Cases of Abnormal Prosthetic Valves

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DISCLOSURE

Relevant Financial Relationship(s)

None

Off Label Usage

None

MAYO CLINIC

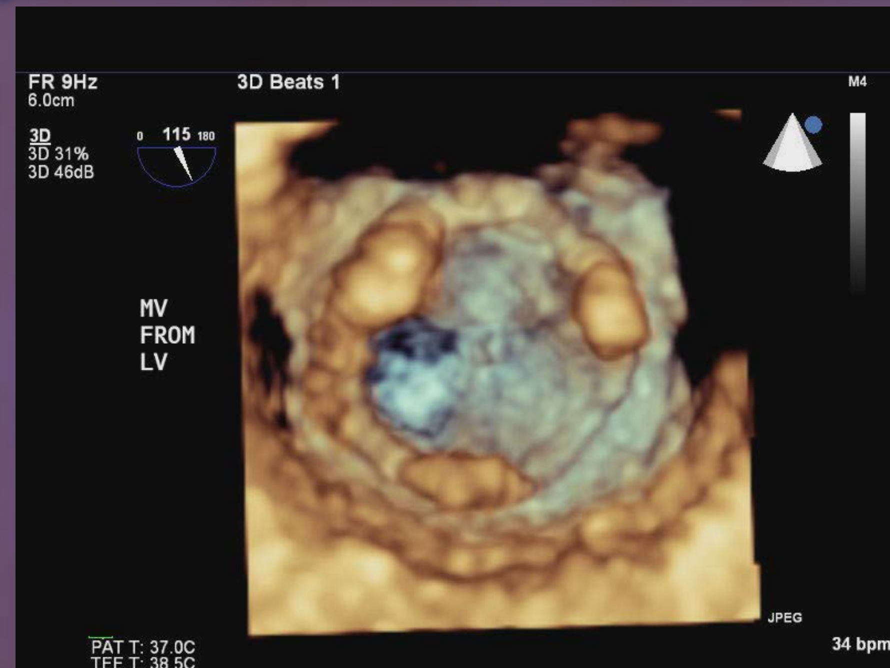
Huffnagel Artificial Valve

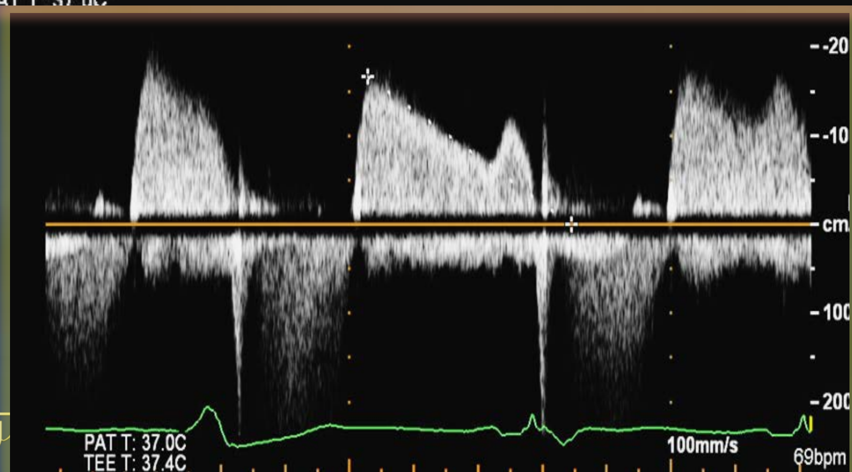
"At the annual meeting of the AHA in California (late 1960's), a patient who had received the Huffnagel artificial valve was being questioned. He was asked the usual question by a member of the audience, i.e. if the loud heart sounds bothered him. He replied, "No." Then after a second thought, he said, "Well occasionally they do. I like to play poker and when I get an unusually good hand, the sounds get louder and faster, and gives me away."

30 yo Woman With Ebstein's Anomaly

- **2009** TVR , MV repair
- **2010** Endocarditis (*S. aureus*)
  Redo MVR (St. Jude Epic)
- **2012** Worsening fatigue, dyspnea
  - Physical Exam
    - HR 77 BPM, BP 110/76 mmHg, Afebrile
    - JVP at earlobe sitting upright, prominent V-wave
    - Heart: RRR, S4, faint systolic murmur + diastolic rumble at LLSB. Faint diastolic rumble at the apex
    - Lungs: clear
    - Abdomen: Shifting dullness
    - Extremities: 1+ edema

Mitral Prosthesis





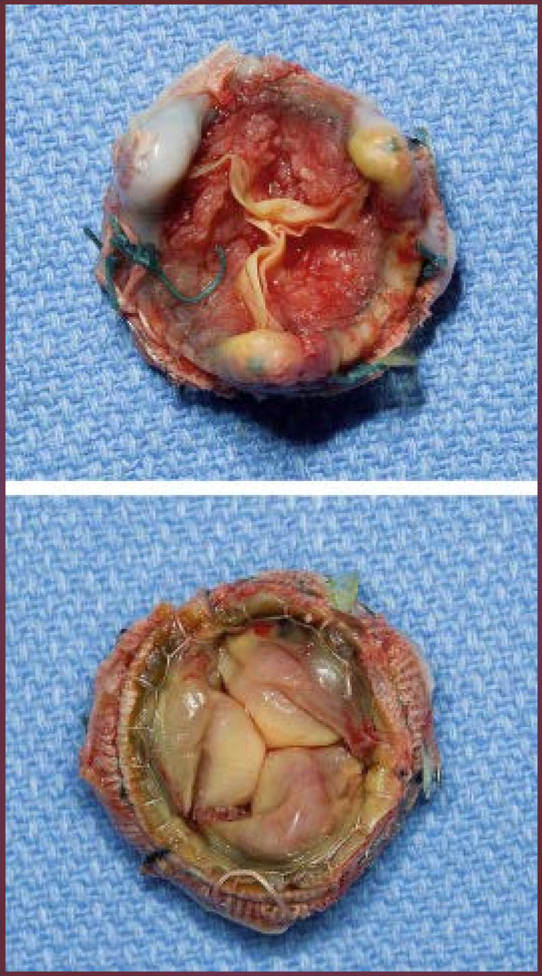
- Diastolic mean gradient: 8 mmHg (HR: 69 BPM)
- Blood cultures negative

What would you recommend?

1. Redo surgery (MVR)
2. Valve-in-valve mitral
3. Fibrinolytic therapy
4. Warfarin

Bioprosthetic Valve Thrombosis: Diagnosis

- Challenging
- TTE: no set criteria
  - Increased gradients
  - Thickened cusps, thrombus
- TEE
  - Soft echodensity in cusps
- CT



Bioprosthetic Valve Thrombosis
Mayo Clinic Experience

European Journal of Cardio-Thoracic Surgery (2014) 1–8
doi:10.1093/ejcts/ezu201

ORIGINAL ARTICLE

Misconceptions, diagnostic challenges and treatment opportunities in bioprosthetic valve thrombosis: lessons from a case series

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Abstract

OBJECTIVES: Bioprosthetic valve thrombosis (BPVT) is a rare but potentially life-threatening complication. Current guidelines favour surgery or thrombolysis as initial treatment. We set forth to characterize timing, diagnostic criteria and treatment strategies in BPVT.

METHODS: A free-text search tool was used to identify patients diagnosed with BPVT at Mayo Clinic between 1997 and 2013. We compared patients treated initially with vitamin K antagonists (VKA group; $N = 15$) versus surgery/thrombolysis (non-VKA group; $N = 17$).

RESULTS: Peak incidence of BPVT was 13–24 months after implantation in both groups. VKA and surgery/thrombolysis decreased prosthetic mean gradients to a similar extent (VKA group: 13 ± 5 to 6 ± 2 mmHg in mitral position, 9 ± 3 to 5 ± 1 mmHg in tricuspid position and 39 ± 3 to 24 ± 7 mmHg in aortic/pulmonary position; non-VKA group: 16 ± 12 to 5 ± 1 mmHg in mitral, 10 ± 5 to 4 ± 1 mmHg in tricuspid and 57 ± 9 to 18 ± 6 mmHg in aortic position; $P = 0.59$ for group effect). NYHA class improved in 11 of 15 patients in the VKA group and 10 of 17 patients in the non-VKA group ($P = 0.39$). There were no deaths, strokes or recognized embolic events; 1 patient in each group experienced gastrointestinal bleeding requiring transfusion. Index transthoracic echocardiogram formally identified BPVT in a minority of patients.

CONCLUSIONS: BPVT may occur late after surgical implantation. VKA therapy resulted in haemodynamic and clinical improvement with minimal risk, and should be considered the first-line therapy in haemodynamically stable patients. Echocardiographic criteria for improving BPVT diagnosis are proposed.

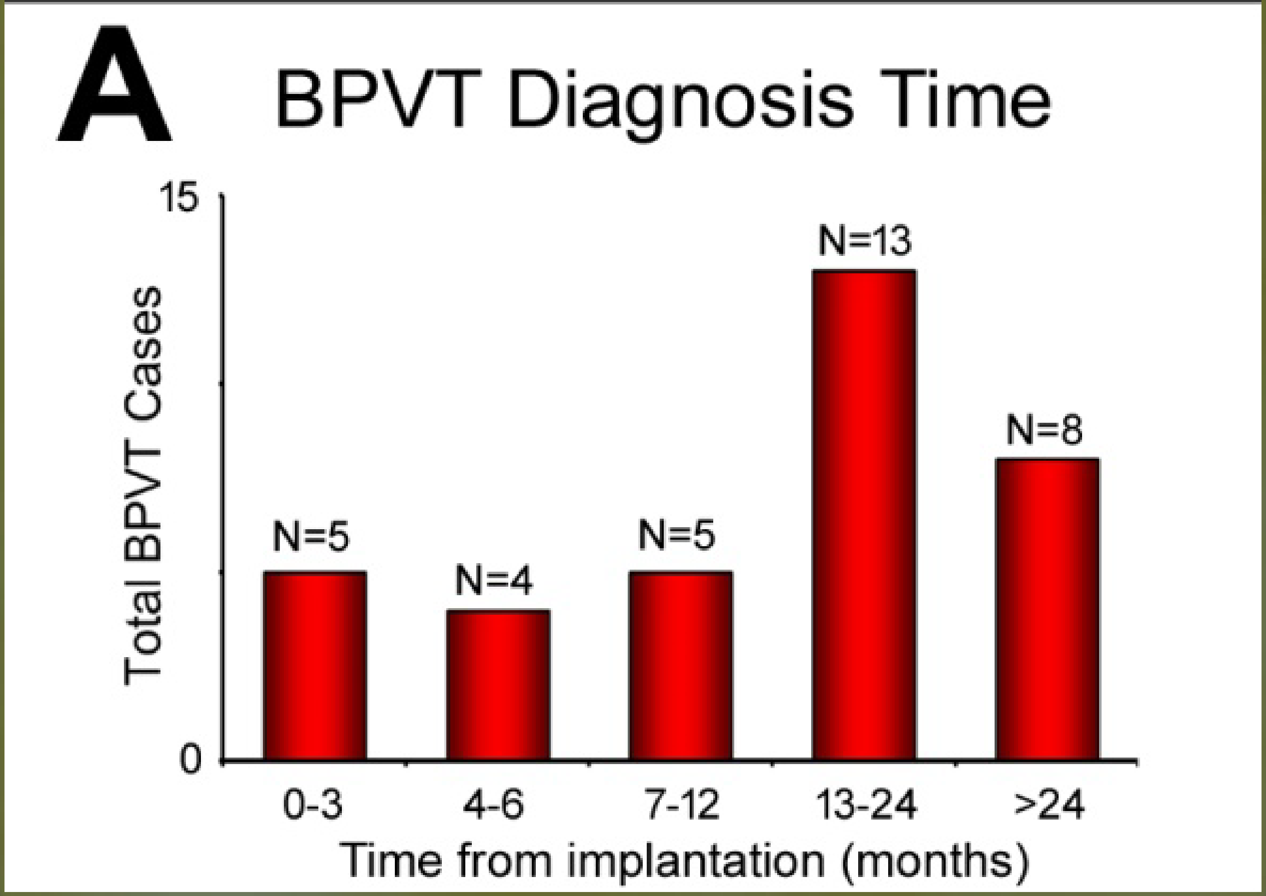
Keywords: Bioprosthetic valves • Prosthetic valve thrombosis • Anticoagulant therapy

MAYO CLINIC

Misconceptions in BPVT

- How good was TTE?
  - Abnormal findings: all patients
  - Possibility of BPVT: *6 of 32*
  - *BPVT not suspected: 8 of 15 undergoing surgery*
- TEE
  - Thrombus seen in all mitral / tricuspid
  - Challenging imaging for aortic BPV; thrombus described in 9/12 patients

