# Acute Aortic Syndromes

## Evaluation by TTE and TEE
### Role of Multi-Modality Imaging

**William K. Freeman, MD, FACC, FASE**

# DISCLOSURES

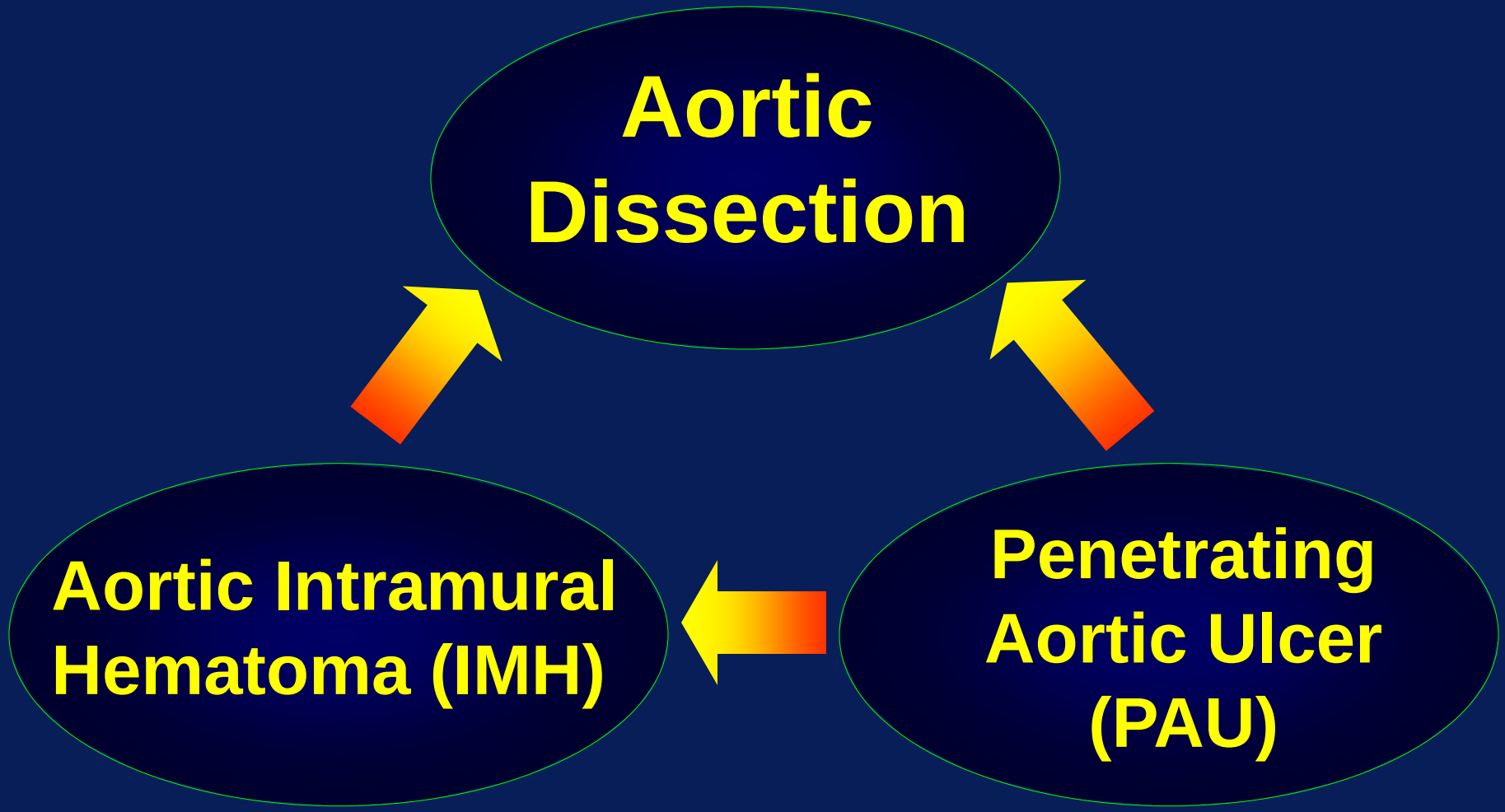
**Relevant Financial Relationship(s)**

**None**

**Off Label Usage**

**None**

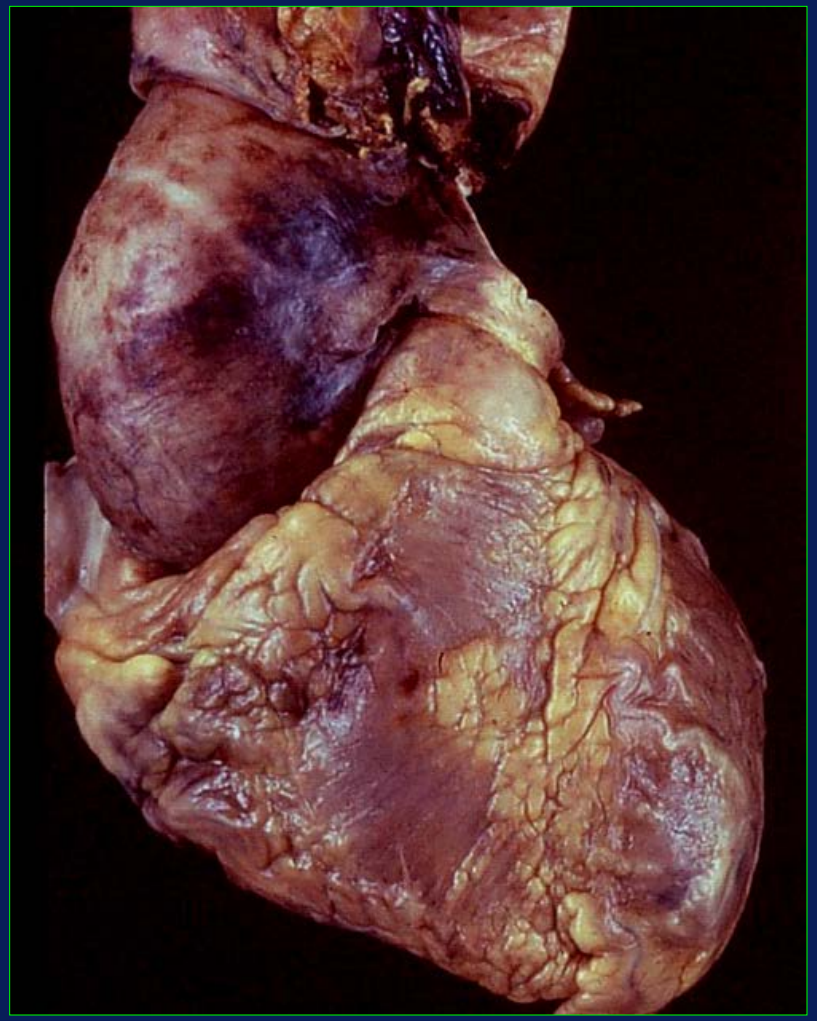
# Acute Aortic Syndrome (AAS)

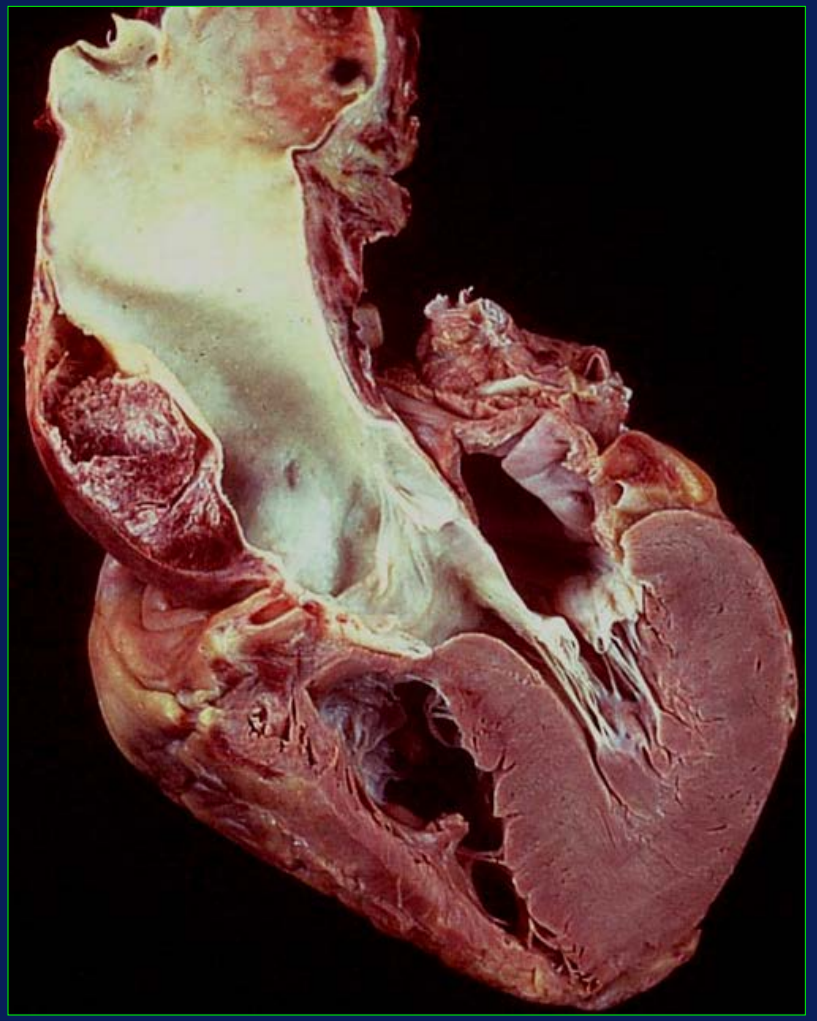



MAYO CLINIC

Vilacosta I, et al. Heart 2001; 85:365

# Aortic Dissection





MAYO CLINIC

Courtesy of WD Edwards, MD

# Risk Conditions for Aortic Dissection

- Hypertension
- Congenital
  Bicuspid AV / aortopathy, coarctation
- Connective tissue disorders
  Marfan & Ehlers-Danlos syndromes
- Iatrogenic
  Prior cardiac surgery, catheterization
- Deceleration chest trauma
- Aortitis

# Another admission with chest pain:

“ . . . No interscapular back pain . . .”

“ . . . No pulse deficits . . .”

“ . . . The chest x-ray looks OK . . .”

“ . . . This shouldn’t be dissection . . .”

# Acute Type A Aortic Dissection

## IRAD: 526 Patients (1996-2001)

| Presenting Symptoms & Signs | |
|---|---|
| No pain reported | 11% |
| Chest pain | 82% |
| Syncope | 19% |
| Neuro deficit | 14% |
| Pulse deficit | 31% |
| Shock or tamponade | 16% |



Trimarchi S, et al. J Thorac Cardiovasc Surg 2005; 129: 112

# Acute Type A Aortic Dissection

## IRAD: 526 Patients (1996-2001)

### Chest X-Ray

| | |
|---|---|
| No widened mediastinum | 38% |
| Entirely normal | 14% |

### ECG

| | |
|---|---|
| Ischemic ST-T changes | 20% |
| Acute or recent infarction | 6% |



Trimarchi S, et al. J Thorac Cardiovasc Surg 2005; 129: 112

# Clinical Misdiagnosis of Acute Aortic Syndrome

## AAS vs. ACS

**66 Patients with AAS**

**Correct Initial Dx**
40 Pts (61%); 15±5 hrs *

**Incorrect Initial Dx**
26 Pts (39%); 51±12 hrs*

**Initial Dx in 21/26 Pts: ACS**

* Time to correct Dx

**Predictors of Missed Dx: Anterior chest pain & age**



Hansen MS, et al. Am J Cardiol 2007; 99:852

# Clinical Misdiagnosis of Acute Aortic Syndrome

## AAS vs. ACS

**Incorrect Initial Dx**
**26 Pts (39%); 51±12 hrs***

→

**Therapy given:**
**ASA 100%**
**Heparin 85%**
**Fibrinolytics 12%**

| | Initial Diagnosis: Correct | Initial Diagnosis: Incorrect |
|---|---|---|
| Hemorrhagic effusion (Pericardial or pleural) | 13% | 38% |
| | | P = 0.02 |
| In-Hospital mortality | 13% | 27% |


Hansen MS, et al. Am J Cardiol 2007; 99:852

# Evaluation of Suspected Aortic Dissection
## Primary Goals of Imaging

**Establish diagnosis**

- Intimal flap

**Localization of dissection**

- Type A (ascending), Type B (descending)

**Risk of pending or ongoing aortic rupture**

- Periaortic hematoma
- Pericardial effusion/coagulum
- Saccular aortic aneurysm

# Evaluation of Suspected Aortic Dissection
## Secondary Goals of Imaging

**Delineate false lumen**

- Entry and exit tears, patency vs. thrombosis

**Aortic root and aortic valve**

- Severity and mechanism of AR
- Potential for aortic valve repair

**Coronary artery compromise**

- Dissection into coronary ostia, ostial obstruction by flap, LV function and RWMA

**Other branch-vessel involvement**

- Brachiocephalic, splanchnic, renal, iliac

# Imaging Modalities In Acute Aortic Dissection

## Aortography

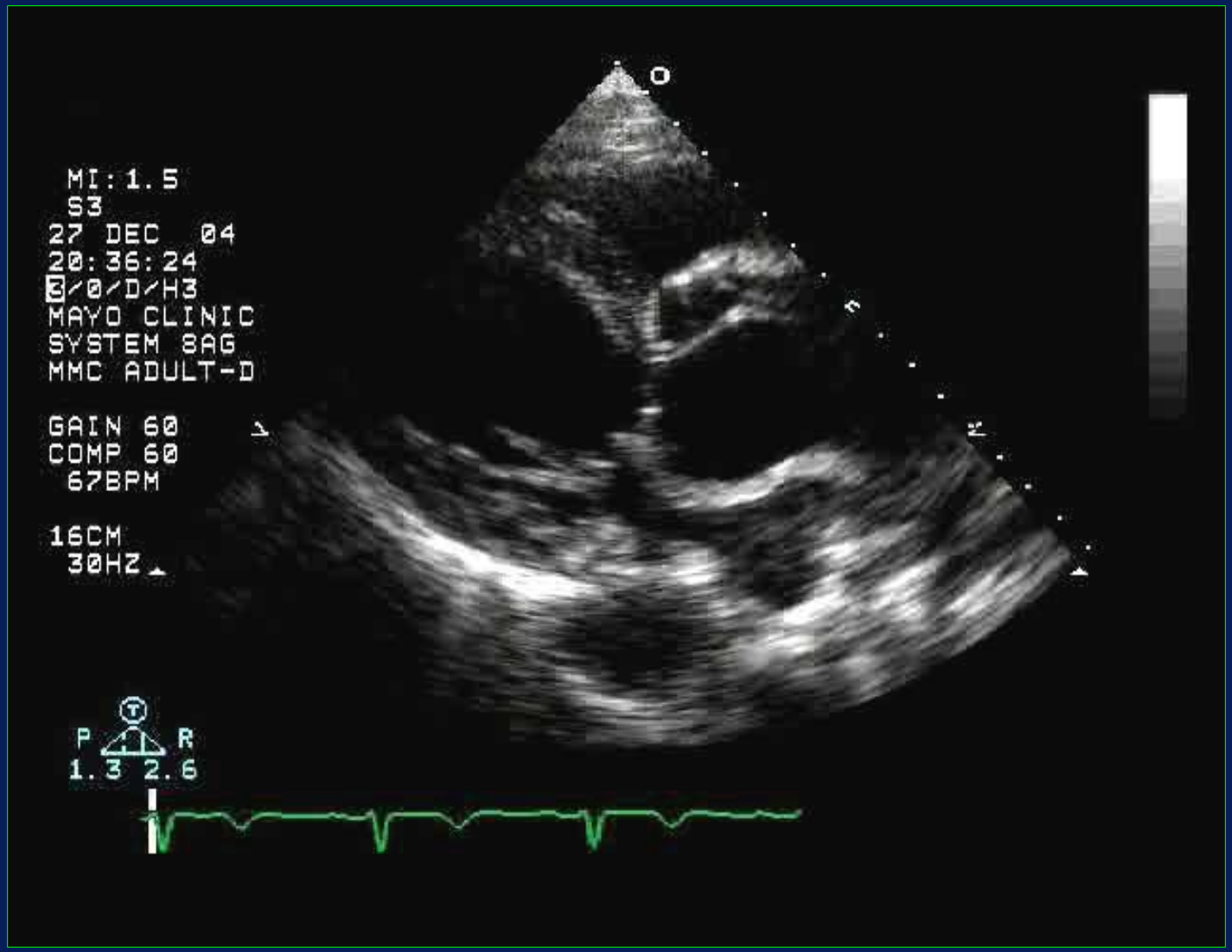
| Sensitivity | ~ 85-90% |
|---|---|

**False negative liability:**

False lumen thrombosis
Aortic intramural hematoma
Equal lumen contrast opacification

Hayter RG, et al. Radiology 2006; 238: 841
Kamalakannan D, et al. Crit Care Clin 2007; 23:779

# TTE


MI:1.5
S3
27 DEC 04
20:36:24
3/0/D/H3
MAYO CLINIC
SYSTEM SAG
MMC ADULT-D
GAIN 60
COMP 60
67BPM
16CM
30HZ
P R
1.3 2.6

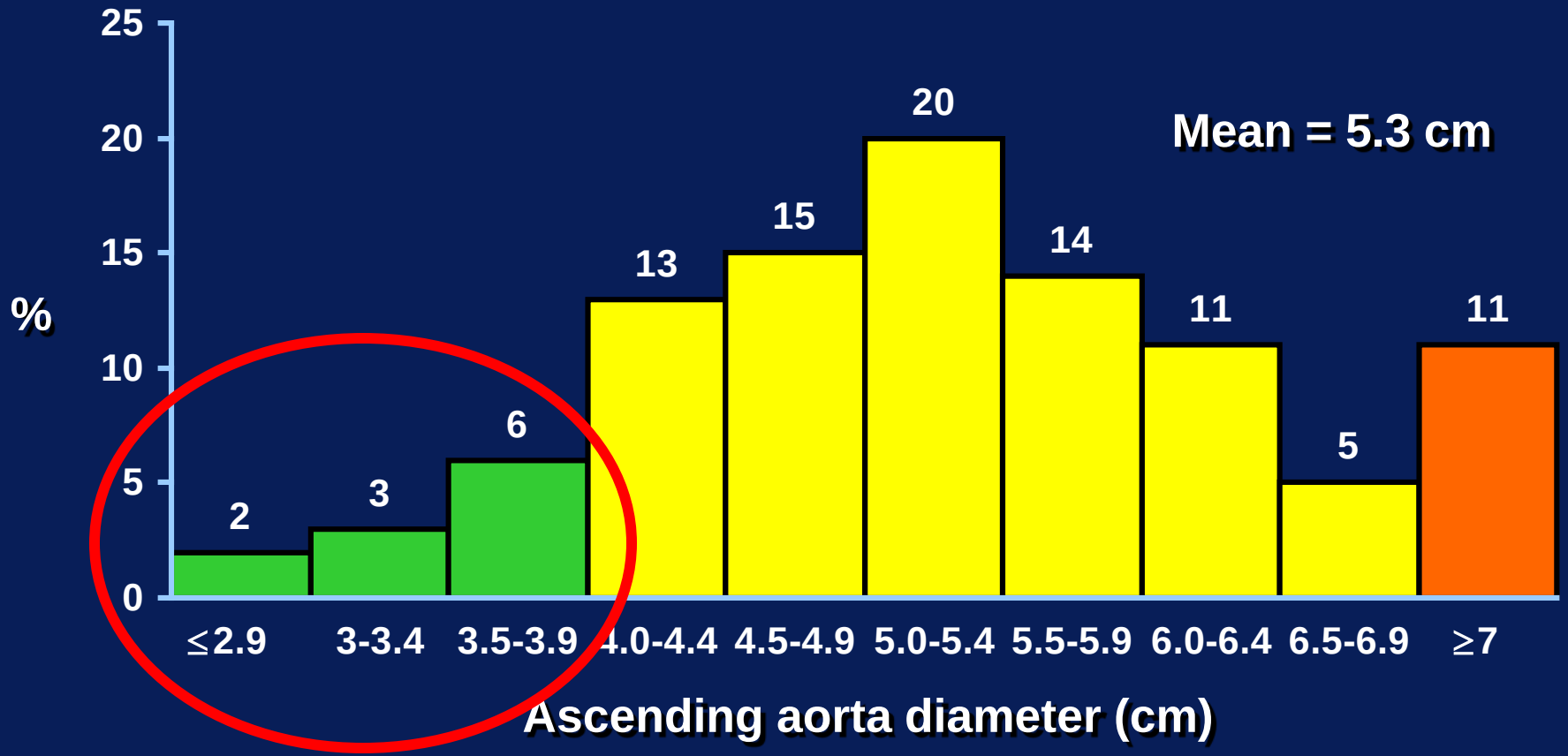
**“ . . . The ascending aorta was not dilated and looked OK on transthoracic echo . . .”**

**“ . . . This shouldn’t be dissection . . .”**

# Type A Acute Aortic Dissection

## Ascending Aortic Diameter at Presentation

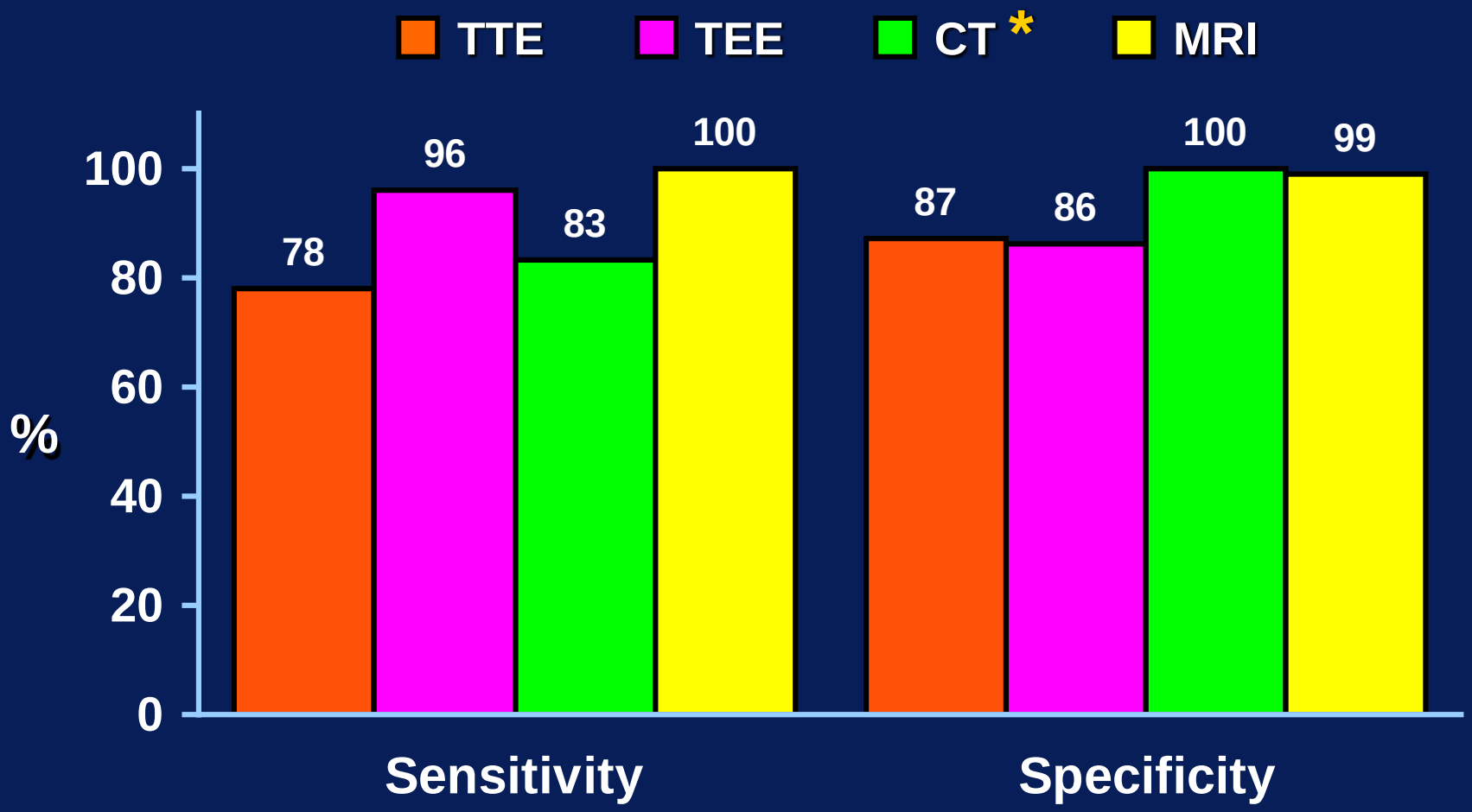
### IRAD: 591 Patients (1996-2005)






