31st Annual ECHO Hawaii

January 17, 2022 | 4:30 – 6:30 PM Session | 20 min

Workshop in Echo Quantitation: Aortic Regurgitation

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Professor of Medicine
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NYU Langone Health

Disclosures

Speakers Bureau (Abbott, Boston Scientific, Medtronic, Philips)
Advisory Board (Siemens)

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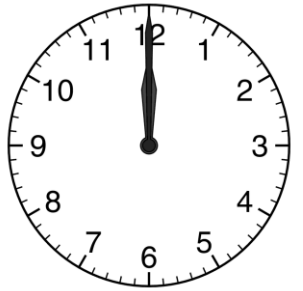
Question #1

Which of the following is NOT a sign of acute severe aortic regurgitation in a patient with a previously normal heart?

A. Diastolic mitral regurgitation
B. Holodiastolic flow reversal in abdominal aorta
C. Marked left ventricular dilatation
D. Premature closure of mitral valve
E. Short pressure half-time of aortic regurgitant jet



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A. Diastolic mitral regurgitation
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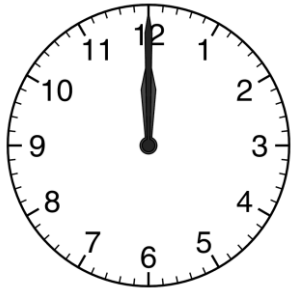
E. Short pressure half-time of aortic regurgitant jet

Question #2

Which of the following is indicative of severe chronic aortic regurgitation?

A. Effective regurgitant orifice area 0.25 cm^2
B. Jet width / LVOT height = 50%
C. Regurgitant fraction 60%
D. Regurgitant volume 45 mL
E. Vena contracta = 5 mm



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Which of the following is indicative of severe chronic aortic regurgitation?

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2017 ASE Valvular Regurgitation Guidelines

Table 11 Grading the severity of chronic AR with echocardiography

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	Mild	Moderate	Severe
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EROA (cm^2)	<0.10	0.10-0.19 / 0.20-0.29	≥0.30

Aortic Regurgitation

	1 ACUTE	2 CHRONIC
Regurgitant Volume Development	Sudden large regurgitant volume	Gradual increase in regurgitant volume
Left Heart Chamber Sizes	Nondilated LV & LA	Markedly dilated LV and often LA
Left Heart Filling Pressures	Suddenly elevated	Gradual elevation over many years
Clinical Presentation	Acute, life-threatening heart failure with preserved LVEF	May be asymptomatic for many years but eventually become symptomatic

GUIDELINES

Case #1

Case Presentation

76-year-old man with prior history hypertension

- 5-week history of **generalize malaise, intermittent fevers, loss of appetite and weight loss**
- 1-week history of progressive **shortness of breath**
- On day of admission, became **lethargic**

Brought in to the Emergency Department by his wife…

Emergency Department Evaluation

Physical Exam

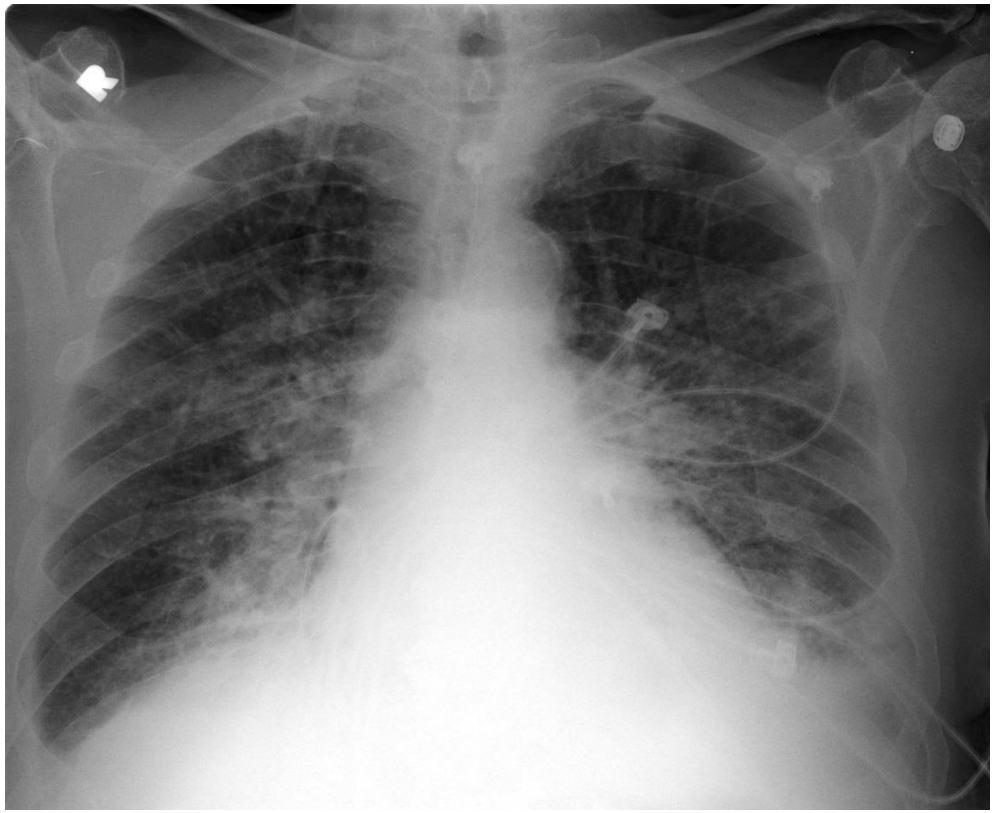
- Temperature 38.5 °C (101.5 ° F)
- BP 125/60 mm Hg - HR 95 (regular)
- Respiratory rate 26
- Room-air saturation 89%
- Lungs – diffuse râles with decreased breath sounds at both bases
- Heart – ED physician reported soft systolic murmur
- Lower extremities – Bilateral pretibial pitting edema

EKG

- Sinus tachycardia

Chest X-ray

- Bilateral pleural effusions
- Pulmonary vascular congestion



Acute Decompensated Heart Failure

Emergency Department Evaluation

General Labs

- White blood cell count
  17,000/µL with 93% neutrophils
- Normocytic anemia
  with hemoglobin 9.1 g/dL
- Erythrocyte sedimentation rate
  75 mm/hour

Blood Cultures

- 6/6 blood culture bottles grew
  Streptococcus gordonii

Streptococcus gordonii

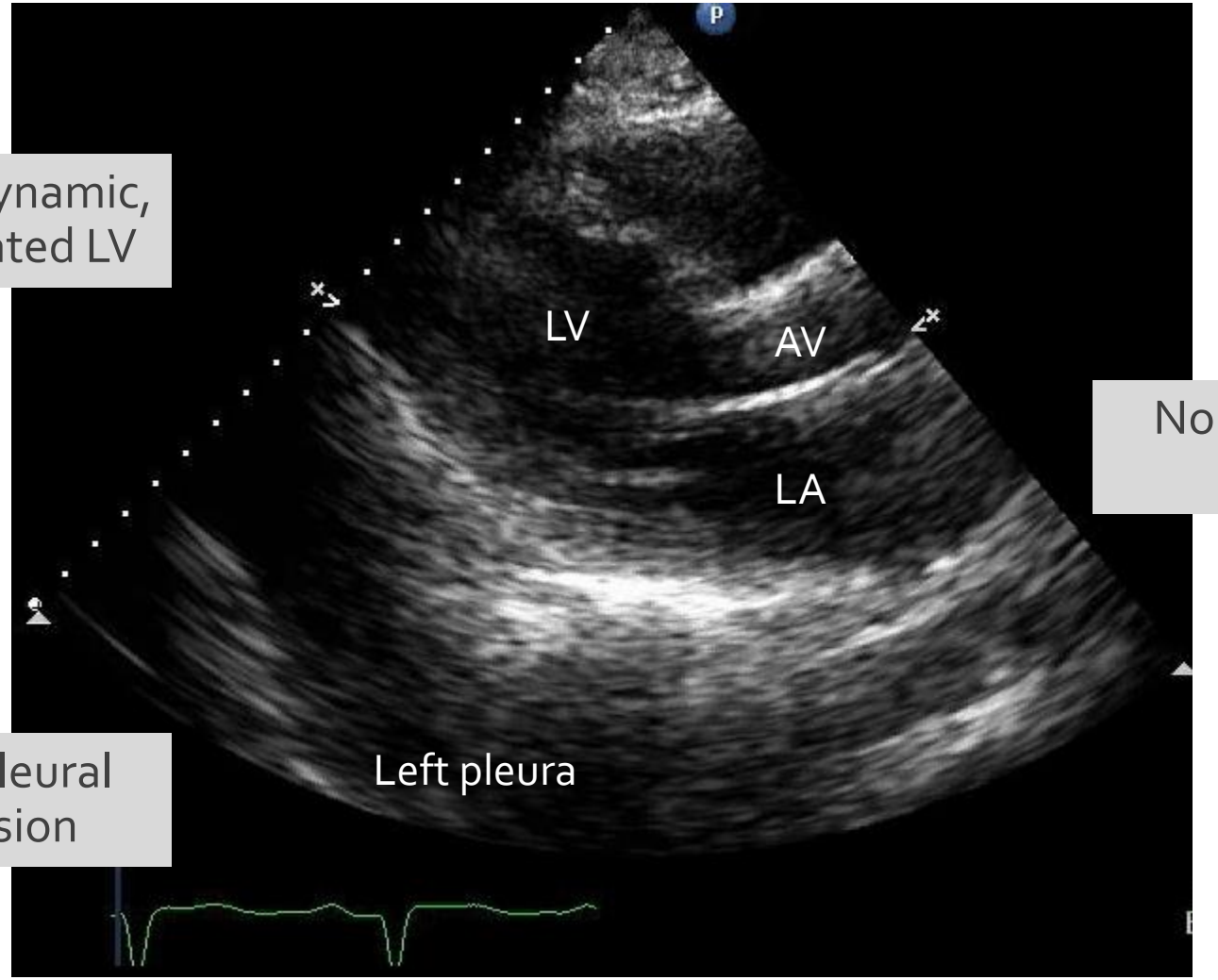
- Part of the group **viridians** streptococci
- Integral members of the human oral flora
- Grows in chains (*στρεπτός* – twisted chain)

Working Diagnoses

Subacute bacterial endocarditis due to *Streptococcus gordonii* (viridans streptococcus)

→ → → Acutely decompensated heart failure

TTE: Parasternal Long-Axis View



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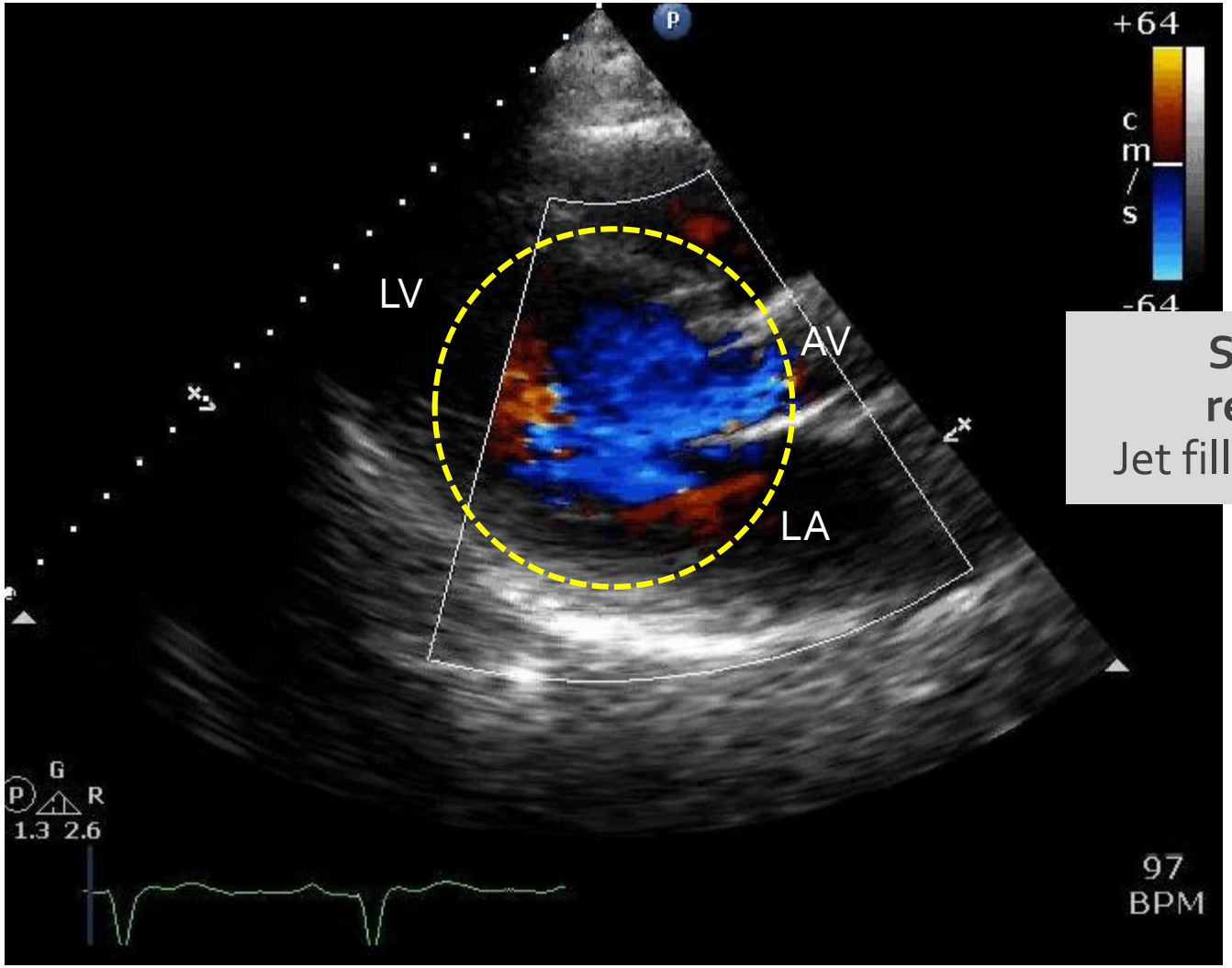
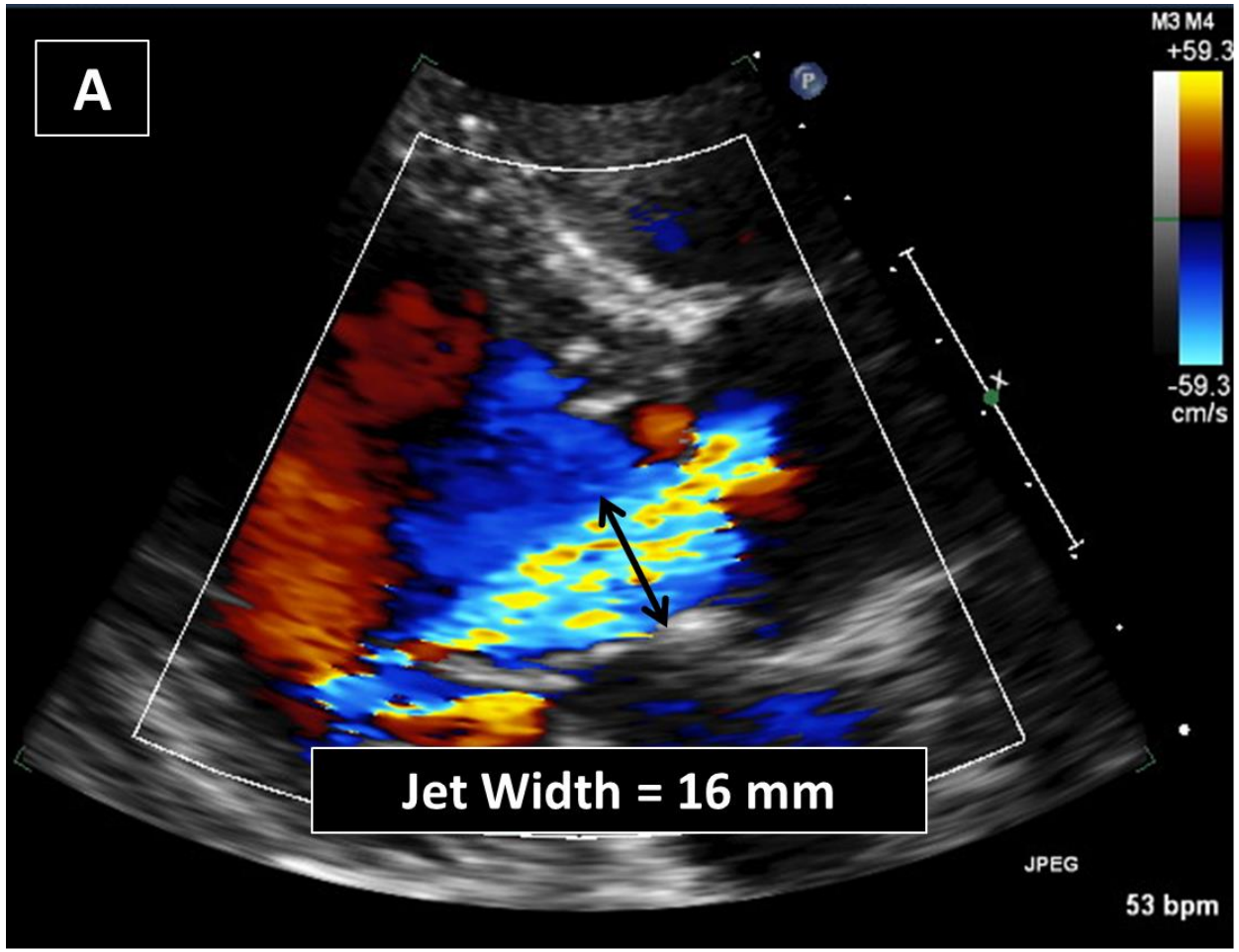
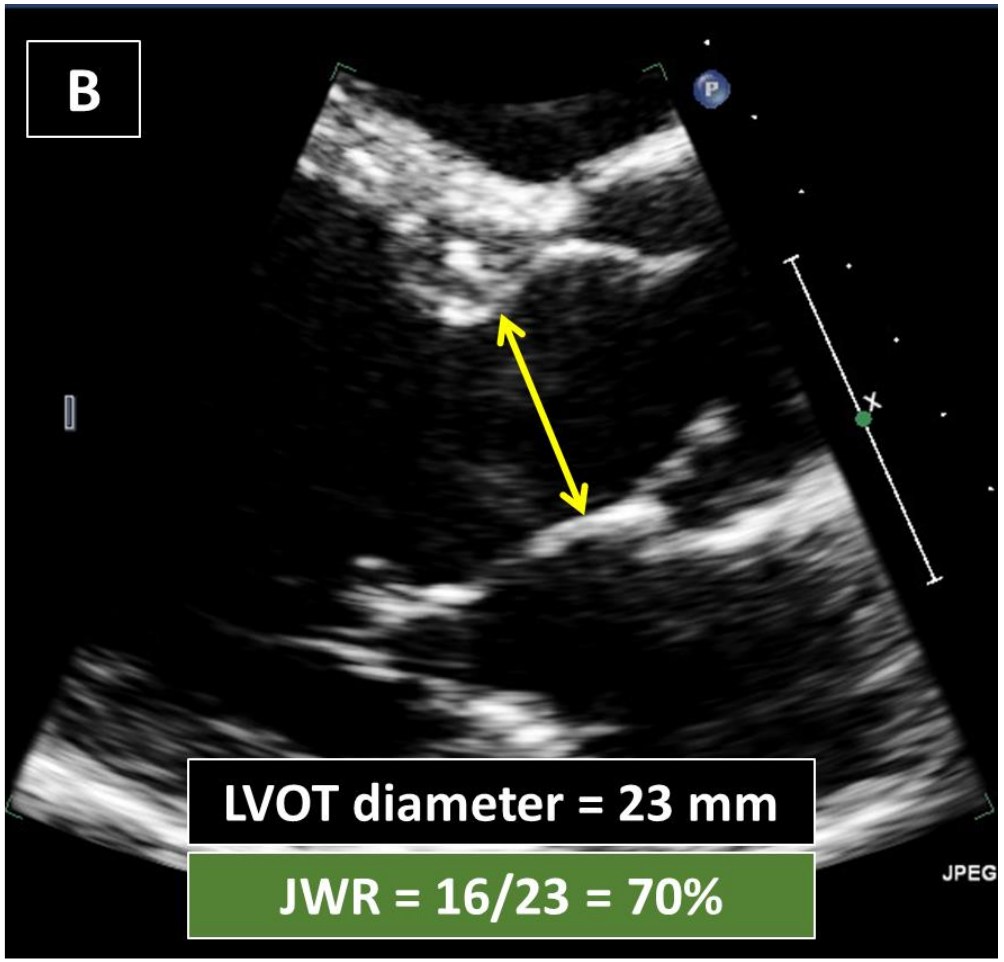


