Diseases Of The Aorta

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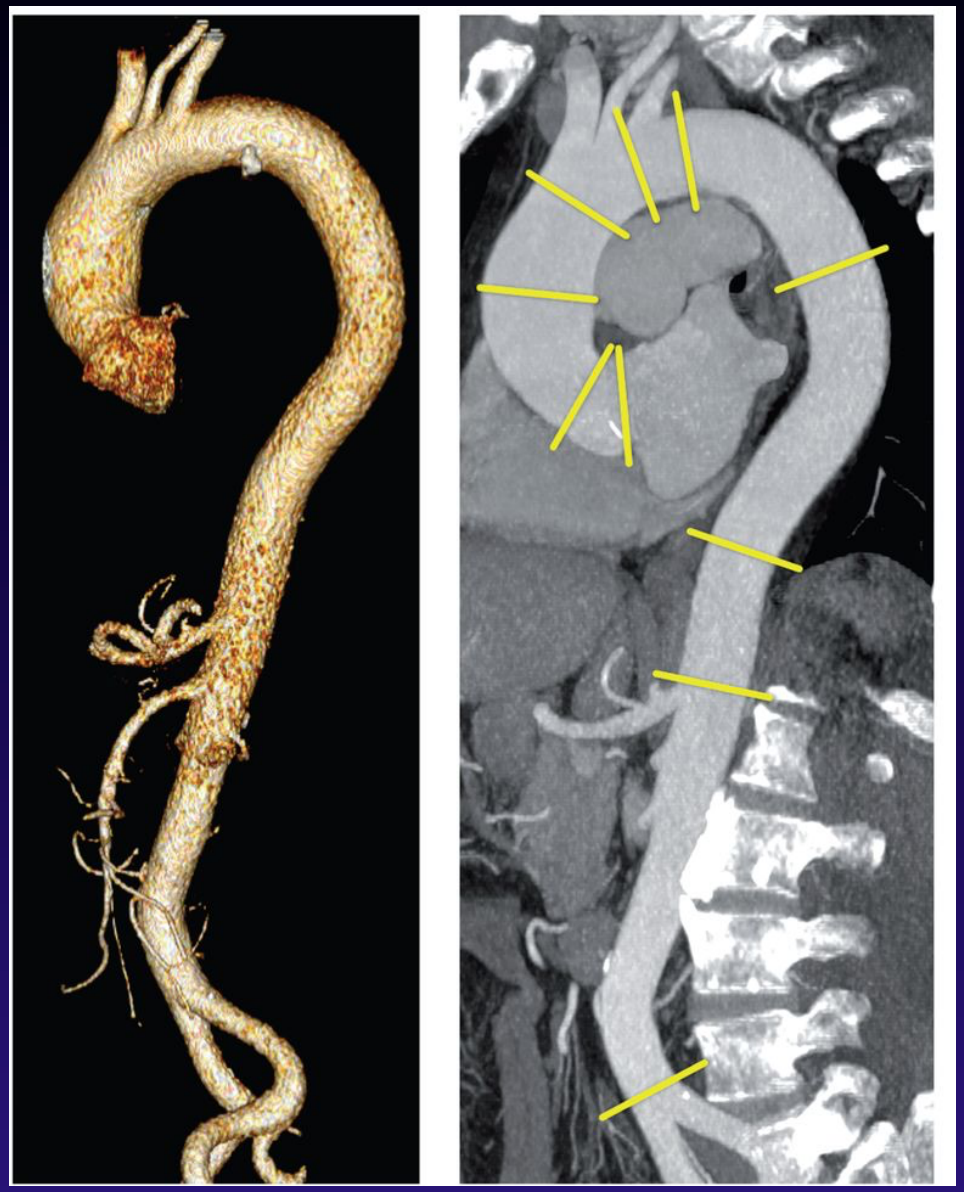
Melbourne Sports Cardiology

POSTERA CRESCAM LAUDE

THE UNIVERSITY OF MELBOURNE

What Happens To Aortas

- Grow
- Pop
- Tear
- Block
- Embolize



Outline

- Anatomy & nomenclature
- Aortic measurements
- Aortic aneurysm
- Acute aortic syndromes
  - aortic dissection and variants
- Aortic coarctation
- Atherosclerosis

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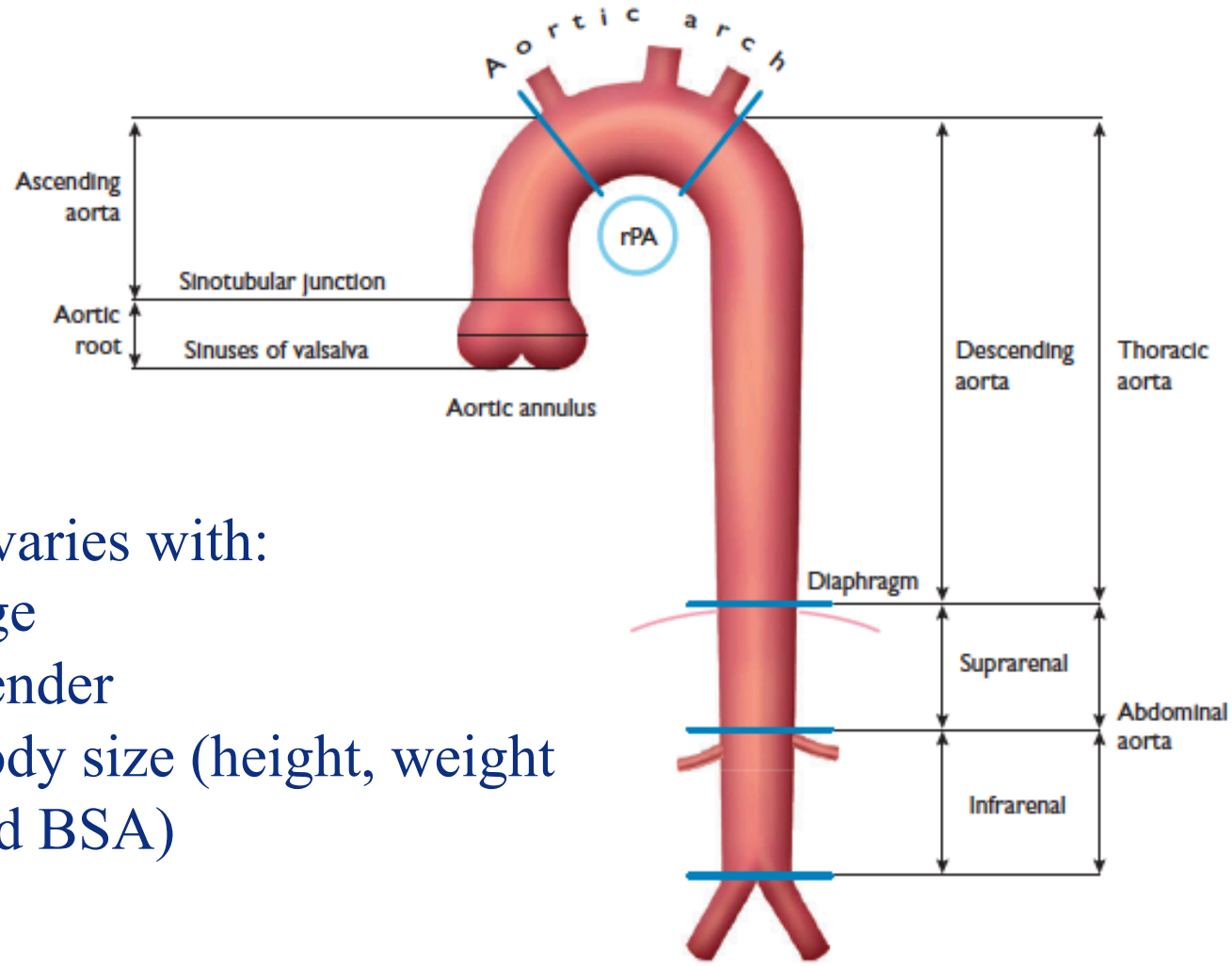
Anatomy

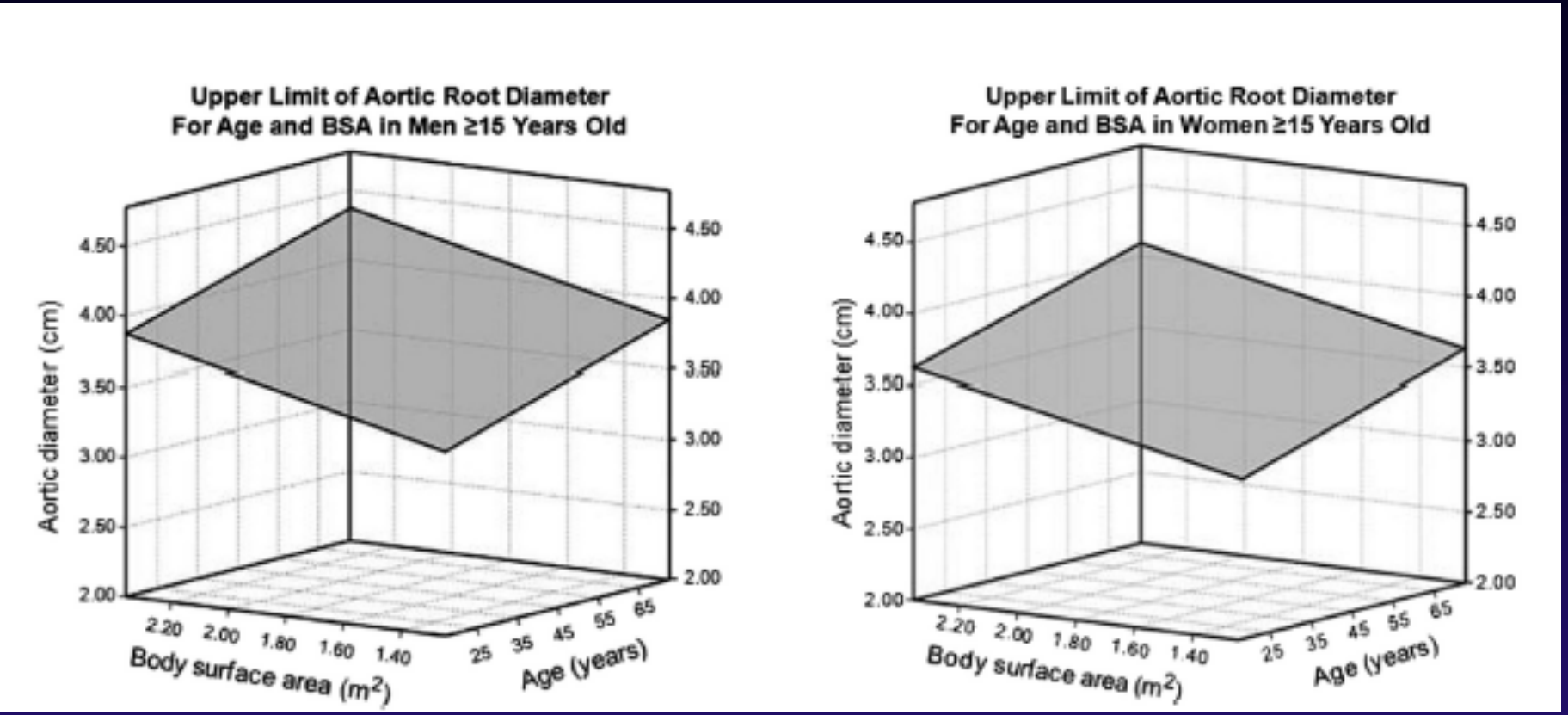


Size varies with:

- Age
- Gender
- Body size (height, weight and BSA)

