Case Studies: Common Tricuspid Valve Lesions

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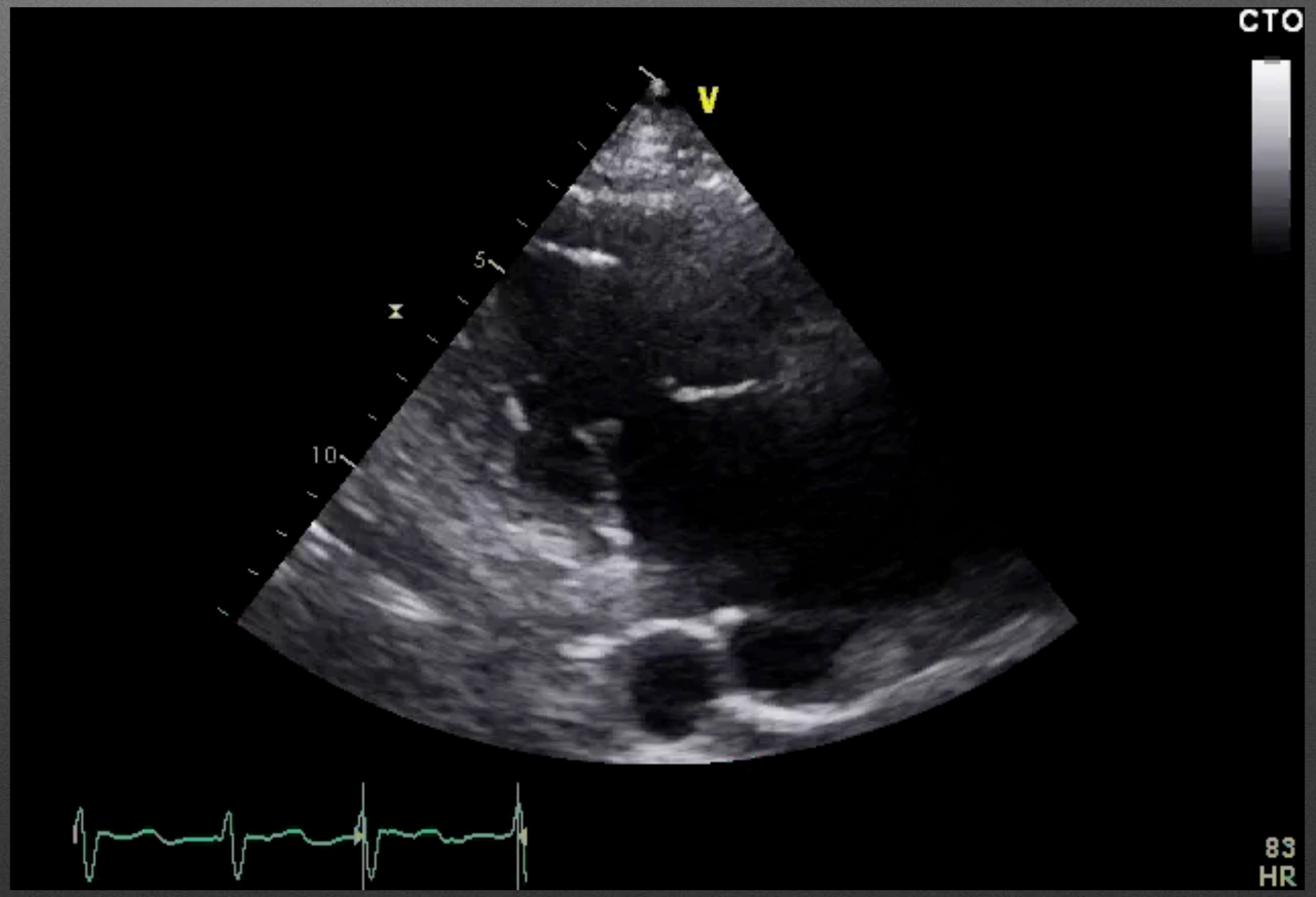
No Disclosures

State-of-the-Art Echocardiography
2018 San Diego, California

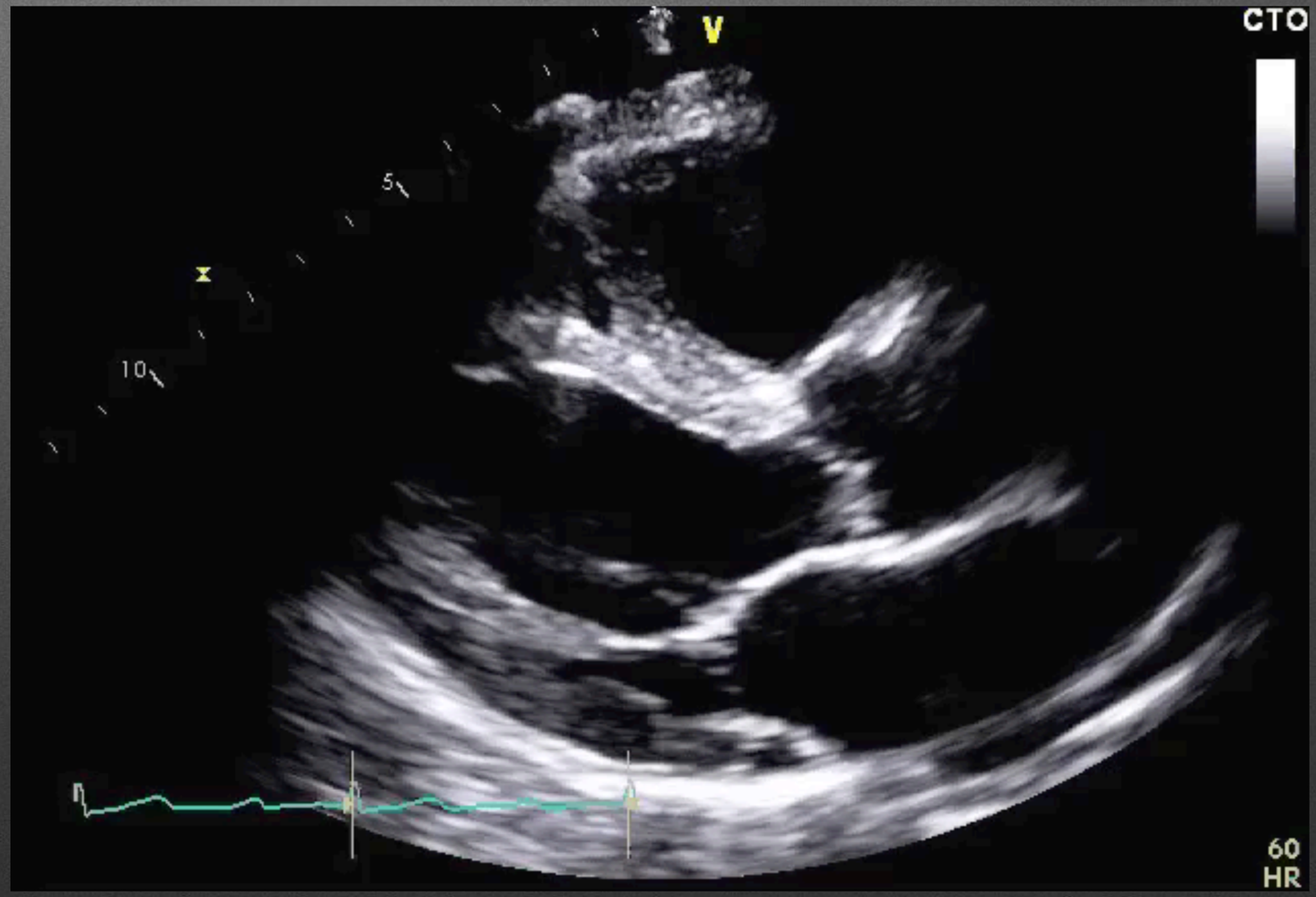
Echo Benefits

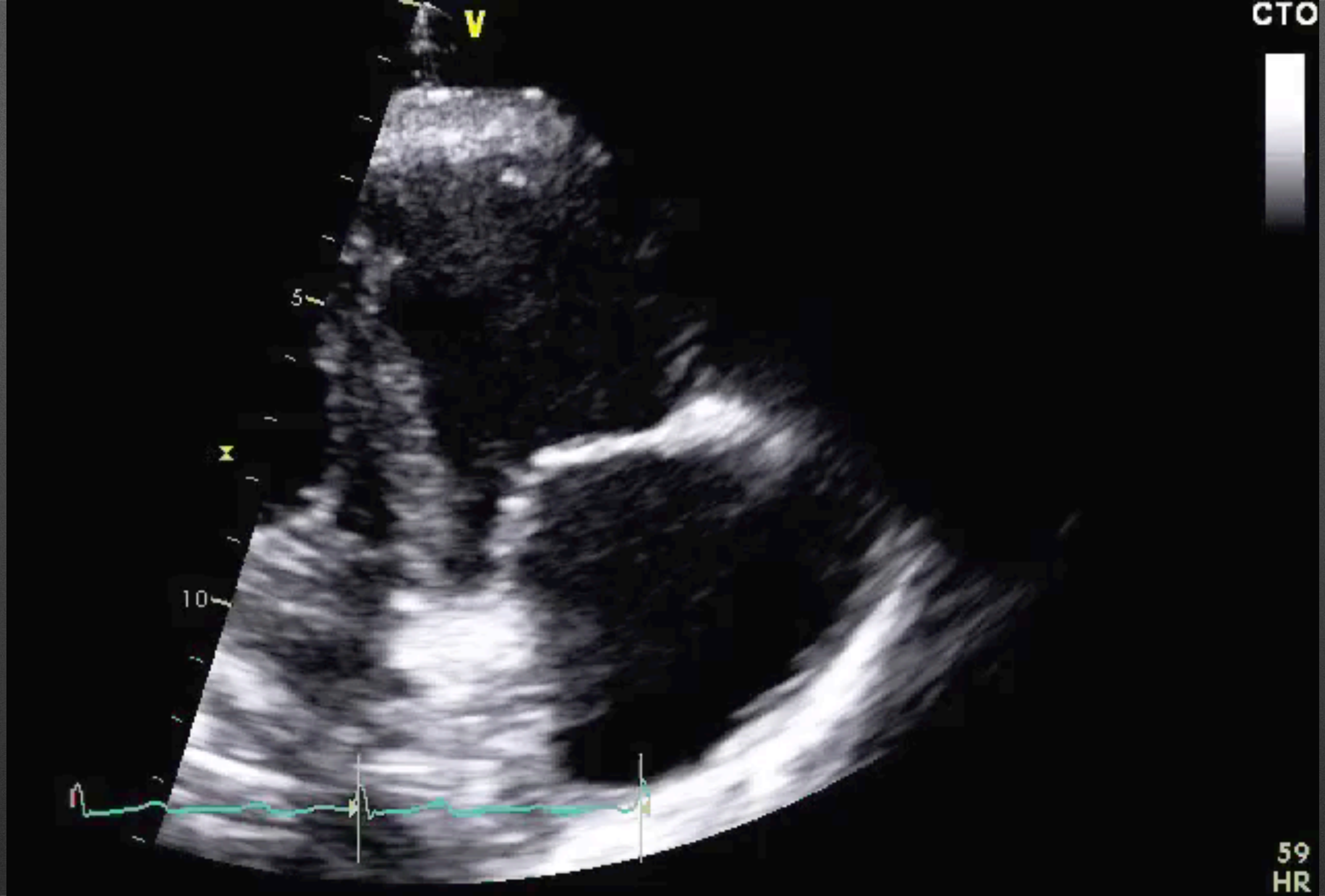
- Right Heart Evaluation
  - RV Size (SAX-Apical)
  - RA Size
  - RV Function
  - Interatrial Septum
  - TR
  - RVSP/PAEDP