Misconceptions in BPVT

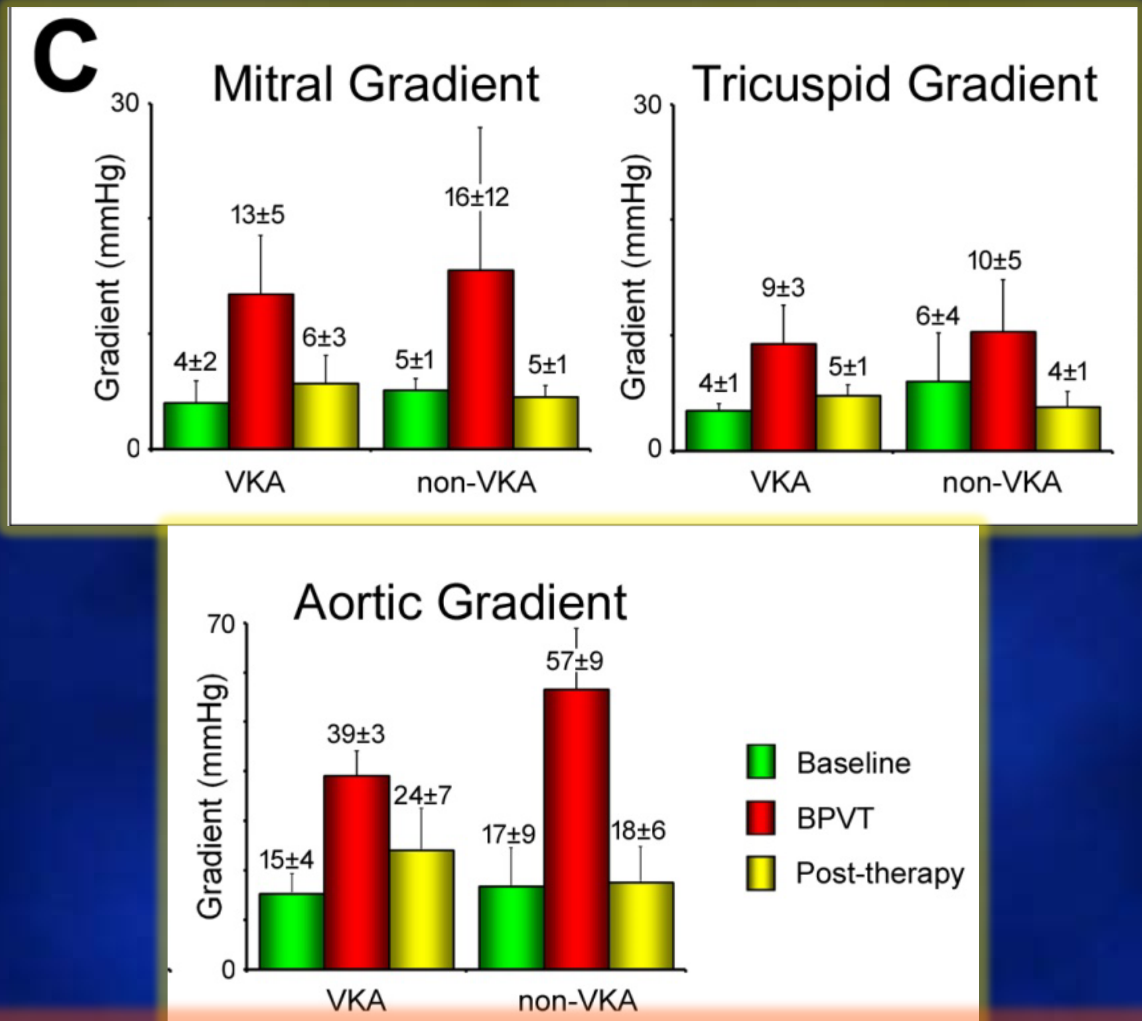


Peak incidence second year

Longest interval: 6.5 years

EJCTS 2014

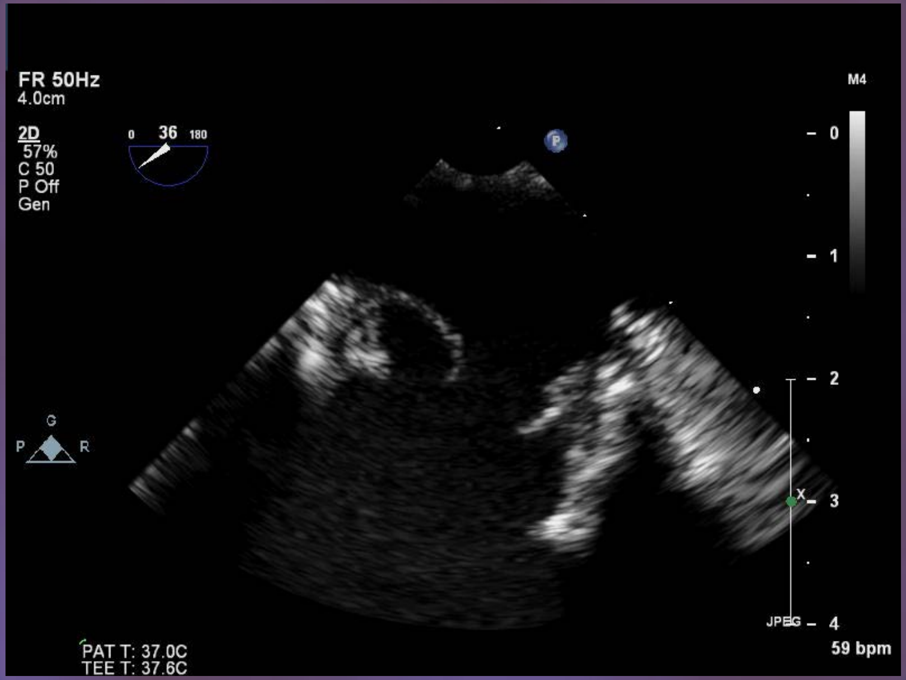
Misconceptions in BPVT

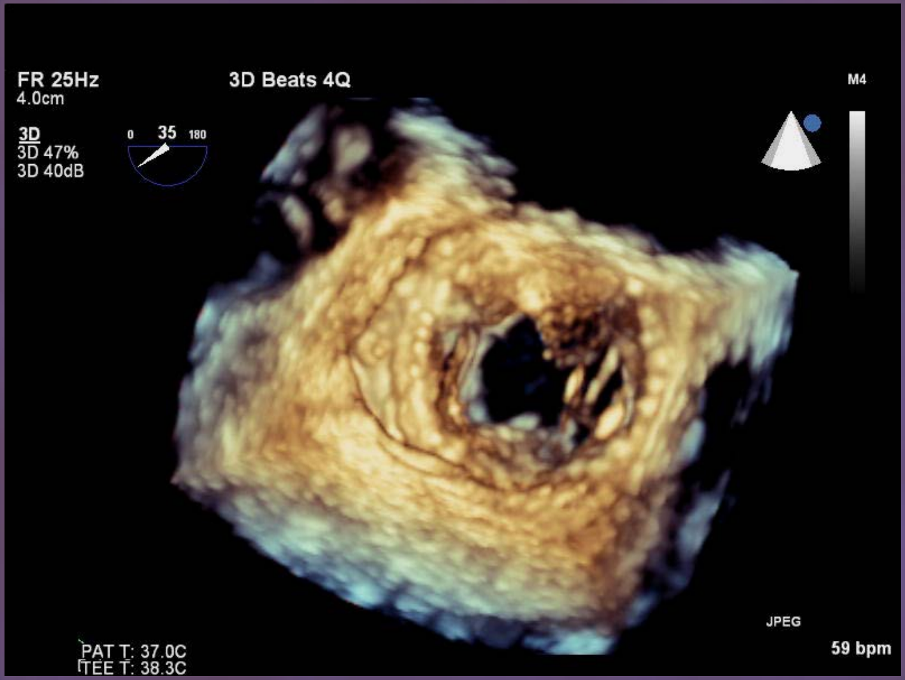


EJCTS 2014

VKA as effective as surgery / lytics

Our patient: One Month VKA





Diastolic mean gradient:
3 mmHg (HR 66 BPM)

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Bioprosthetic Valve Thrombosis Versus Structural Failure

Clinical and Echocardiographic Predictors

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ABSTRACT

BACKGROUND Bioprosthetic valve thrombosis (BPVT) is considered uncommon; this may be related to the fact that it is often unrecognized. Recent data suggest that BPVT responds to vitamin K antagonists, emphasizing the need for reliable diagnosis.

OBJECTIVES This study sought to determine the diagnostic features of BPVT and to formulate a diagnostic model for BPVT.

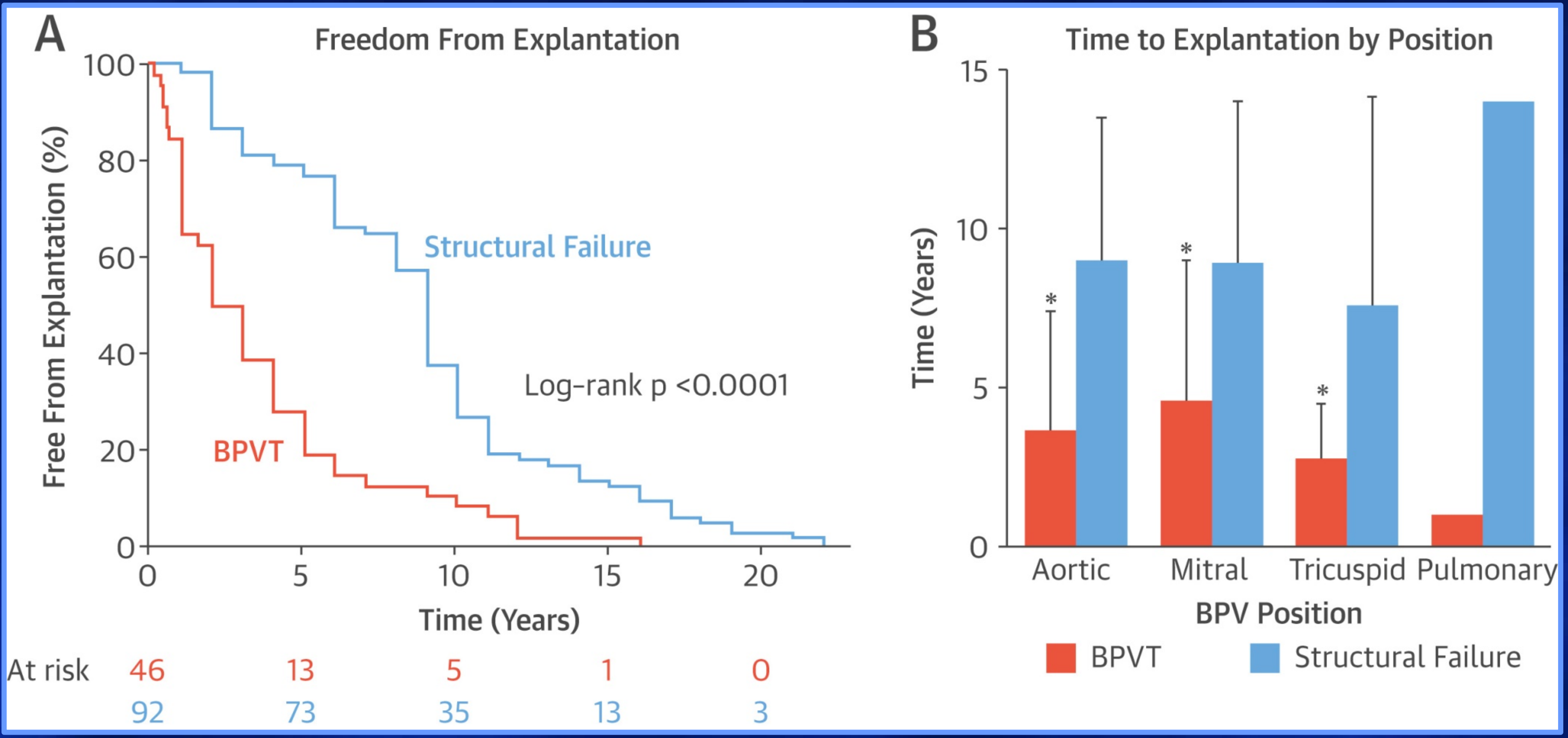
model for BPVT.
OBJECTIVES This study sought to determine the diagnostic features of BPVT and to formulate a diagnostic

BPVT: Mayo Surgical Experience

- **All bioprosthetic re-operations 1994-2014**
- **46 BPVT** ***(11% of all reoperations)***
- **92 structural failure (2:1 for age, gender, prosthetic position, and year of implantation)**

MAYO CLINIC

Egbe et al. JACC 2015.



Egbe et al. JACC 2015.

Proposed Echo Criteria

1. **Increased gradient > 50% over baseline, especially within first 5 years post-implant**
2. **Thickened, <u>non-calcified leaflets</u>**

All 3 parameters: 72% sensitivity, 90% specificity for BPVT

Egbe et al. JACC 2015.

Bioprosthetic Valve Thrombosis

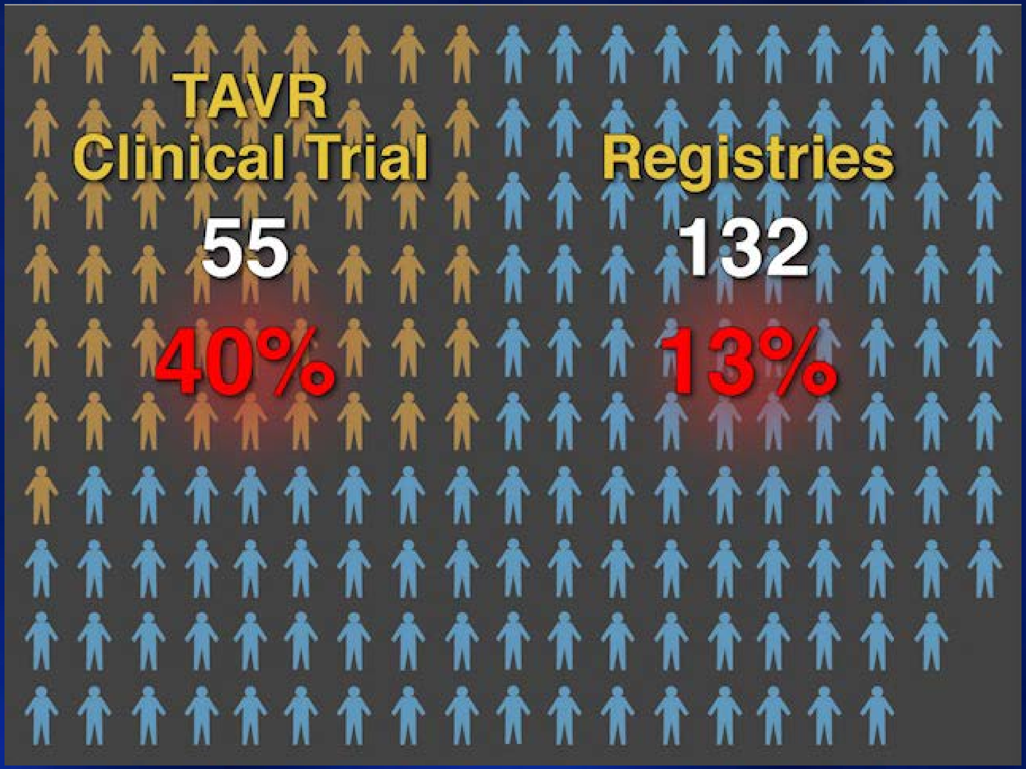
TAVR: A Bigger Problem?

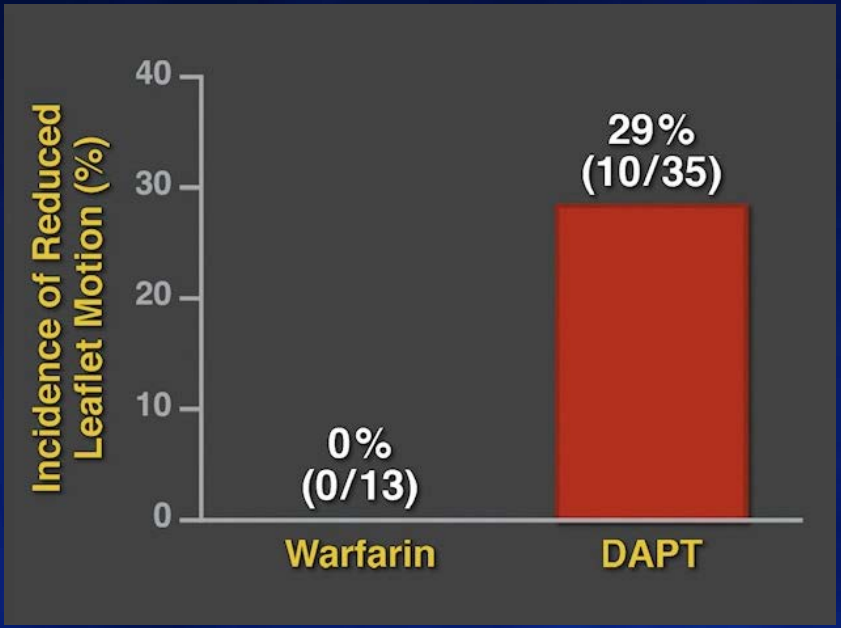
The NEW ENGLAND JOURNAL of MEDICINE

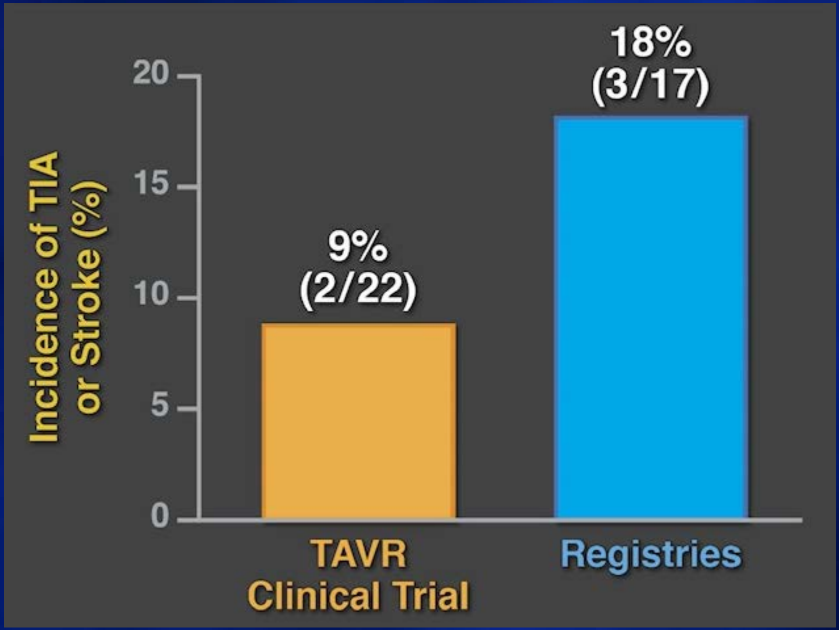
ORIGINAL ARTICLE

Possible Subclinical Leaflet Thrombosis in Bioprosthetic Aortic Valves

R.R. Makkar, G. Fontana, H. Jilaihawi, T. Chakravarty, K.F. Kofoed, O. de Backer, F.M. Asch, C.E. Ruiz, N.T. Olsen, A. Trento, J. Friedman, D. Berman, W. Cheng, M. Kashif, V. Jelnin, C.A. Kliger, H. Guo, A.D. Pichard, N.J. Weissman, S. Kapadia, E. Manasse, D.L. Bhatt, M.B. Leon, and L. Søndergaard