Pape LA et al: Circ 116:1120, 2007

# Noninvasive Diagnosis of Type A Aortic Dissection



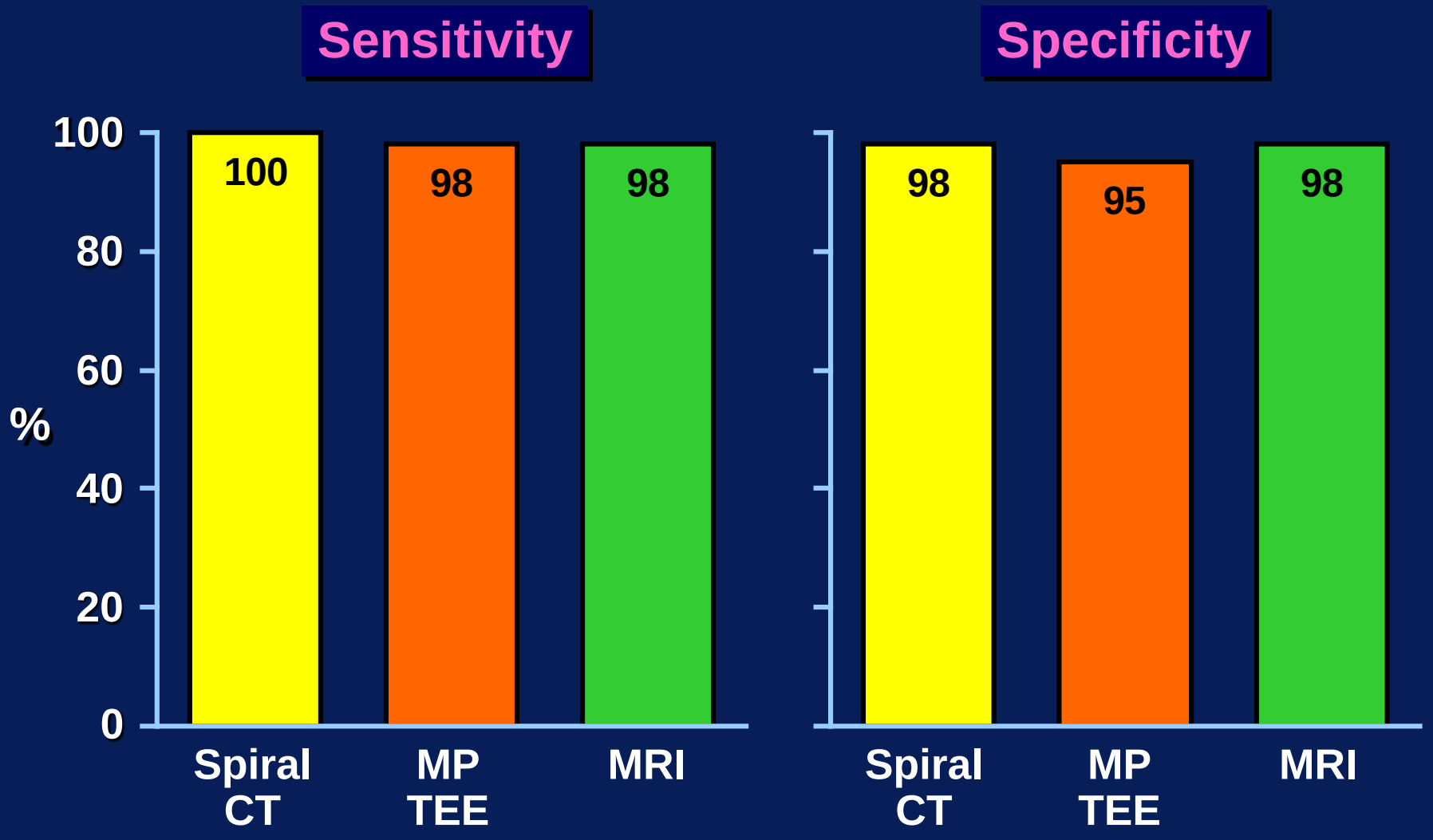

(*Early generation CT)



Nienaber CA et al: NEJM 328:1, 1993

# Contemporary Imaging in Aortic Dissection

## Spiral CT, Multiplane TEE, and MRI: Meta-Analysis of 1,139 Patients






Shiga T, et al. Arch Intern Med 2006; 166: 1350

# Acute Aortic Syndrome (AAS)
## CT Imaging

### Advantages

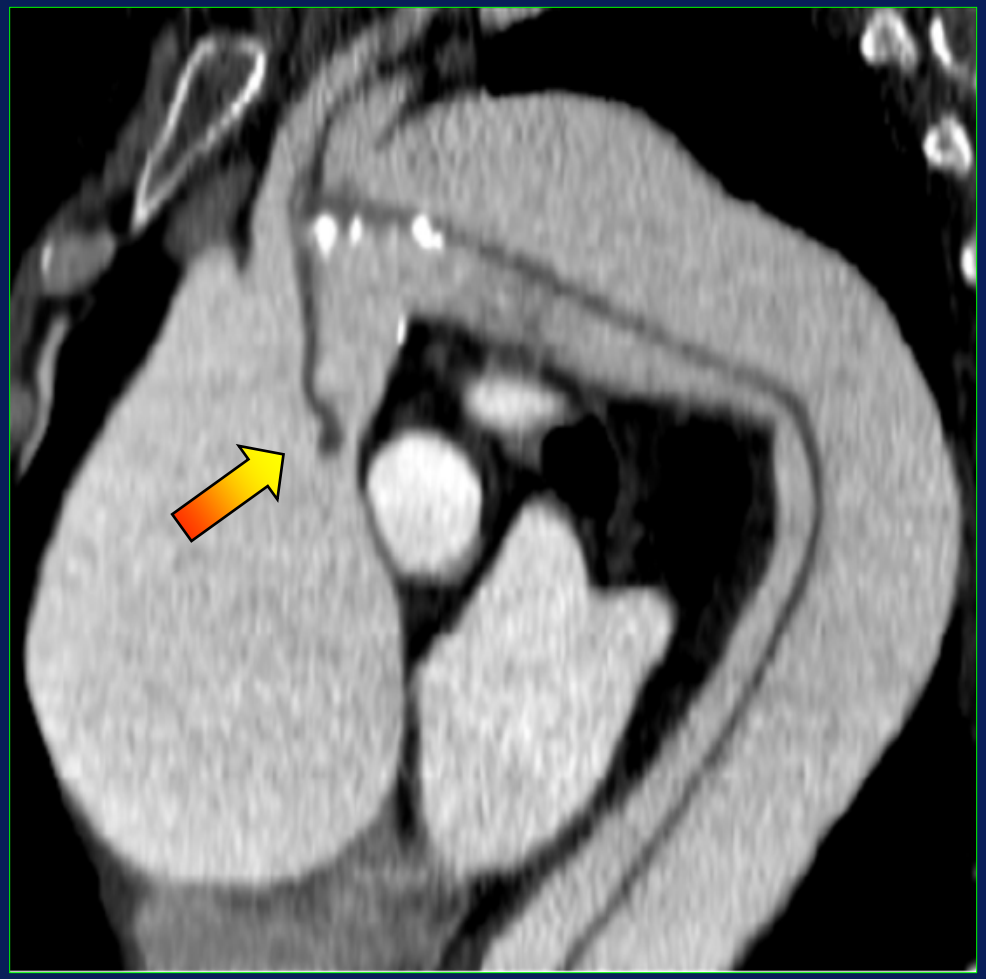
- Very readily available
- Very rapid (MDR-CT)
- Entire aorta imaged
- Branch vessels
- High resolution, 3-D reconstruction
- Least operator dependent

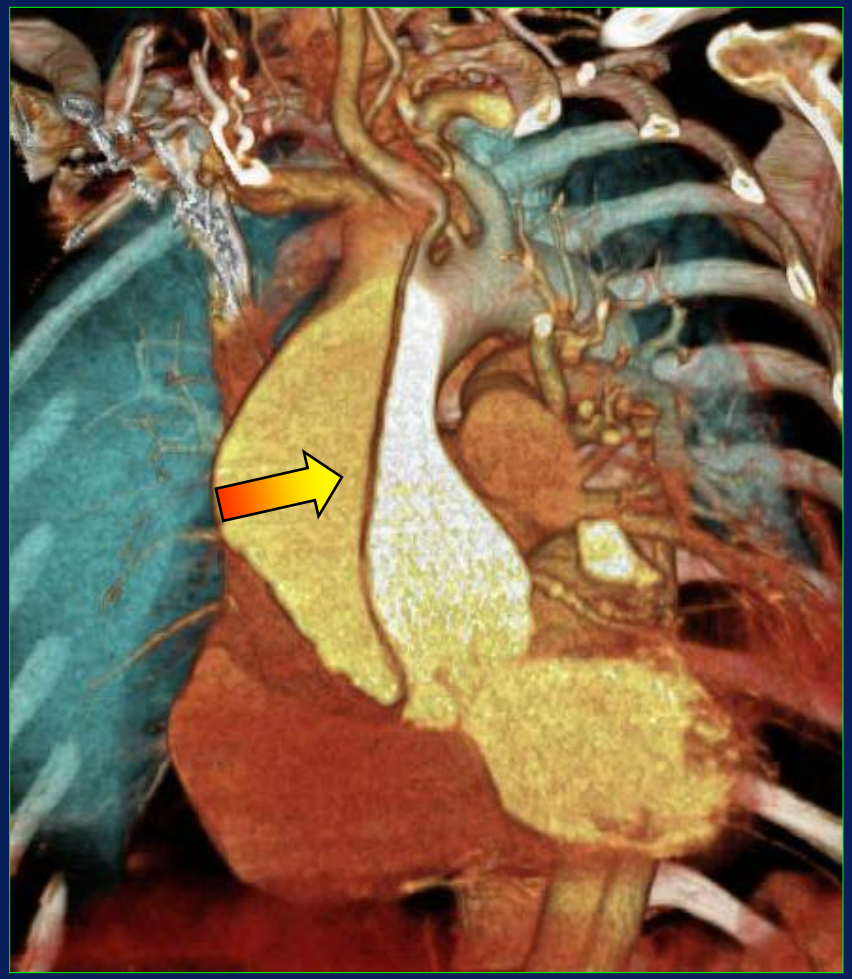
### Limitations

- Aortic valve and aortic regurgitation
- Site of intimal tear
- Contrast issues:
  - Renal dysfunction
  - Allergy
- Sequelae of pericardial effusion

# Type A Aortic Dissection

## 2-D and 3-D CT Imaging



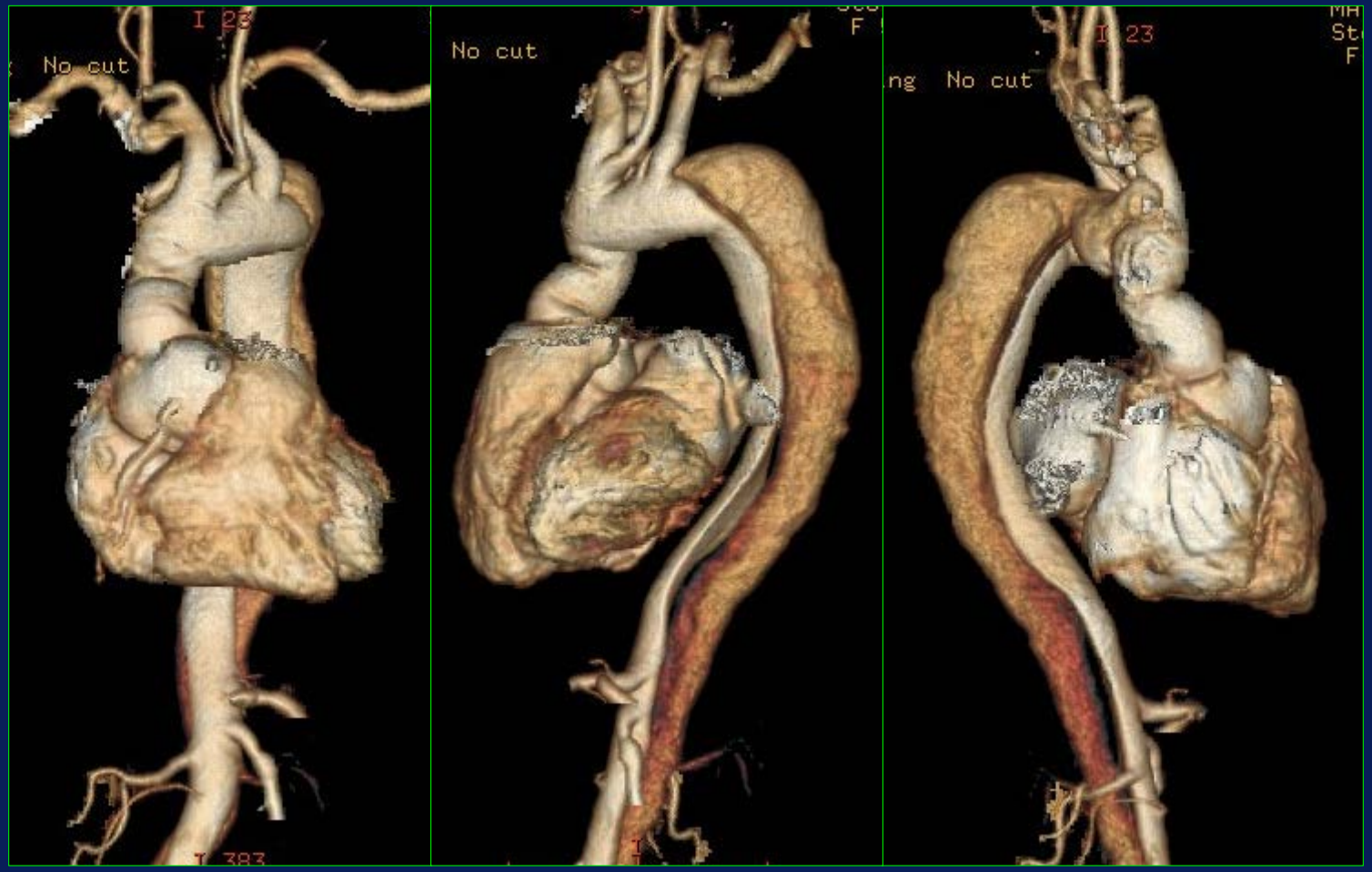


MAYO CLINIC

Courtesy of E.E. Williamson, MD

# Type B Aortic Dissection

## 3-D CT Imaging



# Acute Aortic Syndrome (AAS)

## MRI/MRA Imaging

### Advantages

- Very high resolution, 3-D reconstruction
- Gadolinium contrast *
- Entire aorta imaged
- Branch vessels
- Intraluminal flow
- Aortic regurgitation

### Limitations

- Not readily available
- Long image acquisition time
- Pacemakers, ICDs, metallic implants
- Unstable patients, limited monitoring



* If GFR < 30 ml/min, ~ 4% risk of NFD/NSF

# Aortic Dissection
## MR Imaging

MAYO CLINIC

Courtesy of E.E. Williamson, MD

# Acute Aortic Syndrome (AAS)
## TEE Imaging

### Advantages

- Readily available
- Rapid, bedside exam
- Aortic valve and aortic regurgitation
- Color Doppler of intraluminal flow
- Pericardial effusion and sequelae

### Limitations

- Distal ascending aorta, innominate artery
- Thoracic aorta only
- Branch vessels
- Reverberation artifacts
- Highly operator dependent

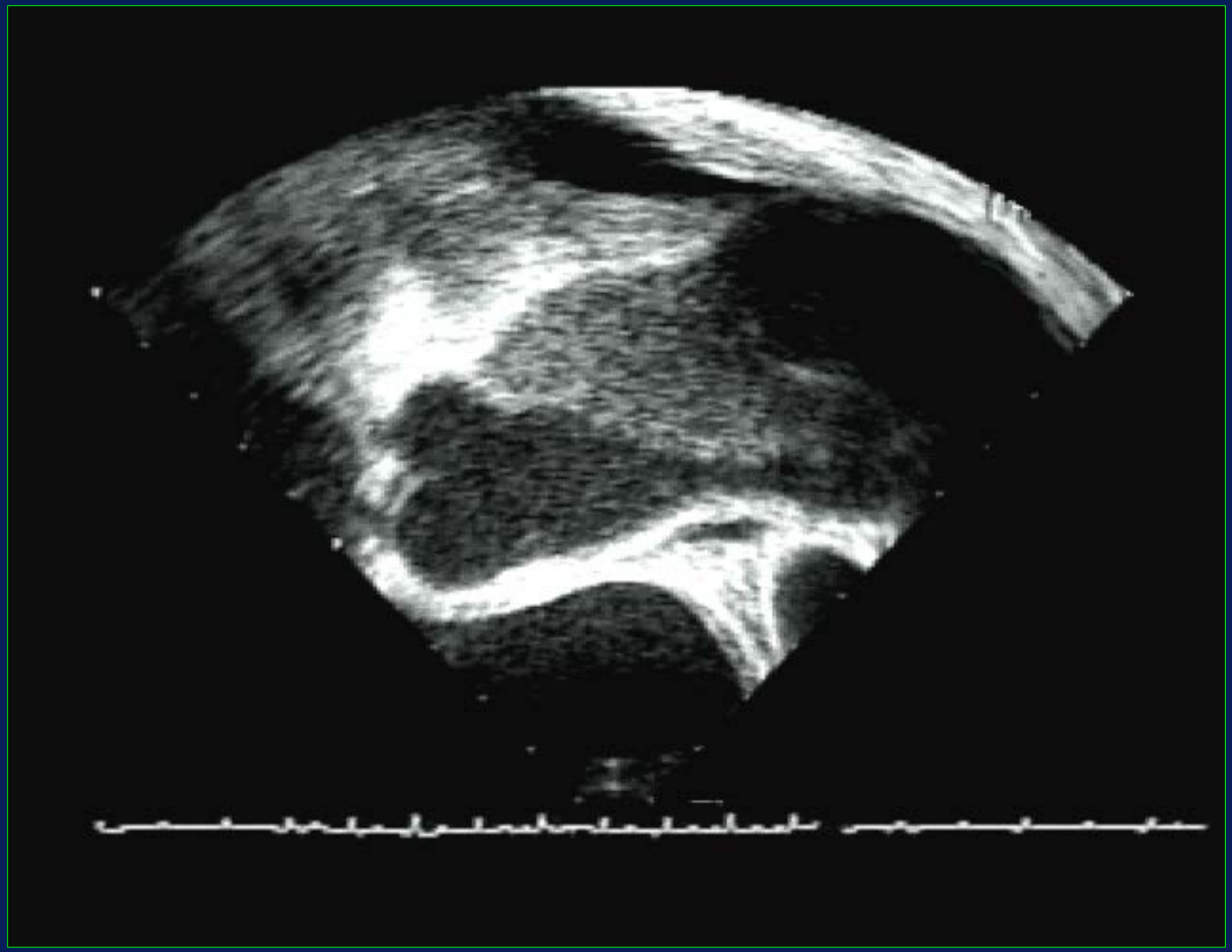
# Acute Type A Aortic Dissection

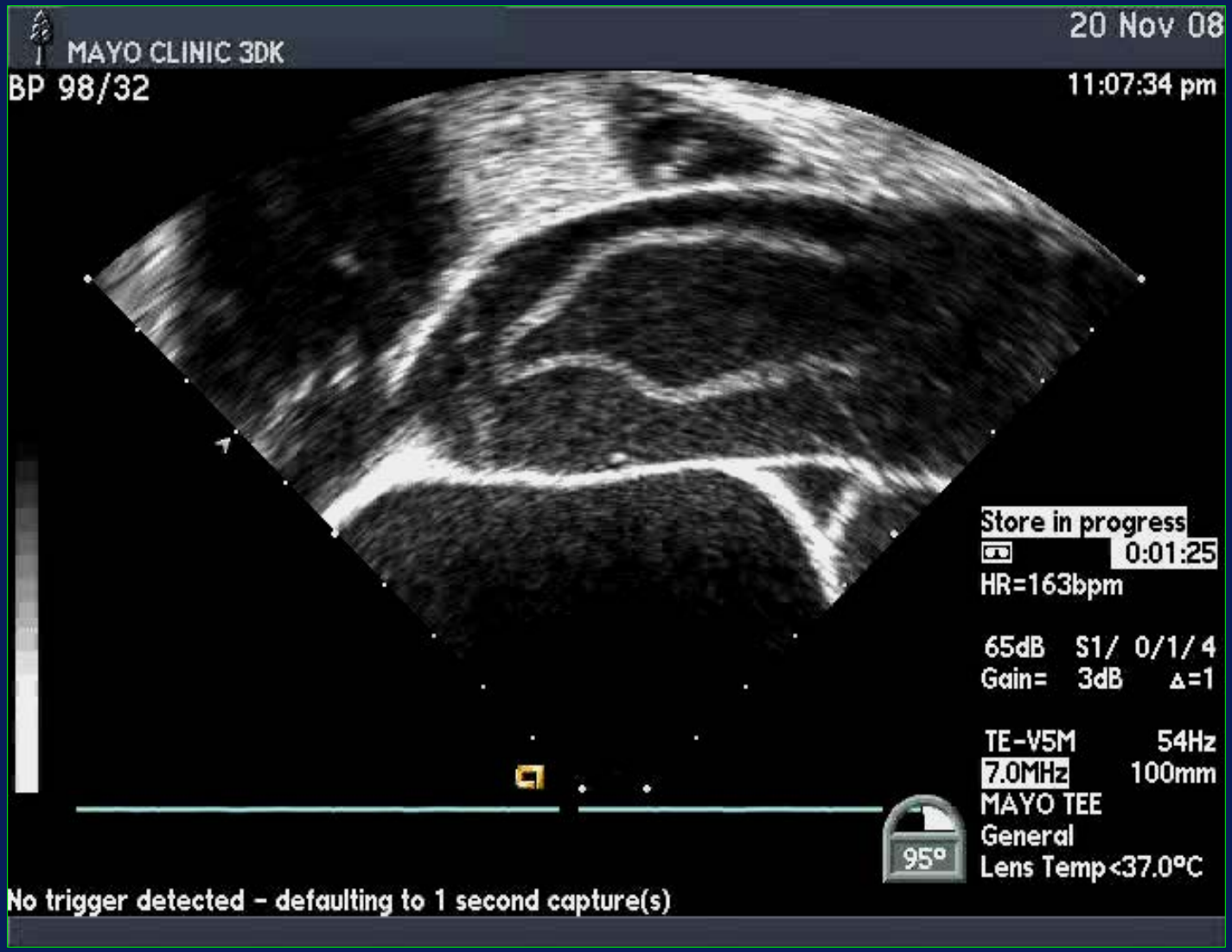
## Intimal Flap: TEE in 40 Patients

| Intimal Flap | |
|---|---|
| Simple linear | 55% |
| Circumferential | 20% |
| Complex | 25% |
| Prolapse into LVOT | 15% |
| Entrance tear detected | 78% |