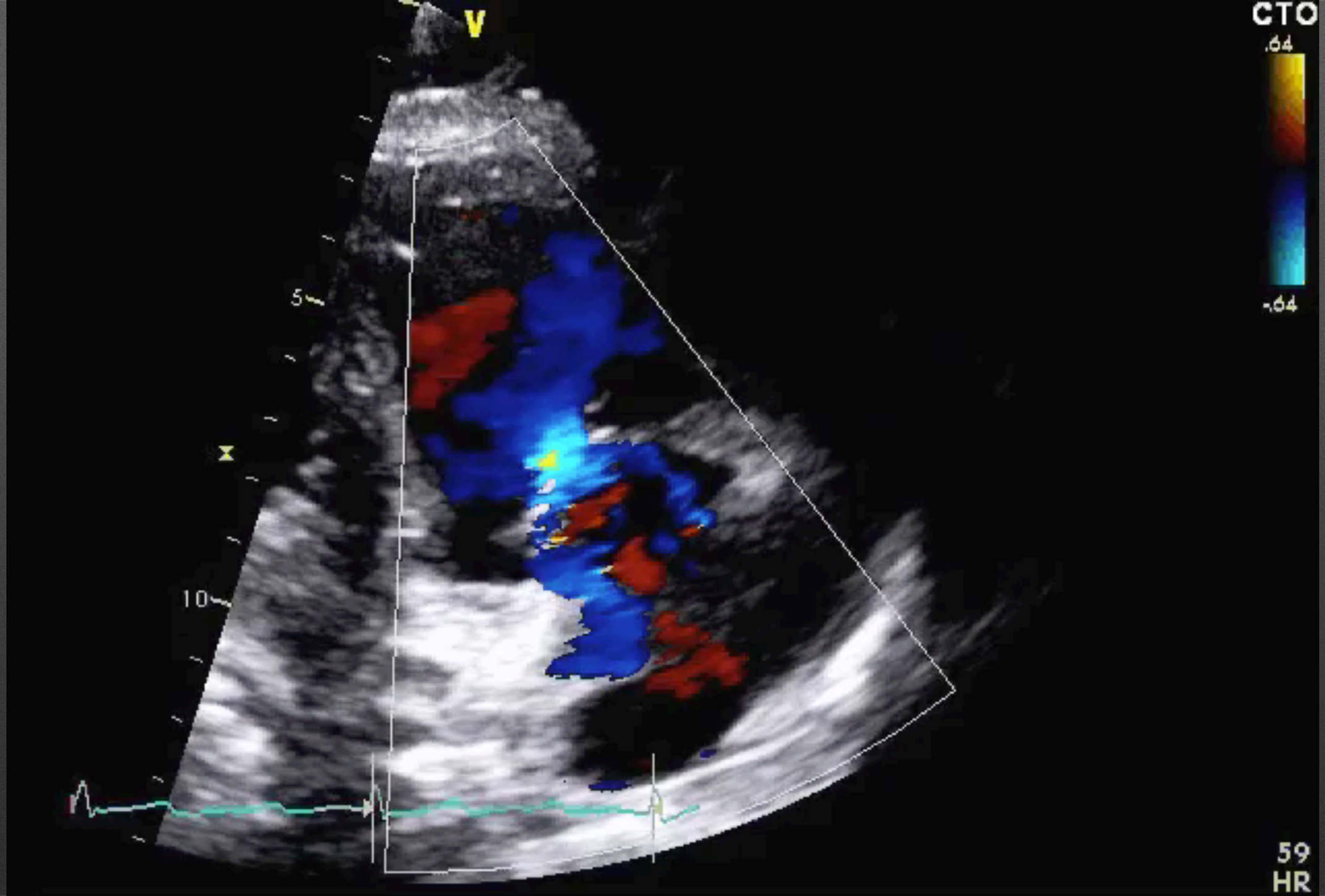


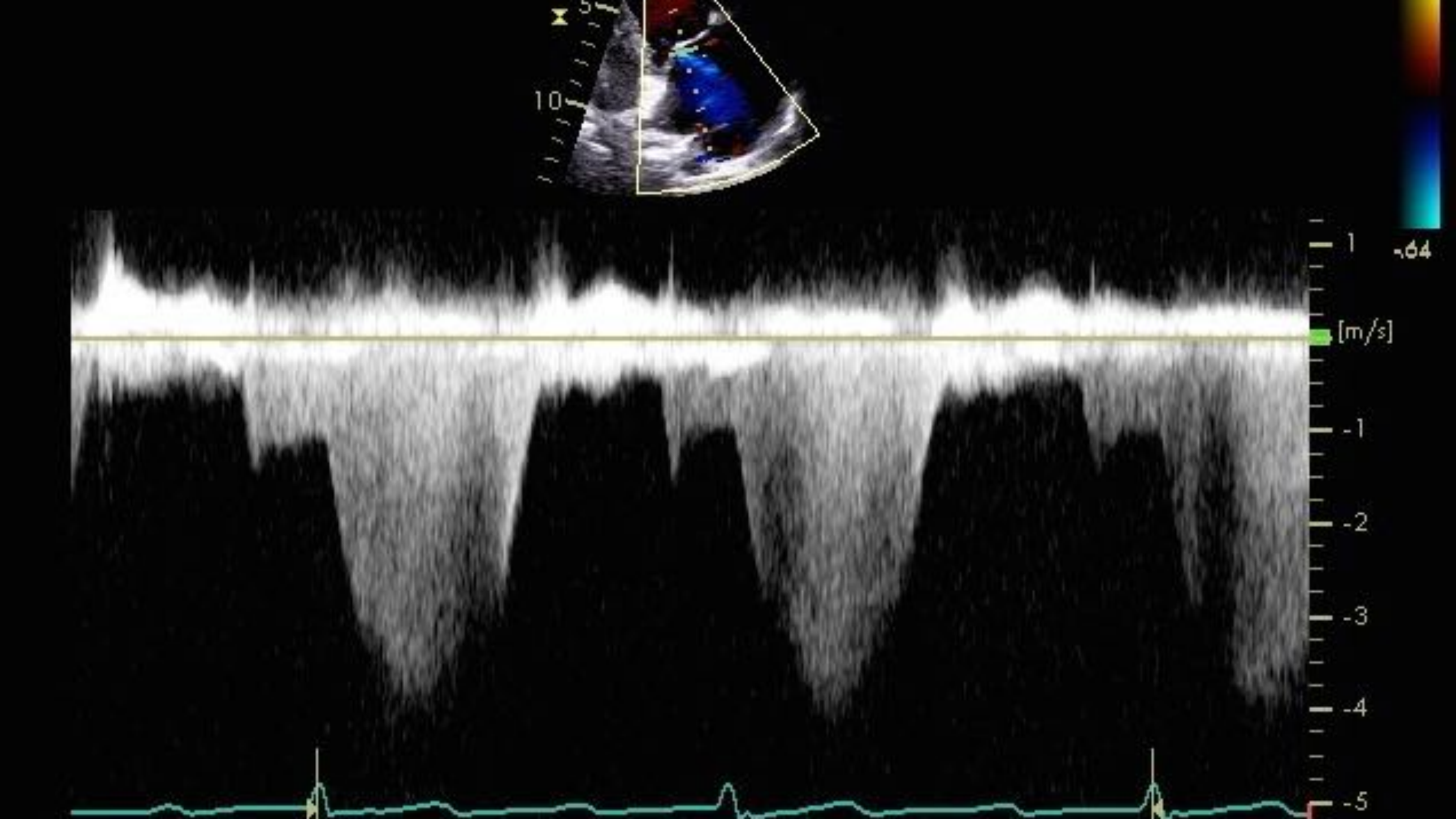
Case 1

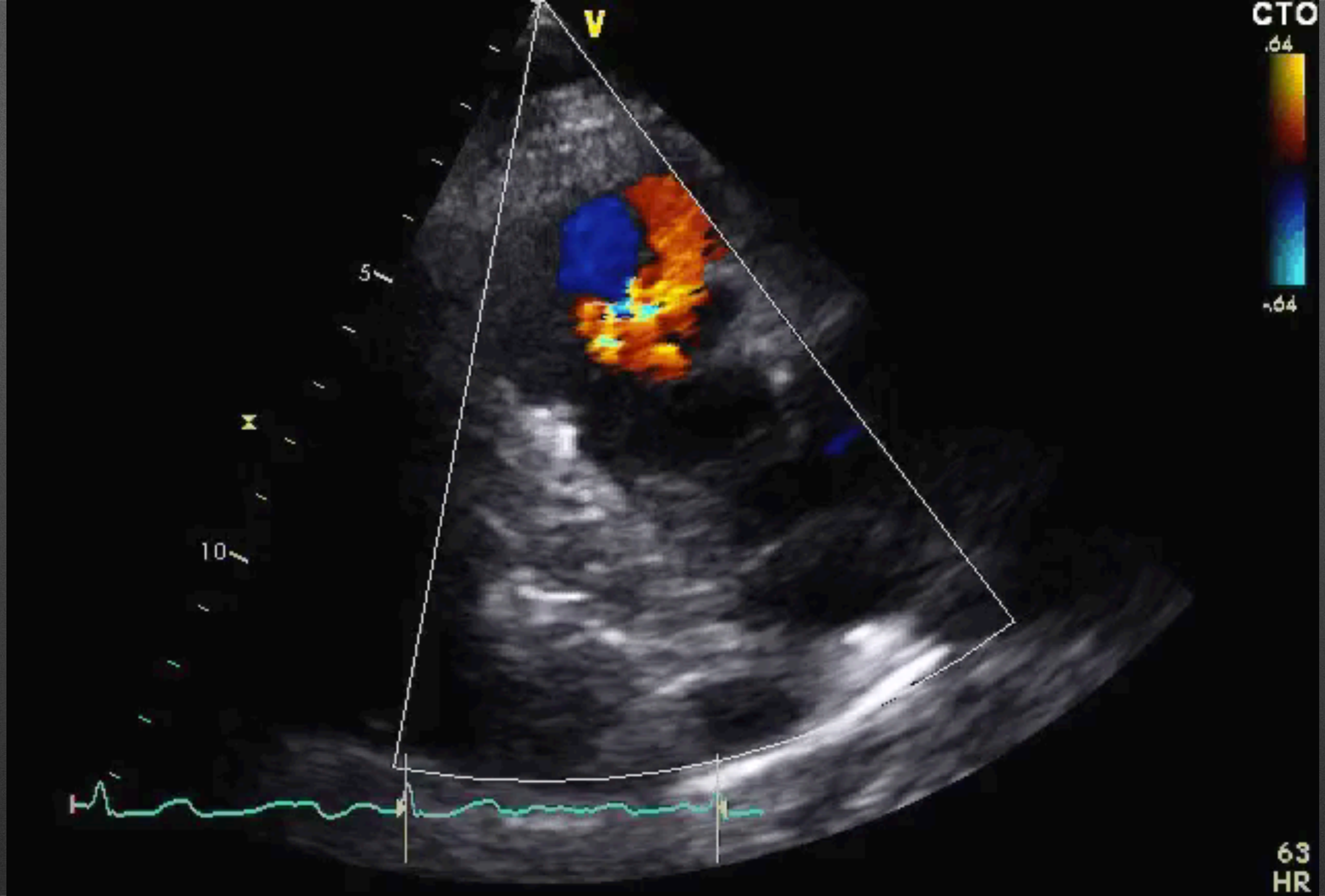
- 48 yr Male
- SOB, Fatigue

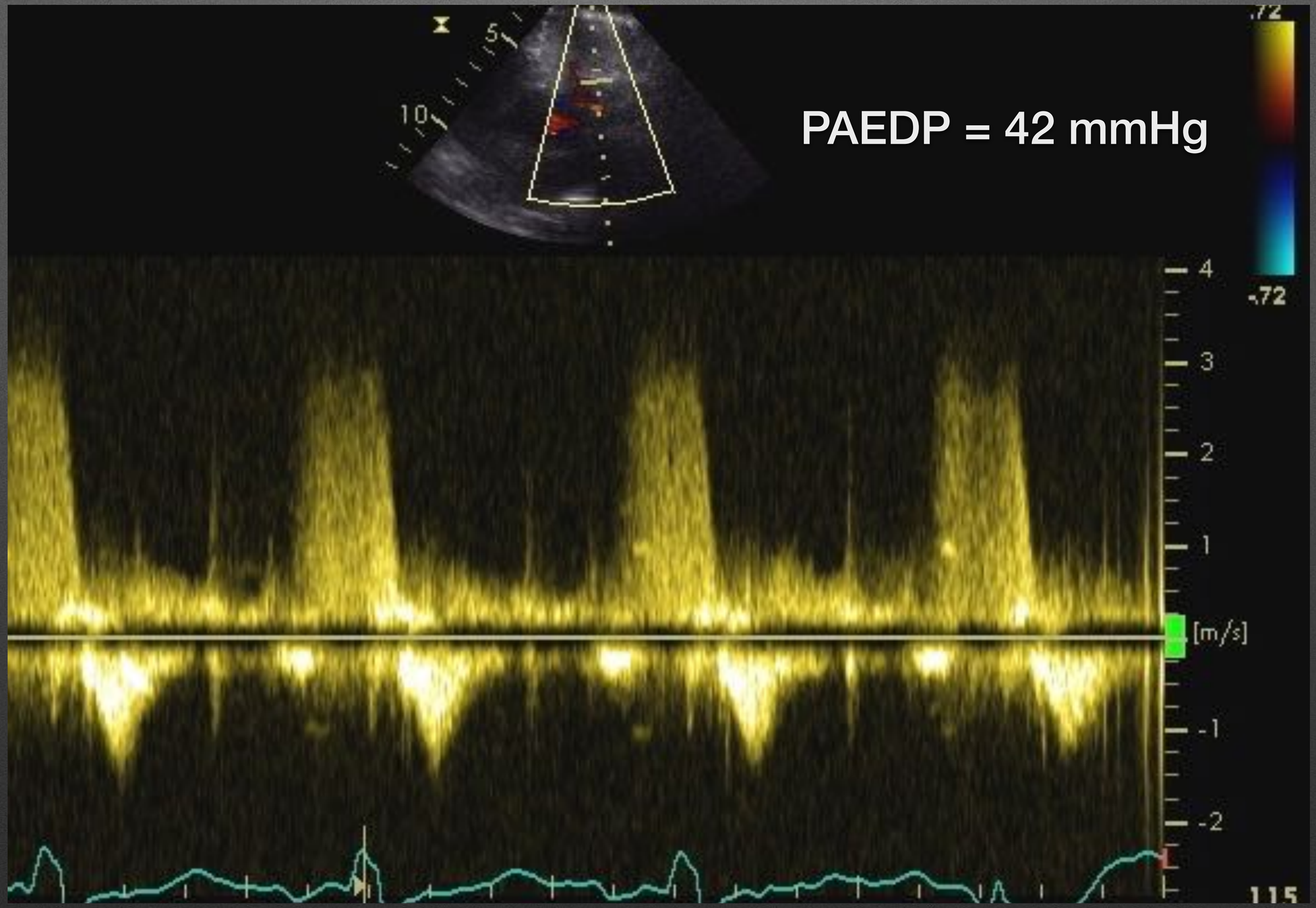


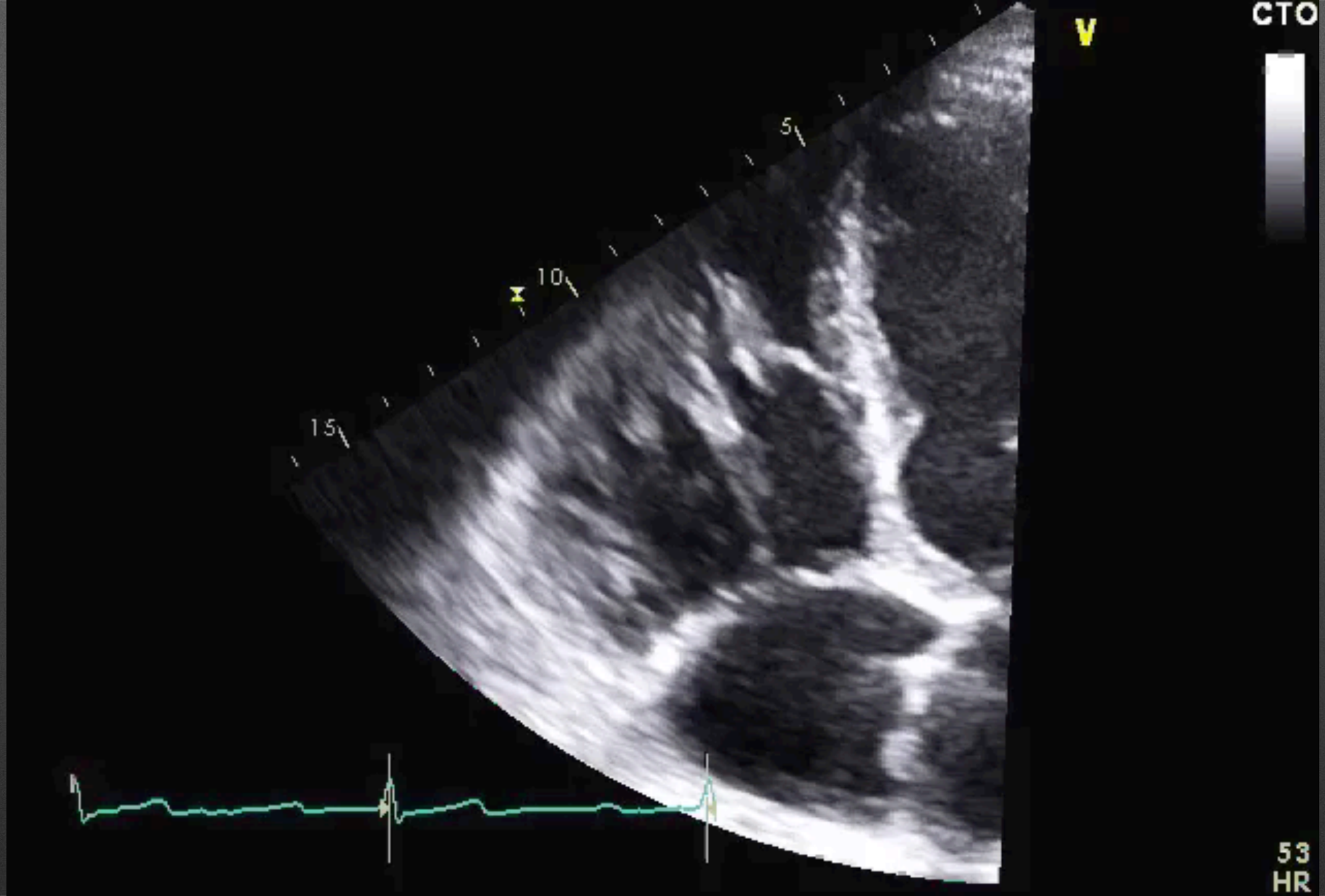

V
5
10
CTO
59
HR

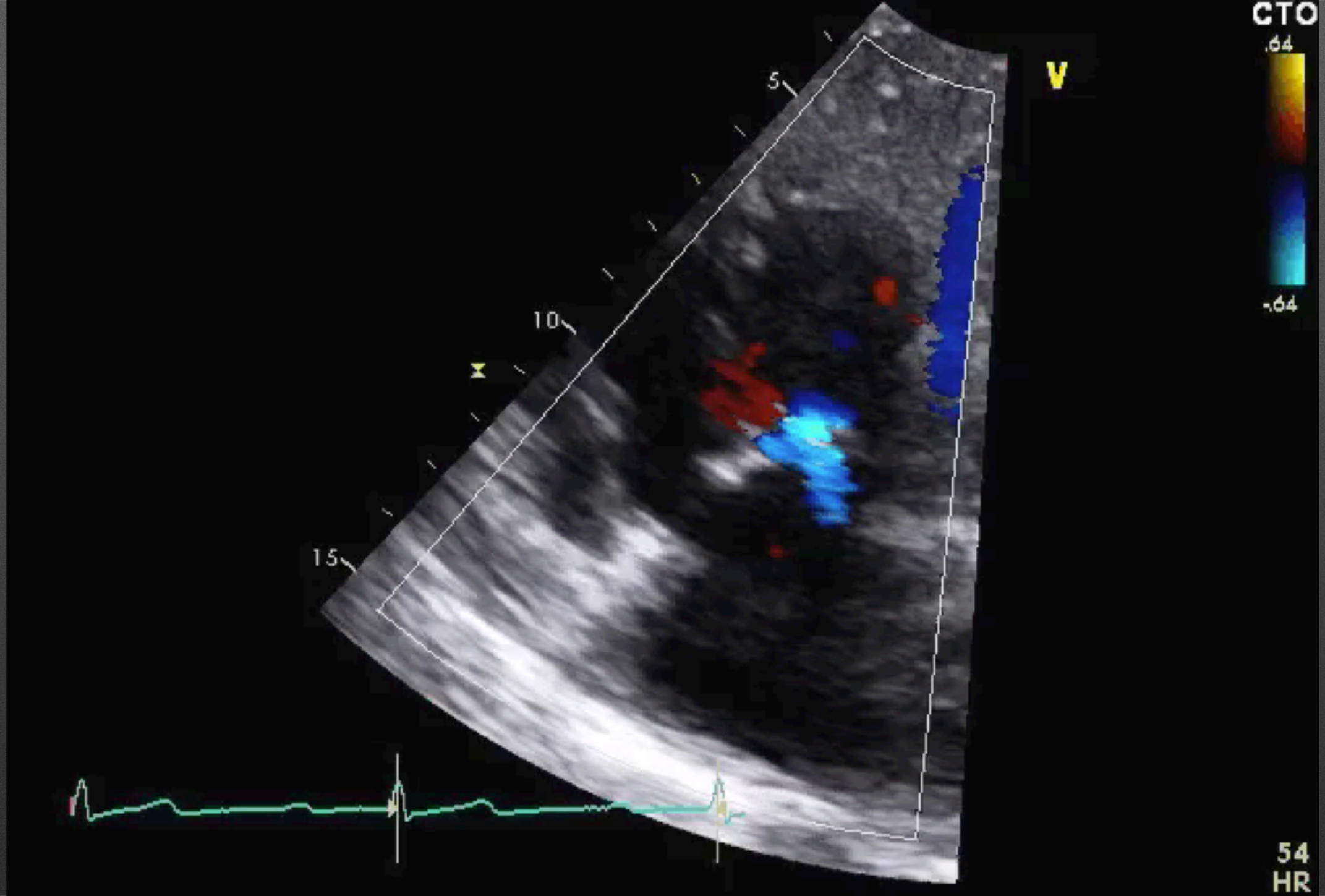

V
5
10
CTO
.64
-.64
59
HR

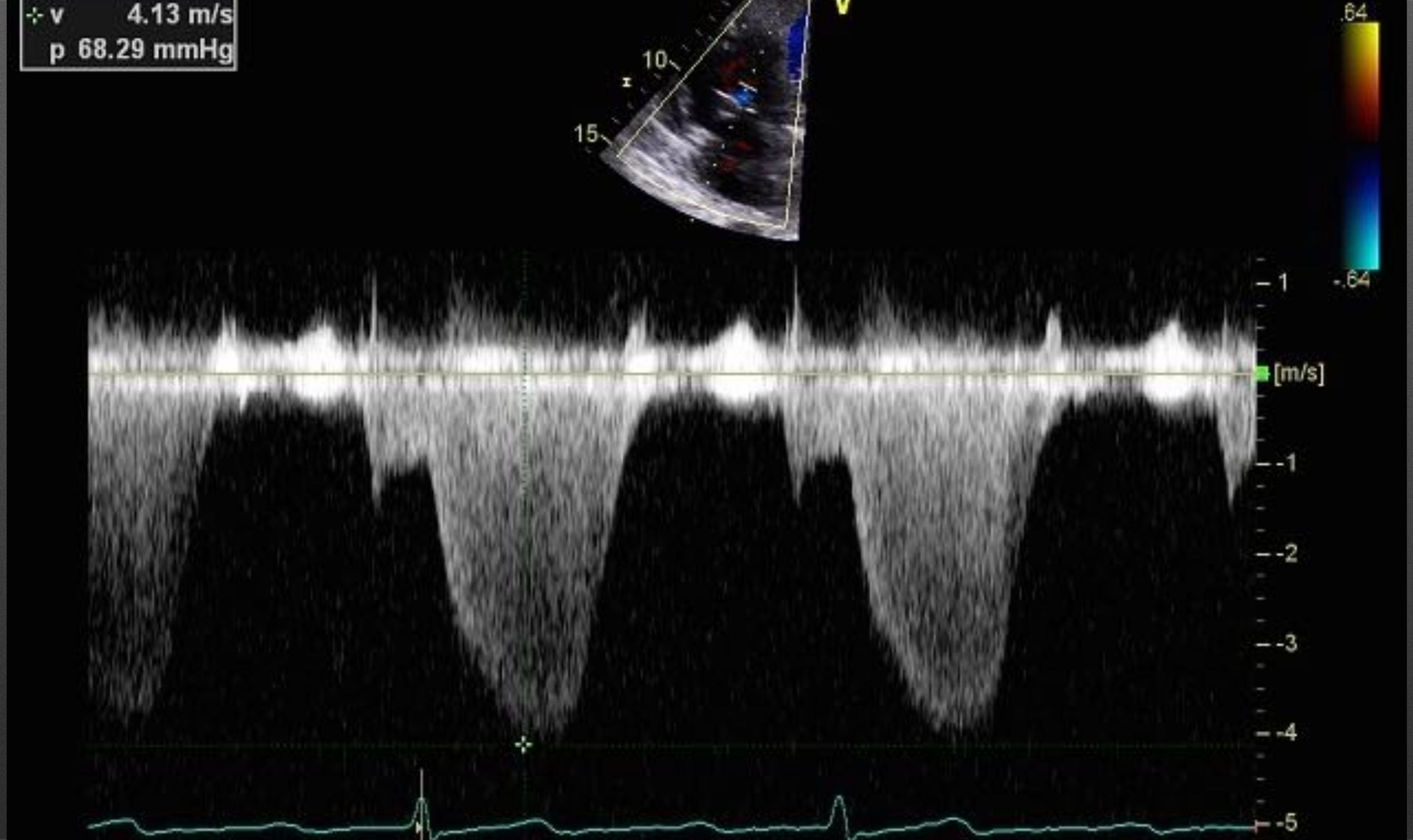

5
10
1
-64
[m/s]
-1
-2
-3
-4
-5

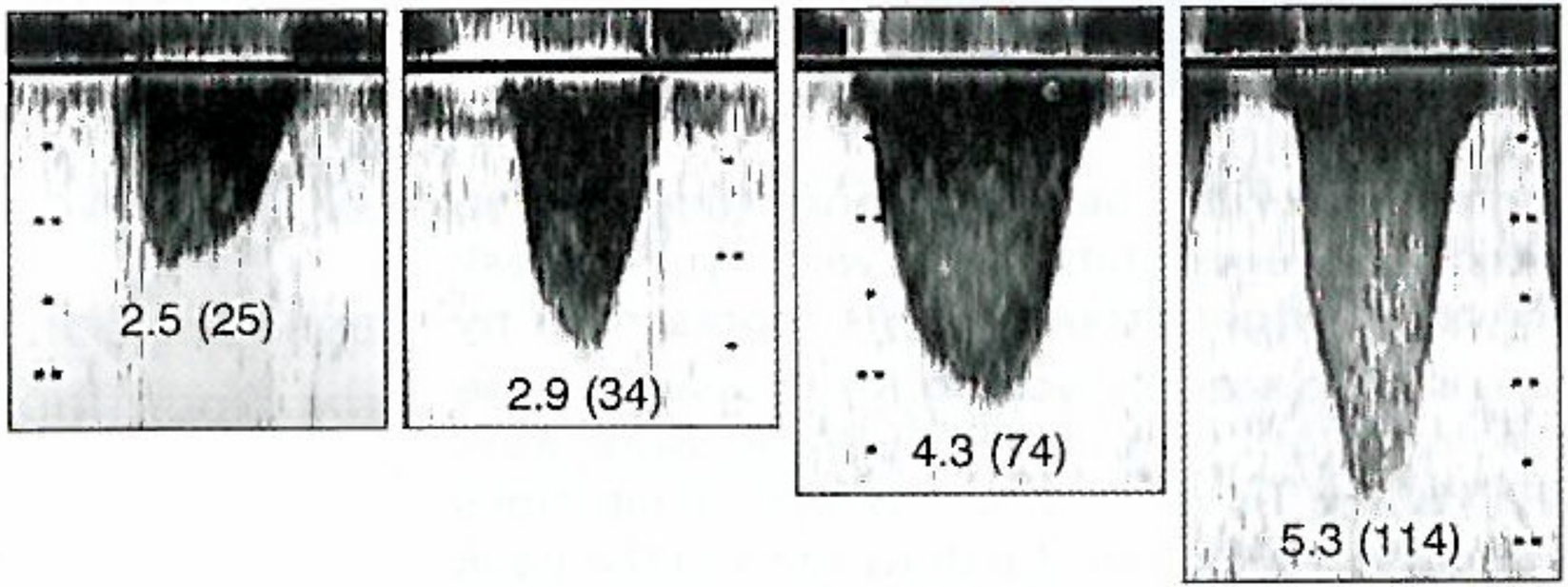

V
5
10
CTO
.64
-.64
63
HR


PAEDP = 42 mmHg
5
10
.72
-.72
4
3
2
1
[m/s]
-1
-2
115


CTO
V
5
10
15
53
HR


CTO
.64
-.64
5
10
15
54
HR


v 4.13 m/s
p 68.29 mmHg
10
15
.64
-.64
1
[m/s]
-1
-2
-3
-4
-5

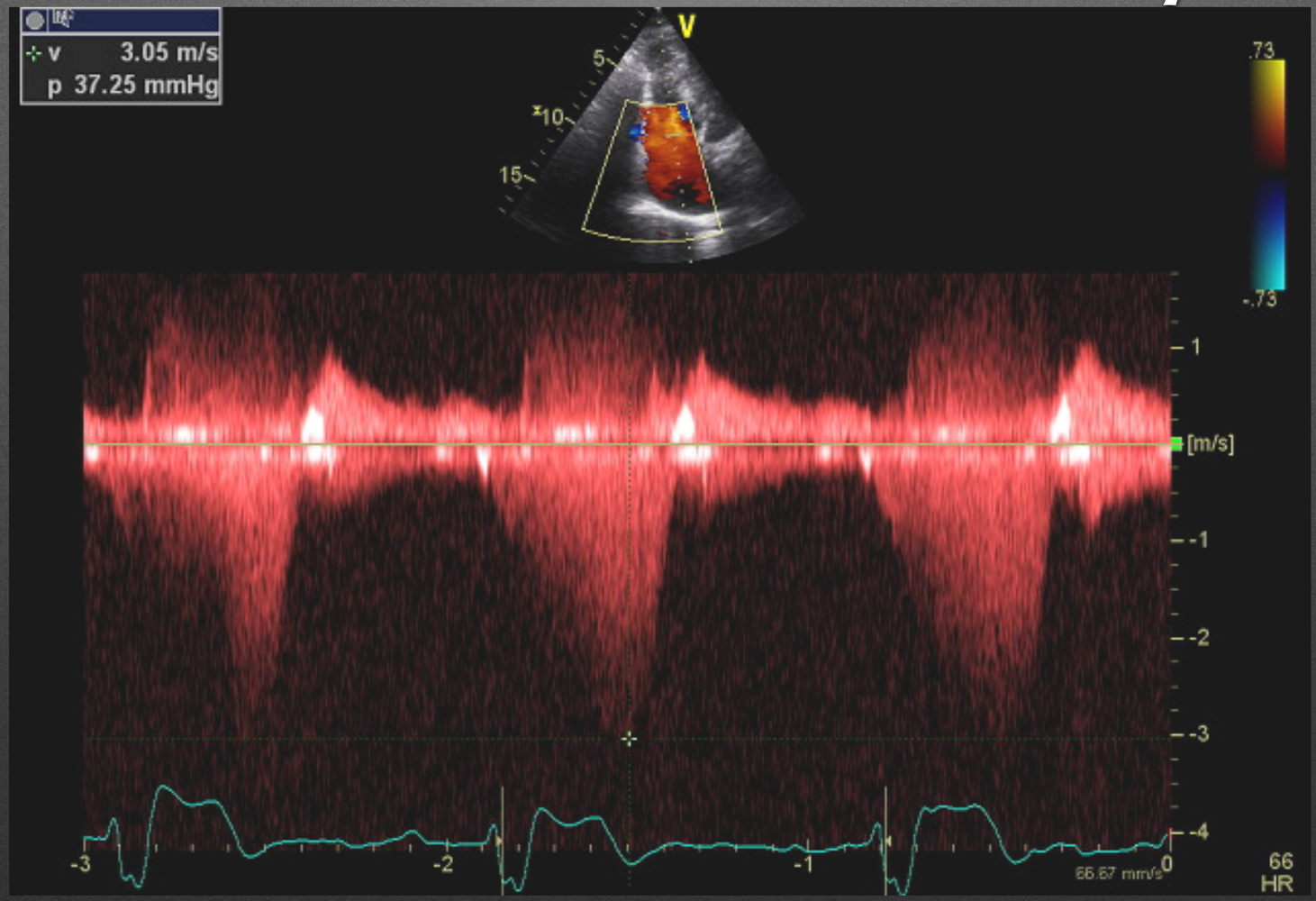


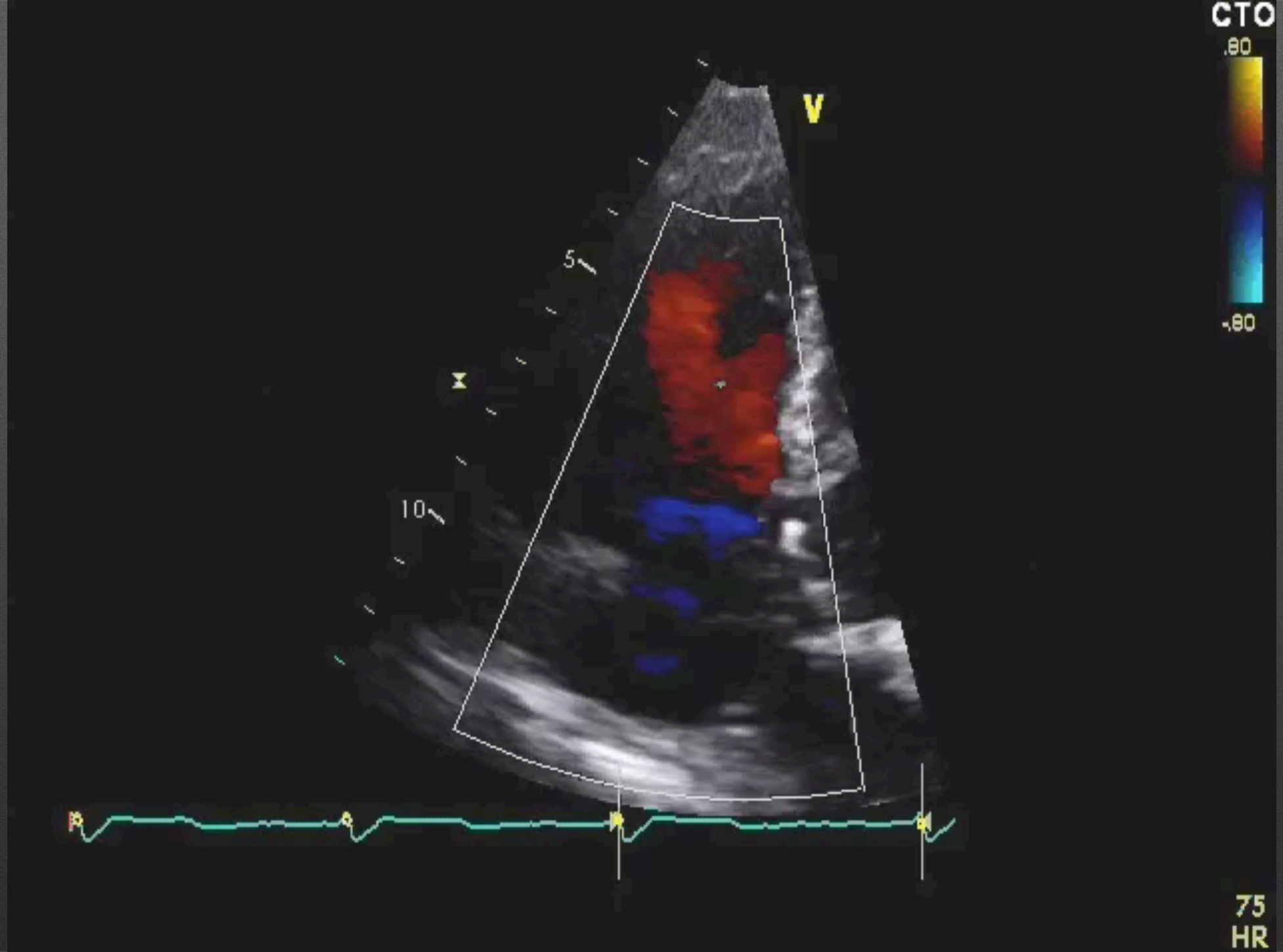
Adapted from: Oh, Tajik, Seward Echo Manual 3rd Edition

- Use multiple windows to obtain maximum TR velocity
- PTF = Parallel to flow!

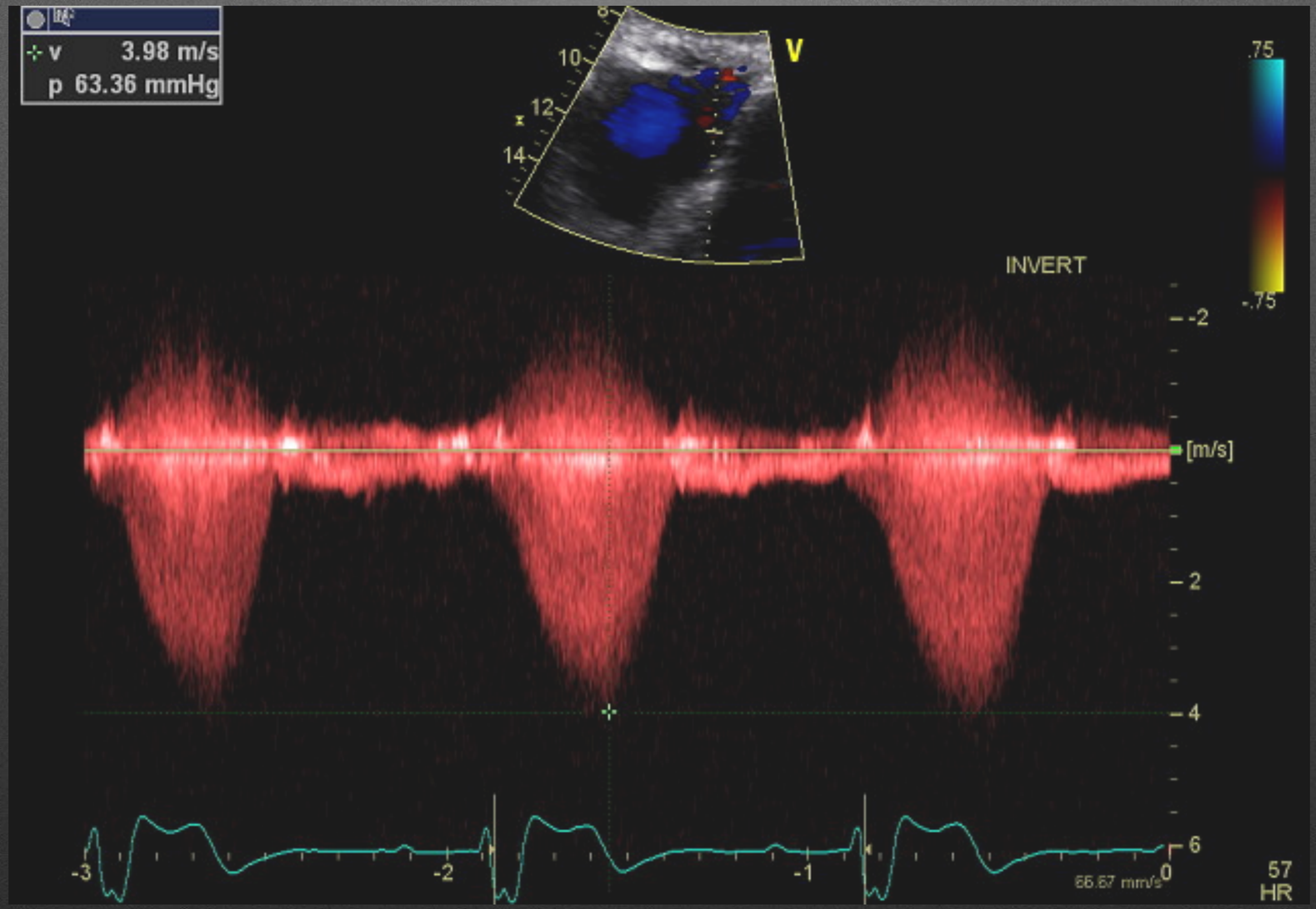
- TR Velocity and TR Volume are not related