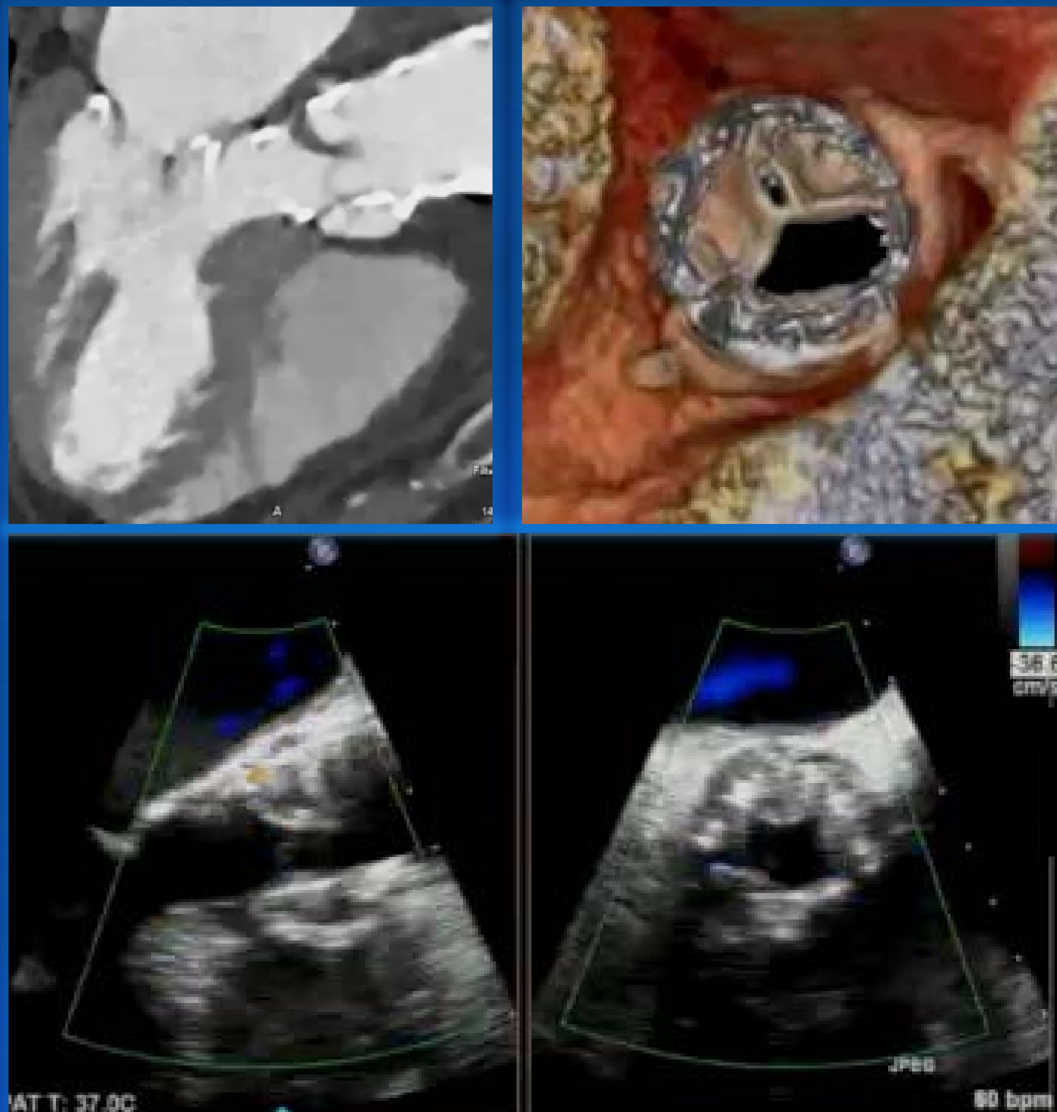




Symptomatic TAVR-related thrombosis is rare (<1%)

Makkar et al, NEJM 2015

CT reconstruction – Portico TAV



Corresponding TEE

Makkar et al, NEJM 2015

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BPVT: Take Home Points

- BPVT diagnosis is <u>challenging</u>
- What we know:
  - BPVT may occur late after implantation
  - TTE increased gradient, may not show mechanism
- When to suspect:
  - BPV gradient > 50% over baseline, restricted cusp mobility, thickened leaflets
- TEE/CT when in doubt

Case: 58 Year-Old Woman

- Progressive Dyspnea (NYHA III)
- Rheumatic heart disease
- 2010
  - Medtronic Mosaic (21mm) AVR
  - MV Repair (27mm Duran ring)
- Obesity
  - BNP not elevated


PHILIPS
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S5-1/MayoAdult
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15cm
2D
55%
C 50
P Low
HGen
M3
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10
P R
1.7 3.4


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S5-1/MayoAdult
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CF
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WF High
Med
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-73.3
cm/s
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P R
1.7 3.4
JPEG
60 bpm

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1.7 3.4


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P R
1.7 3.4
JPEG
53 bpm

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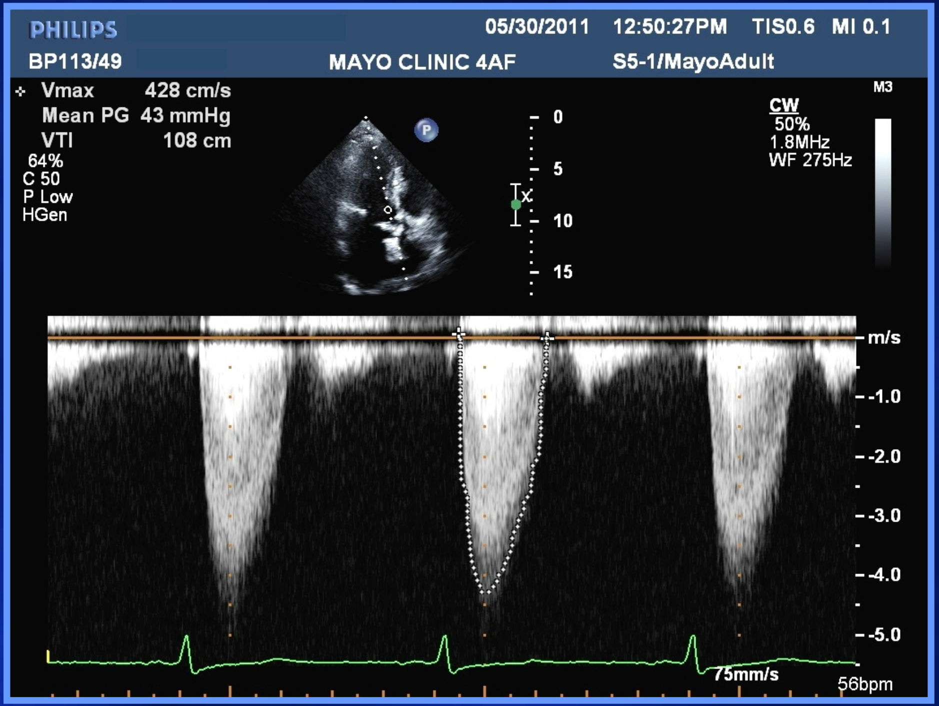
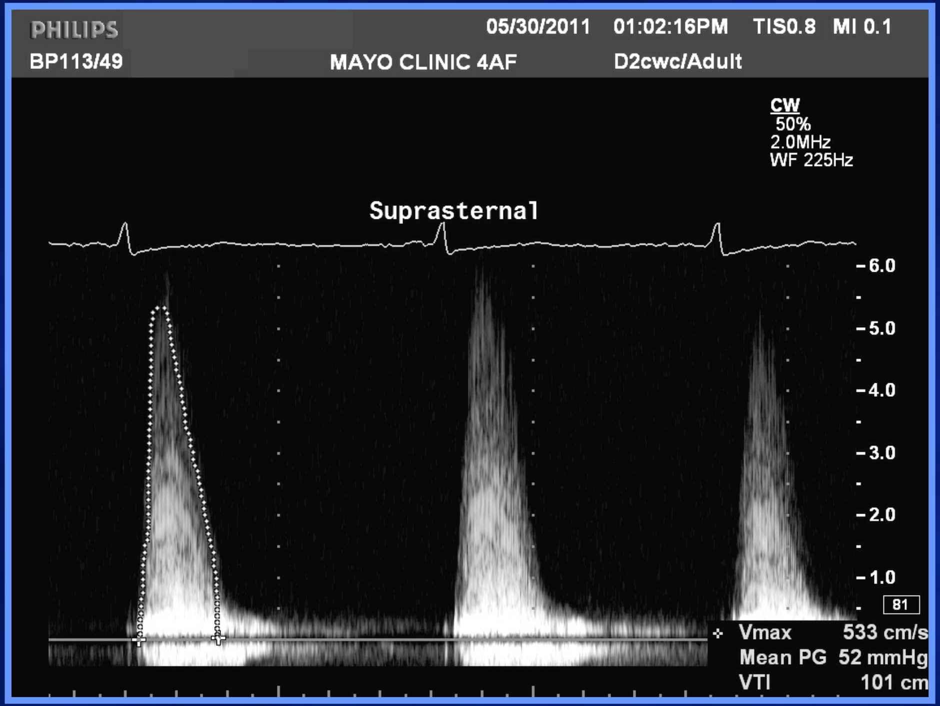
AV Prosthetic Gradient





The gradient across the prosthesis most likely reflects:

A. Patient-prosthesis mismatch
B. Prosthetic obstruction
C. Normal function for this prosthesis
D. Pressure recovery
E. Cannot tell; need more information

Normal Valve-Specific Parameters

1010 Zoghbi et al

Journal of the American Society of Echocardiography
September 2009

Appendix A. Normal Doppler Echocardiographic Values for Prosthetic Aortic Valves*

Valve	Size	Peak gradient (mm Hg)	Mean gradient (mmHg)	Effective orifice area (cm^2)
Medtronic Mosaic *Stented porcine*	21		14.2± 5.0	1.4± 0.4
	23	23.8± 11.0	13.7± 4.8	1.5± 0.4
	25	22.5± 10.0	11.7± 5.1	1.8± 0.5
	27		10.4± 4.3	1.9± 0.1
	29		11.1± 4.3	2.1± 0.2

The Differential Diagnosis

Elevated Prosthetic Aortic Valve Gradient

- Obstruction
  - Dysfunction, thrombus, vegetation, pannus, degeneration
- Patient-prosthesis mismatch
  - EOA too small for body size
- High output state
- Pressure Recovery

Interpretation of Elevated Aortic PV Gradients

Doppler parameter	Expected*	Stenosis	PPM	High Output	Pressure Recovery
Gradient (mmHg)	14 ± 5	High	High	High	High

*Prosthesis-specific: Medtronic Mosaic 21mm

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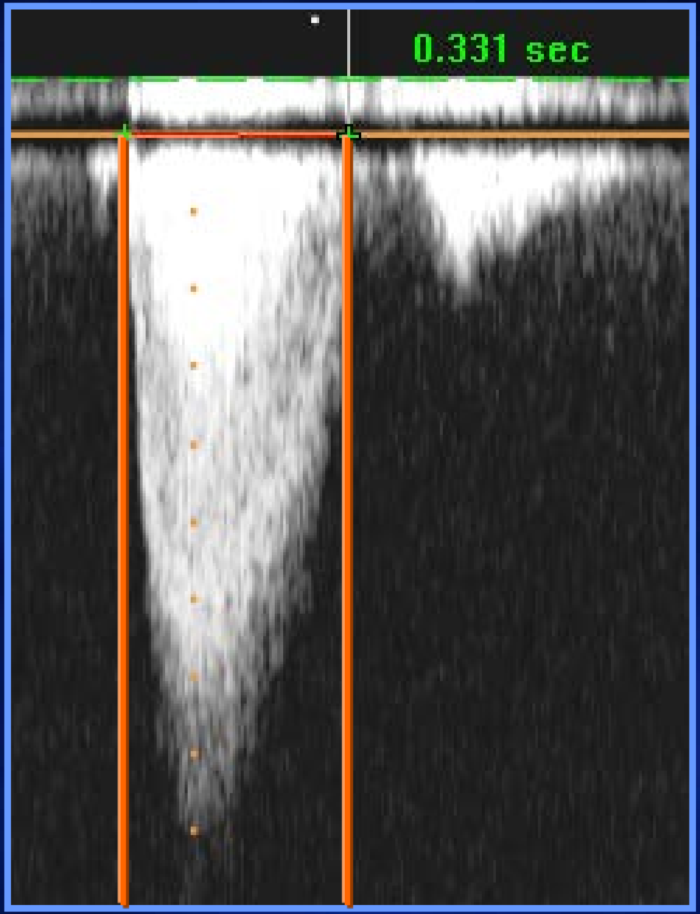
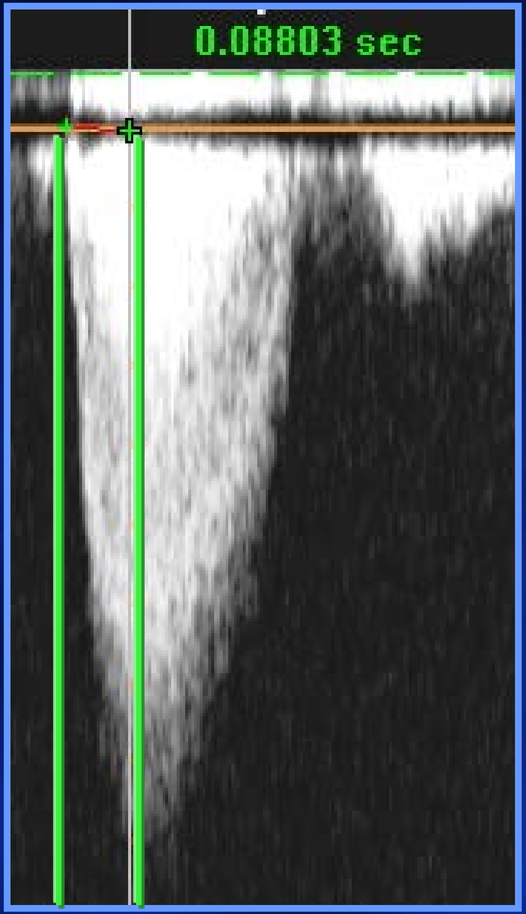
Slide adapted from Darryl Burstow, M.D.



Ejection Time (ET) = 331 msec



Acceleration Time (AT) = 88 msec

AT / ET = 0.27

AT = 88 msec
AT / ET = 0.27

These AV systolic time intervals are most consistent with a:

A. Obstructed prosthesis
B. Normal prosthesis
C. I have no idea

Acceleration Time and Ejection Time

Table 2. ROC Analysis: Differentiation of PAV Stenosis From Controls and PPM

		Best Cutoff to Discriminate PAV Stenosis From Controls and PPM					
Parameter	AUC (95% CI)	Value	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV (%)	NPV (%)
AT, ms	0.92 (0.83–1.00)	100	86	86	85	66	95
ET, ms	0.73 (0.60–0.86)	275	73	68	74	48	85
AT/ET	0.88 (0.78–0.97)	0.37	96	82	85	64	98

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Ben Zekry S, JACC Imaging 2011

Interpretation of Elevated Aortic PV Gradients

Doppler parameter	Expected*	Stenosis	PPM	High Output	Pressure Recovery
Gradient (mmHg)	14 ± 5	High	High	High	High
Accel Time (msec)	≤ 100	> 100	≤ 100	≤ 100	≤ 100
AT / ET	≤ 0.37	> 0.37	≤ 0.37	≤ 0.37	≤ 0.37