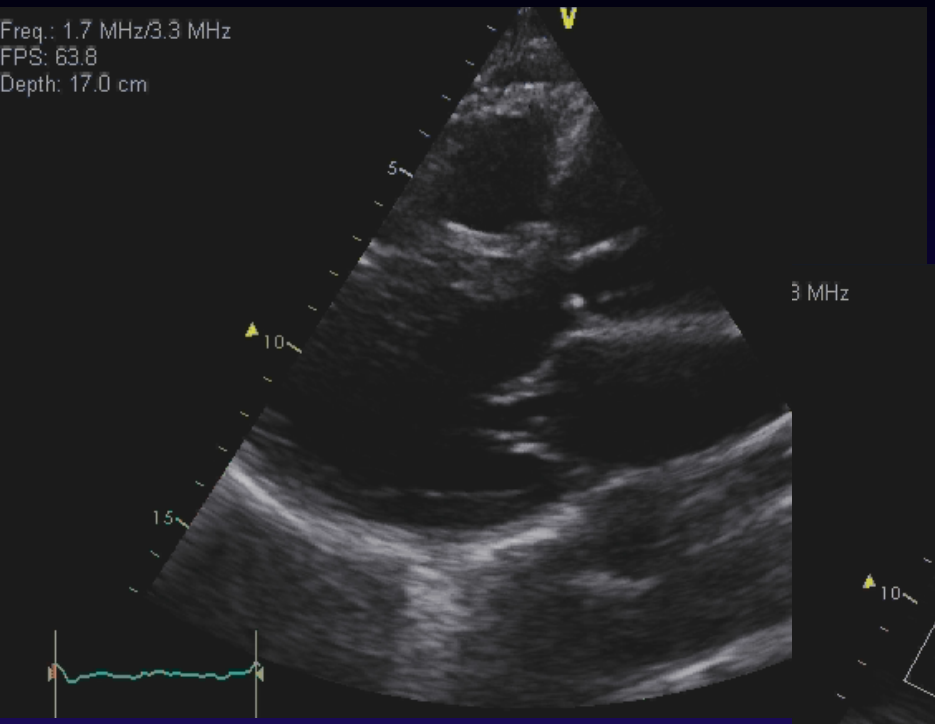
Erbel, *EHJ* 2014 35:2873

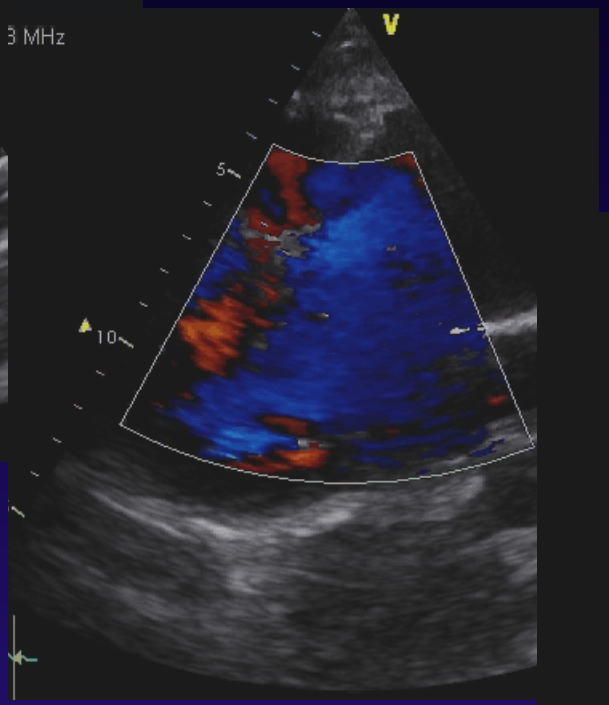
Age, Gender and BSA

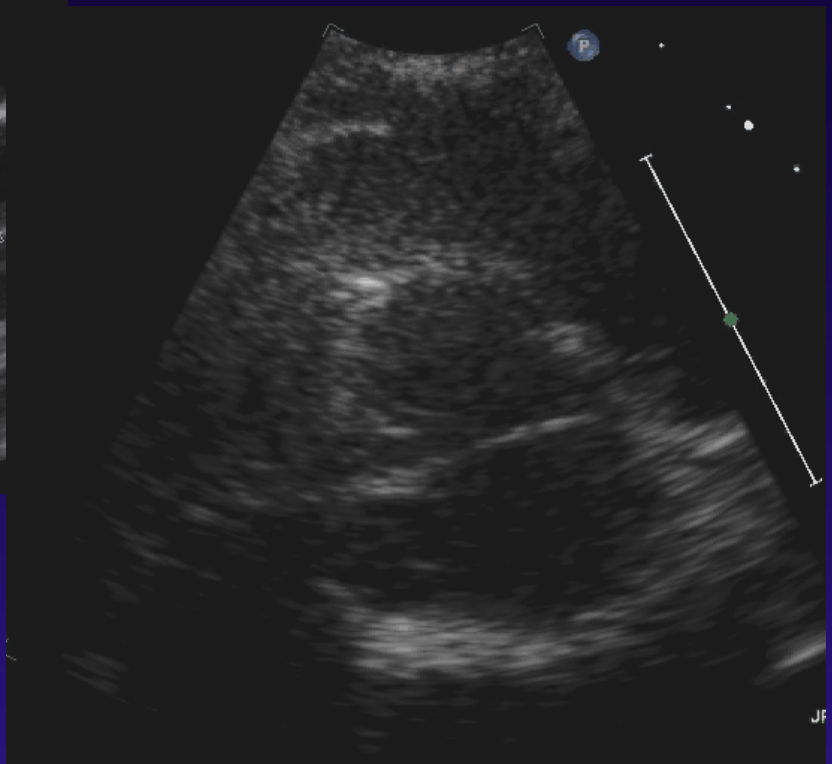


Goldstein *JASE* 2015 28:119

Clinical Case

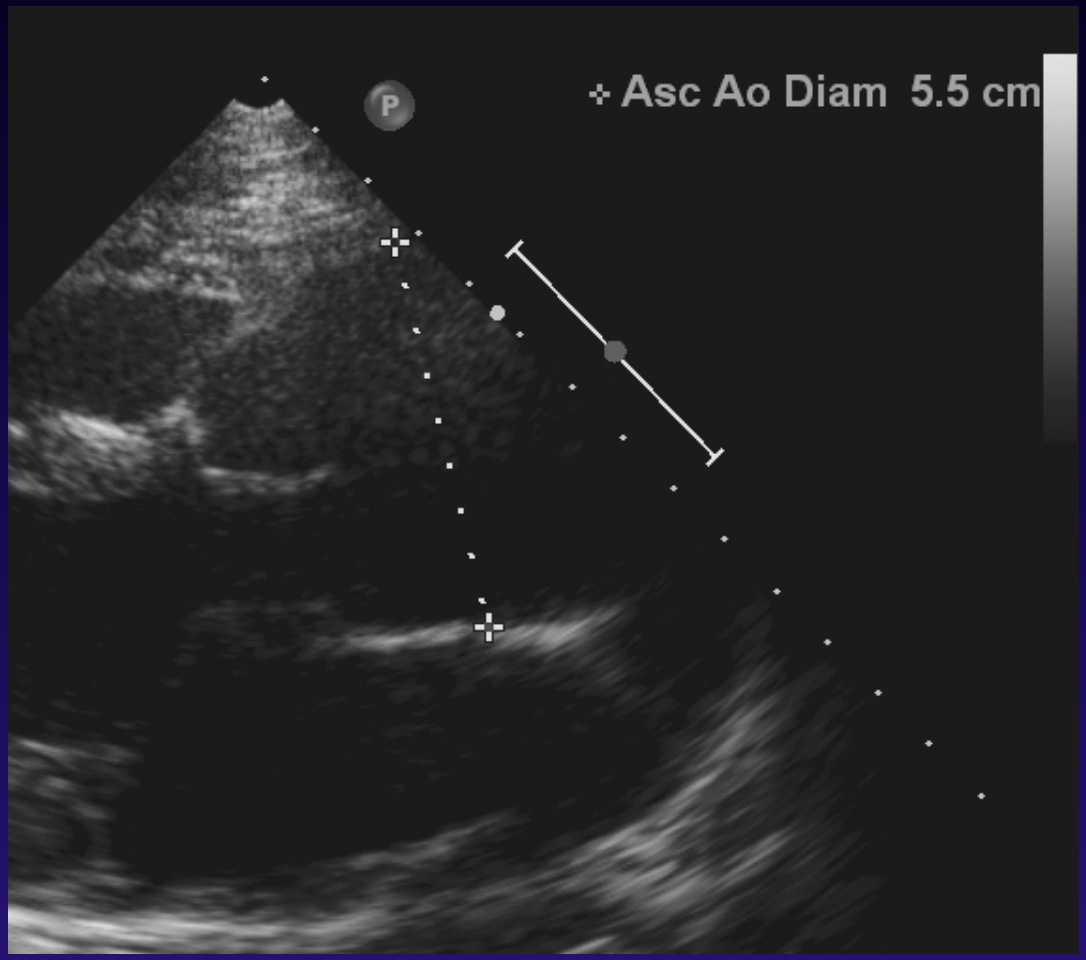




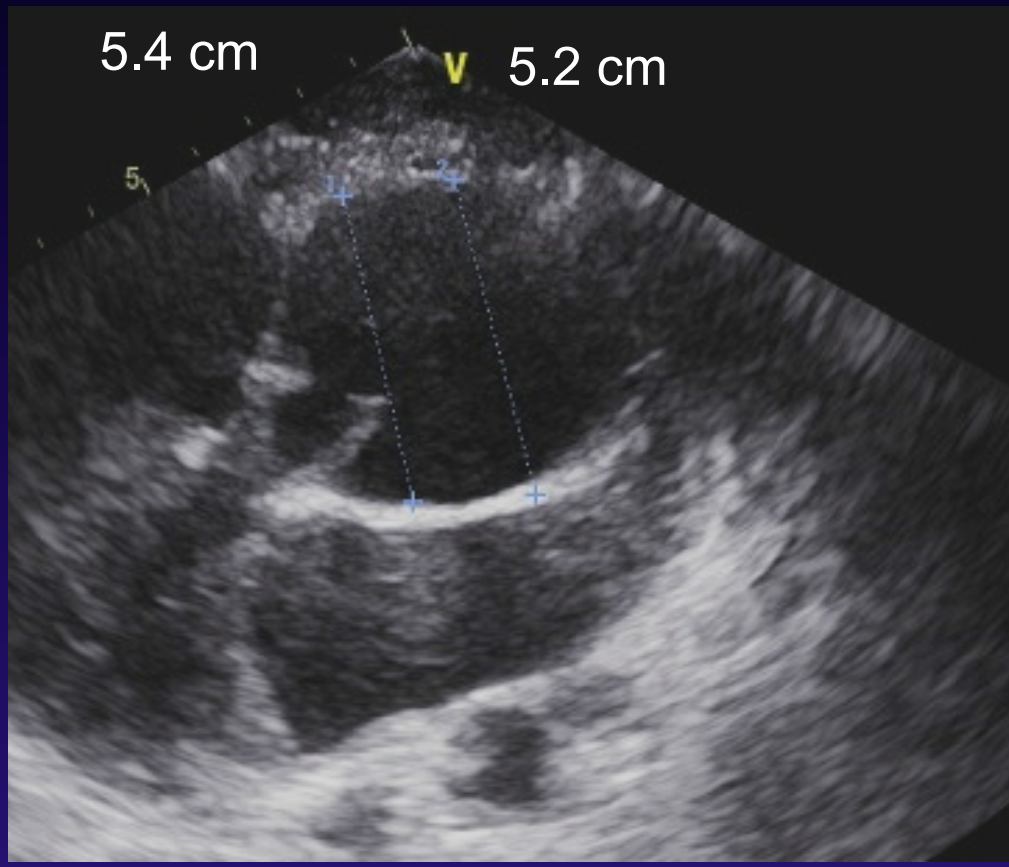


Importance Of Serial Measures

2006



2016



Guidance On Imaging the Aorta

GUIDELINES AND STANDARDS

Multimodality Imaging of Diseases of the Thoracic Aorta in Adults: From the American Society of Echocardiography and the European Association of Cardiovascular Imaging
Endorsed by the Society of Cardiovascular Computed Tomography and Society for Cardiovascular Magnetic Resonance

Steven A. Goldstein, MD, Co-Chair, Arturo Evangelista, MD, FESC, Co-Chair, Suhny Abbara, MD, Andrew Arai, MD, Federico M. Asch, MD, FASE, Luigi P. Badano, MD, PhD, FESC, Michael A. Bolen, MD, Heidi M. Connolly, MD, Hug Cuéllar-Calàbria, MD, Martin Czerny, MD, Richard B. Devereux, MD, Raimund A. Erbel, MD, FASE, FESC, Rossella Fattori, MD, Eric M. Isselbacher, MD, Joseph M. Lindsay, MD, Marti McCulloch, MBA, RDCS, FASE, Hector I. Michelena, MD, FASE, Christoph A. Nienaber, MD, FESC, Jae K. Oh, MD, FASE, Mauro Pepi, MD, FESC, Allen J. Taylor, MD, Jonathan W. Weinsaft, MD, Jose Luis Zamorano, MD, FESC, FASE, Contributing Editors: Harry Dietz, MD, Kim Eagle, MD, John Elefteriades, MD, Guillaume Jondeau, MD, PhD, FESC, Hervé Rousseau, MD, PhD, and Marc Schepens, MD, *Washington, District of Columbia; Barcelona and Madrid, Spain; Dallas and Houston, Texas; Bethesda and Baltimore, Maryland; Padua, Pesaro, and Milan, Italy; Cleveland, Ohio; Rochester, Minnesota; Zurich, Switzerland; New York, New York; Essen and Rostock, Germany; Boston, Massachusetts; Ann Arbor, Michigan; New Haven, Connecticut; Paris and Toulouse, France; and Brugge, Belgium*

(J Am Soc Echocardiogr 2015;28:119-82.)

Goldstein *JASE* 2015 28:119

Measuring The Aorta

- End-diastole
- Leading edge to leading edge
- Perpendicular to the long axis
- Compare to previous images
- Measurements may be different to other modalities

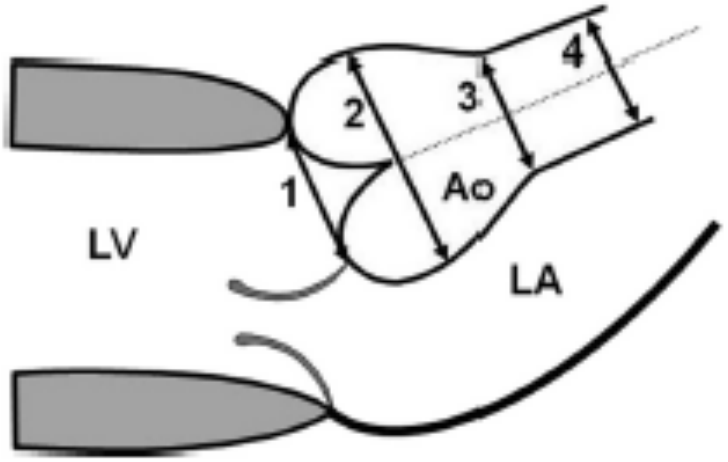


Figure 10 Sites for measurements of the aortic root and ascending aorta. This diagram illustrates the four sites at which measurements are recommended: 1 = aortic valve annulus (hinge point of aortic leaflets), 2 = aortic root at sinuses of Valsalva (maximal diameter, usually midpoint), 3 = STJ, 4 = proximal tubular portion of the ascending aorta. *Ao*, Aorta; *LA*, left atrium; *LV*, left ventricle.

Goldstein *JASE* 2015 28:119

Normal Range

Table 1 Normal aortic root diameter by age for men with BSA of 2.0 m^2

	Age (y)					
	15–29	30–39	40–49	50–59	60–69	≥70
Mean normal (cm)	3.3	3.4	3.5	3.6	3.7	3.8
Upper limit of normal (cm) (95% CI)	3.7	3.8	3.9	4.0	4.1	4.2

Add 0.5 mm per 0.1 m^2 BSA above 2.0 m^2 or subtract 0.5 mm per 0.1 m^2 BSA below 2.0 m^2.[6]
CI, Confidence interval.

Table 2 Normal aortic root diameter by age for women with BSA of 1.7 m^2

	Age (y)					
	15–29	30–39	40–49	50–59	60–69	≥70
Mean normal (cm)	2.9	3.0	3.2	3.2	3.3	3.4
Upper limit of normal (cm)	3.3	3.4	3.6	3.6	3.7	3.9

Add 0.5 mm per 0.1 m^2 BSA above 1.7 m^2 or subtract 0.5 mm per 0.1 m^2 BSA below 1.7 m^2.[6]

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Comparison of methods for imaging the aorta

Advantages/disadvantages	TTE	TOE	CT	MRI	Aortography
Ease of use	+++	++	+++	++	+
Diagnostic reliability	+	+++	+++	+++	++
Bedside/interventional use	++	++	–	–	++
Serial examinations	++	+	++(+)	+++	–
Aortic wall visualization	+	+++	+++	+++	–
Cost	–	–	– –	– – –	– – –
Radiation	0	0	– – –	–	– –
Nephrotoxicity	0	0	– – –	– –	– – –

+ means a positive remark and — means a negative remark. The number of signs indicates the estimated potential value

++(+) only for follow-up after aortic stenting (metallic struts), otherwise limit radiation

European Heart Journal (2014); 35:2873–2926 - doi:10.1093/eurheartj/ehu281

Thoracic Aortic Aneurysm

- Familial / Genetic
  - Marfan syndrome
  - Bicuspid aortic valve-related aortopathy
  - Ehlers-Danlos syndrome (Type IV)
  - Loeys-Dietz syndrome
  - Thoracic aortic aneurysm syndrome
- Acquired
  - Hypertension
  - Infective (Syphilis, salmonella)
  - Atherosclerosis
  - Trauma

Will need echo for surveillance

May need echo for diagnosis

Thoracic Aortic Aneurysm

- Familial / Genetic
  - Marfan syndrome
  - Bicuspid aortic valve-related aortopathy
  - Ehlers-Danlos syndrome (Type IV)

Most common conditions requiring screening of patients & relatives

  - Atherosclerosis
  - Trauma

Choice Of Imaging Modality

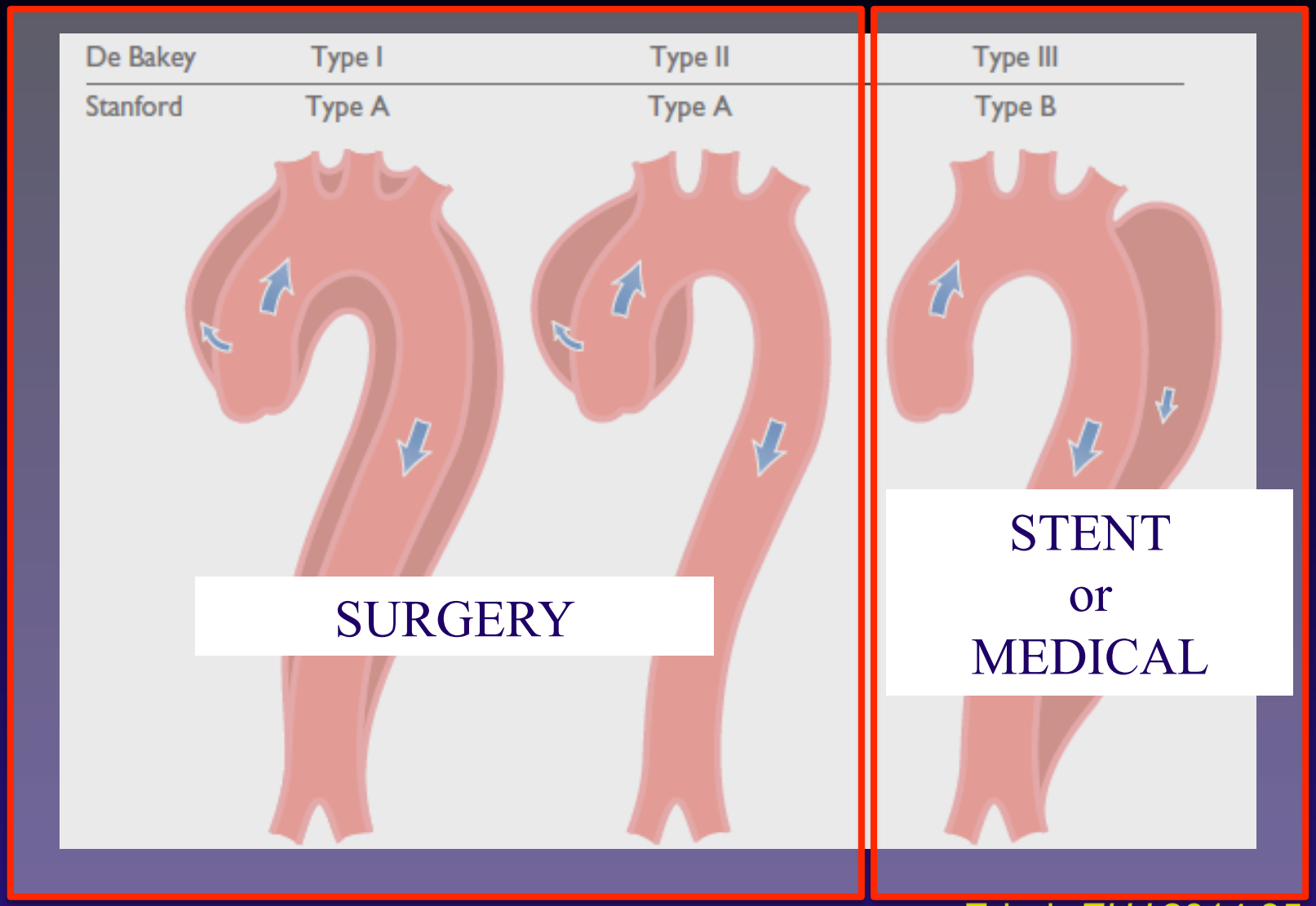
Table 17 Recommendations for choice of imaging modality for TAA

Modality	Recommendation	Advantages	Disadvantages
CT	First-line	• First-line technique for staging, surveillance • Contrast: enhanced CT and MRI very accurate for	• Use of ionizing radiation and ICM • Cardiac motion can cause imaging artifacts
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
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

LV, Left ventricular.