Severe aortic regurgitation
Jet fills the entire LVOT

Aortic Regurgitation: Jet Width to LVOT Height Ratio





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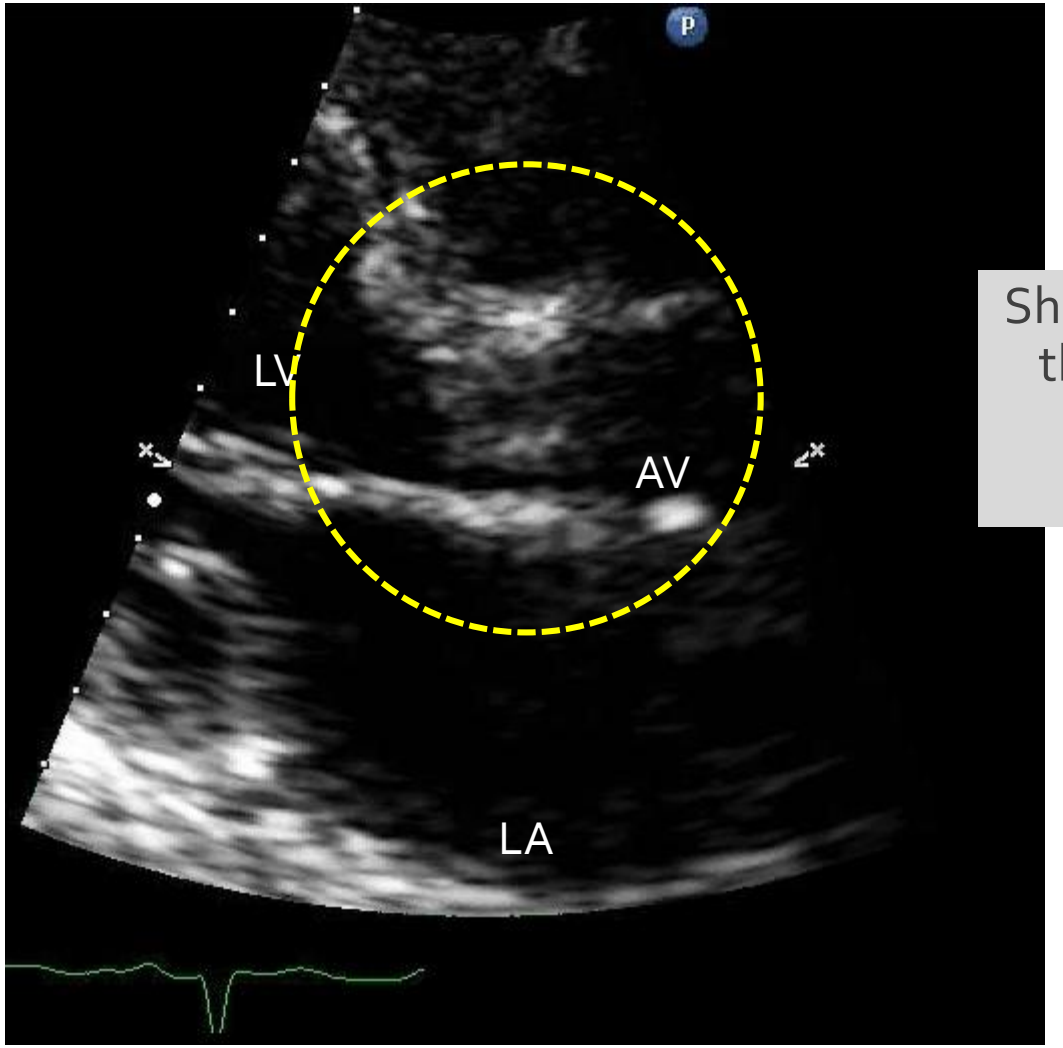
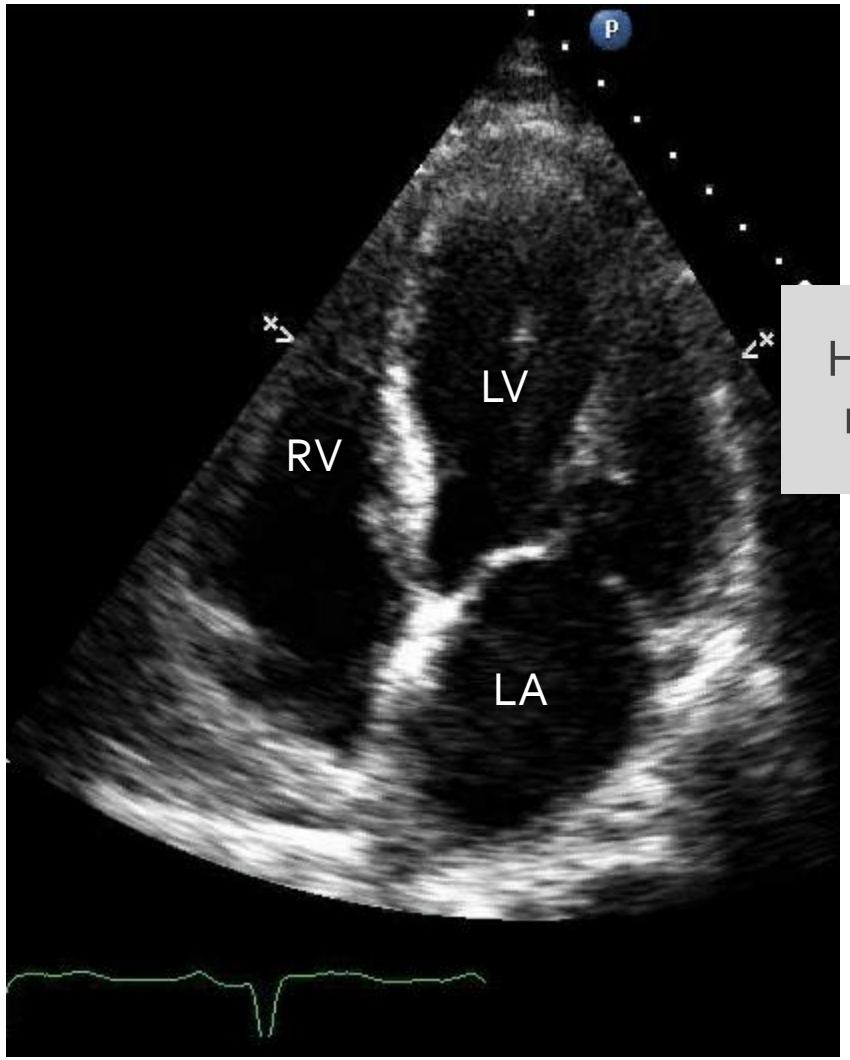


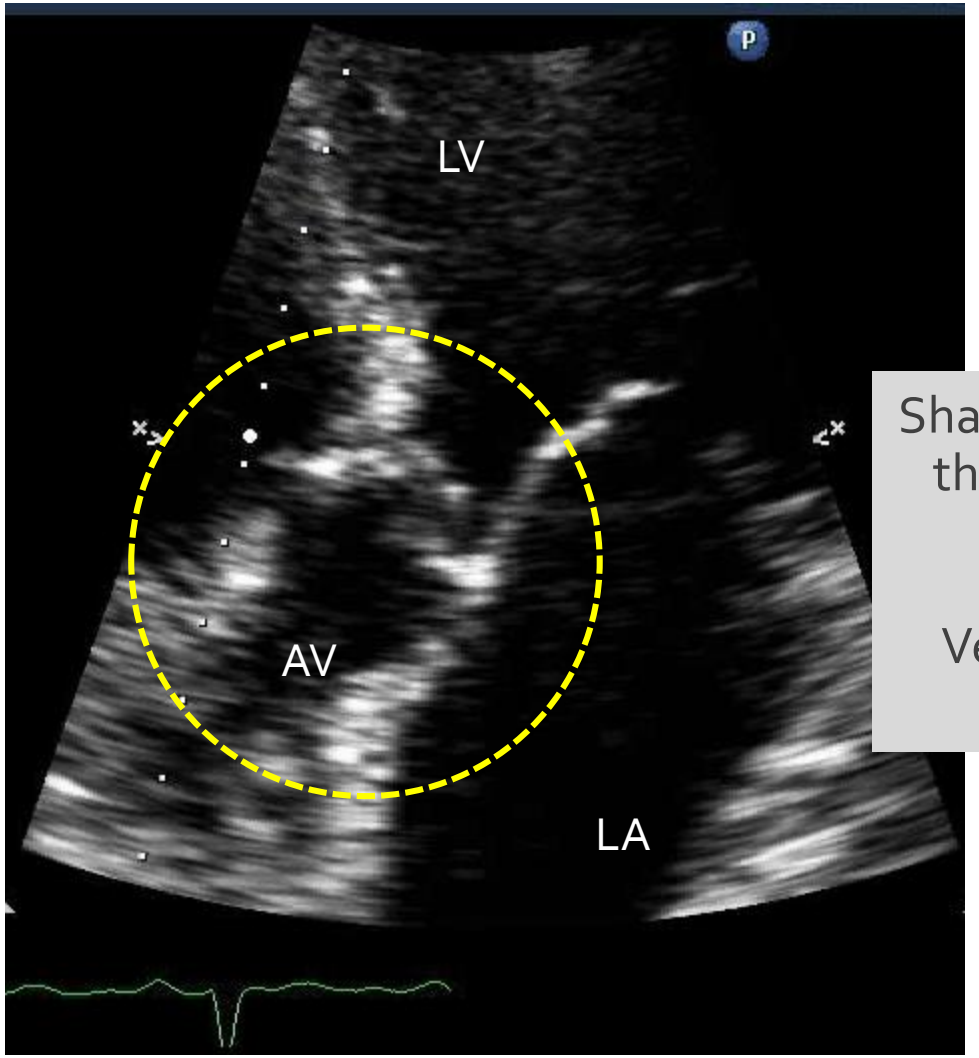
Shaggy echo densities on the **ventricular** side of the aortic valve (vegetations)

TTE: Apical Views



Hyperdynamic, nondilated LV

TTE: Apical Views



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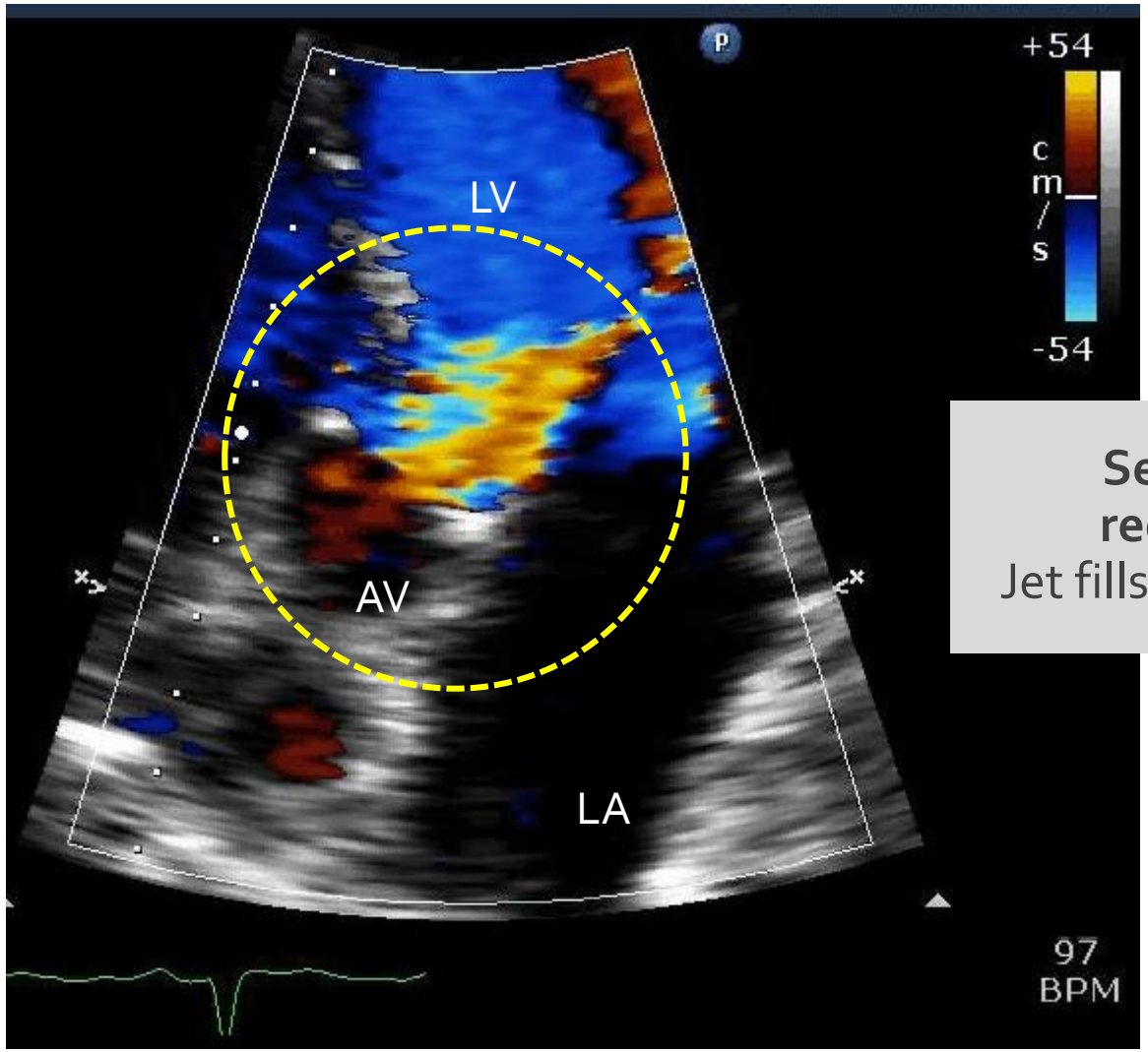
Vegetations AND flail leaflet segments