*Prosthesis-specific: Medtronic Mosaic 21mm

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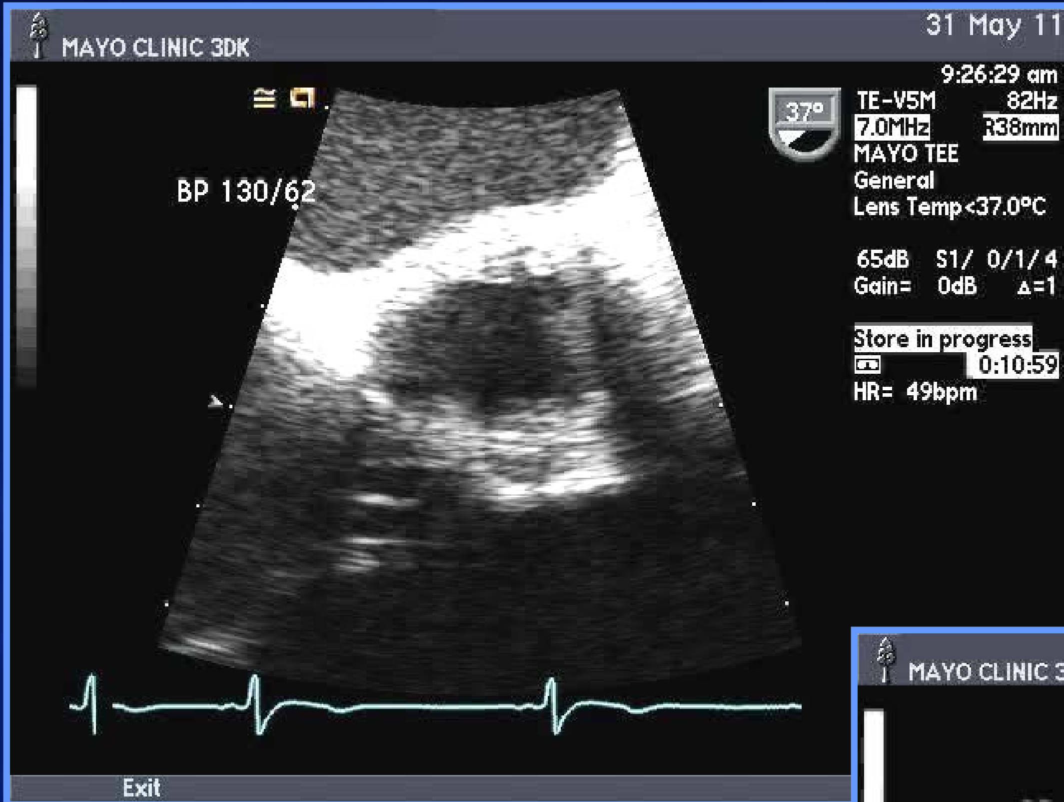
Slide adapted from Darryl Burstow, M.D.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37°
TE-V5M 82Hz
7.0MHz R38mm
MAYO TEE
General
Lens Temp<37.0°C
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Gain= 0dB Δ=1
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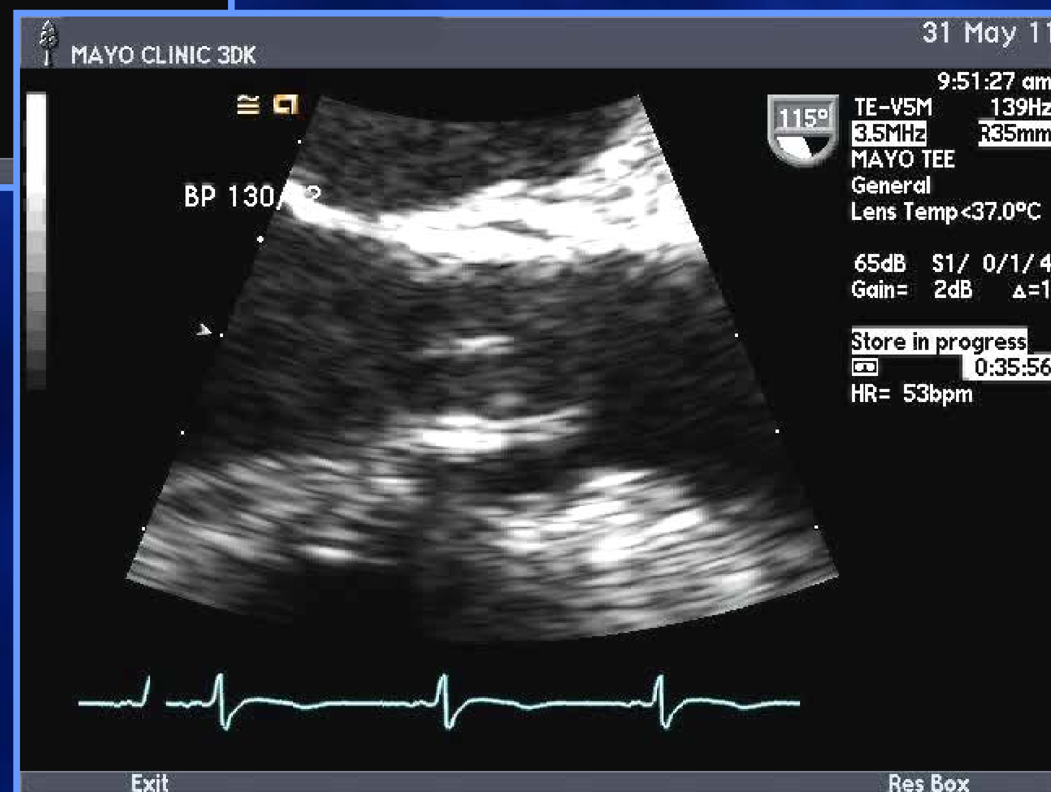
BP 130/62
Exit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TE-V5M 139Hz
3.5MHz R35mm
MAYO TEE
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65dB S1/ 0/1/4
Gain= 2dB Δ=1
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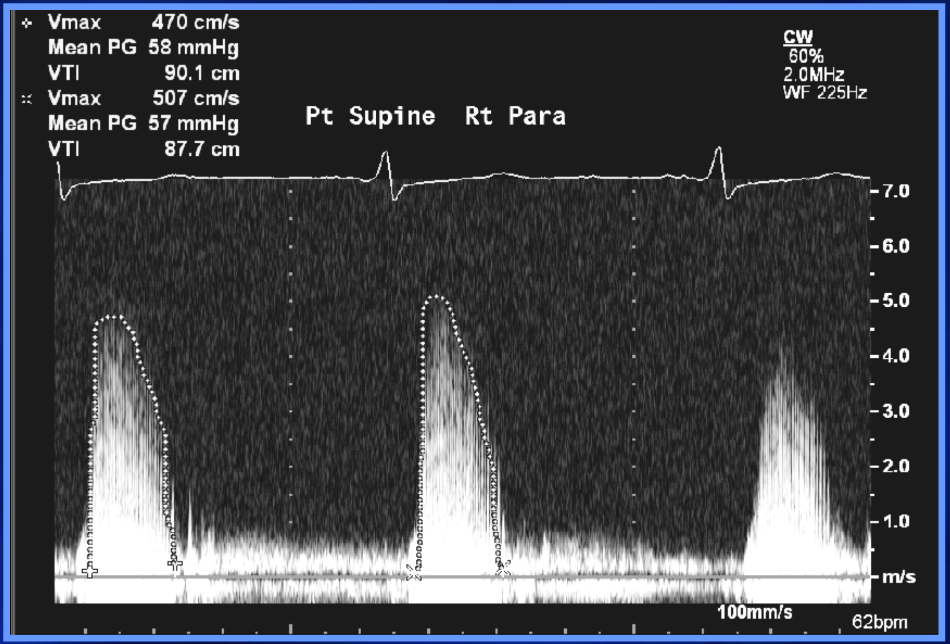
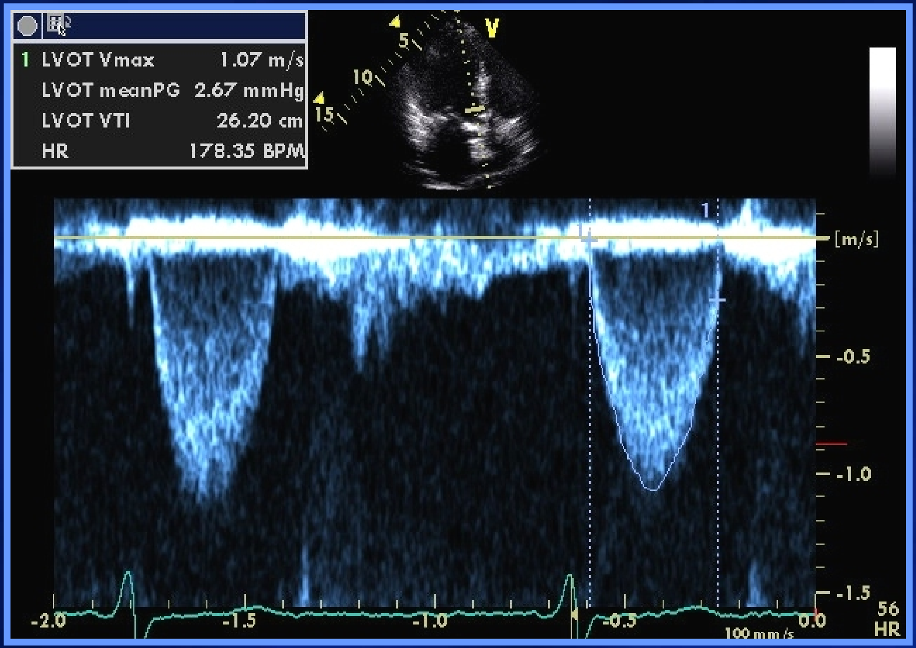
HR= 53bpm
BP 130/
Exit
Res Box

MAYO CLINIC

Dimensionless Index



Mean Gradient = 56 mmHg



LVSVI = 54 cc / m^2
(normal 32-58)

Effective Orifice Area (EOA) = 0.97 cm^2
EOA Index = 0.57 cm^2 / m^2 (BSA 1.7 m^2)
Dimensionless Index (DI) = 0.28

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What is the most likely cause of the elevated gradient in this case?

A. Patient-prosthesis mismatch
B. Prosthetic obstruction
C. High output state
D. Pressure recovery
E. Need more information

Interpretation of Elevated Aortic PV Gradients

Doppler parameter	Expected*	Stenosis	PPM	High Output	Pressure Recovery
Gradient (mmHg)	14 ± 5	High	High	High	High
Accel Time (msec)	≤ 100	> 100	≤ 100	≤ 100	≤ 100
AT / ET	≤ 0.37	> 0.37	≤ 0.37	≤ 0.37	≤ 0.37
Abn Leaflet Motion	No	Yes	No	No	No
EOA (cm^2)	1.4 ± 0.4	Low	Expected	Expected	Varies
EOA Index (cm^2/m^2)	> 0.85	Low	Low	> 0.85	Varies
DVI	>0.25	≤ 0.25	> 0.25	>0.25	Varies

*Prosthesis-specific: Medtronic Mosaic 21mm

MAYO CLINIC

Slide adapted from Darryl Burstow, M.D.

Interpretation of Elevated Aortic PV Gradients

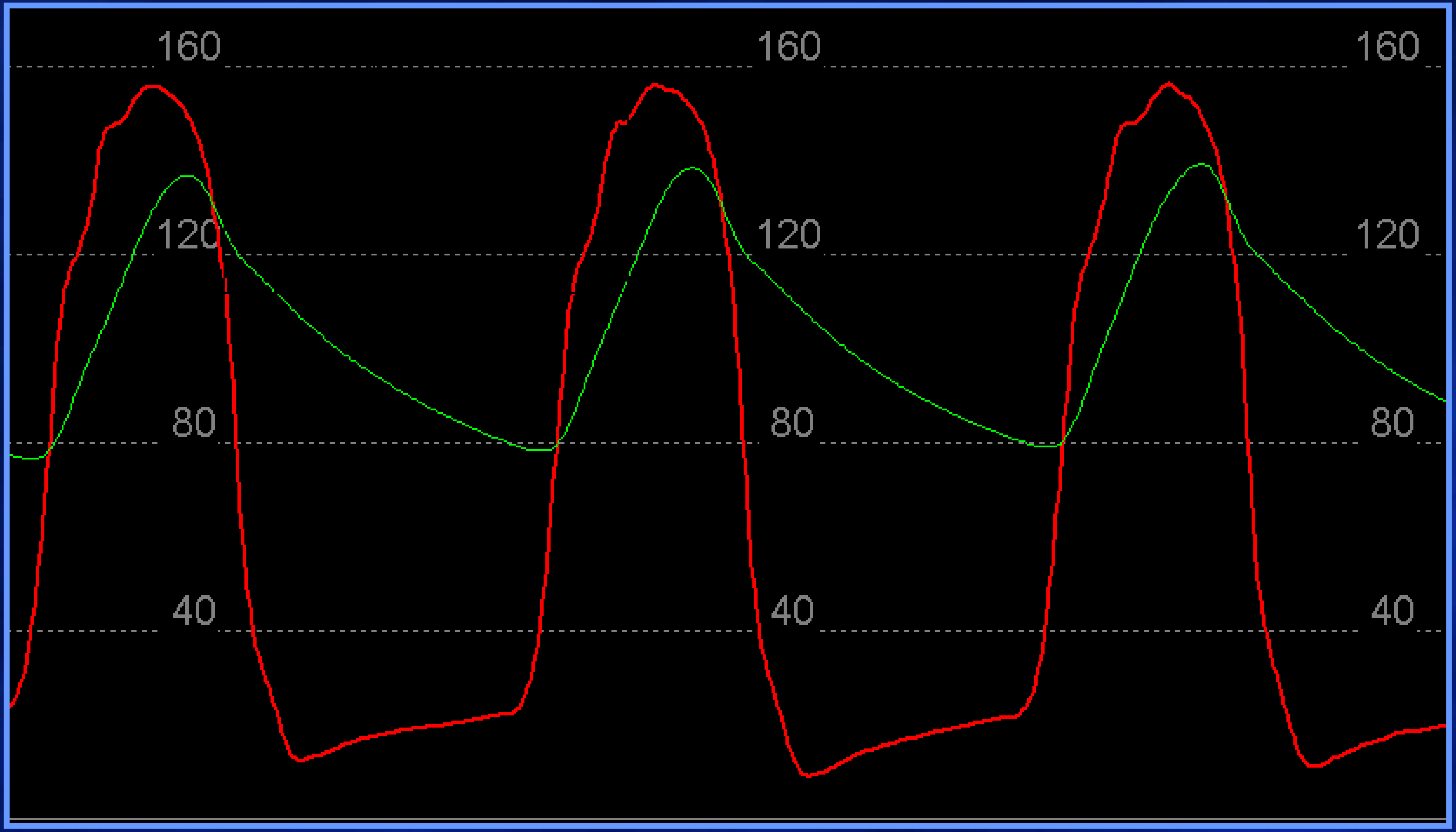
Doppler parameter	Expected*	Stenosis	PPM	High Output	Pressure Recovery
Gradient (mmHg)	14 ± 5	High	High	High	High
Accel Time (msec)	≤ 100	> 100	≤ 100	≤ 100	≤ 100
AT / ET	≤ 0.37	> 0.37	≤ 0.37	≤ 0.37	≤ 0.37
Abn Leaflet Motion	No	Yes	No	No	No
EOA (cm^2)	1.4 ± 0.4	Low	Expected	Expected	Varies
EOA Index (cm^2/m^2)	> 0.85	Low	Low	> 0.85	Varies
DVI	>0.25	≤ 0.25	> 0.25	>0.25	Varies
∆ in EOA & DVI from baseline	No	Yes	No	No	No

*Prosthesis-specific: Medtronic Mosaic 21mm

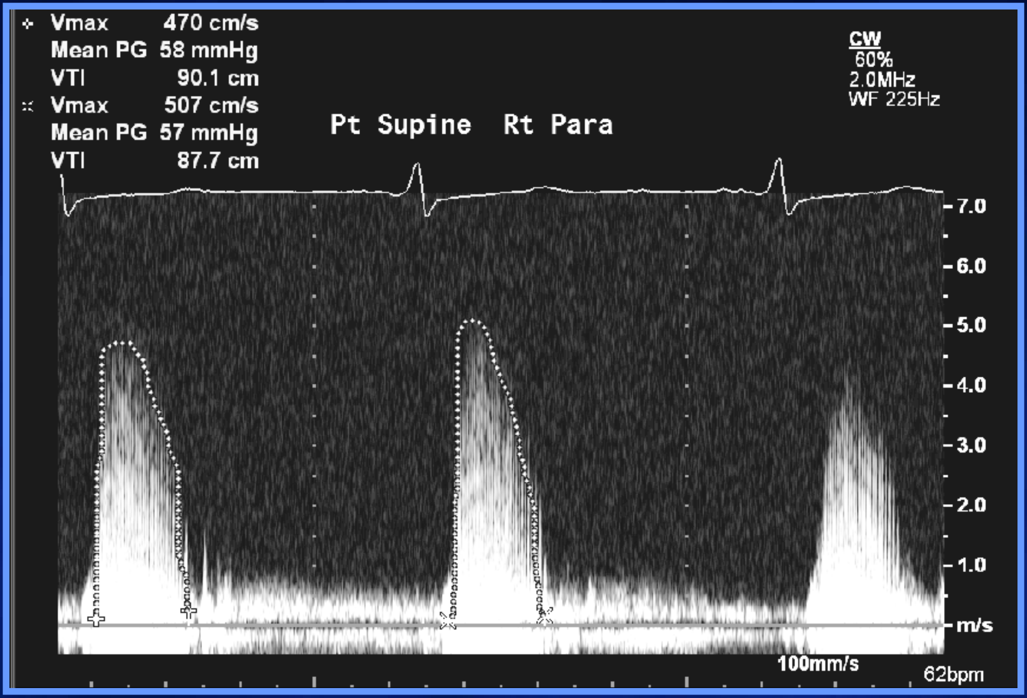
MAYO CLINIC

Slide adapted from Darryl Burstow, M.D.