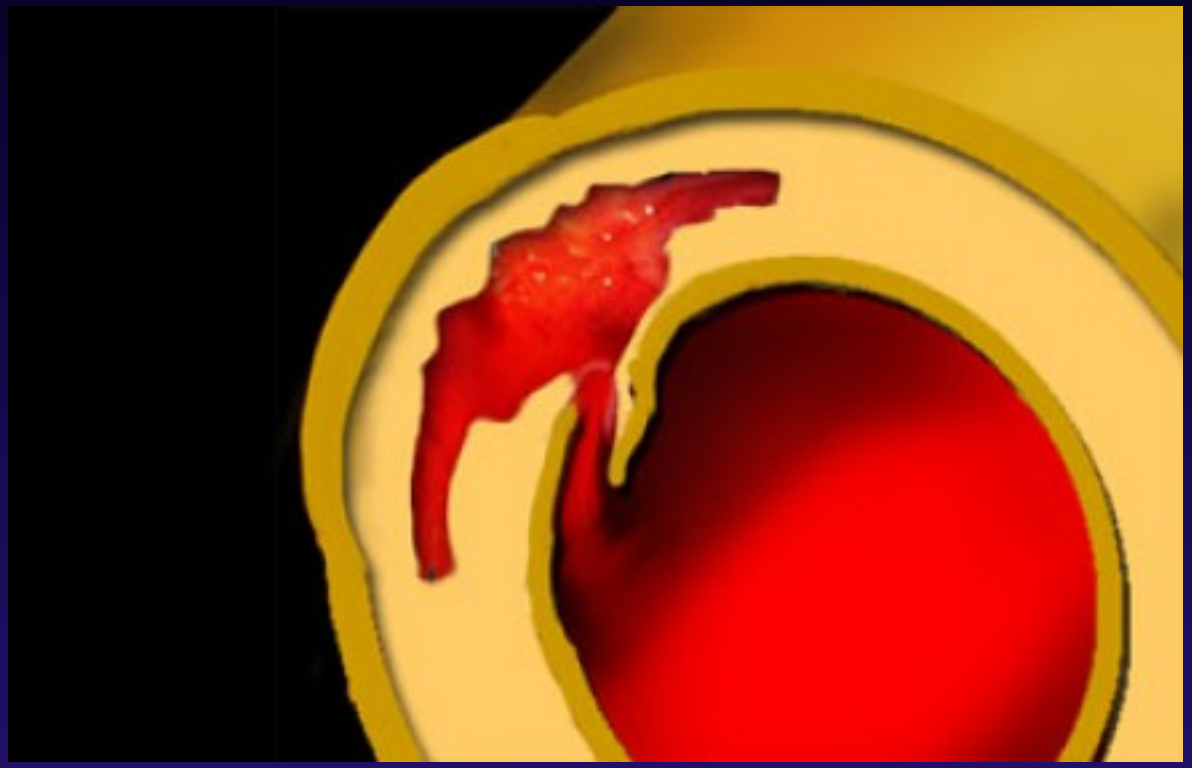
Goldstein *JASE* 2015 28:119

Aortic Dissection - Classification



Erbel, *EHJ* 2014 35:2873

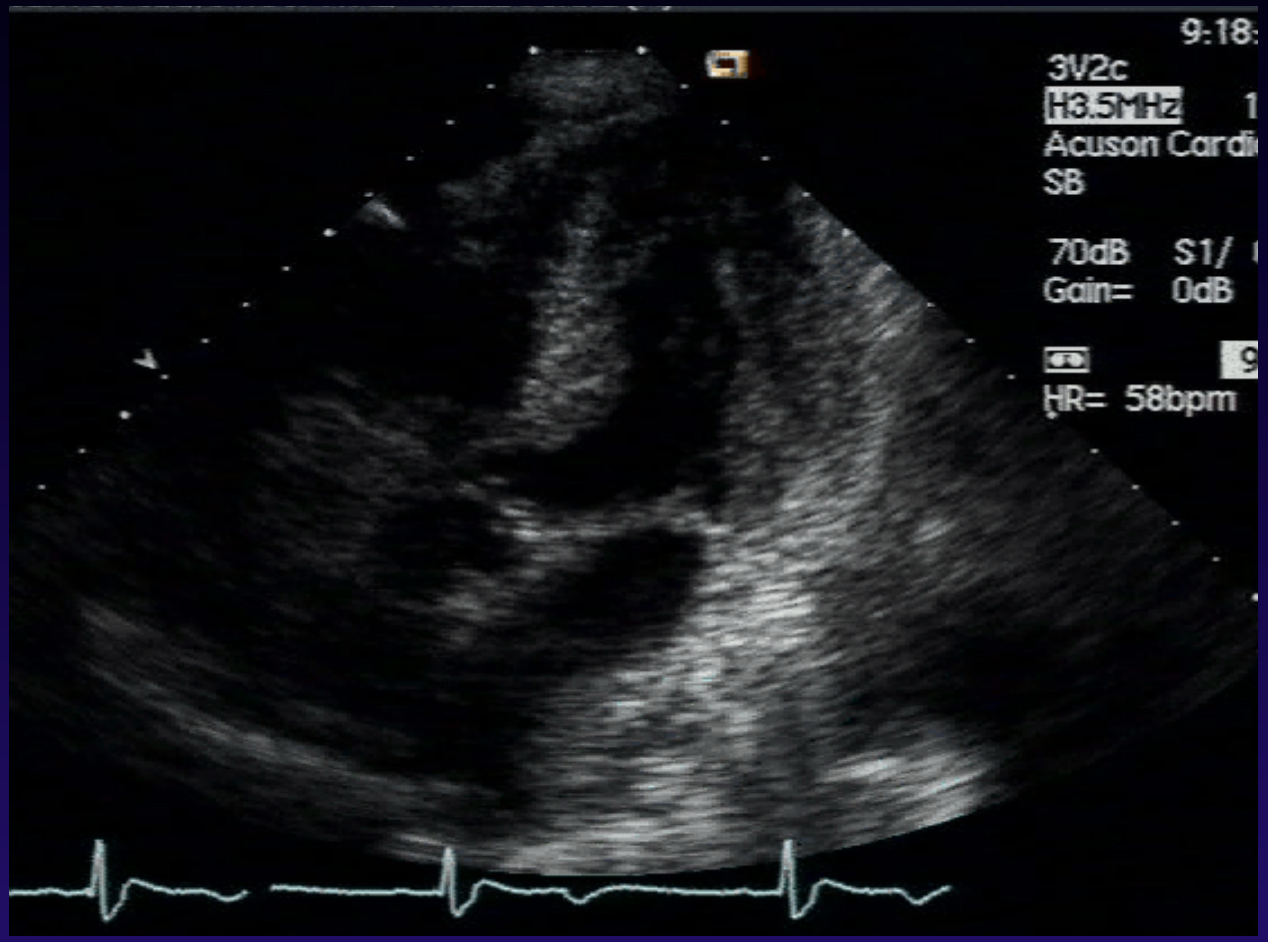
Aortic Dissection



Chest Pain

- 82 Y.O. male
- Sudden onset chest pain in chest and scapula
- Presented to ED
- Minor T wave changes on ECG