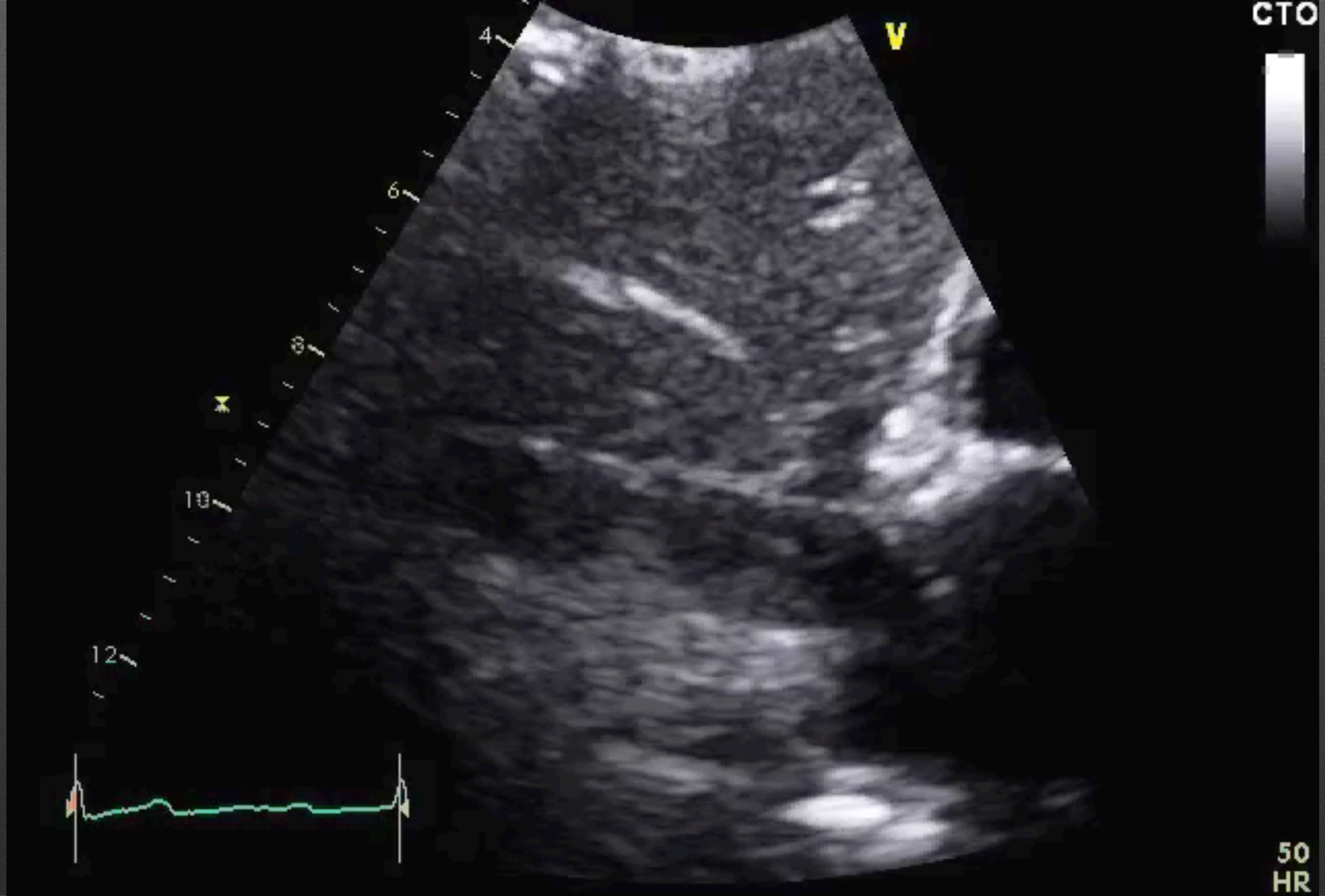
NOT PARALLEL 3.1M/S

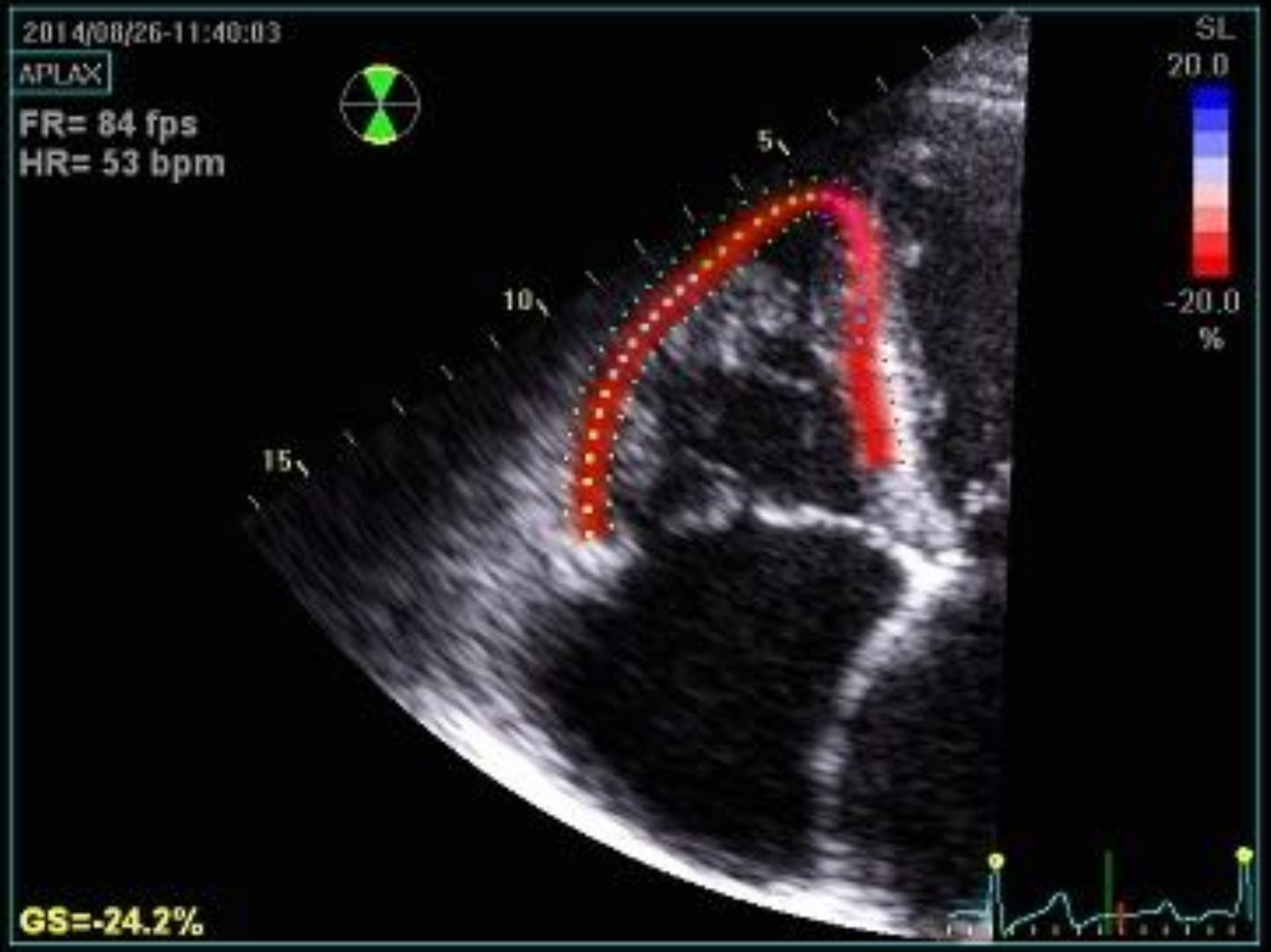



CTO
.80
-.80
V
5
10
75
HR

PARALLEL 4.0 M/S

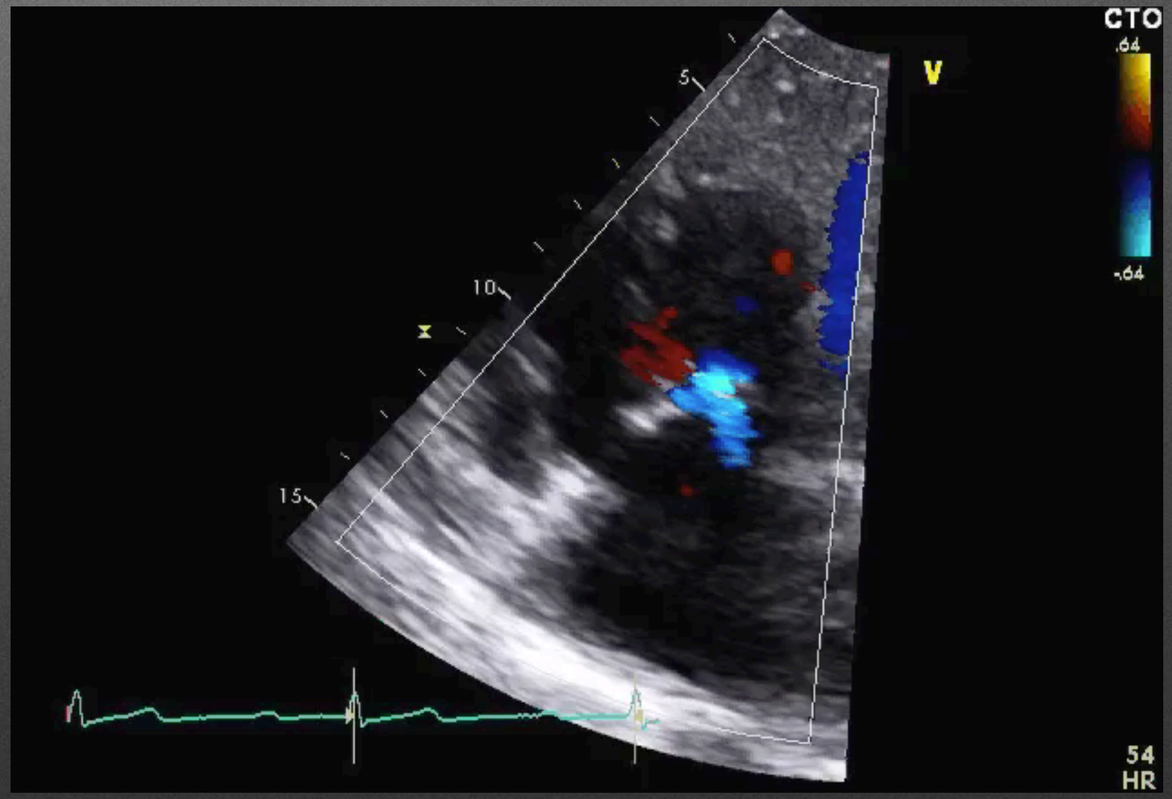



CTO
V
4
6
8
10
12
50
HR


2014/08/26-11:40:03
APLAX
FR= 84 fps
HR= 53 bpm
5
10
15
SL
20.0
-20.0
%
GS=-24.2%

Case #1 Summary

- Mild RVE
- Normal RV Function
- RVSP 76 mmHg
- Mild TR



Tricuspid Regurgitation

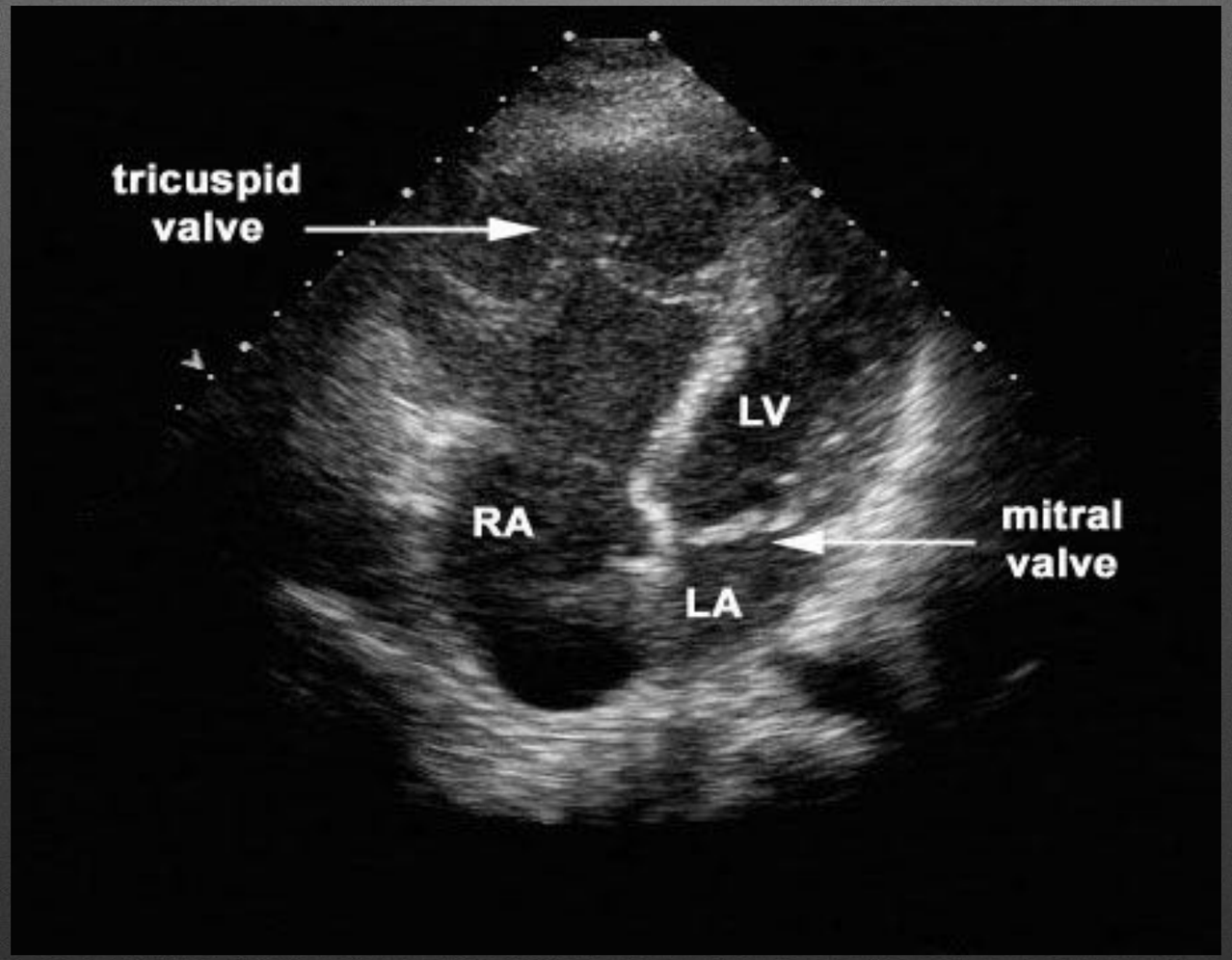
TR Valve Assessment

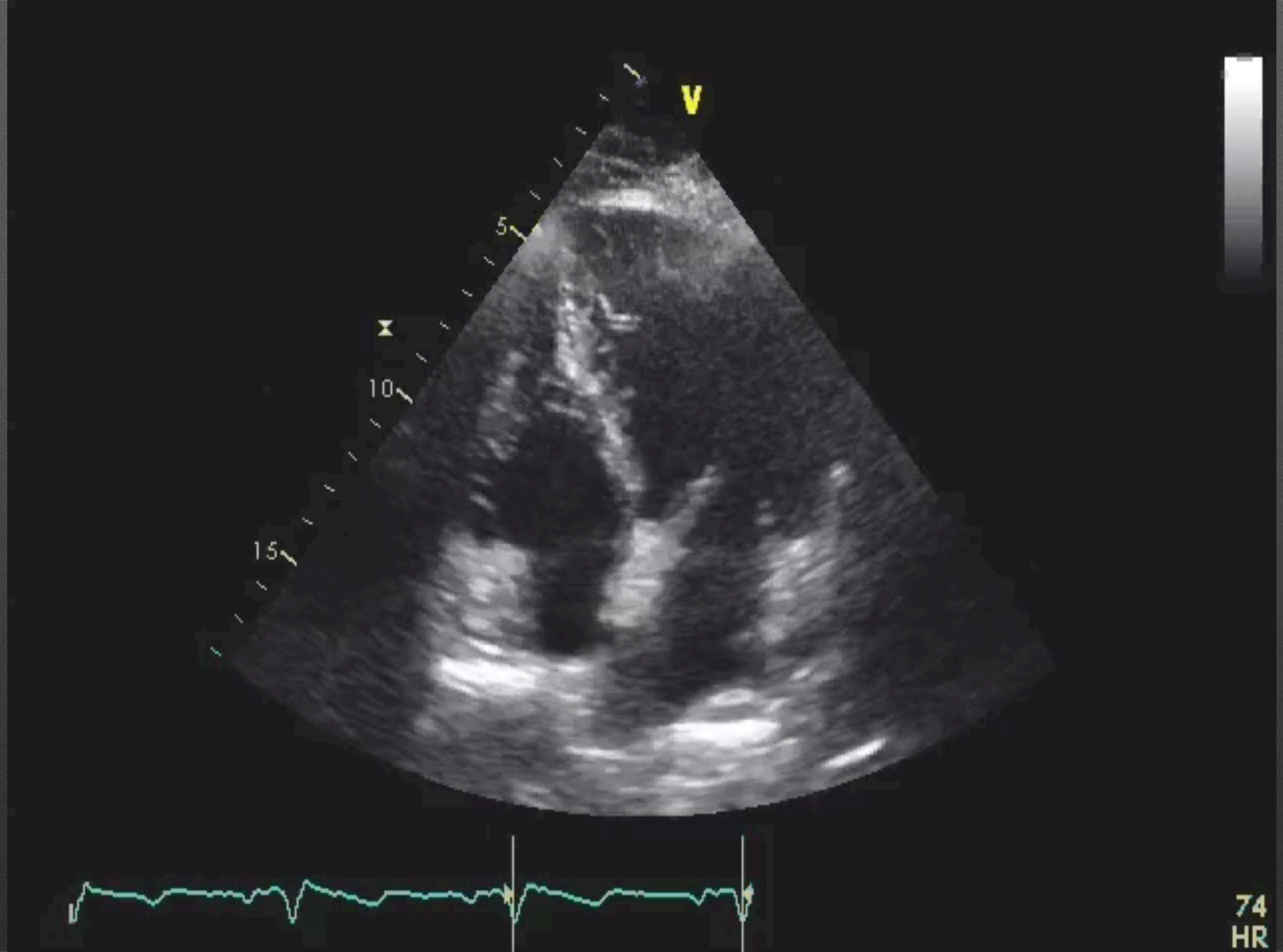
- Measurement of the vena contracta (>7 mm Severe TR)
- Systolic hepatic flow reversals
- PISA TV (angle correction factor)
- Doppler (Shape and Density)
- Color flow jet area

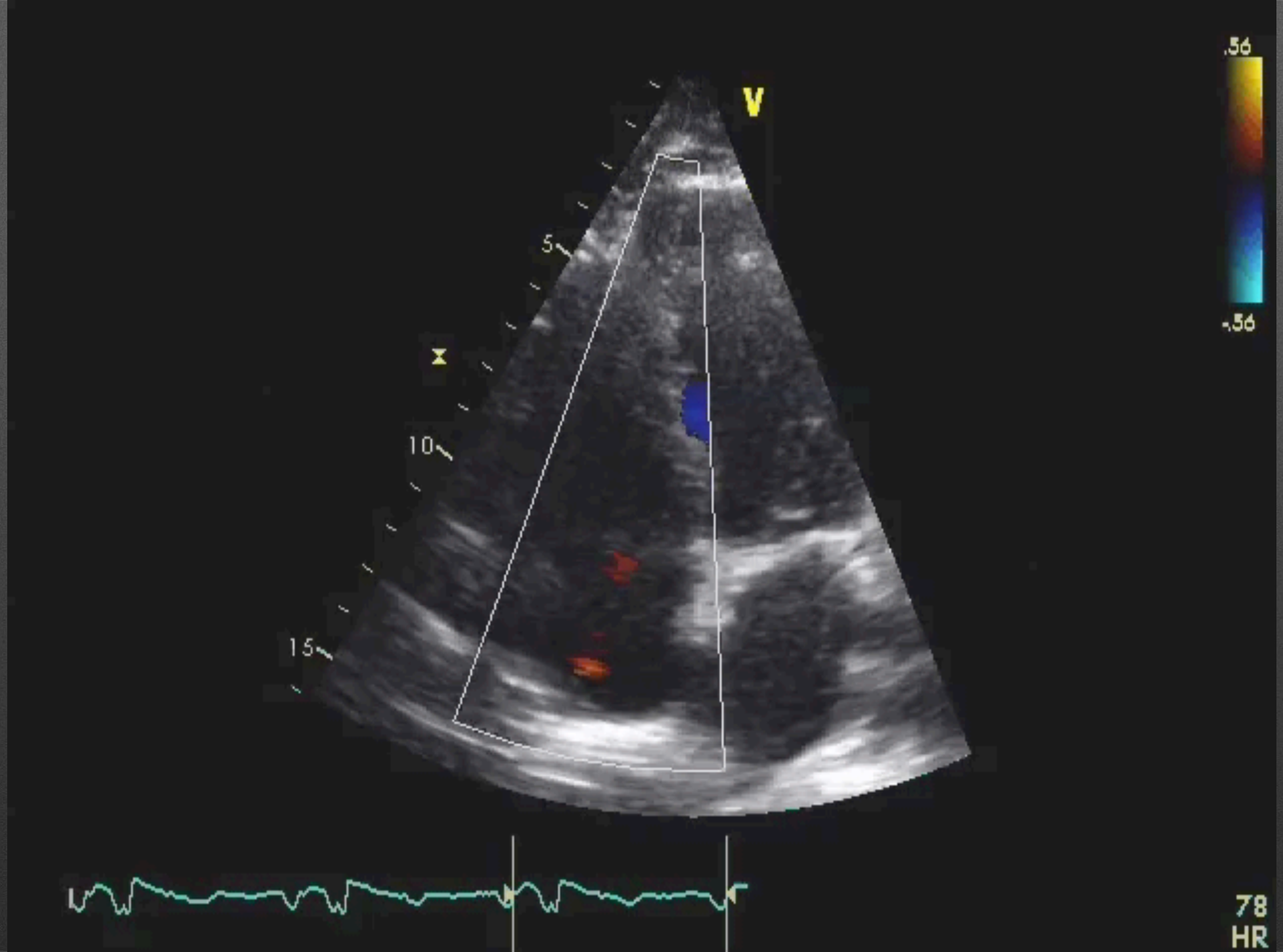
Primary (organic) TR

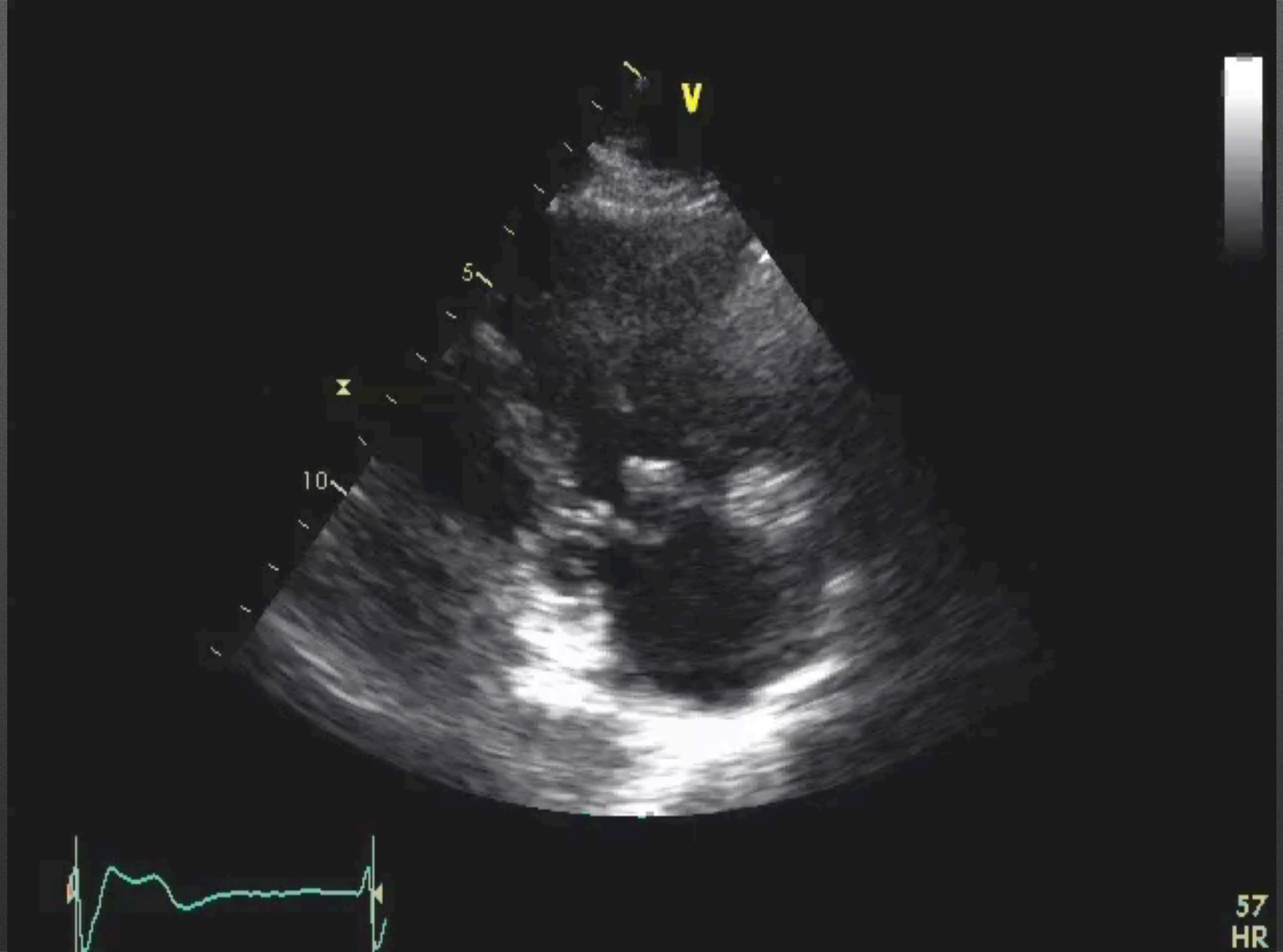
- Pathologic involvement of the leaflets and chordae
  - Rheumatic heart disease
  - Degenerative pathology
  - Congenital
  - Infectious
  - Traumatic
  - Iatrogenic

