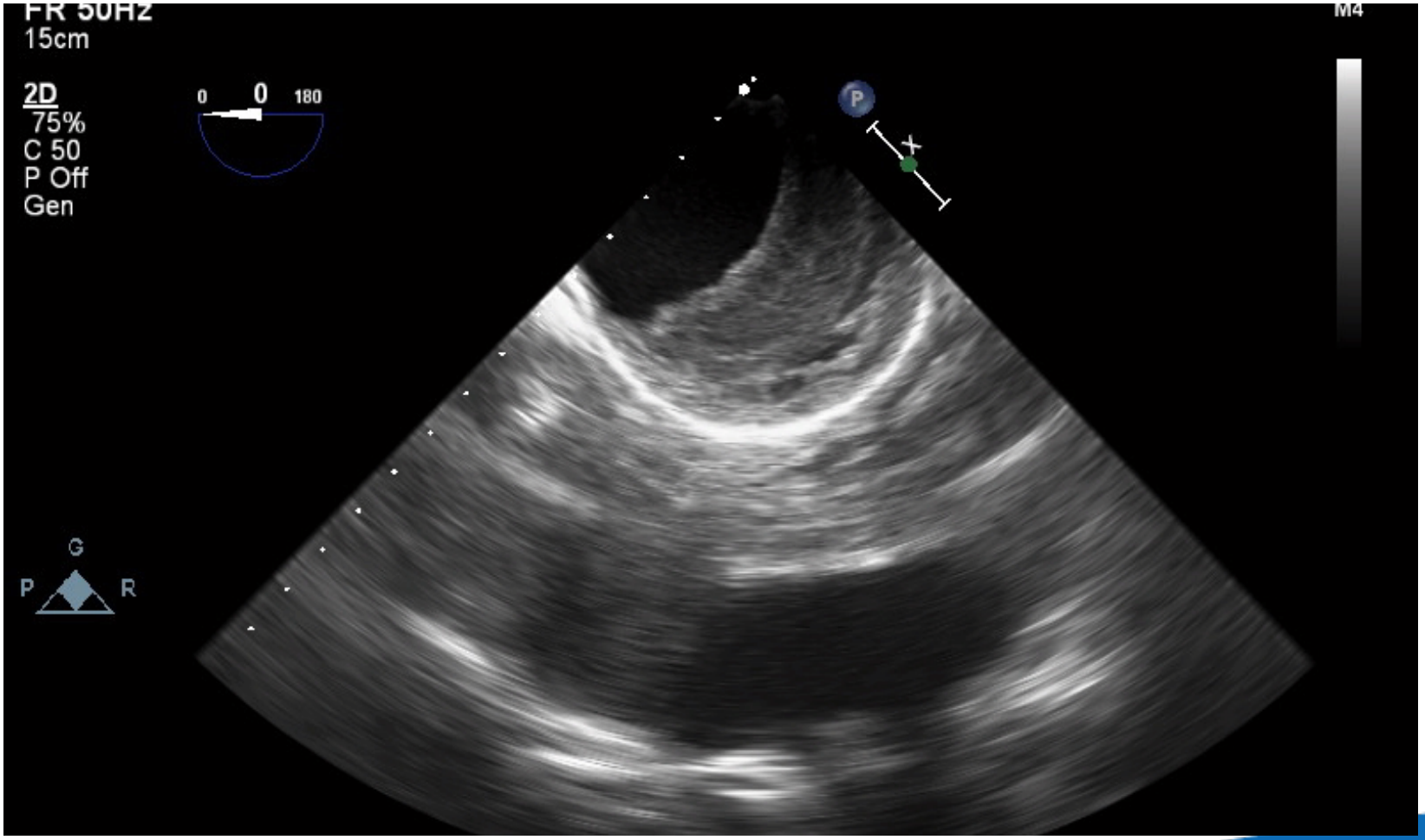
- Which of the following is true regarding the true lumen (please choose all correct option/s)

A. May have reversed/ delayed or absent flow
B. **Diastolic collapse**
C. Often larger
D. **Systolic expansion**
E. Diastolic expansion

Intramural Hematoma

- Variant of aortic dissection
- Accounts for 10% - 25% of AAS
- Underlying cause – rupture of vasa vasorum in the medial layer
- Blood accumulates in the medial layer
- May progress to intimal fracture, classic aortic dissection or frank aortic rupture
- Thickening of aortic wall > 0.5 cm
- Prognosis & classification (Stanford)similar to aortic dissection
- Type A is surgical emergency

IMH



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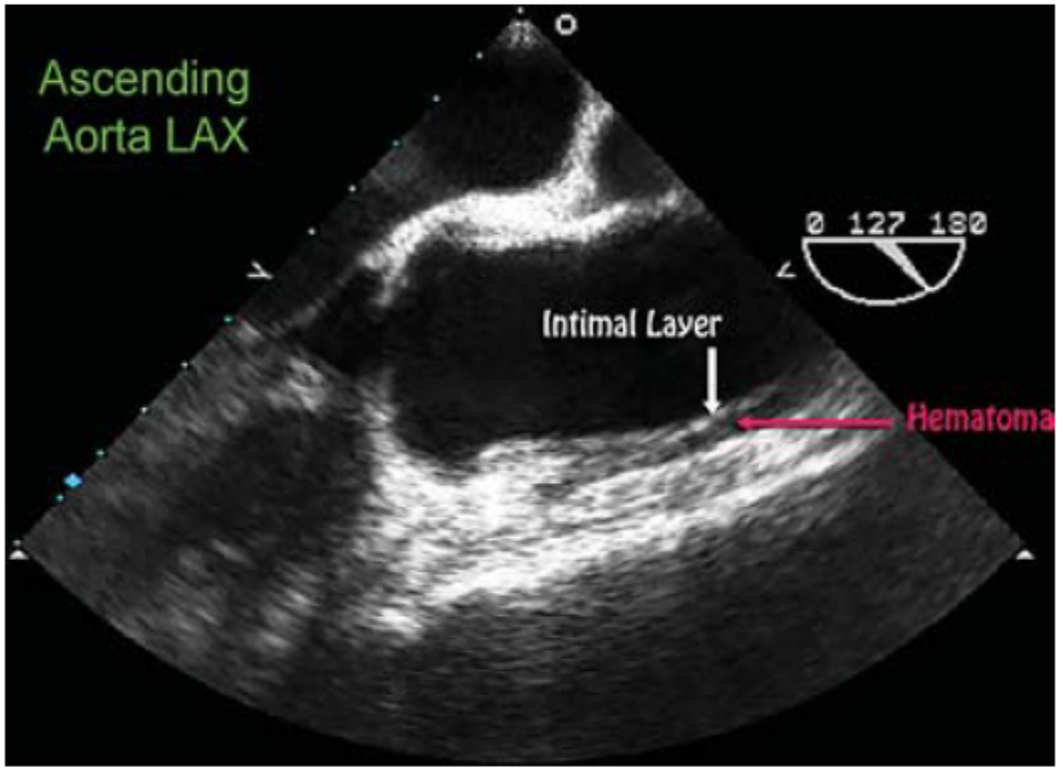
IMH