- Echocardiogram requested - ?AMI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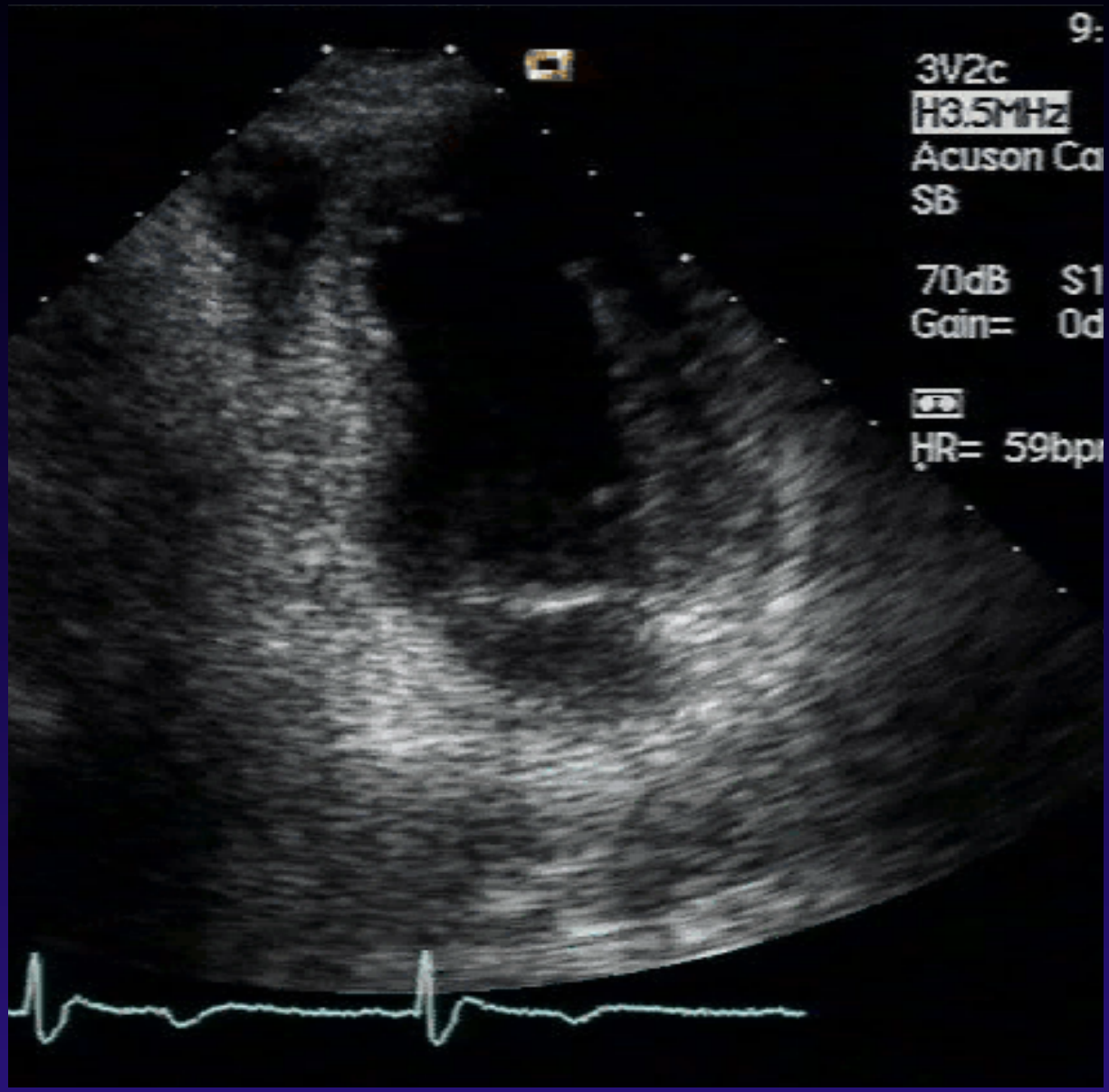
Gain= 0dB
HR= 58bpm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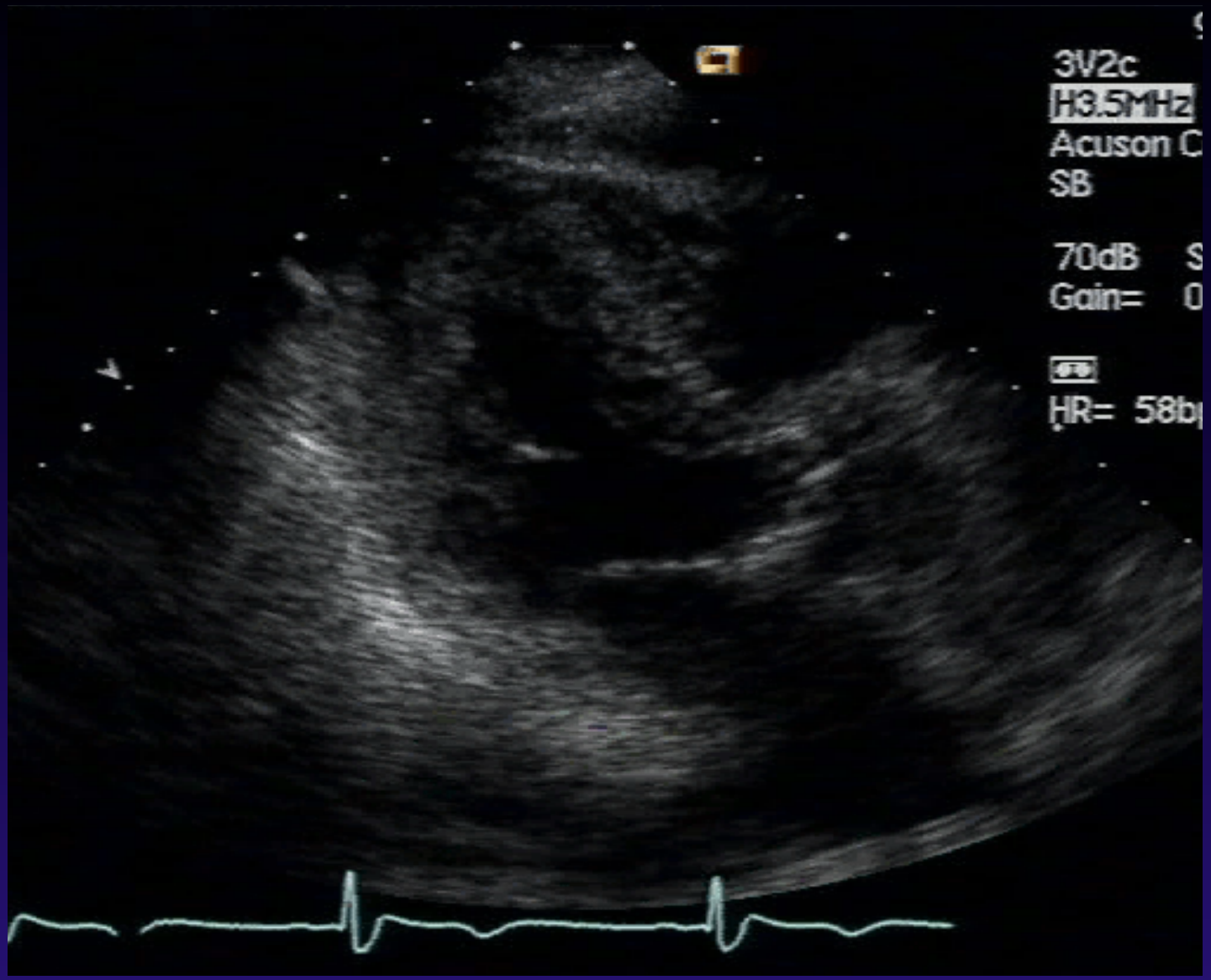
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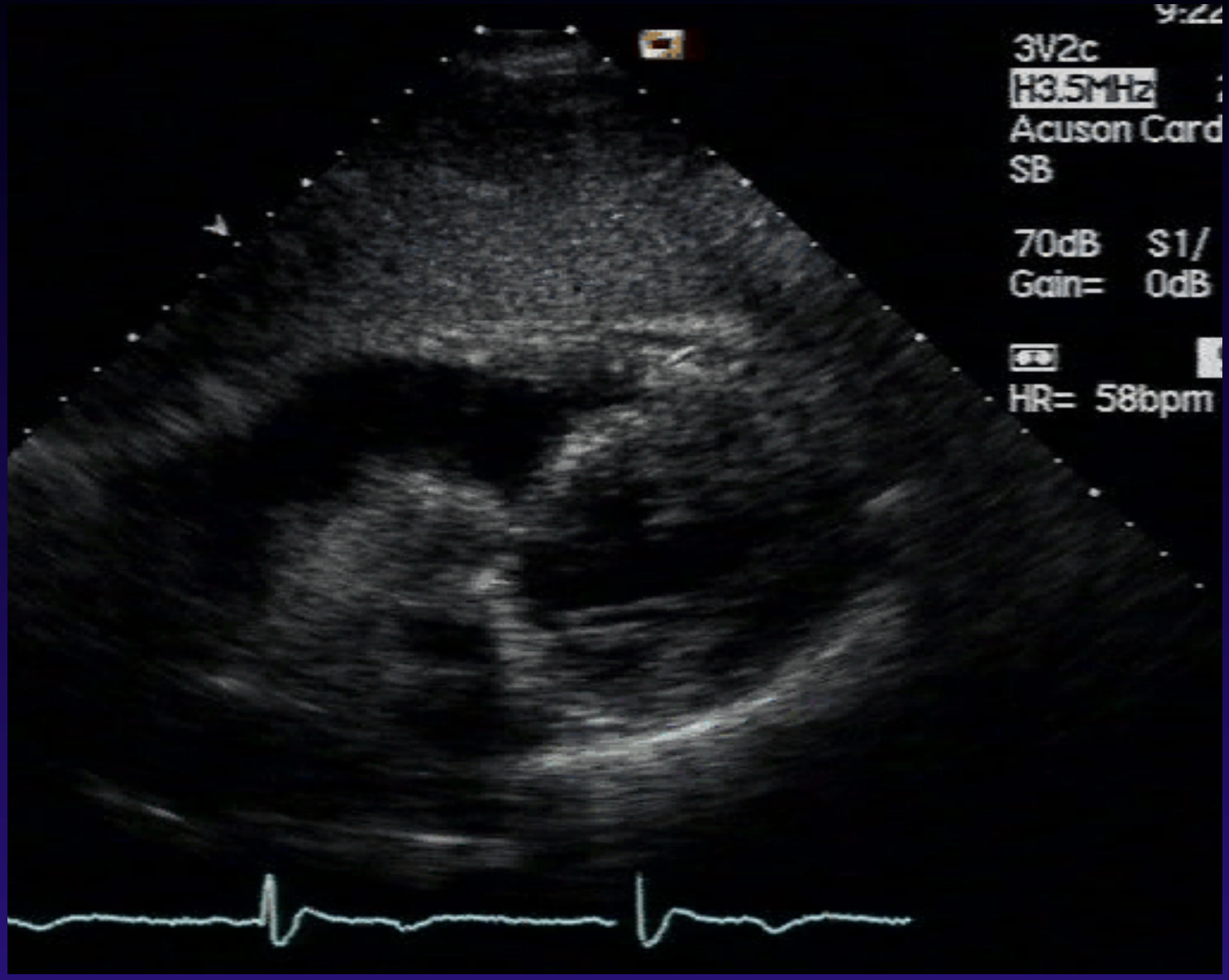
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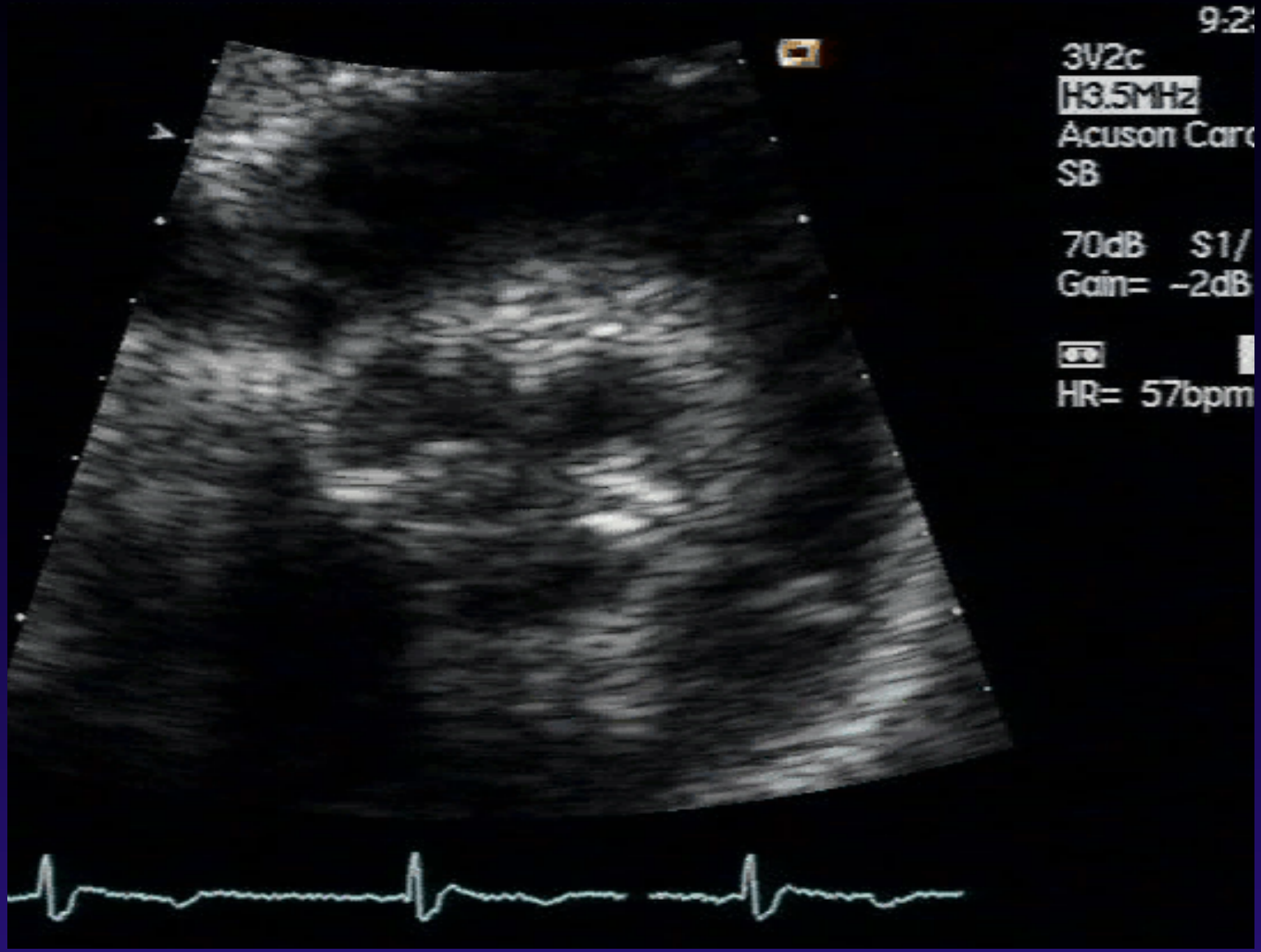
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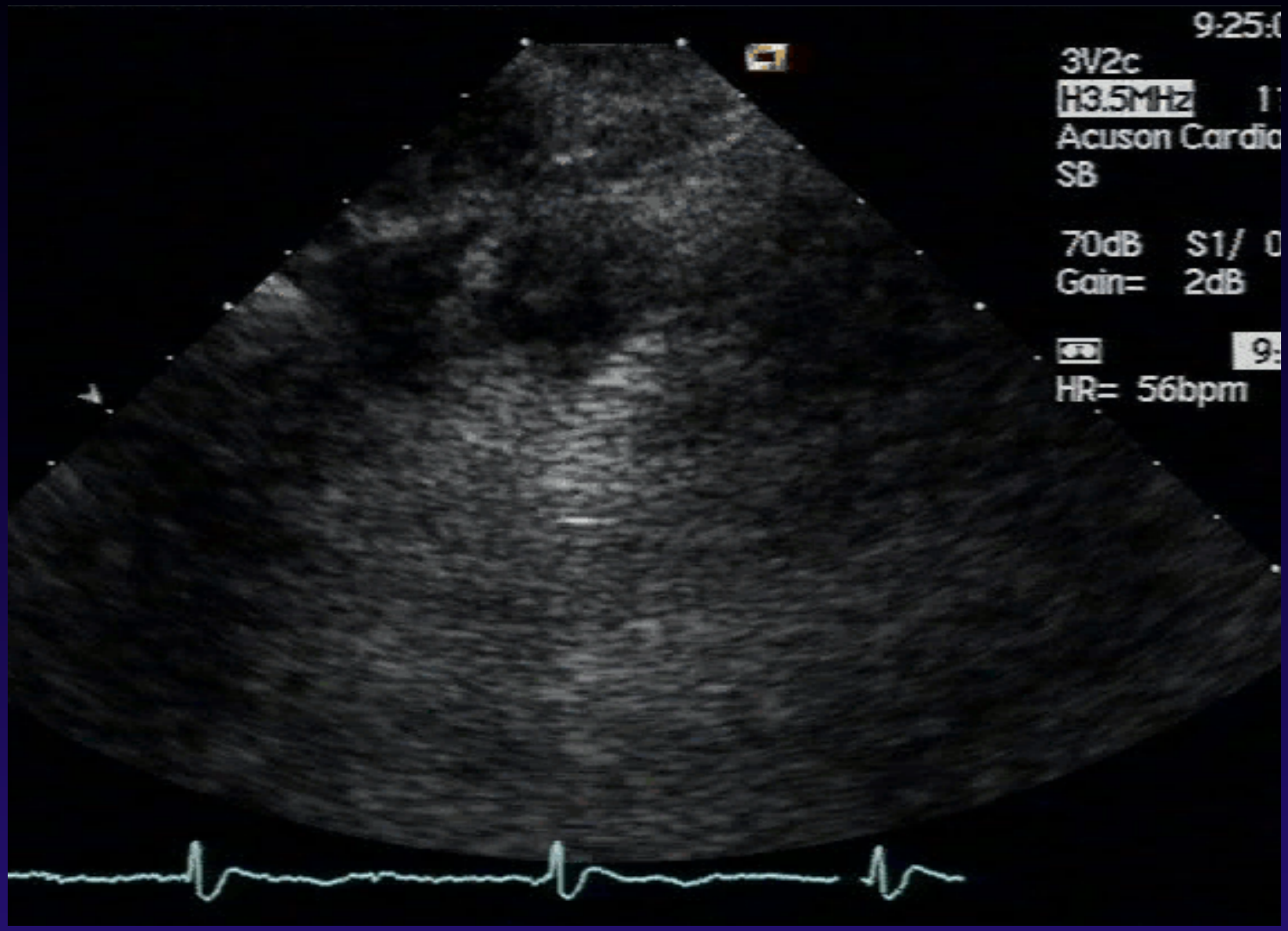
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3V2c
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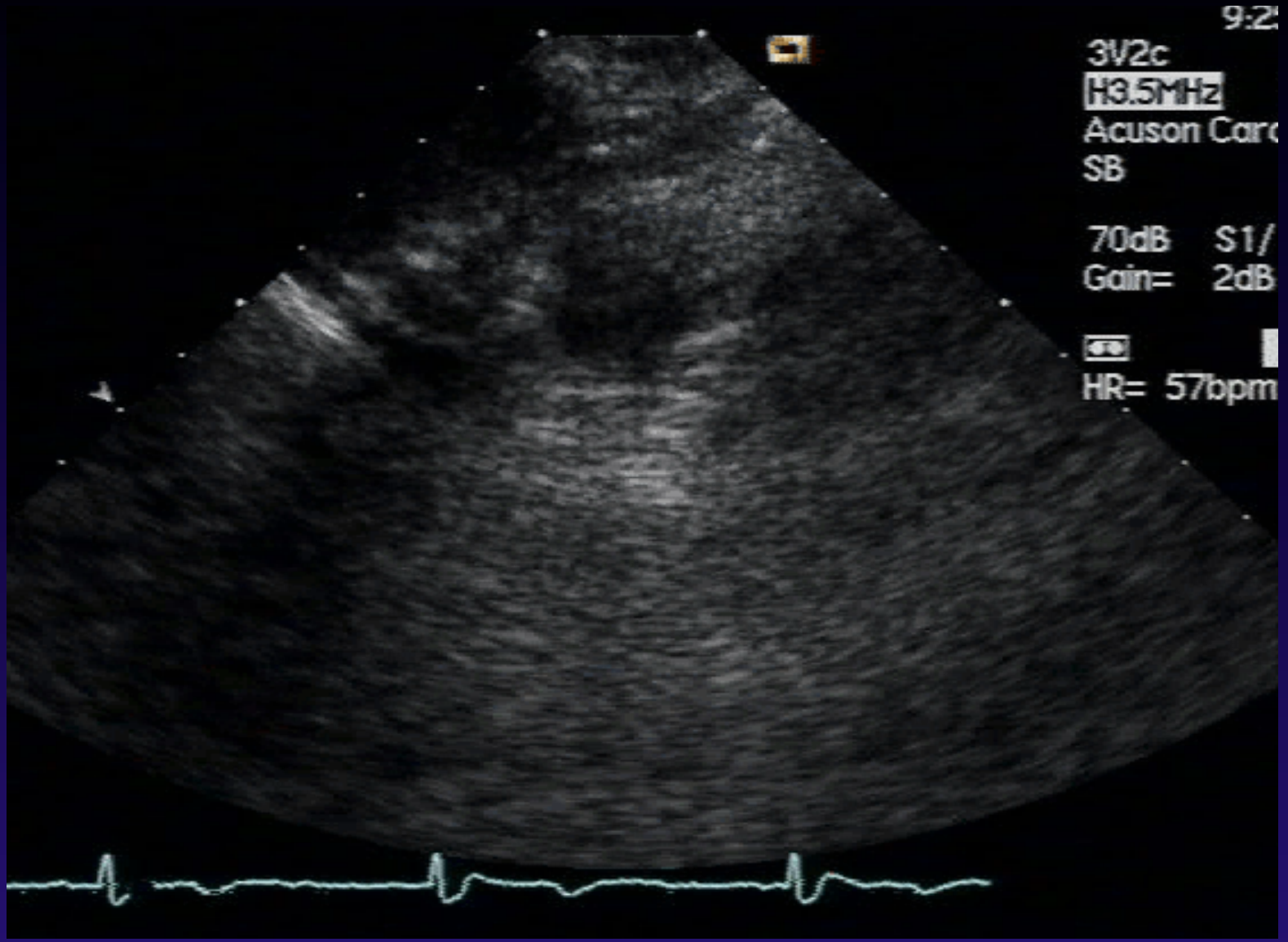
Acuson Cardia
SB
70dB S1/
Gain= 2dB
HR= 56bpm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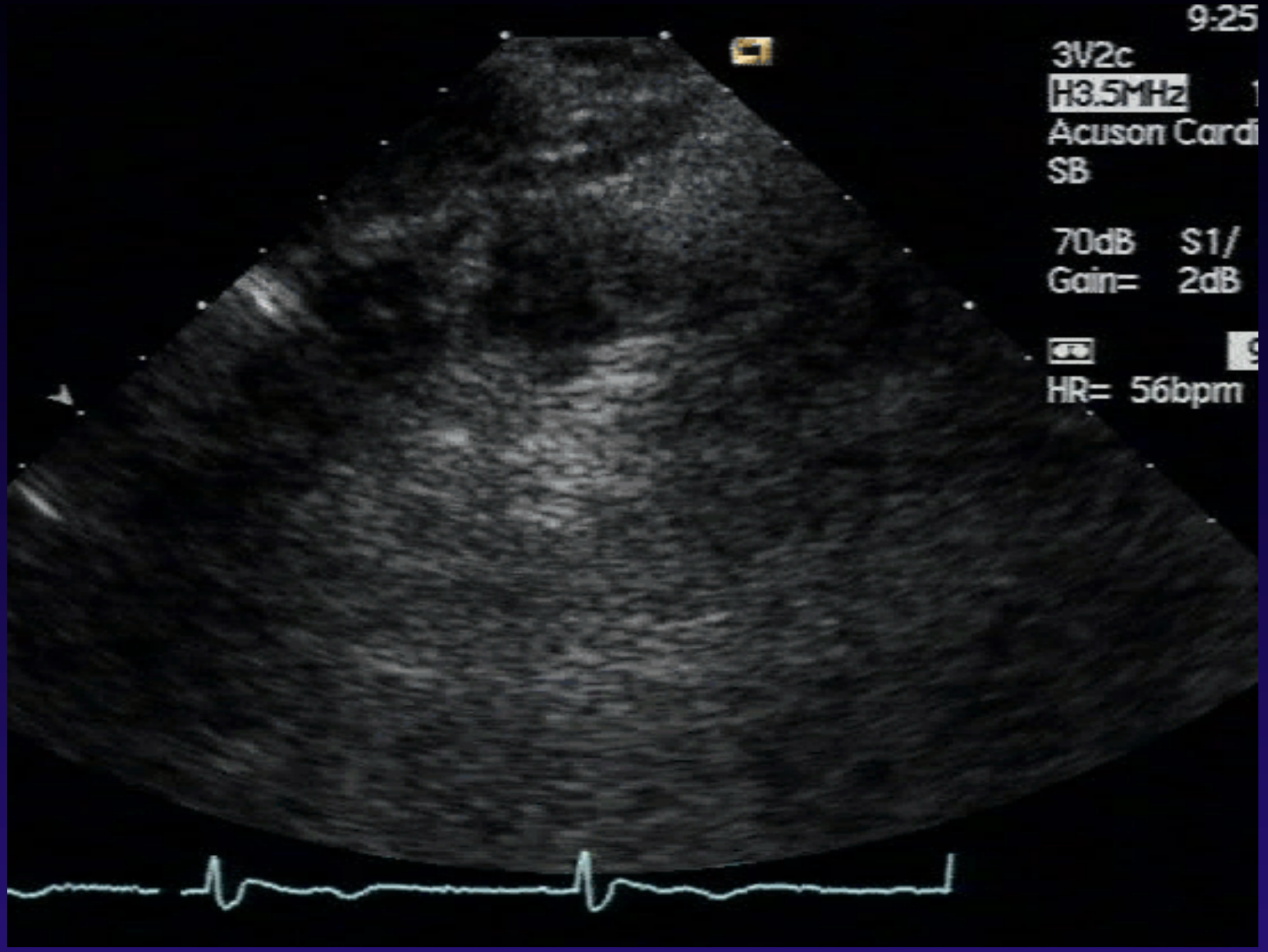
Gain= 2dB
HR= 57bpm