Left Ventricle and Aorta



Mean Gradient: 26 mmHg

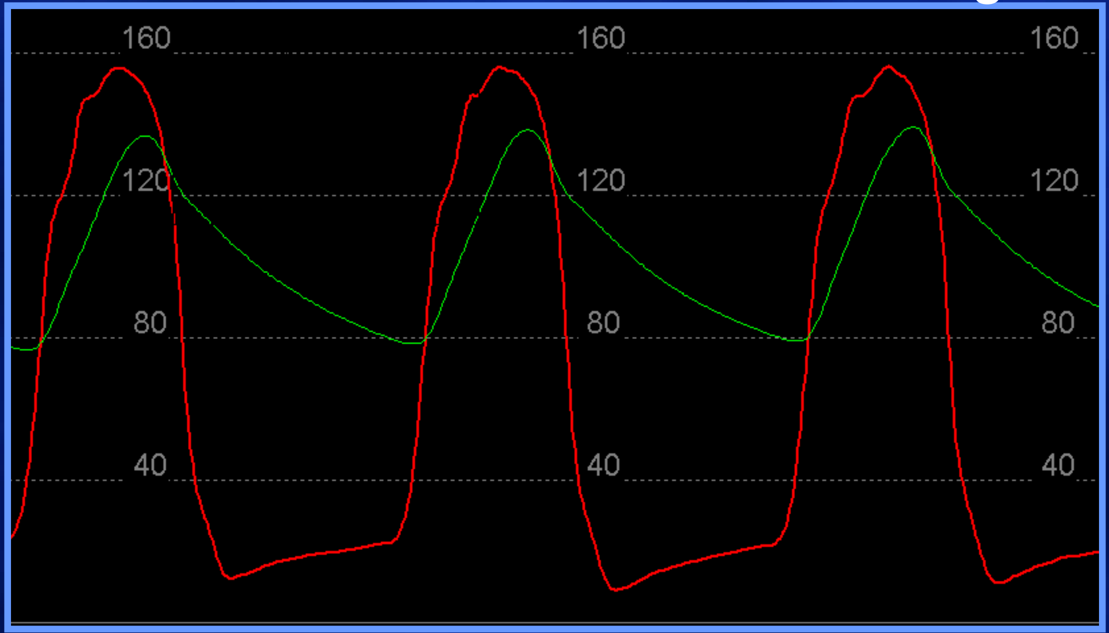


Mean Gradient = 56 mmHg

Surgical Consultation

-AVR not advised
-Medical Rx

Mean Gradient: 26 mmHg



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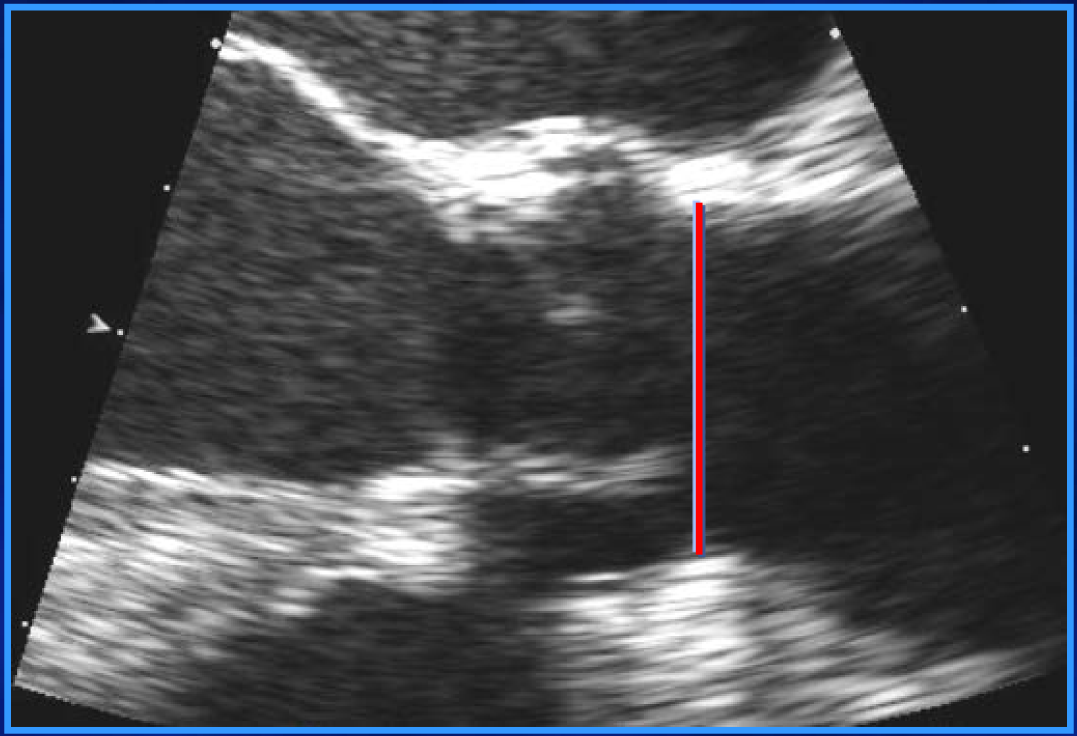
Sinotubular Junction Diameter:
2.1 cm



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Discrepancies Between Catheter and Doppler Estimates of Valve Effective Orifice Area Can Be Predicted From the Pressure Recovery Phenomenon

Practical Implications With Regard to Quantification of Aortic Stenosis Severity

JACC 41(3) 435, 2003

Energy loss coefficient

$$AVA_{predict} = \frac{AAA \times AVA_{Dop}}{AAA - AVA_{Dop}}$$

Routine Adjustment of Doppler Echocardiographically Derived Aortic Valve Area Using a Previously Derived Equation to Account for the Effect of Pressure Recovery

Daniel M. Spevack, MD, Khalid Almuti, MD, Robert Ostfeld, MD, Ricardo Bello, MD, PhD, and Garet M. Gordon, MD, *Bronx, New York*

Take Home Points

- Use Doppler data to identify the cause for a high prosthetic AV gradient (remember AT and AT/ET)
- Pressure recovery may occasionally lead to significant Doppler overestimate of cath gradient
- Pressure recovery is most likely when the aorta is ≤ 3cm or in bileaflet mechanical prostheses (19 or 21mm)
- Correct for pressure recovery with the Energy Loss Index; this may improve risk stratification in AS

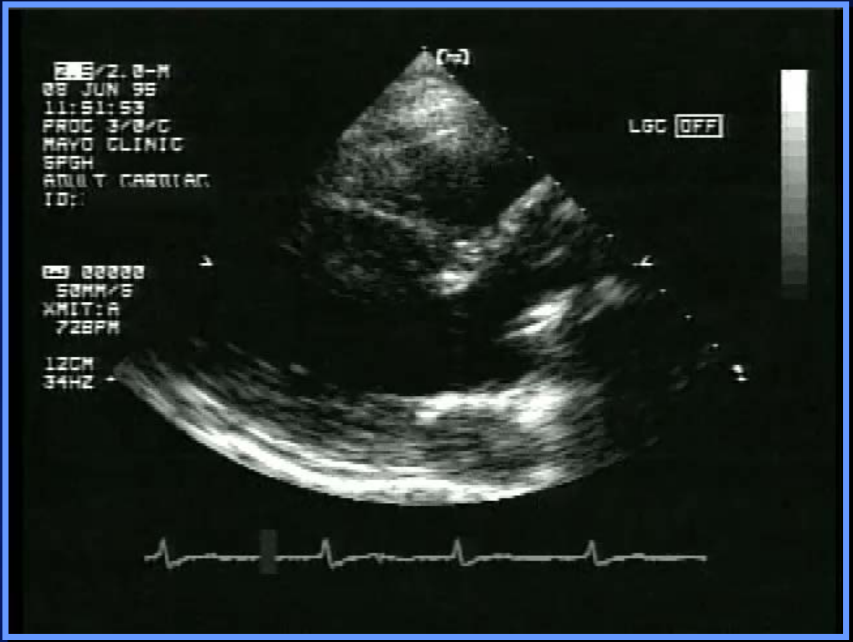
Question

For a Patient with Mechanical Mitral Prosthesis, Which of the Following is *NOT* a sign of Significant Regurgitation?

1. Mitral E velocity 2.3 m/sec
2. Mitral $T_{1/2}$ 150 msec
3. Mitral diastolic mean gradient 10 mmHg
4. IVRT 60 msec
5. MV prosthesis TVI / LVOT TVI ratio 2.6

Doppler Clues to Severe Mechanical MVR Regurgitation

- Mitral E velocity ≥ 2.0 m/sec
- Increased prosthesis mean gradient
- Normal pressure half-time
- Decreased IVRT
- Dense MR CW velocity profile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11:51:53
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SPGH
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ID:
LGC OFF
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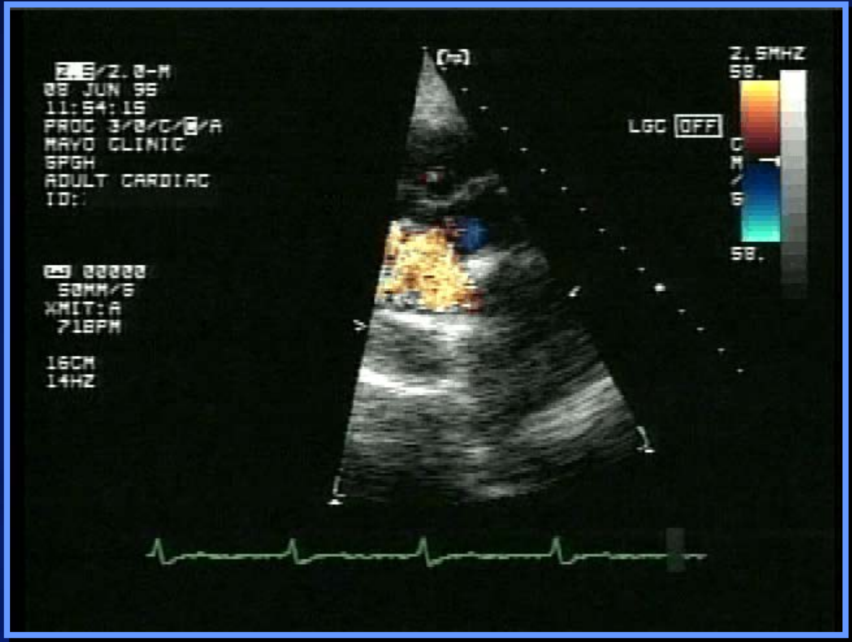
50MM/S
XMIT:A
72BPM
12CM
34HZ


08 JUN 95
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MAYO CLINIC
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50MM/S
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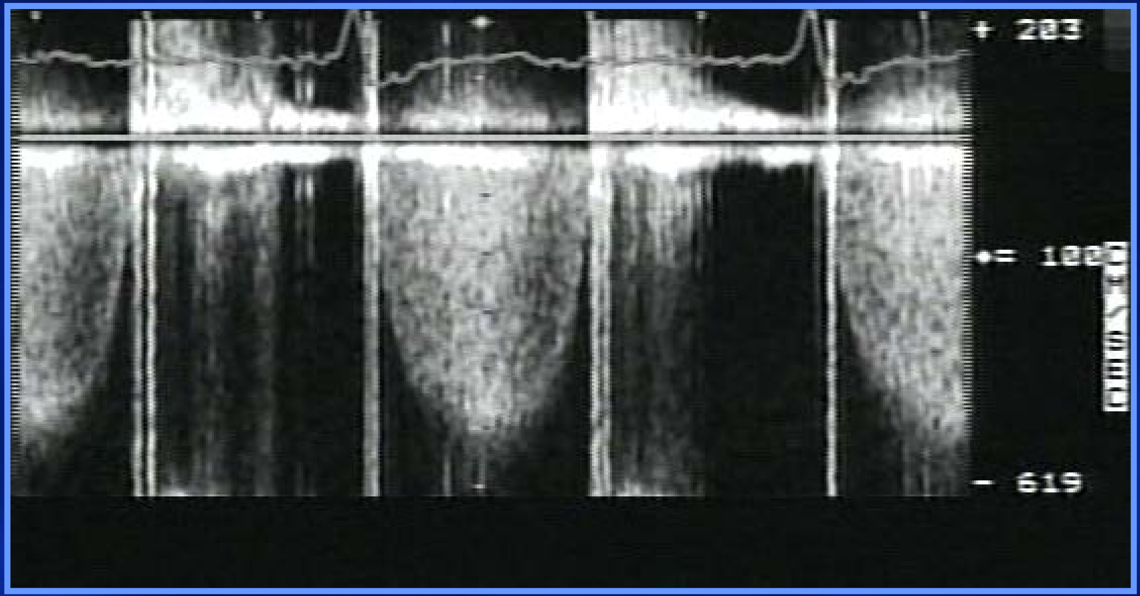
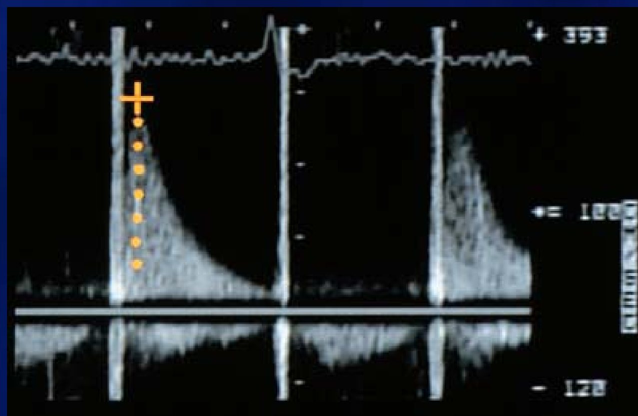
71BPM
16CM
14HZ