TTE: Apical Views



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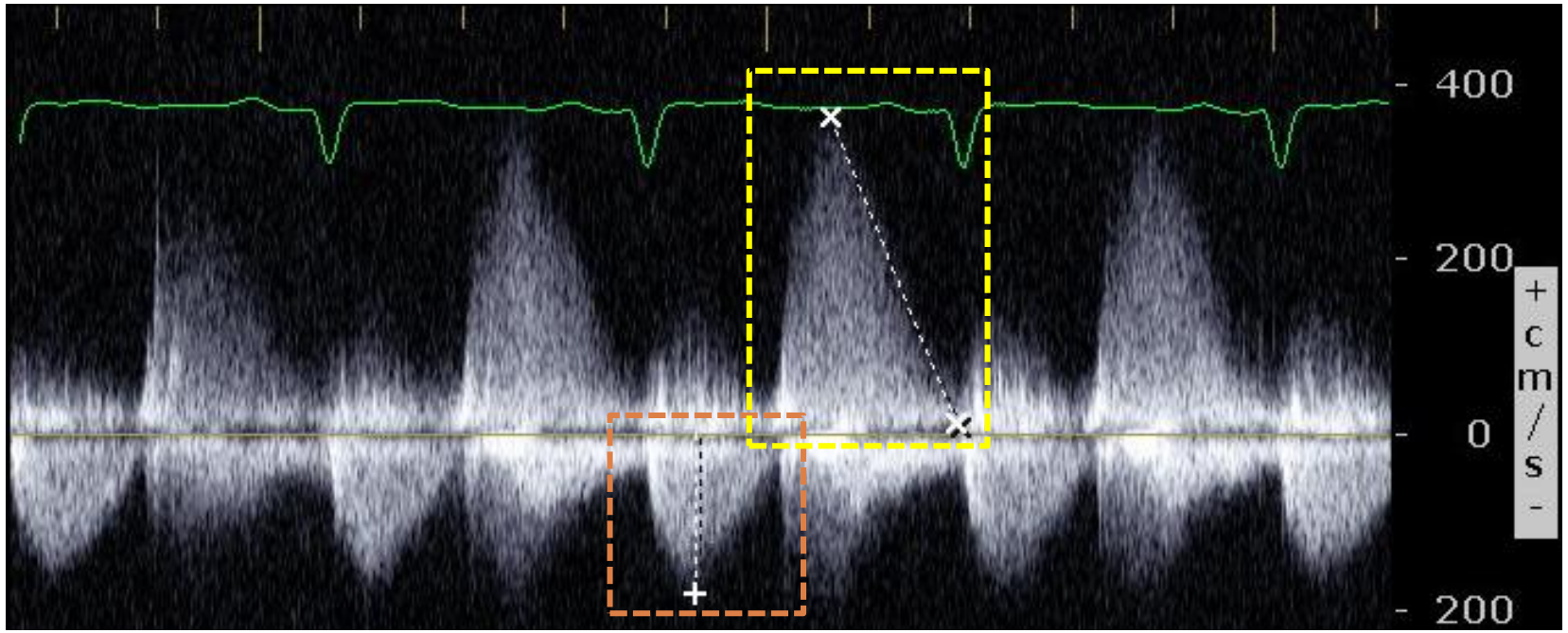
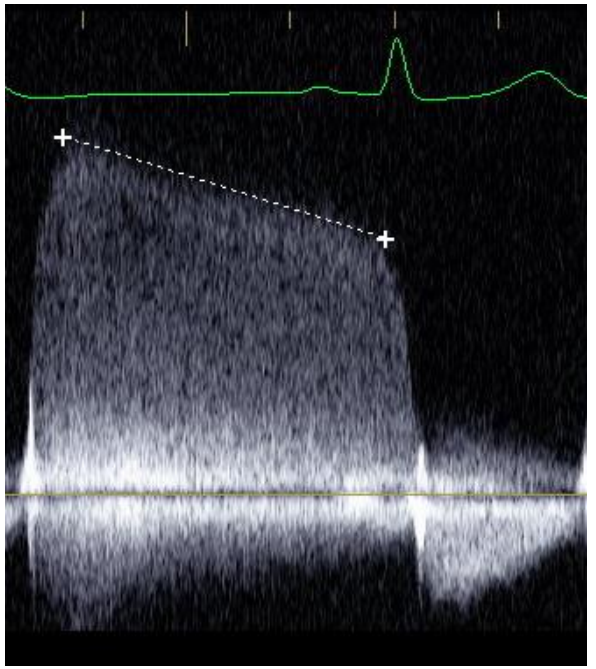
Severe Acute AR: Spectral Doppler

Rapid deceleration time (200 msec)
[Rapid equalization of diastolic aorta-to-LV gradient]

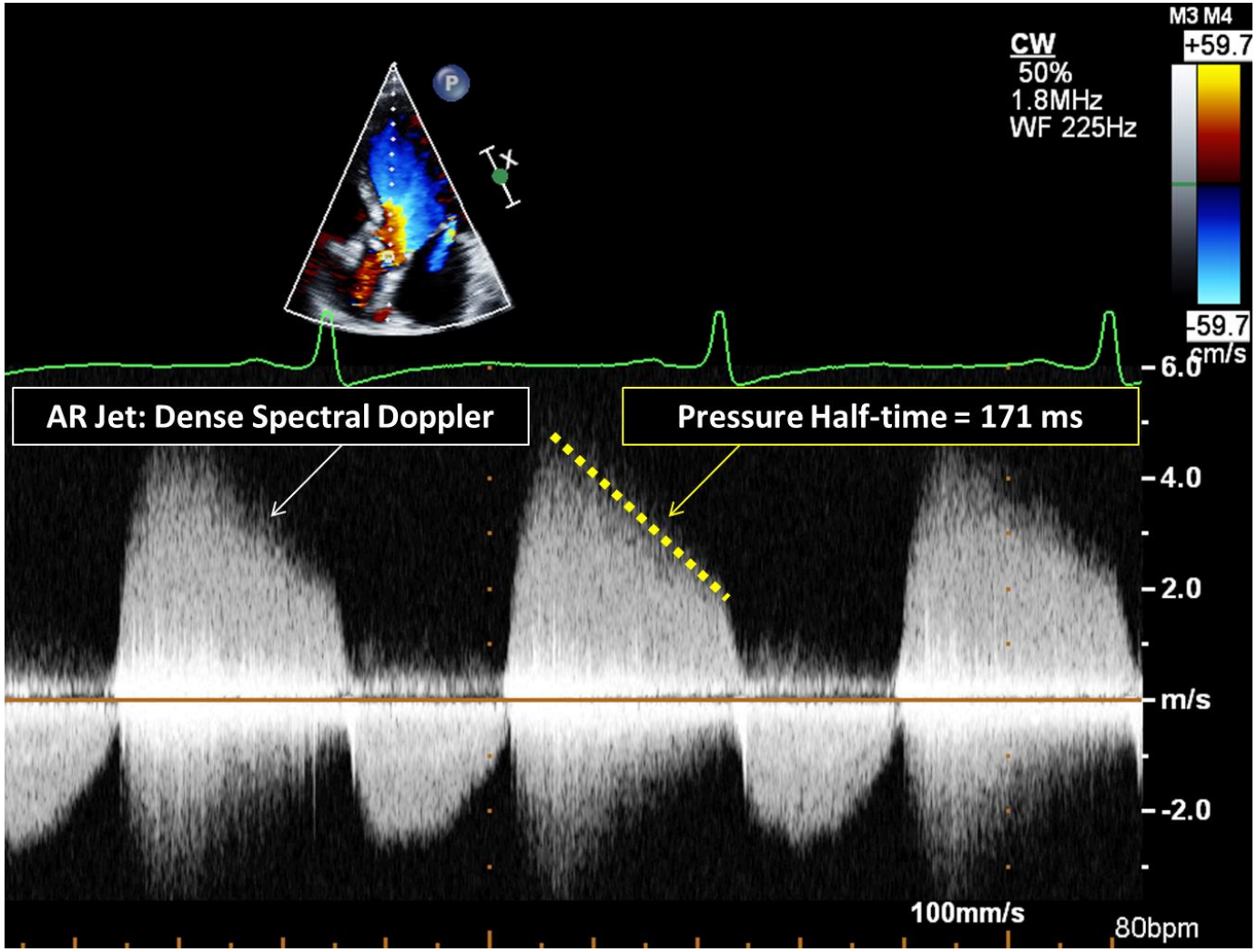


Increased **antegrade** flow
(Vmax 2.0 m/sec)
[True stroke volume + Regurgitant volume]



Mild aortic regurgitation
for comparison

Aortic Regurgitation: Pressure Half-Time



2020 ACC-AHA Valvular Guidelines

4.1.1. Diagnosis of Acute AR

TTE or TEE is indispensable in confirming the presence, severity, and etiology of acute AR; determining whether there is rapid equilibration of the aortic and LV diastolic pressures; visualizing the aortic root; and evaluating LV size and systolic function.[1,2] A short deceleration time on the aortic flow velocity curve and early closure of the mitral valve are indicators of markedly elevated LV end-diastolic pressure. A pressure half-time of <300 ms on the AR velocity curve indicates rapid equilibration of the aortic and LV diastolic pressures. The degree of holodiastolic flow reversal in the aortic arch, in comparison with the forward systolic flow, provides a quick semiquantitative estimate of regurgitant fraction. Acute severe AR caused by aortic dissection is a surgical emergency. CT imaging is the primary approach for diagnosis of

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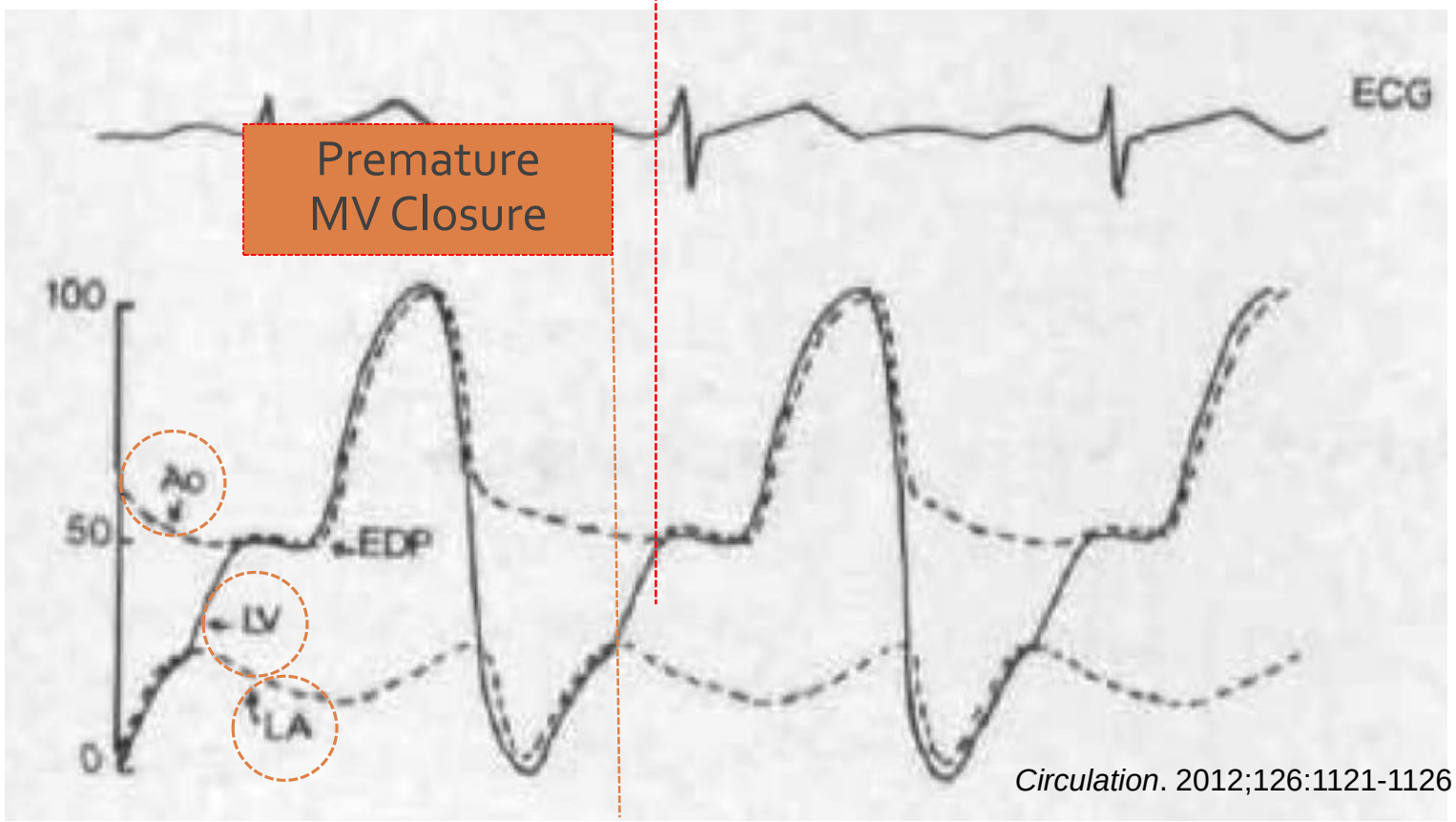
Severe Acute Aortic Regurgitation

Premature equalization
of aorta-to-LV pressure gradient



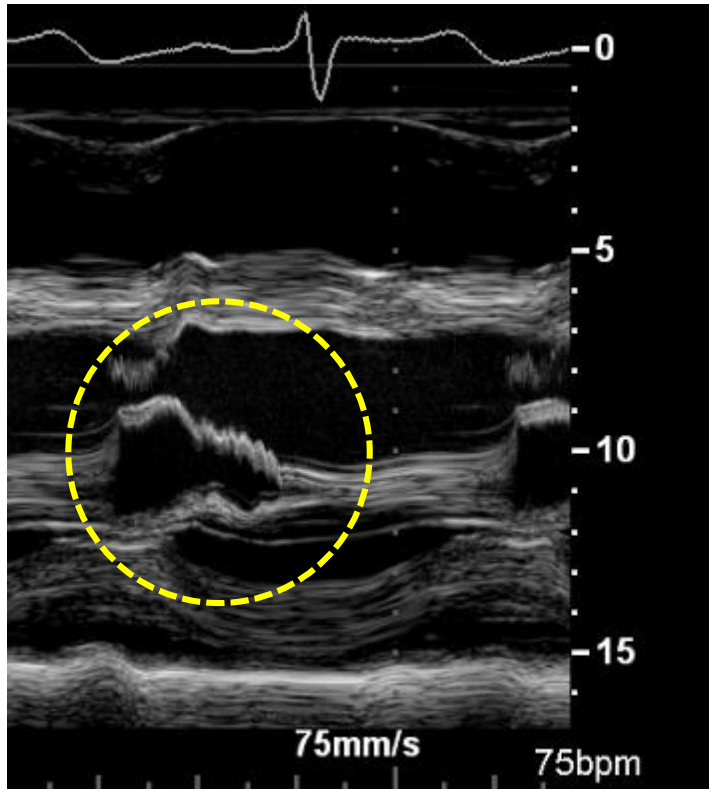
Circulation. 2012;126:1121-1126

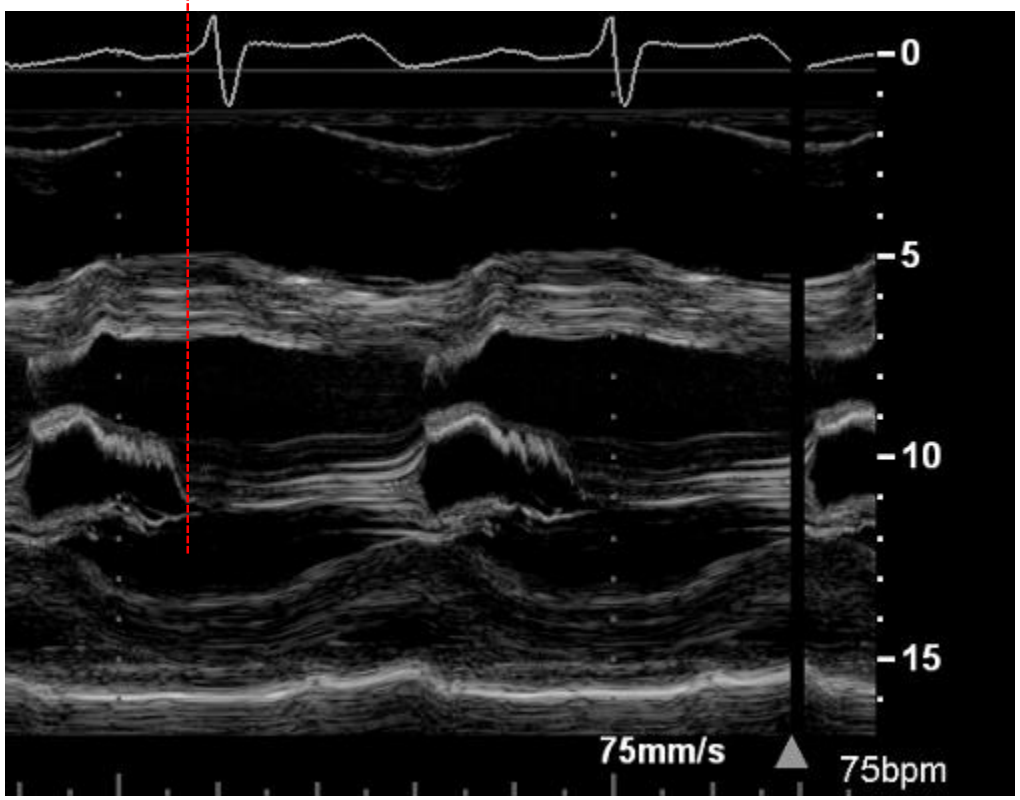
Mitral Valve Closure in Acute AR: M Mode