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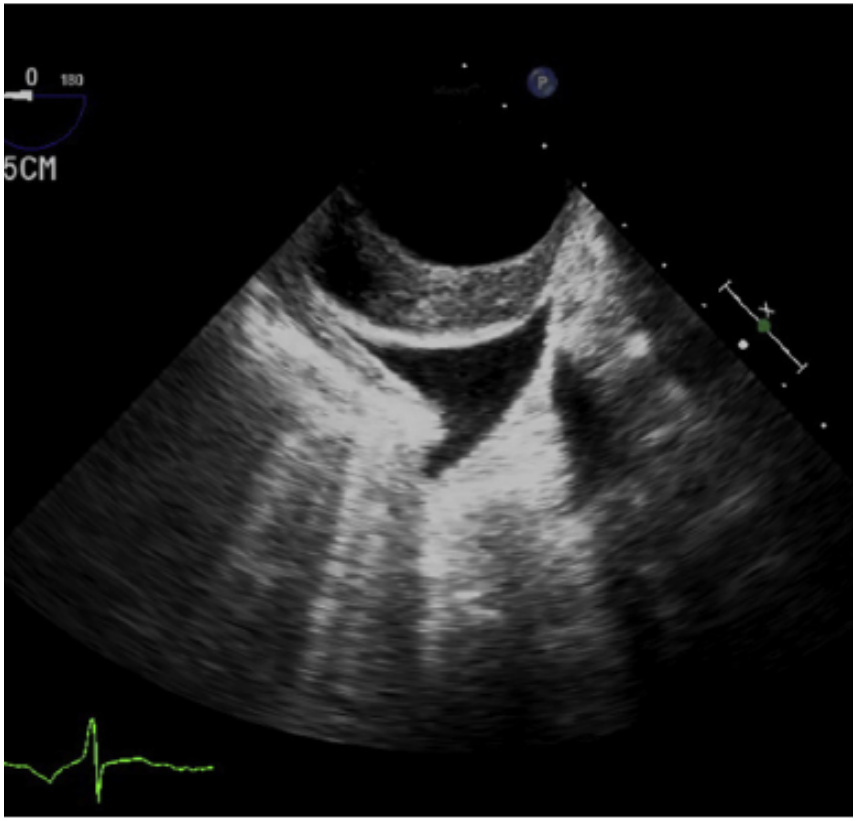
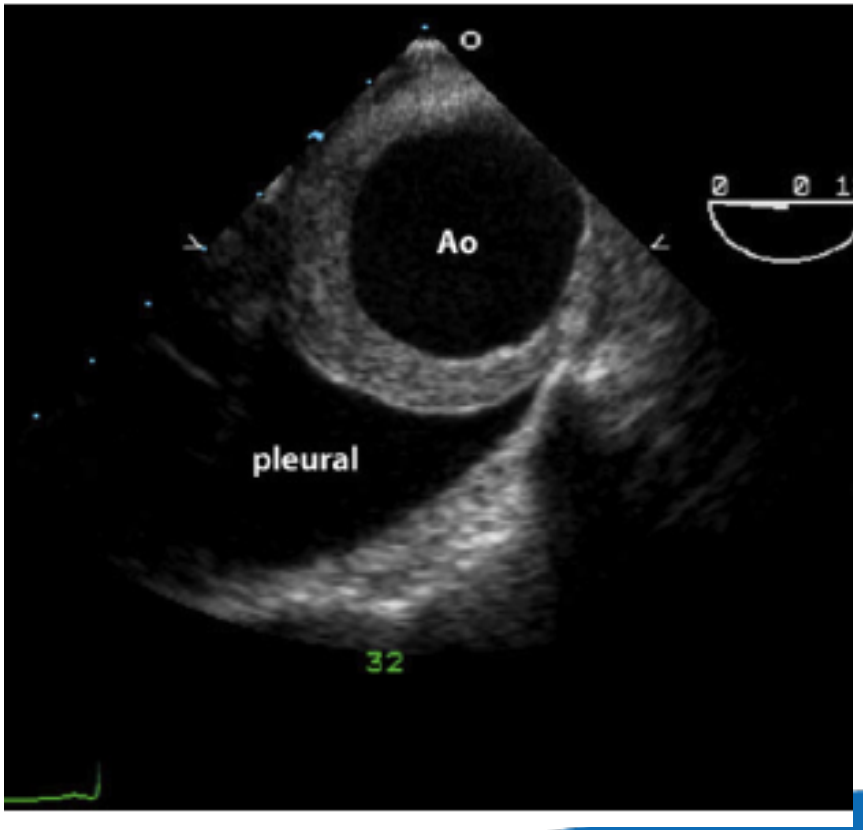
IMH

Crescentic



Concentric



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IMH (Evolution patterns)

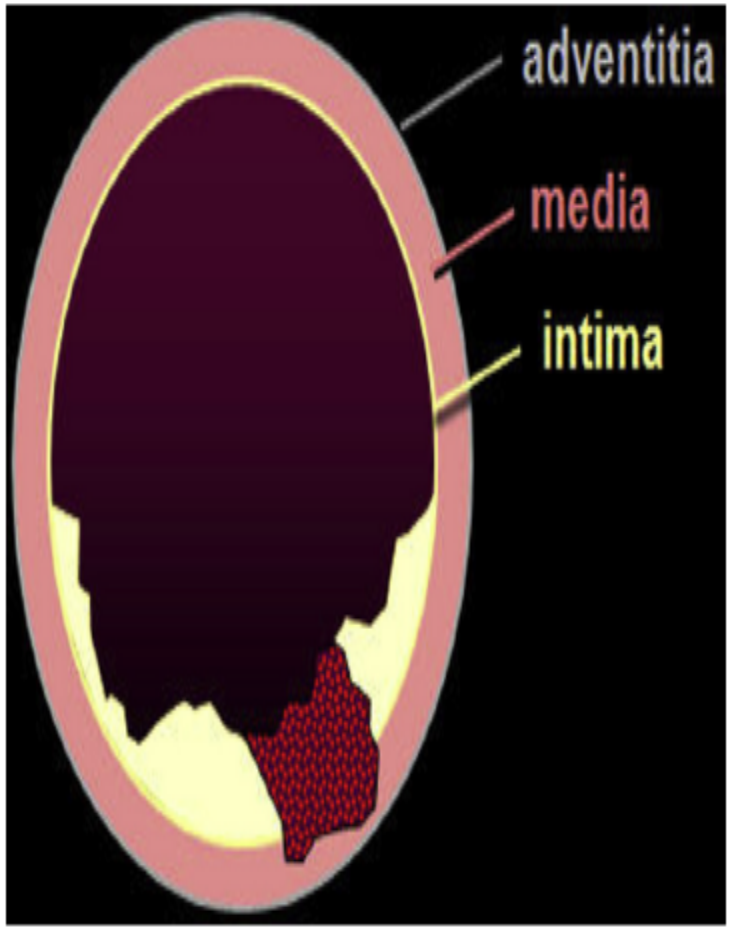
- Regression(34%)
- Classic dissection with longitudinal propagation (12%)
- Localised dissection
- Fusiform aneurysm
- Saccular aneurysm

20%

- Pseudoaneurysm formation (24%)
- Persistence of IMH

Penetrating Atherosclerotic/ Aortic Ulcer (PAU)

- Least common of AAS
- Ulceration of atherosclerotic lesion penetrates into the aortic media
- Most often in mid and distal DTA