9:25
3V2c
H3.5MHz
Acuson Cardi
SB
70dB S1/
Gain= 2dB
HR= 56bpm

Progress

- Urgent CT scan
  - "complex dissection involving the aortic arch, ascending and descending aorta arising from the aortic root….."
- Urgent surgery
  - AVR and repair of dissection

Clinical data useful to assess the *a priori* probability of acute aortic syndromes

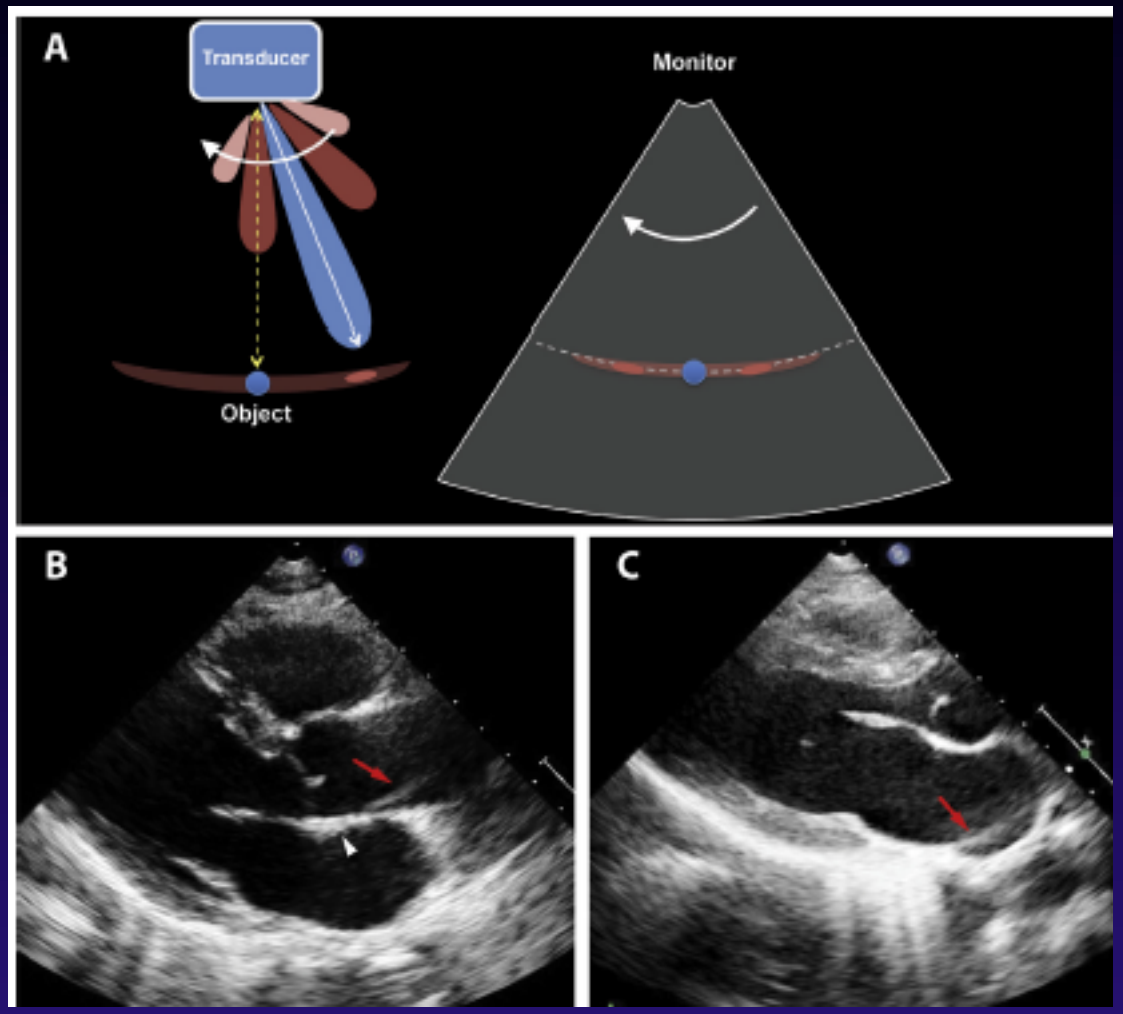
High-risk conditions	High-risk pain features	High-risk examination features
• Marfan syndrome (or other connective tissue diseases) • Family history of aortic disease • Known aortic valve disease • Known thoracic aortic aneurysm • Previous aortic manipulation (including cardiac surgery)	• Chest, back, or abdominal pain described as any of the following: – abrupt onset – severe intensity – ripping or tearing	• Evidence of perfusion deficit: – pulse deficit – systolic blood pressure difference – focal neurological deficit (in conjunction with pain) • Aortic diastolic murmur (new and with pain) • Hypotension or shock

European Heart Journal (2014); 35:2873–2926 - doi:10.1093/eurheartj/ehu281

Role Of Echo in Dissection
TTE & TEE

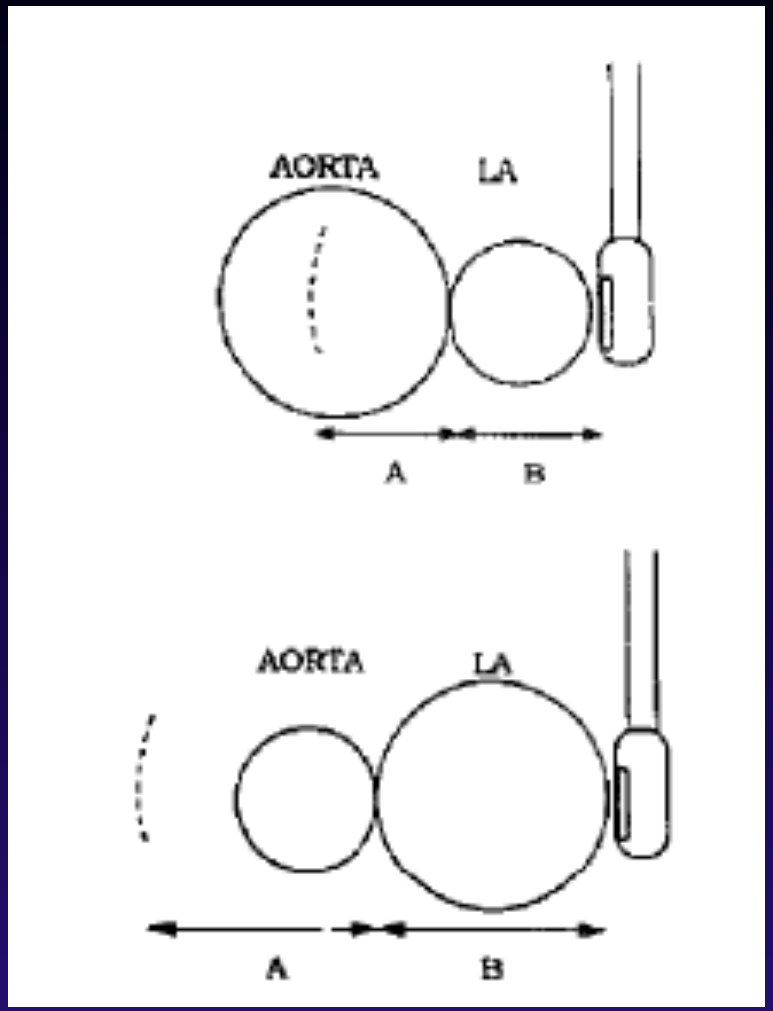
- Identification of a dissection flap
- Determine the extent of dissection & ?location of entry point
- Complications
  - Aortic valve function
  - Pericardial effusion & tamponade
  - LV function and regional wall motion (dissection of coronary ostia)

Artifacts in Aortic Imaging



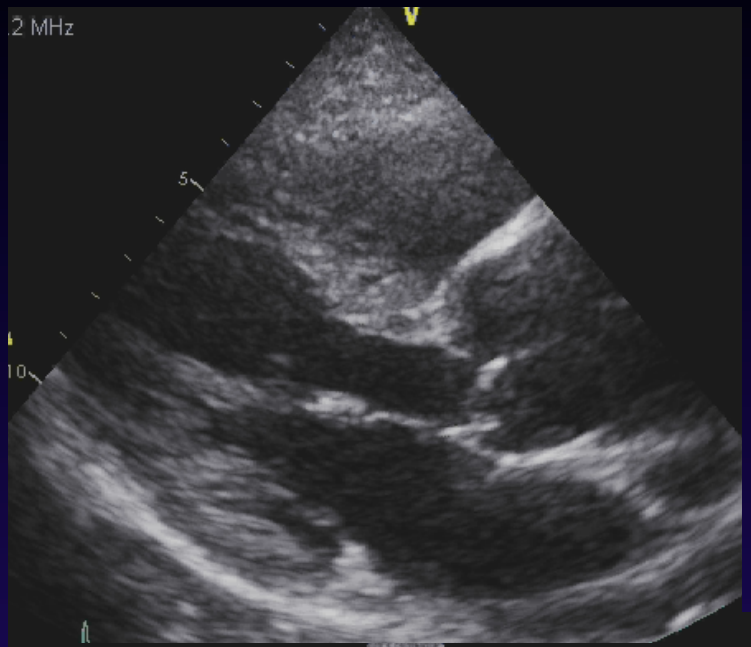
Bertrand *JASE* 2016 29:381

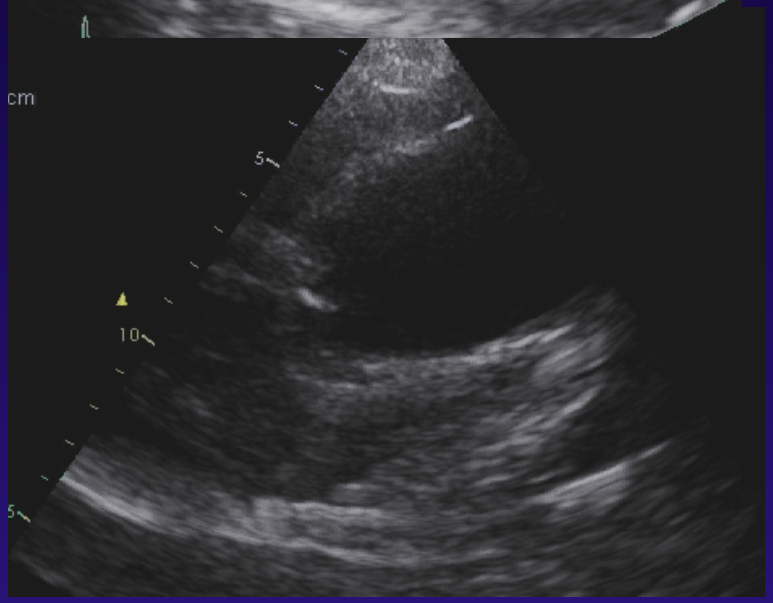
Dissection of Balloon

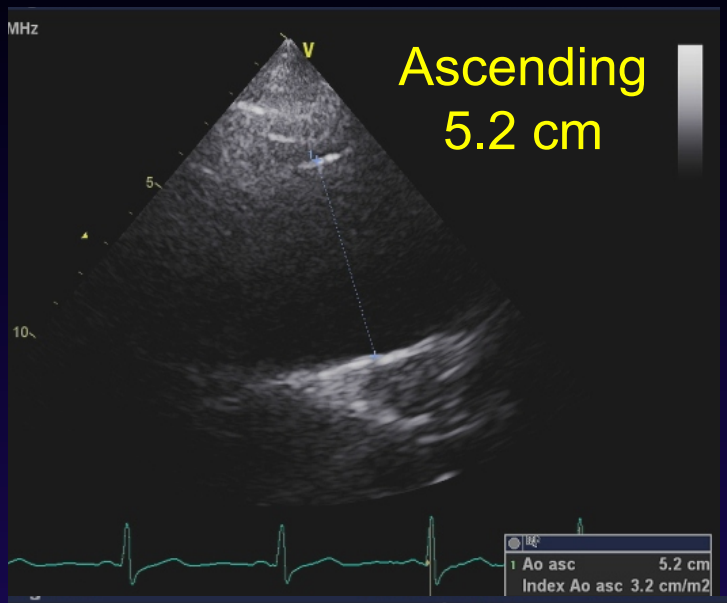


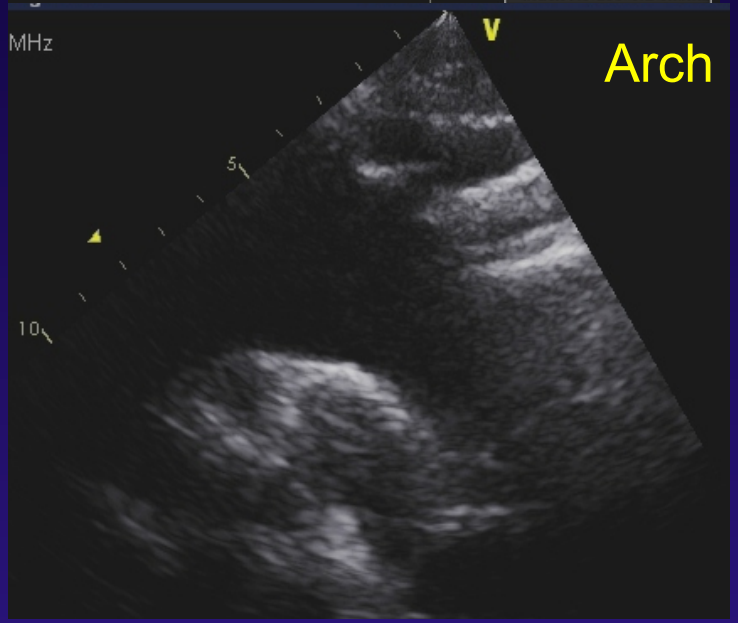
Appelbe *JACC* 1993 21:754

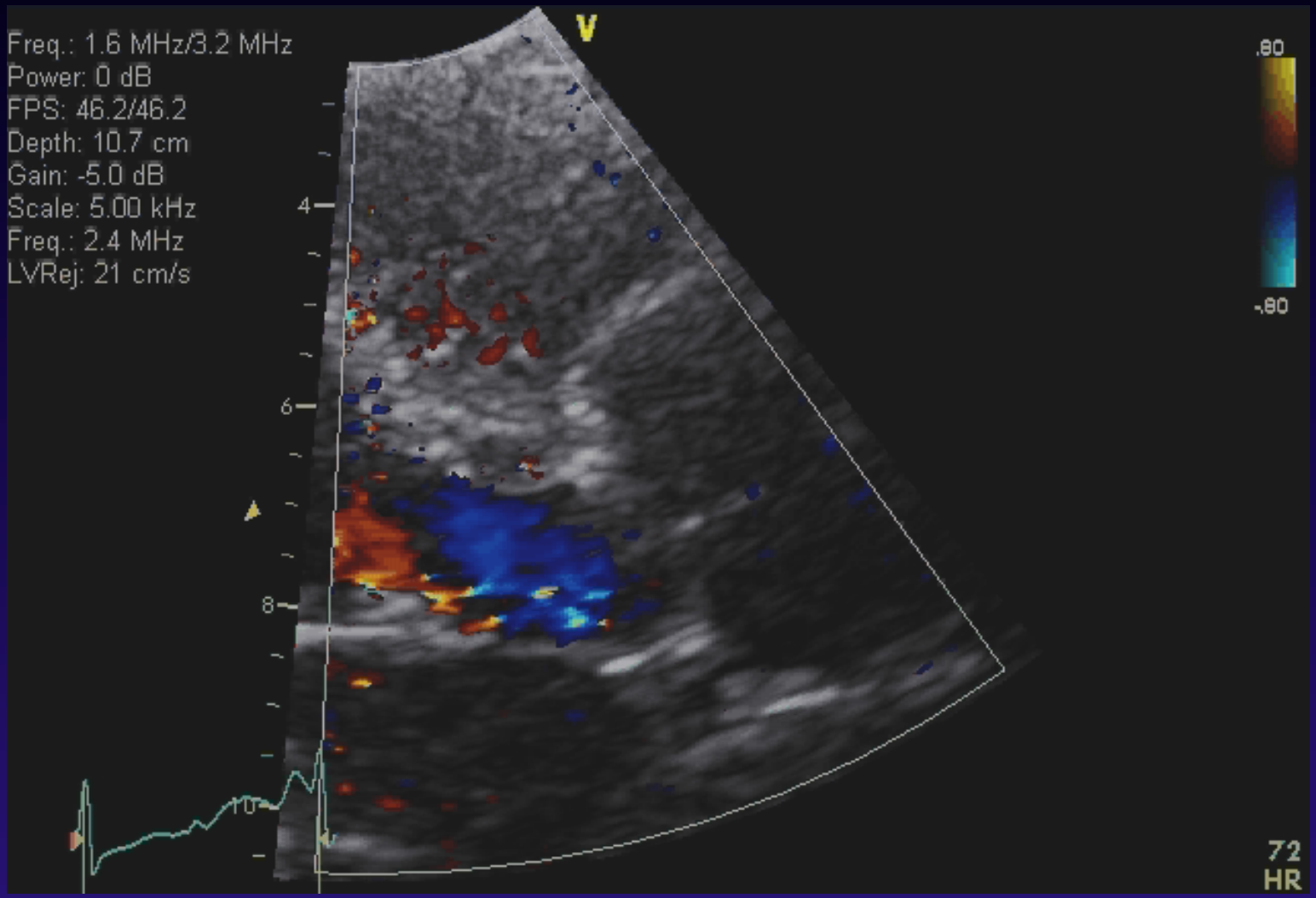
60 YO female with resistant hypertension