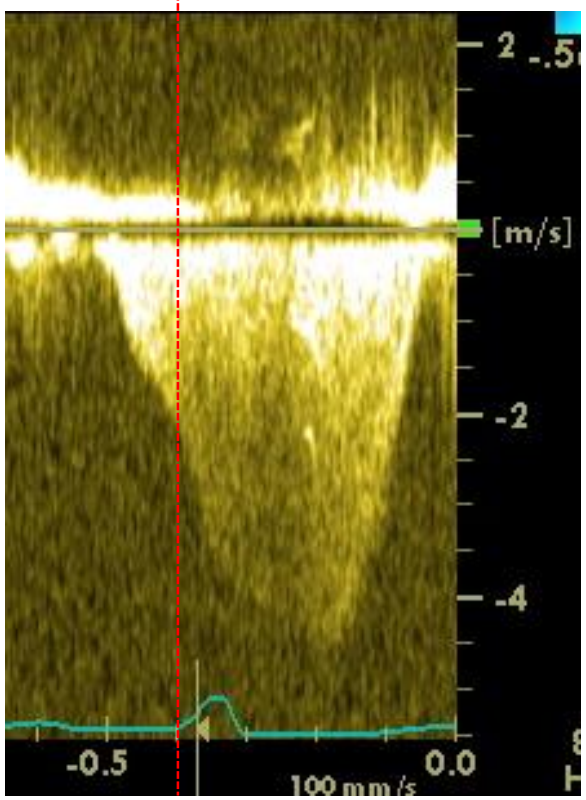
Fluttering of
anterior mitral leaflet

Premature
mitral valve closure

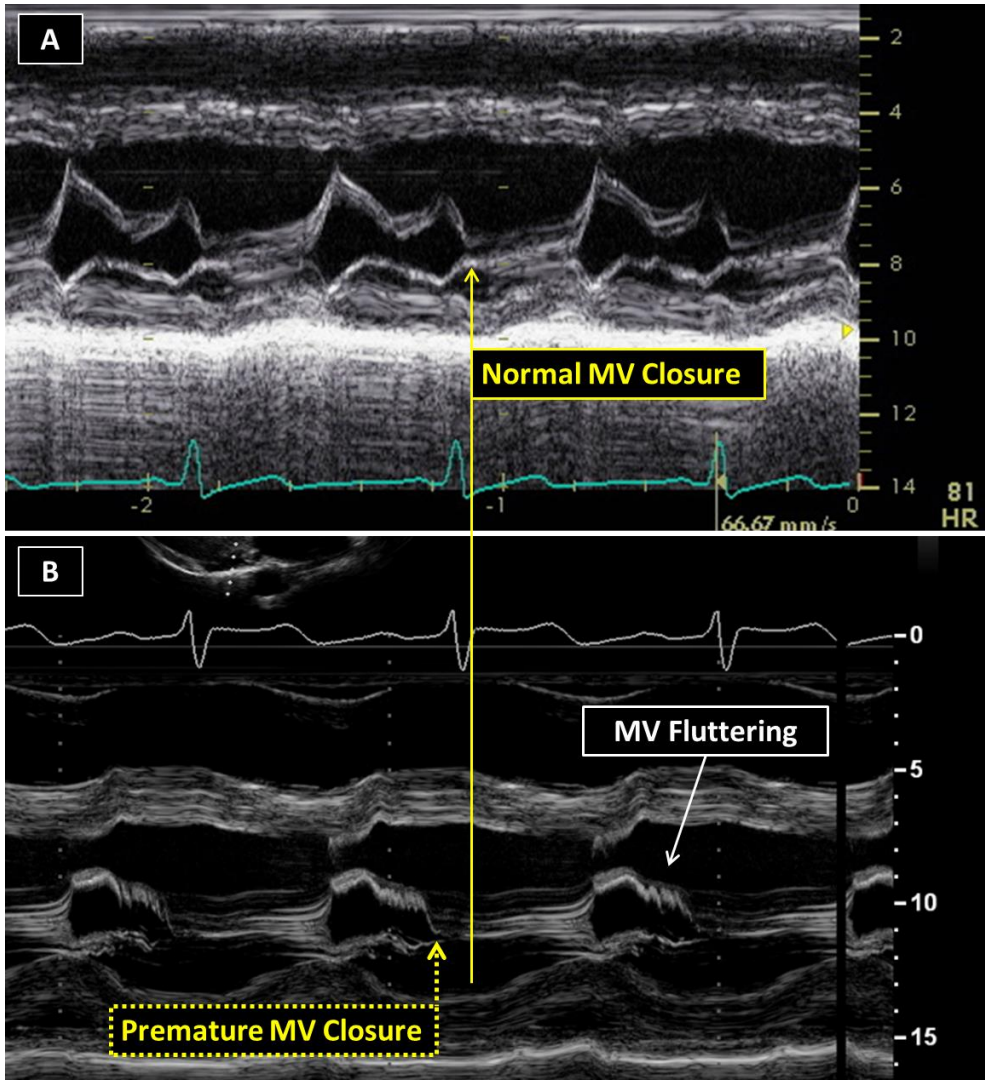
Diastolic
MR







Aortic Regurgitation: Premature MV Closure



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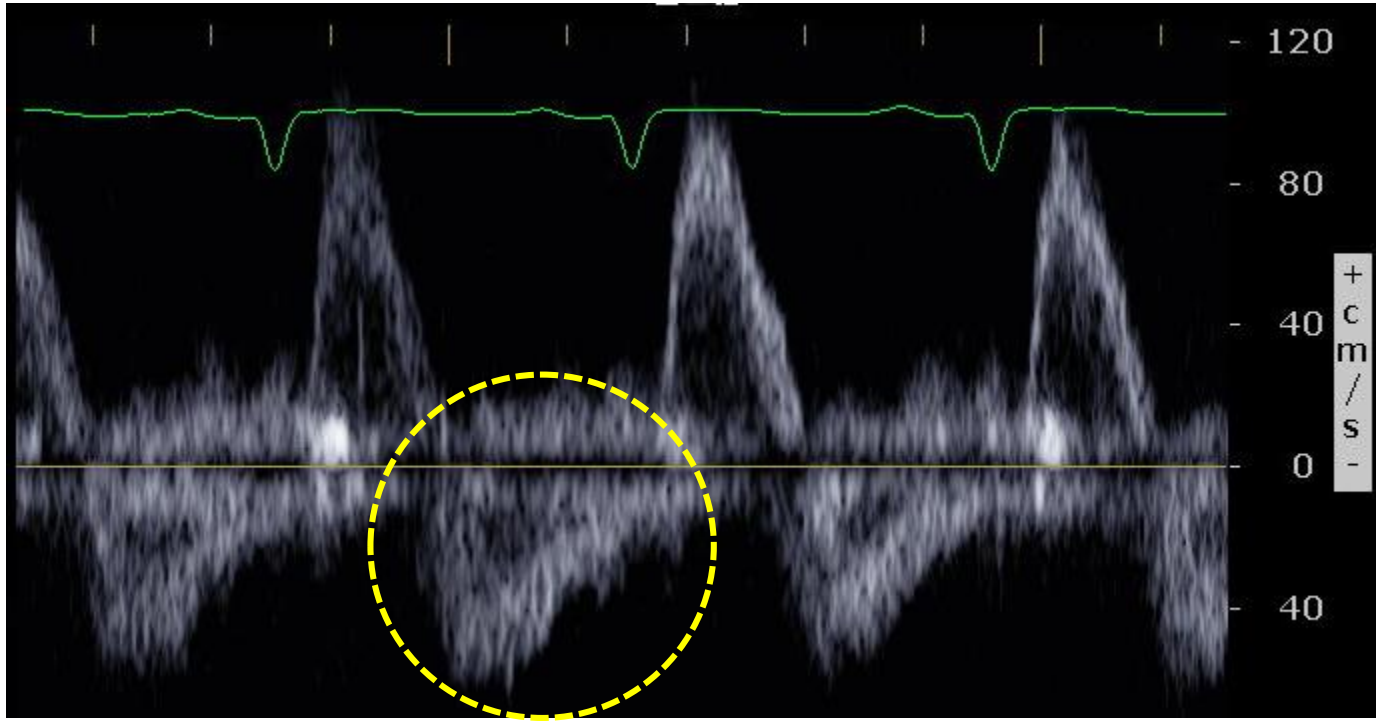
Severe Acute AR: Abdominal Aorta

Holodiastolic flow reversal in abdominal thoracic aorta



Abdominal CT

Soon after admission, patient developed vague left upper quadrant pain.

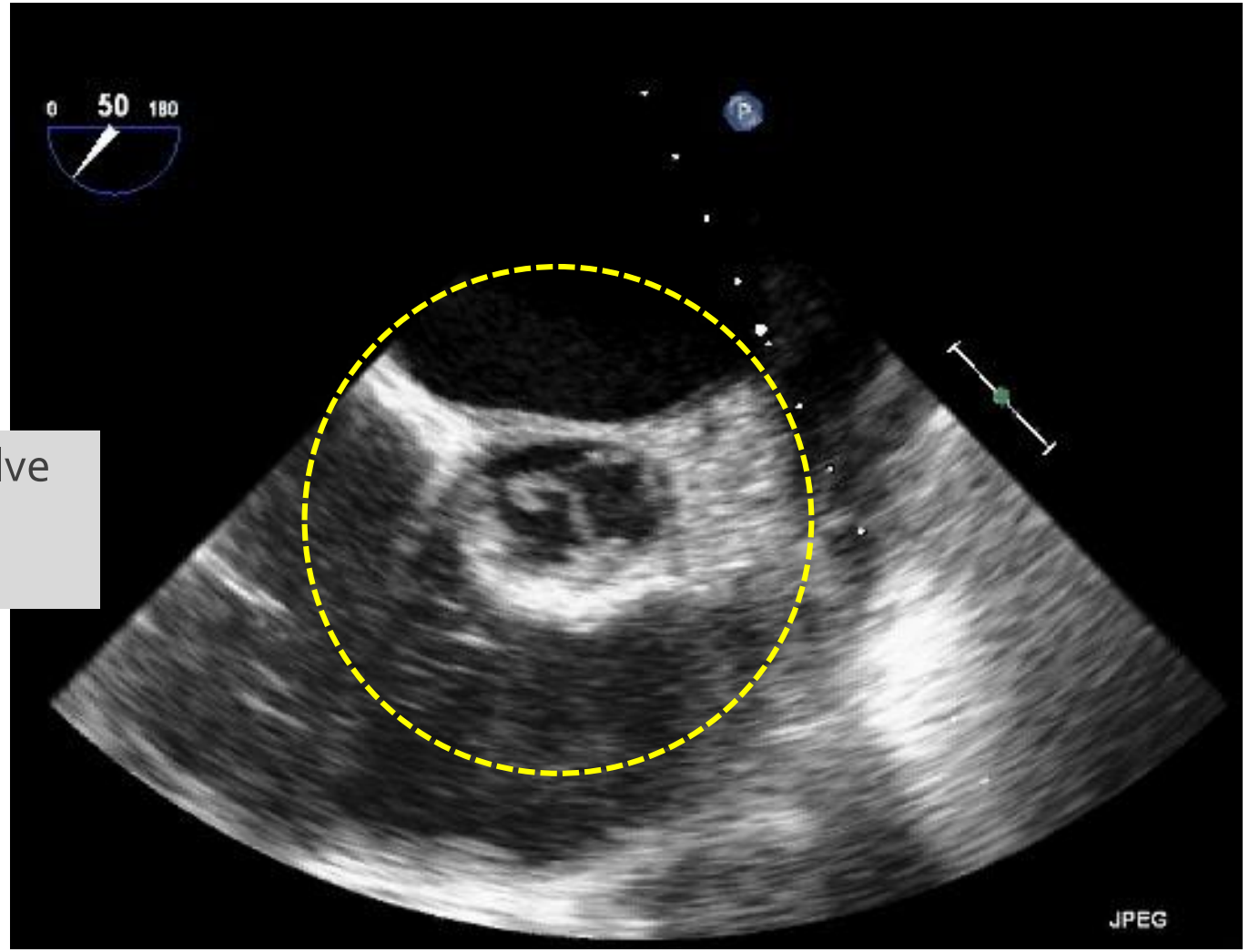
Splenic infarct due to septic emboli

Next Step

Referred promptly for surgical aortic valve replacement

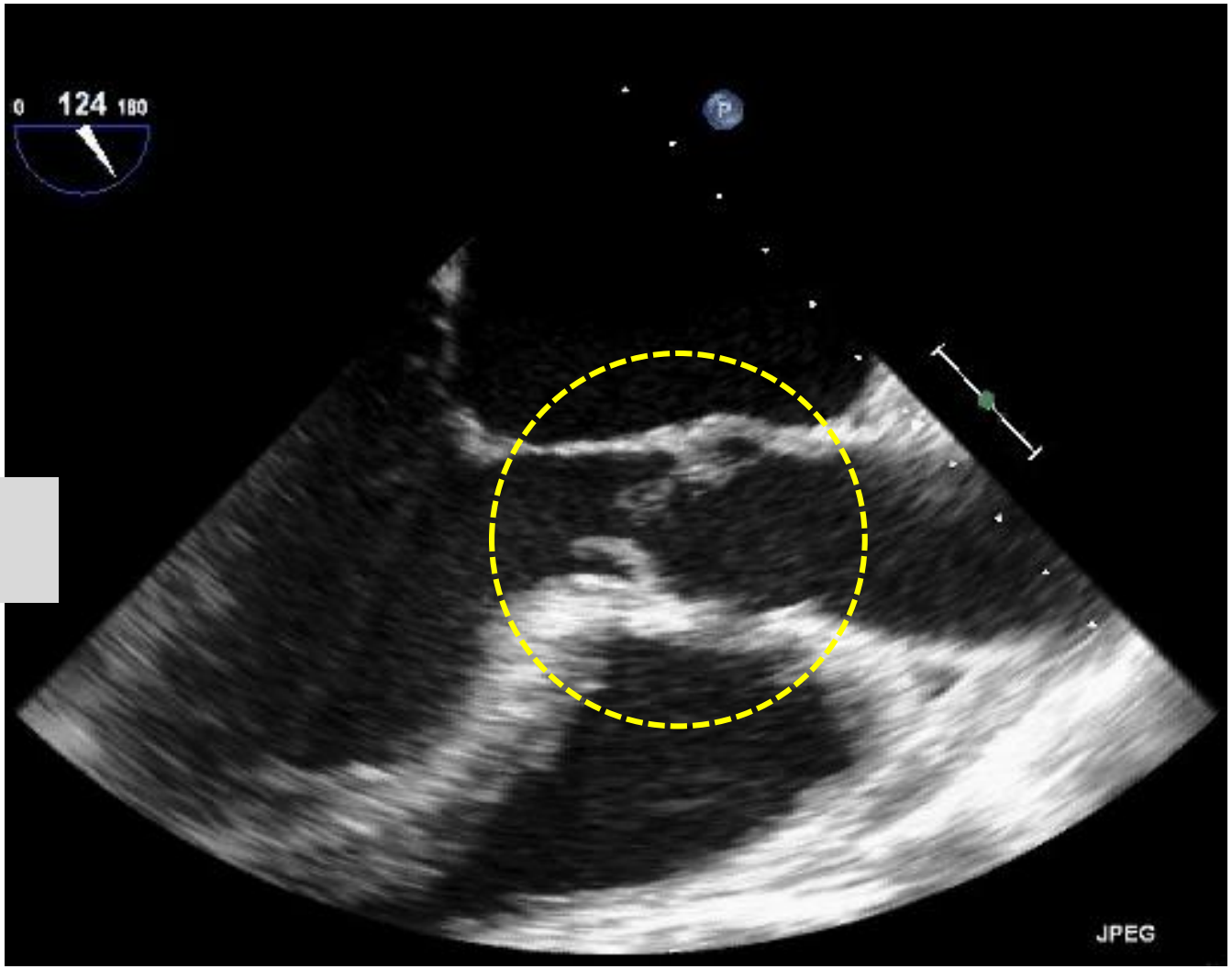
Intraoperative TEE

Trileaflet aortic valve with multiple vegetations



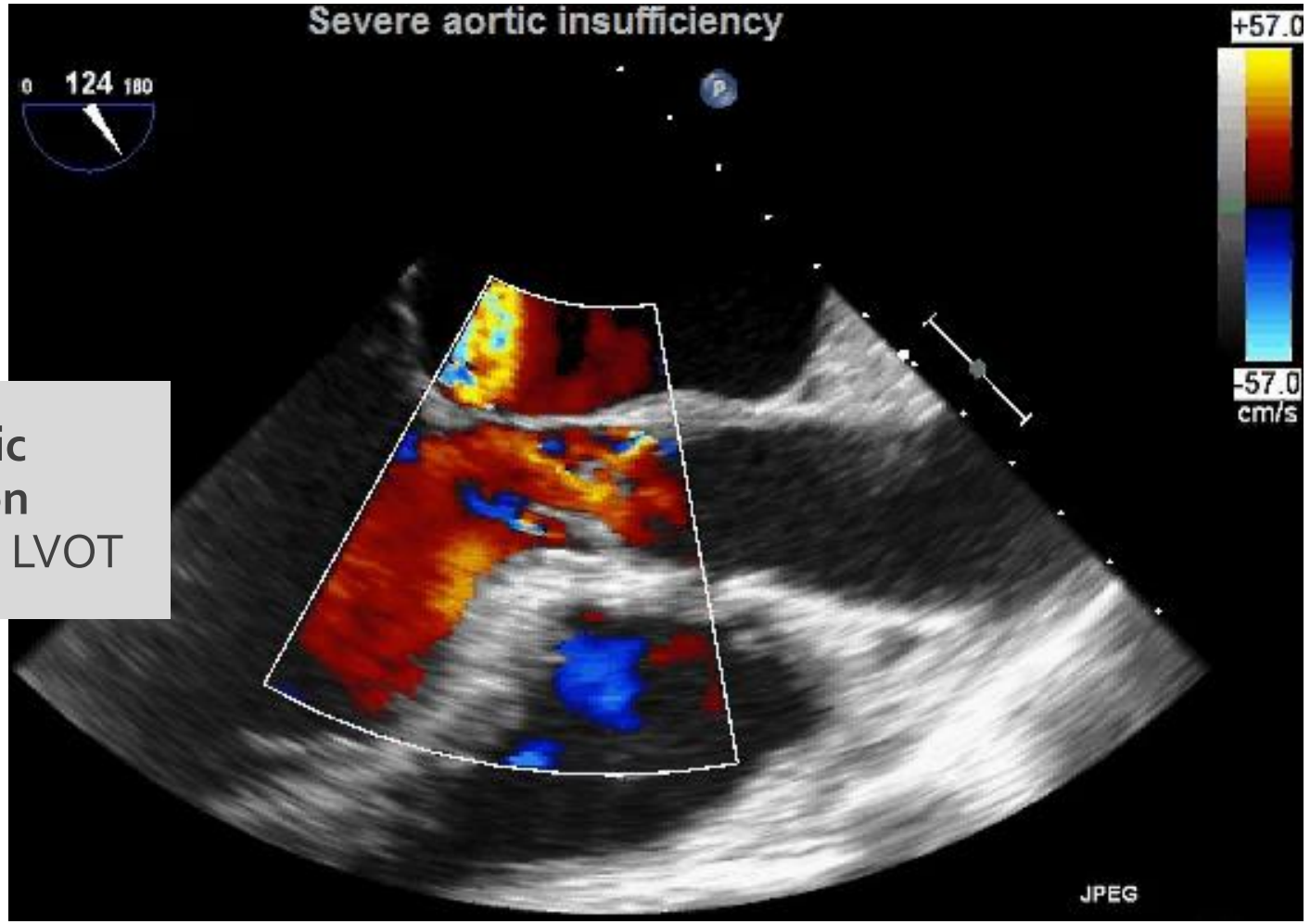
Intraoperative TEE

Flail
aortic leaflets



Intraoperative TEE

Severe aortic regurgitation
Jet fills the entire LVOT



Surgical Aortic Valve Replacement

Native aortic valve replaced with a 23-mm **Carpentier-Edwards Perimount Magna bioprosthesis**