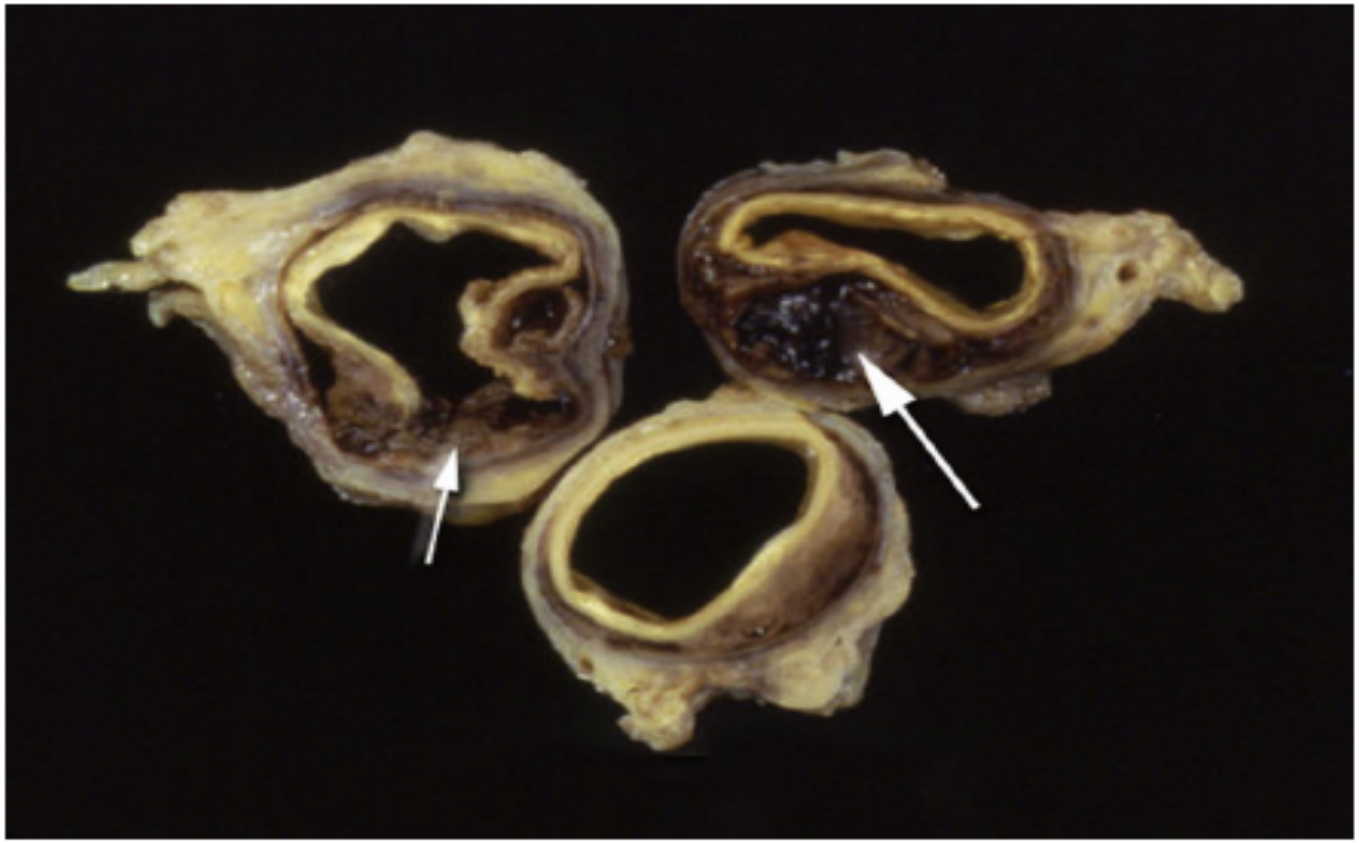


Figure 44 Gross pathology specimen from a patient with a ruptured penetrating atherosclerotic ulcer (*small arrow*) associated with IMH and blood external to the aortic wall (*large arrow*).

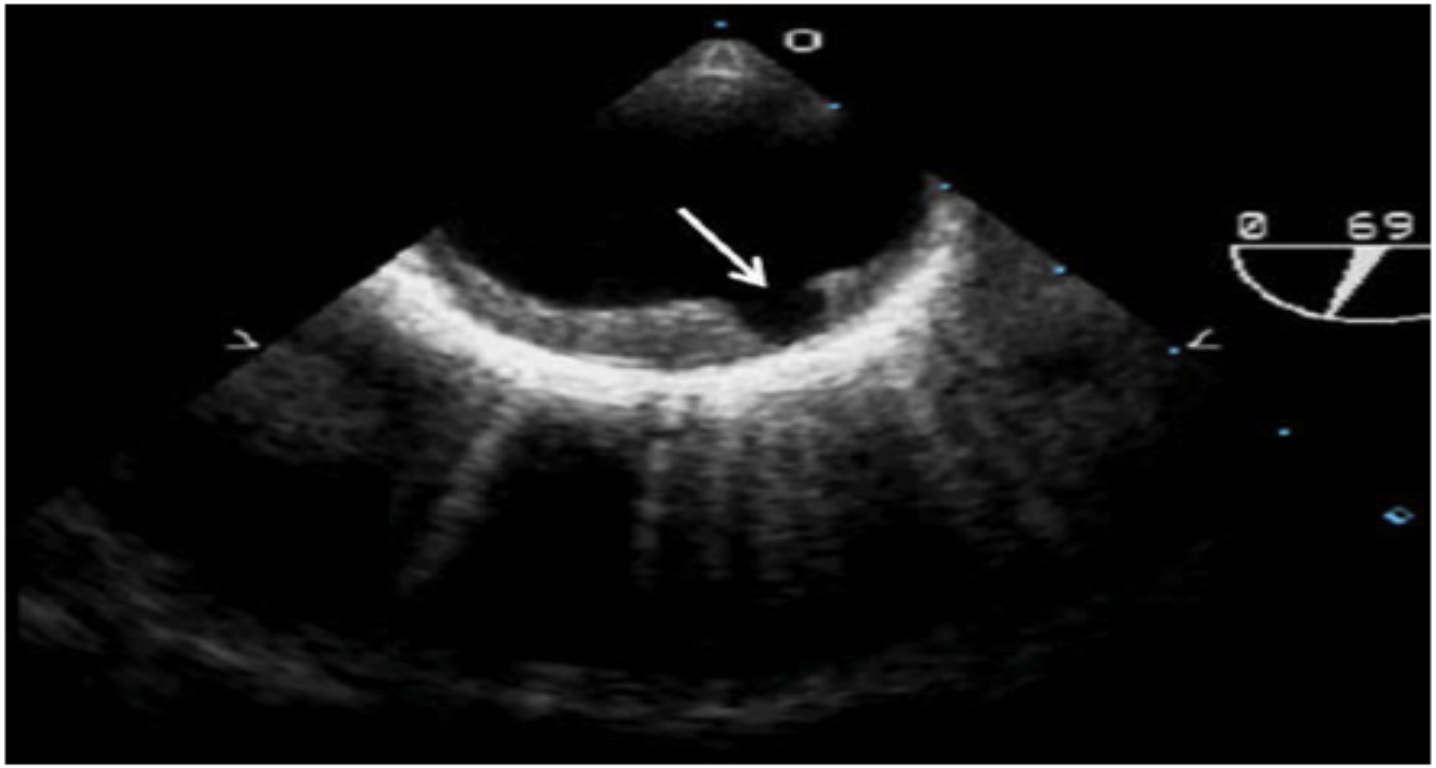


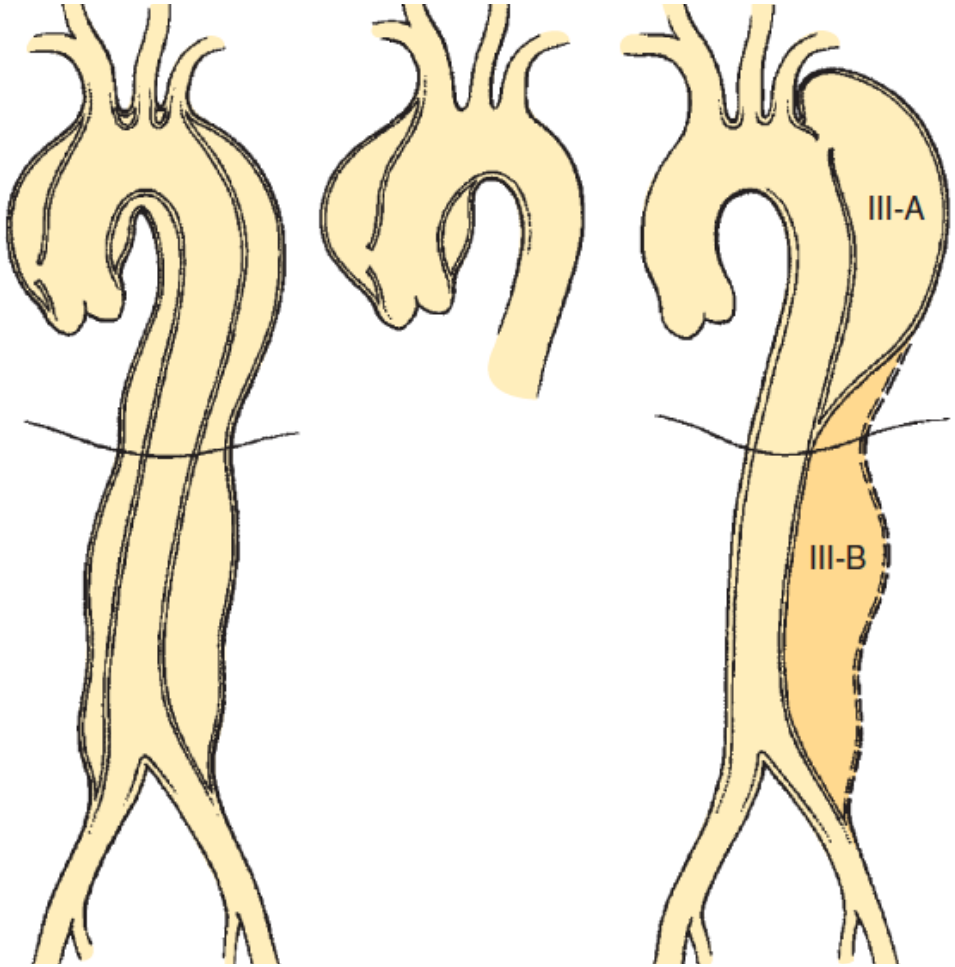
Figure 45 Transesophageal echocardiogram from a patient with a penetrating atherosclerotic ulcer (*arrow*). Note the prominent aortic atheroma (not labeled).