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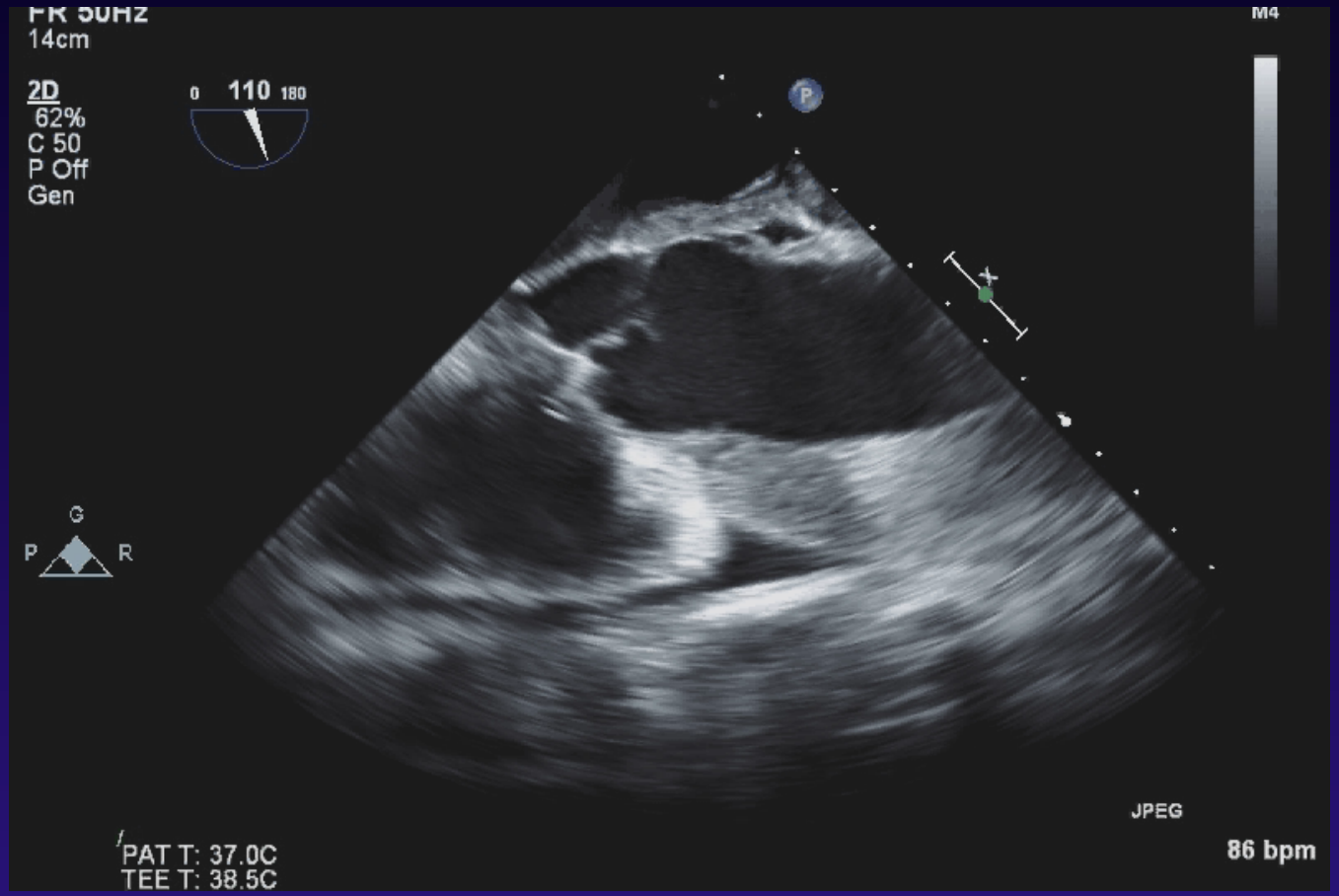
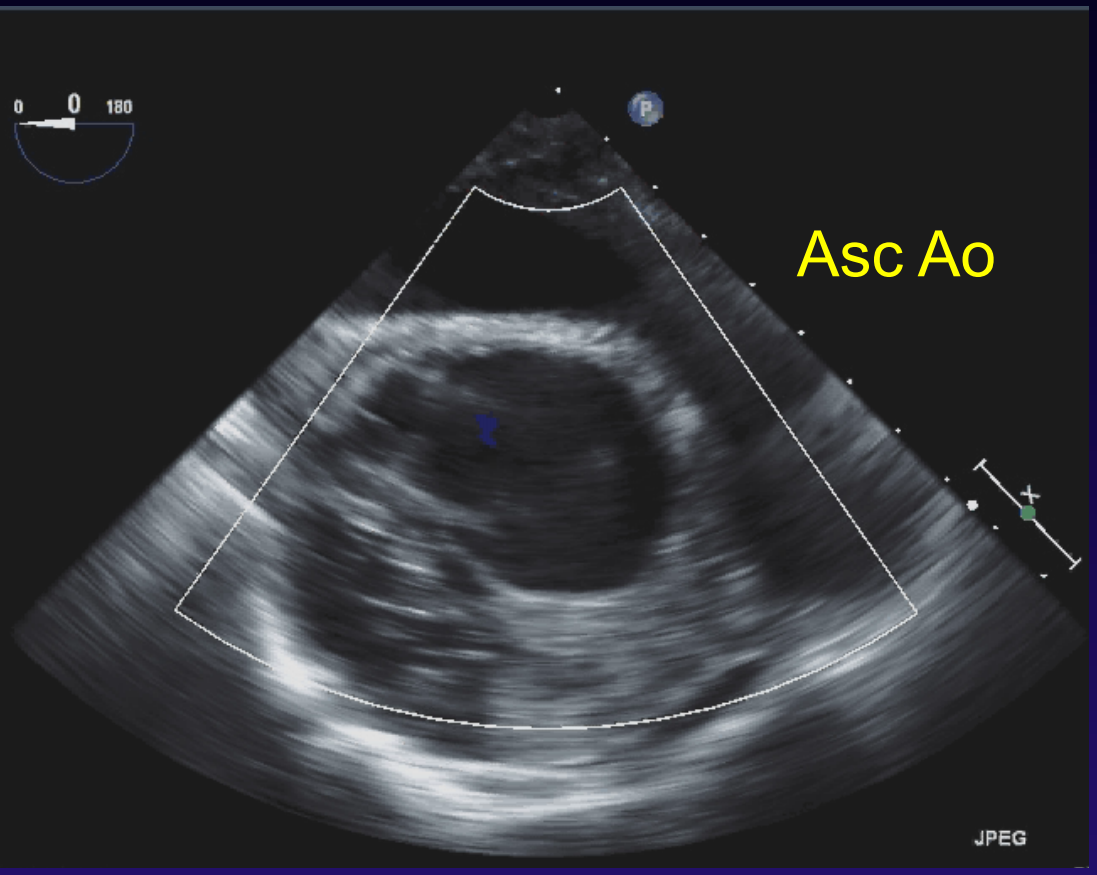
Power: 0 dB
FPS: 46.2/46.2
Depth: 10.7 cm
Gain: -5.0 dB
Scale: 5.00 kHz
Freq.: 2.4 MHz
LVRej: 21 cm/s
V
.80
-.80
4
6
8
10
72
HR

Admitted to Hospital for Ix of HPT & Aorta

- Pain during procedure with marked hypertension
- Subsequent chest pain and hypotension

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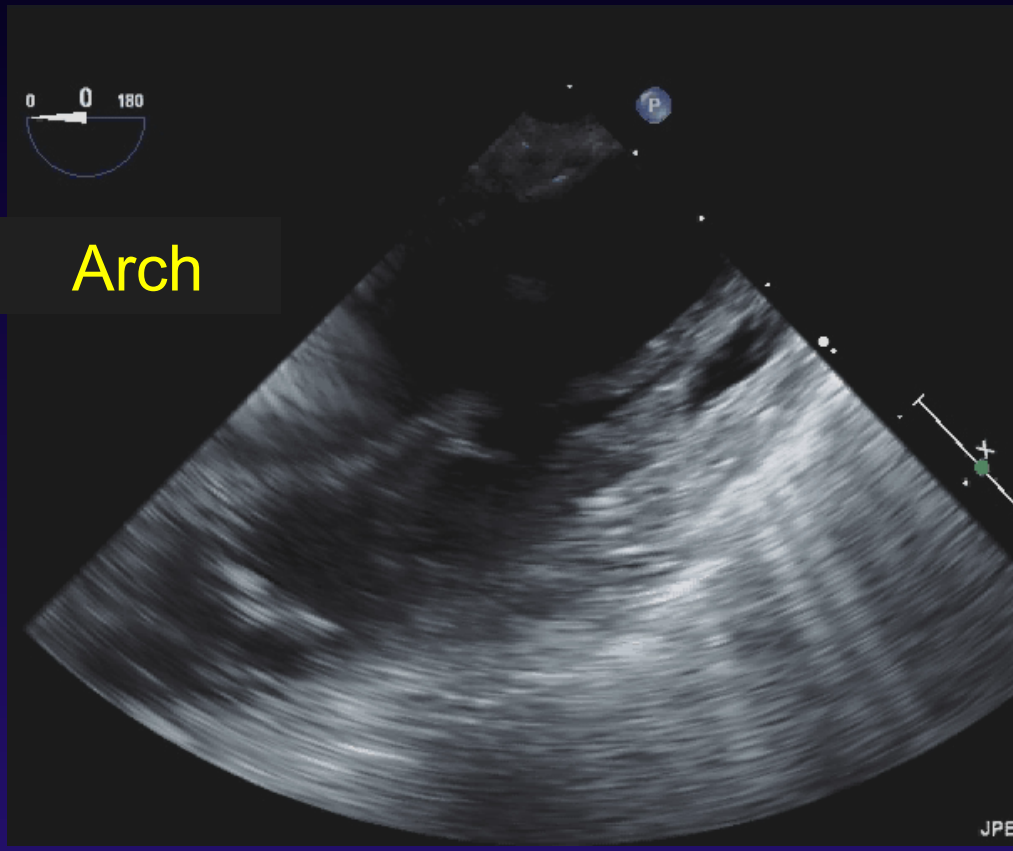
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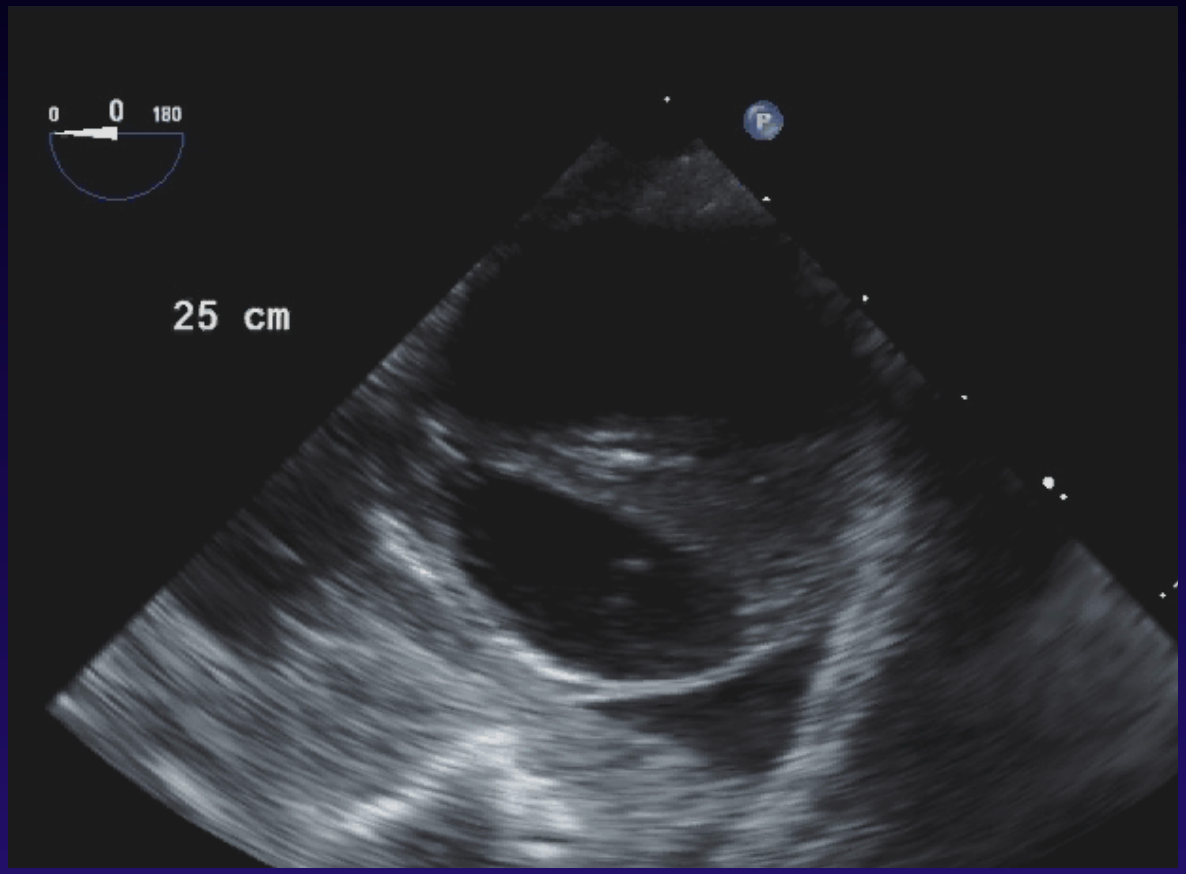
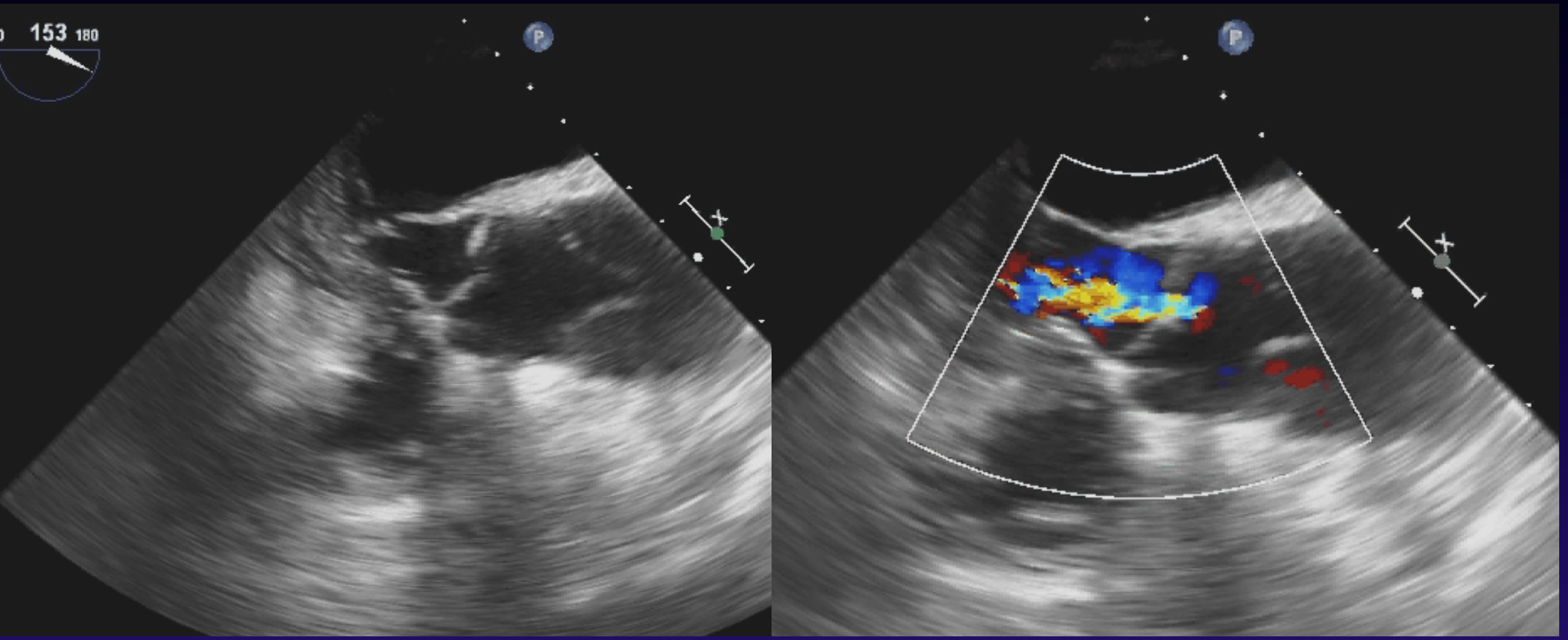
Arch