Armstrong WF, et al. J Am Soc Echocardiogr 1996: 9: 646

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Store in progress
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65dB S1/ 0/1/ 4
Gain= 3dB Δ=1
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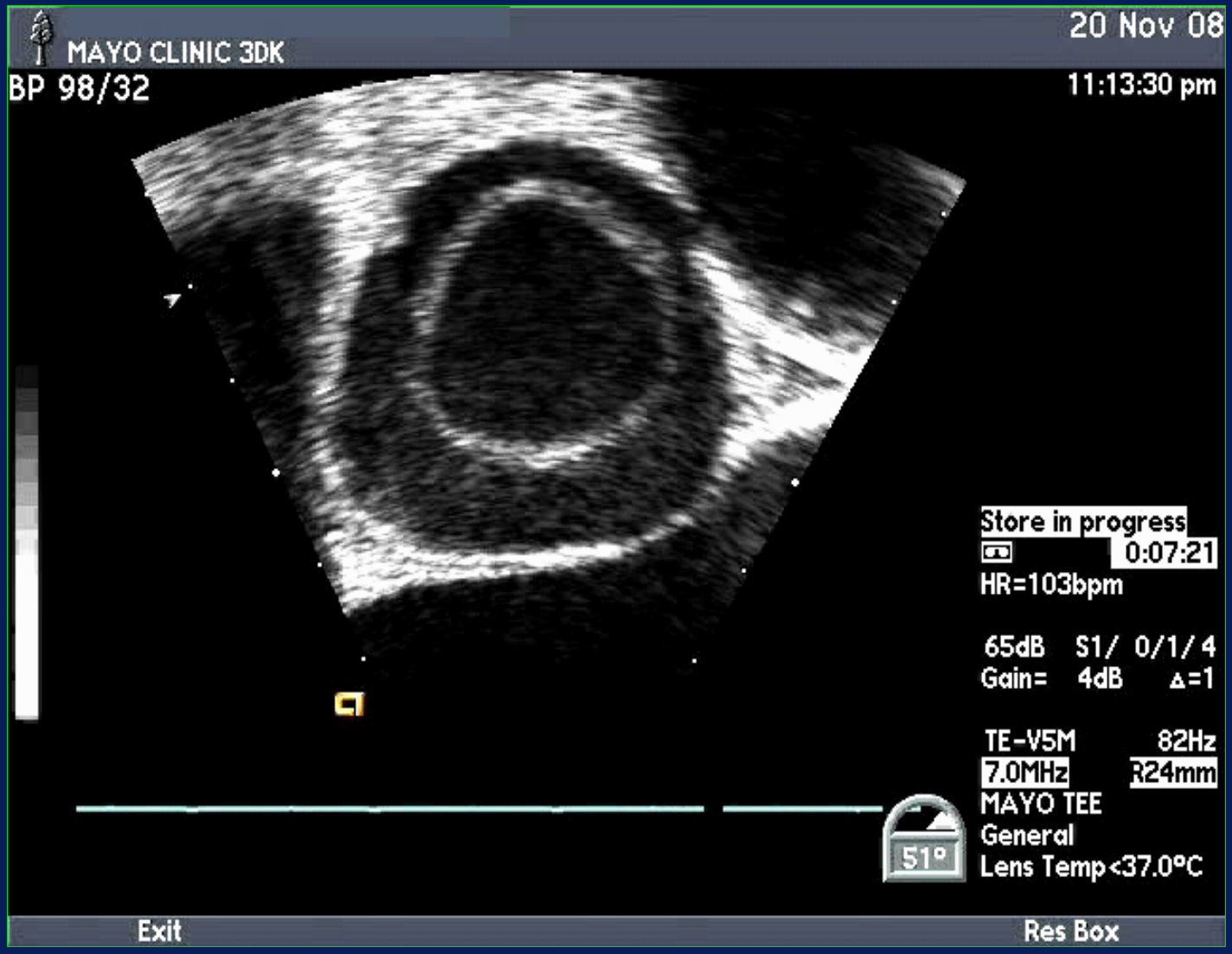
7.0MHz 100mm
MAYO TEE
General
Lens Temp<37.0°C
95°
No trigger detected - defaulting to 1 second capture(s)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TE-V5M 82Hz
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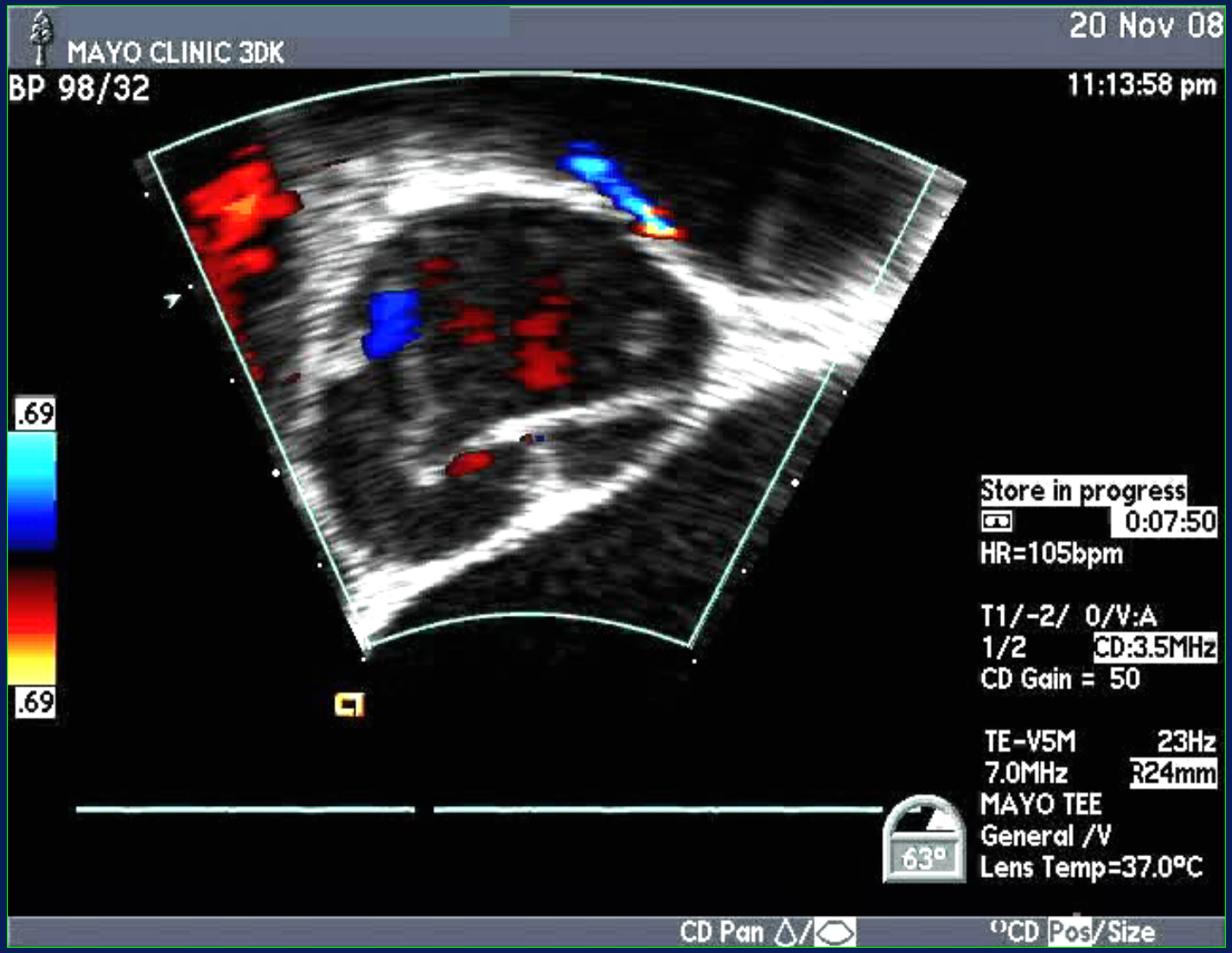
MAYO TEE
General
Lens Temp<37.0°C
51°
Exit
Res Box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BP 98/32
11:13:58 pm
.69
.69
Store in progress
0:07:50
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T1/-2/ 0/V:A
1/2
CD:3.5MHz
CD Gain = 50
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R24mm
MAYO TEE
General /V
Lens Temp=37.0°C
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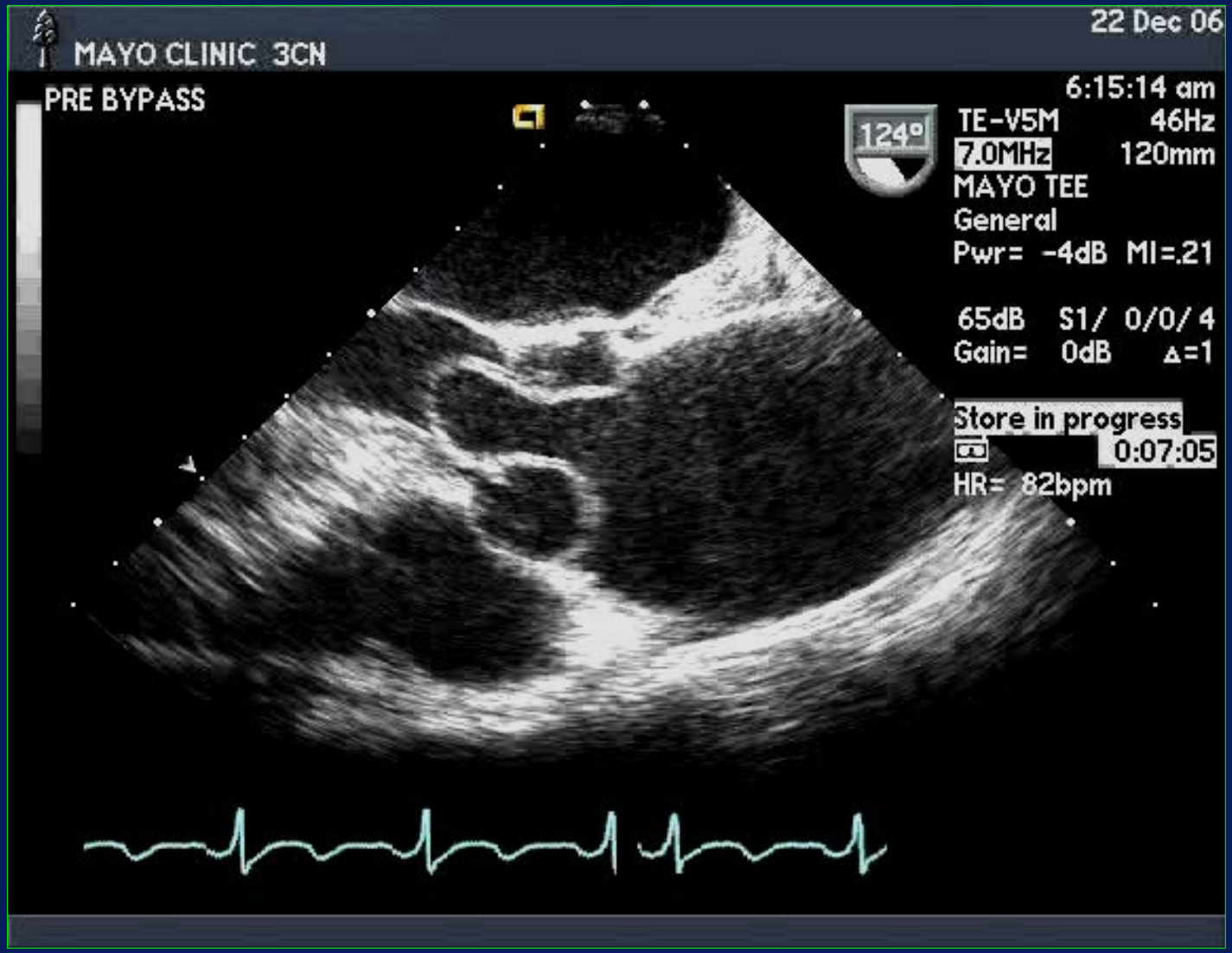
CD Pan
CD Pos/Size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PRE BYPASS
6:15:14 am
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TE-V5M
46Hz
7.0MHz
120mm
MAYO TEE
General
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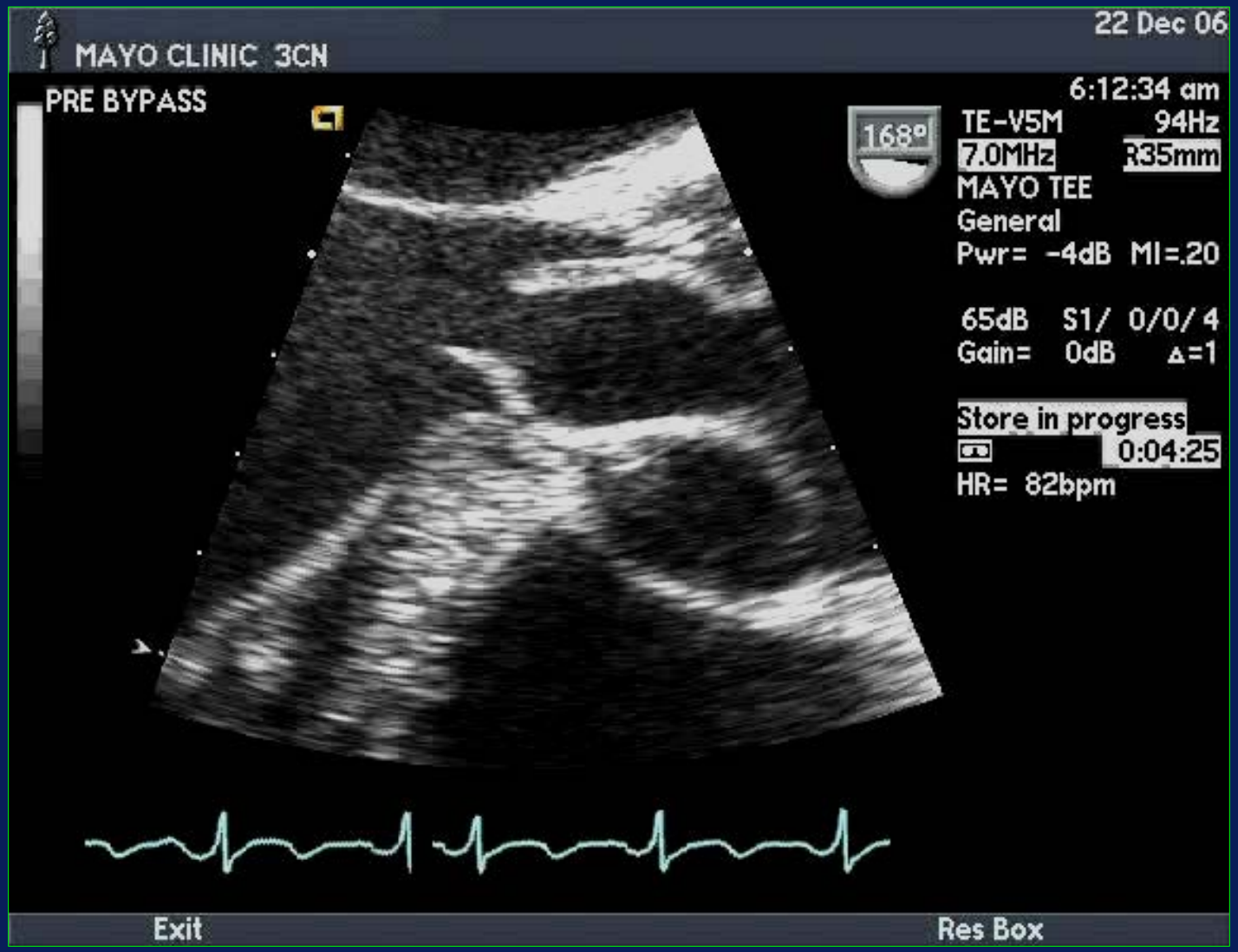
65dB S1/ 0/0/ 4
Gain= 0dB Δ=1
Store in progress
0:07:05
HR= 82bpm


MAYO CLINIC 3CN
22 Dec 06
PRE BYPASS
6:12:34 am
168°
TE-V5M
94Hz
7.0MHz
R35mm
MAYO TEE
General
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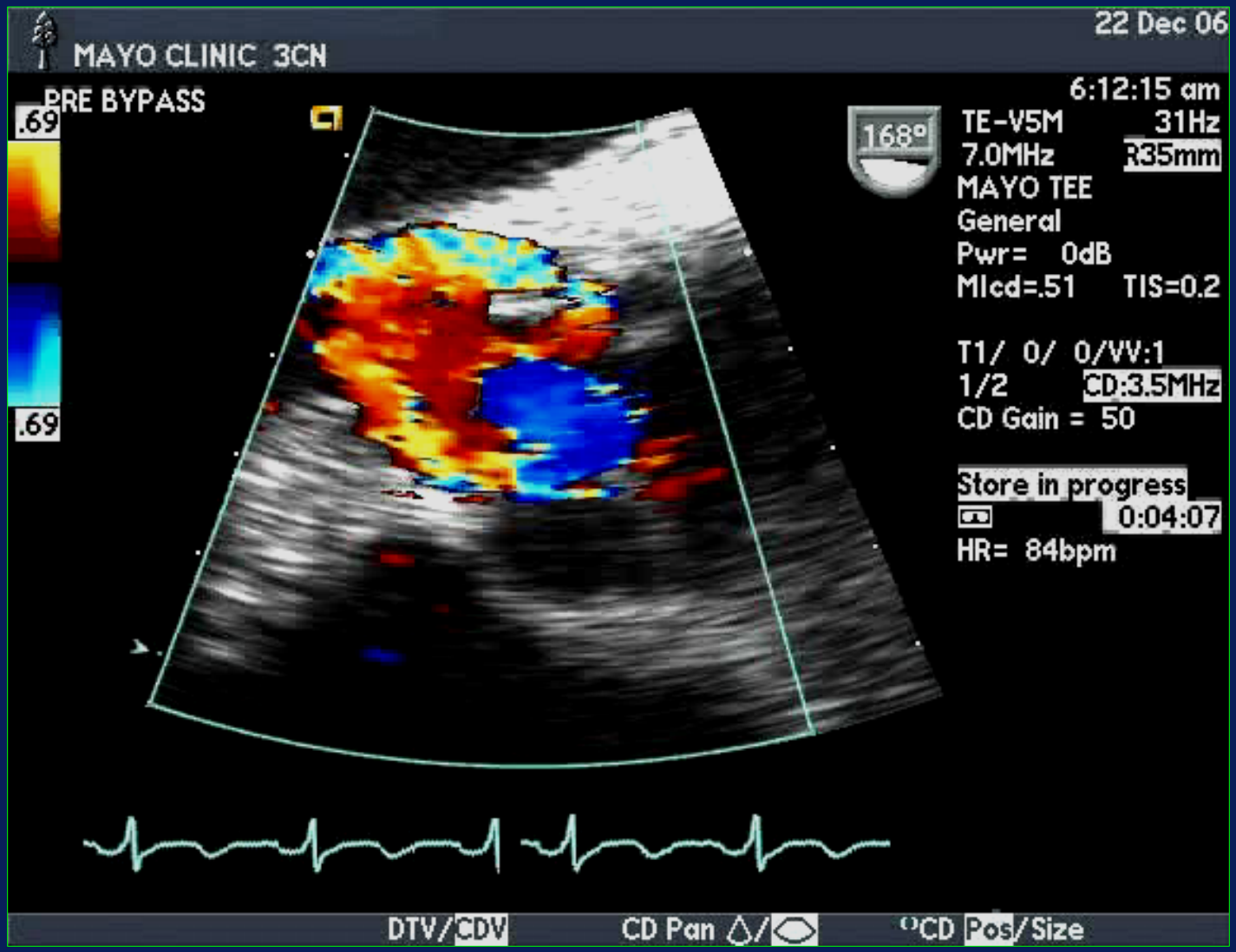
65dB S1/ 0/0/ 4
Gain= 0dB Δ=1
Store in progress
0:04:25
HR= 82bpm
Exit
Res Box