Table 13 PAUs: imaging parameters to report
Lesion Location
Lesion width, length, depth
Aortic diameter at the level of the lesion
Presence/absence/extent of IMH
Contrast extension beyond/outside aortic wall
Mediastinal hematoma
Pleural effusion
Presence and length of false lumen

PAUs

- May progress to
  - True aneurysm
  - Pseudoaneurysm
  - Rupture into mediastinum or pleural cavity (rare)
  - Embolization

Type B dissection



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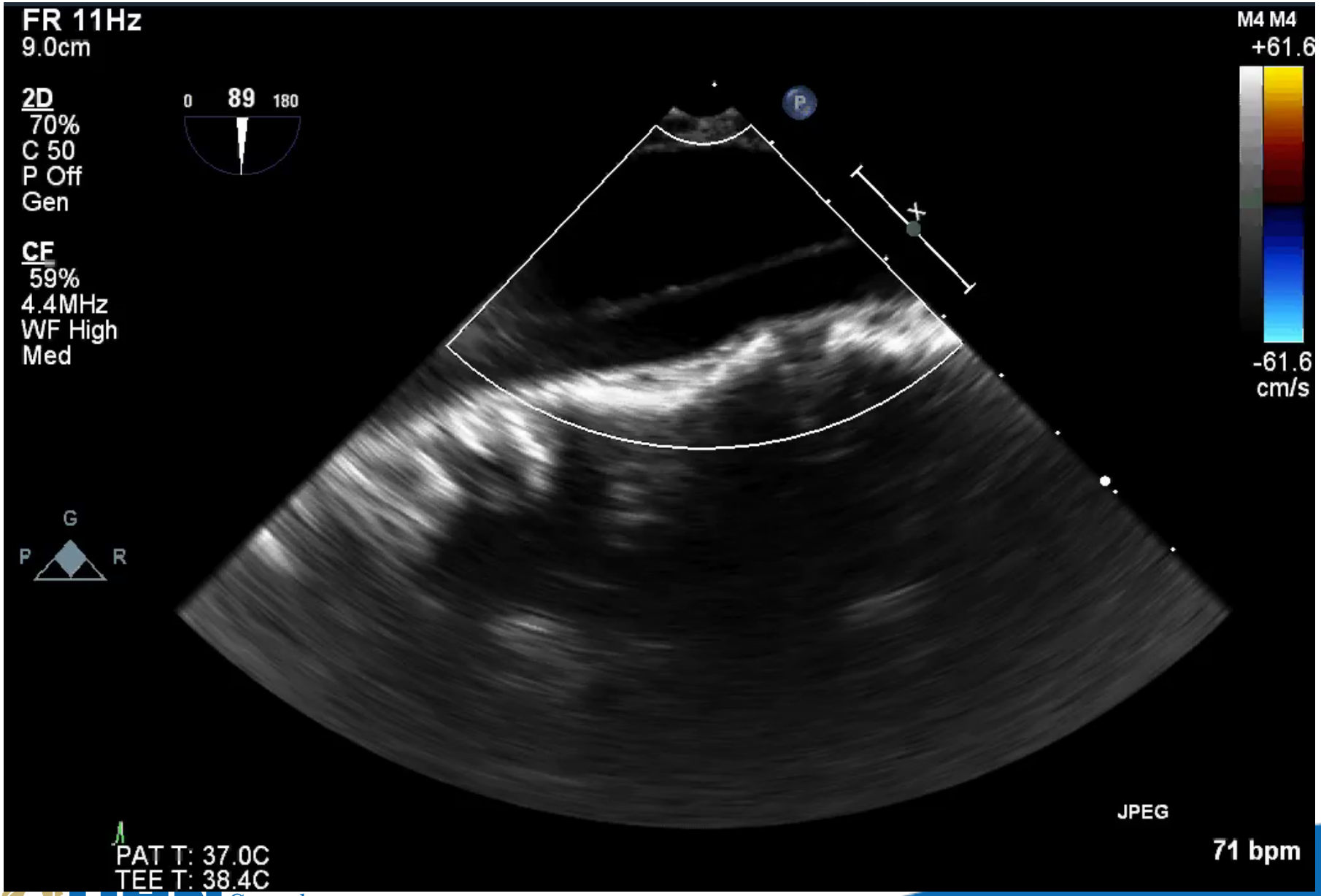
TEE for TEVAR in type B Dissection

- Confirm correct guidewire placement in true lumen
- TEE can rule out plaques at proximal neck and prevent endoleak.
- For assessing retrograde Type A dissection during the procedure
- Useful with Dacron graft but not with PTFE or Gore-tex prosthesis