Epilogue

Patient recovered fully

Now doing well 5 years after aortic valve surgery

Case #2

Case Presentation

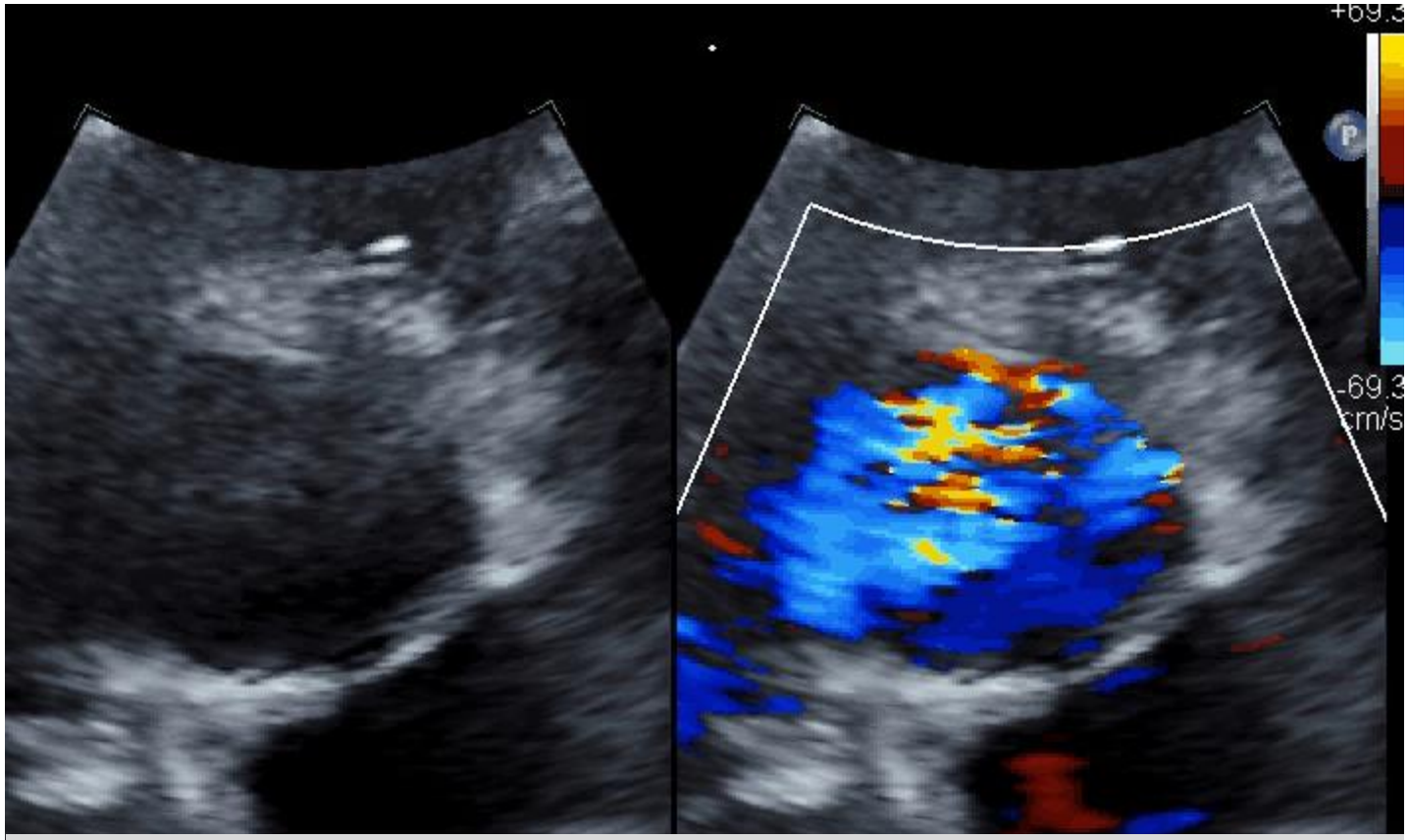
27-year-old woman with known **chronic severe aortic regurgitation**

- At age 12, had **aortic valve endocarditis** of native **3-leaflet aortic valve**
- Reports no exercise limitation
- Now comes for routine TTE
- BSA 1.8 m^2

Question

Should she be referred for aortic valve replacement based on echocardiographic findings
even in the absence of symptoms?

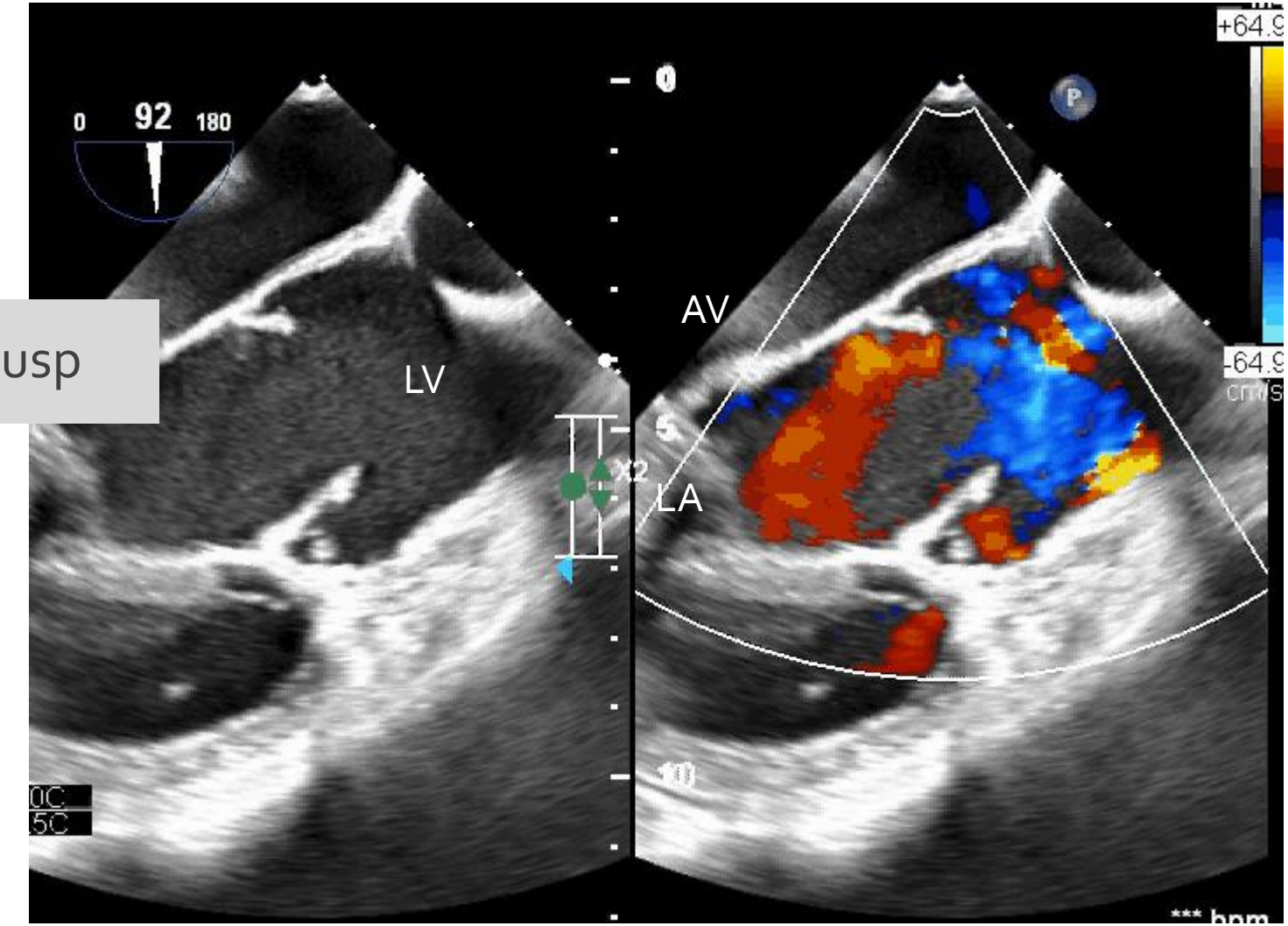
TTE: Parasternal Short-Axis View



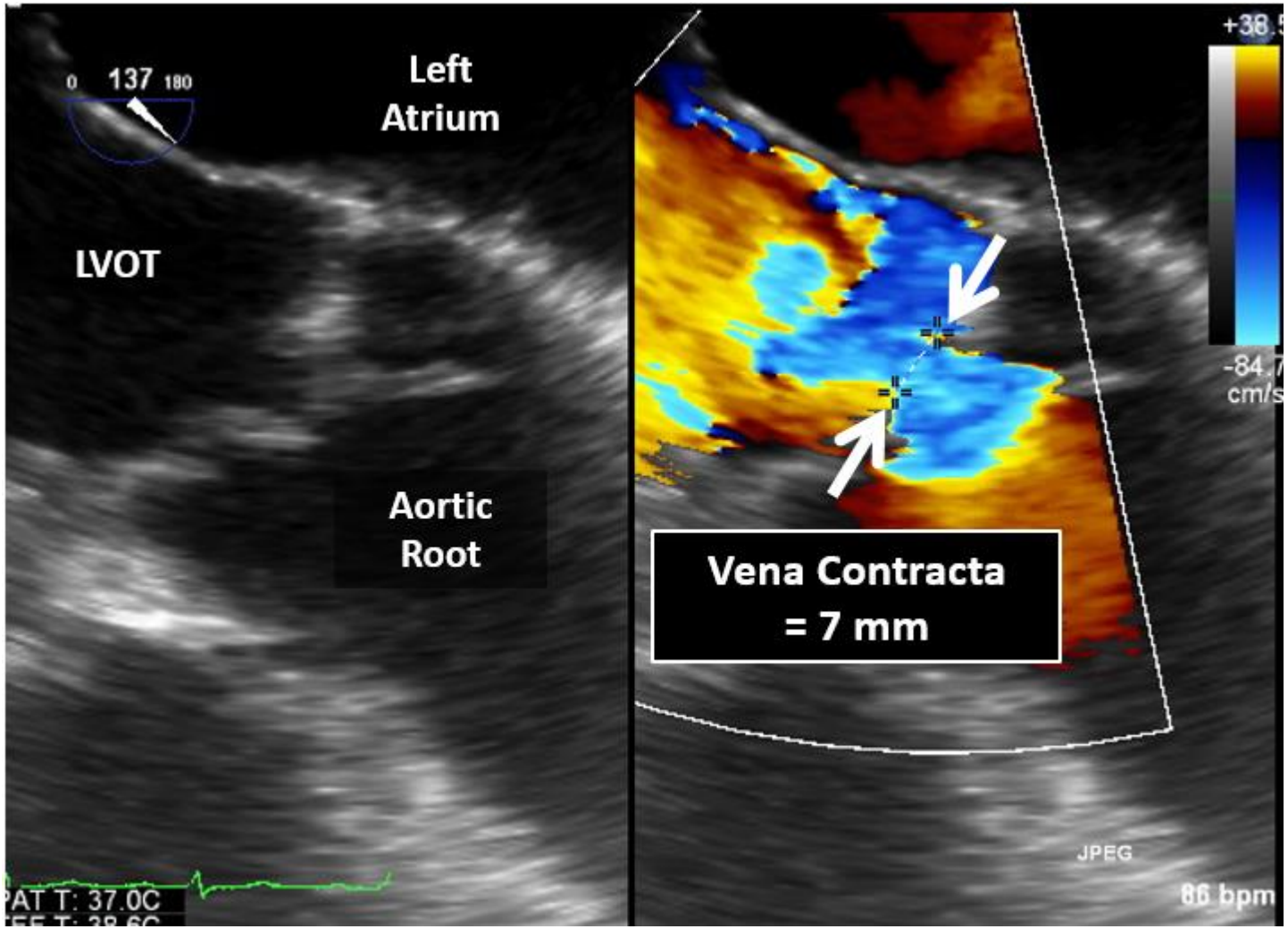
Severe Aortic Regurgitation
3-leaflet Aortic Valve

TEE

Flail Aortic Cusp



AR Quantification: Vena Contracta



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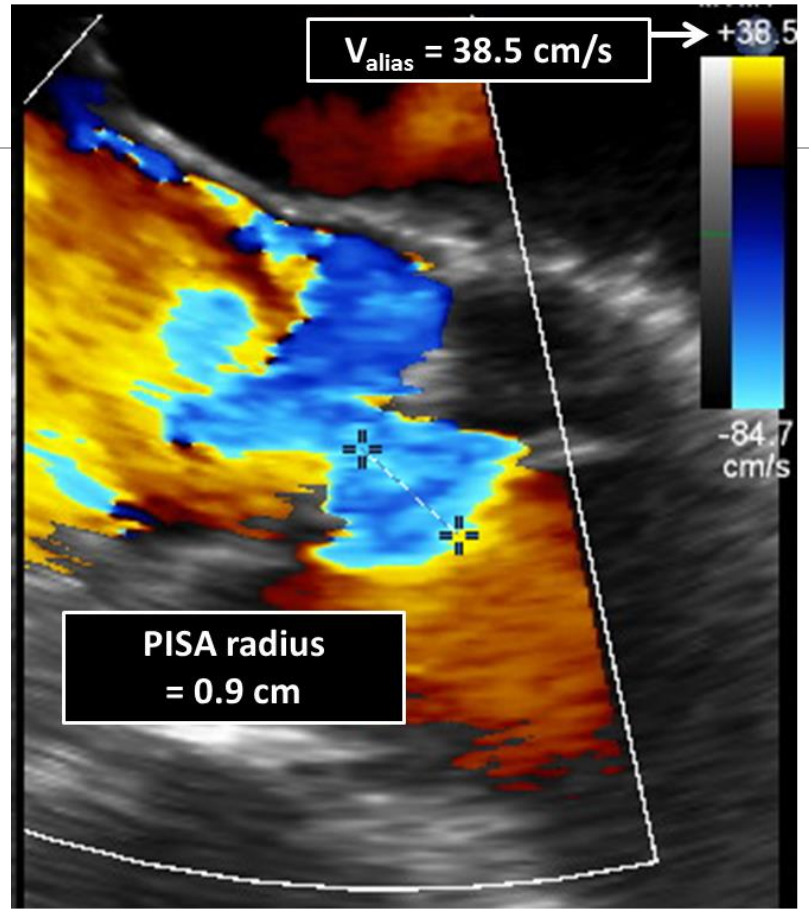
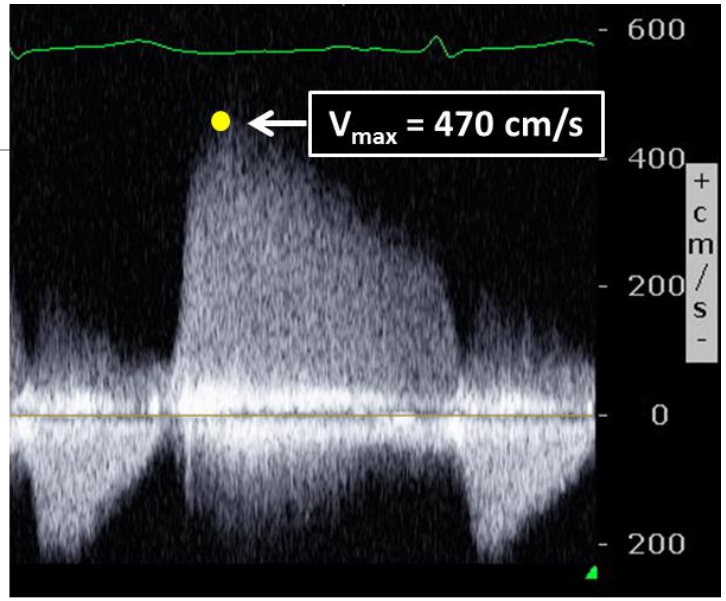
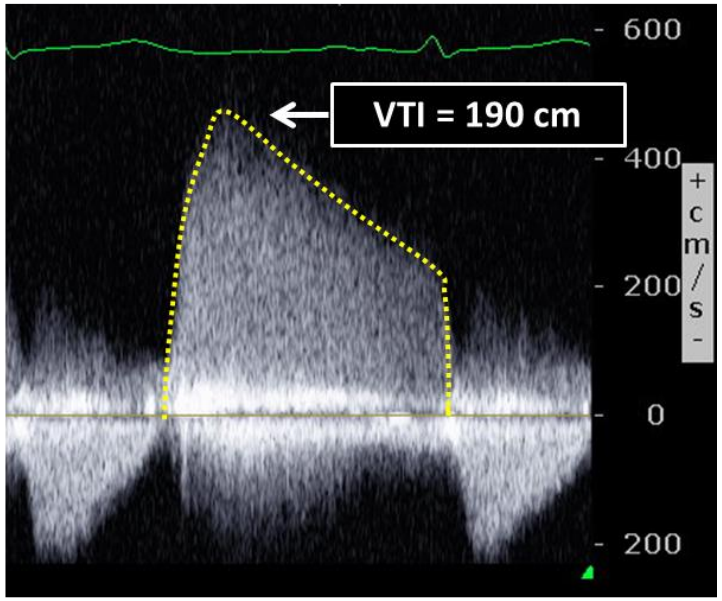
AR: PISA