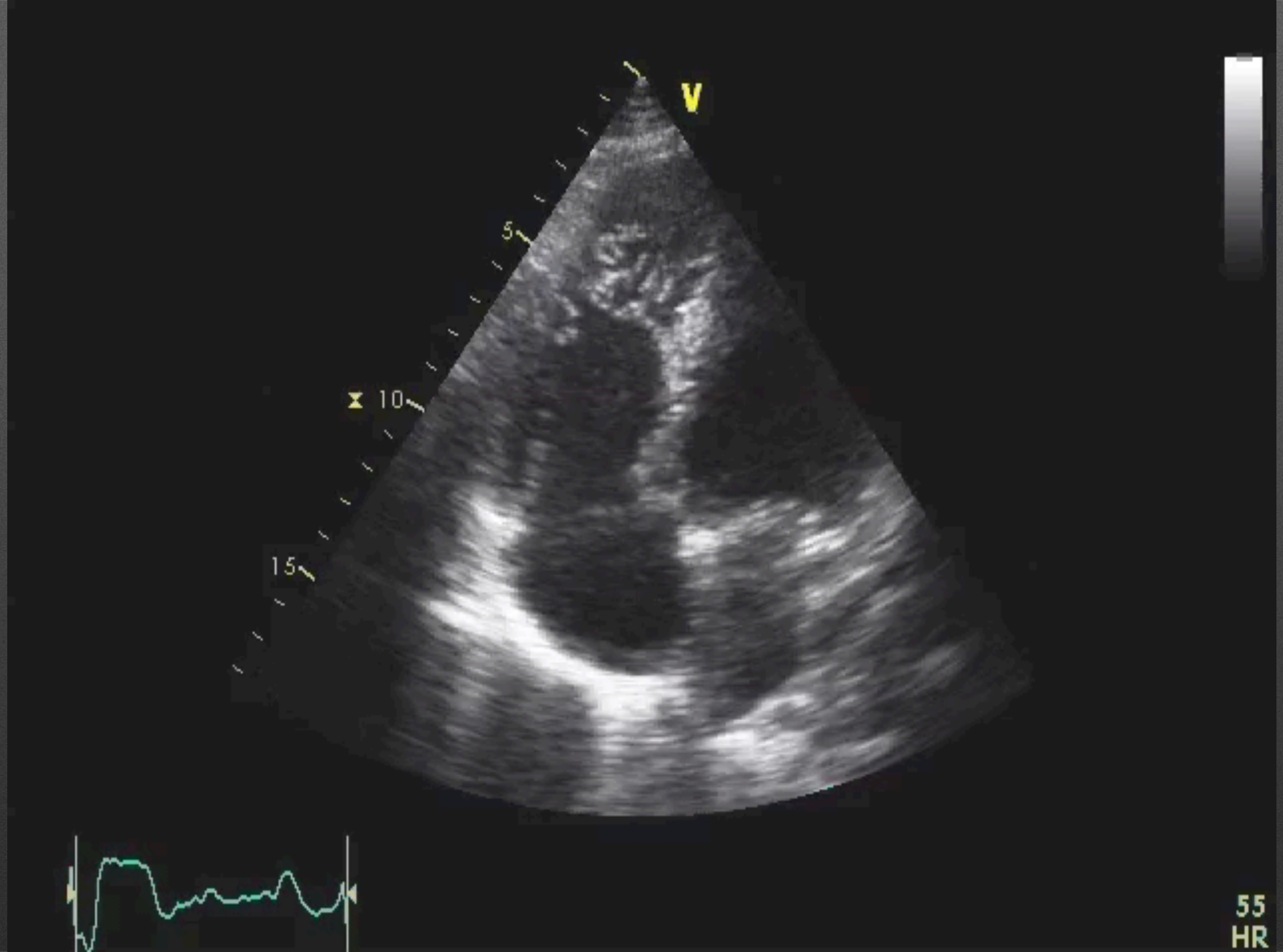
EBSTEIN'S ANAMOLY

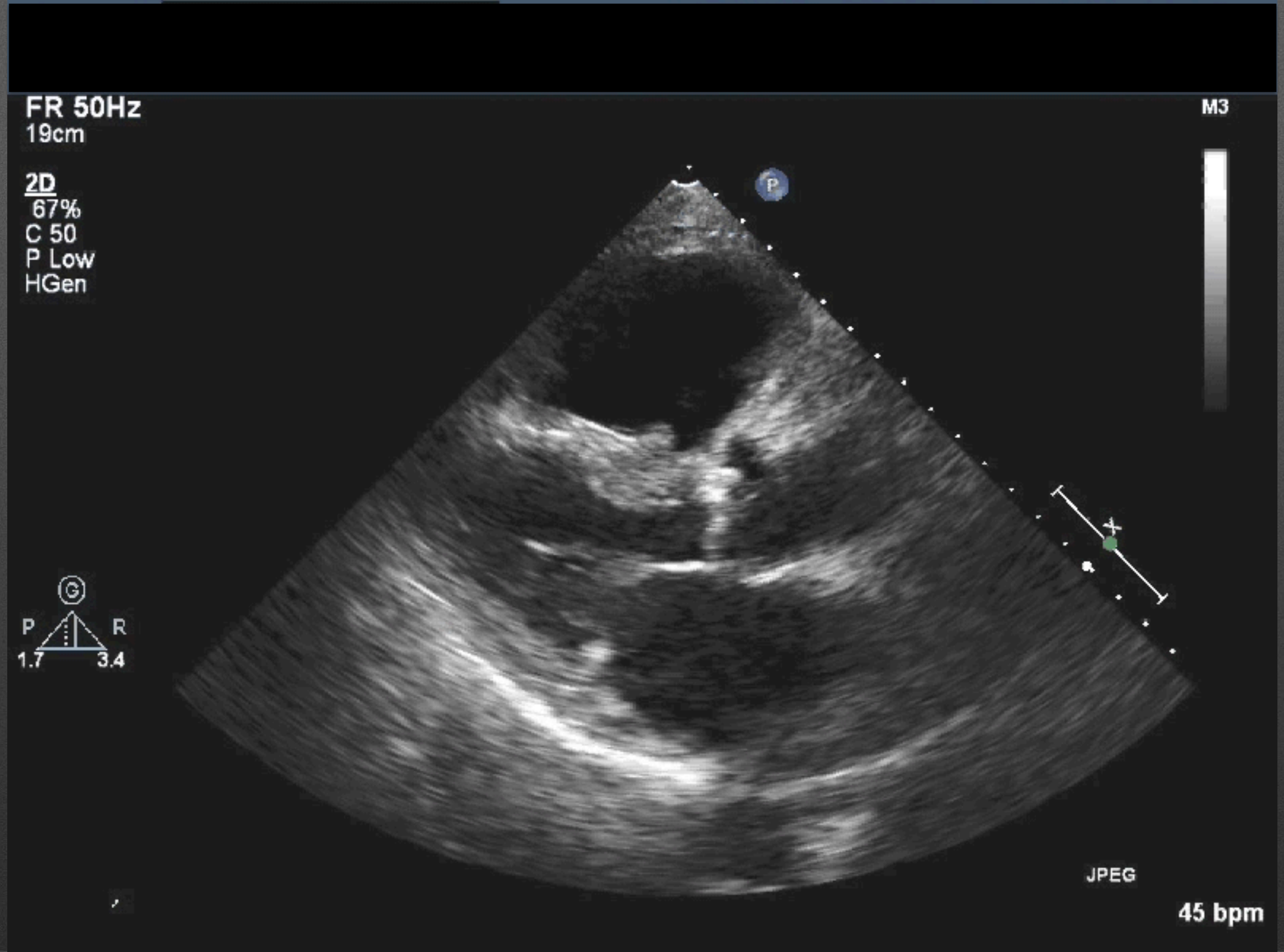


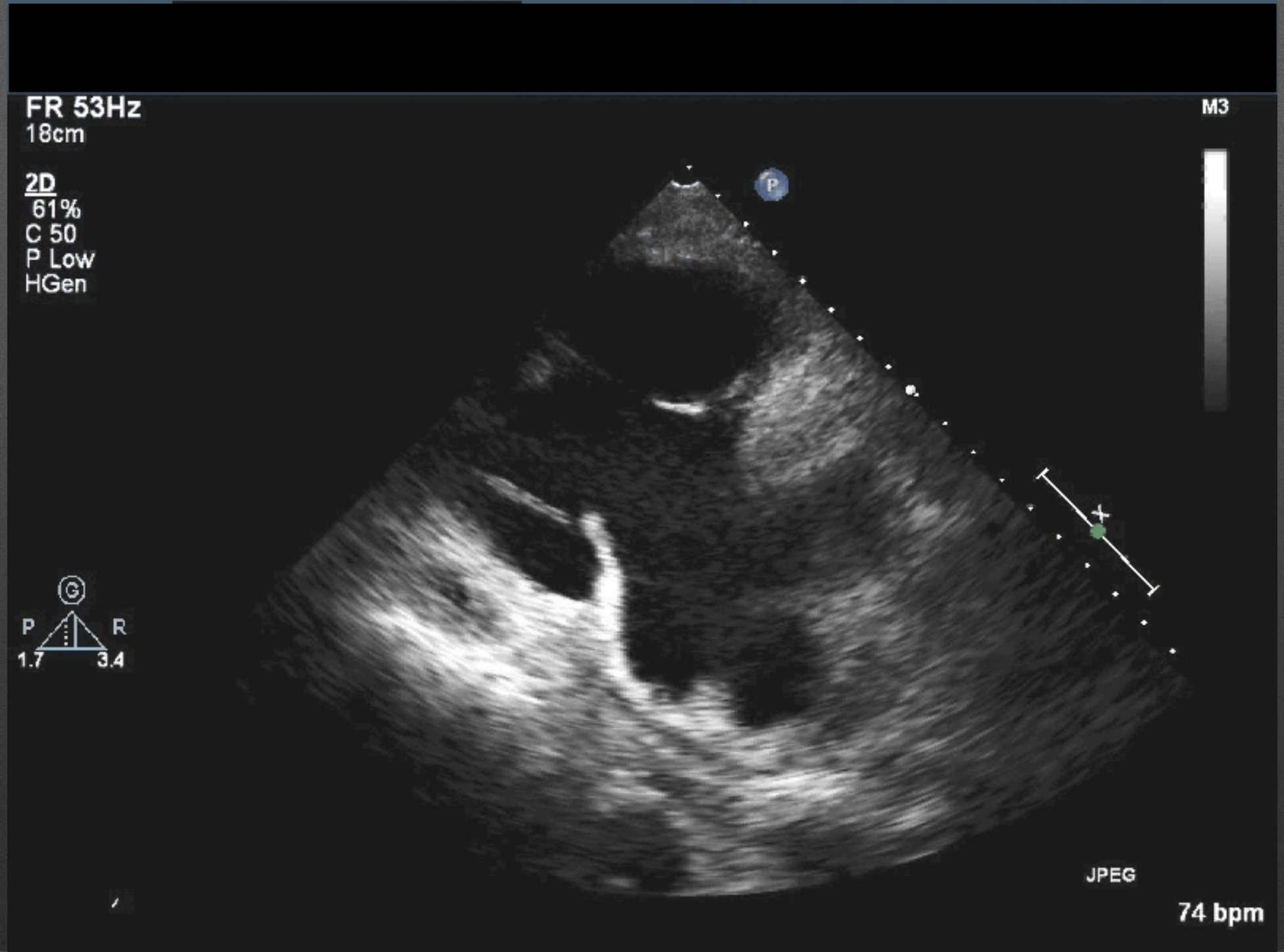

V
5
10
15
74
HR

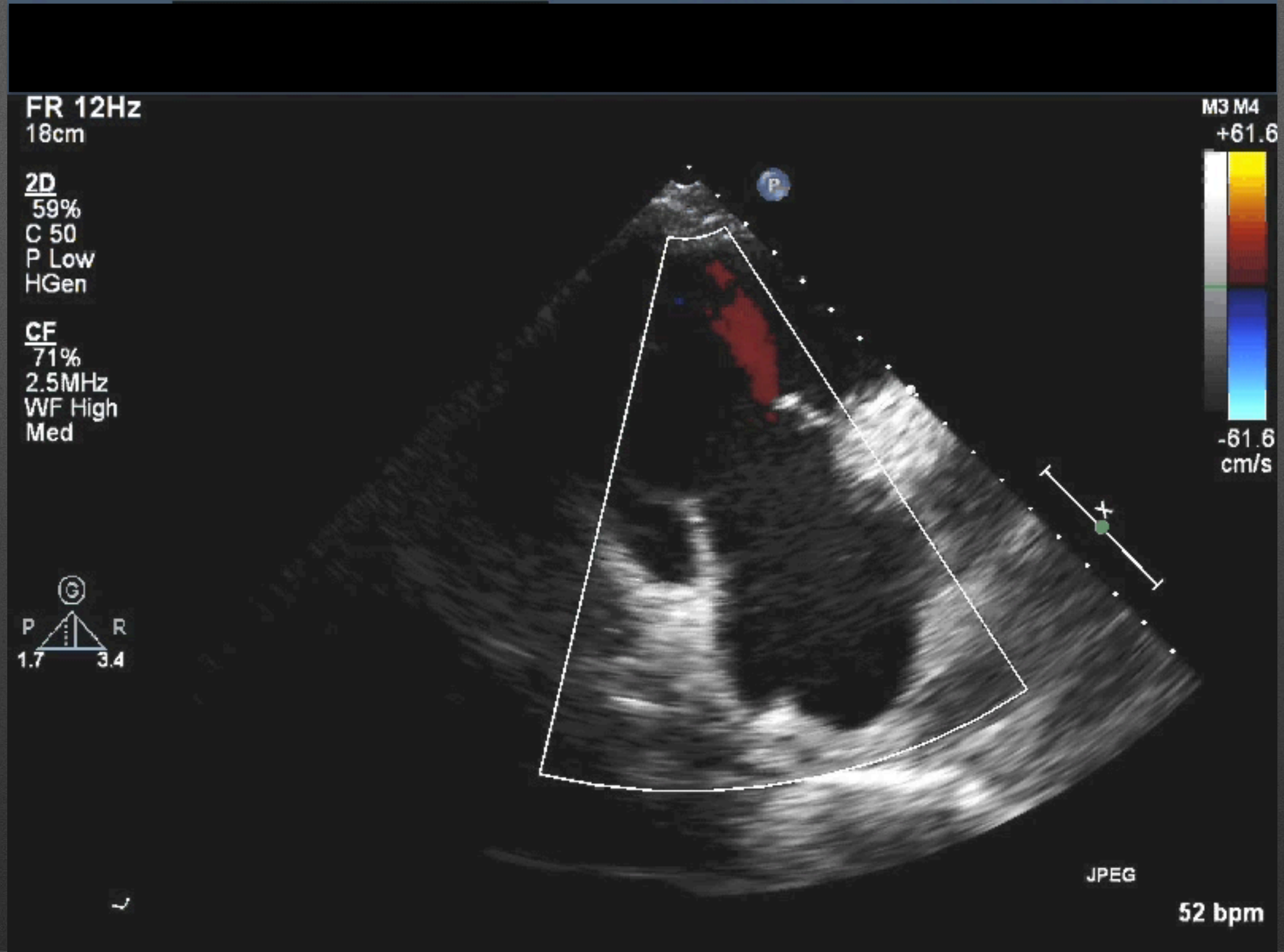

.56
-.56
V
5
10
15
78
HR


V
5
10
57
HR


V
5
10
15
55
HR

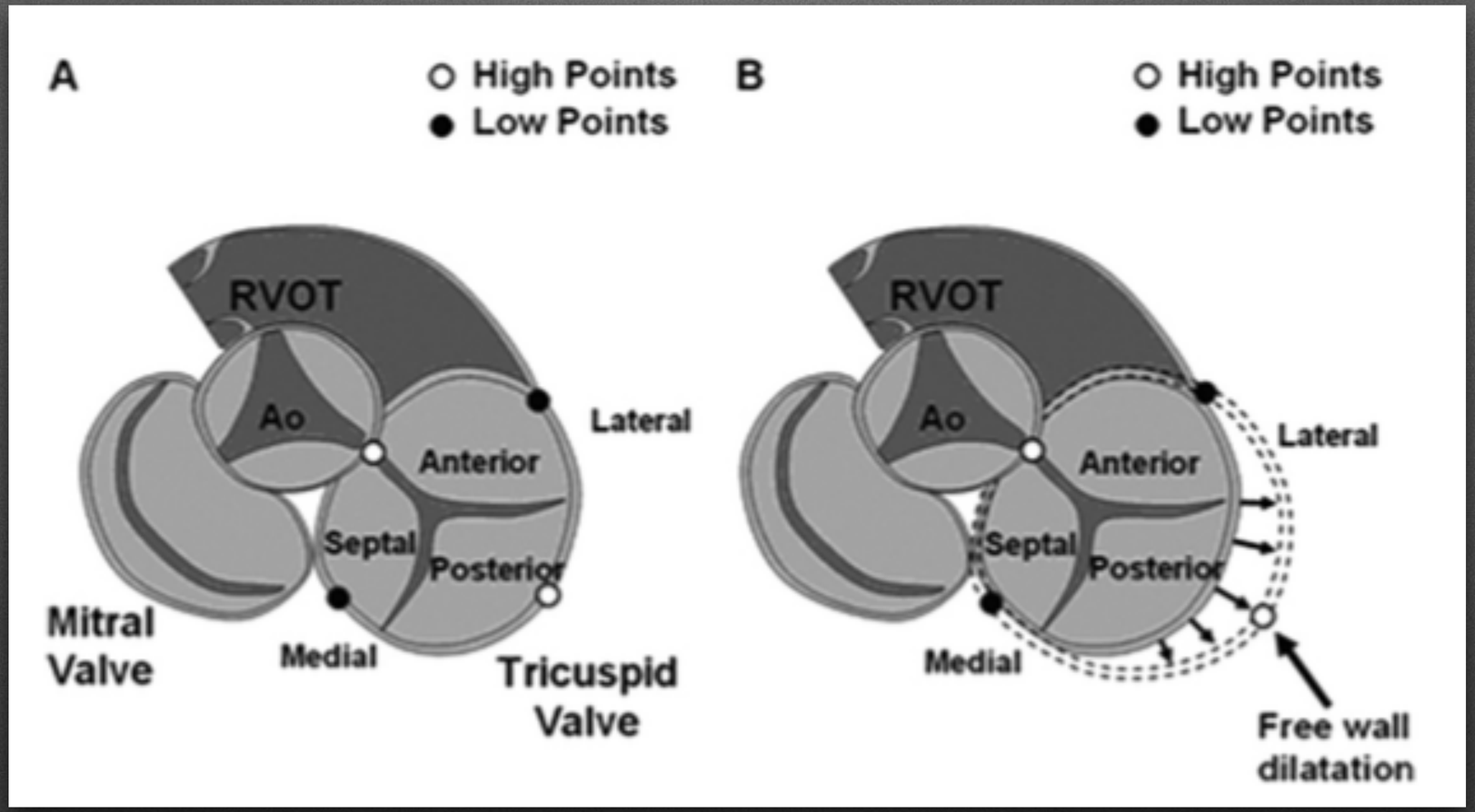

FR 50Hz
19cm
2D
67%
C 50
P Low
HGen
M3
P
G
P
R
1.7
3.4
JPEG
45 bpm


FR 53Hz
18cm
2D
61%
C 50
P Low
HGen
M3
P
G
P
R
1.7
3.4
JPEG
74 bpm


FR 12Hz
18cm
2D
59%
C 50
P Low
HGen
CF
71%
2.5MHz
WF High
Med
G
P
R
1.7
3.4
M3 M4
+61.6
-61.6
cm/s
JPEG
52 bpm

Functional TR

- The most common cause of TR is functional, defined as regurgitation with structurally normal leaflets and chords
- The cause of functional TR appears to be tricuspid annular dilatation (due to right ventricular or right atrial enlargement) and tethering of the tricuspid valve leaflets

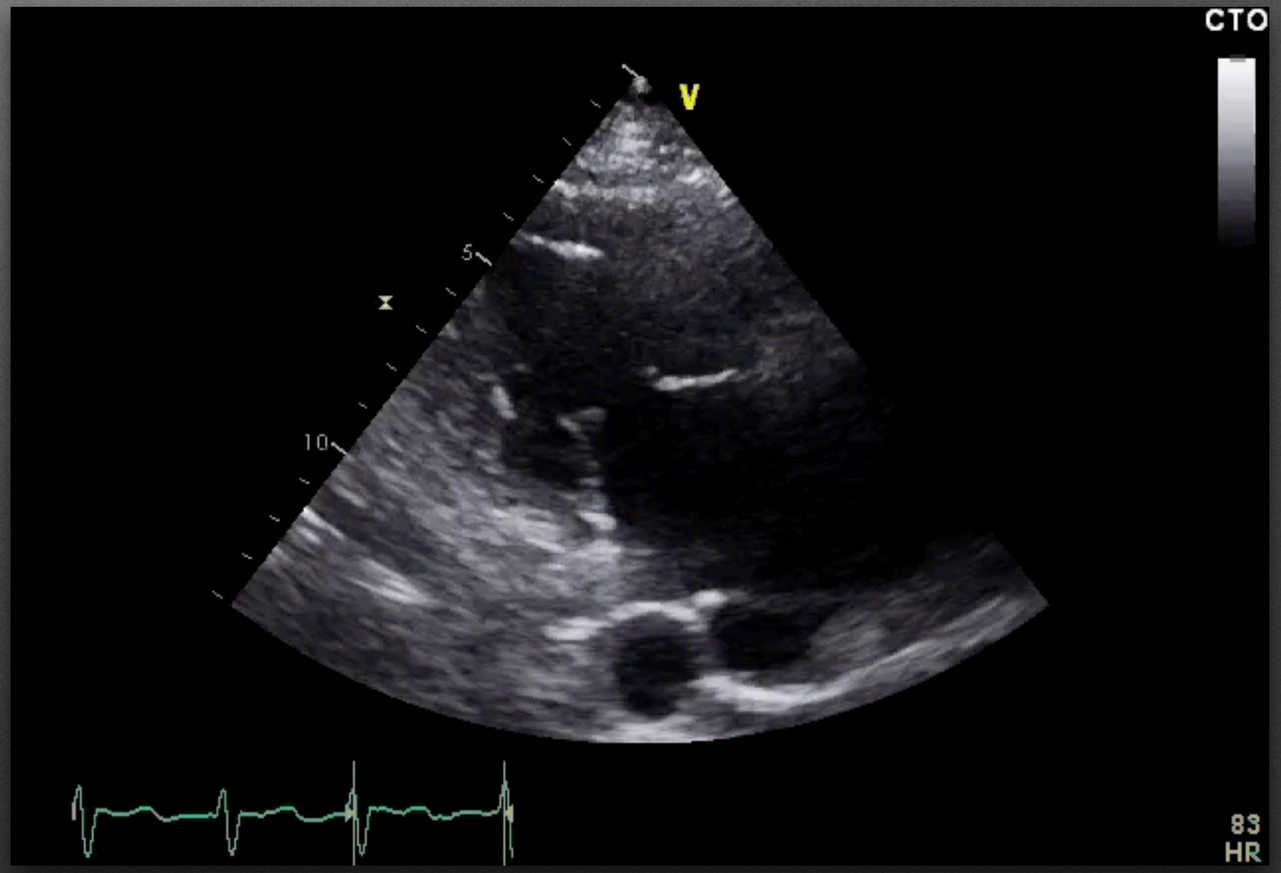


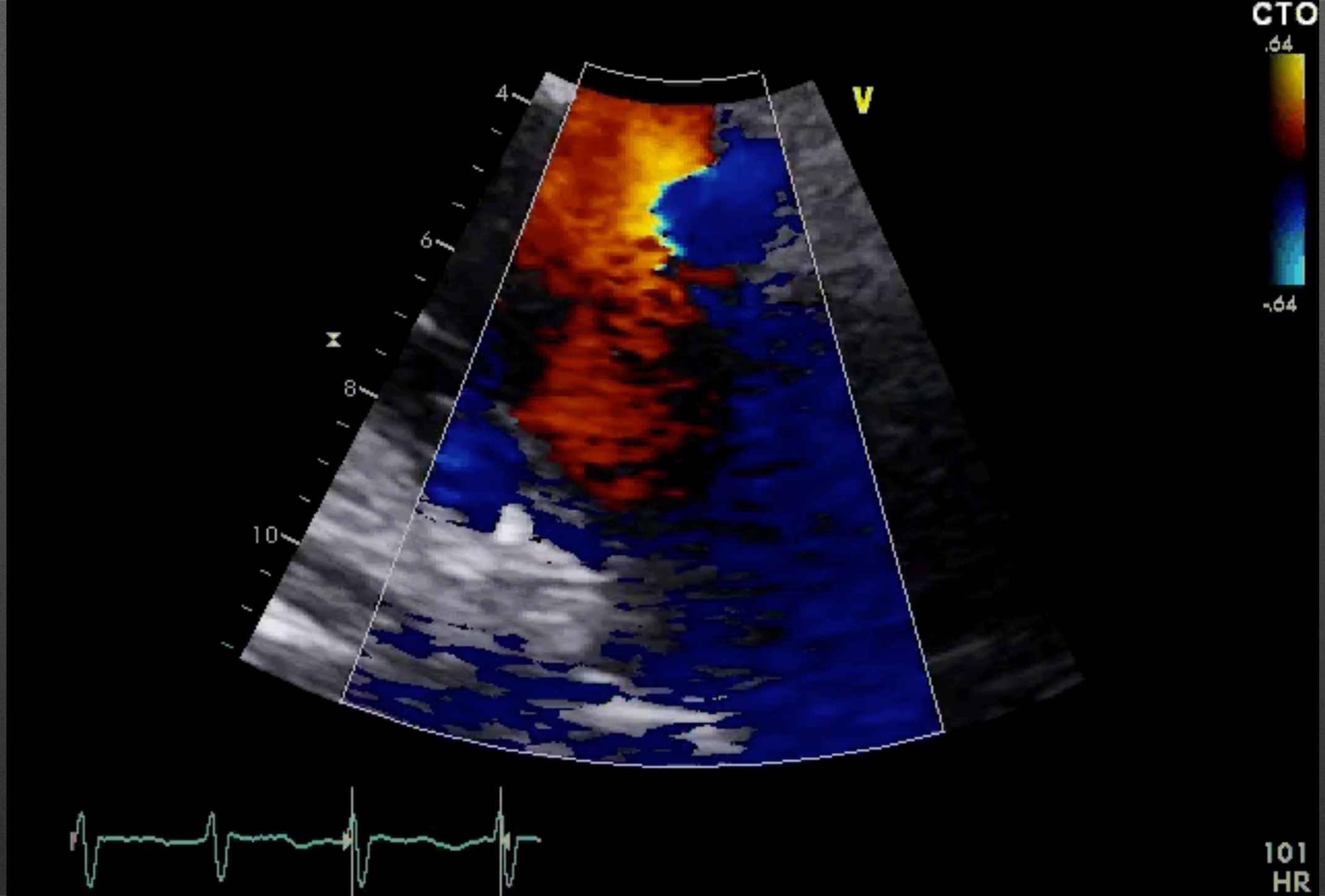
Functional TR

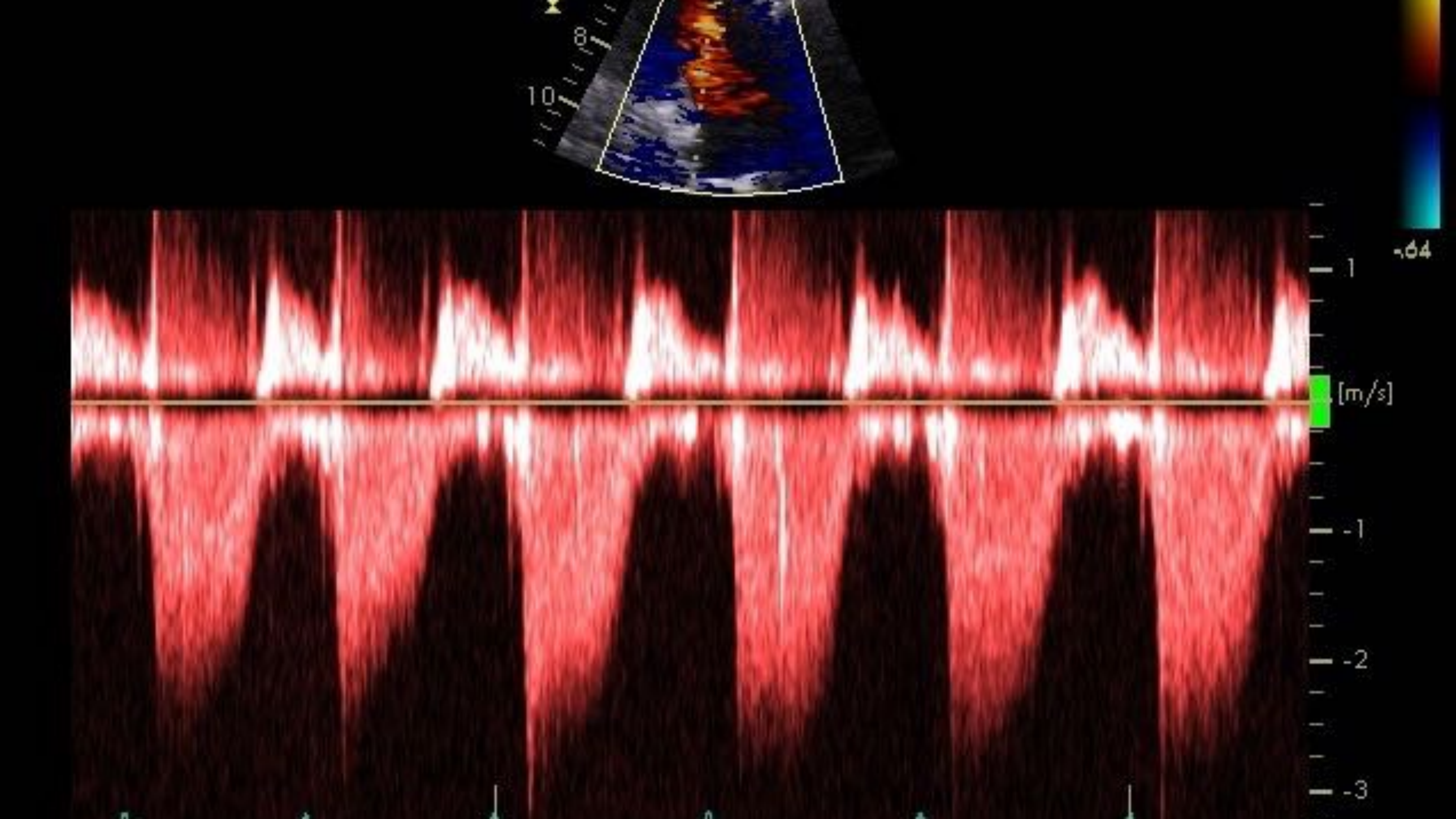
Adapted from: Ton-Nu TT, Levine RA, Handschumacher MD, et al: Geometric determinants of func- tional tricuspid regurgitation: Insights from 3-dimensional echocardiography. Circulation 114:143-149, 2006

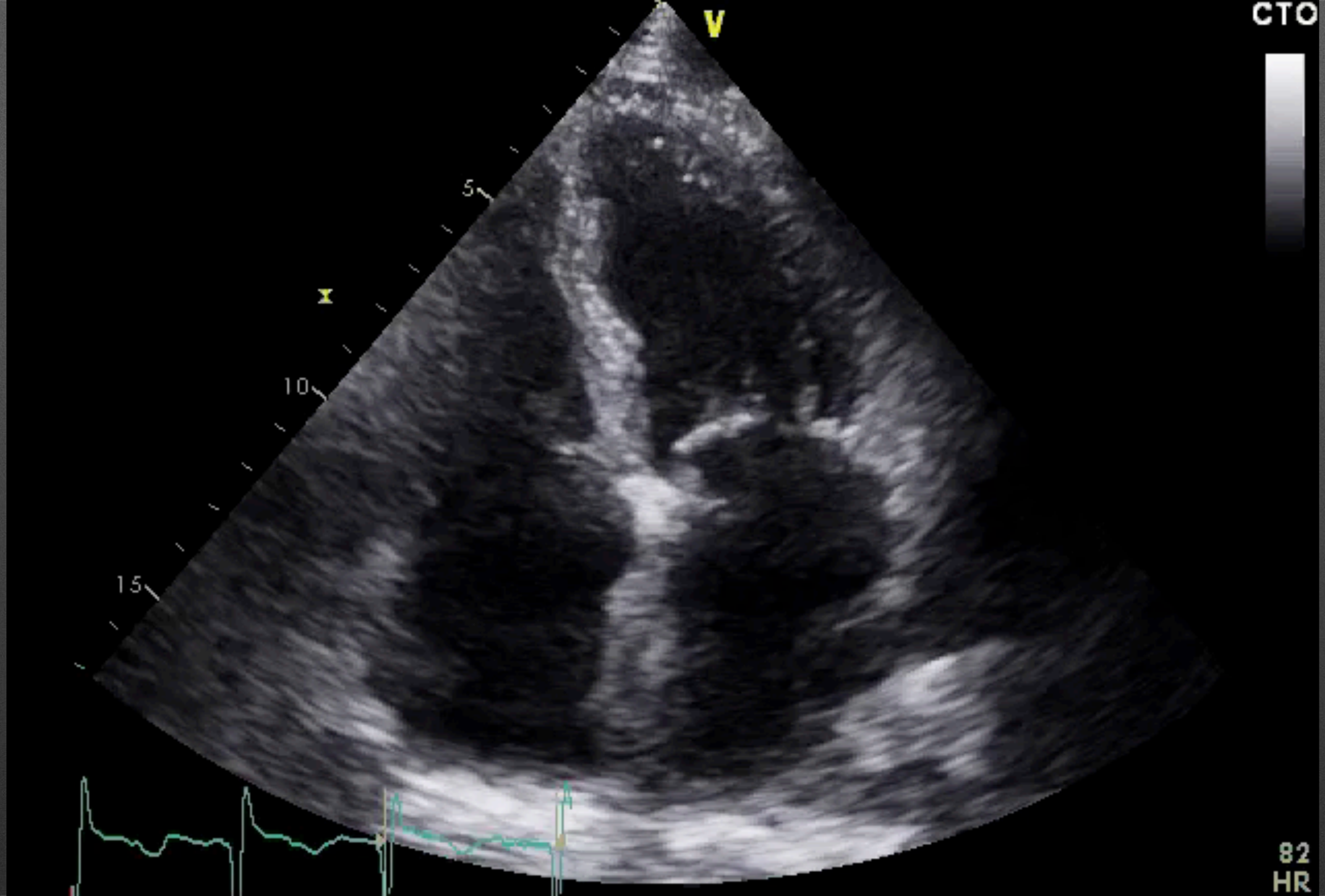
Case #2

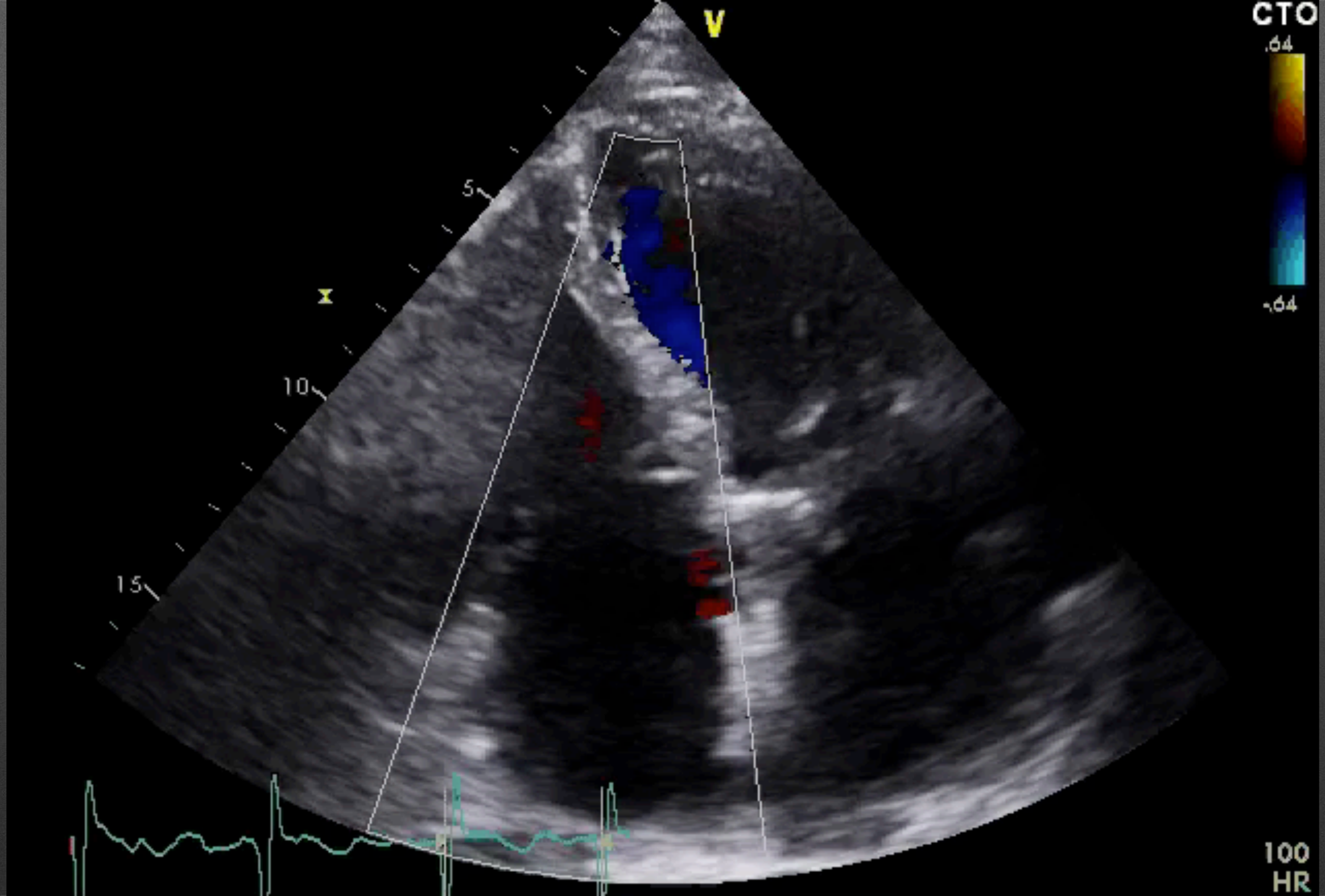
- 72 yr old Female
- Know Primary PHTN RVSP 85 mmHg, Limited Echo to Assess Flolan Treatment