Descending Thoracic Aorta

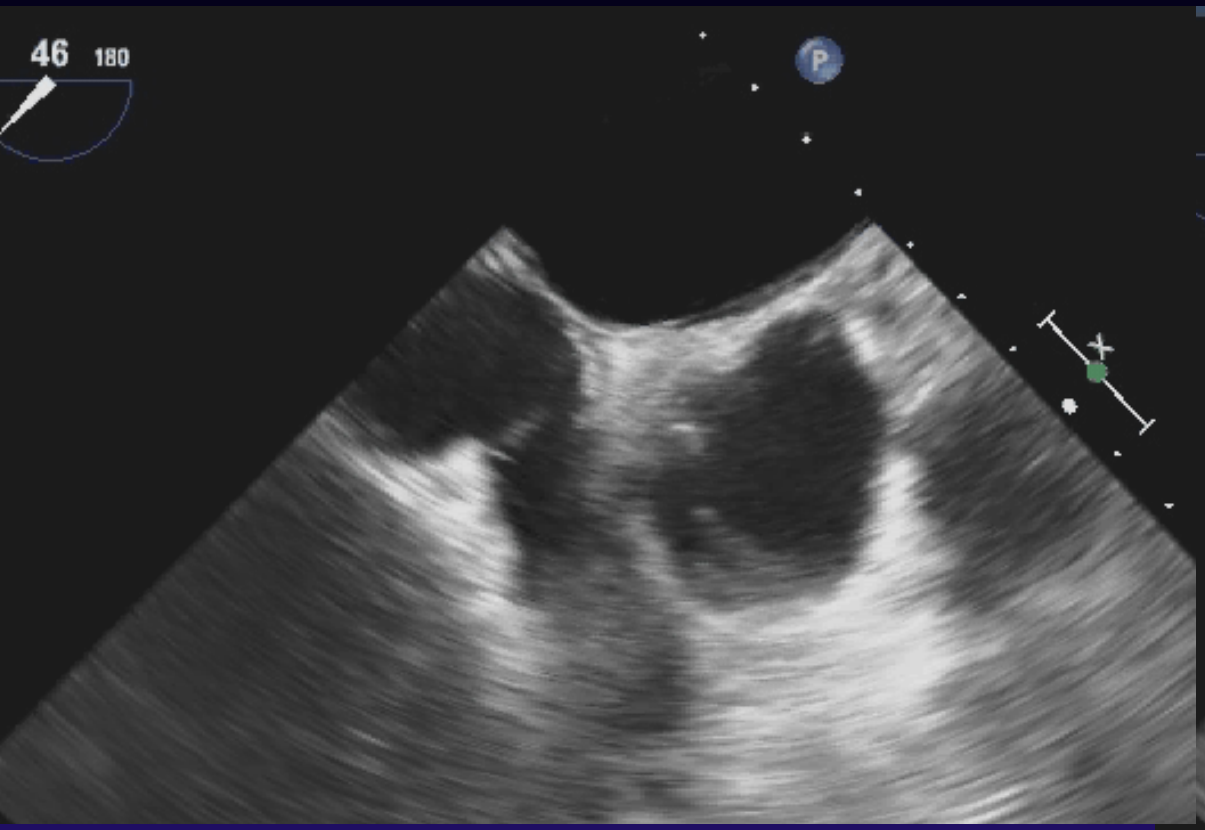


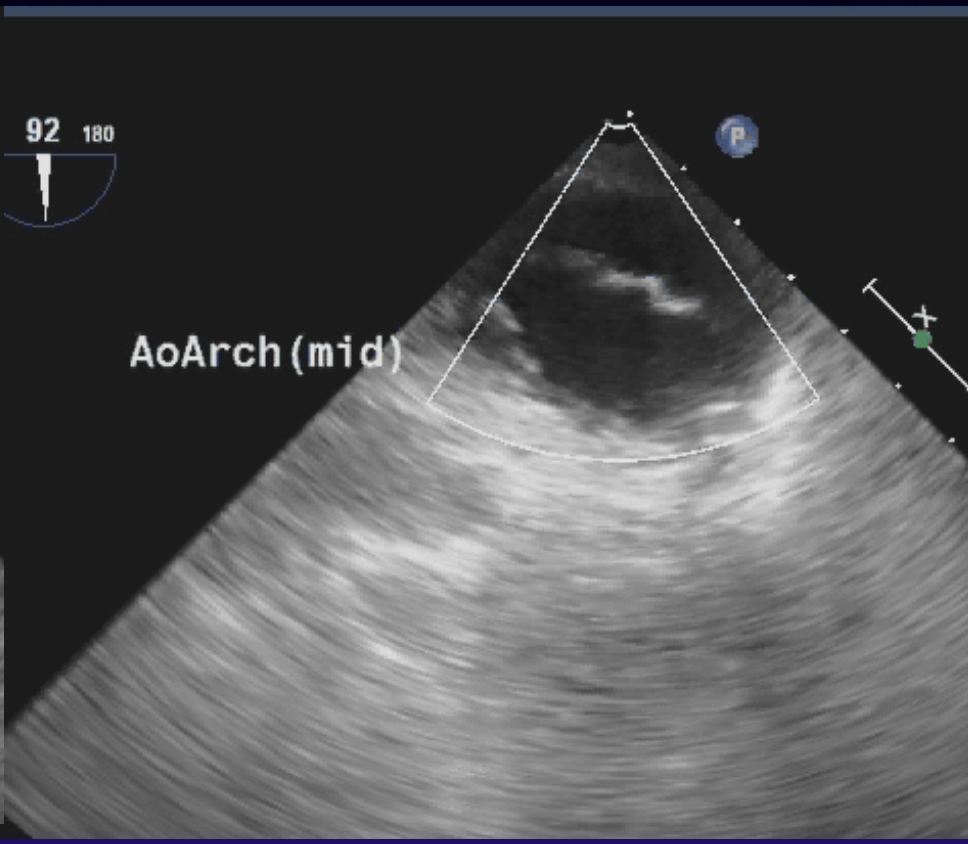
- Type A dissection
- True vs False Lumen
- Surgery