MAYO CLINIC 3CN
22 Dec 06
PRE BYPASS
6:12:15 am
.69
.69
168°
TE-V5M 31Hz
7.0MHz R35mm
MAYO TEE
General
Pwr= 0dB
MIcd=.51 TIS=0.2
T1/ 0/ 0/VV:1
1/2 CD:3.5MHz
CD Gain = 50
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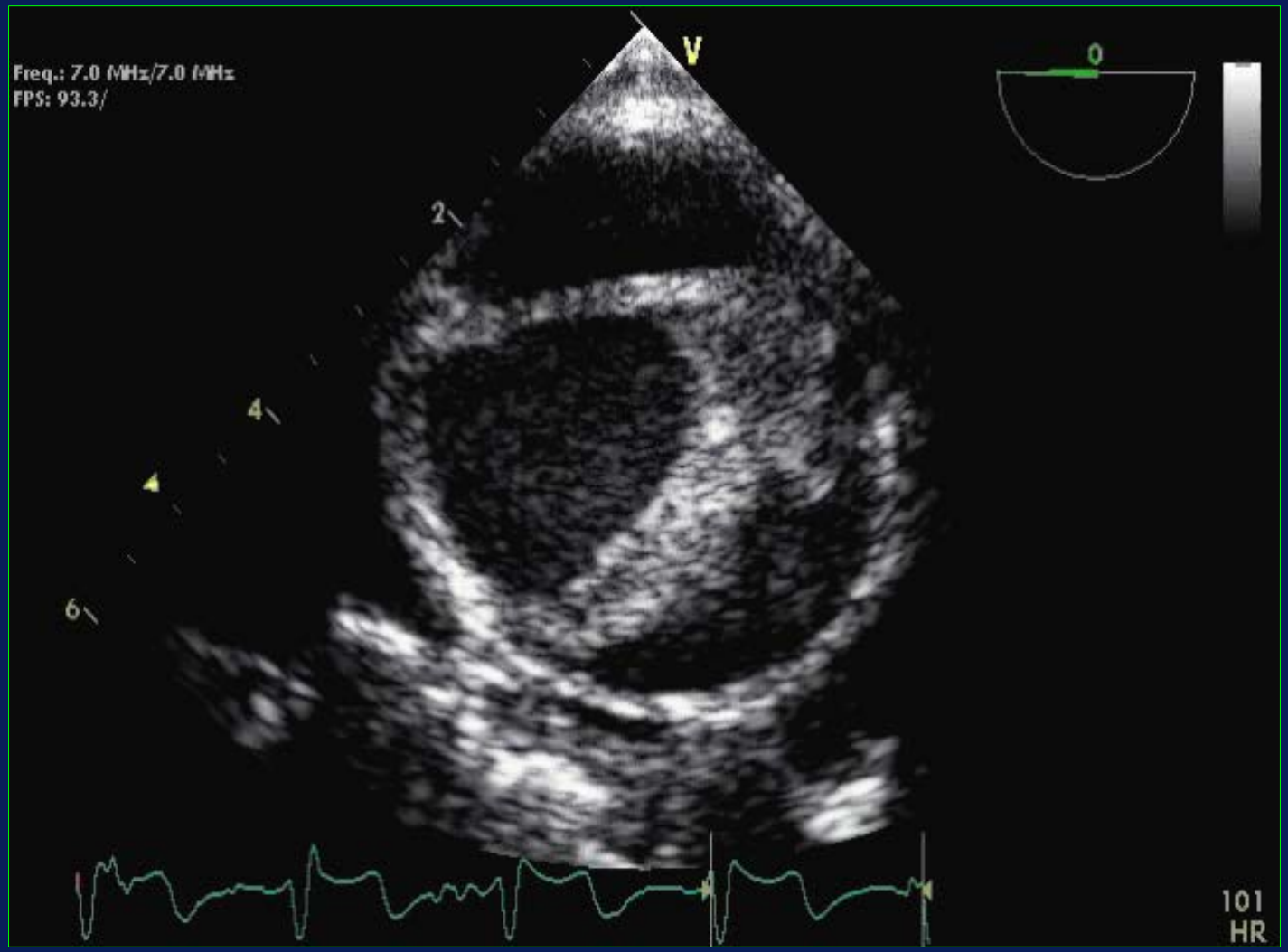
0:04:07
HR= 84bpm
DTV/CDV
CD Pan
CD Pos/Size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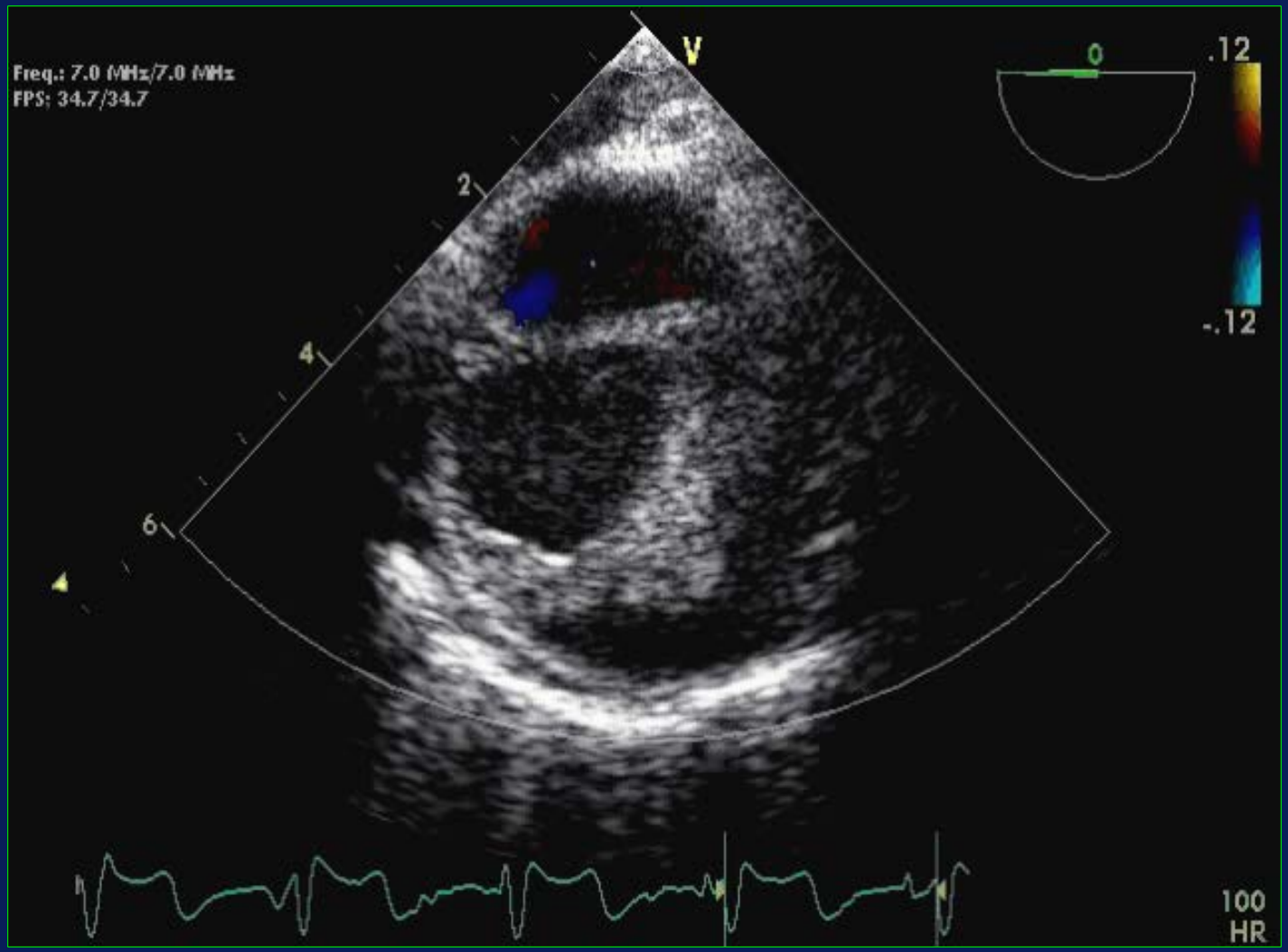
V
0
2
4
4
6
101
HR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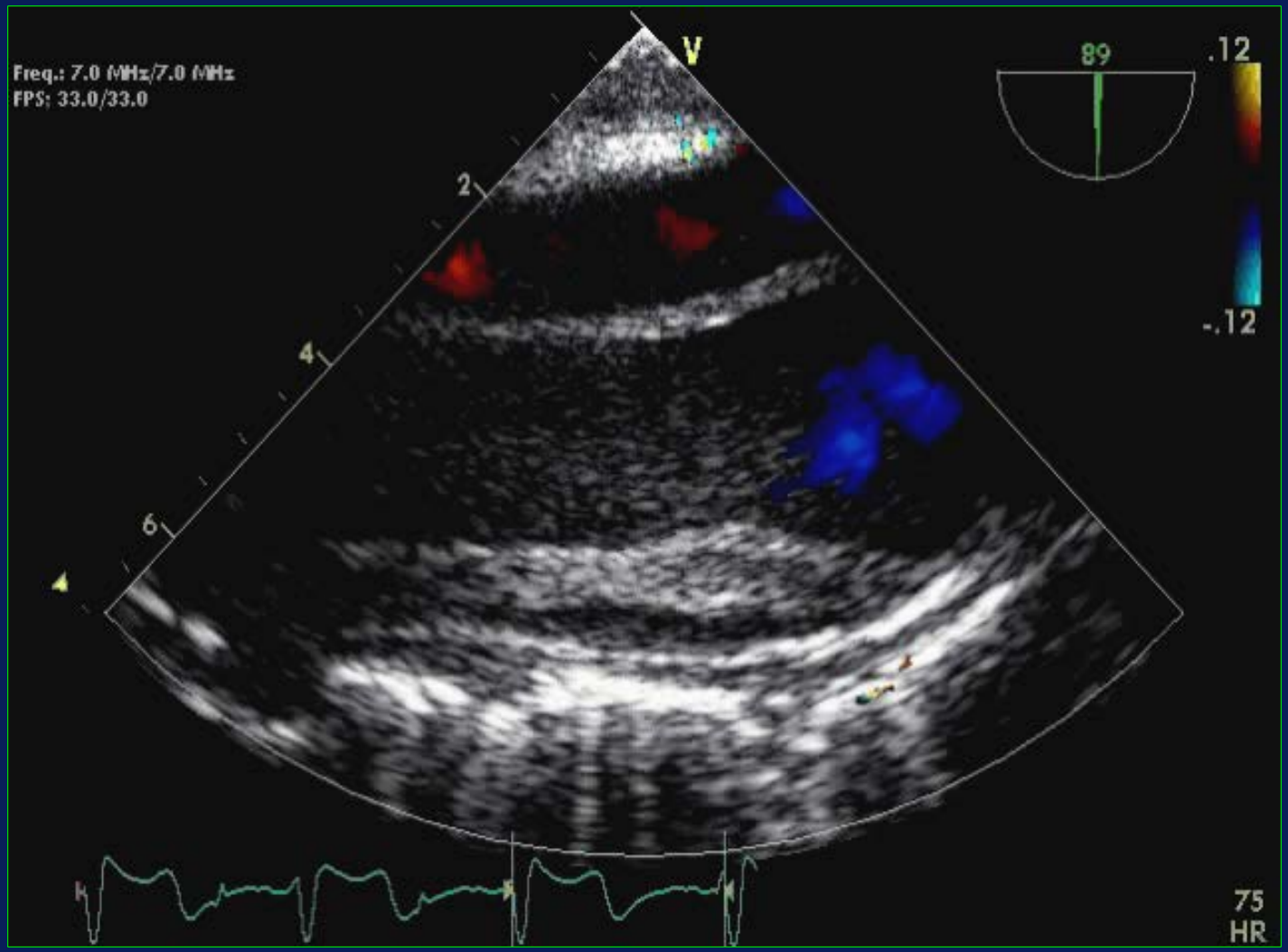
V
2
4
6
0
.12
-.12
100
HR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-.12
2
4
6
4
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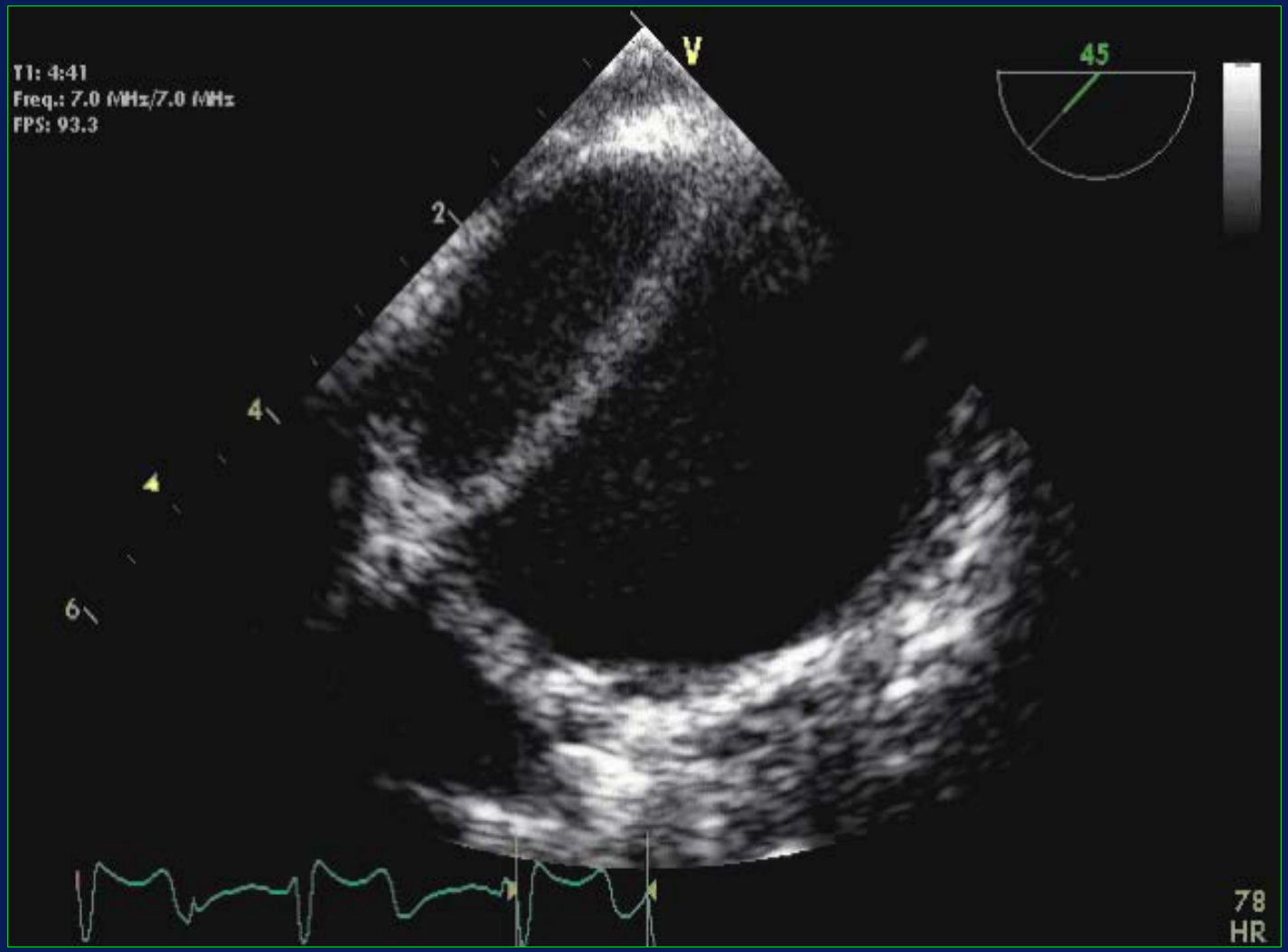
HR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V
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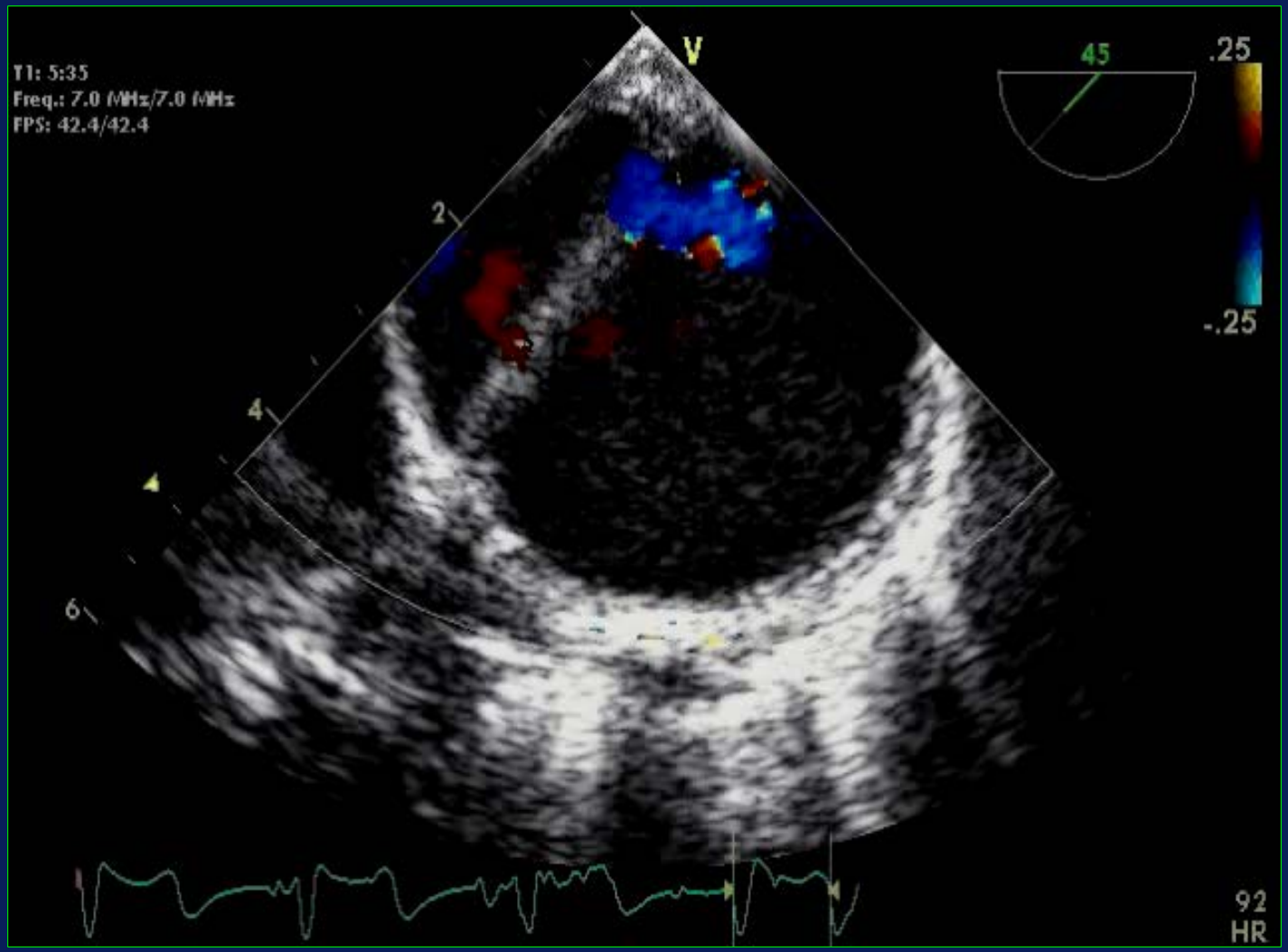
2
4
6
78
HR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FPS: 42.4/42.4
V
45
.25
-.25
2
4
4
6
92
HR

# Acute Type A Aortic Dissection

## TEE Findings in 74 Patients

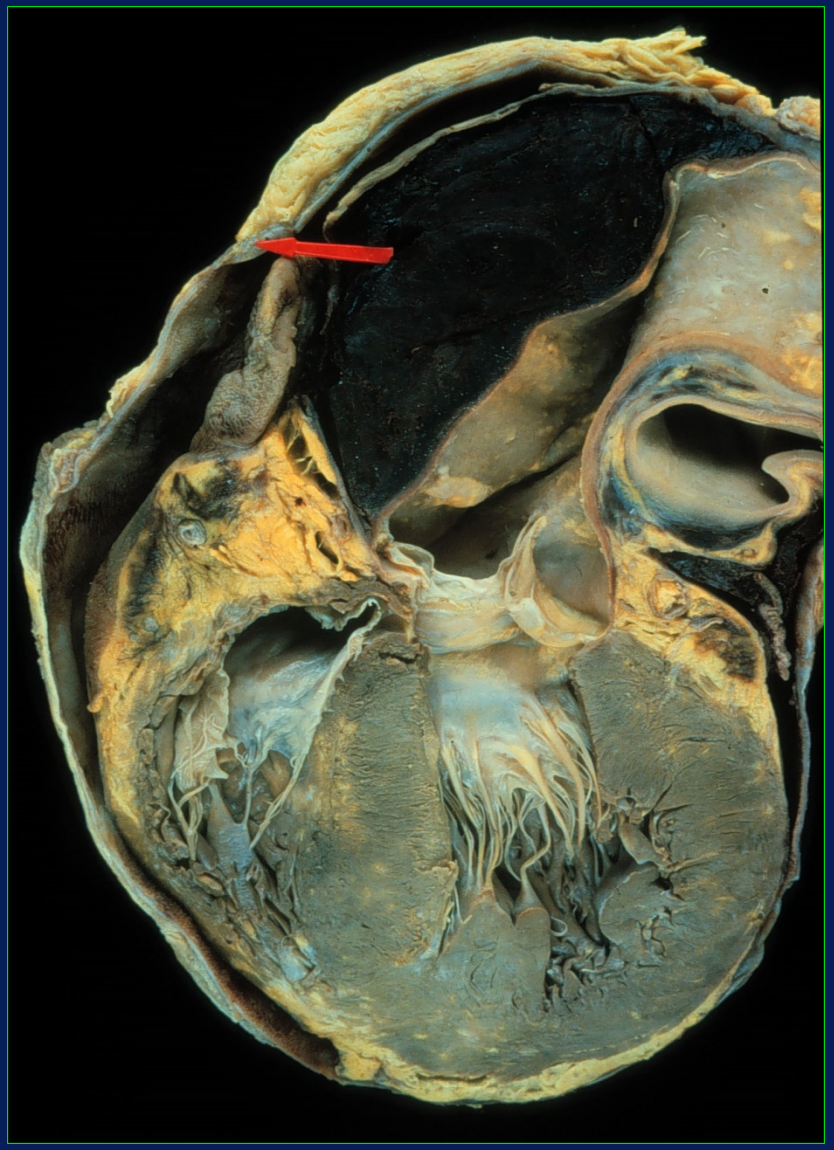
| | |
|---|---|
| False lumen thrombosis | 8 - 41% |
| Aortic regurgitation (grade 2- 4/4) | 35 - 45% |
| Coronary dissection or compromise | 18 - 35% |
| Aortic rupture | 6 - 10% |
| Pericardial effusion (small to large) | 24 - 48% |

Ballal RS, et al: Circulation 1991; 84:1903

Armstrong WF, et al. J Am Soc Echocardiogr 1996; 9: 646

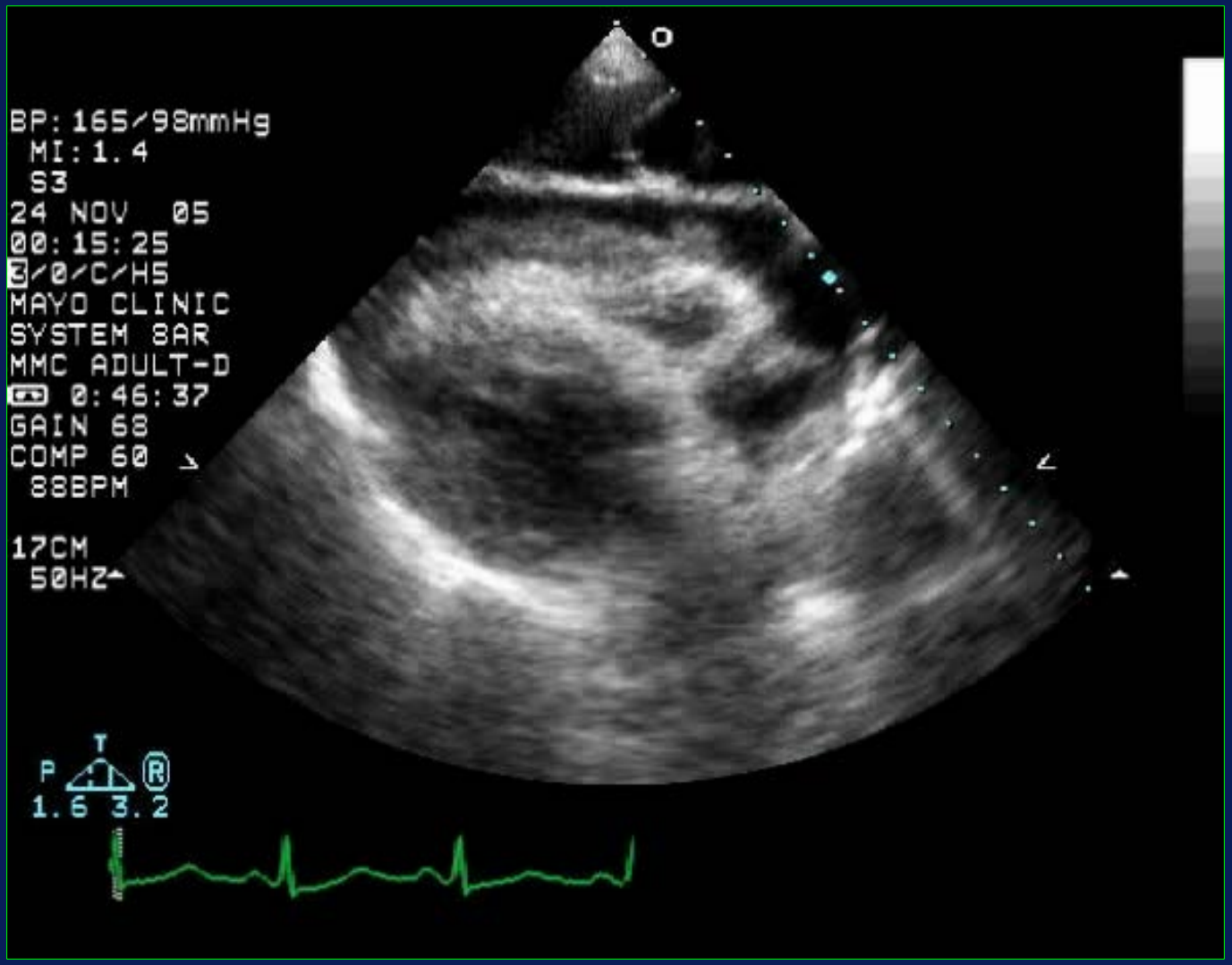
# Type A Aortic Dissection:

## Rupture into the pericardial space

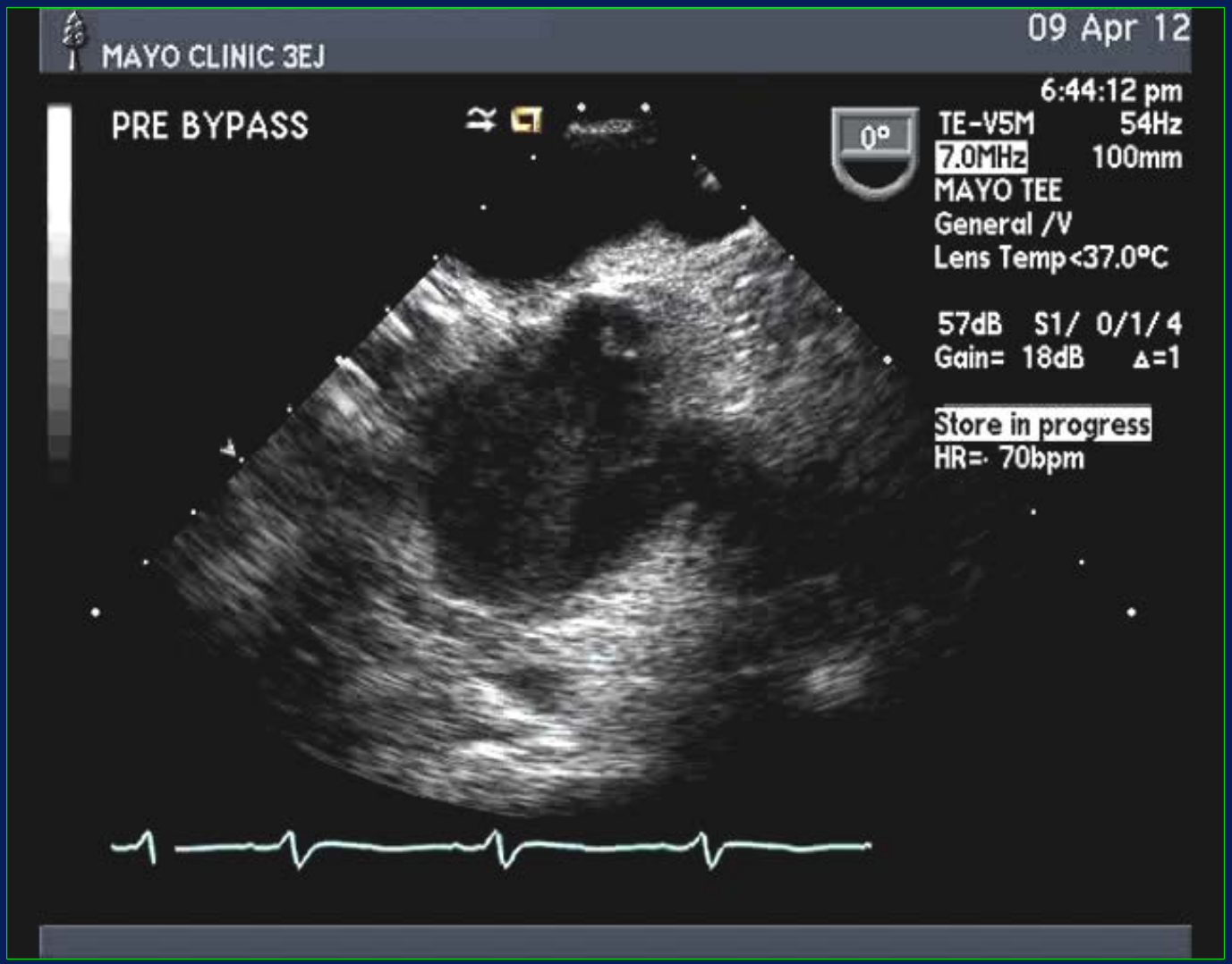


Courtesy of W.D. Edwards, M.D.