+ 203
100
- 619

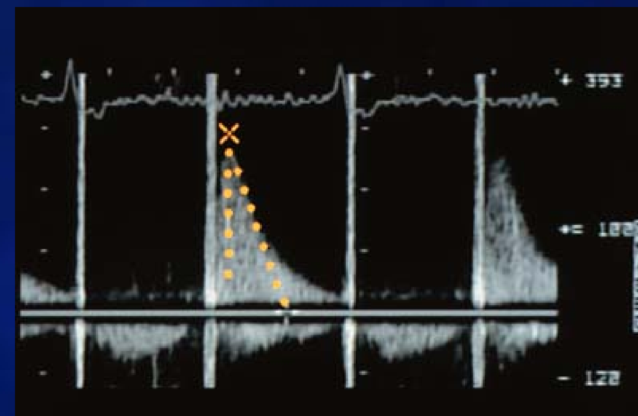
MAYO CLINIC

Mitral St. Jude Medical Prosthesis
CW Doppler

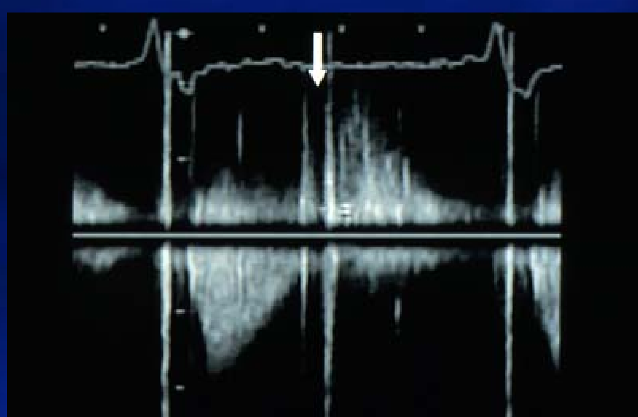
E=2.9 m/s

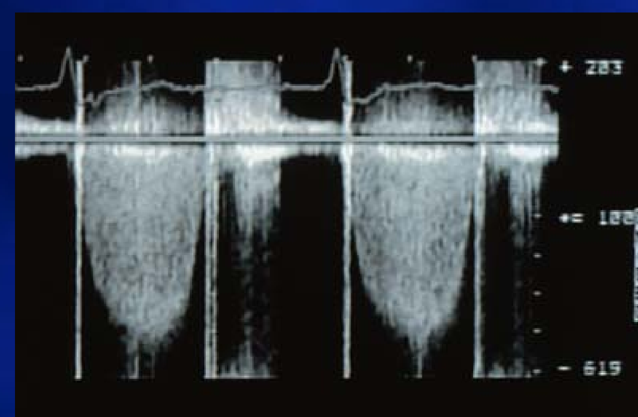


t/2=55 msec



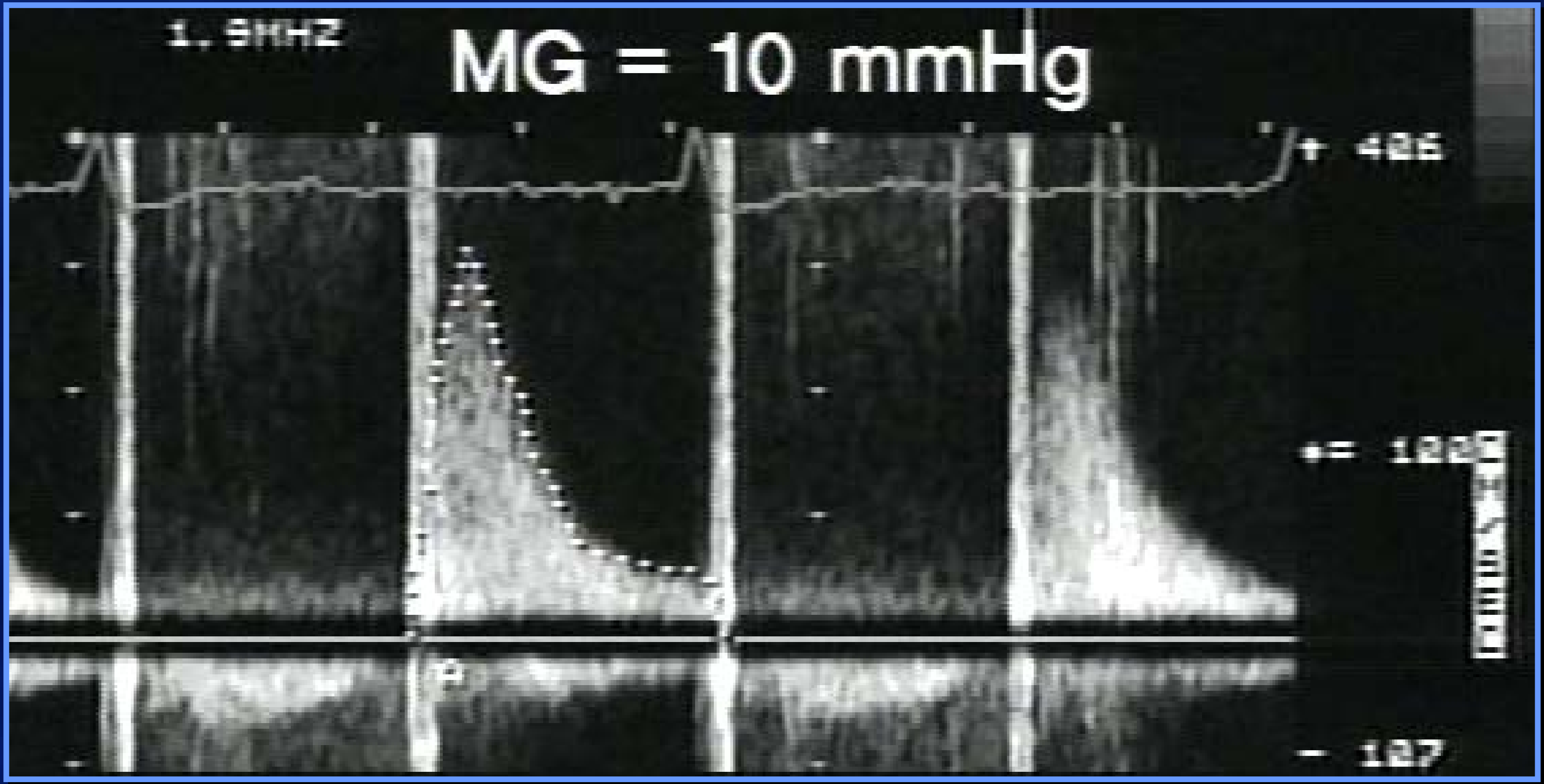
IVRT=55 msec





Severe Periprosthetic Regurgitation

Mechanical MVR



MAYO CLINIC

Peak Early Diastolic Velocity Rather Than Pressure Half-Time Is the Best Index of Mechanical Prosthetic Mitral Valve Function

Valerian Fernandes, MD, Leopoldo Olmos, MD, Sherif F. Nagueh, MD, Miguel A. Quiñones, MD, and William A. Zoghbi, MD

Reliable screening of mechanical prosthetic mitral valve (PMV) dysfunction by transthoracic echocardiography (TTE) is mandatory because transesophageal echocardiography (TEE) cannot be routinely used. However, acoustic shadowing seriously hampers detection of PMV dysfunction with TTE, particularly regurgitation. To identify TTE indexes that can detect PMV dysfunction (regurgitation or obstruction), 134 patients (age 60 ± 12 years, 64 men) with PMV who underwent TTE and TEE within 3 ± 5 days were assessed. There were 73 normal and 61 dysfunctional valves (40 regurgitant, 21 obstructive). By multivariate analysis, peak E velocity was the best predictor of a dysfunctional valve. Both peak E velocity (E ≥1.9 m/s; sensitivity 92%, specificity 78%) and the ratio of velocity-time integrals of flow through the prosthesis to that of the left ventricular outflow (VTI_{pmv}/VTI_{lvo} ≥2.2; sensitivity 91%, specificity 74%) were successful in detecting PMV dysfunction. Although pressure half-time (PHT) readily identified PMV obstruction, it did not detect regurgitation. Logistic models including peak E velocity and VTI_{pmv}/VTI_{lvo} or PHT were equally successful in detecting PMV dysfunction. However, all 3 variables were needed to best distinguish among normal, obstructed, and regurgitant valves. A peak E velocity ≥1.9 m/s and VTI_{pmv}/VTI_{lvo} ratio ≥2.2 predicted valve regurgitation in 83% of valves when PHT was <130 ms, and valve stenosis in 95% when PHT was >130 ms. Importantly, a peak E velocity <1.9 m/s, VTI_{pmv}/VTI_{lvo} ratio <2.2, and a PHT <130 ms had a predictive accuracy for a normal valve of 98%. Thus, TTE Doppler indexes can be used as screening parameters of PMV dysfunction and help select patients for further diagnostic evaluation with TEE.

(Am J Cardiol 2002;89:704–710)

Mechanical Prosthetic Mitral Valve Dysfunction

Doppler index	Sens (%)	Spec (%)	PPV (%)	NPV (%)
E ≥1.9 m/sec	92	78	83	90
$VTI_{PMV}/VTI_{LVO} \geq 2.2$	91	74	80	87
PHT ≥130 msec	38	99	96	57

Fernandes V: Am J Cardiol 89, 3/15/02

Mechanical MVR with ↑Gradient

Increased T1/2

Normal T1/2

Obstructed

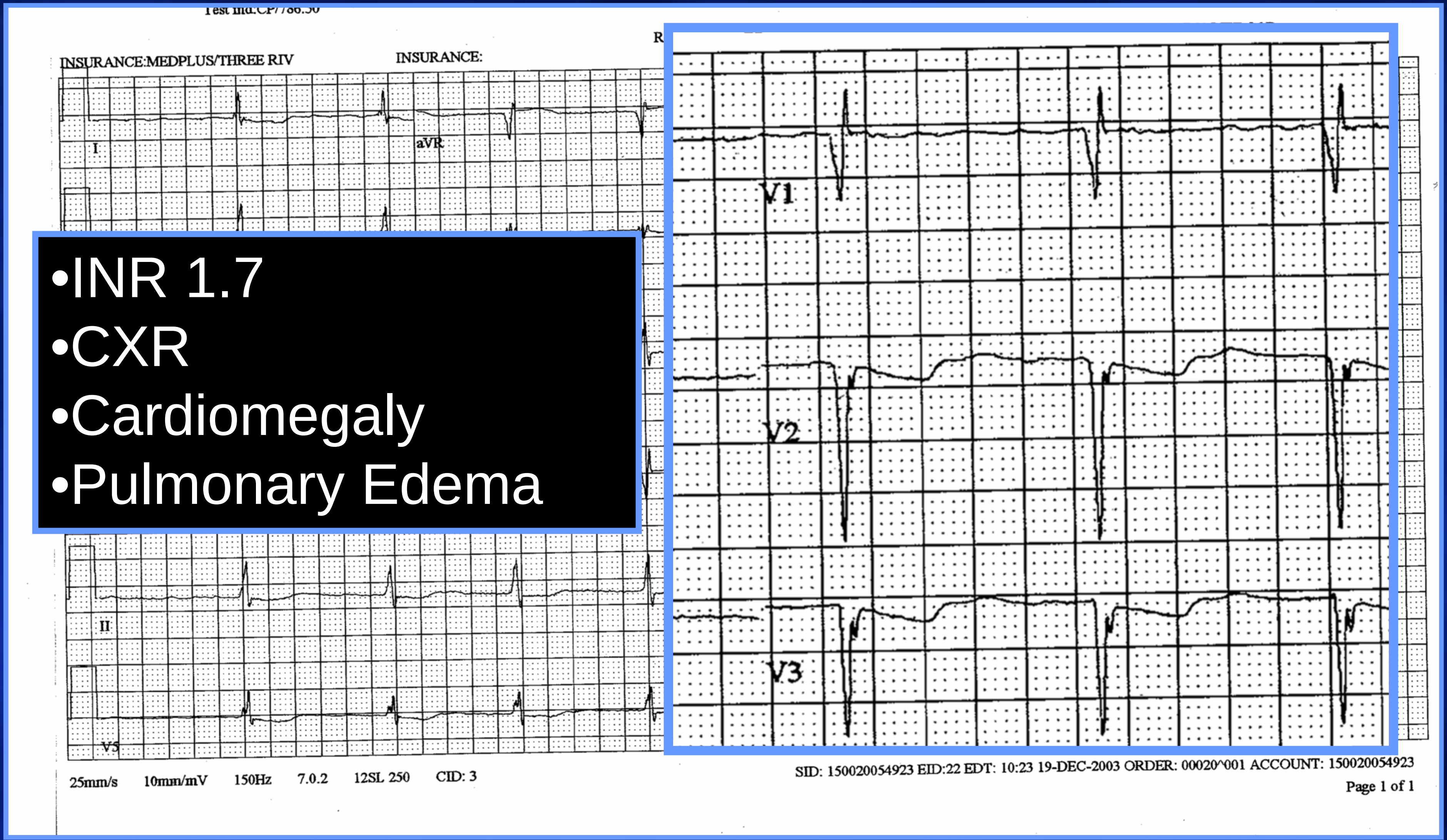
Significant MR or High Output

Prosthesis TVI / LVOT TVI ratio > 2.2

Case

- 53 year old female
  - Hx of CABG, Redo CABG & ST Jude MVR
  - CHF (LV EF 30%)
    - NYHA class II
  - Chronic Atrial Fibrillation
- Coumadin held for colonoscopy
  - No LMWH bridging!
- Sudden onset severe dyspnea
  - SBP 85 mmHg
  - Muffled S1
  - Diastolic murmur