$EROA = 2\pi r^2 * V_{alias} / V_{max}$

$EROA = 2\ (3.14)\ (0.9)^2 * 38.5 / 470$

$EROA = 0.42\ cm^2$

$RegVol = EROA * VTI = 0.42 * 190$

$RegVol = 79\ mL$

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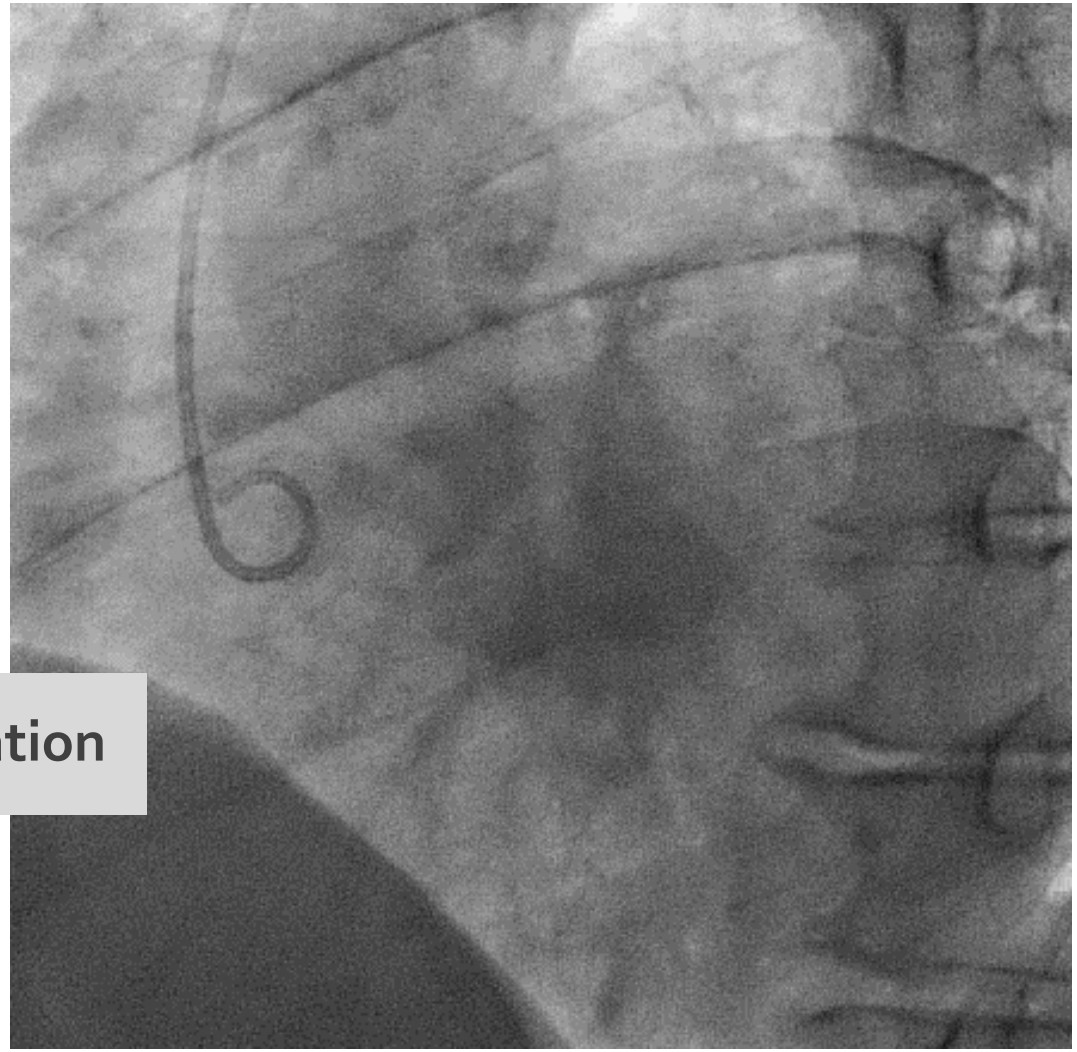
EROA (cm^2)	<0.10	0.10-0.19 / 0.20-0.29	≥0.30

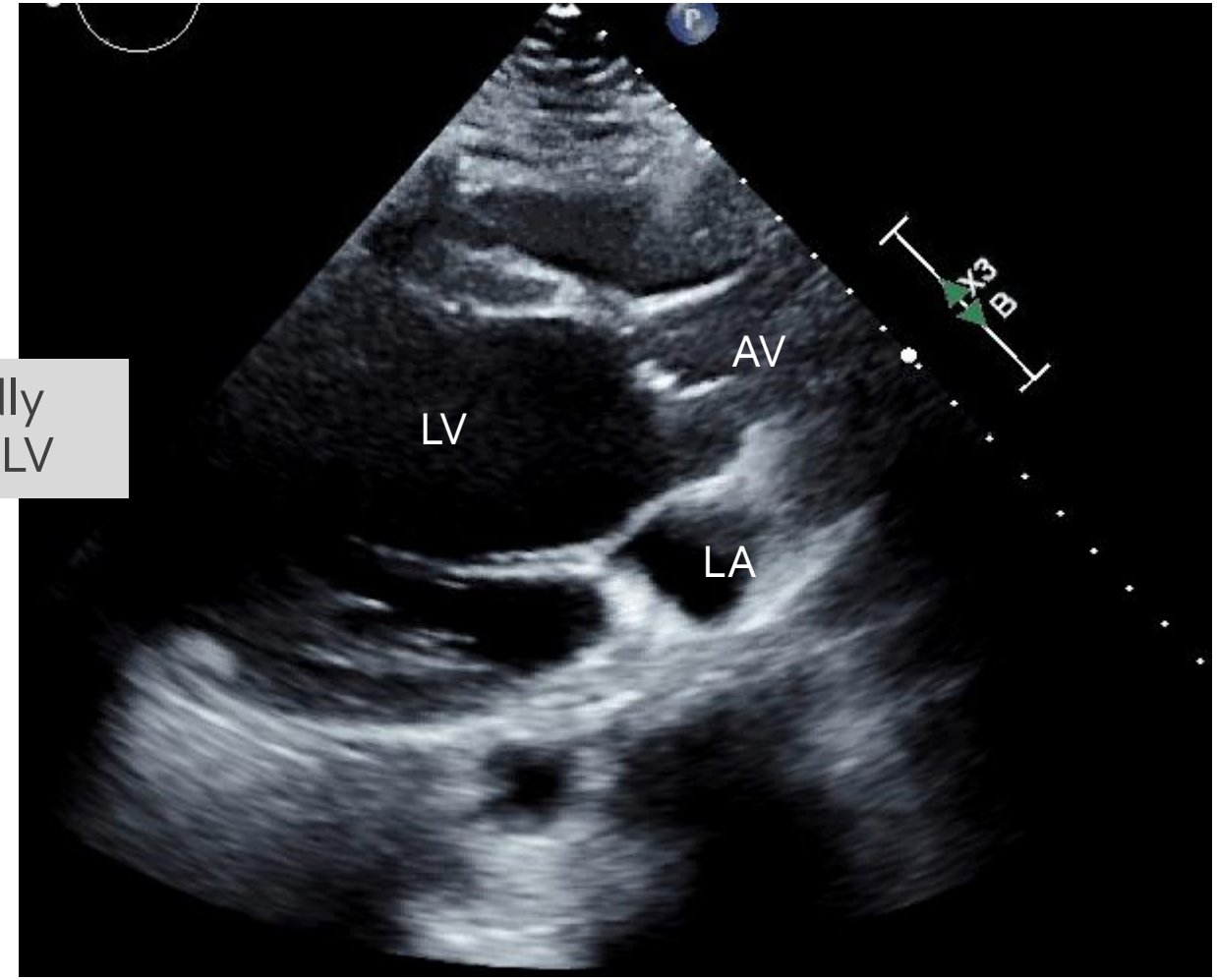
Cardiac Cath: Aortogram



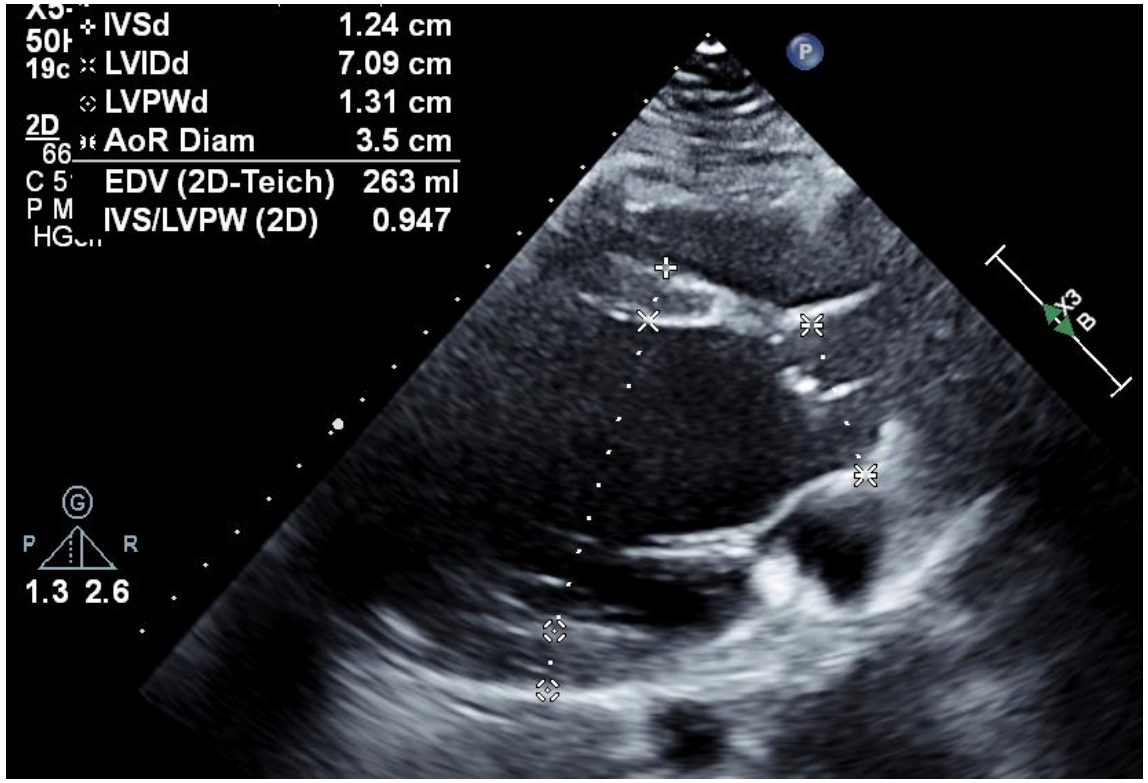
Severe Aortic Regurgitation

TTE: Parasternal Long-Axis View

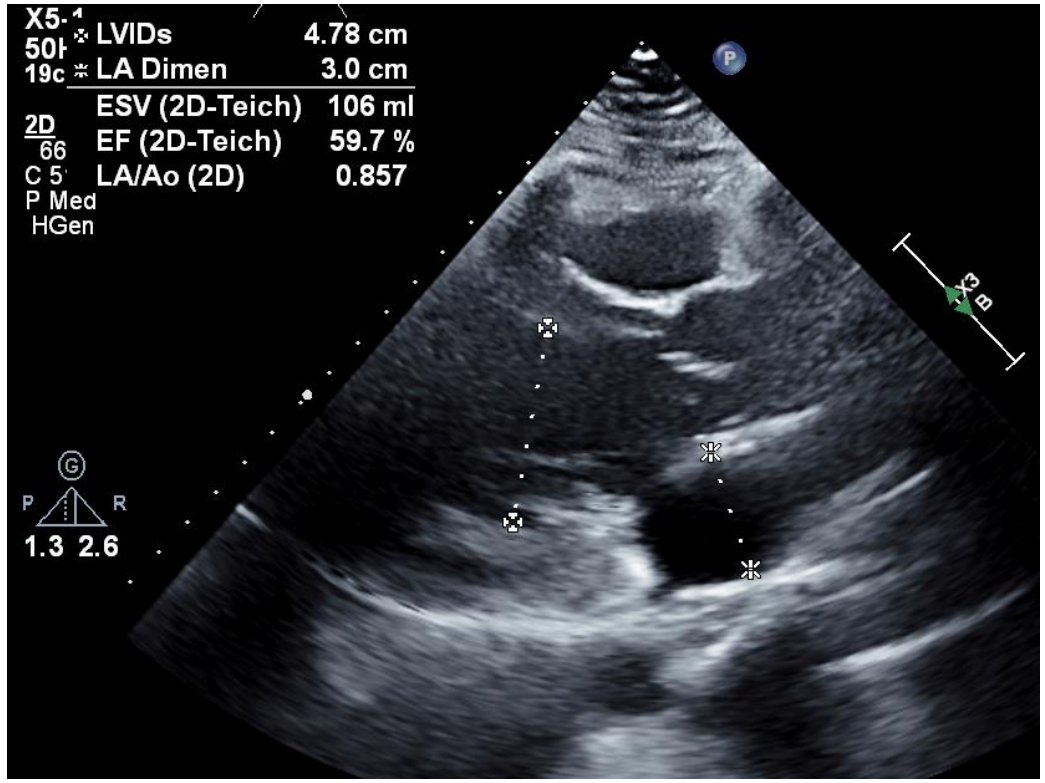
Markedly Dilated LV



TTE: Parasternal Long-Axis View

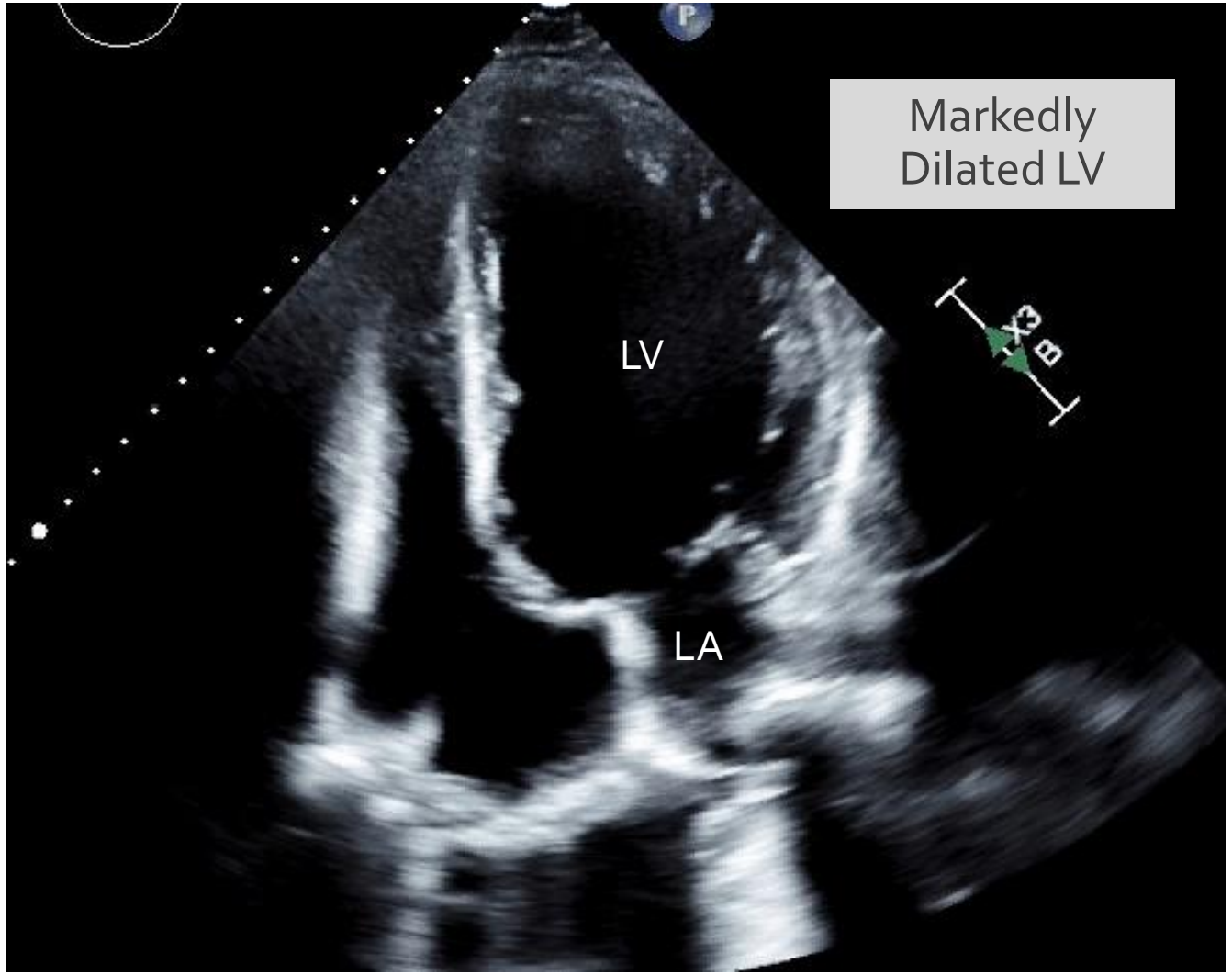


LV End-diastolic Diameter
7.1 cm

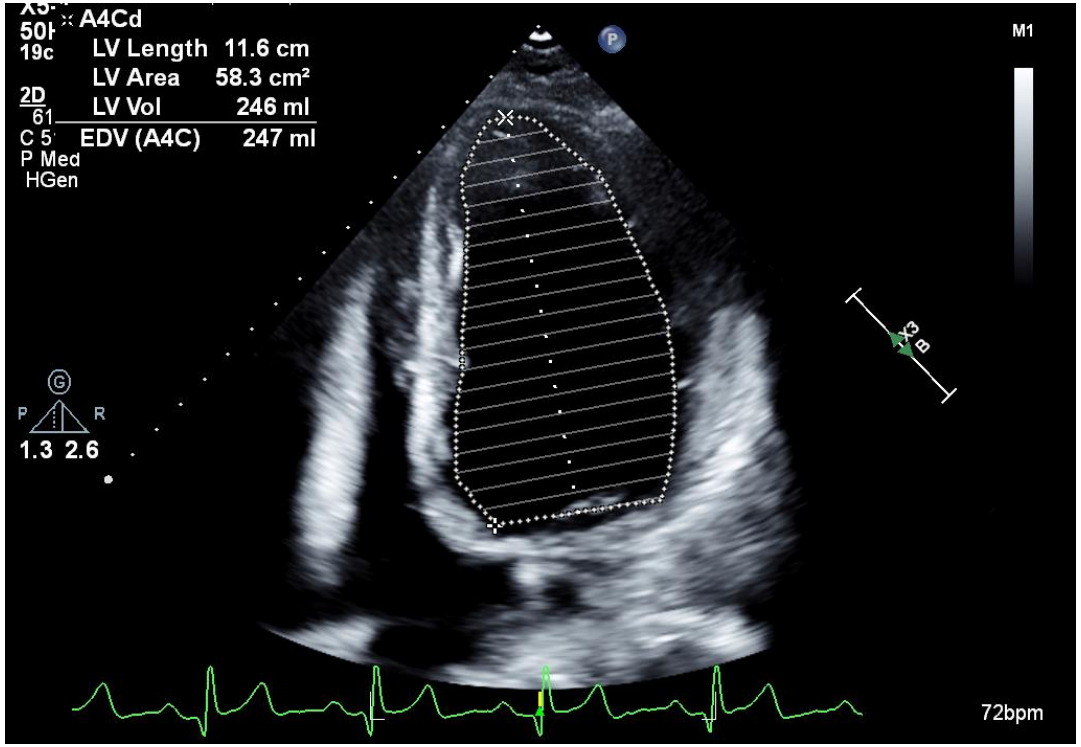


LV End-systolic Diameter
4.8 cm (**27** mm/m²)