FR 11Hz
9.0cm
2D
70%
C 50
P Off
Gen
0
89
180
CF
59%
4.4MHz
WF High
Med
G
P
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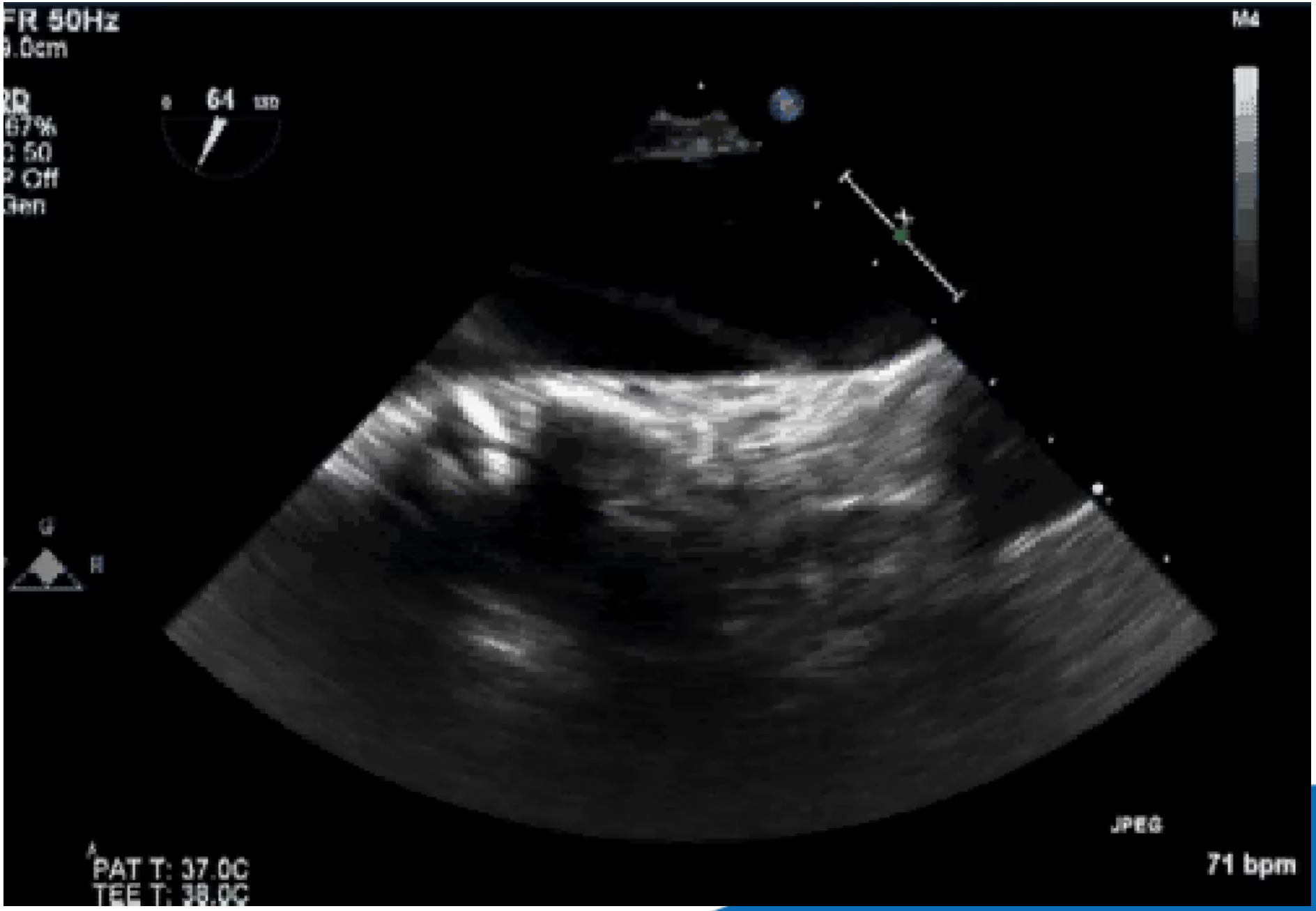
M4 M4
+61.6
-61.6
cm/s
JPEG
71 bpm
PAT T: 37.0C
TEE T: 38.4C


FR 50Hz
M4
64
JPEG
PAT T: 37.0C
71 bpm

Endoleaks

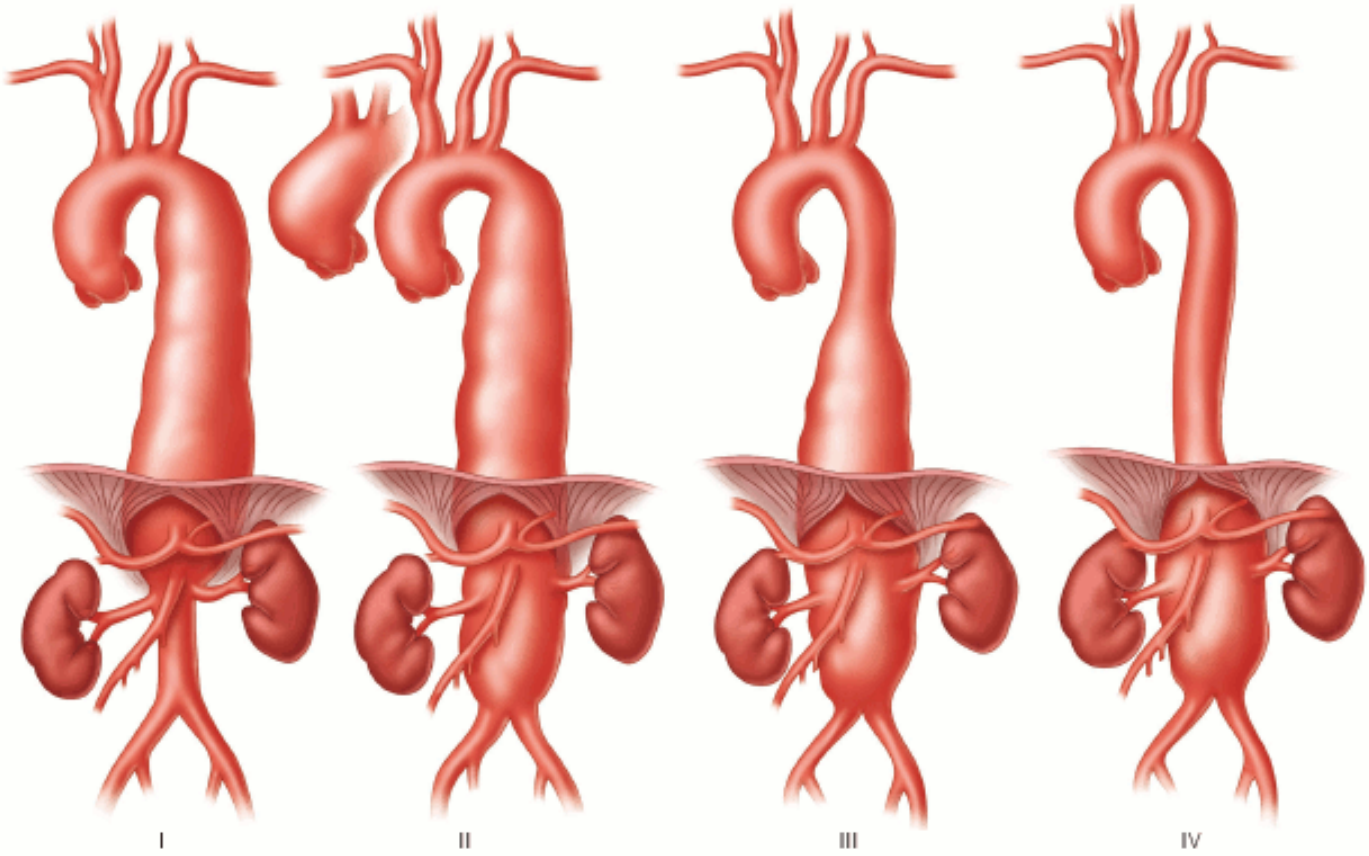
Type	*Cause of Perigraft Flow*	*Consequences and Therapeutic Strategy*
I	Inadequate seal at proximal and/or distal landing zone	Systemic blood pressure is transmitted to aneurysm with risk for rupture: timely repair is indicated.
II	Retrograde flow from aortic branches into aneurysm	It may thrombose. If aneurysm is expanding, aortic branch embolization is indicated.
III	Structural failure of stent, e.g., perforations, fractures	Systemic blood pressure is transmitted to aneurysm with risk for rupture: timely repair is indicated.
IV	Stent graft fabric porosity	This usually occurs at implantation and disappears with anticoagulation reversal.
V	Aneurysm expansion without obvious endoleak ("endodistention")	The endovascular repair can be strengthened with a second stent.

Question

Q. Type 1 endoleak after TEVAR is

A. Inadequate seal at proximal/ distal landing zone
B. Retrograde flow from aortic branch into the aneurysm
C. Structural failure of the stent e.g. perforations, fractures
D. Stent graft porosity

Crawford Classification



Type II = highest risk group

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Question

Q. Choose the false statement/s

A. As per Crawford system of classification for Thoracoabdominal aortic aneurysm, Type 2 is associated with highest complications.

B. The ascending aortic diameter > 4 cm is an indication for surgical repair.

C. The threshold for surgical repair for aortic aneurysms is less by 0.5cm in patients with Marfan's syndrome than normal.