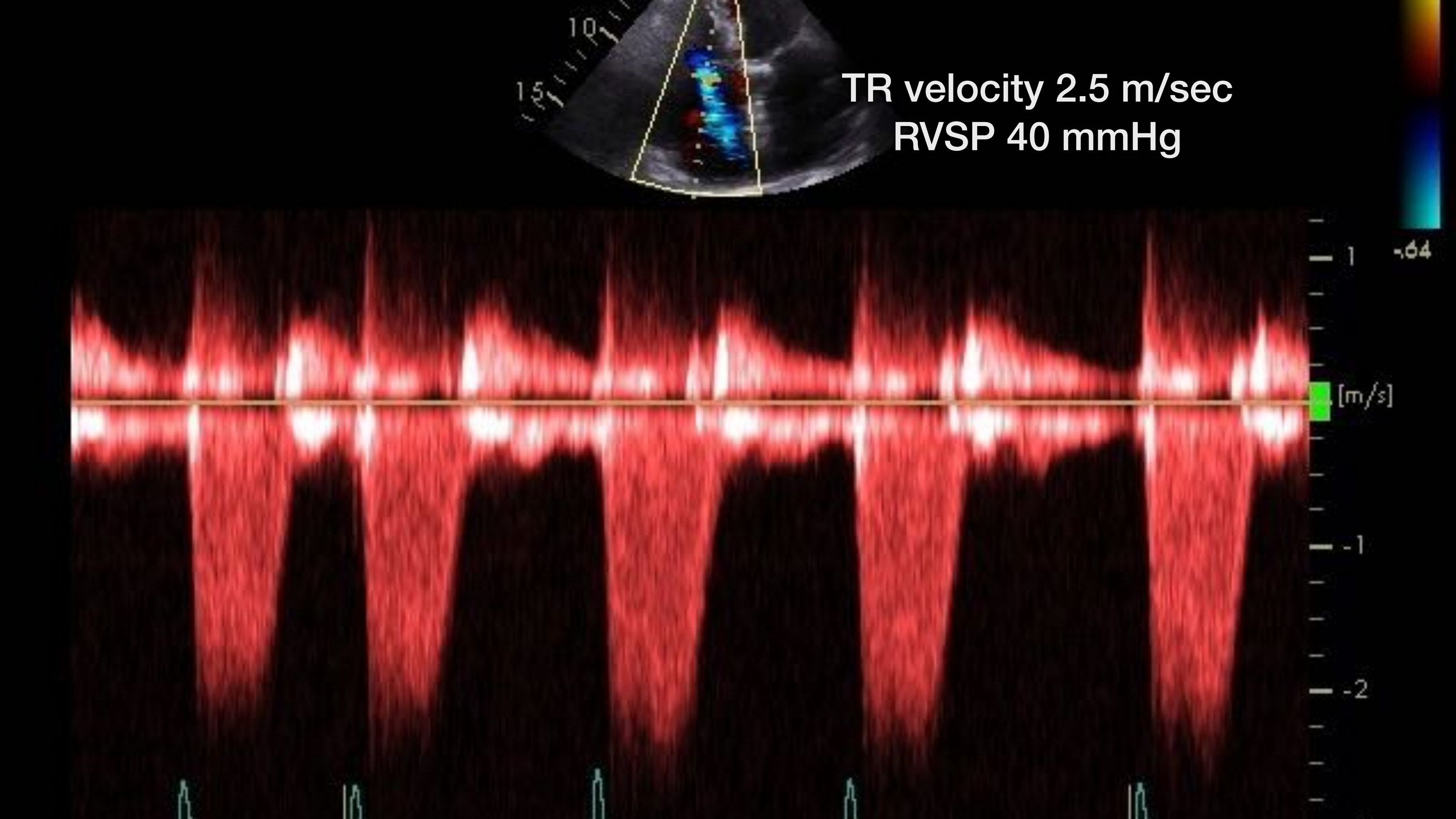


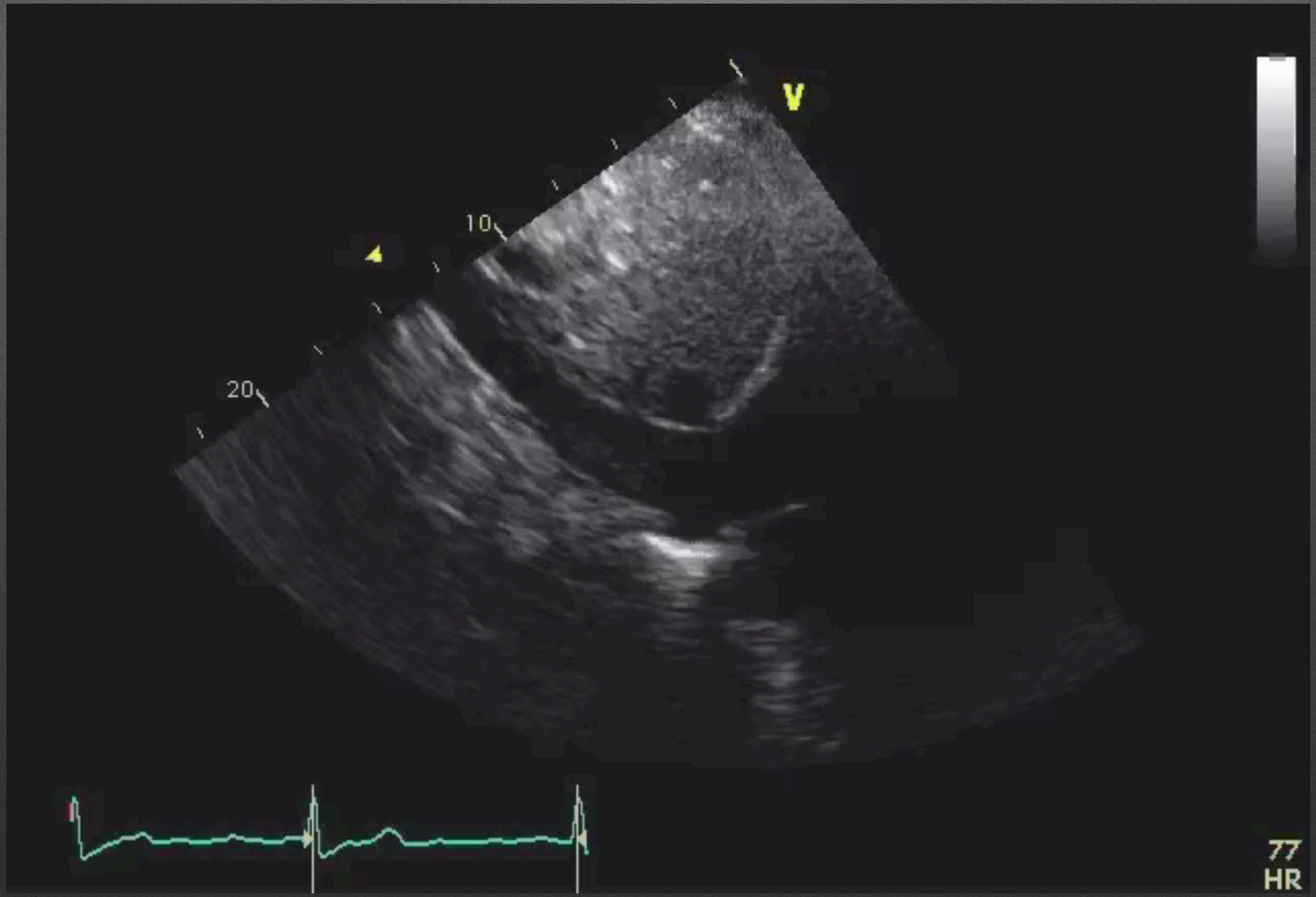

CTO
.64
-.64
V
4
6
8
10
101
HR


8
10
-64
1
[m/s]
-1
-2
-3


V
X
5
10
15
CTO
82
HR

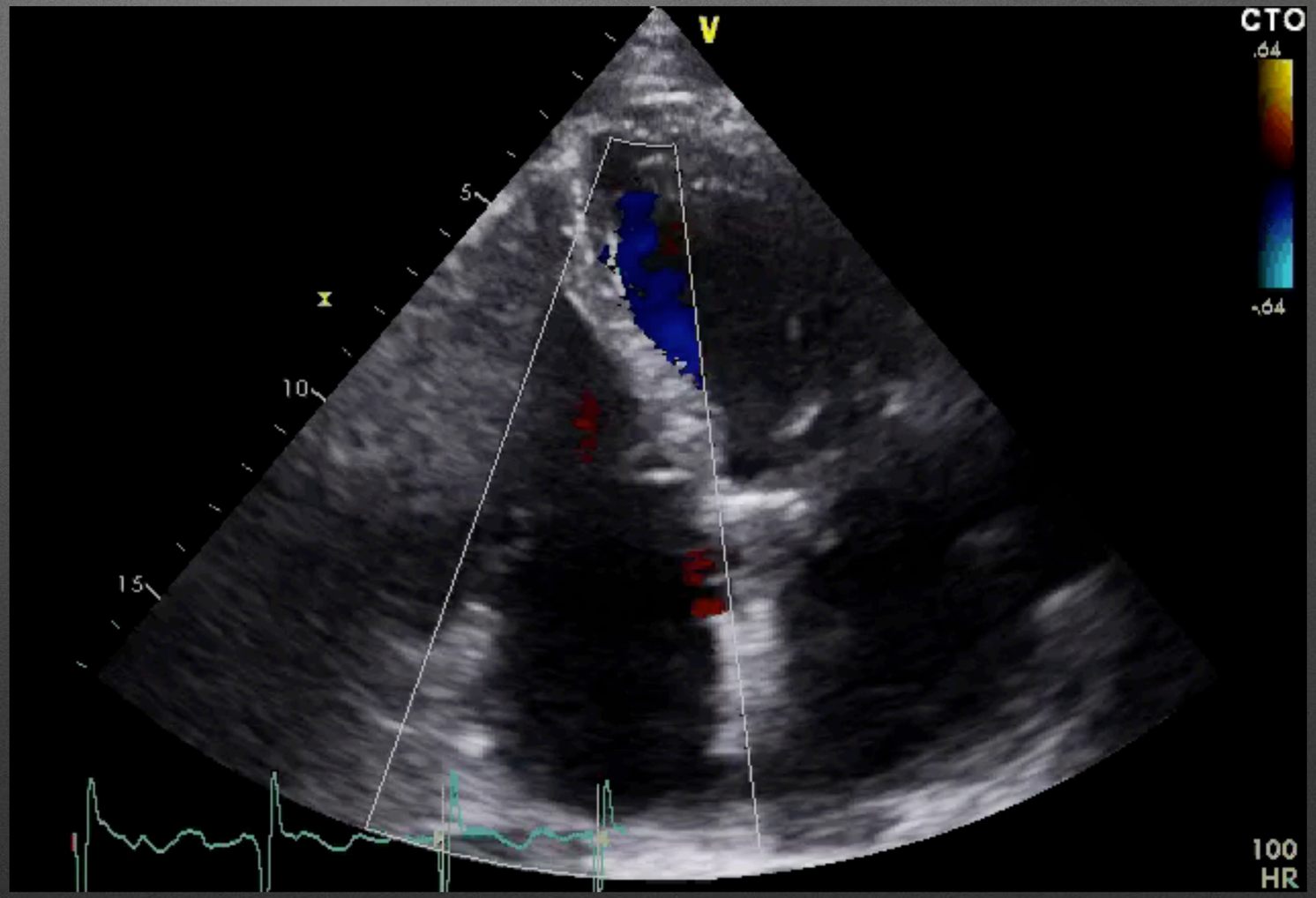

V
CTO
.64
-.64
5
10
15
100
HR


TR velocity 2.5 m/sec
RVSP 40 mmHg
10
15
1
-64
[m/s]
-1
-2


V
10
20
77
HR

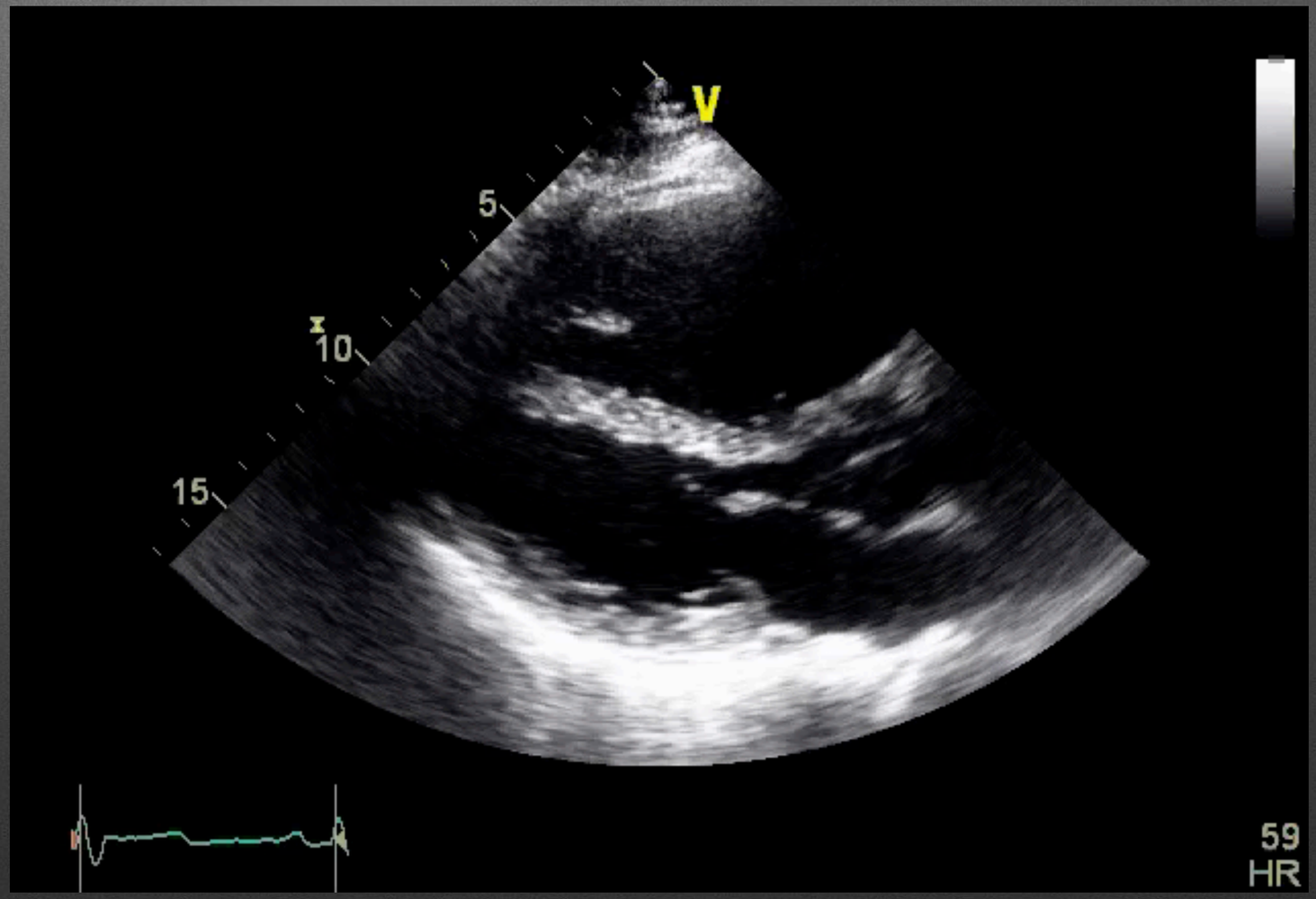
Case #2 Summary

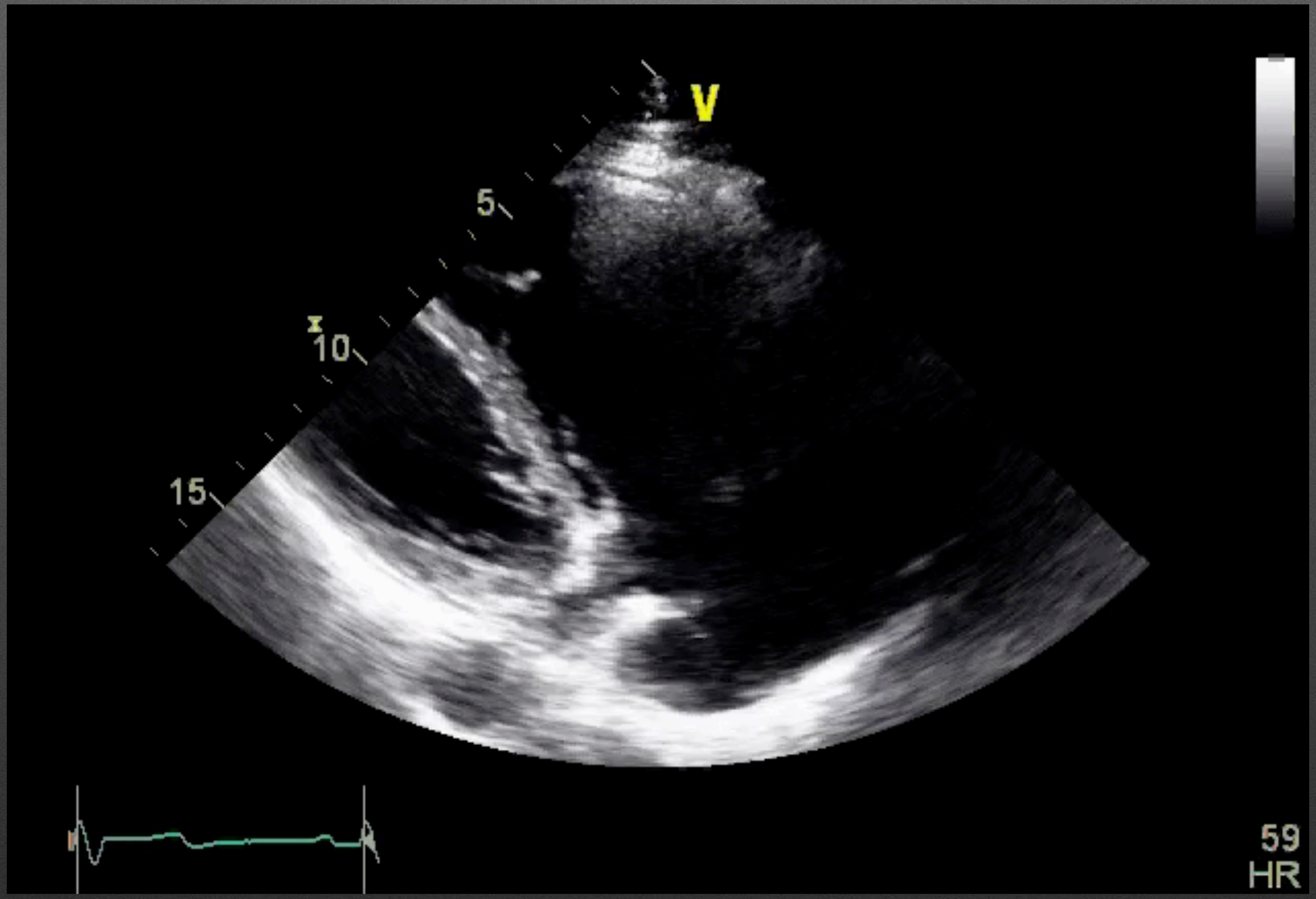
- Moderate RVE
- Mildly reduced RV function
- RVSP = 40 mmHg
- Moderate TR