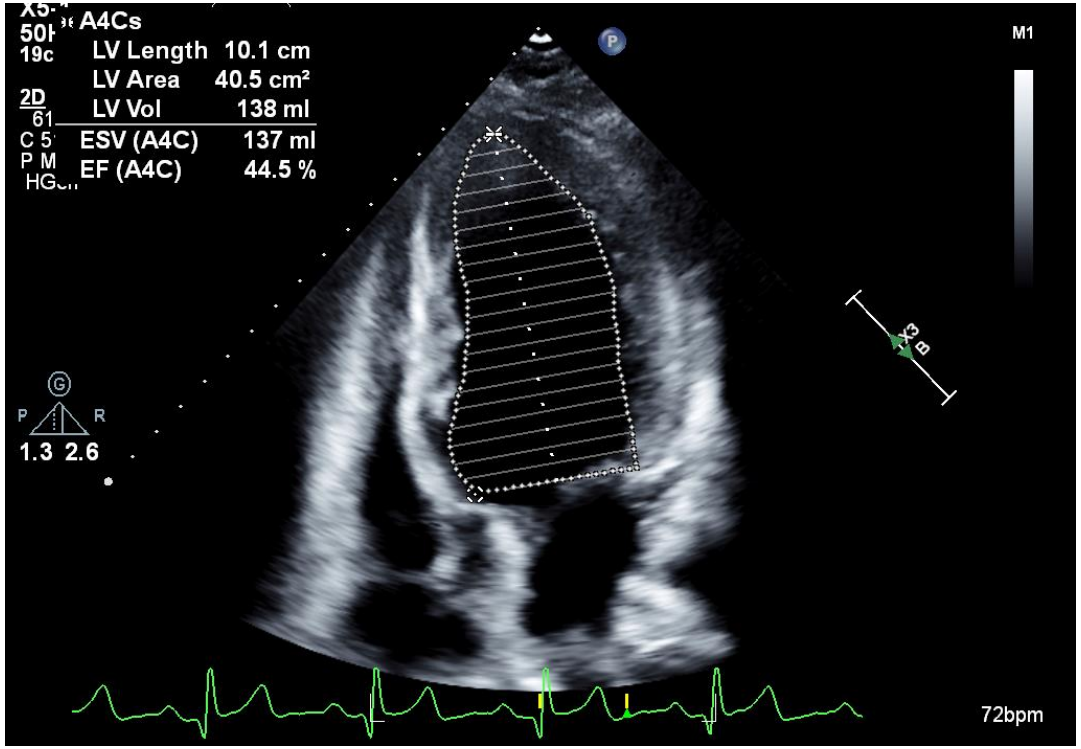
TTE: Apical 4-Chamber View



TTE: Apical Views

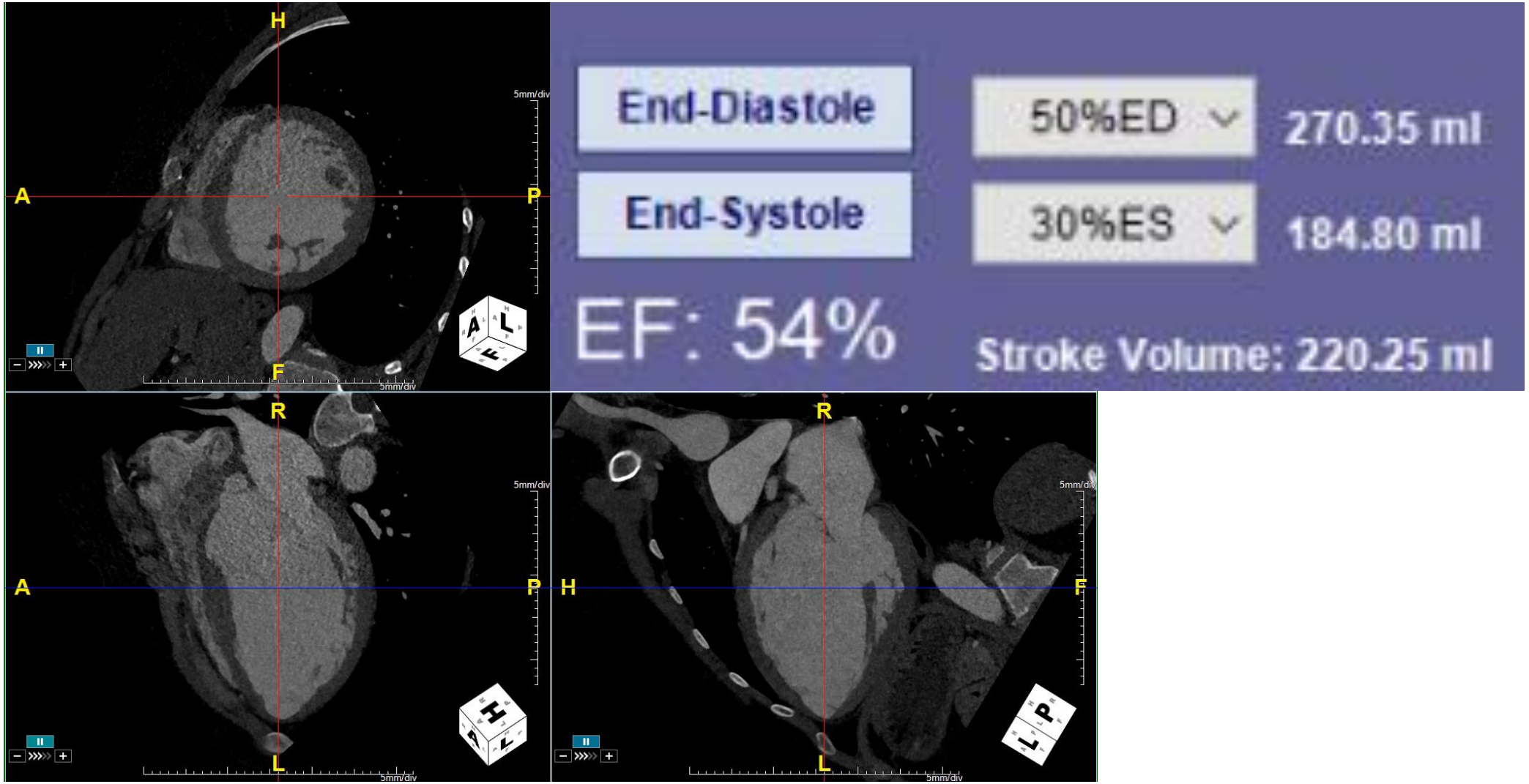


LV End-diastolic Volume
247 mL (**137** mL/m²; normal < 75 mL/m²)



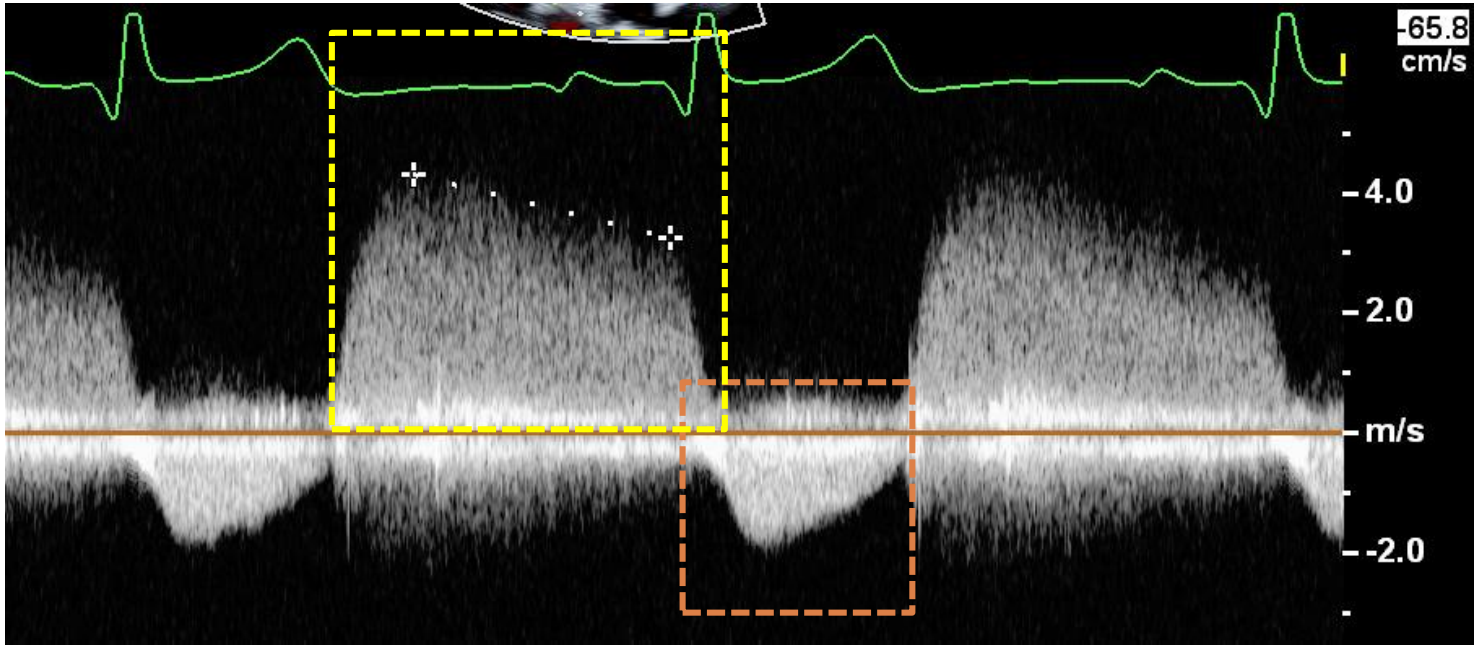
LV Ejection Fraction
45% cm

Chest CT Angiography



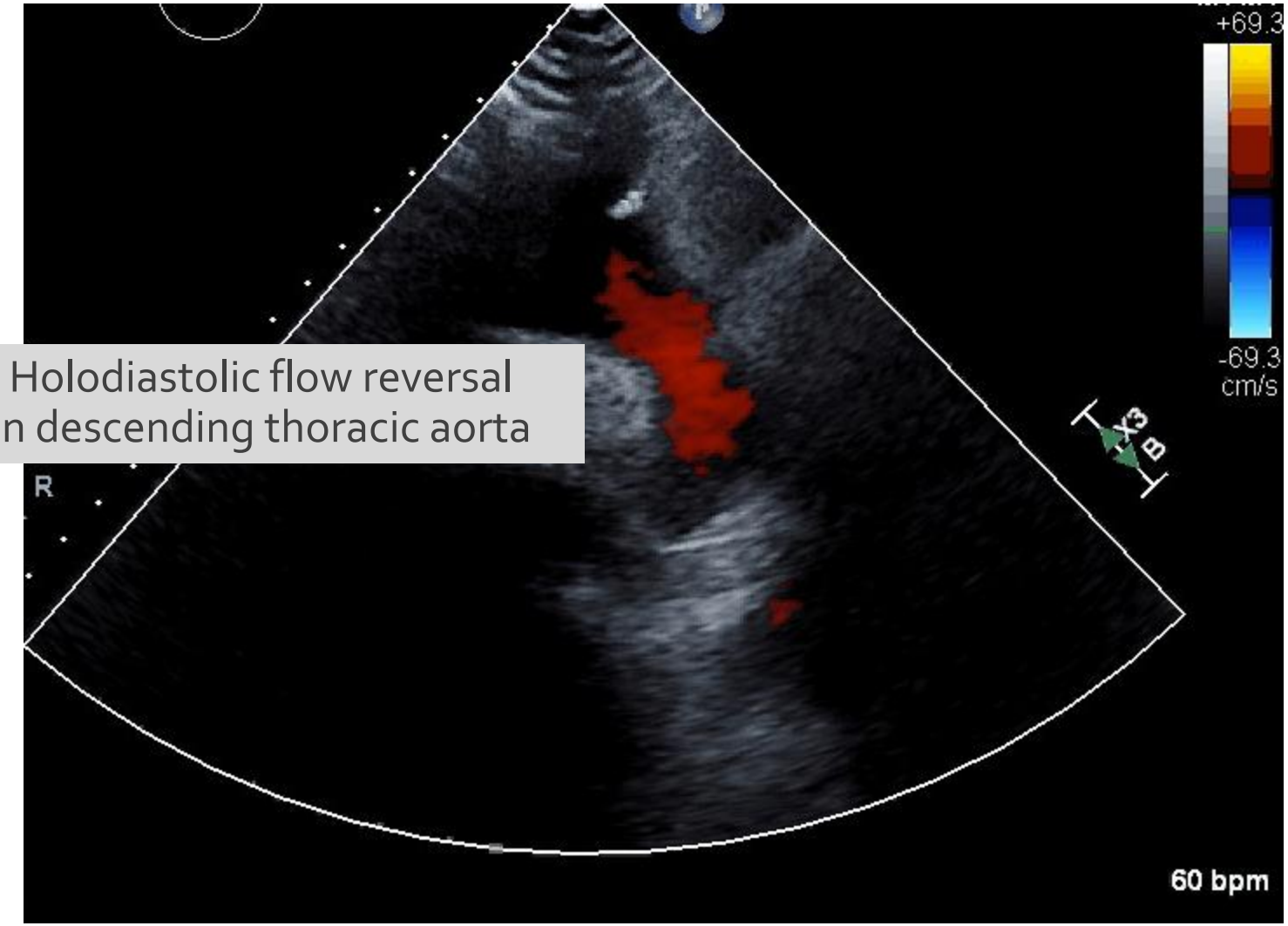
TTE: Spectral Doppler

Deceleration time **430** msec
[Despite severe AR, relatively flat deceleration slope]



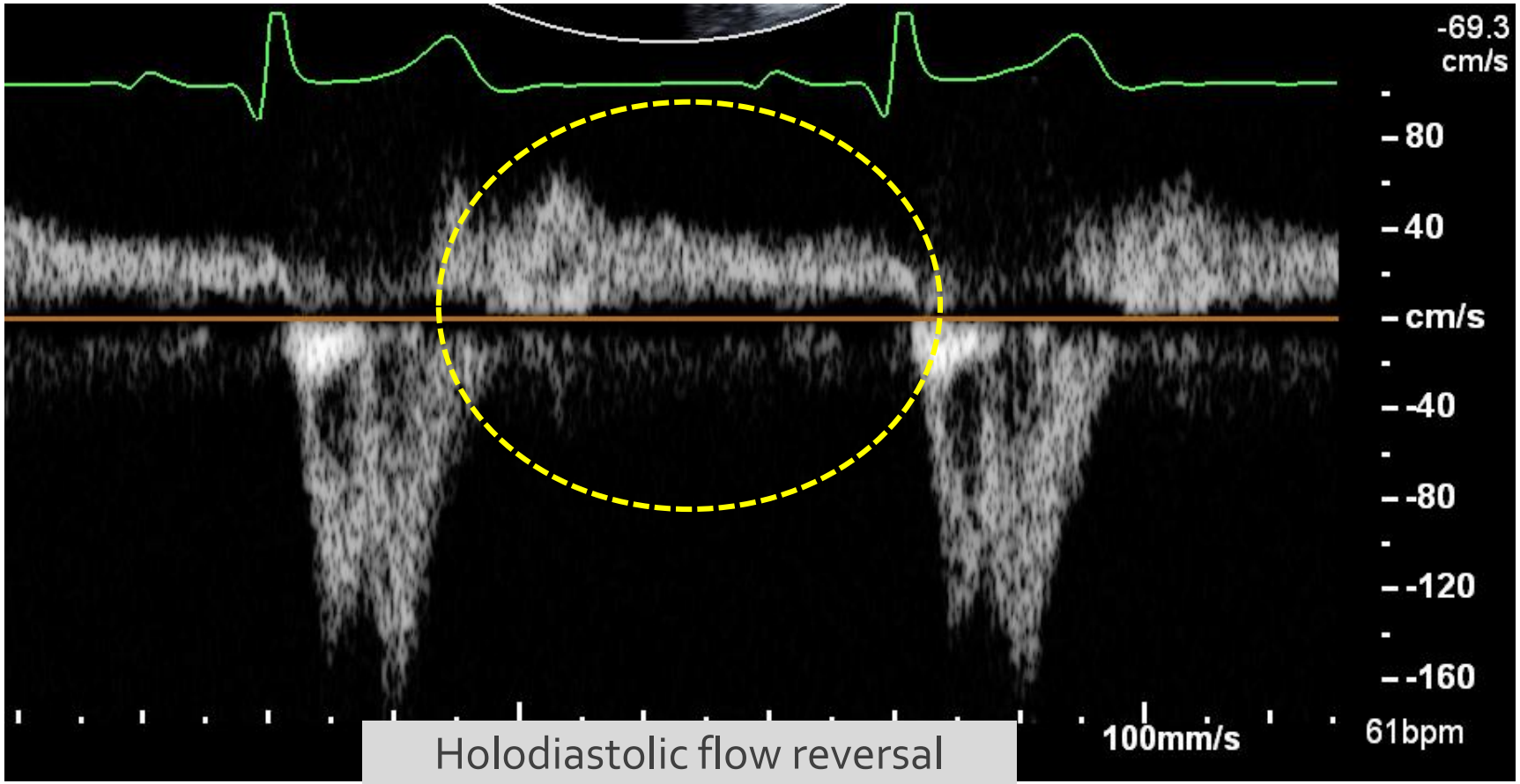
Increased **antegrade** flow
(Vmax 2.0 m/sec)
[True stroke volume + Regurgitant volume]