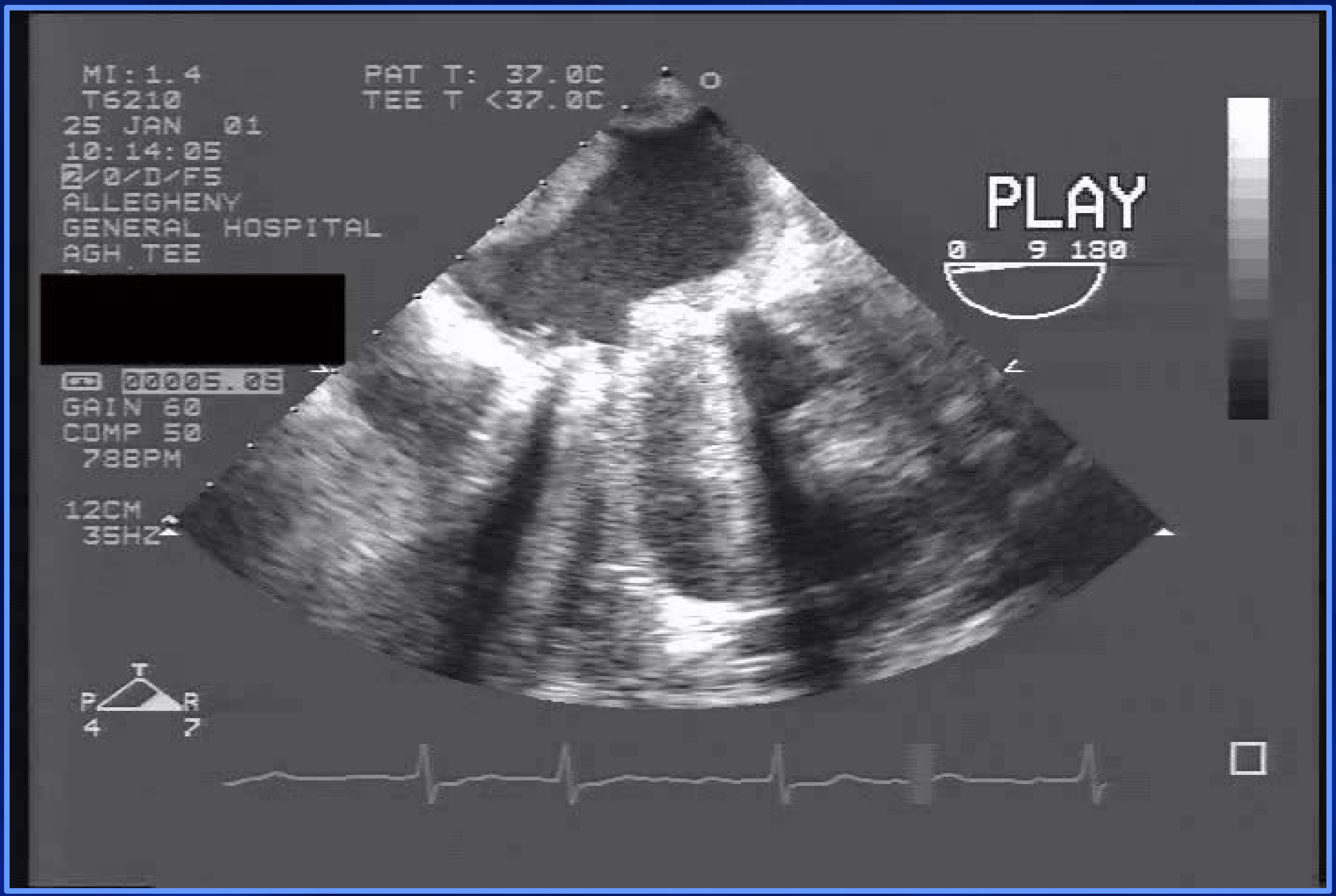
No Change in Baseline EKG



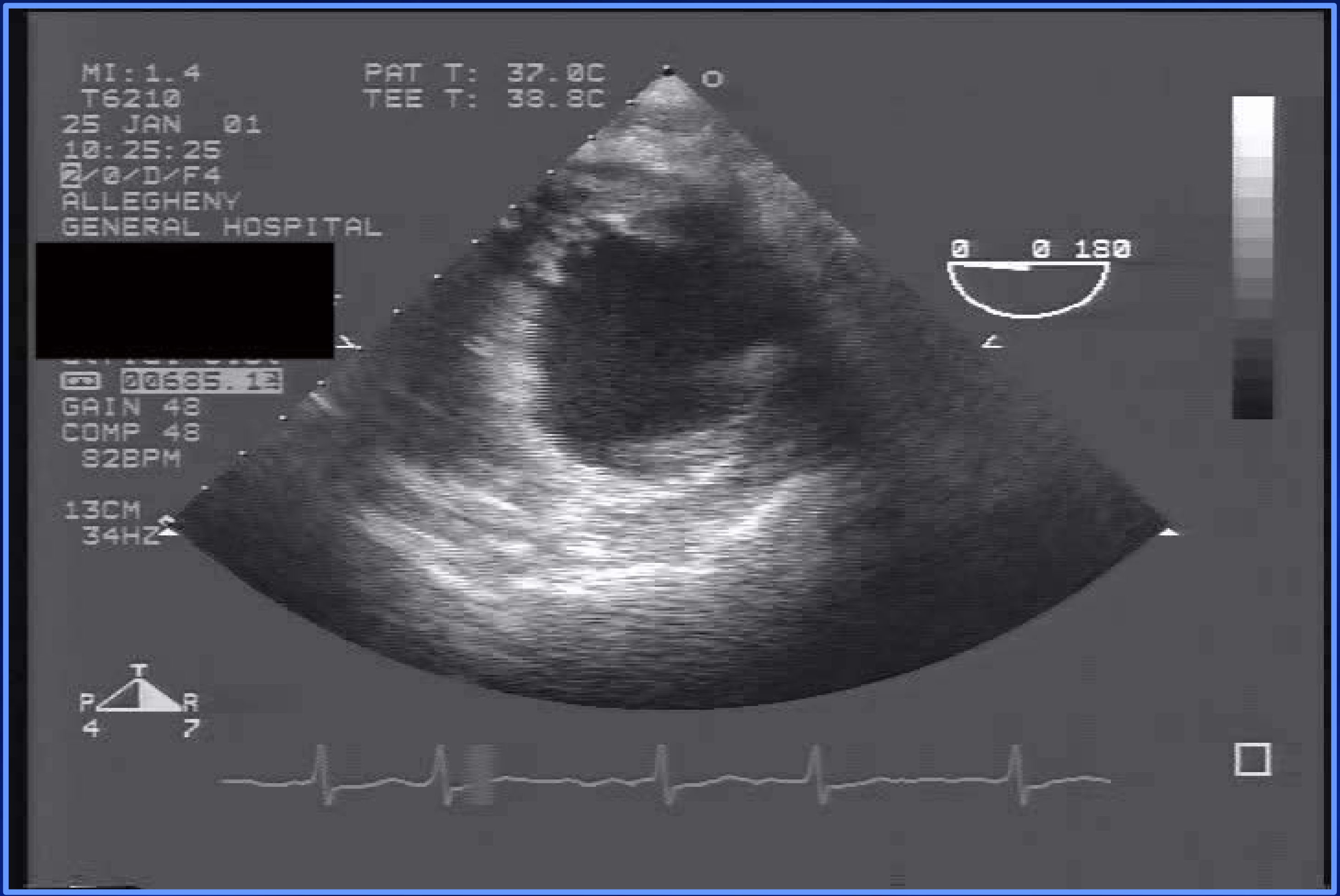
- INR 1.7
- CXR
- Cardiomegaly
- Pulmonary Edema

Emergent TEE

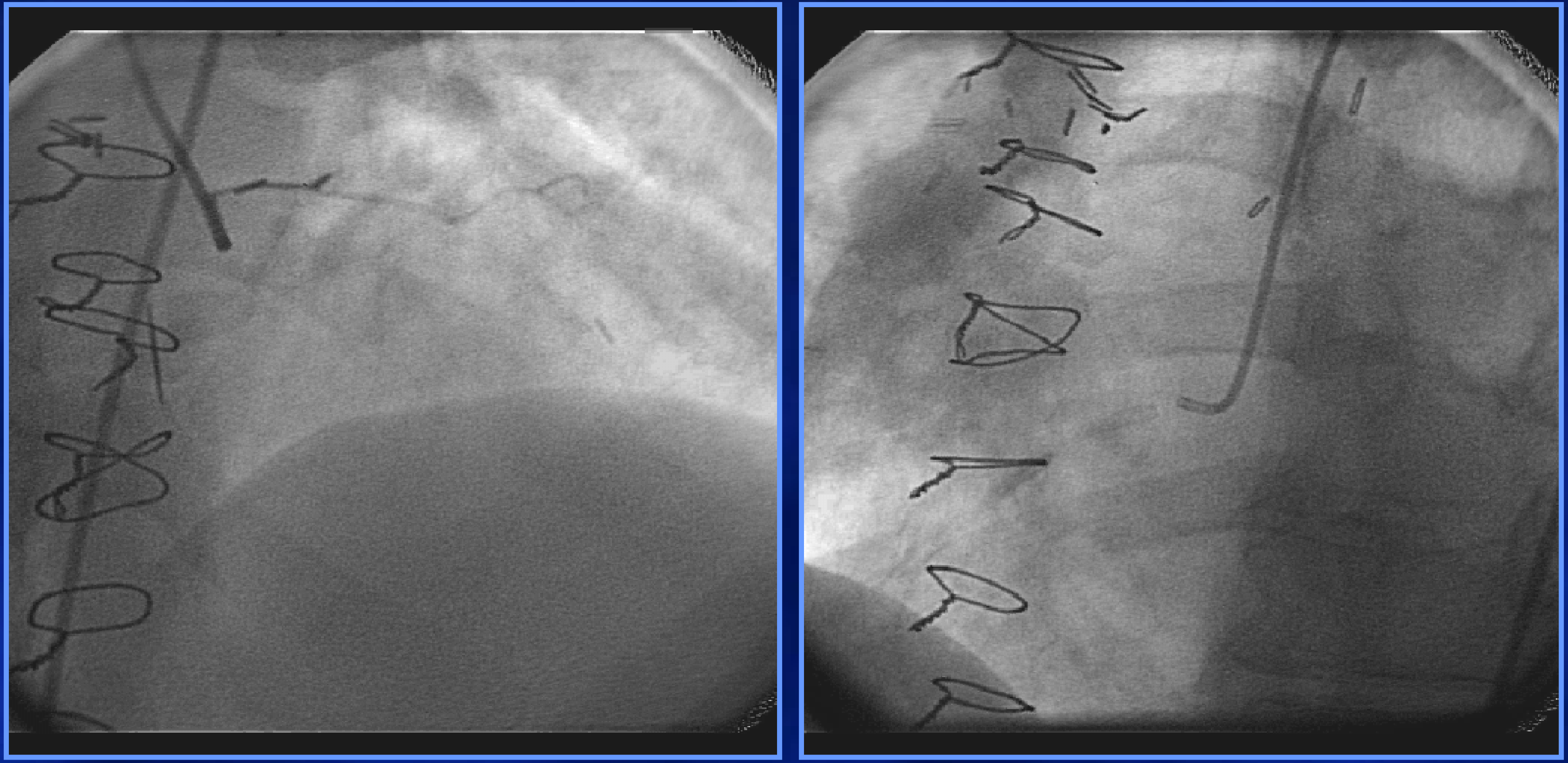
Mean Gradient 20 mmHg



Severe LV Systolic Dysfunction

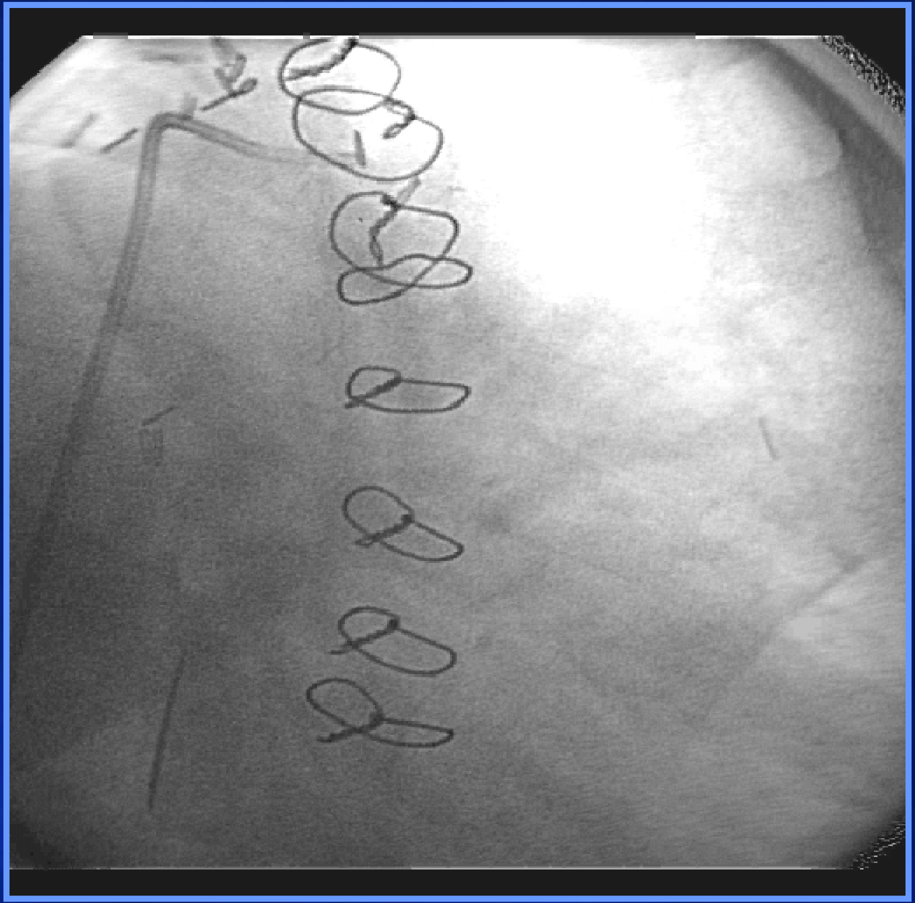


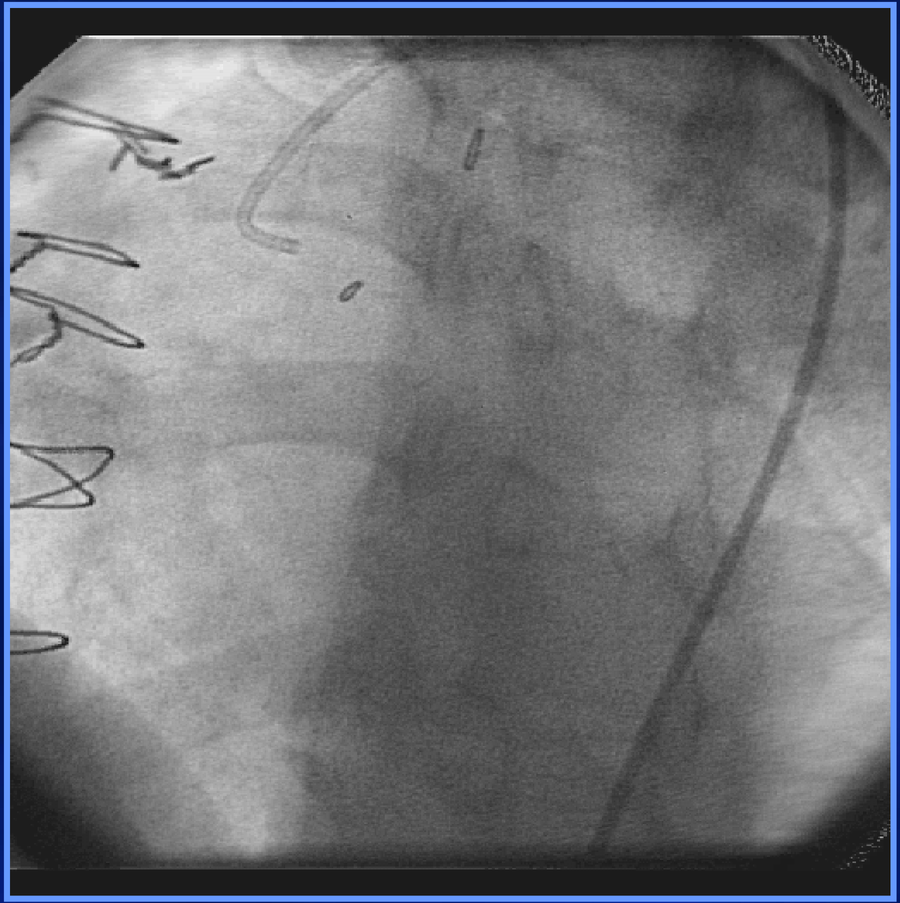
Cardiac Cath



Total Occlusion of LAD, LCx, and RCA

Only One Patent Graft





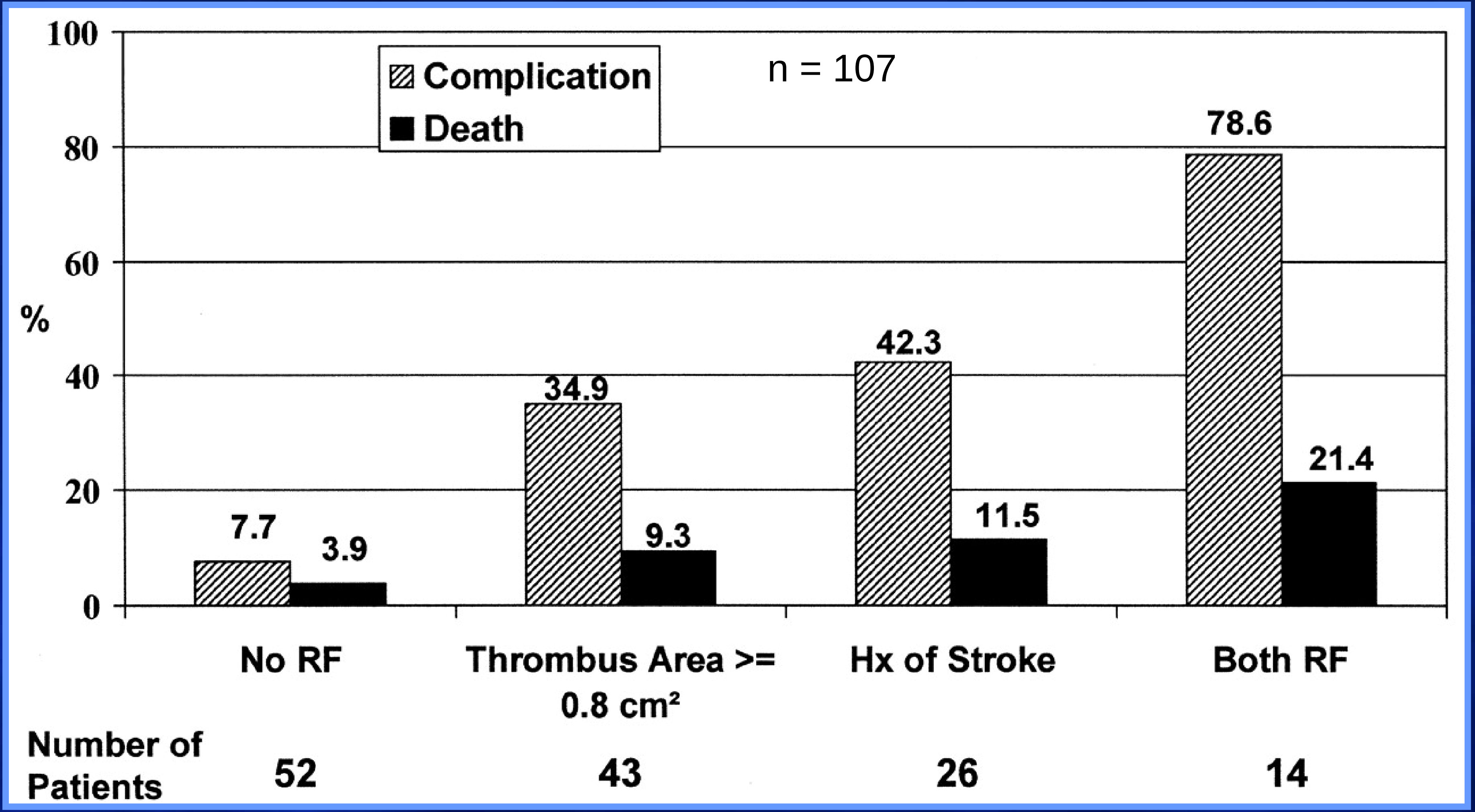
Significant Collaterals

What would you recommend now?

1. **Immediate CT Surgery**
2. **Thrombolysis**
3. **Heparin and Prayer**

Can TEE help decide ?