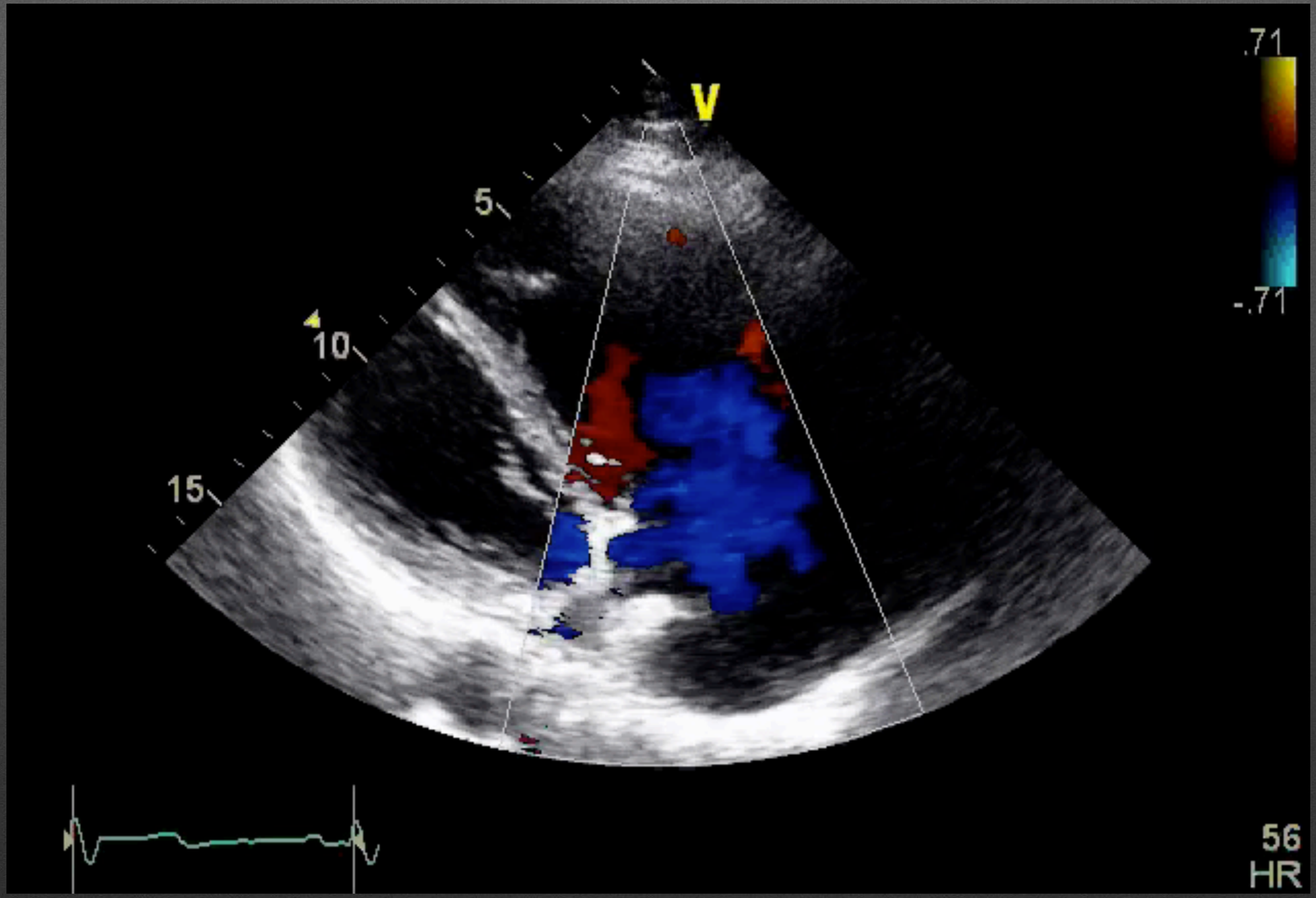


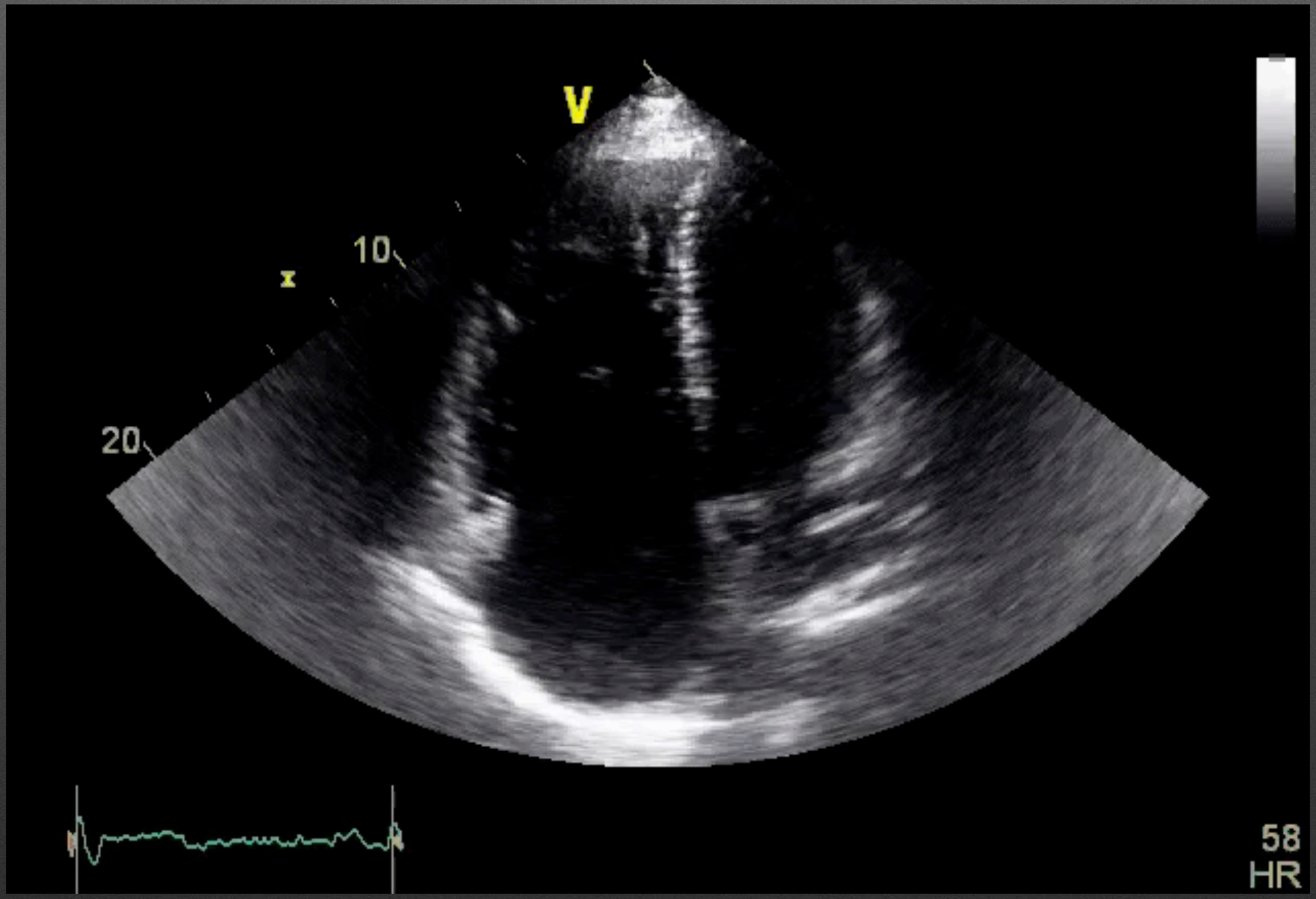
Case #3

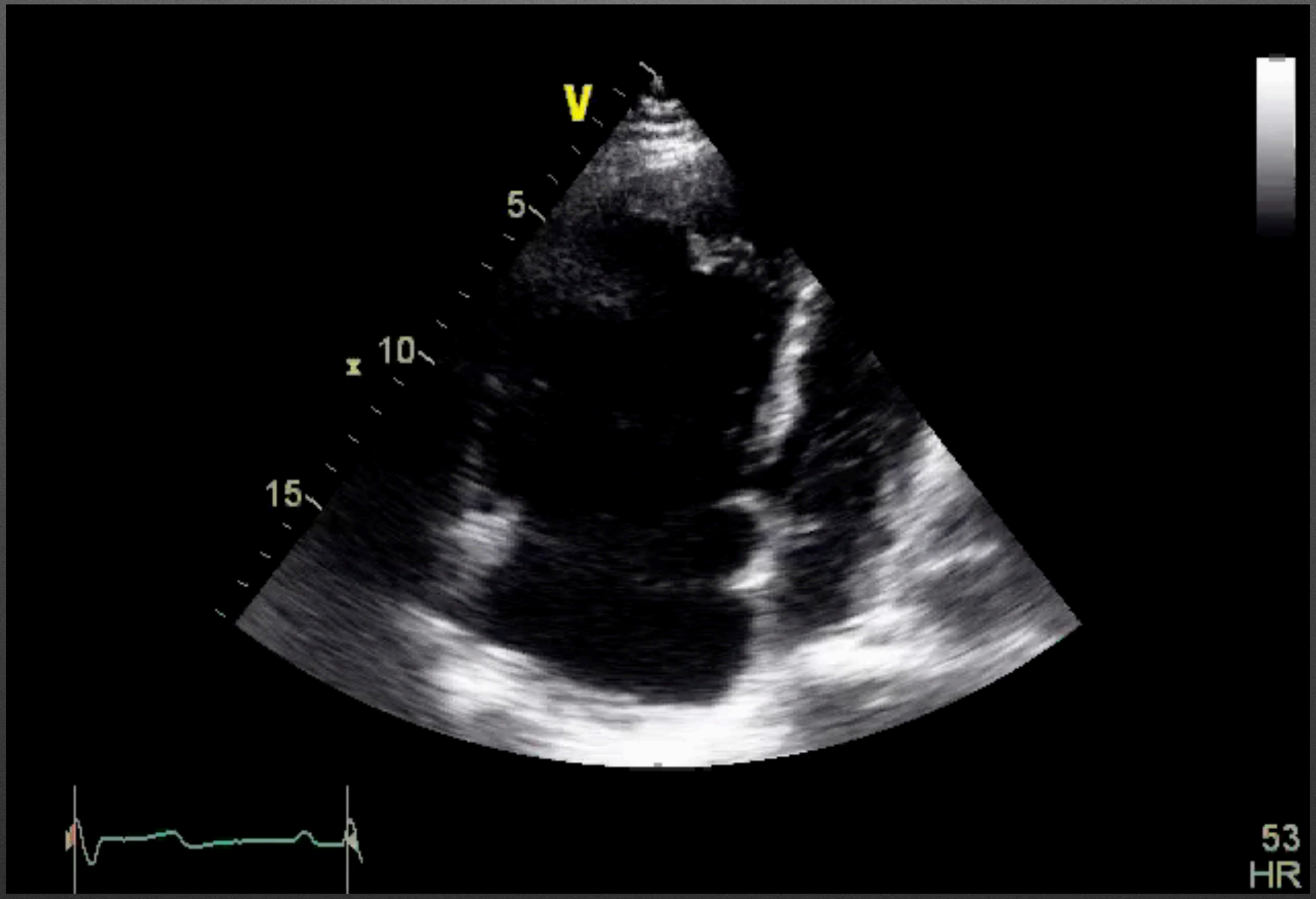
- 59 yr old Female
- Primary PHTN patient