D. Both TTE and TEE are good modalities to evaluate aneurysm involving the distal ascending aorta

Table 15 Etiologies of TAAs

1. Marfan syndrome
2. BAV-related aortopathy
3. Familial TAA syndrome
4. Ehlers-Danlos syndrome type IV (vascular type)
5. Loeys-Dietz syndrome

Table 17 Recommendations for choice of imaging modality for TAA

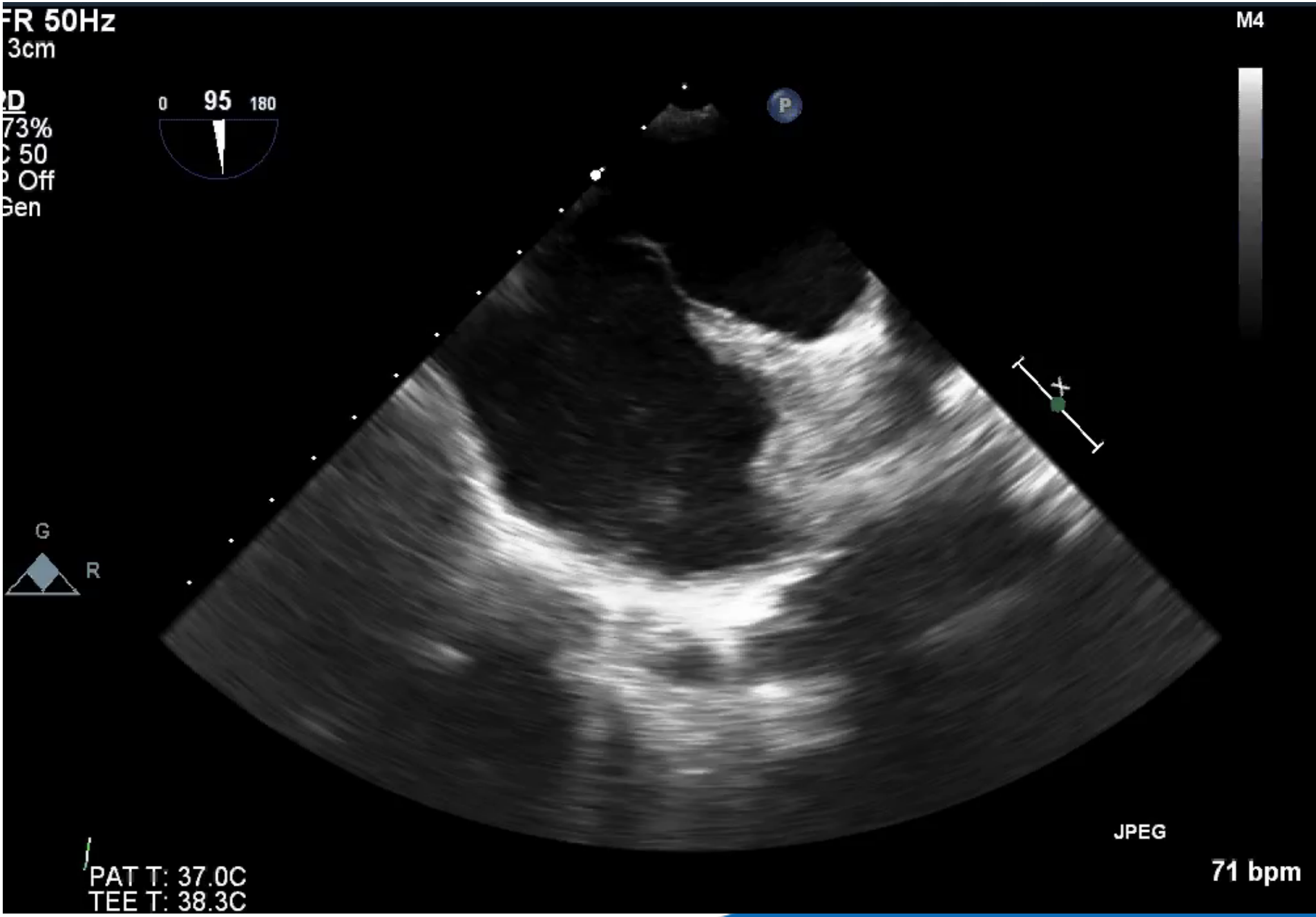
Modality	Recommendation	Advantages	Disadvantages
CT	First-line	• First-line technique for staging, surveillance • Contrast: enhanced CT and MRI very accurate for measuring size of all TAAs (superior to echocardiography for distal ascending aorta, arch, and descending aorta) • All segments of aorta and aortic branches well visualized	• Use of ionizing radiation and ICM • Cardiac motion can cause imaging artifacts
MRI	Second-line	• Ideal technique for comparative follow-up studies • Excellent modality in stable patients • Preferred for follow-up for younger patients • Avoids ionizing radiation • Can image entire aorta	• Examination times longer than CT • Benefits from patient cooperation (breath hold) • Limited in emergency situations in unstable patients and patients with implantable metallic devices • Benefits from gadolinium
TTE	Second-line	• Usually diagnostic for aneurysms effecting aortic root • Useful for family screening • Useful for following aortic root disease • Excellent reproducibility of measurements • Excellent for AR, LV function	• Distal ascending aorta, arch, and descending aorta not reliably imaged
TEE	Third-line	• Excellent for assessment of AR mechanisms • Excellent images of aortic root, ascending aorta, arch, and descending thoracic aorta	• Less valuable for routine screening or serial follow-up (semi-invasive) • Distal ascending aorta may be poorly imaged • Does not permit full visualization of arch vessels • Limited landmarks for serial examinations
Aortography	Third-line	• Reserved for therapeutic intervention • Useful to guide endovascular procedures	• Invasive; risk for contrast-induced nephropathy • Visualizes only aortic lumen • Does not permit accurate measurements

TABLE 21-5 Indications for Surgical Repair of Thoracic Aortic Aneurysms

Atherosclerotic aneurysm diameter	
Ascending aorta	≥5.5 cm
Descending aorta	≥6.5 cm
Marfan's or familial thoracic aneurysm diameter	
Ascending aorta	≥5.0 cm
Descending aorta	≥6.0 cm
Severe aortic regurgitation	
Aortoannular ectasia with aortic root aneurysm	
Rupture	
Refractory pain	

TEE during TAA repair

- Check other valves
- LV and RV function
- Guide cannulation for CPB
- Volume status during LHB


FR 50Hz
3cm
2D
73%
C 50
P Off
Gen
0
95
180
P
M4
G
R
JPEG
PAT T: 37.0C
TEE T: 38.3C
71 bpm

Question

Q. Choose the correct statement/s

A. As per Crawford system of classification for Thoracoabdominal aortic aneurysm, Type 2 is associated with highest complications.

B. The ascending aortic diameter > 4 cm is an indication for surgical repair.

C. The threshold for surgical repair for aortic aneurysms is less by 0.5cm in patients with Marfan's syndrome than normal.

D. Both TTE and TEE are good modalities to evaluate aneurysm involving the distal ascending aorta

Question

Q. Choose the correct statement/s

A. **As per Crawford system of classification for Thoracoabdominal aortic aneurysm, Type 2 is associated with highest complications**.

B. The ascending aortic diameter > 4 cm is an indication for surgical repair.

C. **The threshold for surgical repair for aortic aneurysms is less by 0.5cm in patients with Marfan's syndrome than normal**.