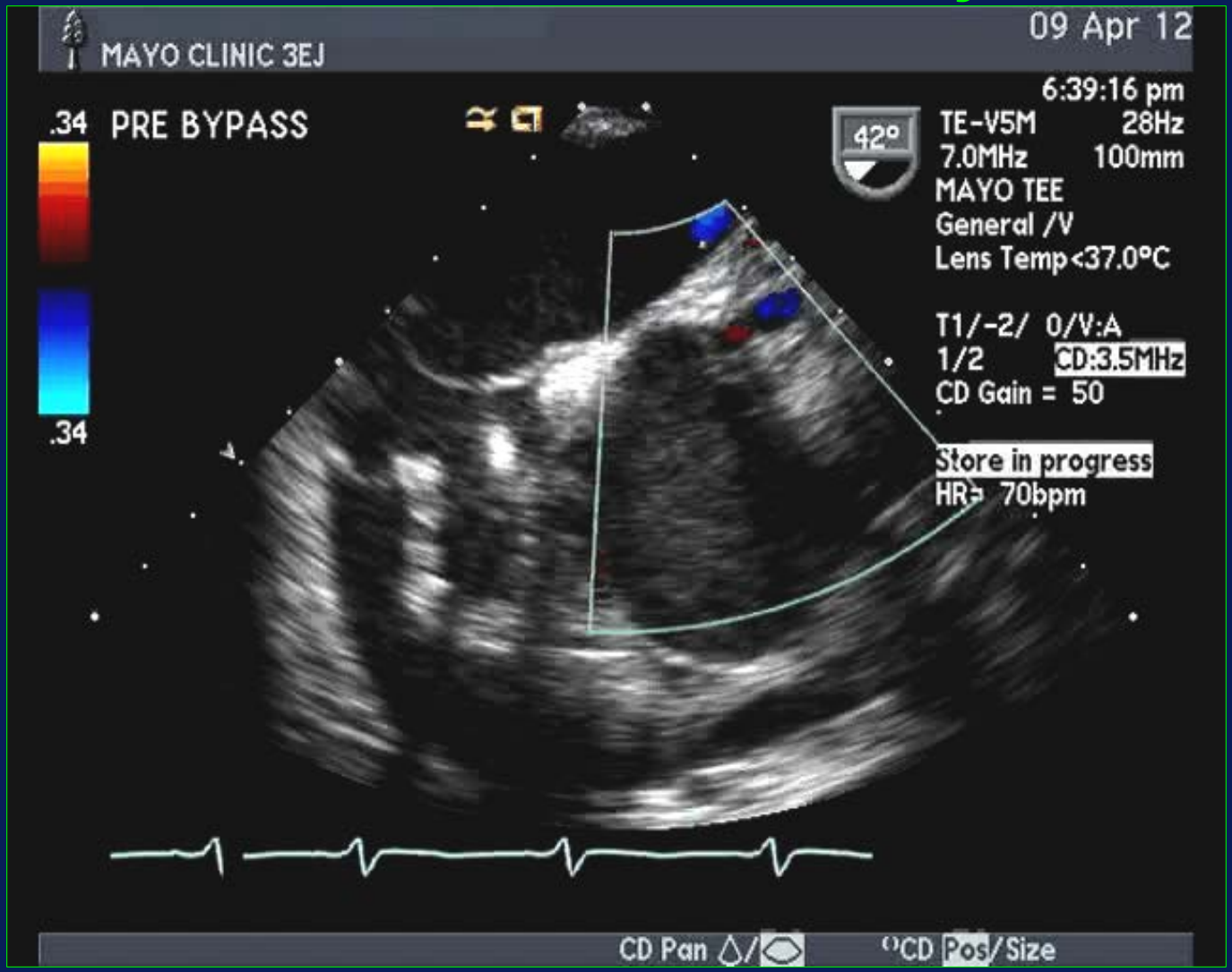
# Type A Aortic dissection: Coagulum tamponade



# Type A aortic dissection: Extension to left main coronary ostium



# Type A aortic dissection: Extension to left main coronary ostium



# TEE in Acute Type A Aortic Dissection (IRAD; 522 Patients)

## Multivariate Predictors of Mortality

**Surgical Pts (n=434)**

↓

**Periaortic hematoma**
**Pericardial tamponade**

**Medical Pts (n=88)**

↓

**False lumen patency**

**"Protective"** → **False lumen thrombosis**
**Flap localized to Asc aorta**



Bossone E, et al. Am Heart J 2007; 153: 1013

# Imaging in Dissection of the Descending Aorta

## Impact of the False Lumen

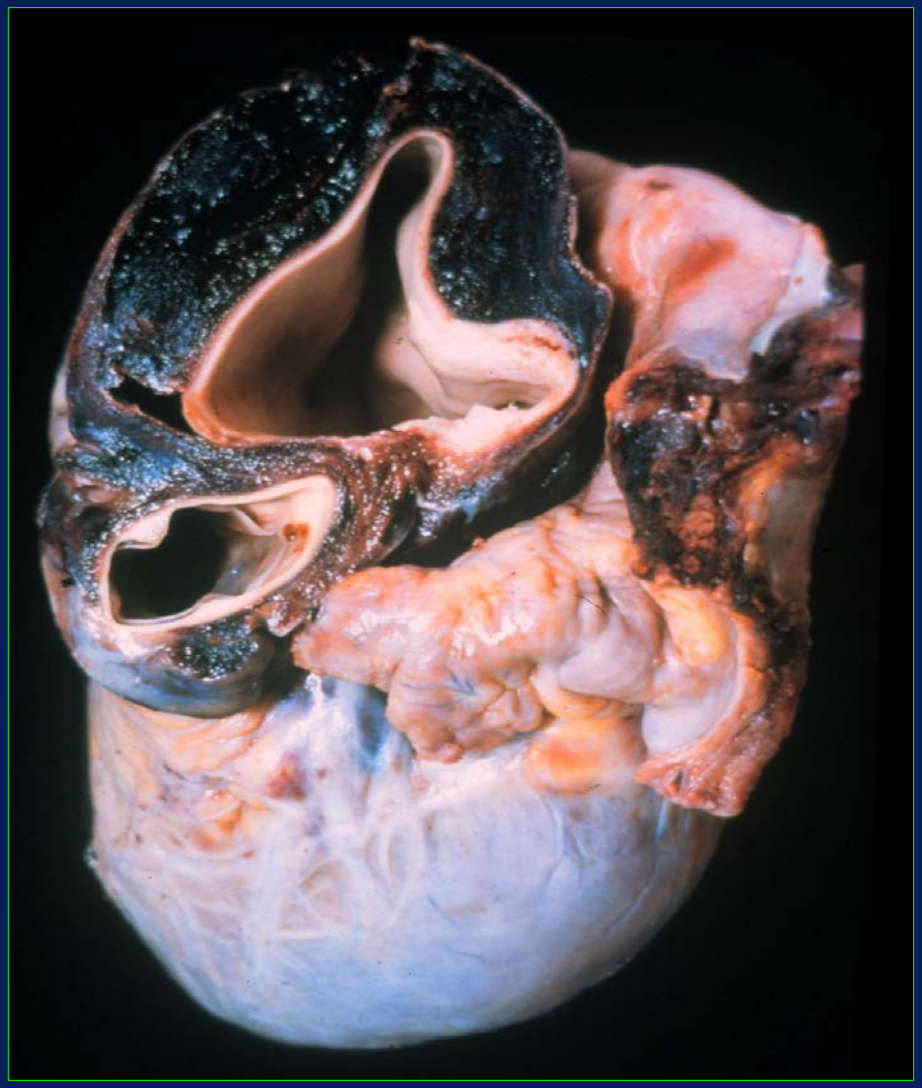
| Initial false lumen diameter | Progression to aneurysm (≥6 cm) | Mortality |
|---|---|---|
| < 22 mm | 5% | 5% |
| ≥ 22 mm | 42% | 17% |
| | P < 0.001 | P = 0.09 |

*Surgical Type A (n=51), Medical Type B (n= 49): CT follow-up 31± 27 mos.



Song JM, et al. JACC 2007; 50: 799

# Aortic Intramural Hematoma (IMH)



# Aortic Intramural Hematoma (IMH)
## Pathoanatomic Mechanisms

- Spontaneous rupture and hemorrhage of vasa vasorum within aortic media
- Penetrating aortic ulcer (PAU)

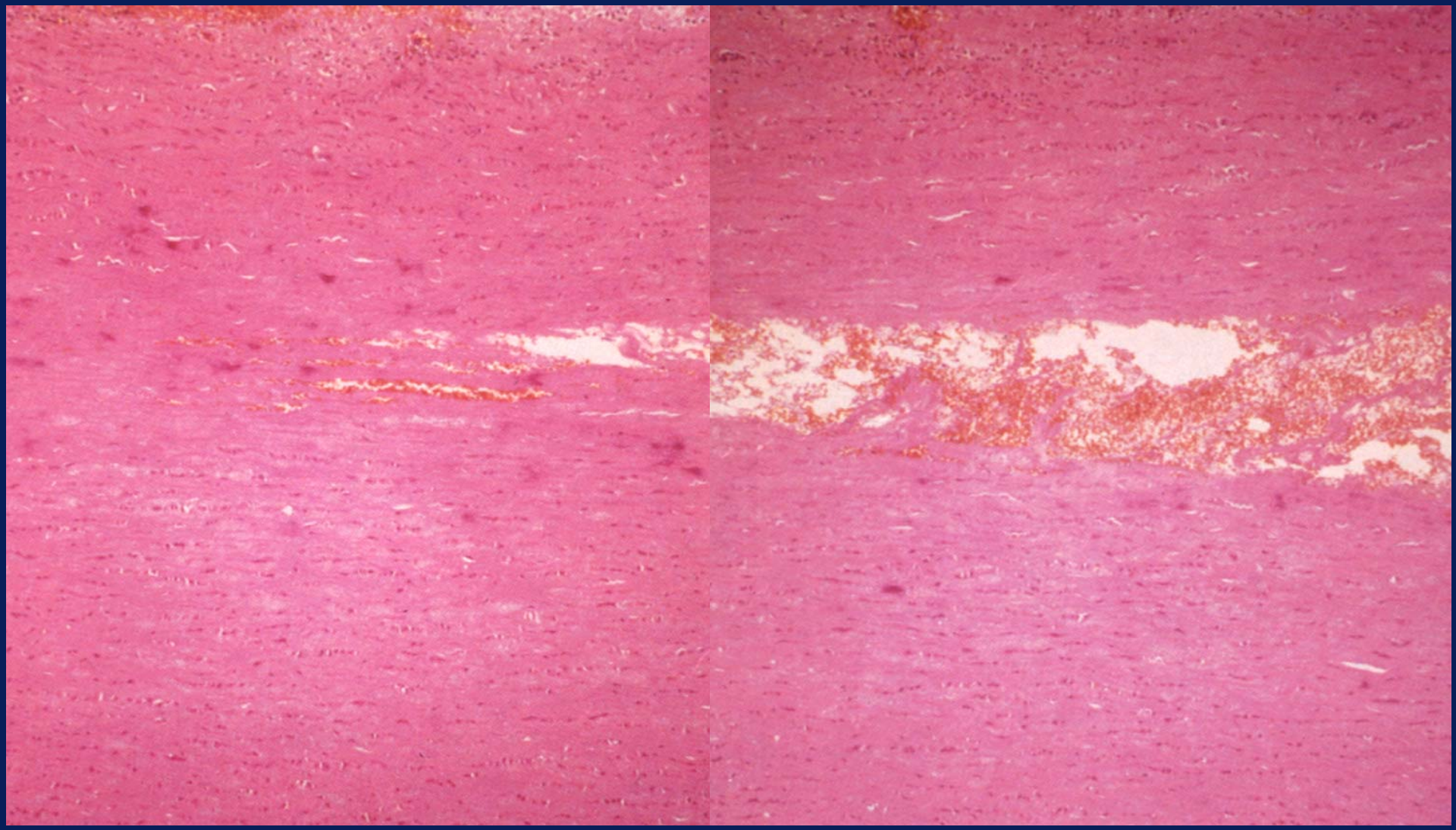
Stanson AW et al: Ann Vasc Surg 1:15, 1986
Mohr-Kahaly S et al: JACC 23:658, 1994
Nienaber CA et al: Circulation 92:1465, 1995

# Aortic Intramural Hematoma
## Clinical Associations

| | |
|---|---|
| Hypertension | 70-90% |
| Extensive aortic atherosclerosis | 20-30% |
| Trauma (deceleration or iatrogenic) | 2-7% |
| Marfan syndrome | 0-3% |

Maraj R, et al. Am J Cardiol 2000; 86: 664
Sueyoshi E. J Vasc Surg 2002: 35: 1179
Evangelista A, et al. Circulation 2005; 111: 1063

# Intramedial Aortic Hemorrhage



MAYO CLINIC

Nienaber CA, et al. Circulation 1995; 92: 1465.

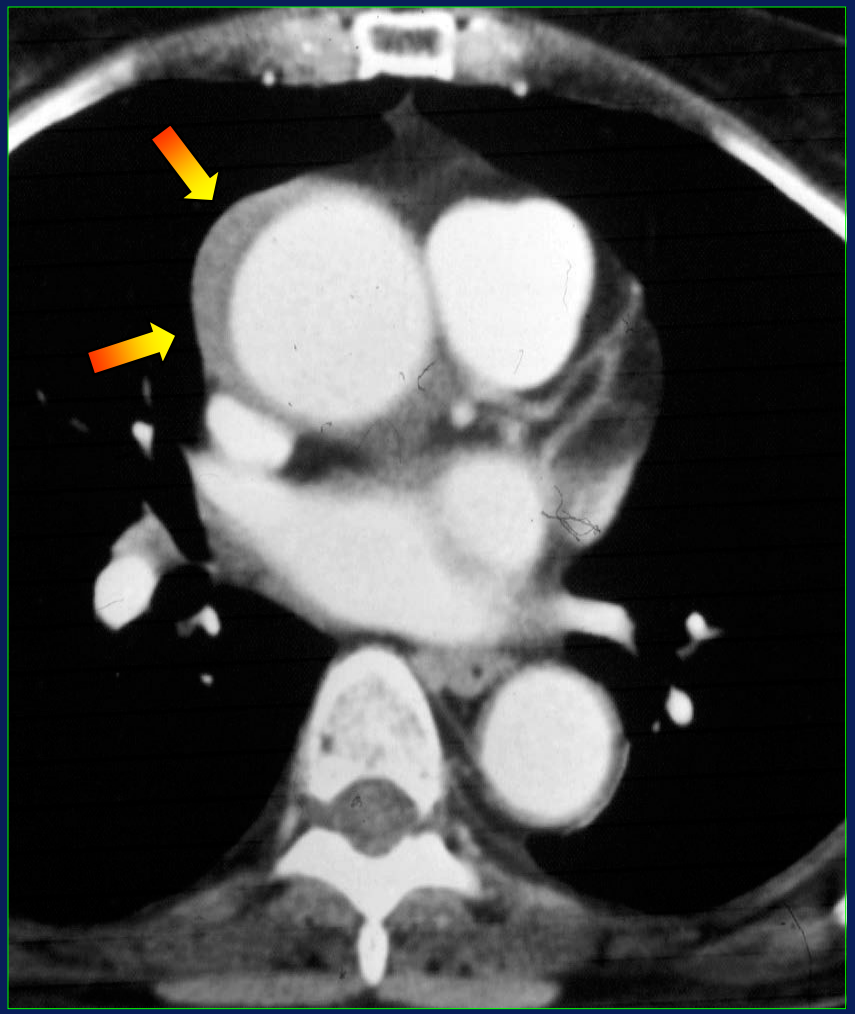
# Aortic Intramural Hematoma (IMH)
## Diagnostic Criteria

- Crescentic or circumferential thickening of aortic wall > 3-7 mm
  - TEE: thrombus echodensity ± lucencies
  - CT: high attenuation
  - MR: ↑↑ intensity on T1 imaging
- Central displacement of intimal calcium
- No mobile intimal flap
- No communicating blood flow from aortic lumen into IMH