Severe Chronic AR: Descending Aorta



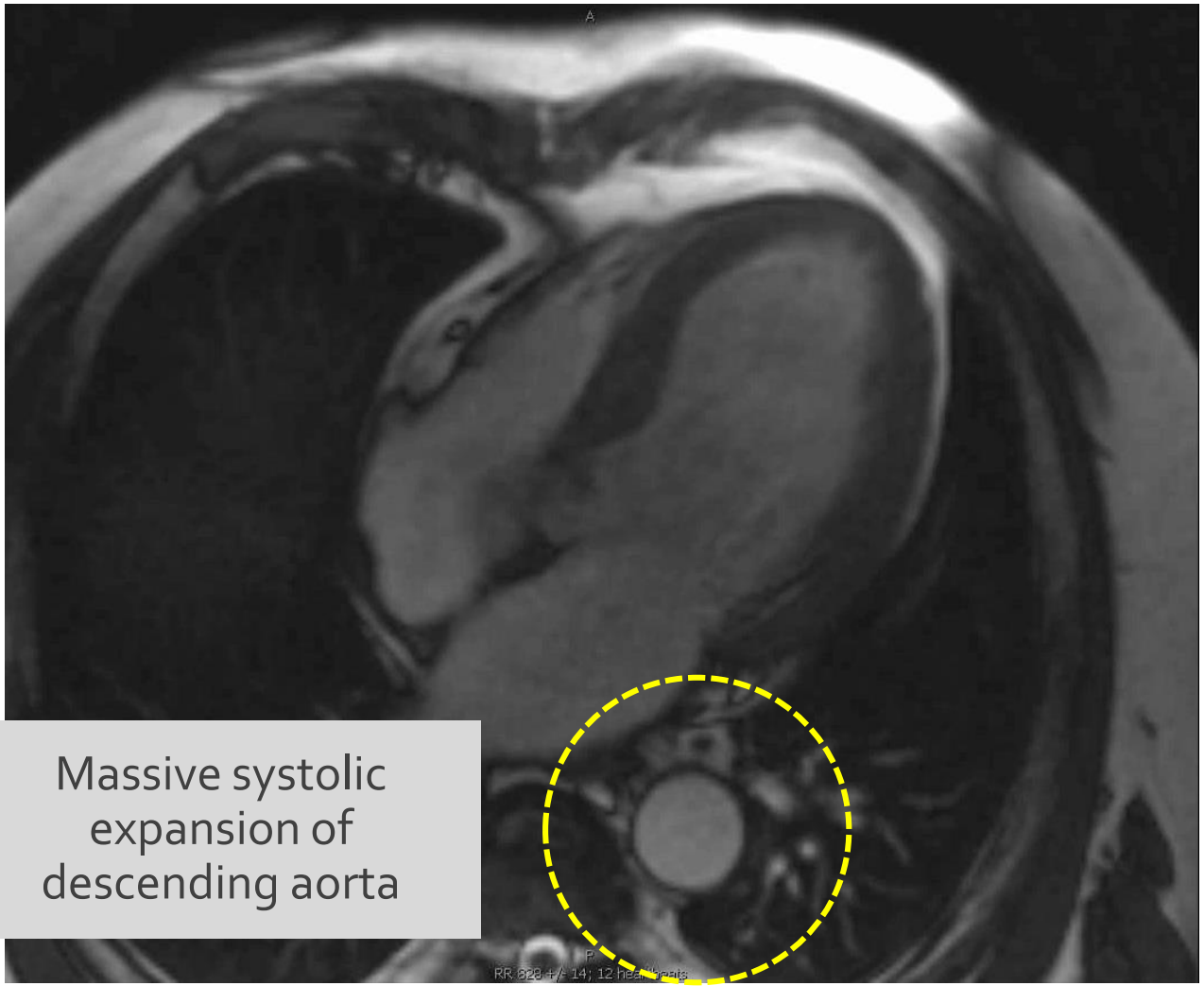
Holodiastolic flow reversal
in descending thoracic aorta

Severe Chronic AR: Abdominal Aorta

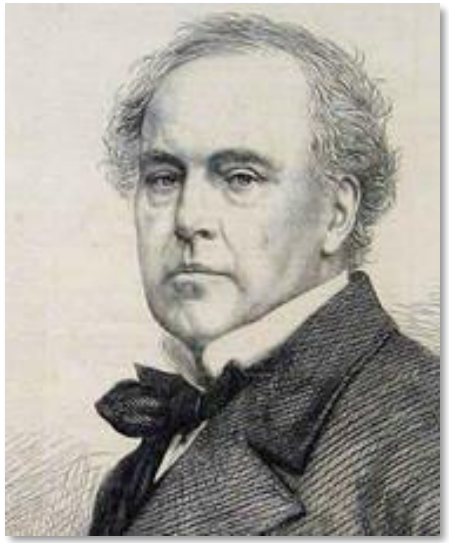


Holodiastolic flow reversal
in abdominal thoracic aorta

MRI: Severe Chronic AR



Massive systolic expansion of descending aorta



Sir Dominic Corrigan
(1802–1880)
Irish Physician

Rapid rise and drop in peripheral pulse in severe chronic AR is known as **Corrigan's** or **water hammer pulse**.

Question

Should she be referred for aortic valve replacement based on imaging findings even in the absence of symptoms?

Valvular Disease Guideline

ASE GUIDELINES AND STANDARDS

Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation

A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance

William A. Zoghbi, MD, FASE (Chair), David Adams, RCS, RDCS, FASE, Robert O. Bonow, MD, Maurice Enriquez-Sarano, MD, Elyse Foster, MD, FASE, Paul A. Grayburn, MD, FASE, Rebecca T. Hahn, MD, FASE, Yuchi Han, MD, MMSc,* Judy Hung, MD, FASE, Roberto M. Lang, MD, FASE, Stephen H. Little, MD, FASE, Dipan J. Shah, MD, MMSc,* Stanton Shernan, MD, FASE, Paaladinesh Thavendiranathan, MD, MSc, FASE,* James D. Thomas, MD, FASE, and Neil J. Weissman, MD, FASE, *Houston and Dallas, Texas; Durham, North Carolina; Chicago, Illinois; Rochester, Minnesota; San Francisco, California; New York, New York; Philadelphia, Pennsylvania; Boston, Massachusetts; Toronto, Ontario, Canada; and Washington, DC*

J Am Soc Echocardiogr. **2017** Apr;30(4):303-371

ACC/AHA CLINICAL PRACTICE GUIDELINE

2020 ACC/AHA Guideline for the Management of Patients With Valvular Heart Disease

A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

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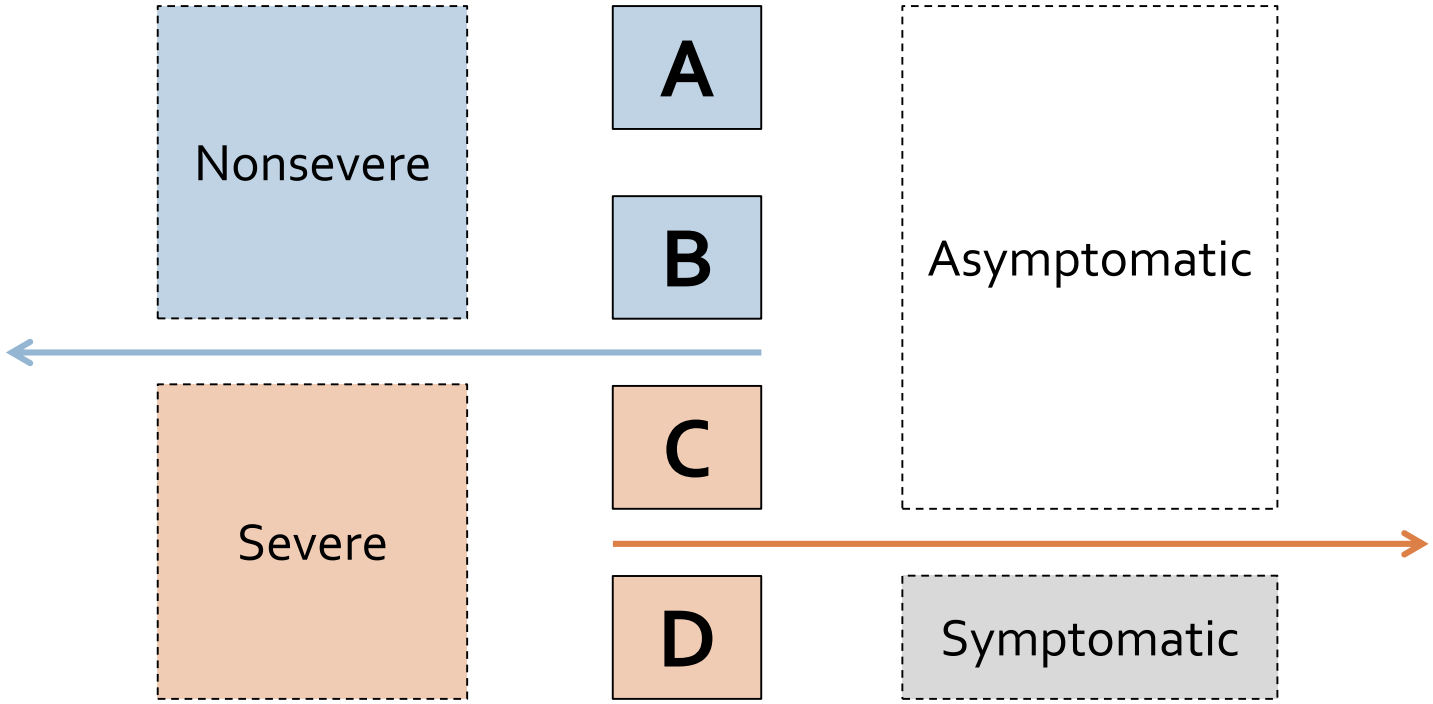
Developed in collaboration with and endorsed by the American Association for Thoracic Surgery, American Society of Echocardiography, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons

ACC/AHA Joint Committee on Clinical Practice Guidelines Members, see page e184

Circulation. **2021**;143:e72–e227

Stages of Valvular Heart Disease

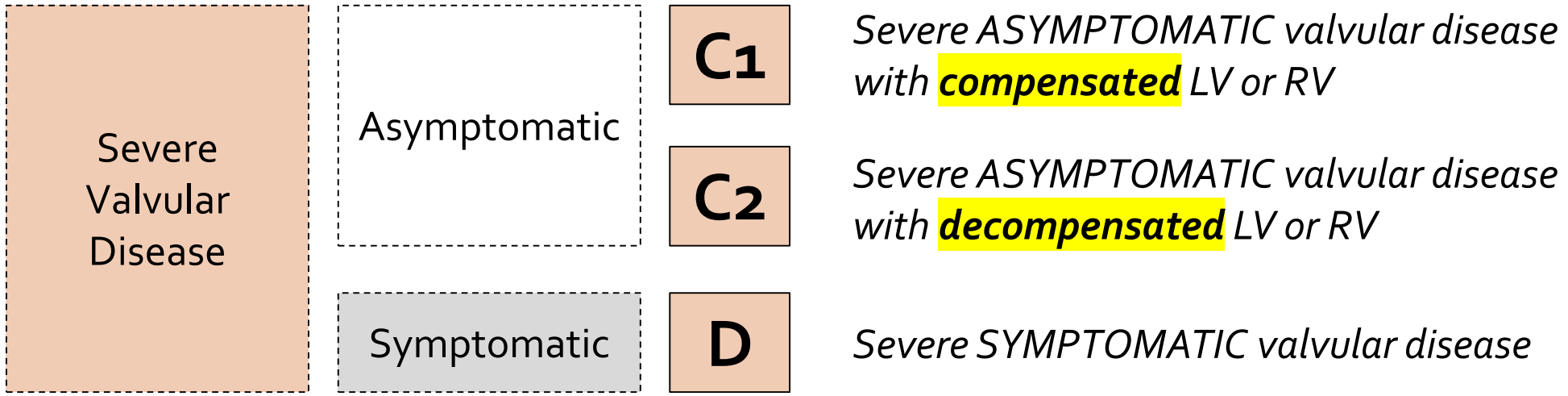
2014 ACC/AHA Valvular Guidelines



Valvular disease is typically NOT symptomatic unless SEVERE!

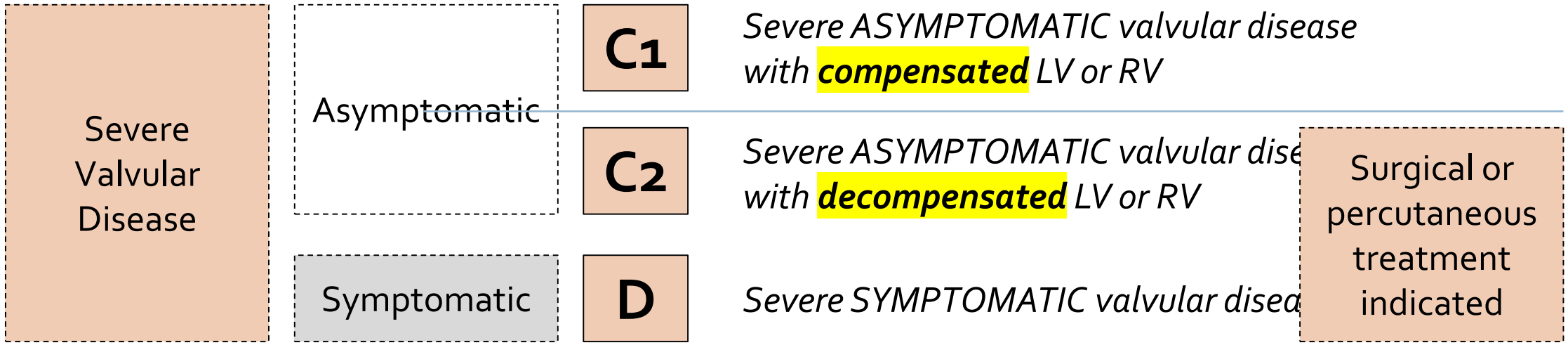
Stages of Valvular Heart Disease

2014 ACC/AHA Valvular Guidelines



Stages of Valvular Heart Disease

2014 ACC/AHA Valvular Guidelines



Chronic Aortic Regurgitation

C	Asymptomatic severe AR	Calcific aortic valve disease Bicuspid valve (or other congenital abnormality) Dilated aortic sinuses or ascending aorta Rheumatic valve changes IE with abnormal leaflet closure or perforation	Severe AR: Jet width ≥65% of LVOT Vena contracta >0.6 cm Holodiastolic flow reversal in the proximal abdominal aorta Regurgitant volume ≥60 mL/beat Regurgitant fraction ≥50% ERO ≥0.3 cm^2 Angiography grade 3 to 4 In addition, diagnosis of chroni severe AR requires evidence of LV dilation	C1: Normal LVEF (>55%) and mild to moderate LV dilation (LVESD <50 mm) C2: Abnormal LV systolic function with depressed LVEF (≤55%) or severe LV dilation (LVESD >50 mm or indexed LVESD >25 mm/m^2)	None; exercise testing is reasonable to confirm symptom status
D	Symptomatic severe AR	Calcific valve disease Bicuspid valve (or other congenital abnormality) Dilated aortic sinuses or ascending aorta Rheumatic valve changes Previous IE with abnormal leaflet closure or perforation	Severe AR: Doppler jet width ≥65% of LVOT Vena contracta >0.6 cm Holodiastolic flow reversal in the proximal abdominal aorta Regurgitant volume ≥60 mL/beat Regurgitant fraction ≥50% ERO ≥0.3 cm^2 Angiography grade 3 to 4 In addition, diagnosis of chronic severe AR requires evidence of LV dilation	occur with normal systolic function (LVEF >55%), mild to moderate LV dysfunction (LVEF 40% to 55%), or severe LV dysfunction (LVEF <40%) Moderate to severe LV dilation is present	Exertional dyspnea or angina or more severe HF symptoms

55/50 RULE
EF ≤ 55%
LVESD ≥ 50 mm
(≥ 25 mm/m^2)

Chronic Mitral Regurgitation

2020 ACC/AHA Valvular Heart Disease

		MR Etiology	MR Severity	Chamber Dilatation	
C	Asymptomatic severe MR	Severe mitral valve prolapse with loss of coaptation or flail leaflet Rheumatic valve changes with leaflet restriction and loss of central coaptation Prior IE Thickening of leaflets with radiation heart disease	Central jet MR >40% LA or holosystolic eccentric jet MR Vena contracta ≥0.7 cm Regurgitant volume ≥60 mL Regurgitant fraction ≥50% ERO ≥0.40 cm^2 Angiographic grade 3+ to 4+	Moderate or severe LA enlargement LV enlargement Pulmonary hypertension may be present at rest or with exercise C1: LVEF >60% and LVESD <40 mm C2: LVEF ≤60% and/or LVESD ≥40 mm	None
D	Symptomatic severe MR	Severe mitral valve prolapse with loss of coaptation or flail leaflet Rheumatic valve changes with leaflet restriction and loss of central coaptation Prior IE Thickening of leaflets with radiation heart disease	Central jet MR >40% LA or holosystolic eccentric jet MR Vena contracta ≥0.7 cm Regurgitant volume ≥60 mL Regurgitant fraction ≥50% ERO ≥0.40 cm^2 Angiographic grade 3+ to 4+	Moderate or severe LA enlargement LV enlargement Pulmonary hypertension present	Decreased exercise tolerance Exertional dyspnea

60/40 RULE
EF ≤ 60%
LVESD ≥ 40 mm

Stress Testing

Chronic Mitral vs. Aortic Regurgitation

C1: LVEF >60% and LVESD <40 mm C2: LVEF ≤60% and/or LVESD ≥40 mm	**EF/ESD Rule** **60/40 Rule** EF ≤ 60% LVESD ≥ 40 mm	**MITRAL REGURGITATION**
C1: Normal LVEF (>55%) and mild to moderate LV dilation (LVESD <50 mm) C2: Abnormal LV systolic function with depressed LVEF (≤55%) or severe LV dilation (LVESD >50 mm or indexed LVESD >25 mm/m²)	**EF/ESD Rule** **55/50 Rule** EF ≤ 55% LVESD ≥ 50 mm (LVESDi > 25 mm/m²)	**AORTIC REGURGITATION**

Answer

She should be referred for aortic valve replacement even in the absence of symptoms (ACC/AHA Stage C2)

	Guidelines Cutoffs	Patient Values	
LVEF	≤ 55%	45 - 54%	✓
LV End-diastolic Diameter	> 50 mm	48 mm	
Indexed LVED Diameter	> 25 mm/m^2	27 mm/m^2	✓

Answer

She should be referred for aortic valve replacement even in the absence of symptoms (ACC/AHA Stage C2)

Carpentier-Edwards PERIMOUNT Magna Ease Aortic Valve

Built upon the Carpentier-Edwards PERIMOUNT bioprosthesis design.

Thank You

New York University Langone Medical Center

Short Biography

Muhamed Sarić
MD, PhD, MPA

- Born in Sarajevo, Bosnia-Herzegovina
- Director of Noninvasive Cardiology and Professor of Medicine at NYU
- Primary interest is the use of 3D echocardiography in guiding percutaneous repairs of structural heart disease. At NYU my colleagues and I performed the first transseptal transcatheter mitral valve replacement in the world on June 15, 2016 using Caisson valve system.
- First to describe the tilt-up-then-left or TUPLE maneuver, which improves the diagnosis of atrial septal defects (ASDs), and facilitates its repair.
- Published numerous articles and book chapters in the field of cardiology, biochemistry and history of medicine.
- Chairman of the American Society of Echocardiography (ASE) guidelines committee for the use of echocardiography in the evaluation of a cardiac source of embolism
- Recipient of multiple teaching awards including the 2017 Richard Popp Excellence in Teaching Award from the American Society of Echocardiography