D. Both TTE and TEE are good modalities to evaluate aneurysm involving the distal ascending aorta

Epiaortic ultrasonography

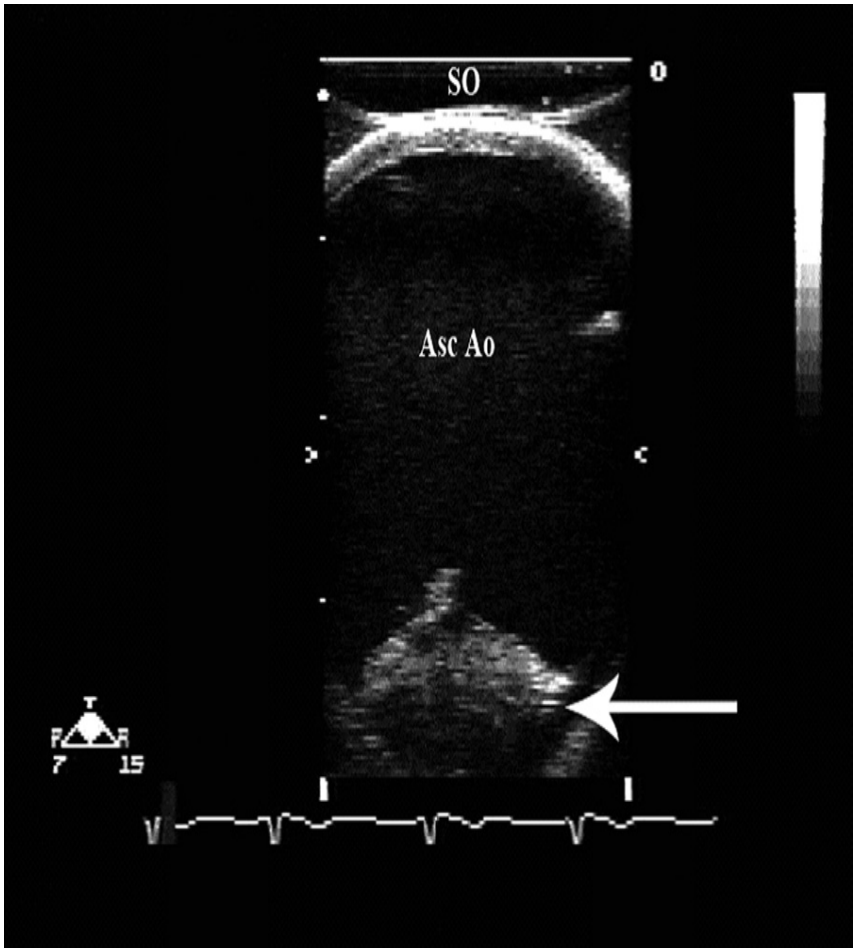
- Intraoperative tool for accurate assessment of ascending aortic pathology/ atheromas
- Risk factors for perioperative stroke
  - Advanced age
  - Female sex
  - H/o cerebrovascular disease
  - PVD
  - DM
  - HTN
  - Prev Cardiac surgery
  - CPB > 2 hrs
  - **Proximal aortic atherosclerosis or a calcified aorta**

- **Incidence of stroke in cardiac surgical population**
  - Off pump CABG 1.9%
  - On pump CABG 3.8%
  - Aortic valve surgery 4.8%
  - Mitral valve surgery 8.8%
  - Combined CABG + valve 7.4%

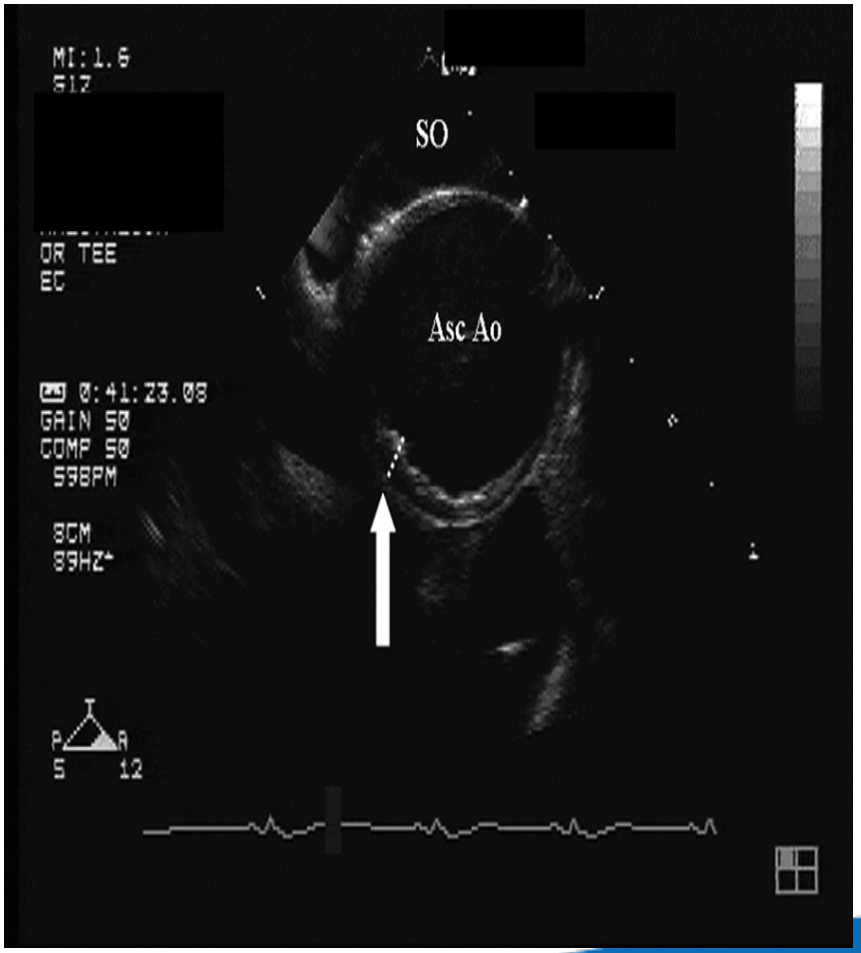
Epiaortic Ultrasonography

- Transducers
  - > 7 MHz
  - Linear sequential array transducers (rectangular shaped image)
  - Phased-array transducers (fan shaped image; requires a stand-off device to view anterior surface of aorta)
  - Matrix array transducers (3D, X-plane)

Linear array



Phased array



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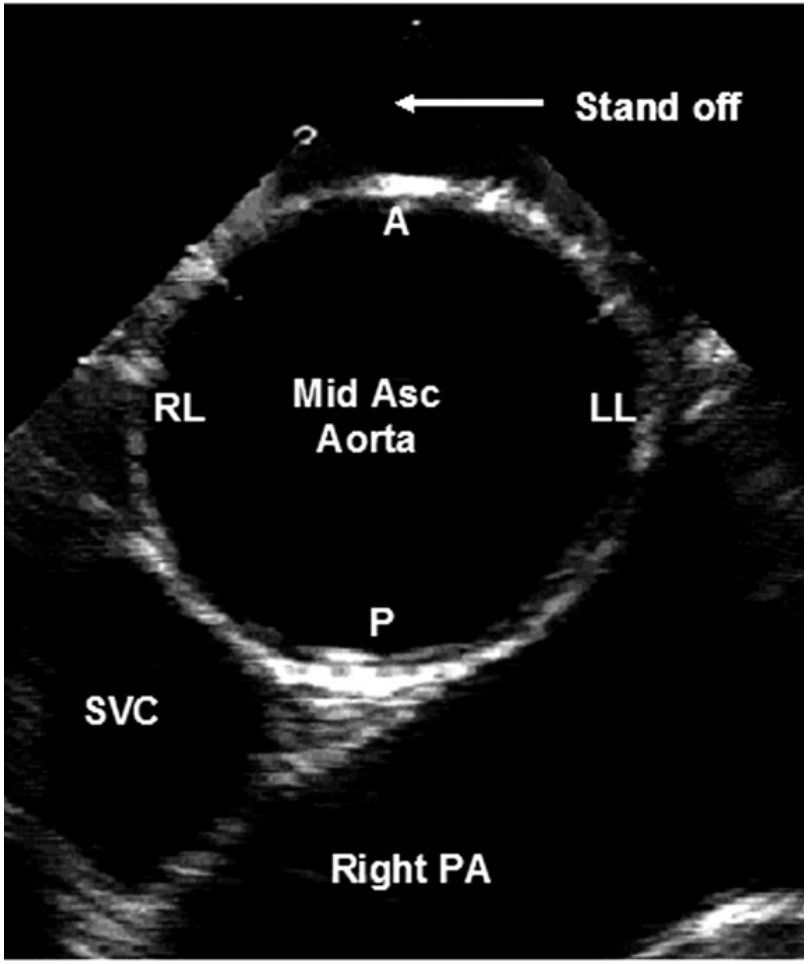