# Aortic Intramural Hematoma

## CT Imaging

Noncontrast

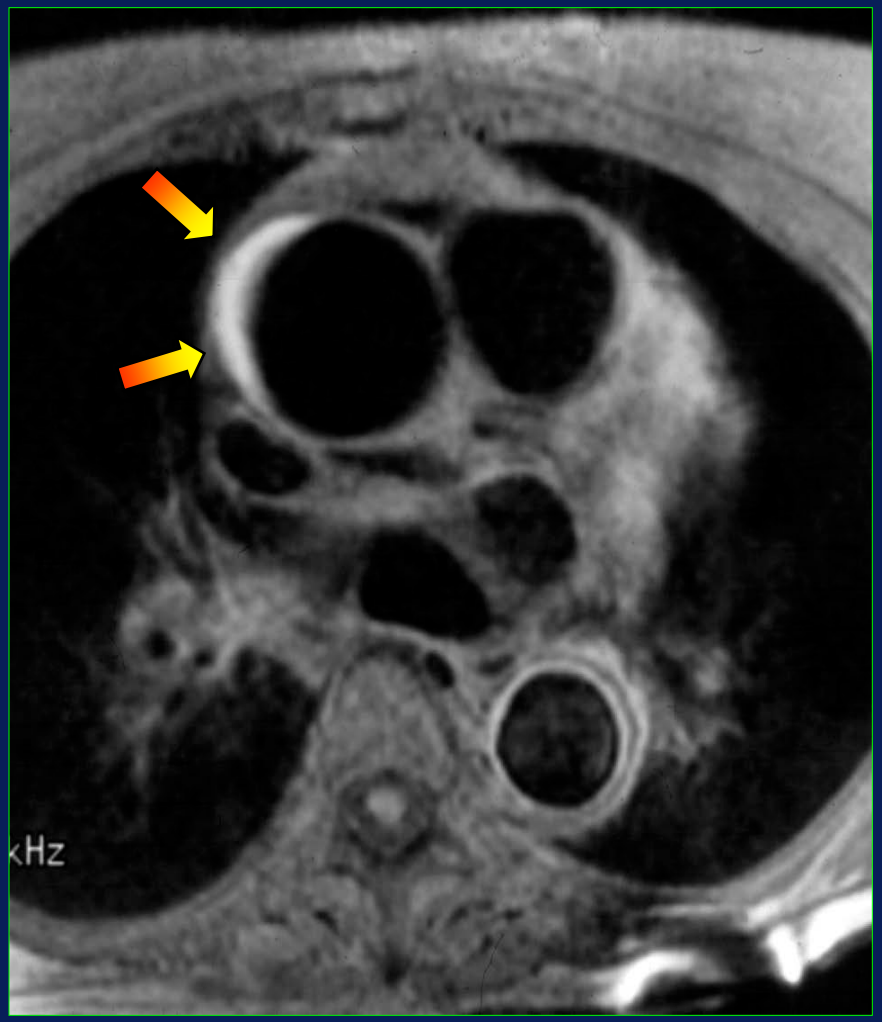


Contrast

MAYO CLINIC

# Type A Aortic Intramural Hematoma

## MR Imaging



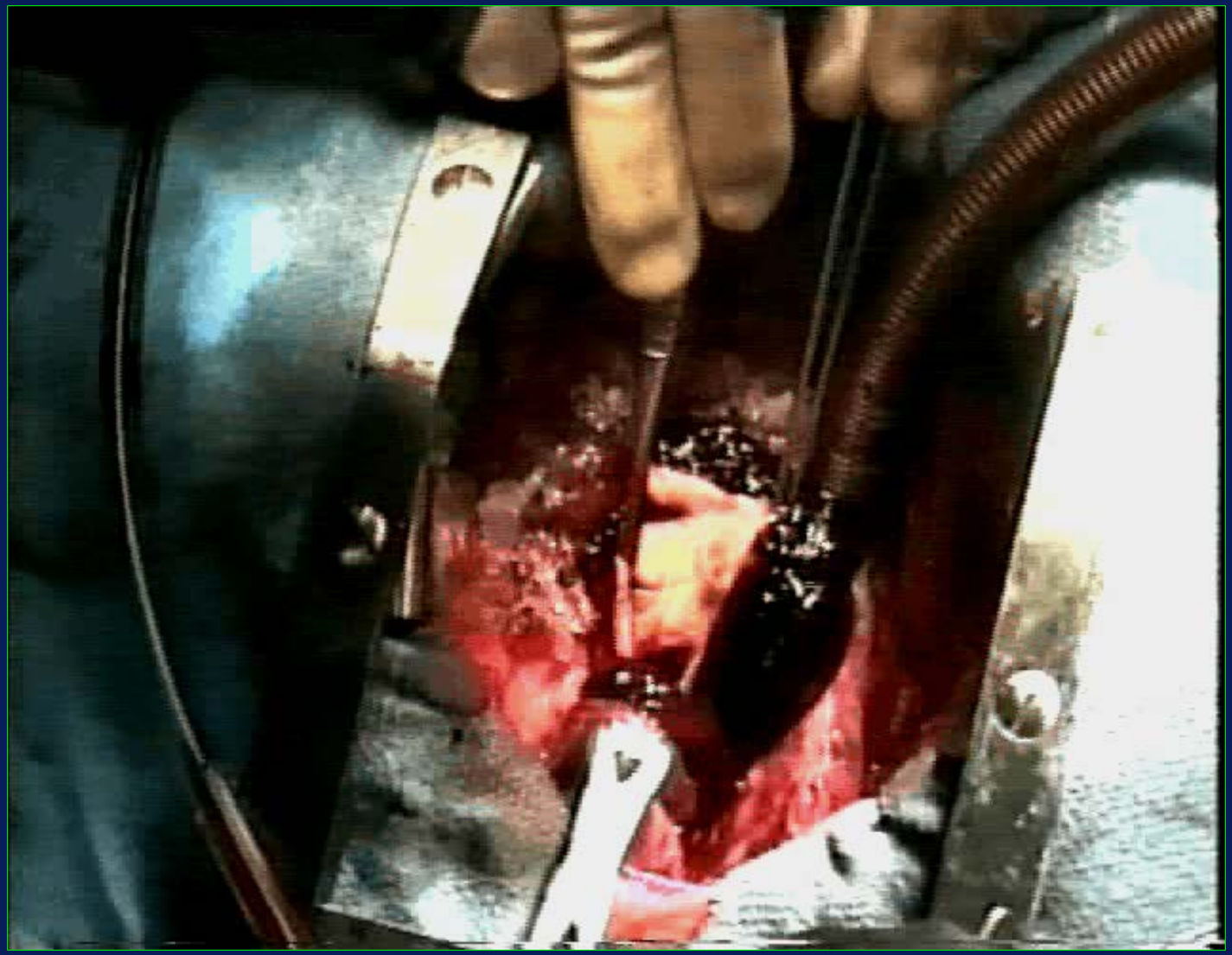
# Type A Aortic Intramural Hematoma

## TEE Imaging

# Type A Aortic Intramural Hematoma

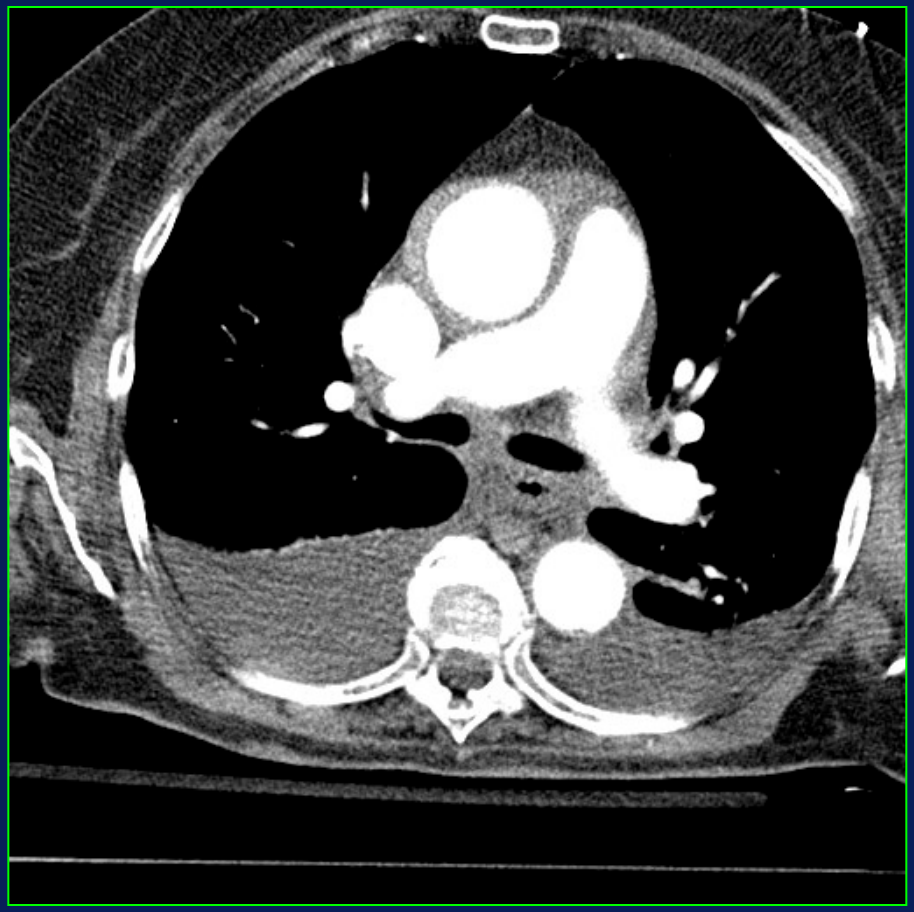
## TEE Imaging

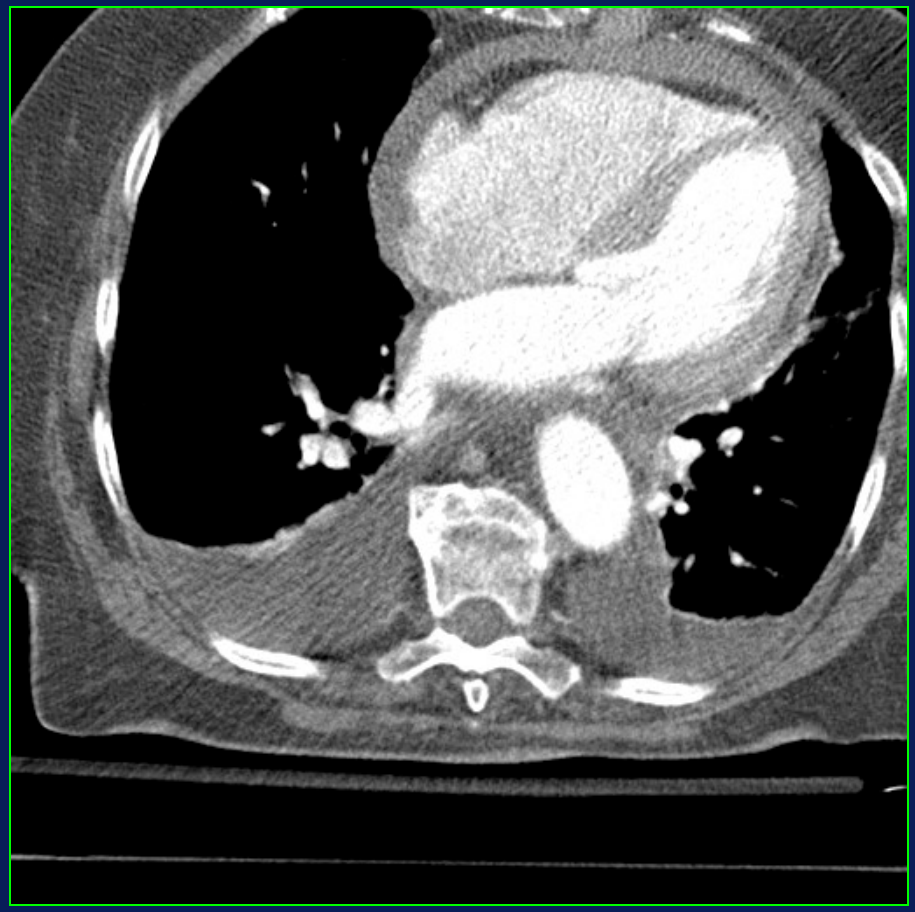
# Type A Aortic Intramural Hematoma



# 80 y/o woman: Syncope at Wal*mart

## CT Negative for PE; pericardial and pleural effusions





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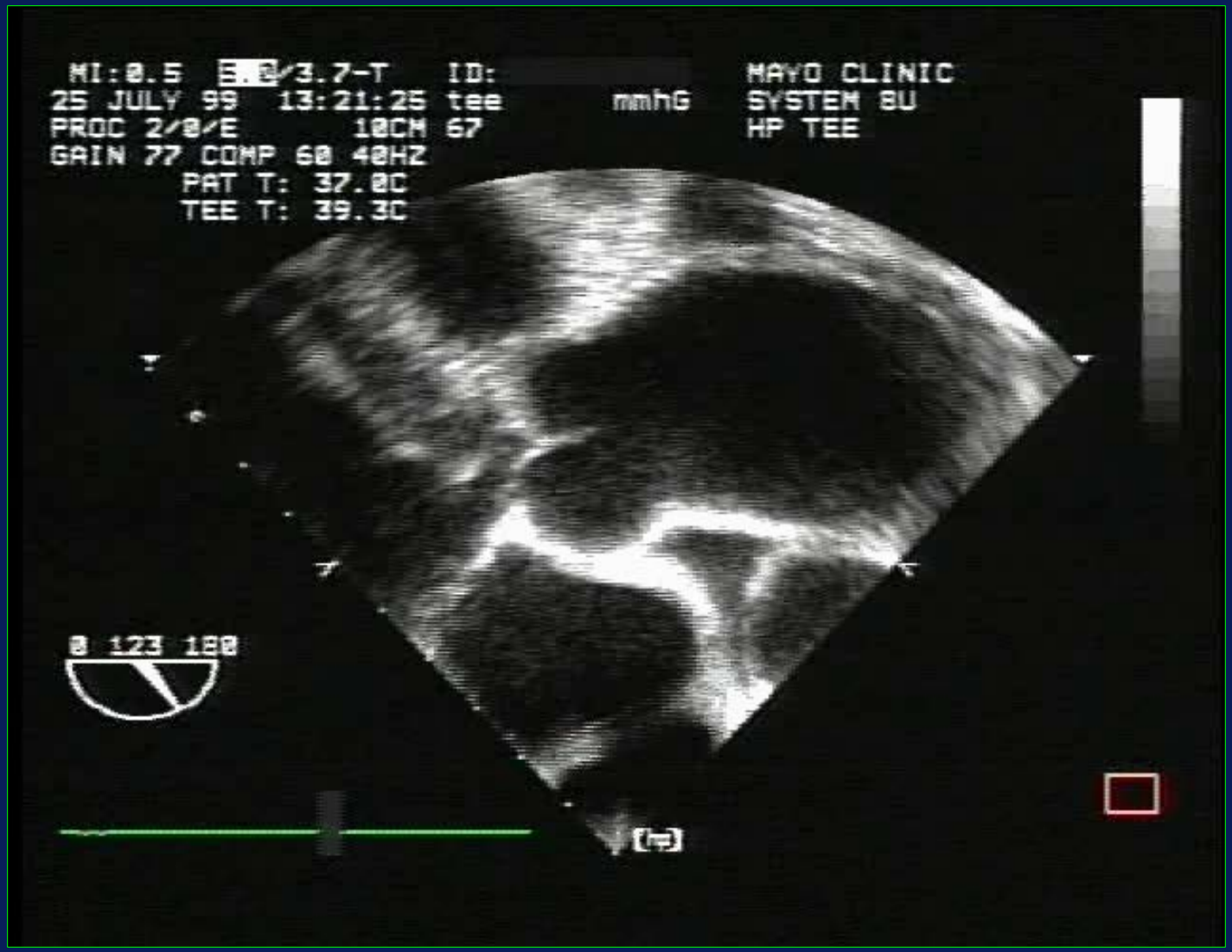

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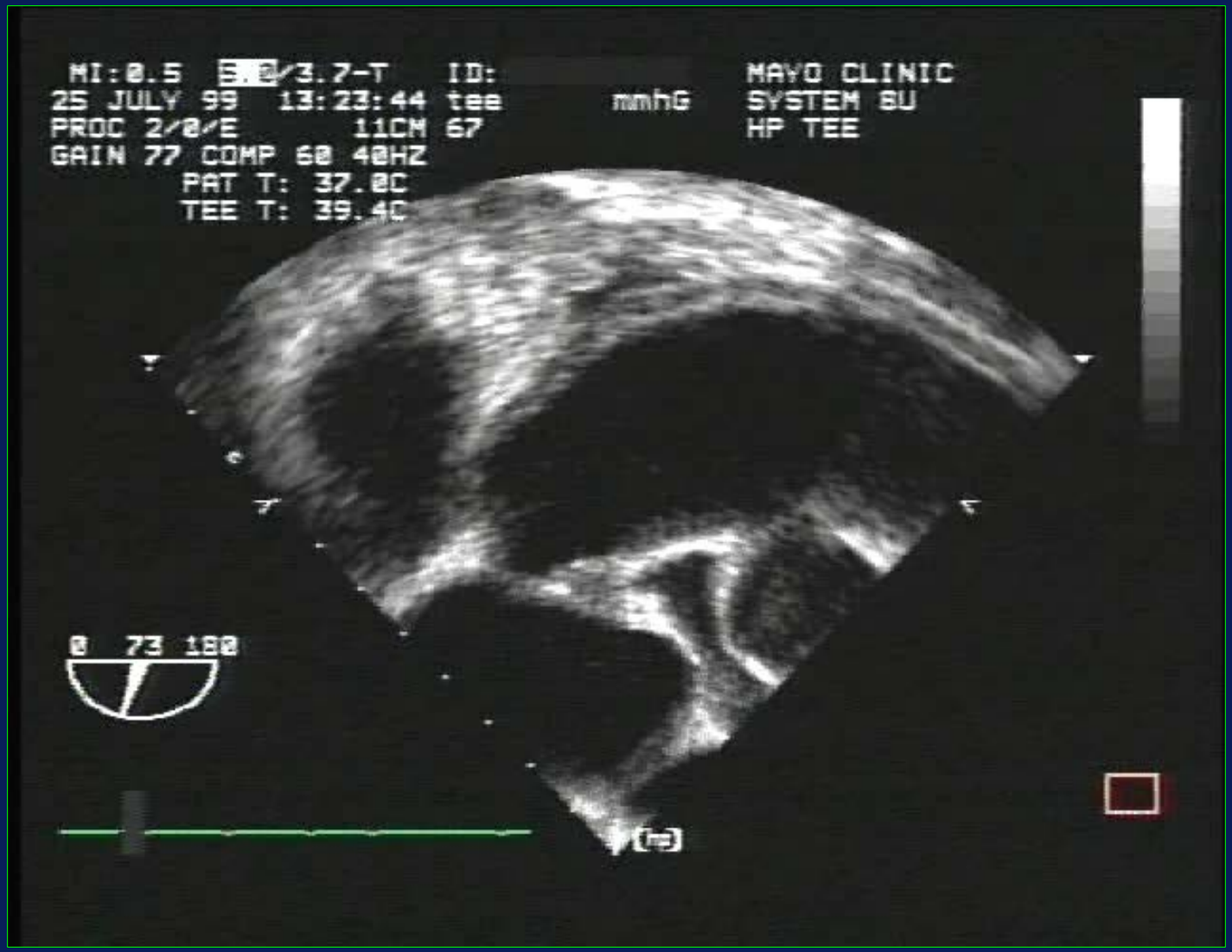

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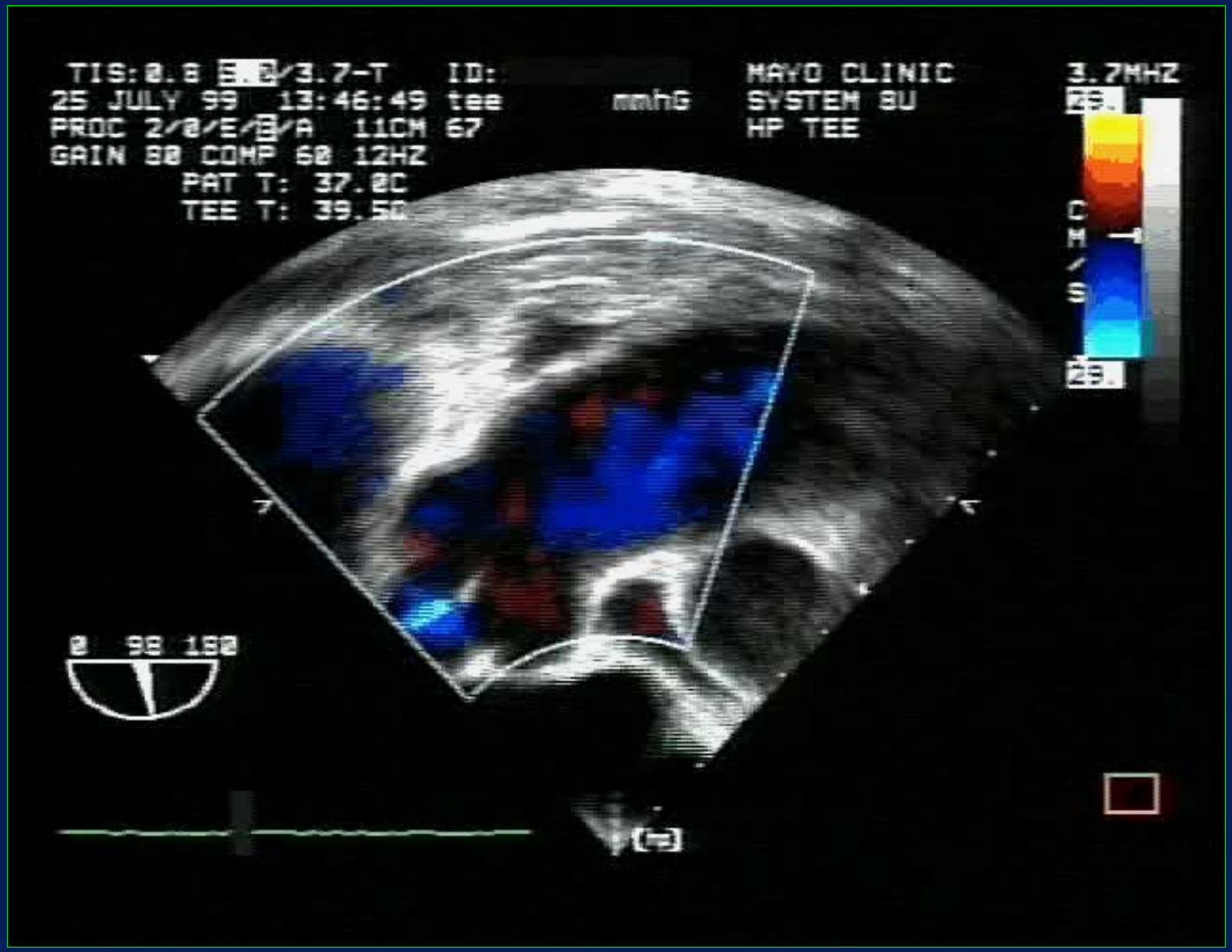

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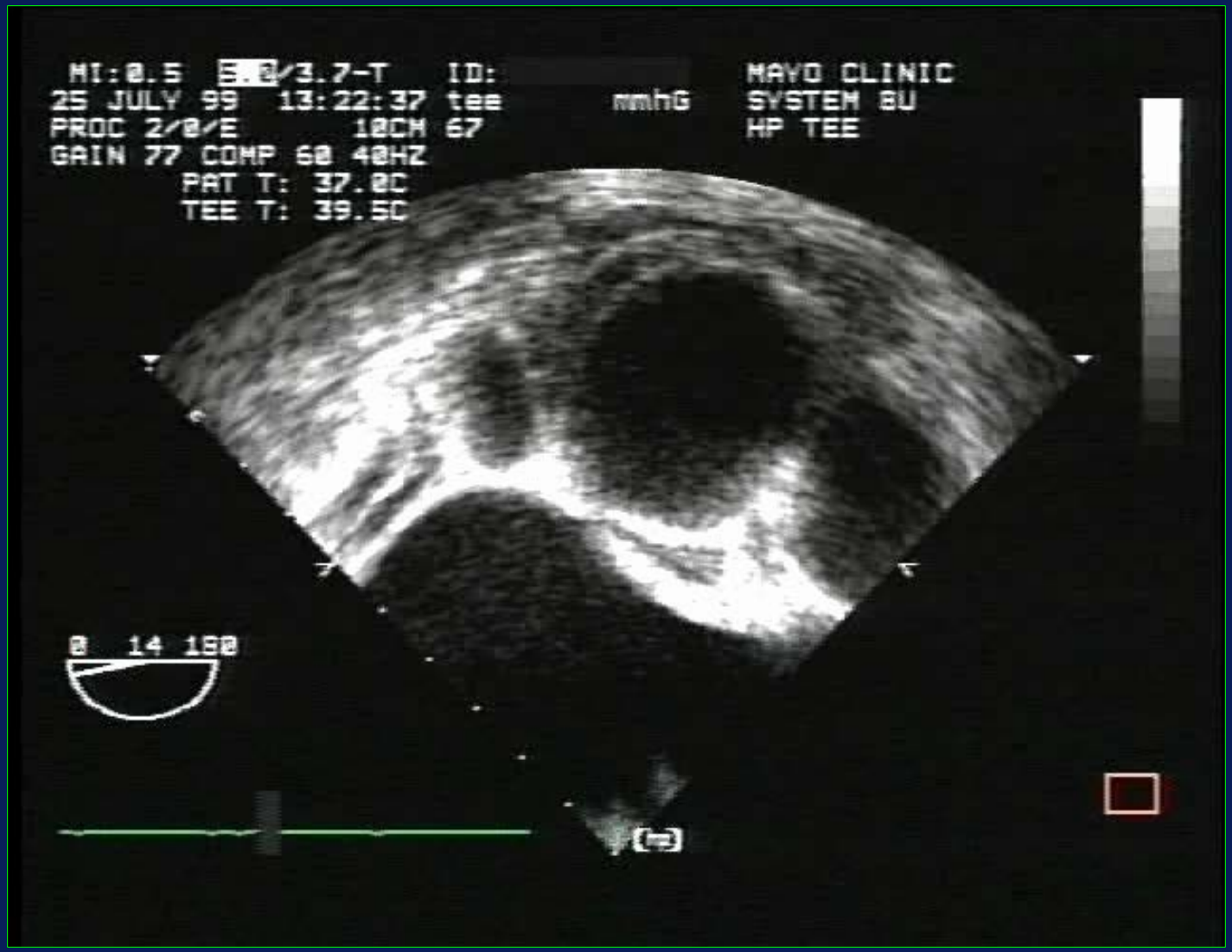
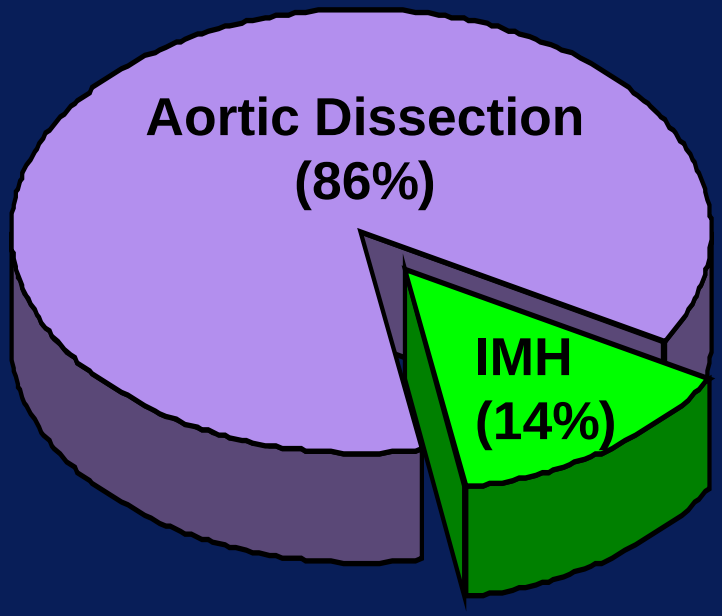


# 80 y/o woman: Syncope at Wal*mart

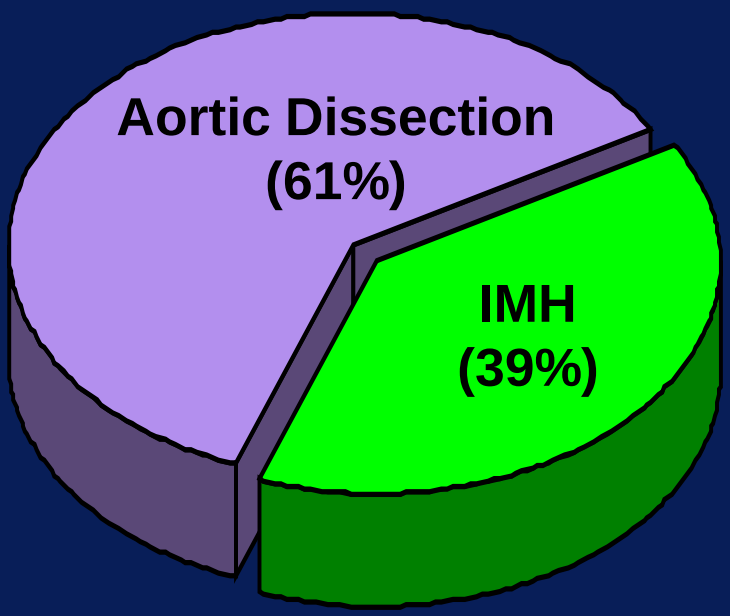
# Aortic Intramural Hematoma (IMH)

## Incidence Relative to Aortic Dissection

### Western Populations
(n = 1,400)




### Eastern Populations
(n = 909)






Song JK, et al. Int J Cardiol 2007; 115: 14

Progression to "classical" dissection
Ascending: 10-20%
Descending: 5%

Nonprogressive localized intimal flap:
10-30%

# Aortic Intramural Hematoma (IMH)

Regression of IMH
Descending: 50-70%
Ascending: possible

Aortic rupture
Type A >B: ~ 5%

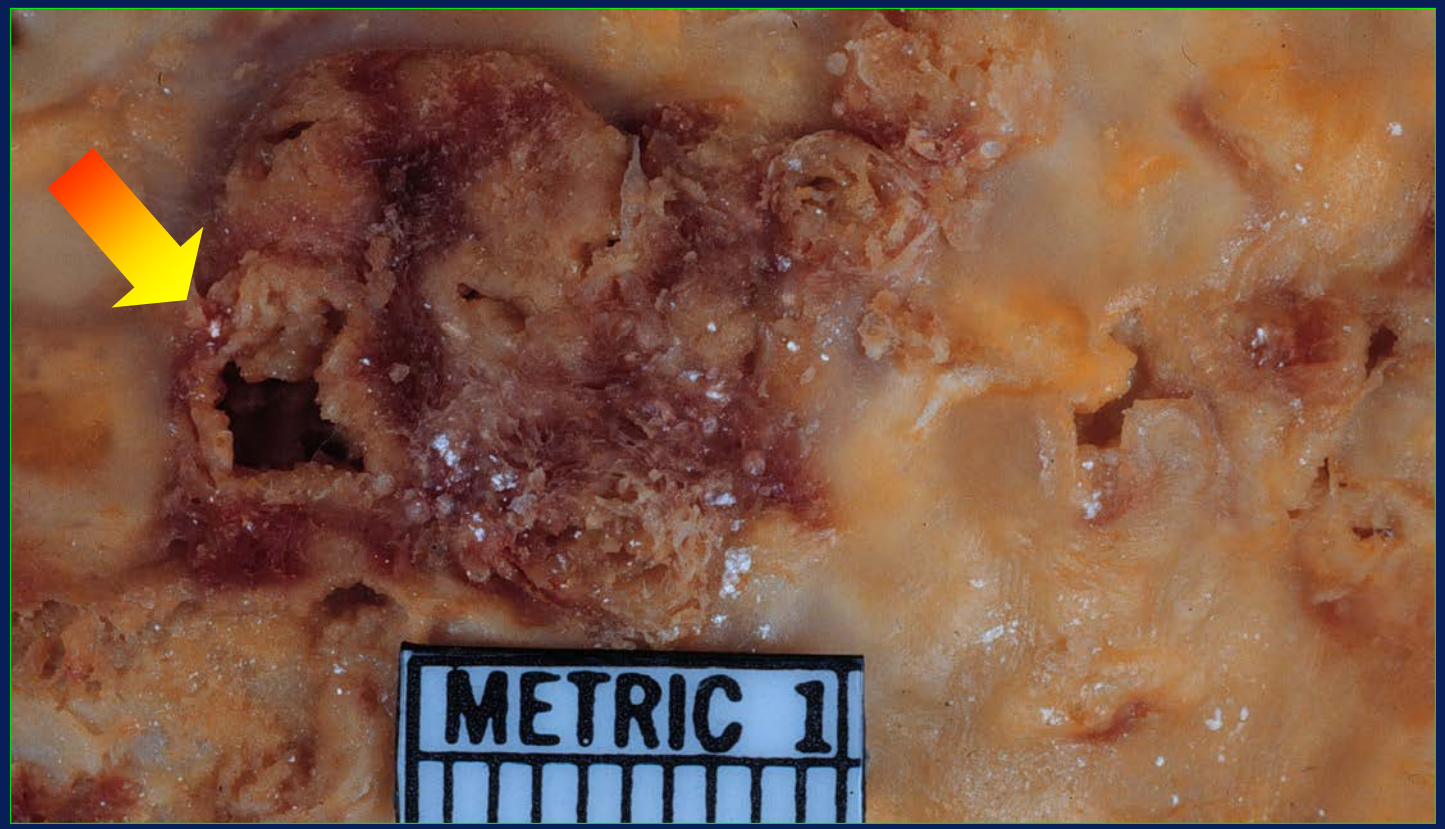
Sueyoshi E. J Vasc Surg 2002: 35: 1179
Kodolitsch YV. Circulation 2003; 107: 1163
Evangelista A. Circulation 2003; 108: 583
Song JK. JACC 2001; 37: 1604