Chest Pain 3 Weeks Post CABG

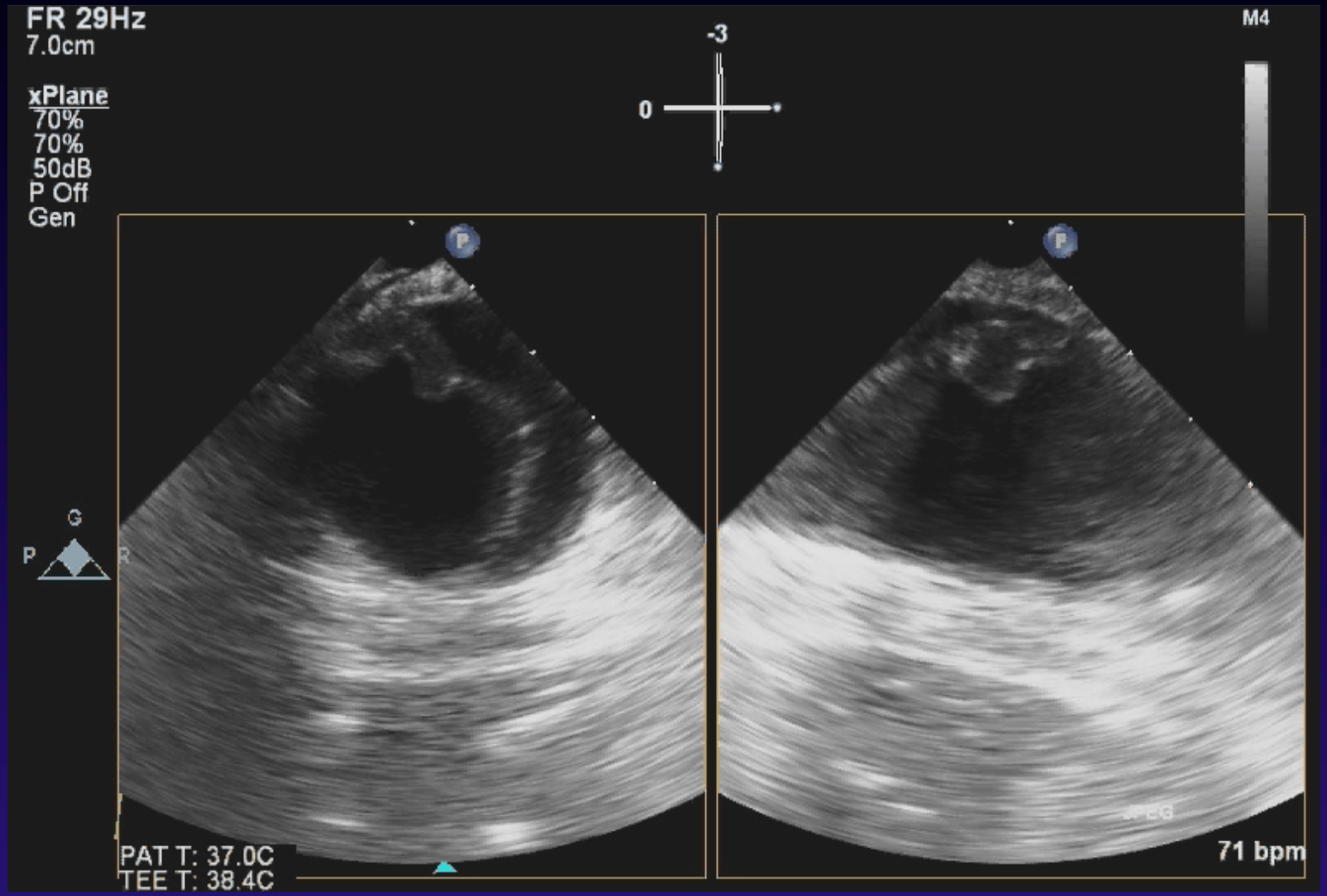


Urgent TEE

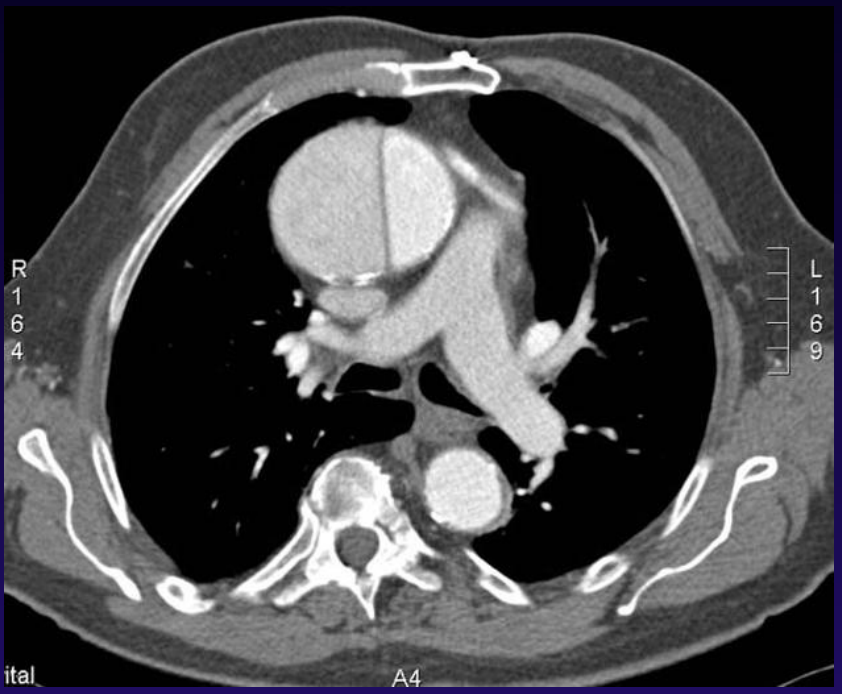


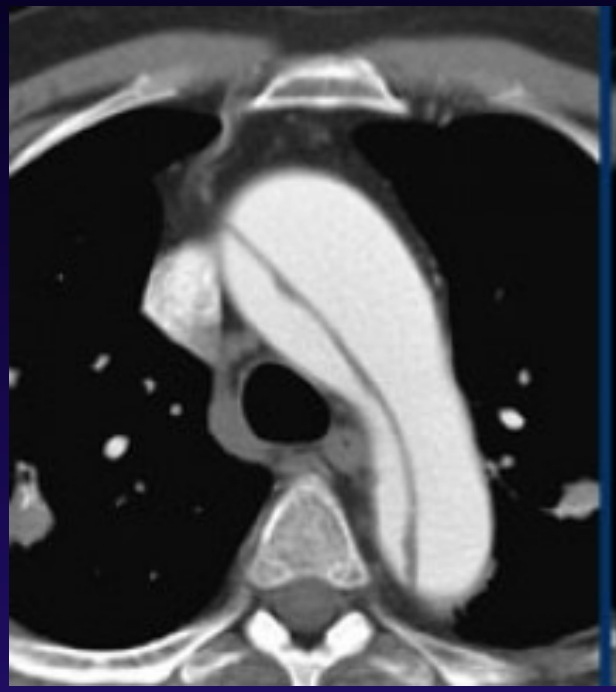


Descending Aorta

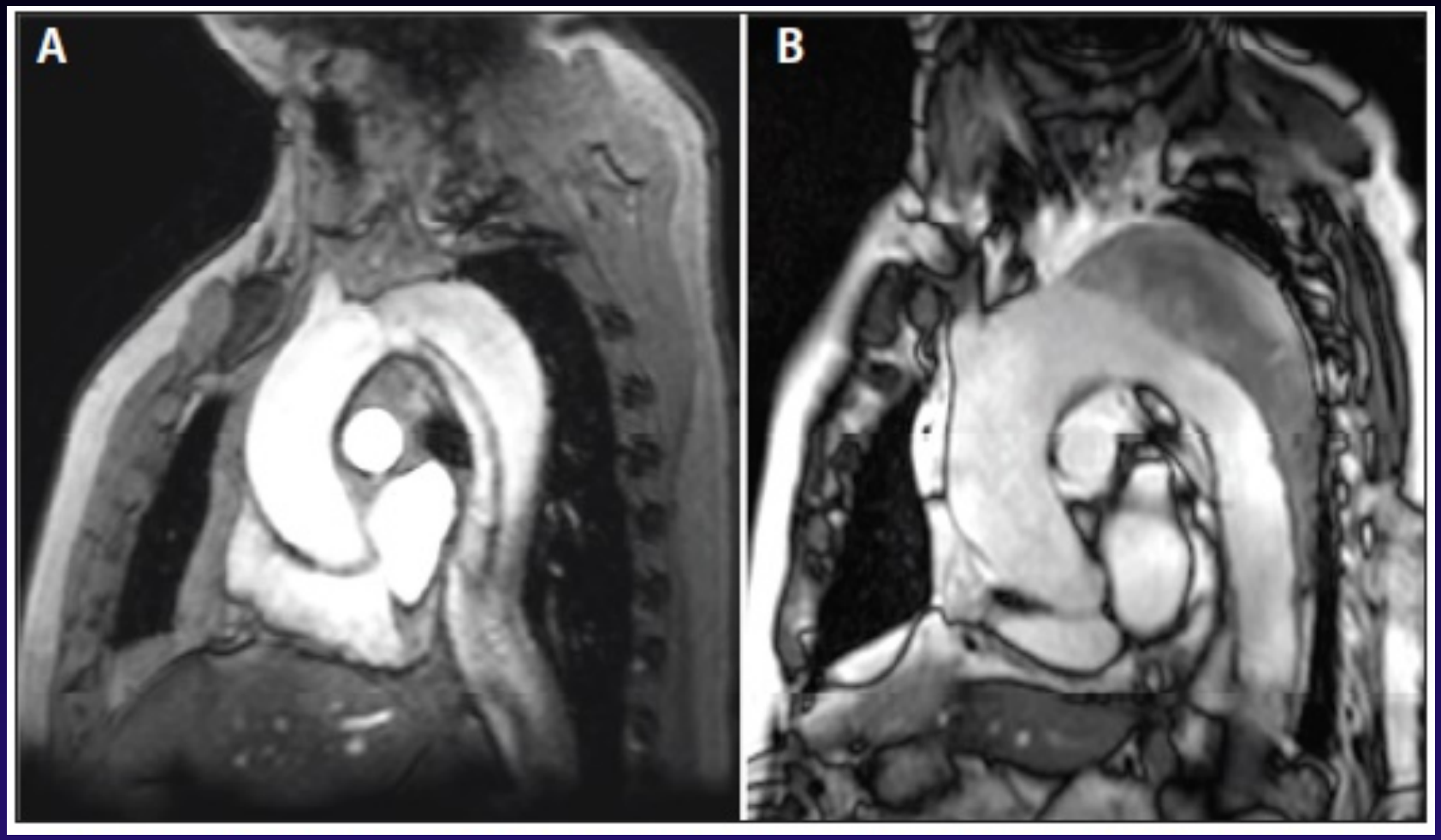


CT scanning for dissection





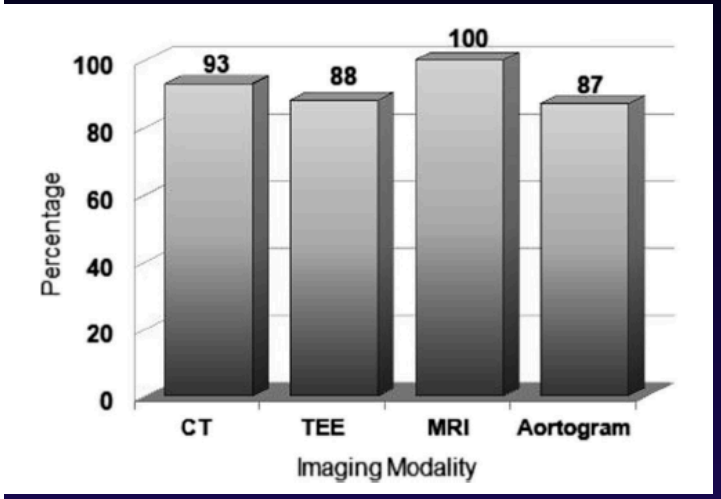
MRI for Aortic Dissection



Test Accuracy

TABLE 3 Sensitivity of the Four Imaging Modalities

Image Modality	Overall	Stanford Classification of Aortic Dissection	
		Type A	Type B
TEE	88% (170/193)	90% (144/158)	80% (28/35)
CT	93% (353/379)	93% (180/193)	93% (173/186)
MRI	100% (9/9)	100% (2/2)	100% (7/7)
Aortography	87% (21/24)	87% (13/15)	89% (8/9)



Moore *AmJCard* 2002 89:1235

Goldstein *JASE* 2015 28:119

Choice of Imaging Modality for Aortic Dissection

Table 9 Recommendation for choice of imaging modality for aortic dissection

Modality	Recommendation	Advantages	Disadvantages
CT	First-line	• Initial test in >70% of patients* • Widely available, quickest diagnostic times • Very high diagnostic accuracy • Relatively operator independent • Allows evaluation of entire aorta, including arch vessels, mesenteric vessels and renal arteries	• Ionizing radiation exposure • Requires iodinated contrast material • Pulsation artifact in ascending aorta (can be improved with ECG gating)
TEE	First- and second-line	• Very high diagnostic accuracy in thoracic aorta • Widely available, portable, convenient, fast • Excellent for pericardial effusion, and presence, degree and mechanism(s) of AR and LV function • Can detect involvement of coronary arteries • Safely performed on critically ill patients, even those on ventilators • Optimal procedure for guidance in OR	• Operator dependent (depends on skill of operator) • "Blind spot" upper ascending aorta, proximal arch • Not reliable for cerebral vessels, celiac trunk, SMA, etc. • Reverberation artifacts can potentially mimic dissection flap (can be differentiated from flaps in vast majority) • Semi-invasive
TTE	Second-line	• Often initial imaging modality in ER • Provides assessment of LV contractility, pericardial effusion, RV size and function, PA pressure • Presence and severity of AR	• Sensitivity not sufficient distal to aortic root • Descending thoracic aorta imaged less easily and accurately • Misses IMH and PAU
MRI	Third-line	• 3D multiplanar, and high resolution • Very high diagnostic accuracy • Does not require ionizing radiation or iodinated contrast • Appropriate for serial imaging over many years	• Less widely available • Difficult monitoring critically ill patients • Not feasible in emergent or unstable clinical situations • Longer examination time • Caution with use of gadolinium in renal failure
Angiography	Fourth-line	• Rarely necessary	• Often misses IMH (up to 10%–20% of ADs) • Long diagnostic time • Requires ICM • Morbidity • Less sensitivity than CT, TEE, and MRI

AD, Aortic dissection; *ECG*, electrocardiographic; *ER*, emergency room; *ICM*, iodinated contrast media; *IMH*, intramural hematoma; *LV*, left ventricular; *OR*, operating room; *PA*, pulmonary artery; *PAU*, penetrating atherosclerotic ulcer; *RV*, right ventricular; *SMA*, superior mesenteric artery.

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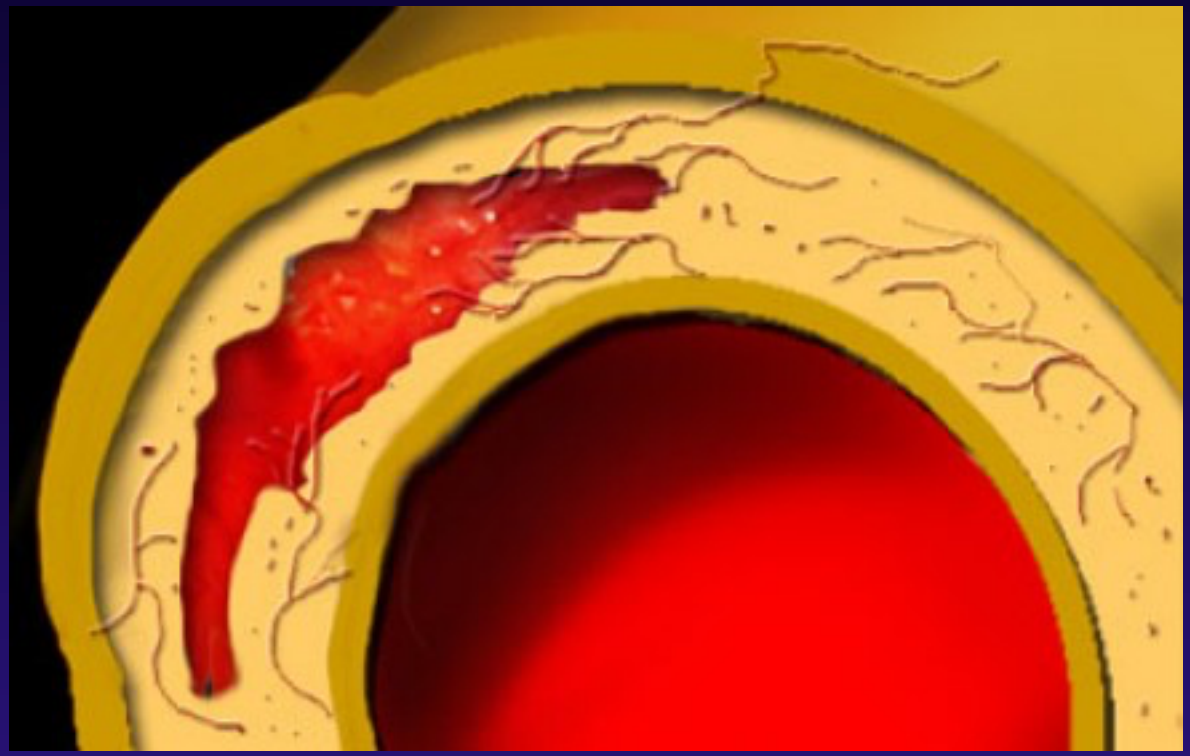
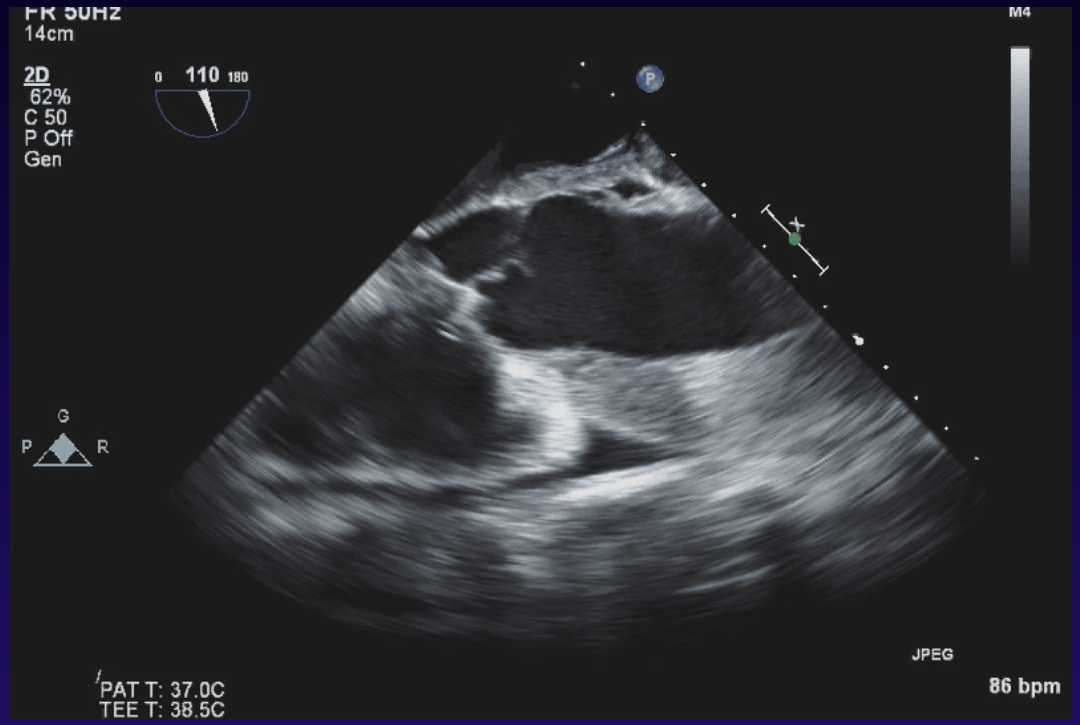
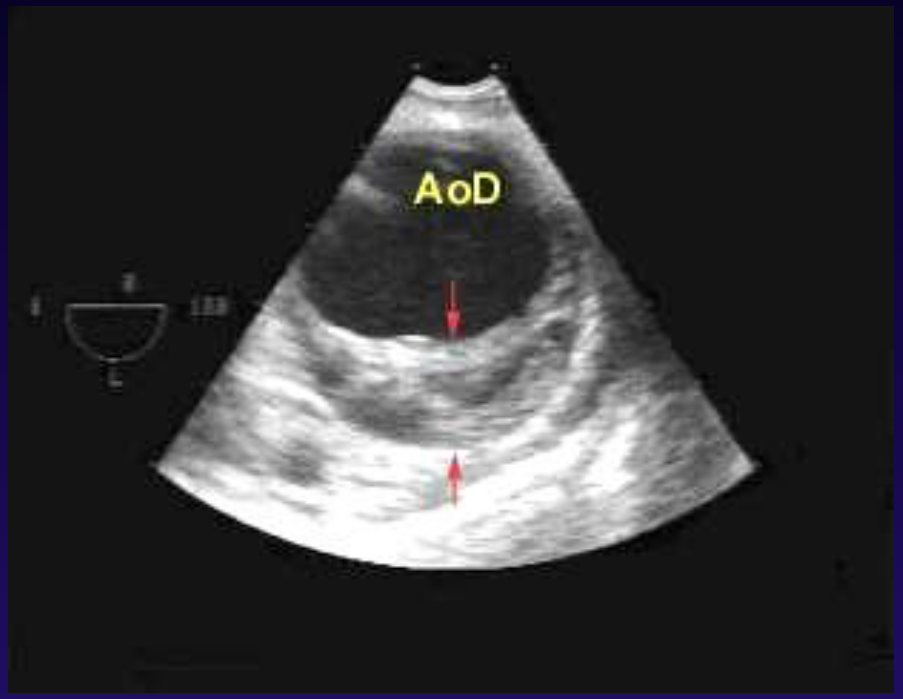
Intramural Haematoma

- A localized contained dissection



Admitted to Hospital for Ix of HPT & Aorta

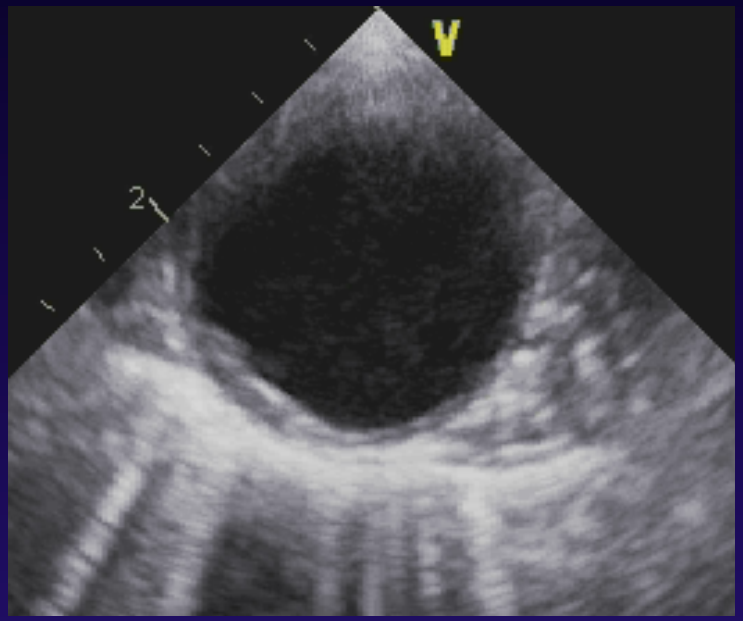


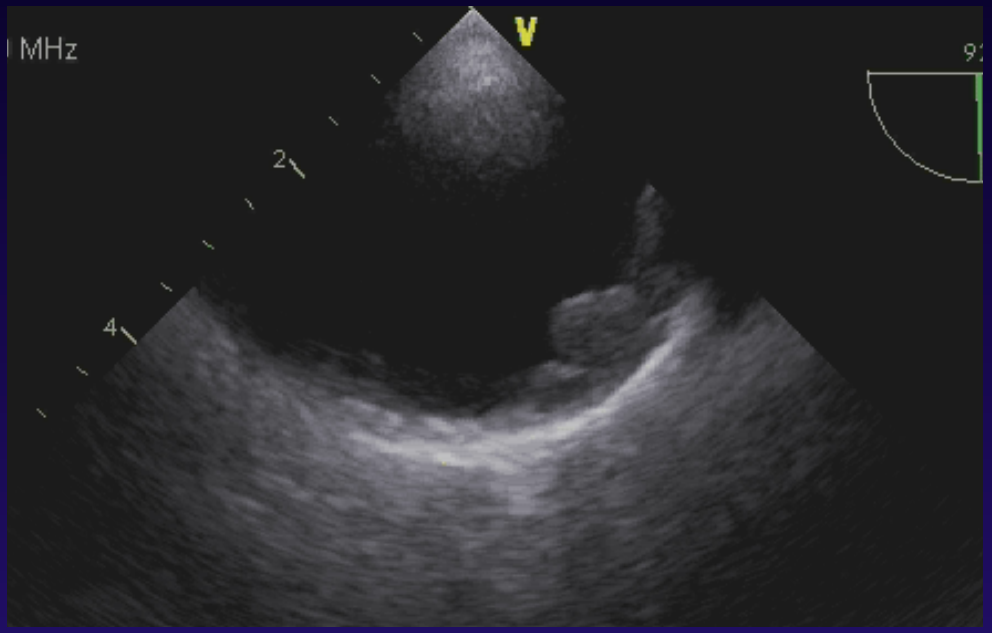


Aortic Coarctation

Aortic Atheroma

- May be a source of systemic embolism





Summary

- Both TTE and TEE have a role in the investigation & management of aortic disease
- Often used in conjunction with other imaging modalities
- Consistent and accurate measurement is critical for serial studies
- Echo provides additional information about valve & ventricular funciton in aortic dissection