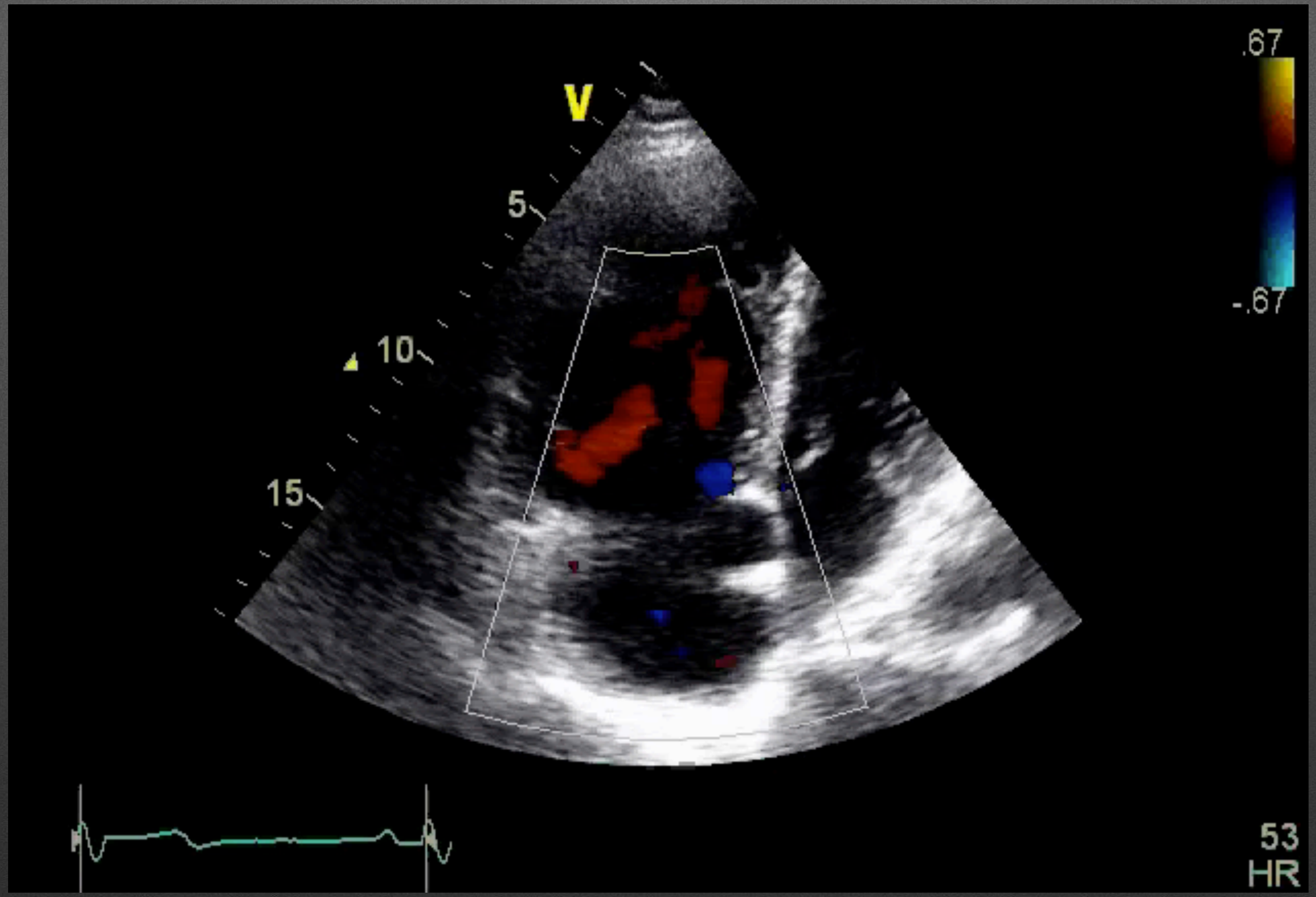


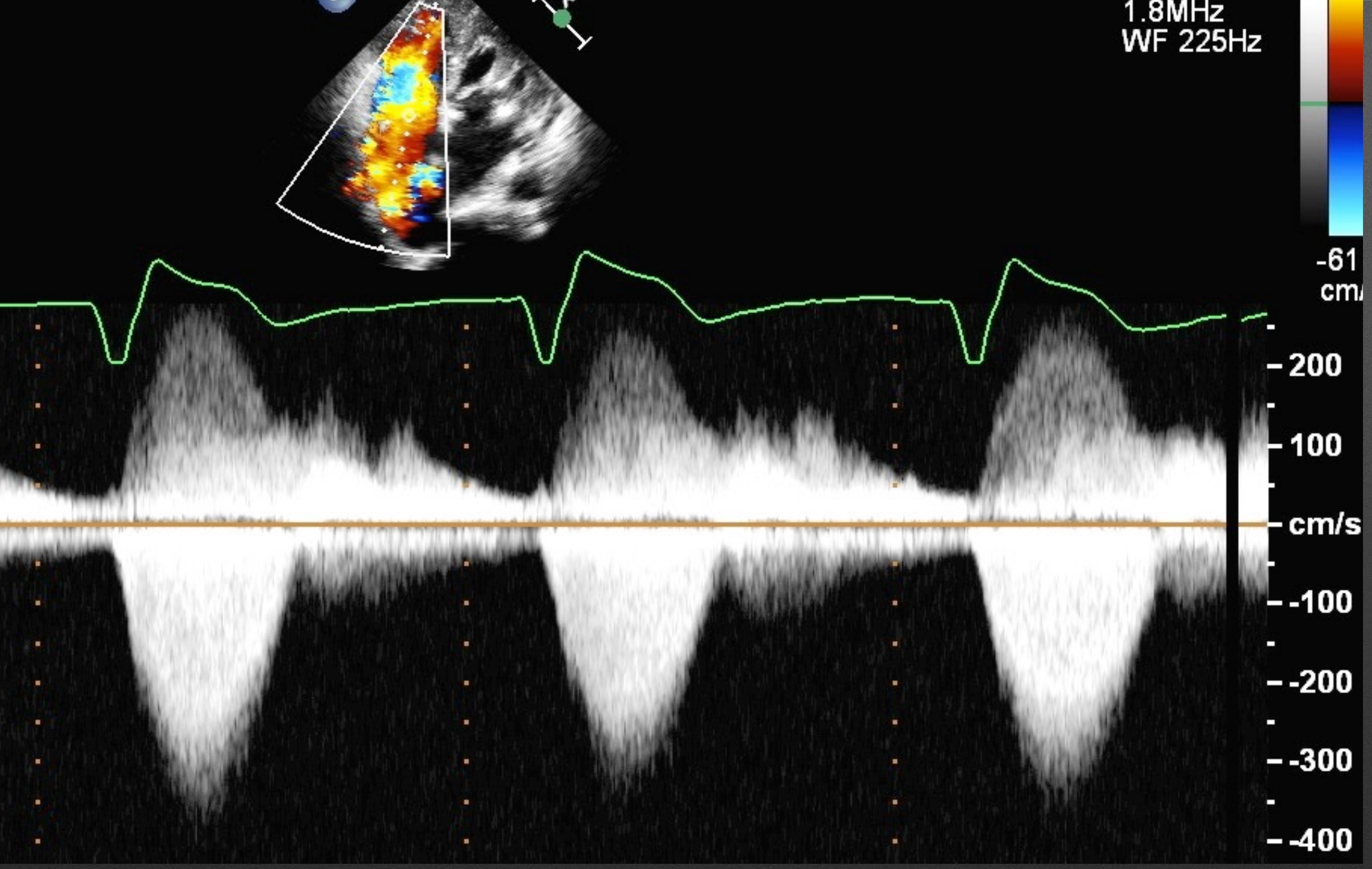

V
5
10
15
59
HR

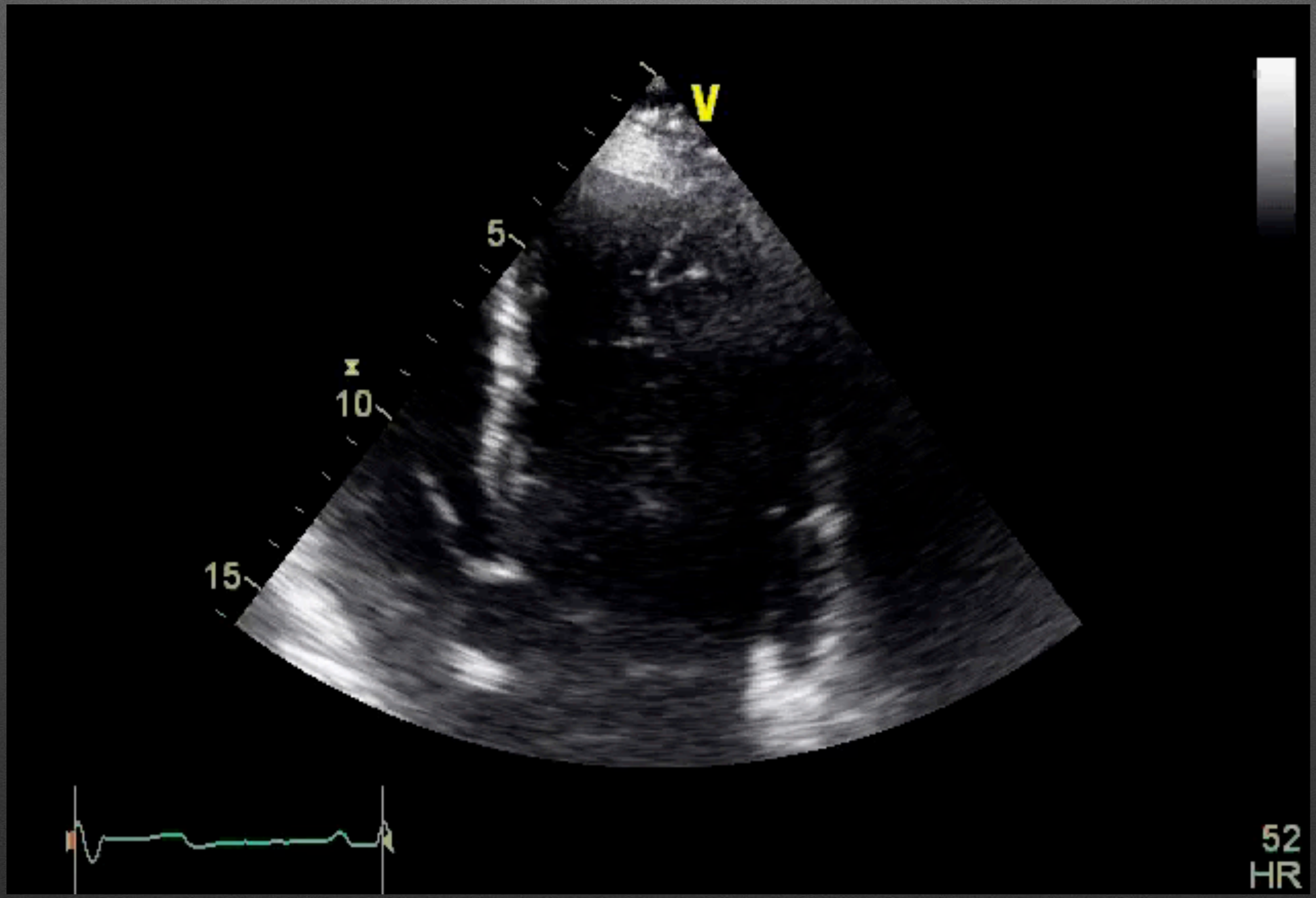

.71
-.71
V
5
10
15
56
HR

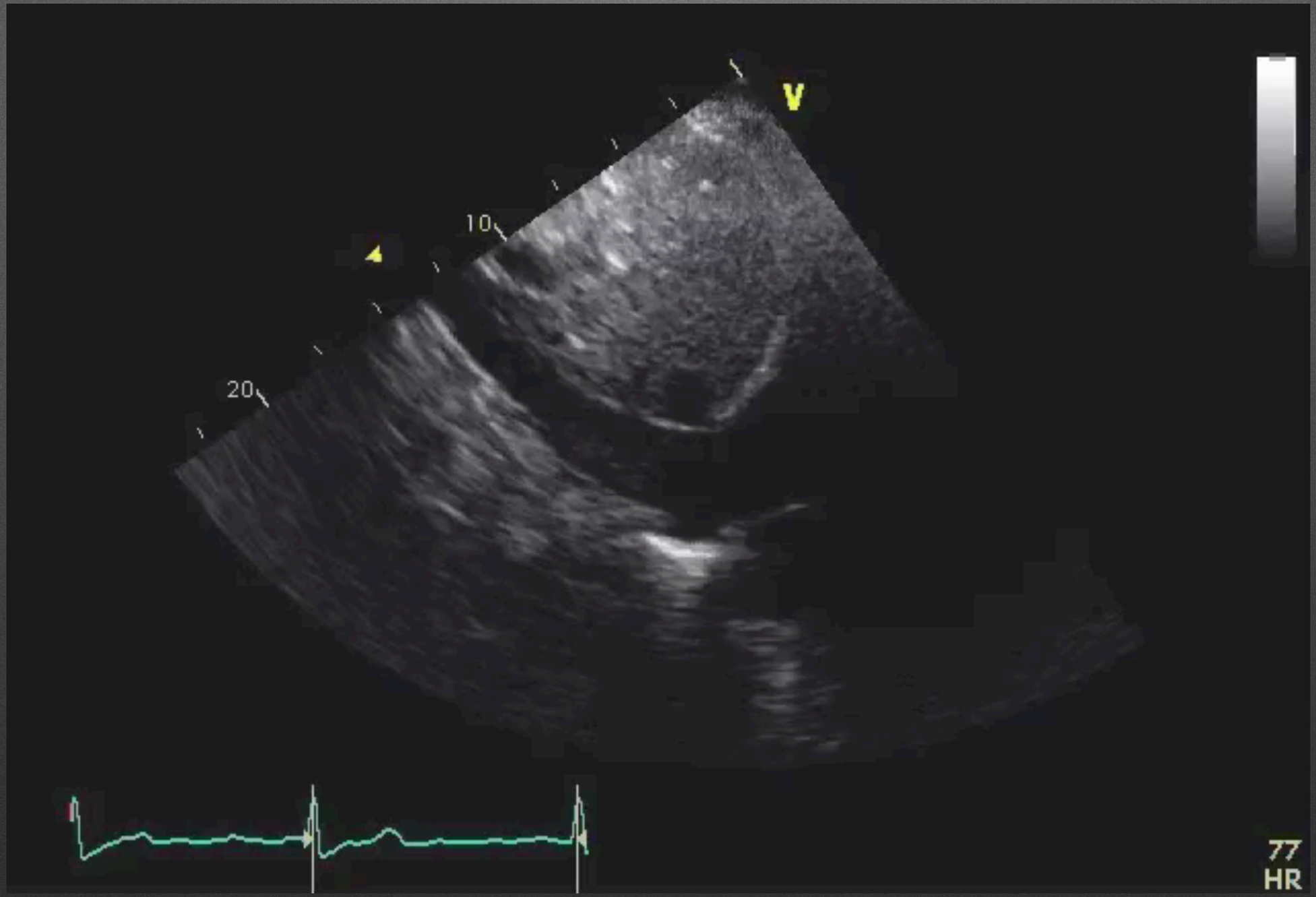

V
10
20
58
HR

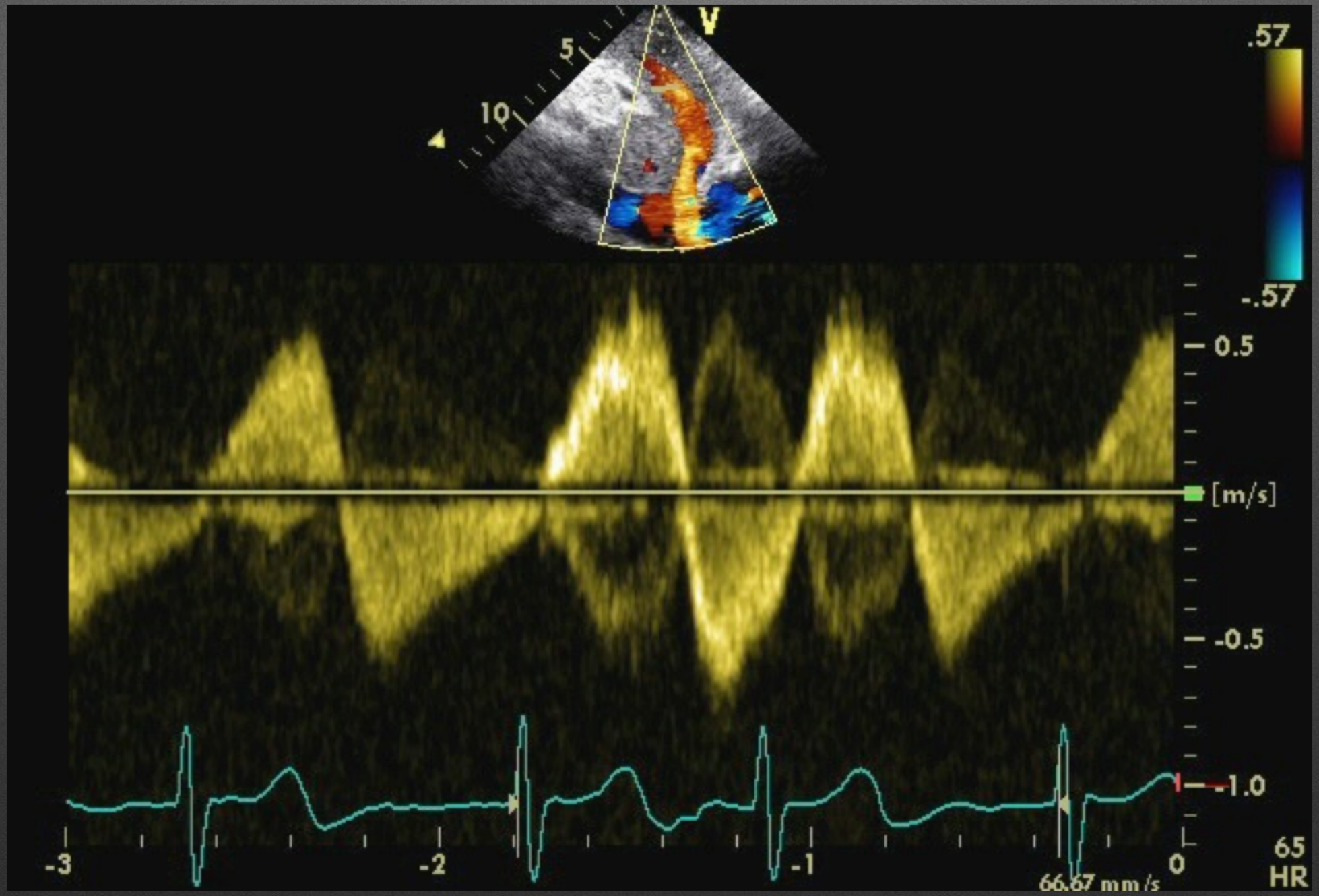

V
5
10
15
53
HR

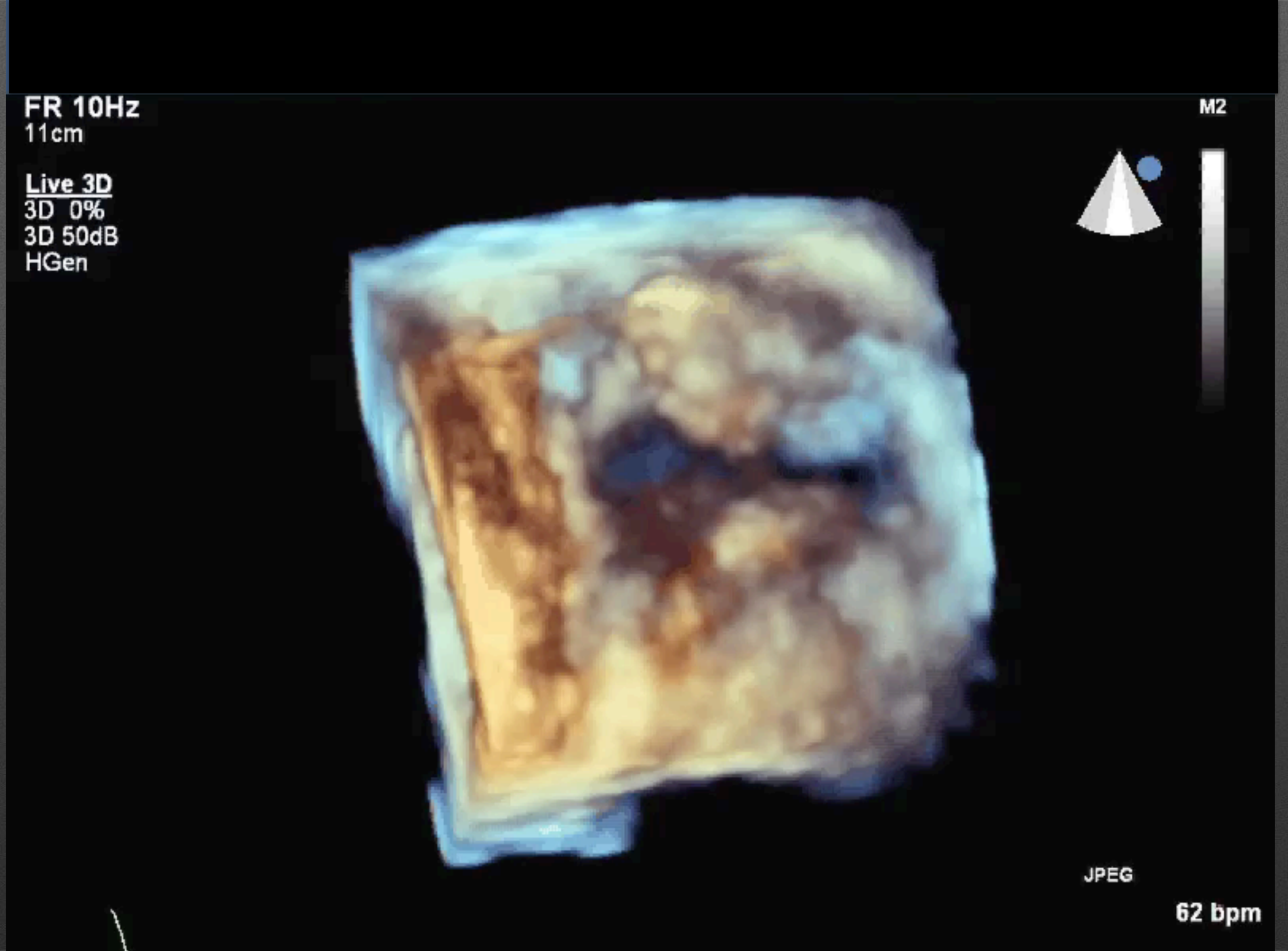

V
5
10
15
.67
-.67
53
HR


1.8MHz
WF 225Hz
-61
cm/
200
100
cm/s
-100
-200
-300
-400


V
5
10
15
52
HR


V
10
20
77
HR


V
5
10
.57
-.57
0.5
[m/s]
-0.5
-1.0
-3
-2
-1
0
66.67 mm/s
65
HR


FR 10Hz
11cm
Live 3D
3D 0%
3D 50dB
HGen
M2
JPEG
62 bpm

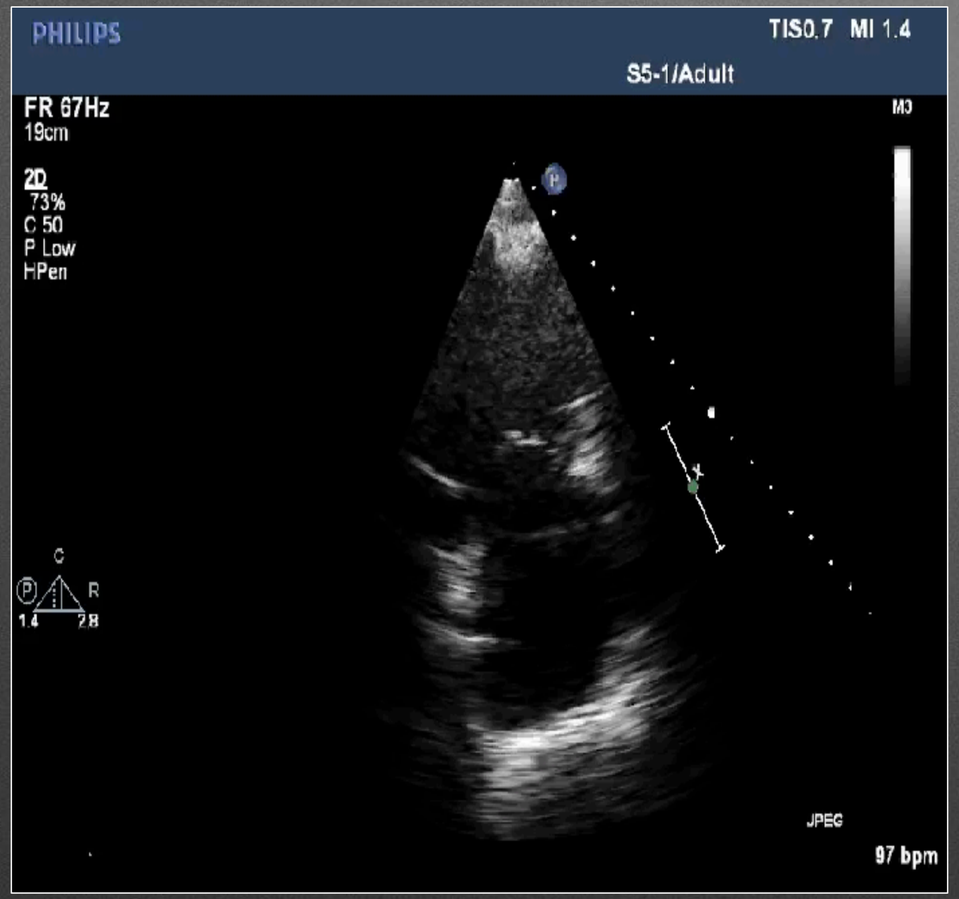
JPE

Case #3 Summary

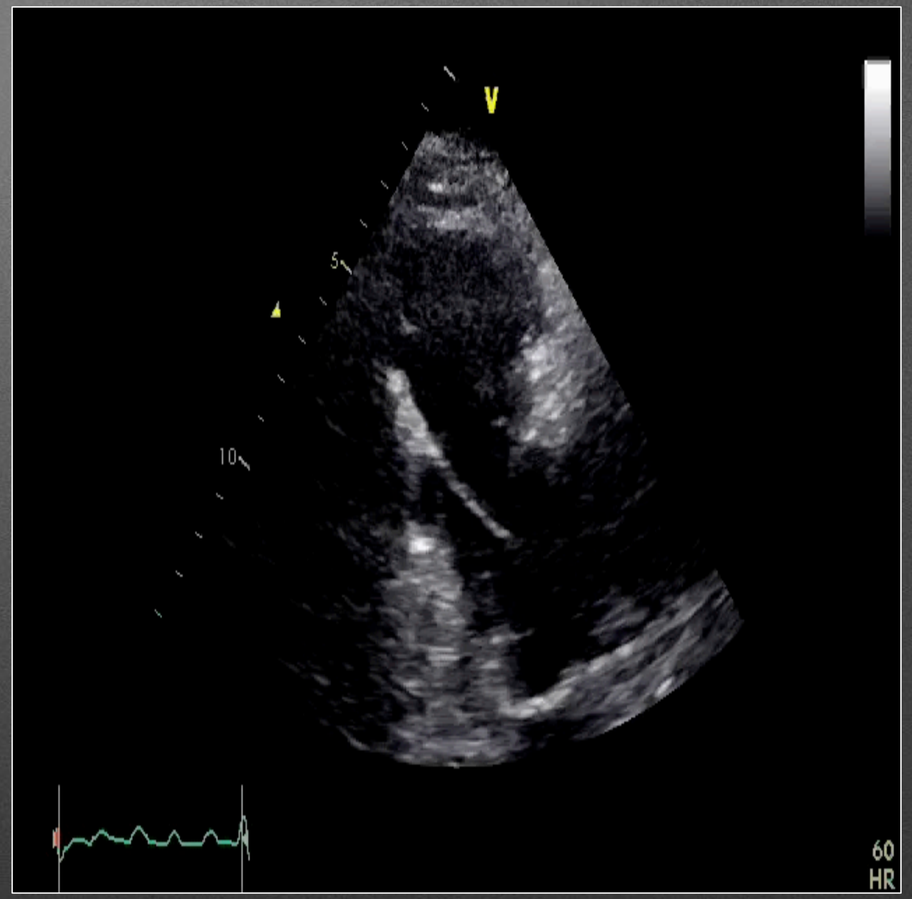
- Severe RV enlargement
- Severe RV systolic dysfunction
- Severe Tricuspid Regurgitation, due to incomplete coaptation and annular dilatation
- RVSP 66 mmHg

TV Disease Due to Pacemaker

CASE 4


PHILIPS
TIS0.7 MI 1.4
S5-1/Adult
FR 67Hz
19cm
M3
2D
73%
C 50
P Low
HPen
C
P
R
1.4
28
JPEG
97 bpm

CASE 5

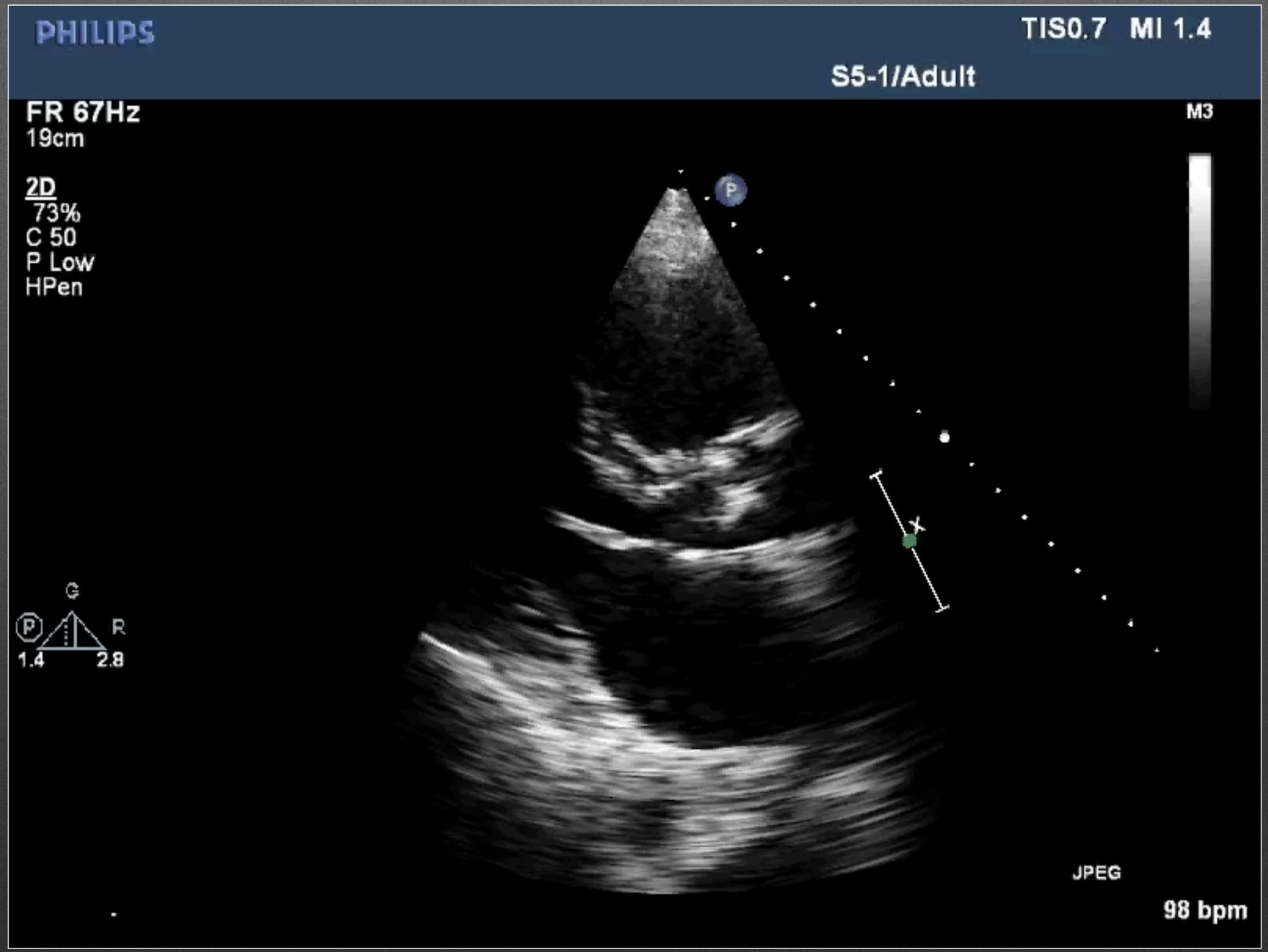

V
5
10
60
HR

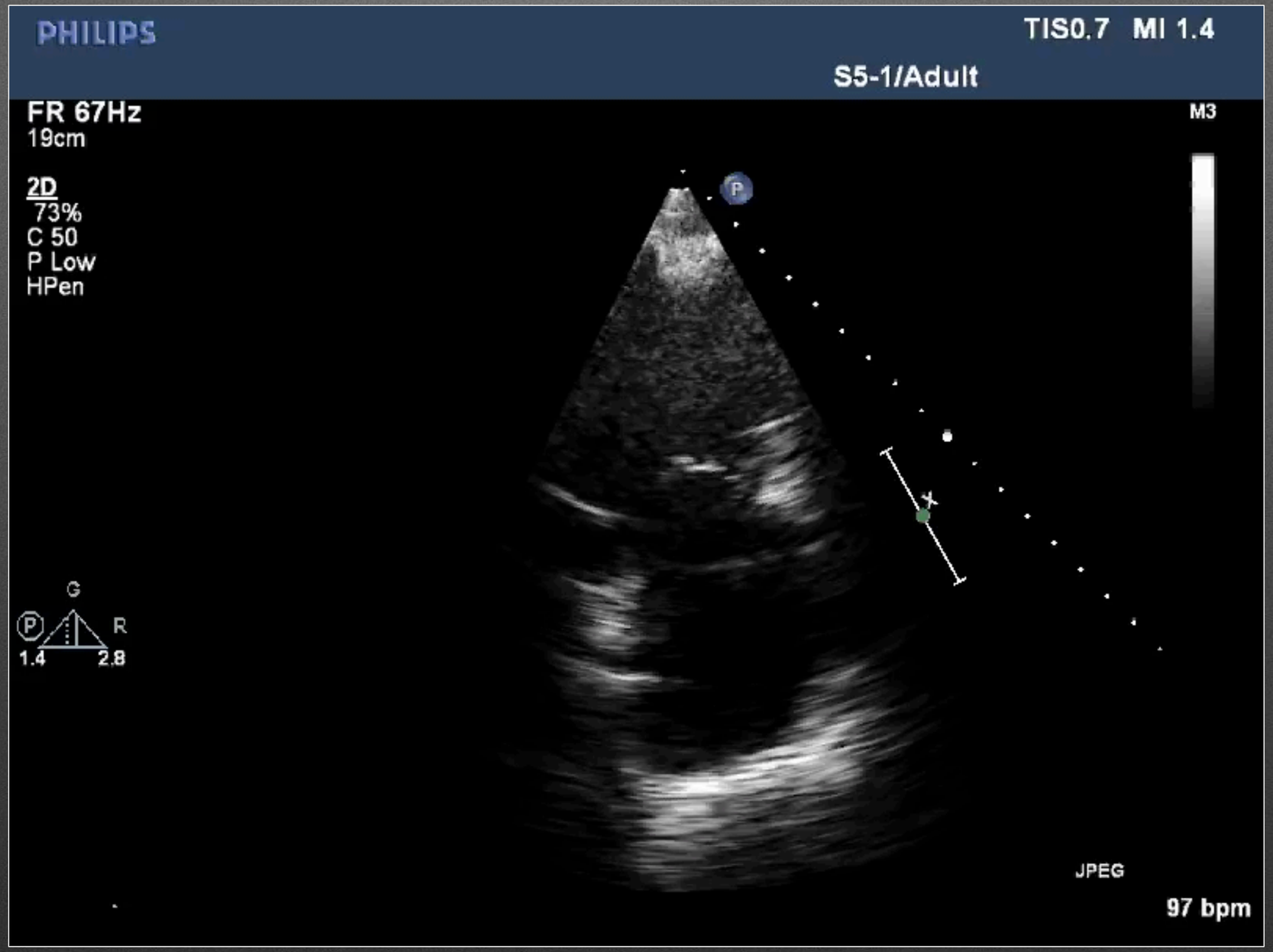
Case 4

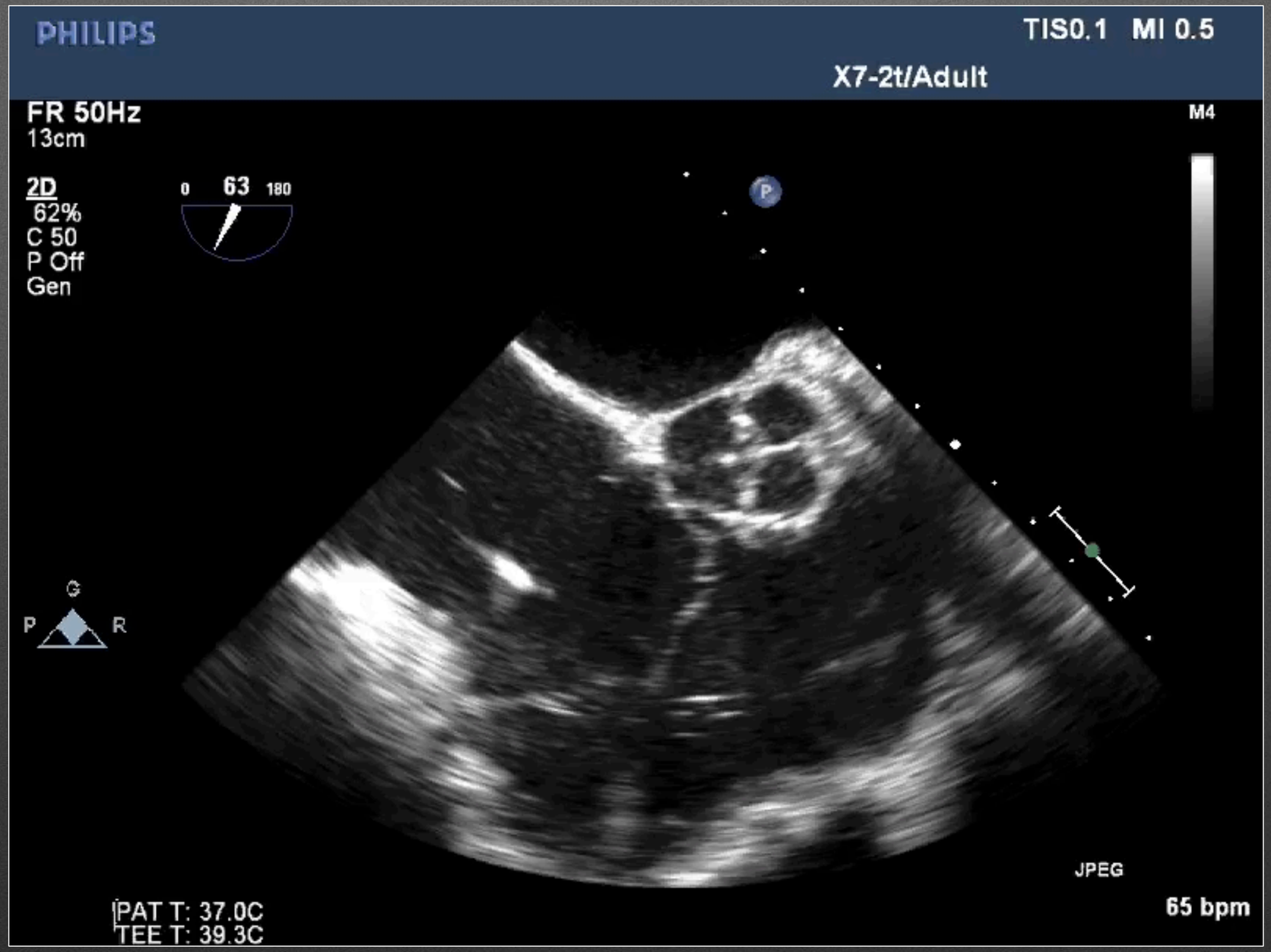
- 64 y/o male
- Pacemaker implantation X 8 yrs

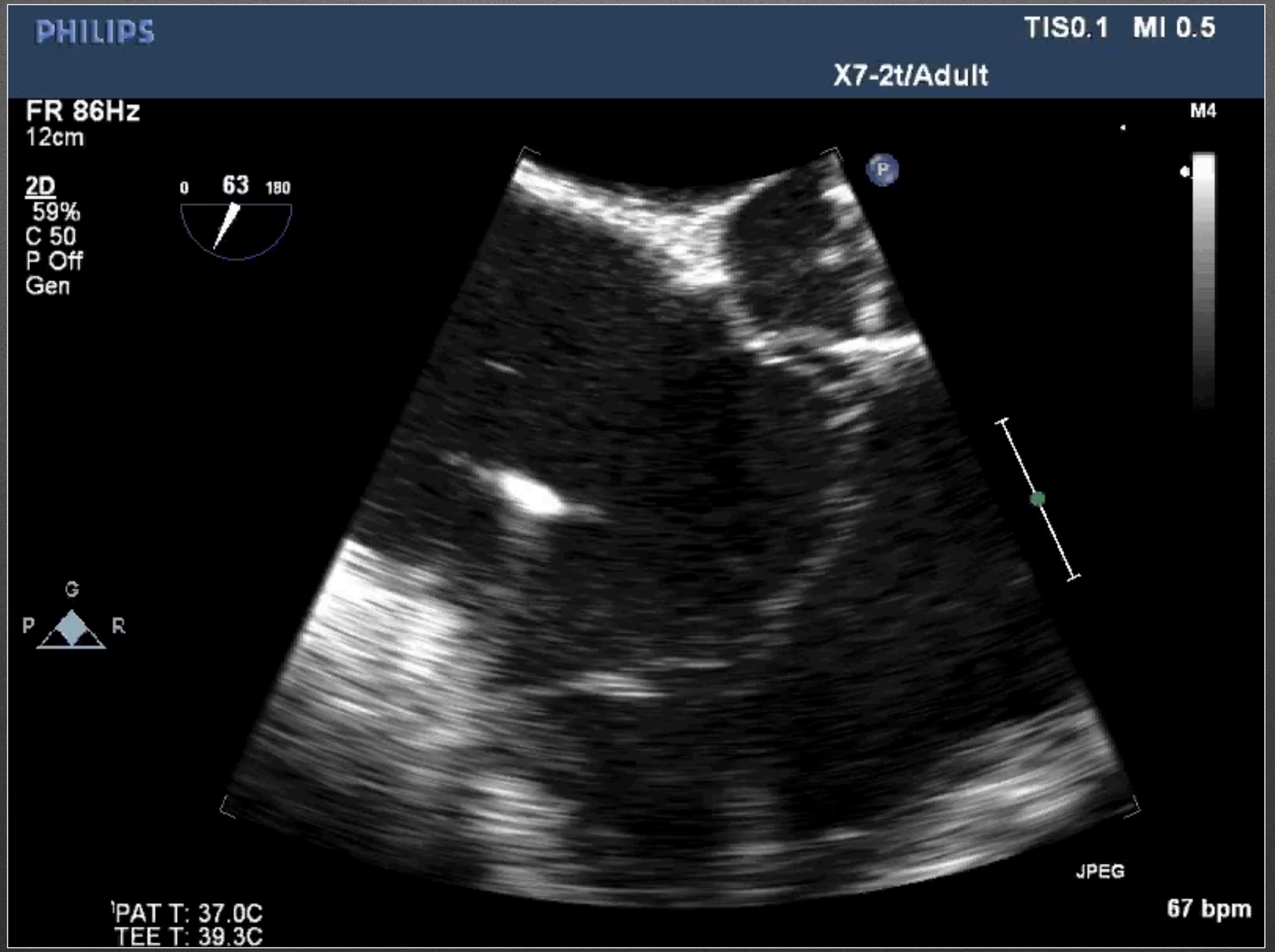
Clinical presentation:

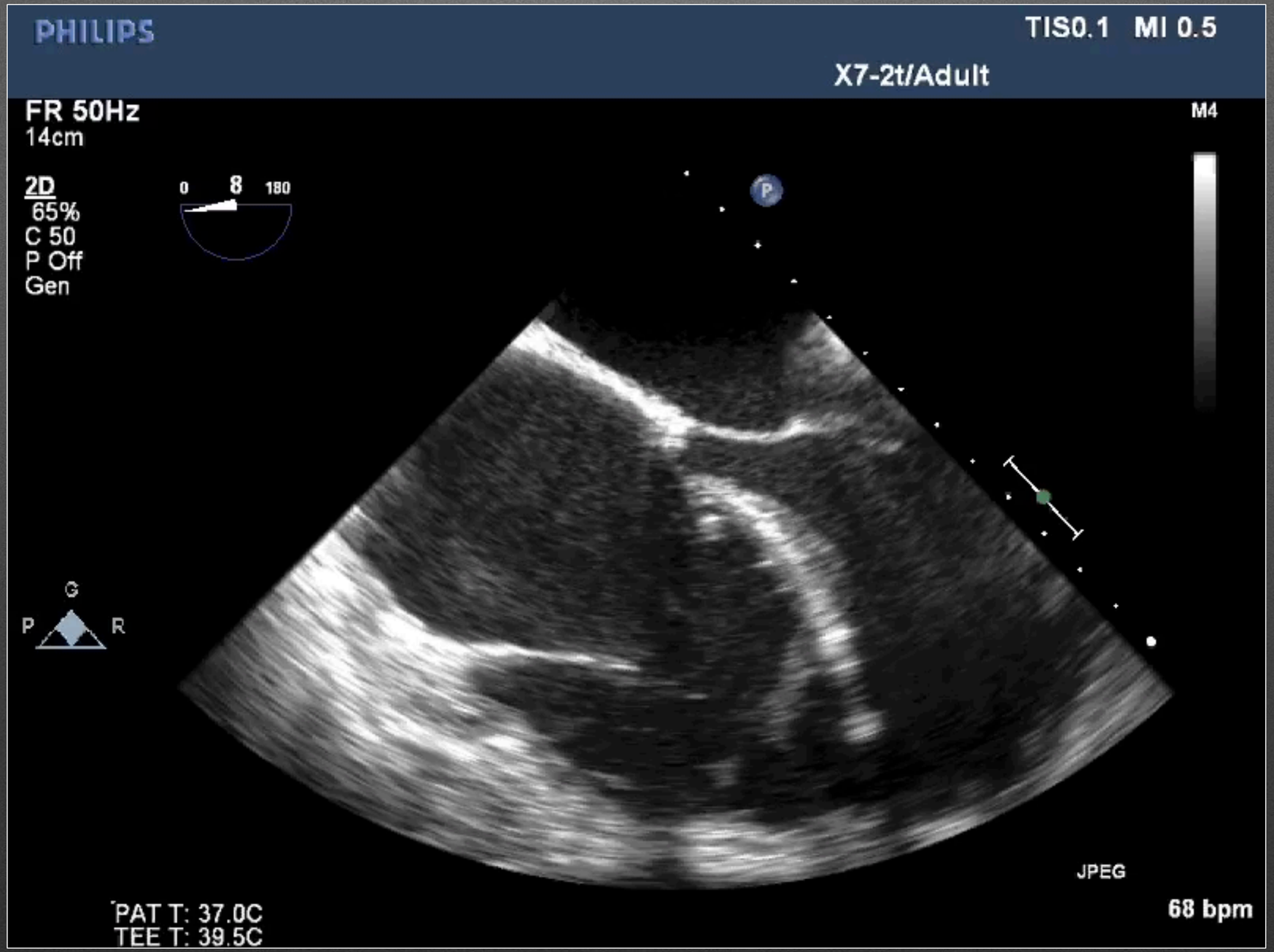
- Dyspnea
- Lower extremity edema

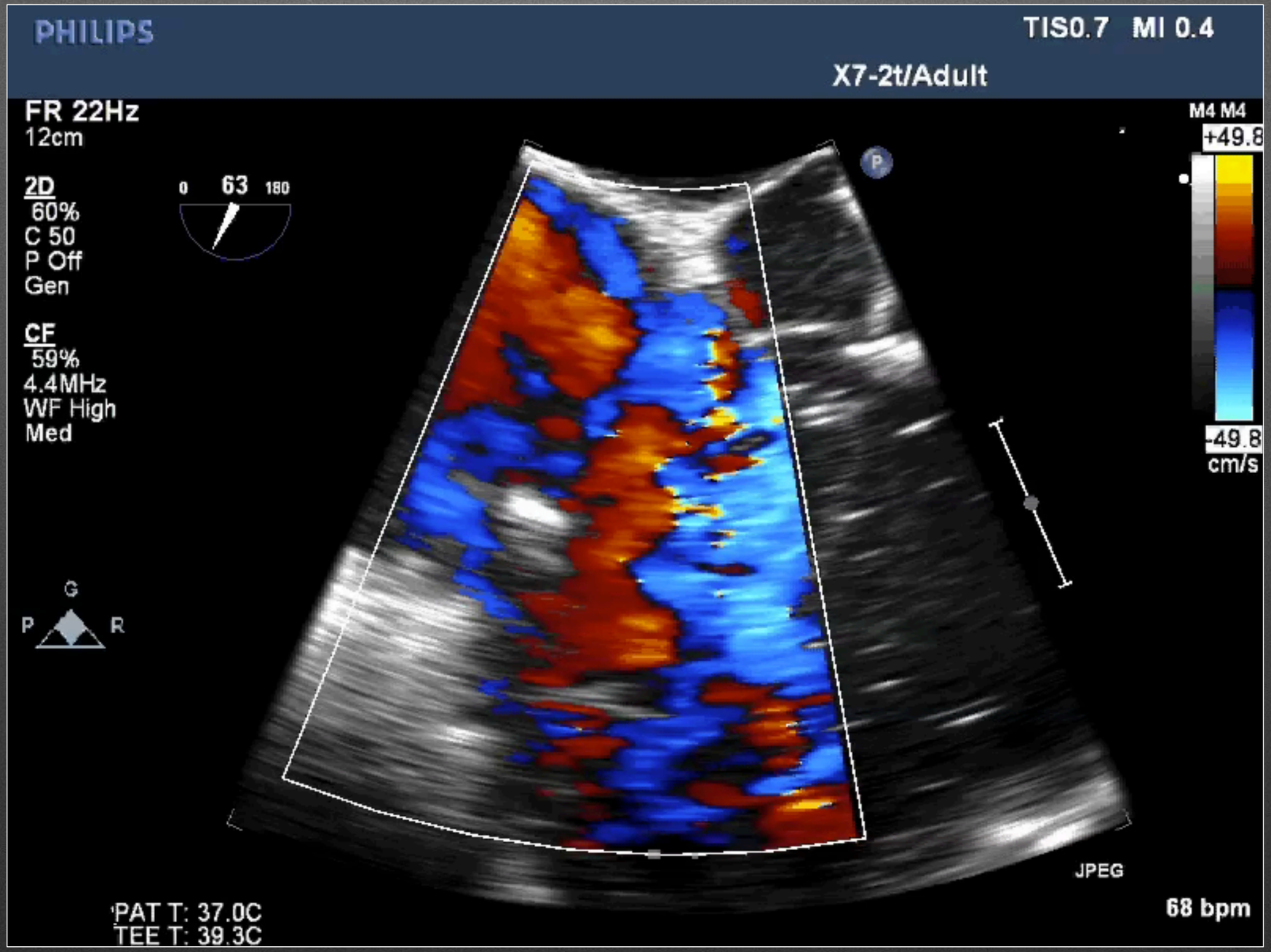

PHILIPS
TIS0.7 MI 1.4
S5-1/Adult
FR 67Hz
19cm
2D
73%
C 50
P Low
HPen
M3
P
X
G
P
R
1.4
2.8
JPEG
98 bpm