# Aortic Intramural Hematoma (IMH)
## Predictors of Progression

- Ascending aorta involvement
- Aortic diameter > 4.0 cm
- Thickness of IMH ≥ 1.0 cm
- Presence of PAU
- Echolucent zones within IMH
- Late:  absence of β-blocker therapy

Kodolitsch YV, et al. Circulation 2003; 107: 1163
Sueyoshi E, et al. J Vasc Surg 2002: 35: 1179
Kaji S, et al. Circulation 2003; 108: II-307

# Penetrating Aortic Ulcer (PAU)



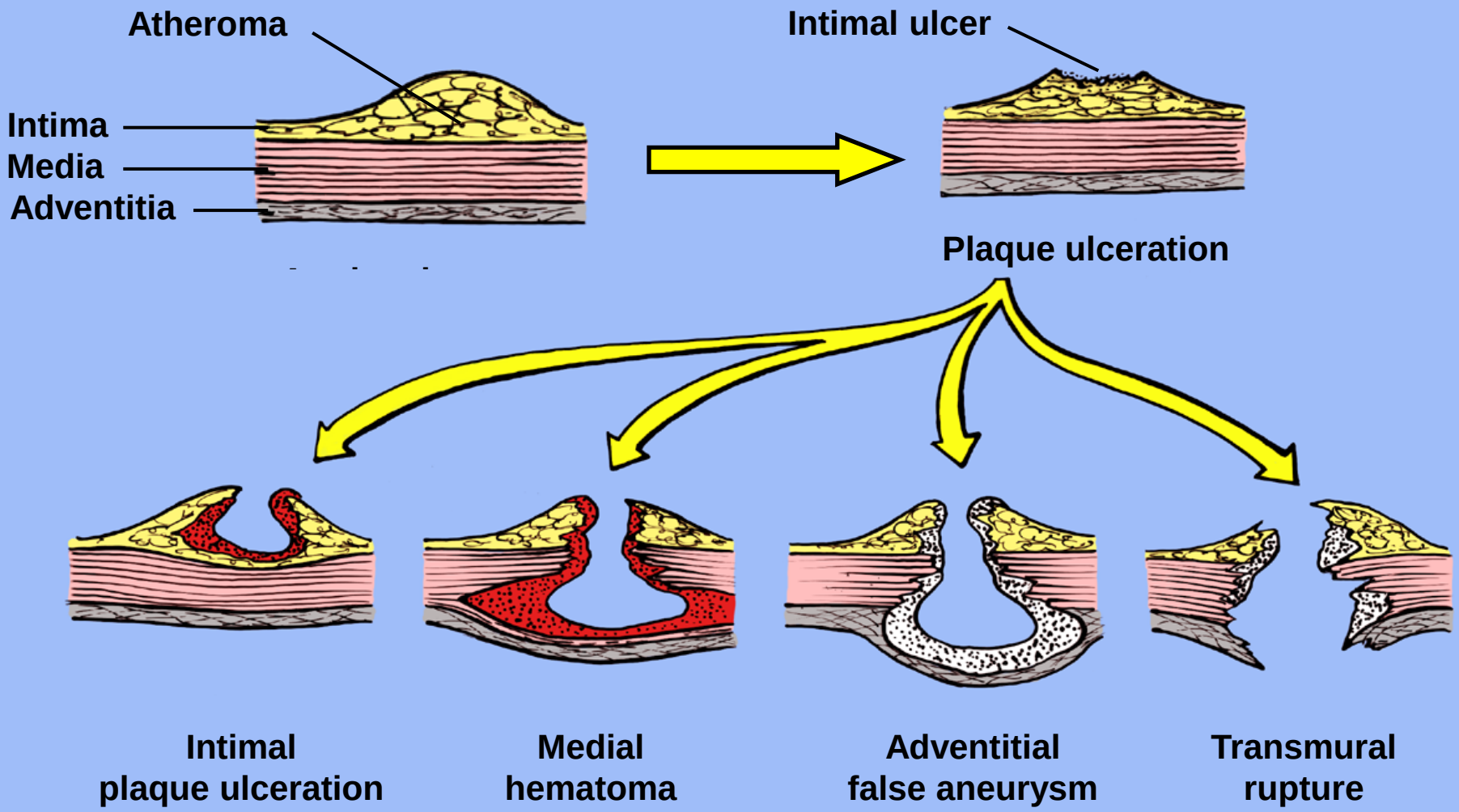

MAYO CLINIC

Courtesy of WD Edwards, MD

# Penetrating Aortic Ulcer (PAU)

- Complicates extensive aortic atheromatous disease
- Disruption of internal elastic lamina $\rightarrow$ extension into media
- Elderly, hypertensive (>90%) patients
- Symptoms of pain: May mimic aortic dissection or ACS

# Penetrating Aortic Ulcer (PAU)



# 87 y/o Male: Interscapular back pain; creatinine 2.7

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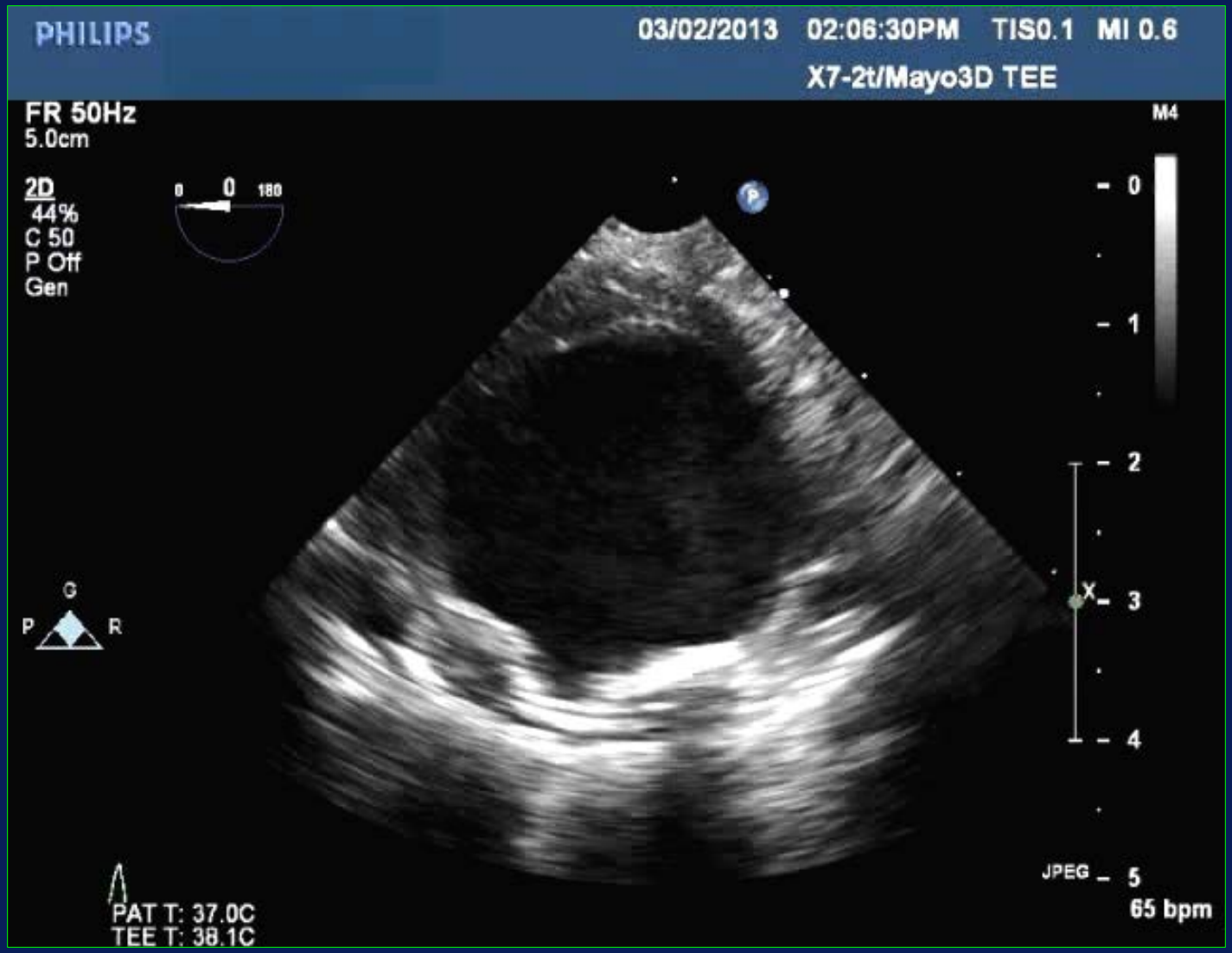
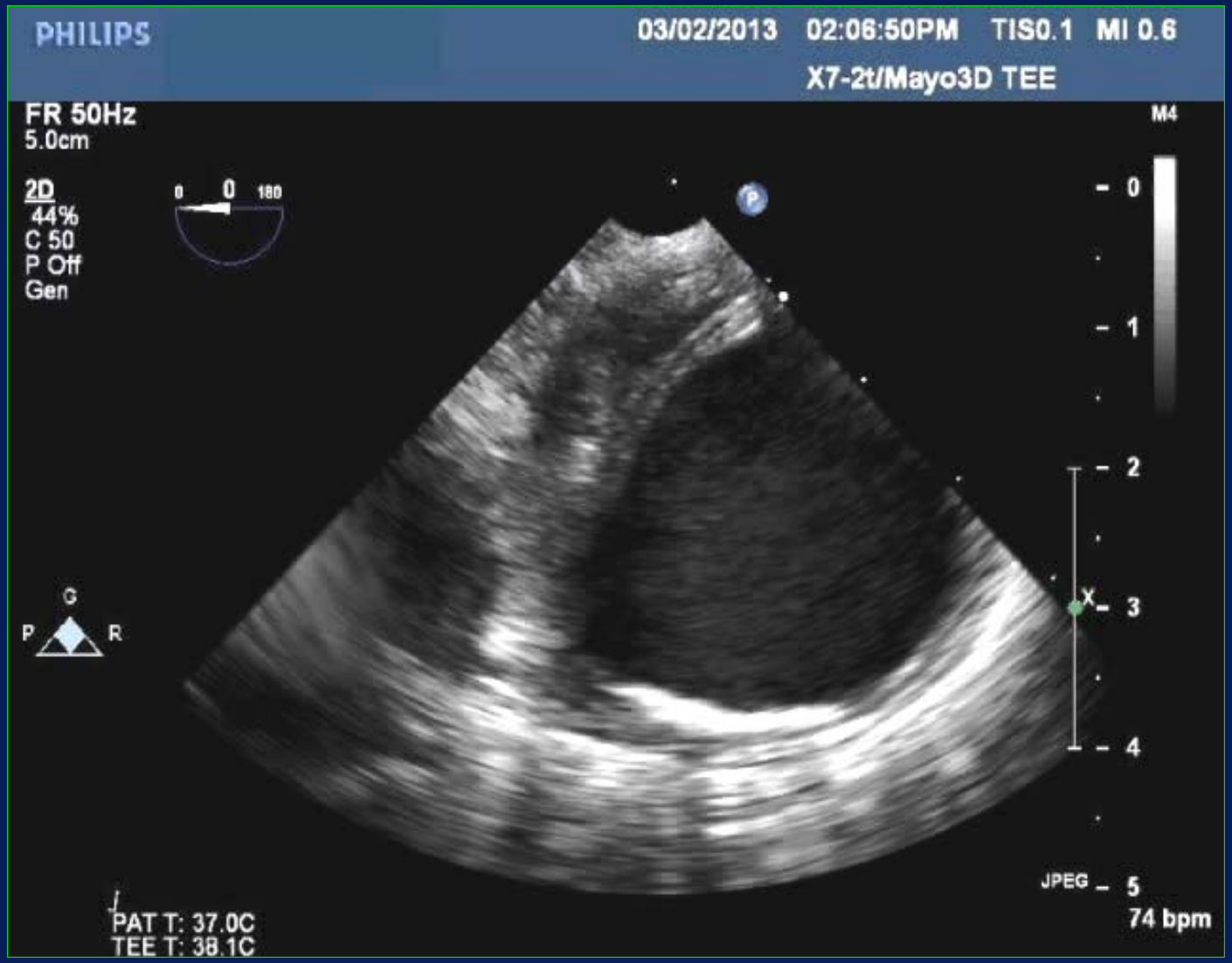
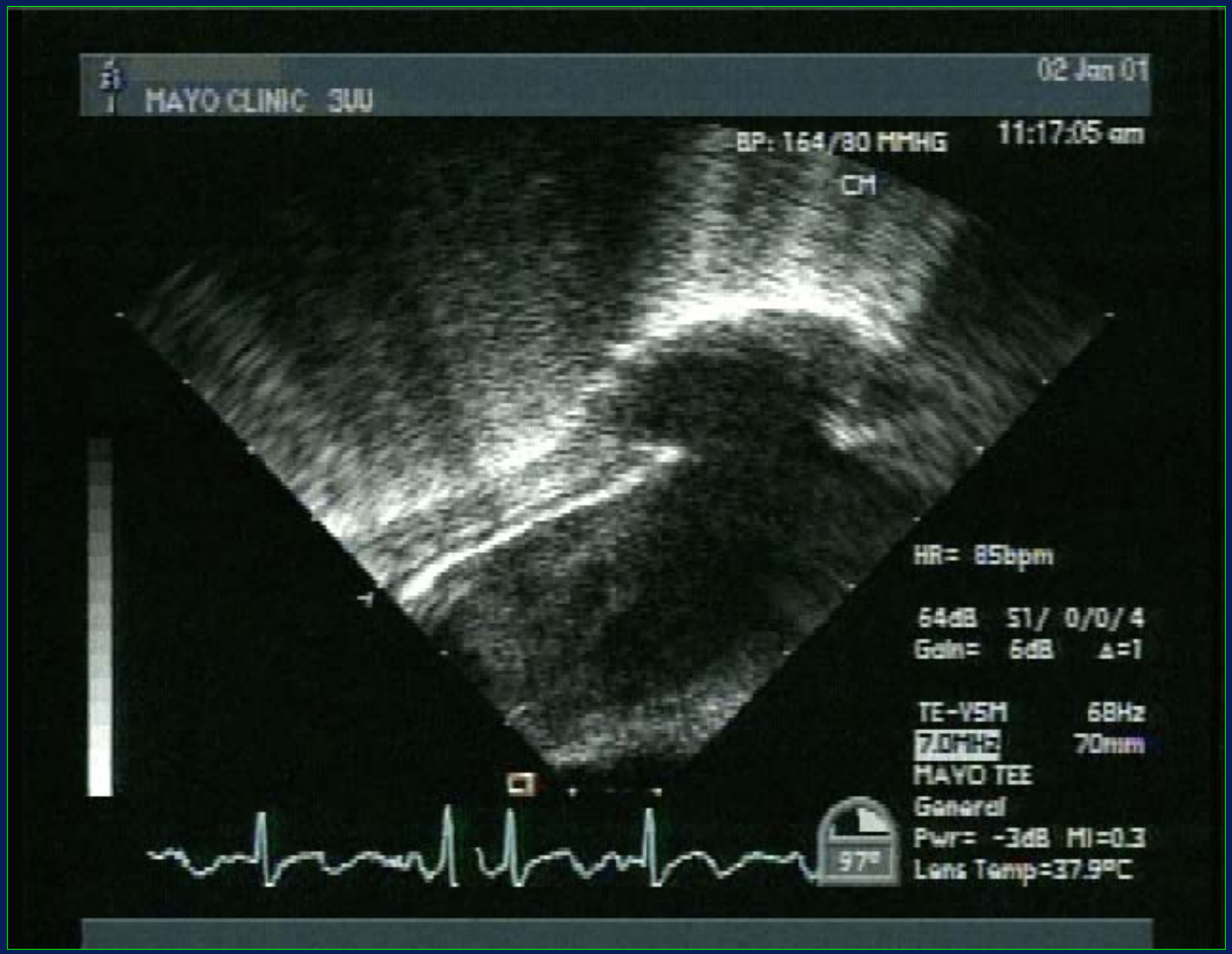
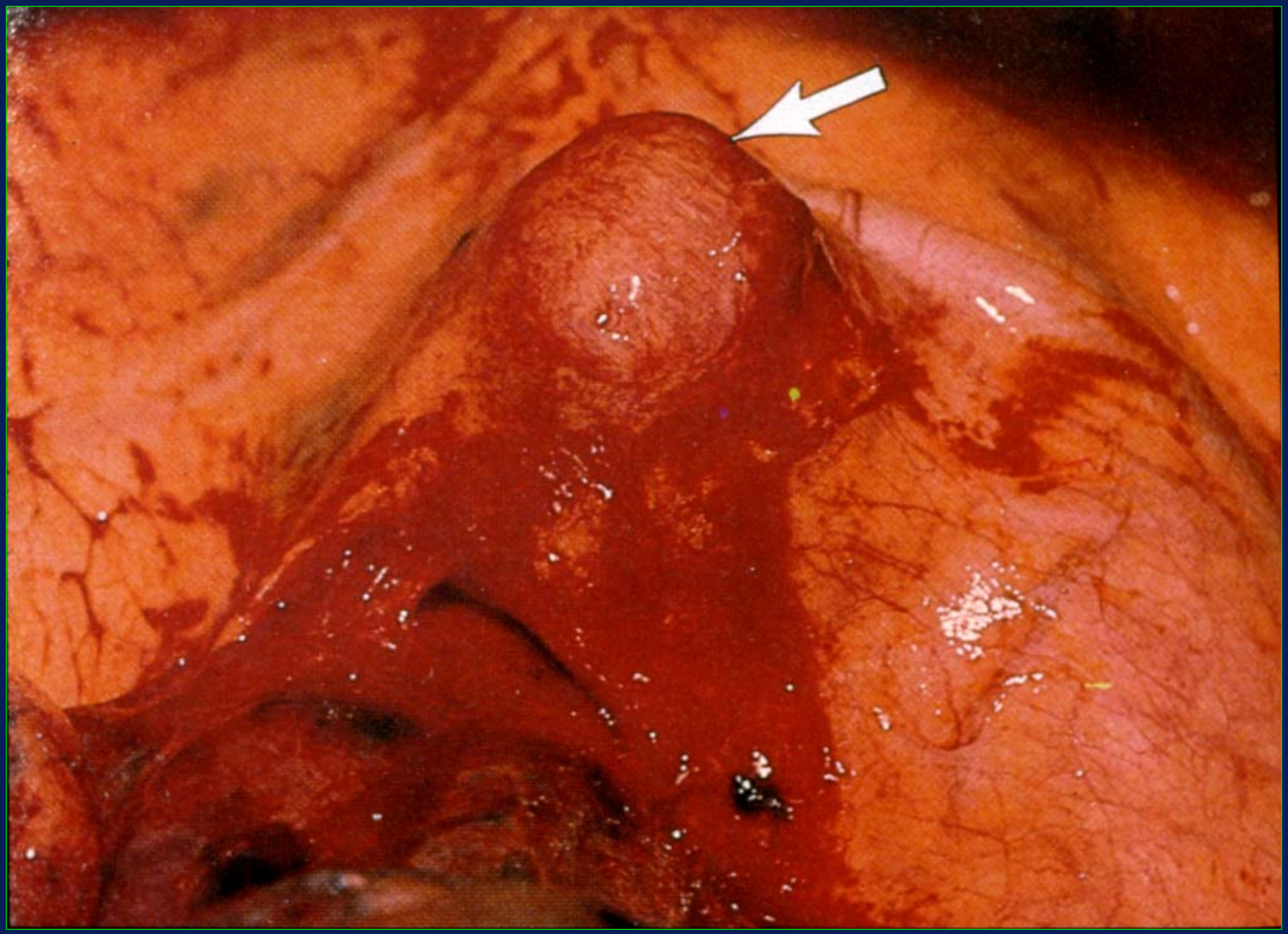


# 87 y/o Male: Interscapular back pain; creatinine 2.7



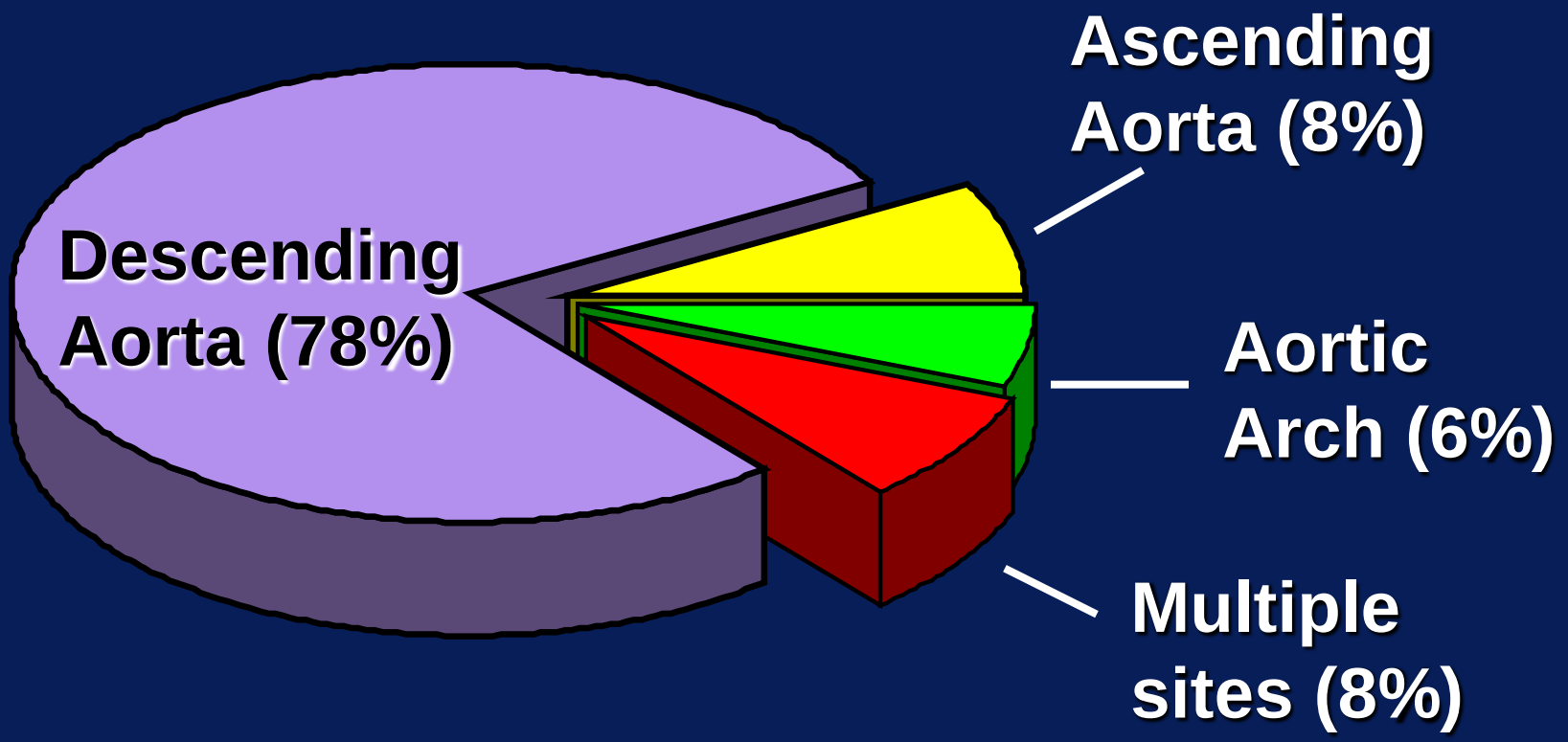
# Penetrating aortic ulcer with saccular aneurysm