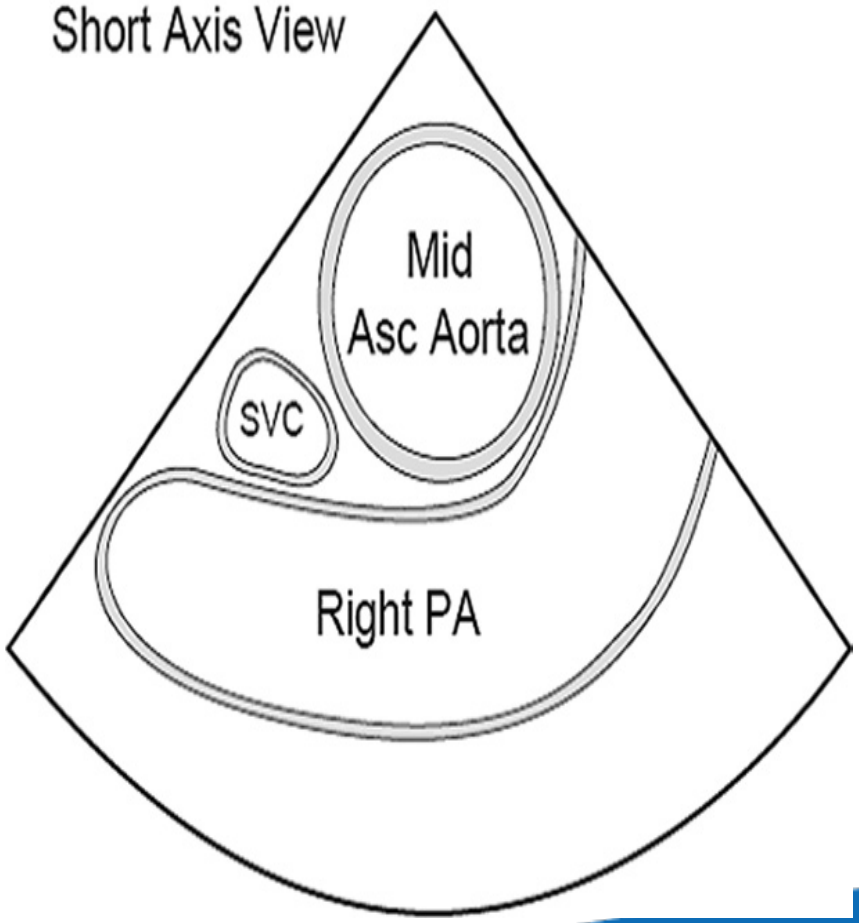

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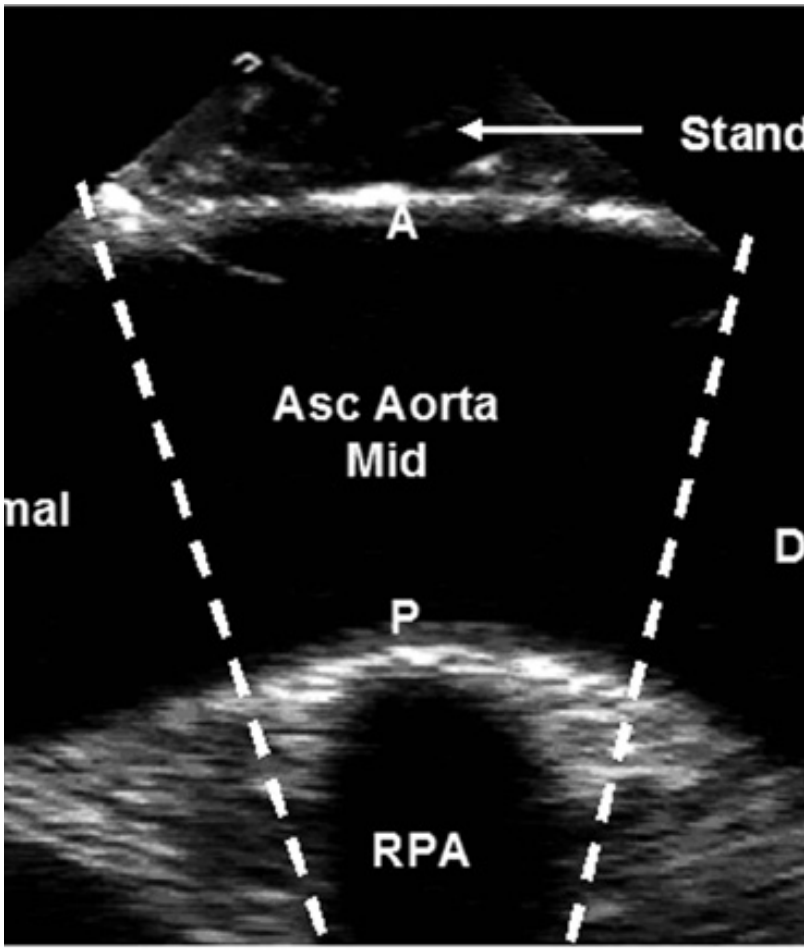

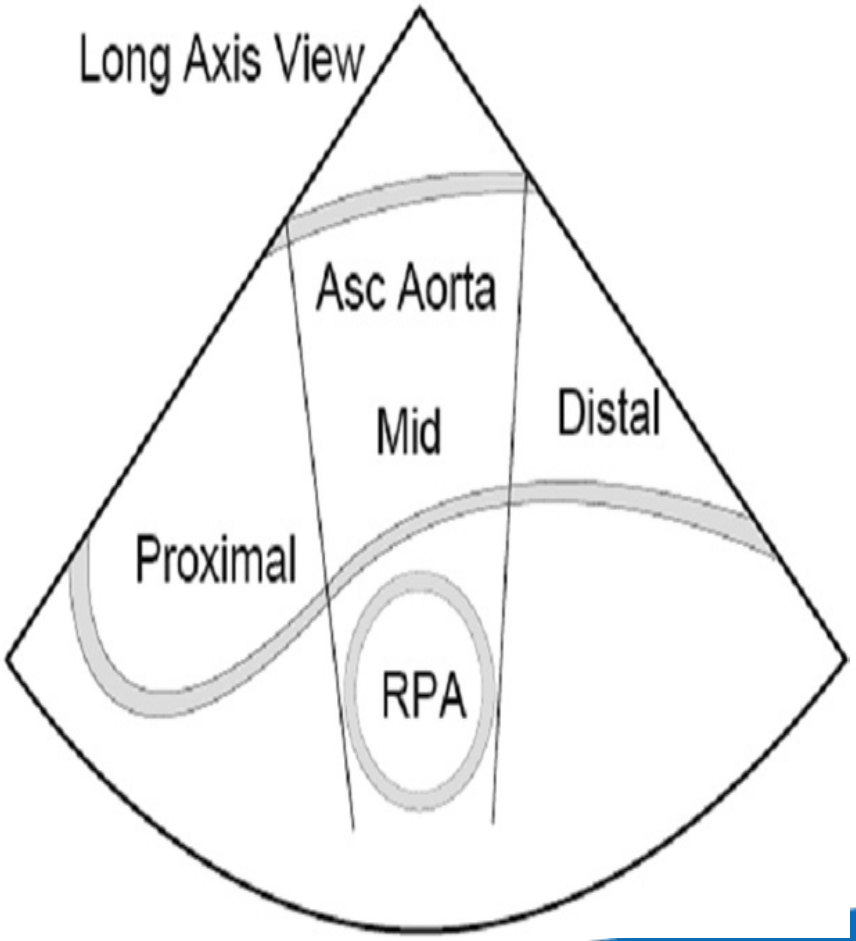

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Table 26 Grading system for severity of aortic atherosclerosis

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