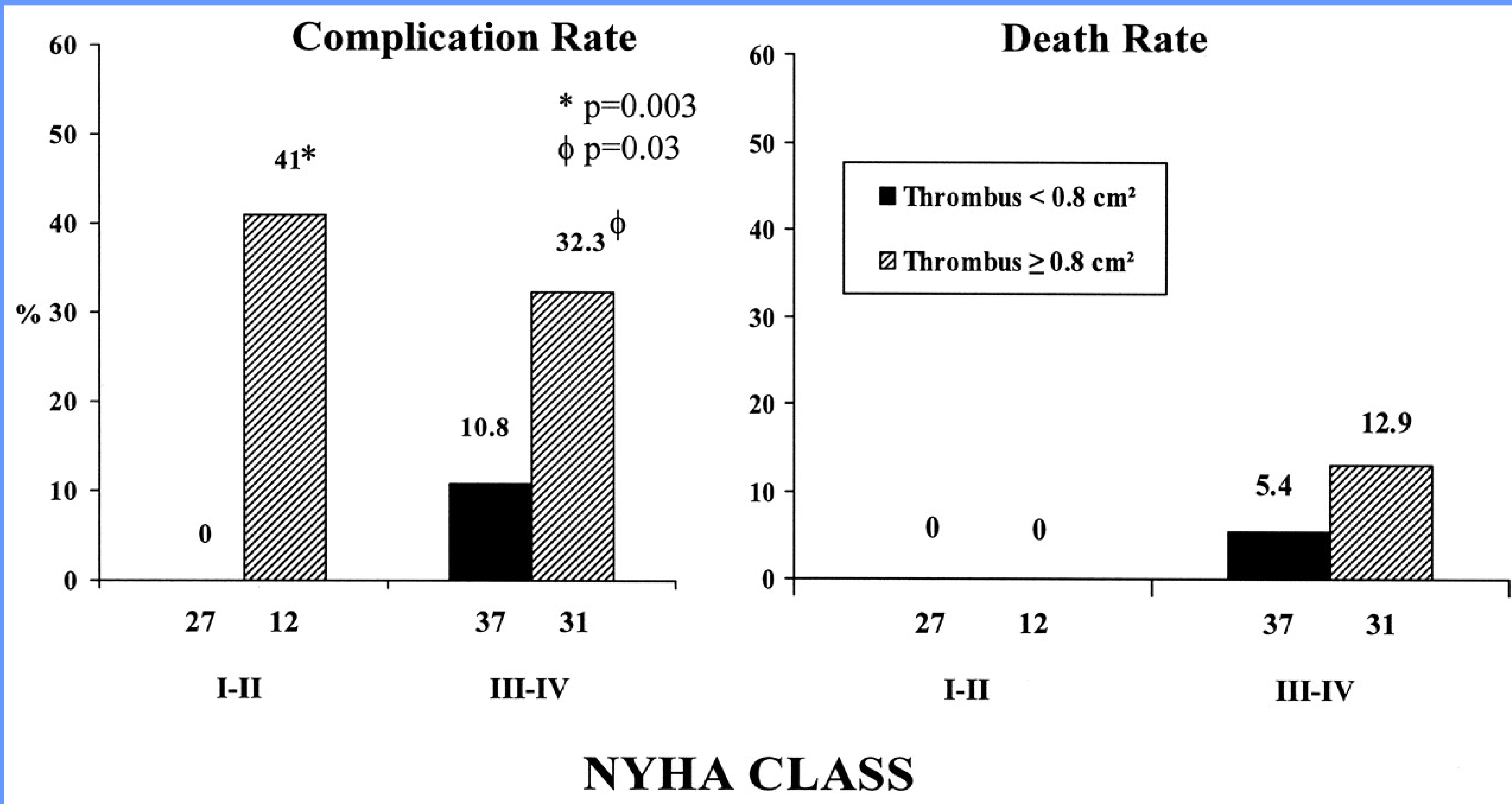
PRO-TEE Registry



MAYO CLINIC

Tong, A. T. et al. *J Am Coll Cardiol* 2004;43:77-84

PRO-TEE Registry



Tong, A. T. et al. *J Am Coll Cardiol* 2004;43:77-84

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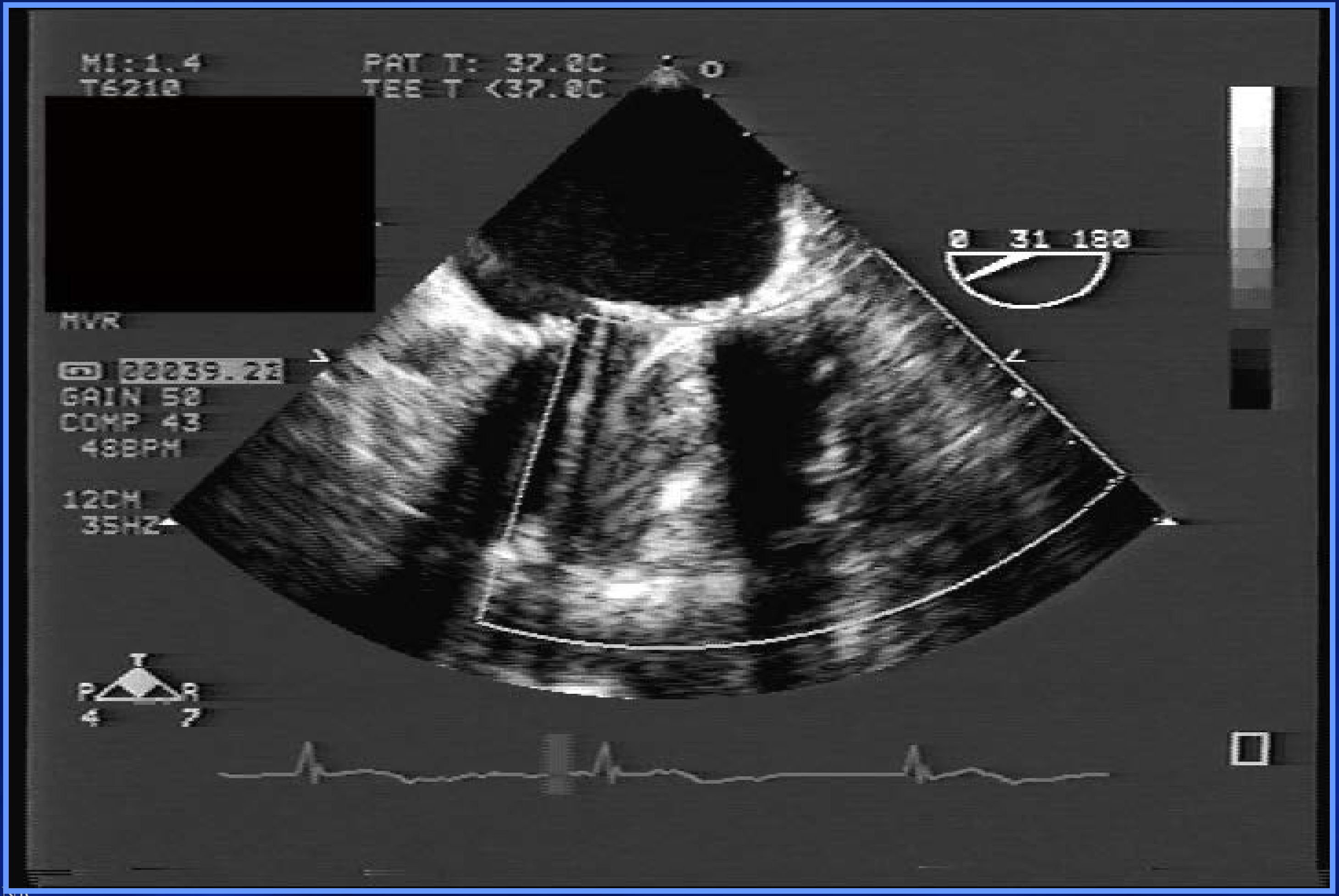
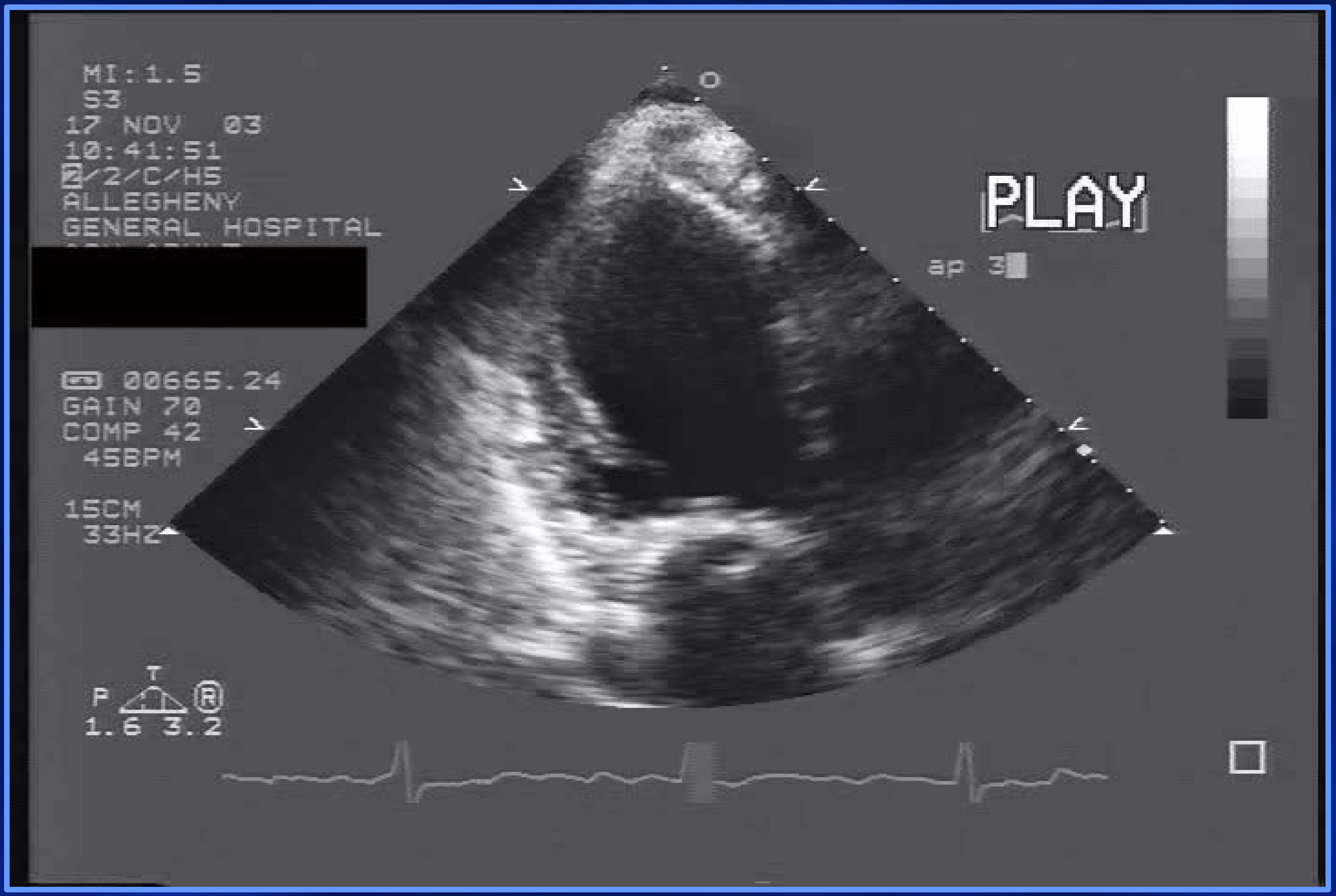
Follow-up TEE After Thrombolysis



Follow-up at 1 year: NYHA Class III-IV

Mean Gradient 9 mmHg (INR 3.5-4.5)



More Follow-up

- Worsening angina in addition to HF
- Inferolateral and anterior ischemia on vasodilator stress testing
- Placed on Plavix in anticipation of cardiac cath & possible PTCA/Stent
  - Known single patent SVG to LCx
    - All native vessels occluded proximally but LAD and RCA filled via collaterals
  - Not candidate for 3rd CT surgery
  - Not candidate for Heart Transplant

Sudden Onset Improvement in Symptoms

TTE Performed

Mean Gradient 4 mmHg

Another Miraculous "*CURE*"

Prosthetic Valve Thrombosis: Medical Therapy

Recommendations	COR	LOE
Fibrinolytic therapy is reasonable for patients with a thrombosed left-sided prosthetic heart valve, recent onset (<14 days) of NYHA class I to II symptoms, and a small thrombus	IIa	B
Fibrinolytic therapy is reasonable for thrombosed right-sided prosthetic heart	IIa	B

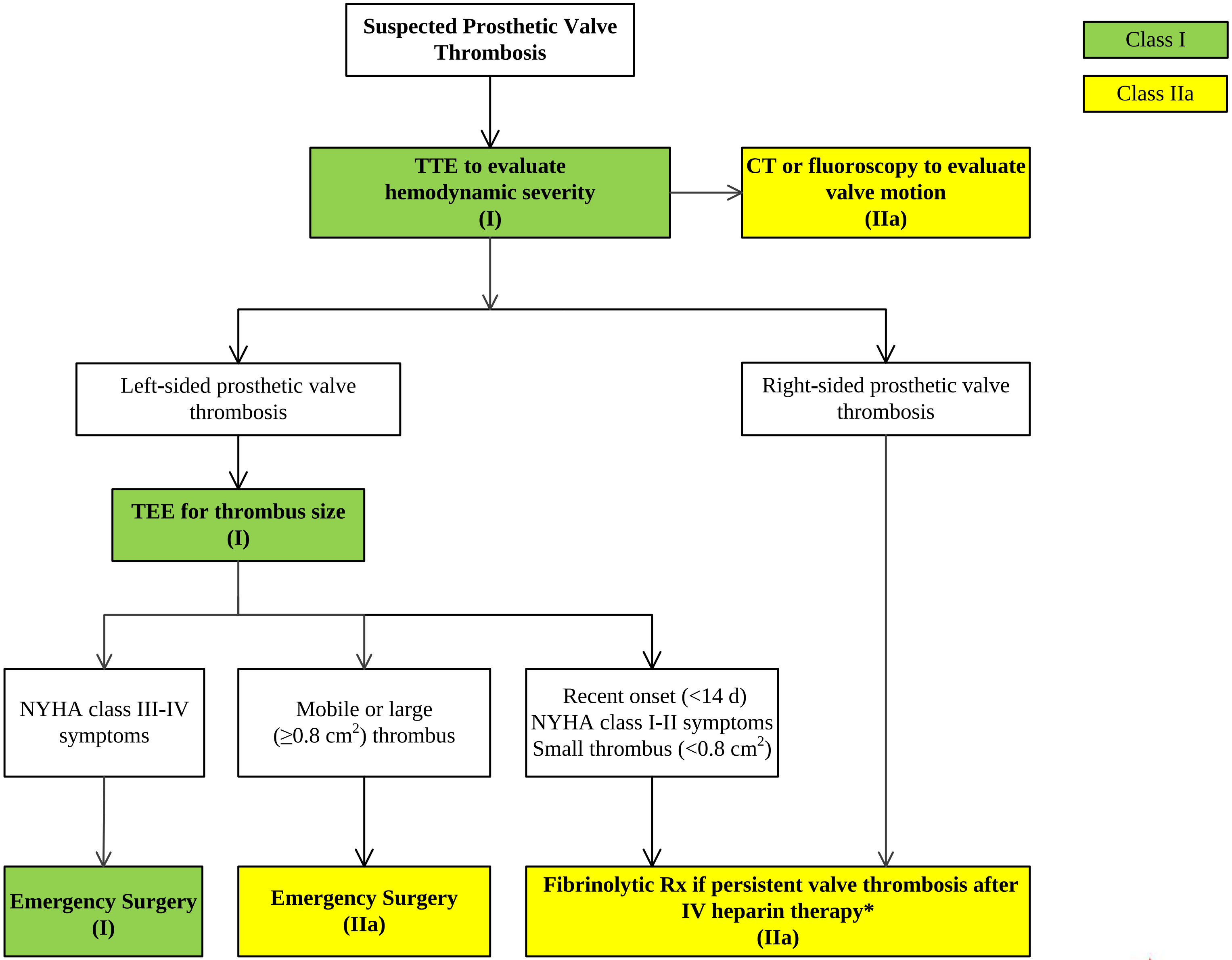
Nishimura RA et al. Circulation. 2014 Jun 10;129(23):e521-643

Prosthetic Valve Thrombosis: Intervention

Recommendations	COR	LOE
Emergency surgery is recommended for patients with a thrombosed left-sided prosthetic heart valve with NYHA class III to IV symptoms	I	B
Emergency surgery is reasonable for patients with a thrombosed left-sided prosthetic heart valve with a mobile or large thrombus (>0.8 cm^2)	IIa	C

Nishimura RA et al. Circulation. 2014 Jun 10;129(23):e521-643

Evaluation and Management of Suspected Prosthetic Valve Thrombosis



Thank You!

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@MDMankad