Courtesy of JP Cooke, MD

# Penetrating Aortic Ulcer (PAU)
## Location in 131 Patients




Cho KR, et al. J Thorac Cardiovasc Surg 2004; 127:1393
Tittle SL, et al. J Thorac Cardiovasc Surg 2002; 123:1051

# Penetrating Aortic Ulcer (PAU)

## Complications of PAU

| Intramural Hematoma (~80%) | Localized Dissection (~30%) | Saccular aneurysm (~50%) | Complete Rupture (~10%) |
|---|---|---|---|

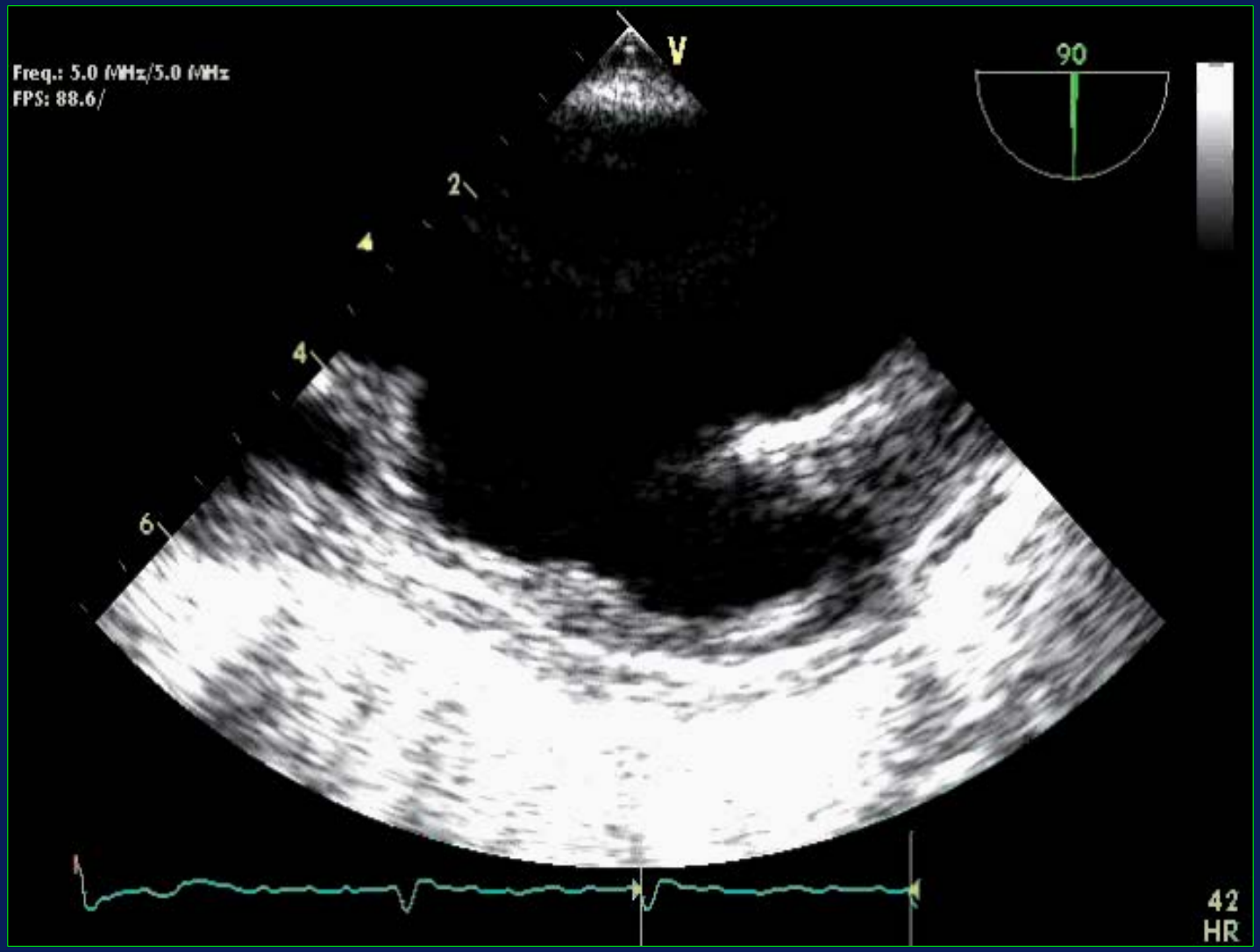
**High Risk PAU: Diameter > 2 cm, Depth > 1cm**


Cho KR, et al. J Thorac Cardiovasc Surg 2004; 127:1393

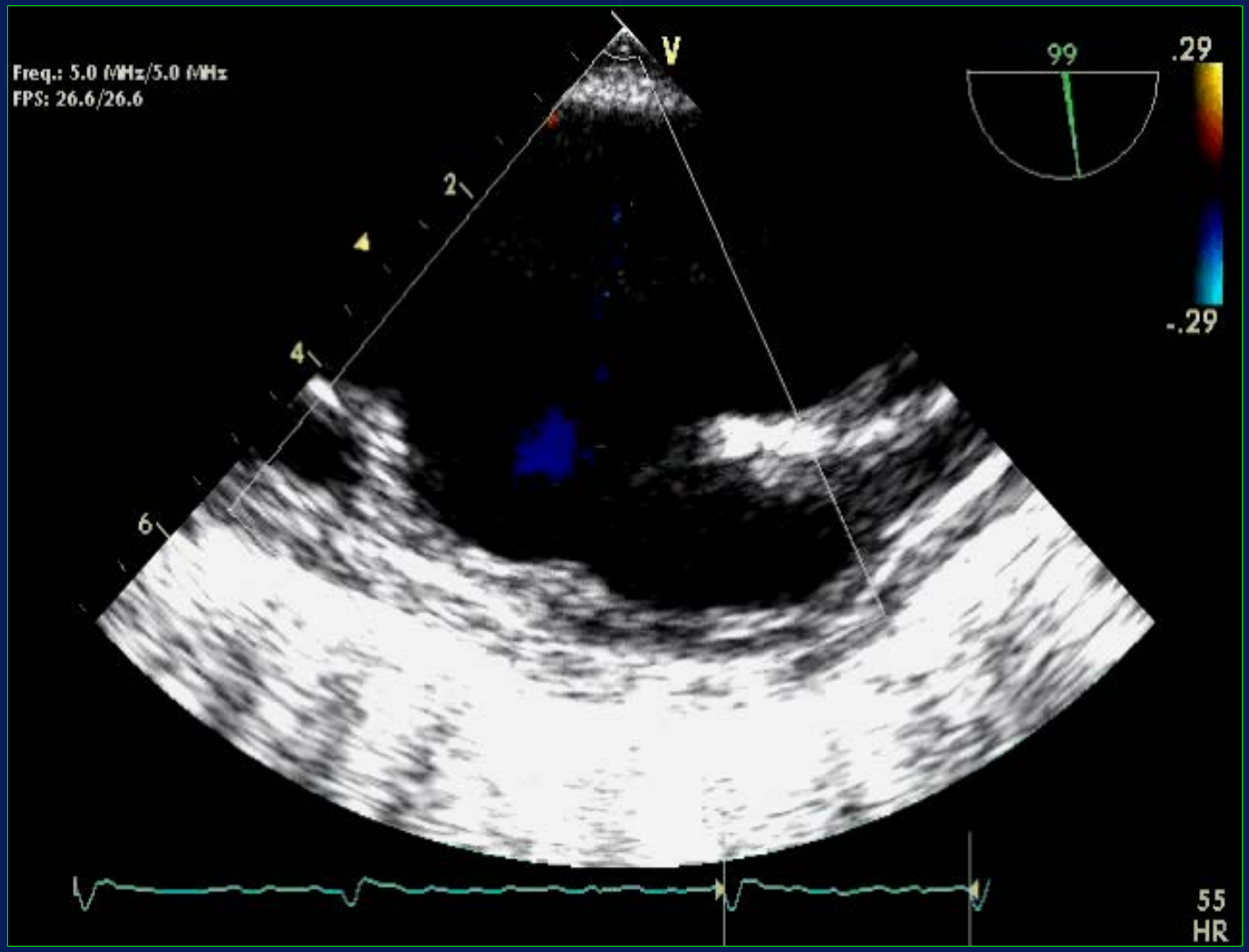
Ganaha F, et al. Circulation 2002; 106:342

Vilacosta I, et al. JACC 1998: 32; 83

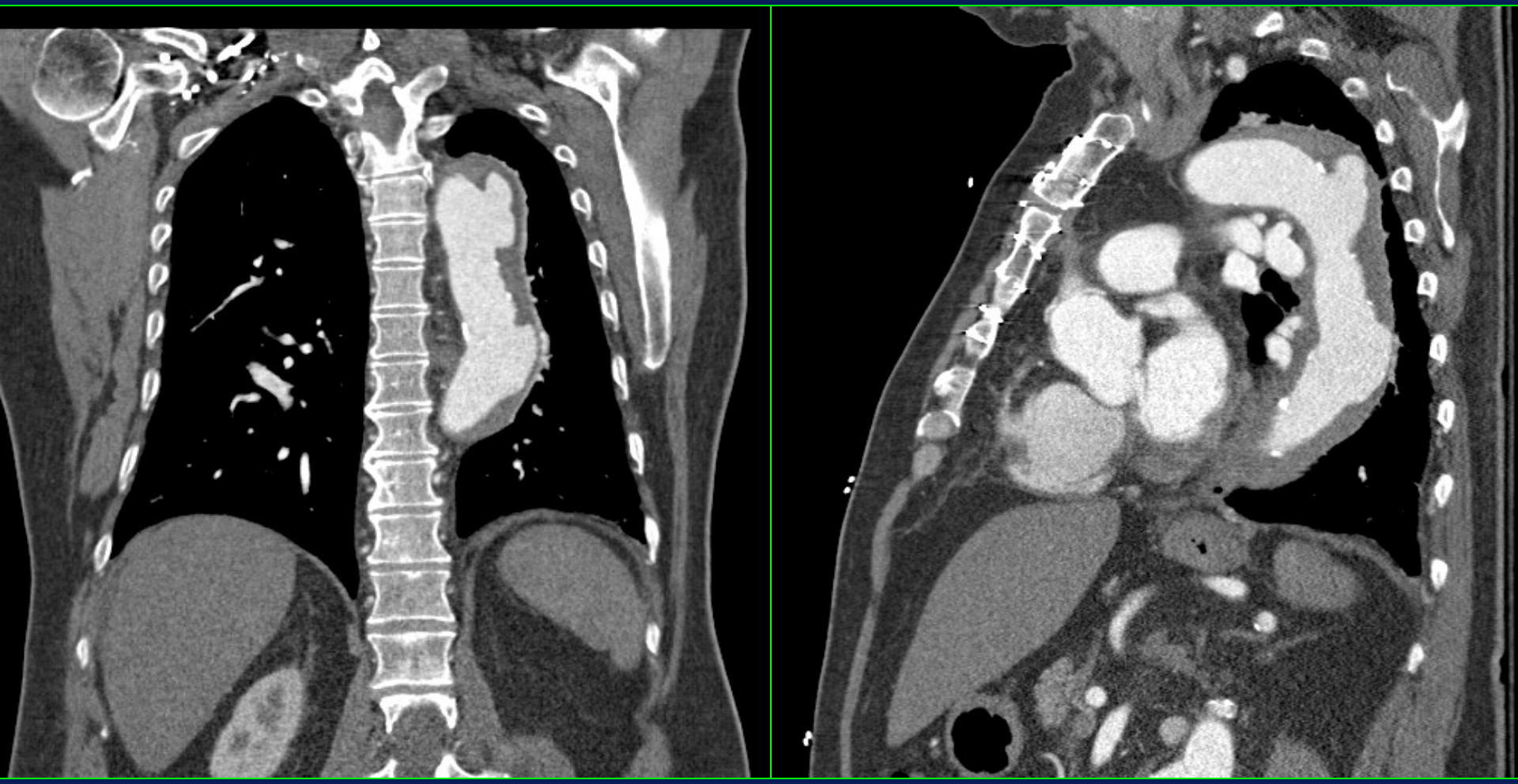
# Interscapular back pain 4 yrs after CABG

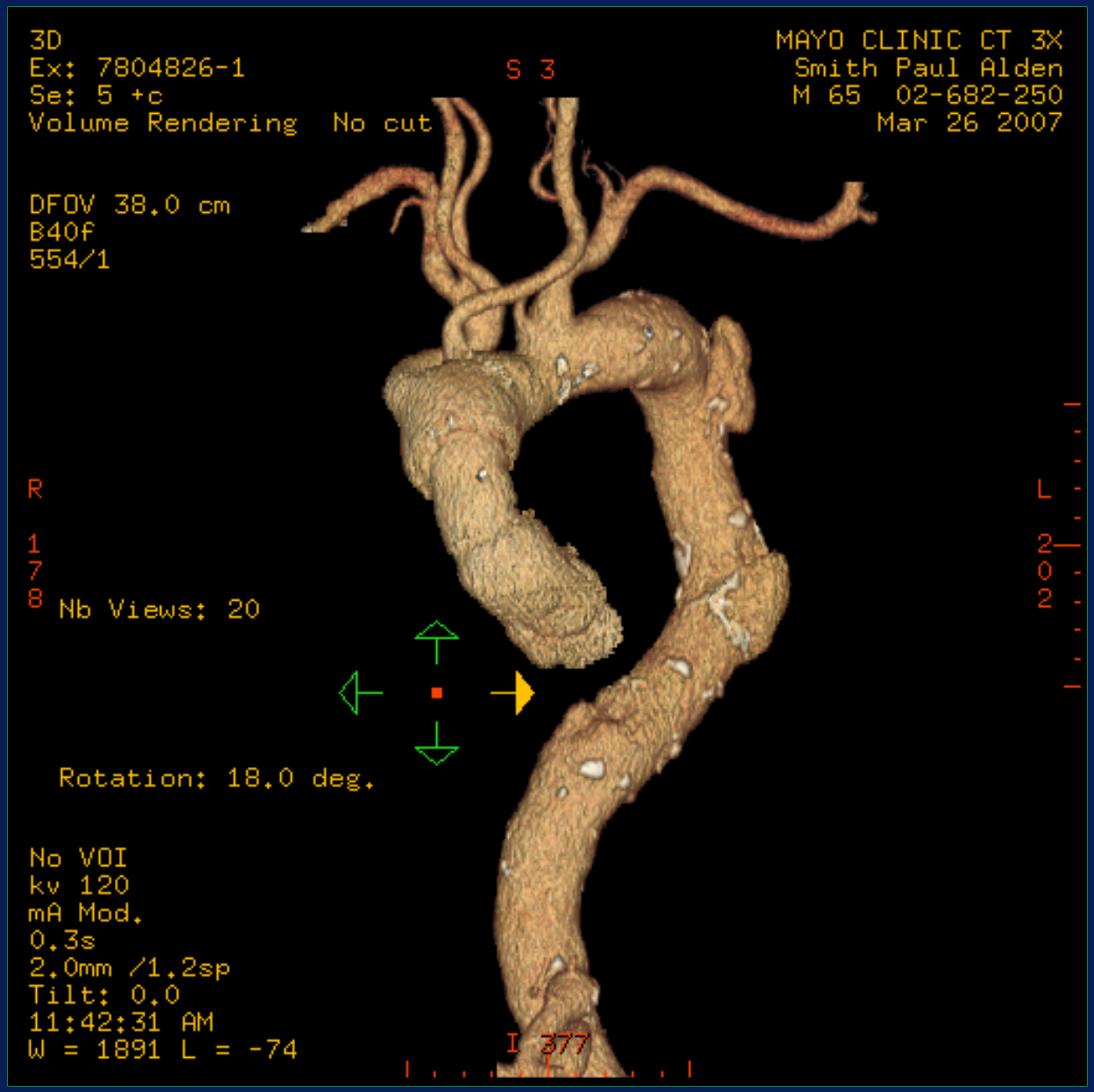


# Interscapular back pain 4 yrs after CABG



# Interscapular back pain 4 yrs after CABG

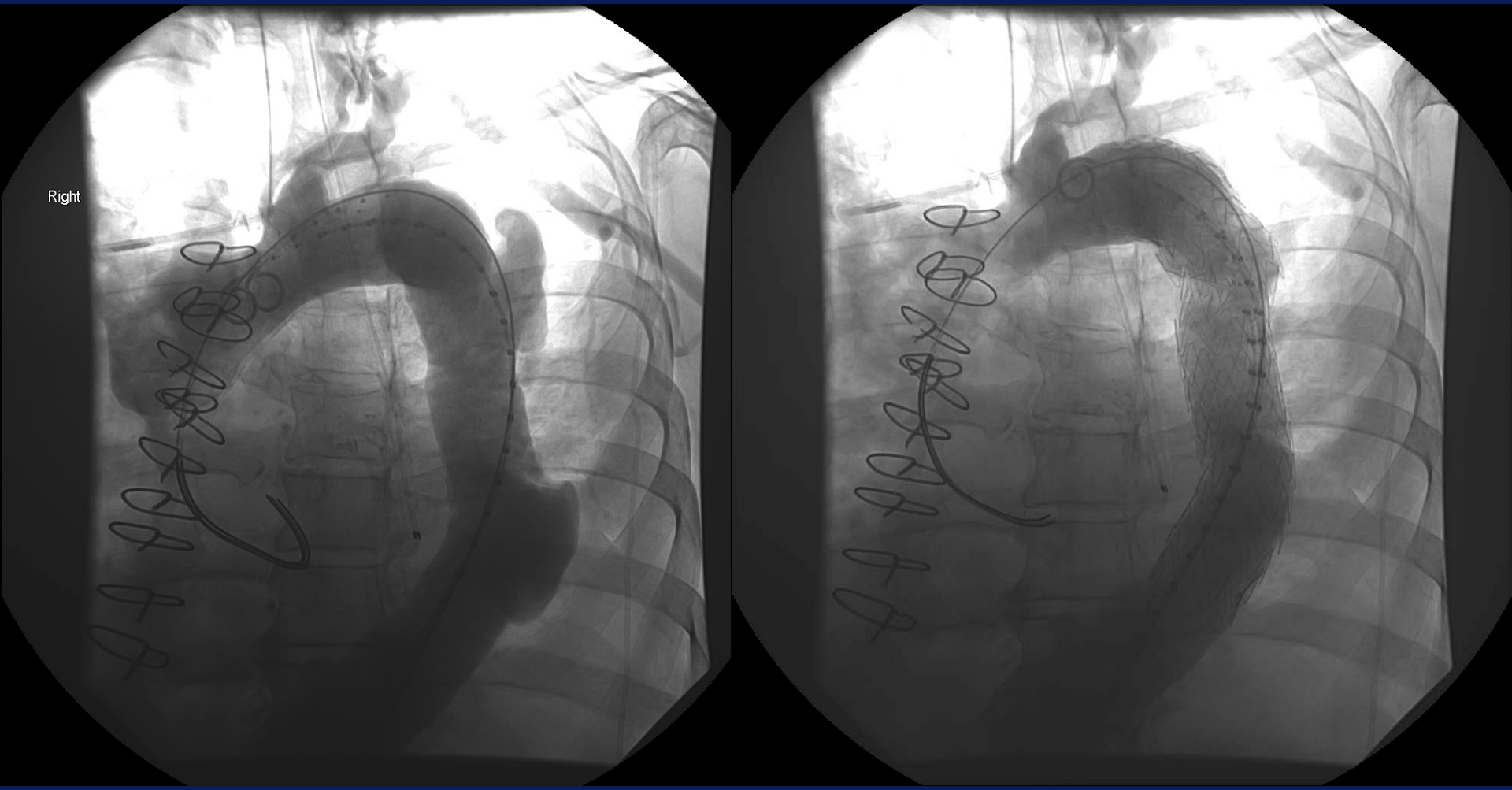


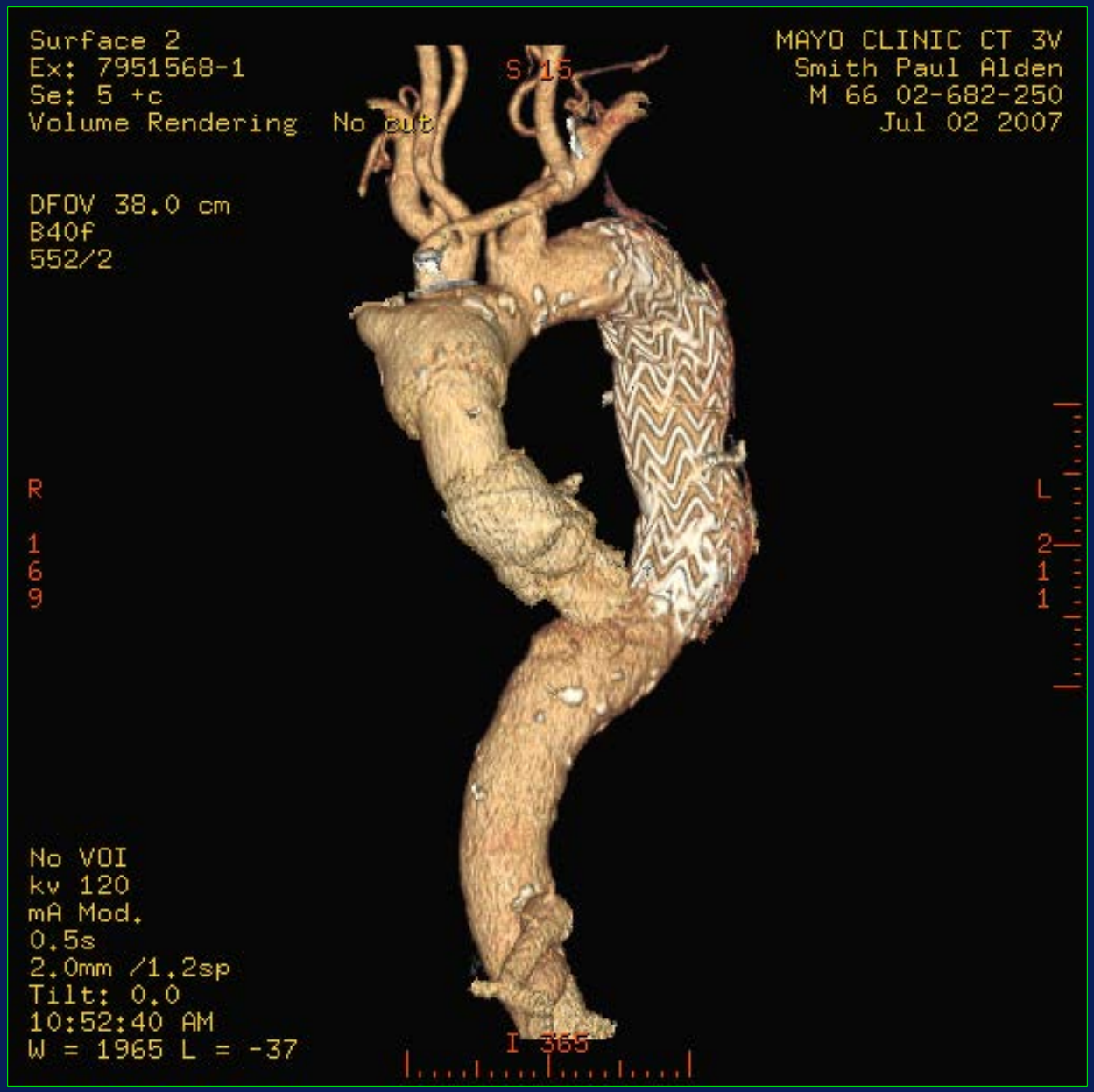

3D
Ex: 7804826-1
Se: 5 +c
Volume Rendering No cut
S 3
MAYO CLINIC CT 3X
Smith Paul Alden
M 65 02-682-250
Mar 26 2007
DFOV 38.0 cm
B40f
554/1
R
178
Nb Views: 20
L
202
Rotation: 18.0 deg.
No VOI
kv 120
mA Mod.
0.3s
2.0mm /1.2sp
Tilt: 0.0
11:42:31 AM
W = 1891 L = -74
I 377

# Endovascular Stenting: Angio

## Before

## After




Surface 2
Ex: 7951568-1
Se: 5 +c
Volume Rendering No cut
S 15
MAYO CLINIC CT 3V
Smith Paul Alden
M 66 02-682-250
Jul 02 2007
DFOV 38.0 cm
B40f
552/2
R
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6
9
L
2
1
1
No VOI
kv 120
mA Mod.
0.5s
2.0mm /1.2sp
Tilt: 0.0
10:52:40 AM
W = 1965 L = -37
I 365

# Acute Aortic Syndrome (AAS)

Index of clinical suspicion is **critical** to making the correct diagnosis

Appropriate imaging must be pursued if AAS is in the differential diagnosis

Complimentary imaging modalities are often required for management