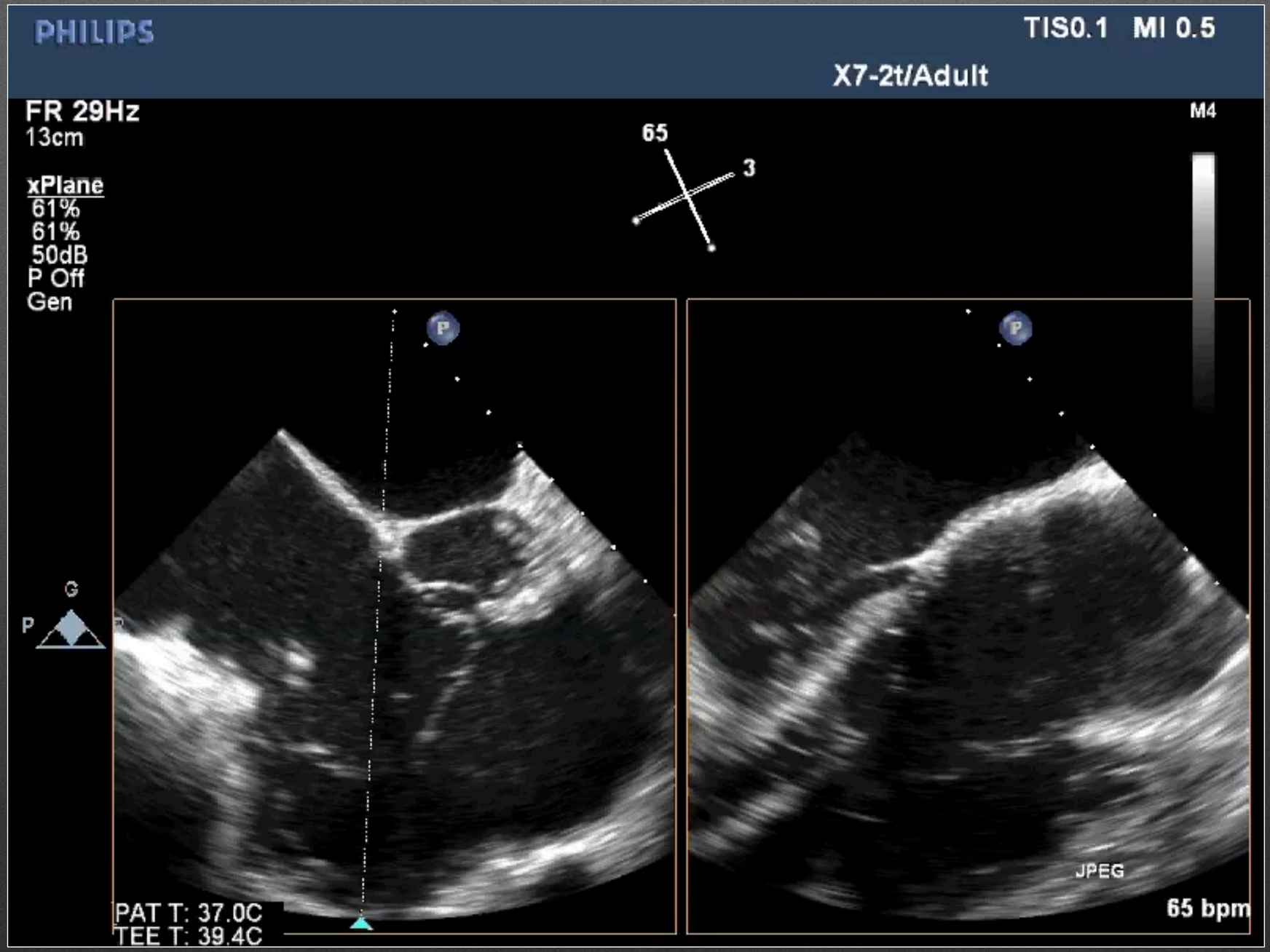

PHILIPS
TIS0.7 MI 1.4
S5-1/Adult
FR 67Hz
19cm
2D
73%
C 50
P Low
HPen
M3
P
G
P
R
1.4
2.8
JPEG
97 bpm

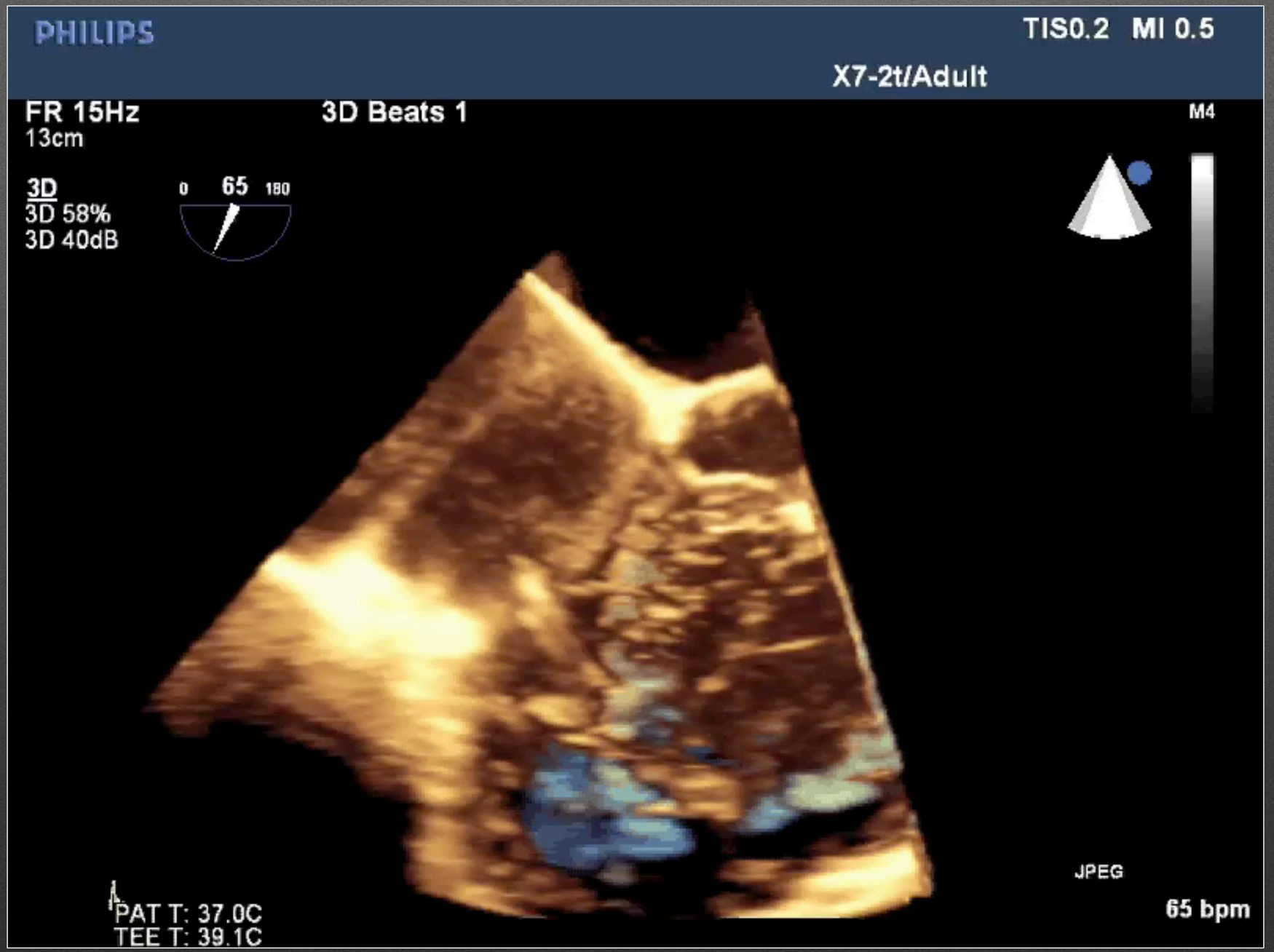

PHILIPS
TIS0.1 MI 0.5
X7-2t/Adult
FR 50Hz
13cm
M4
2D
62%
C 50
P Off
Gen
0 63 180
G
P R
JPEG
65 bpm
PAT T: 37.0C
TEE T: 39.3C


PHILIPS
TIS0.1 MI 0.5
X7-2t/Adult
FR 86Hz
12cm
2D
59%
C 50
P Off
Gen
0 63 180
M4
G
P R
JPEG
PAT T: 37.0C
TEE T: 39.3C
67 bpm


PHILIPS
TIS0.1 MI 0.5
X7-2t/Adult
FR 50Hz
14cm
M4
2D
65%
C 50
P Off
Gen
0 8 180
P
G
P R
JPEG
PAT T: 37.0C
TEE T: 39.5C
68 bpm

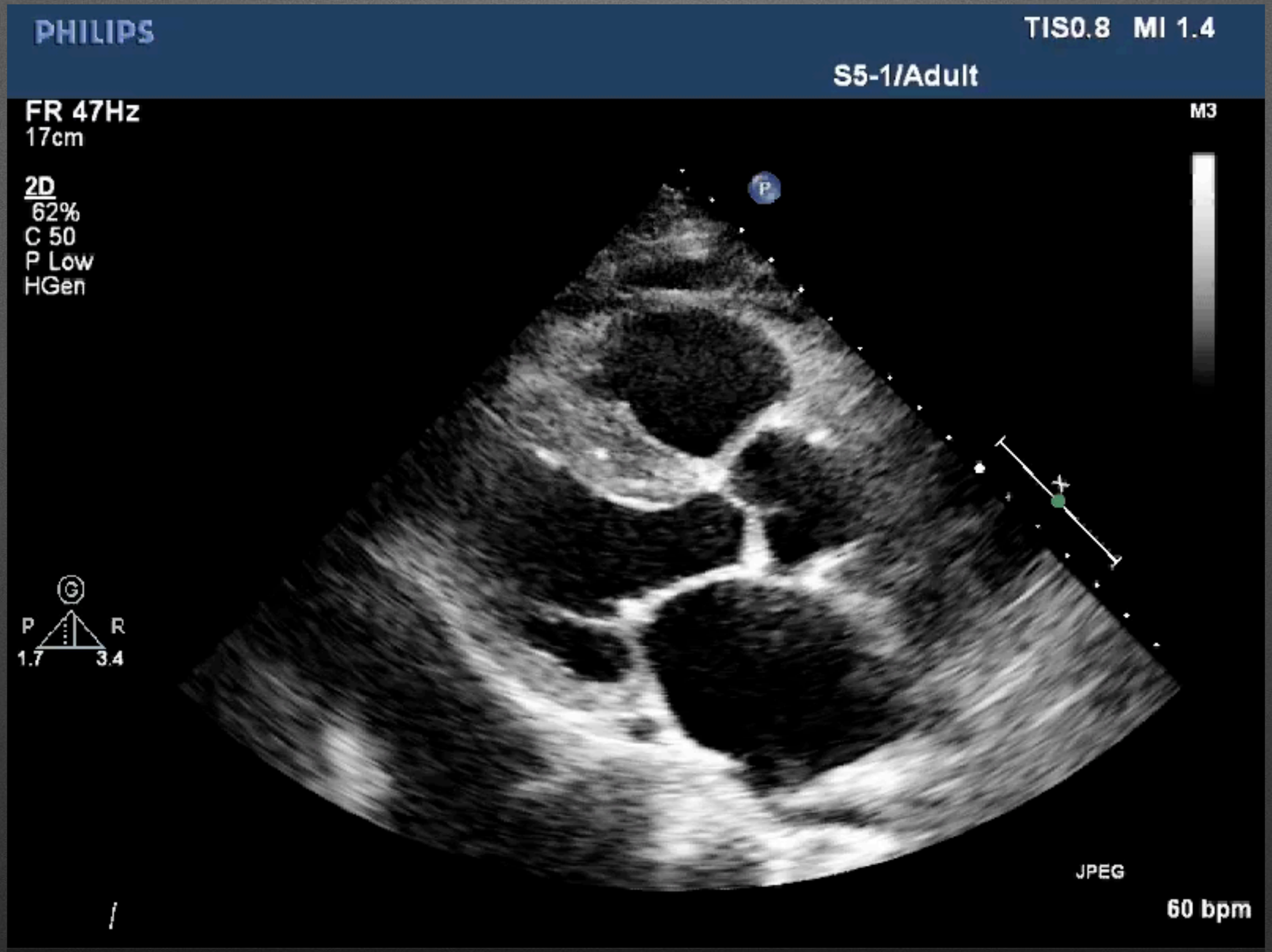

PHILIPS
TIS0.7 MI 0.4
X7-2t/Adult
FR 22Hz
12cm
2D
60%
C 50
P Off
Gen
0 63 180
CF
59%
4.4MHz
WF High
Med
M4 M4
+49.8
-49.8
cm/s
G
P R
JPEG
PAT T: 37.0C
TEE T: 39.3C
68 bpm

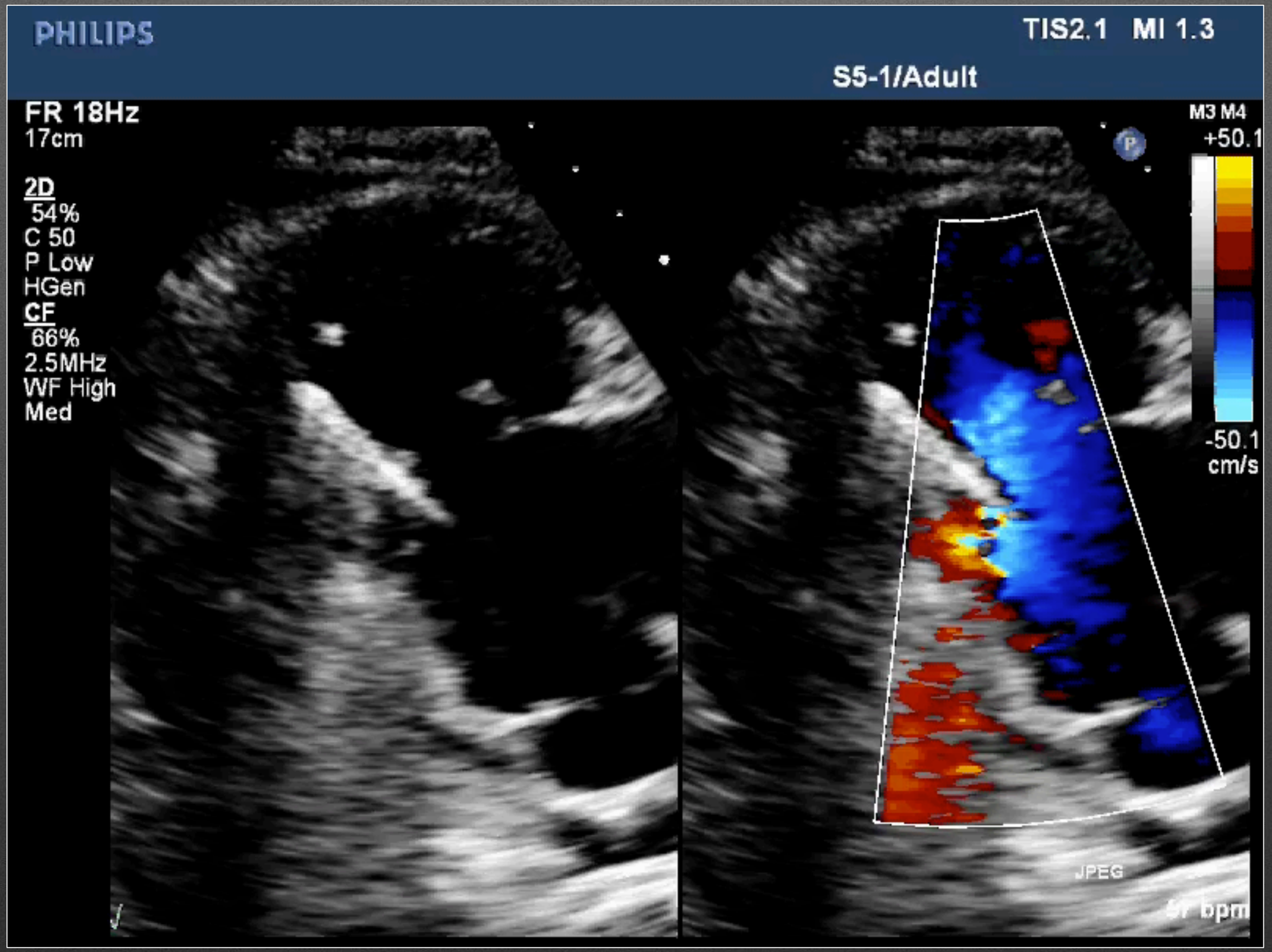

PHILIPS
TIS0.1 MI 0.5
X7-2t/Adult
FR 29Hz
13cm
xPlane
61%
61%
50dB
P Off
Gen
65
3
M4
G
P
PAT T: 37.0C
TEE T: 39.4C
JPEG
65 bpm

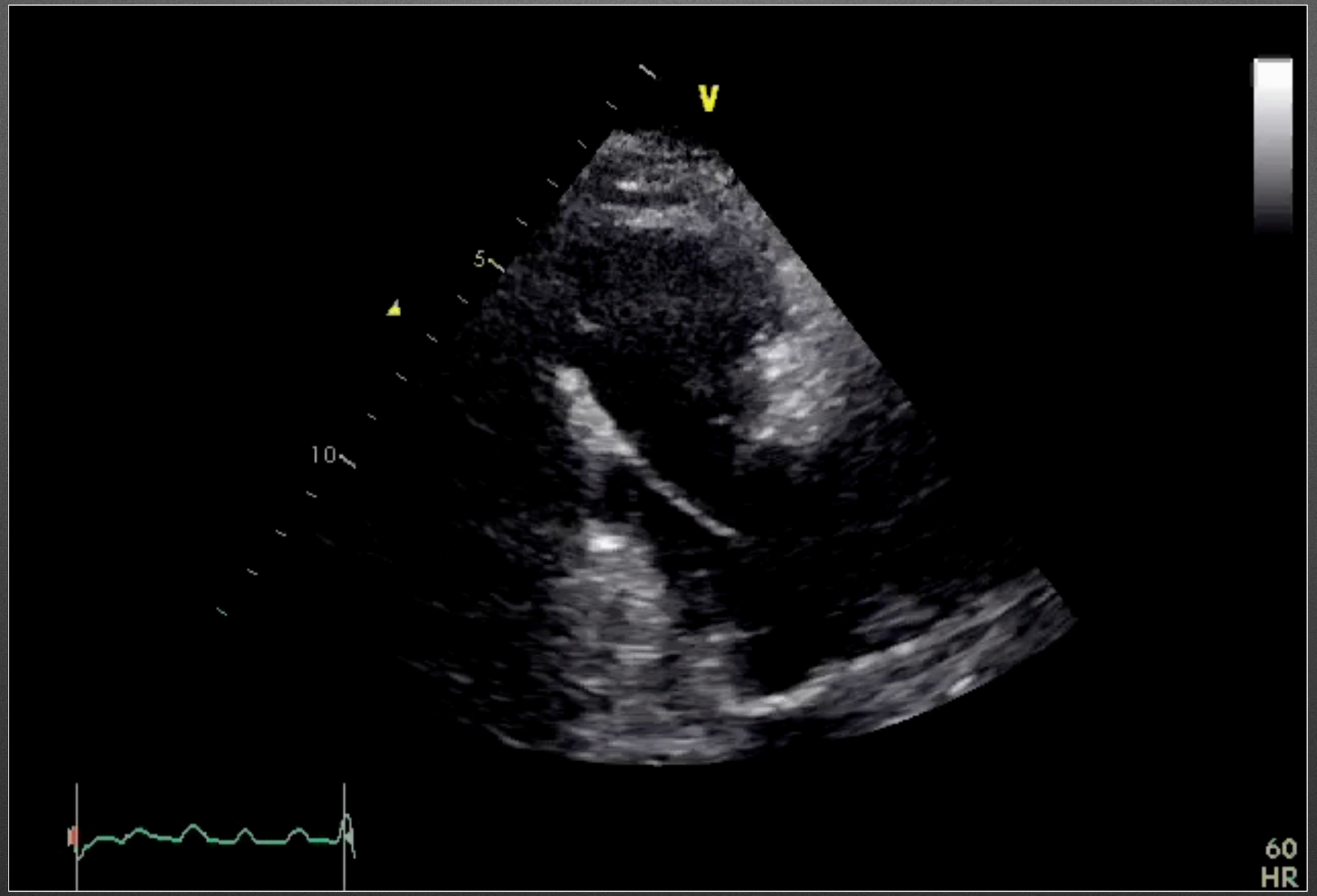

PHILIPS
TIS0.2 MI 0.5
X7-2t/Adult
FR 15Hz
13cm
3D Beats 1
M4
3D
3D 58%
3D 40dB
0
65
180
JPEG
PAT T: 37.0C
TEE T: 39.1C
65 bpm

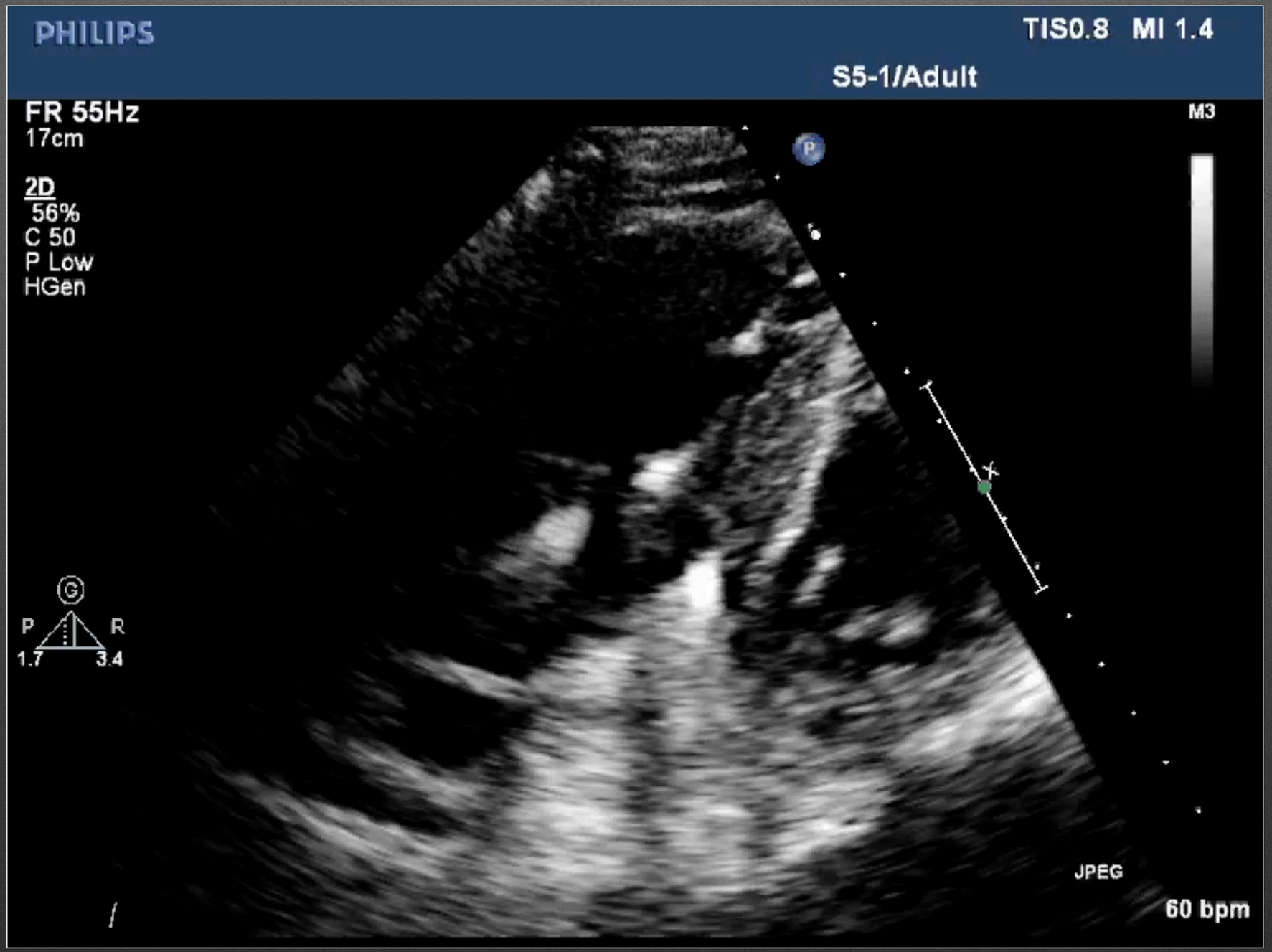
Case 5

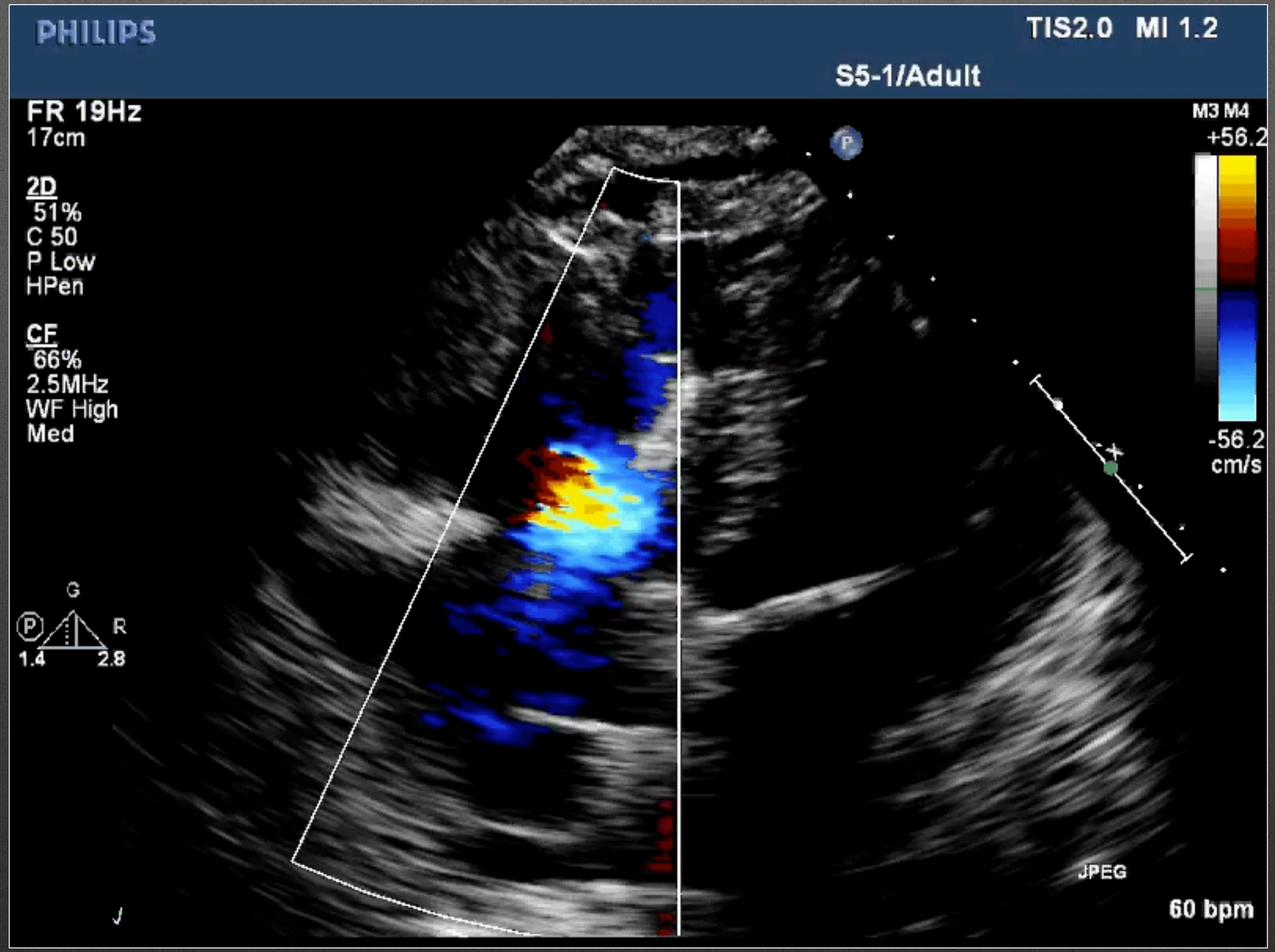
- 58 y/o female
- Pacemaker implantation X 9 yrs
- Clinical presentation
  - Dyspnea

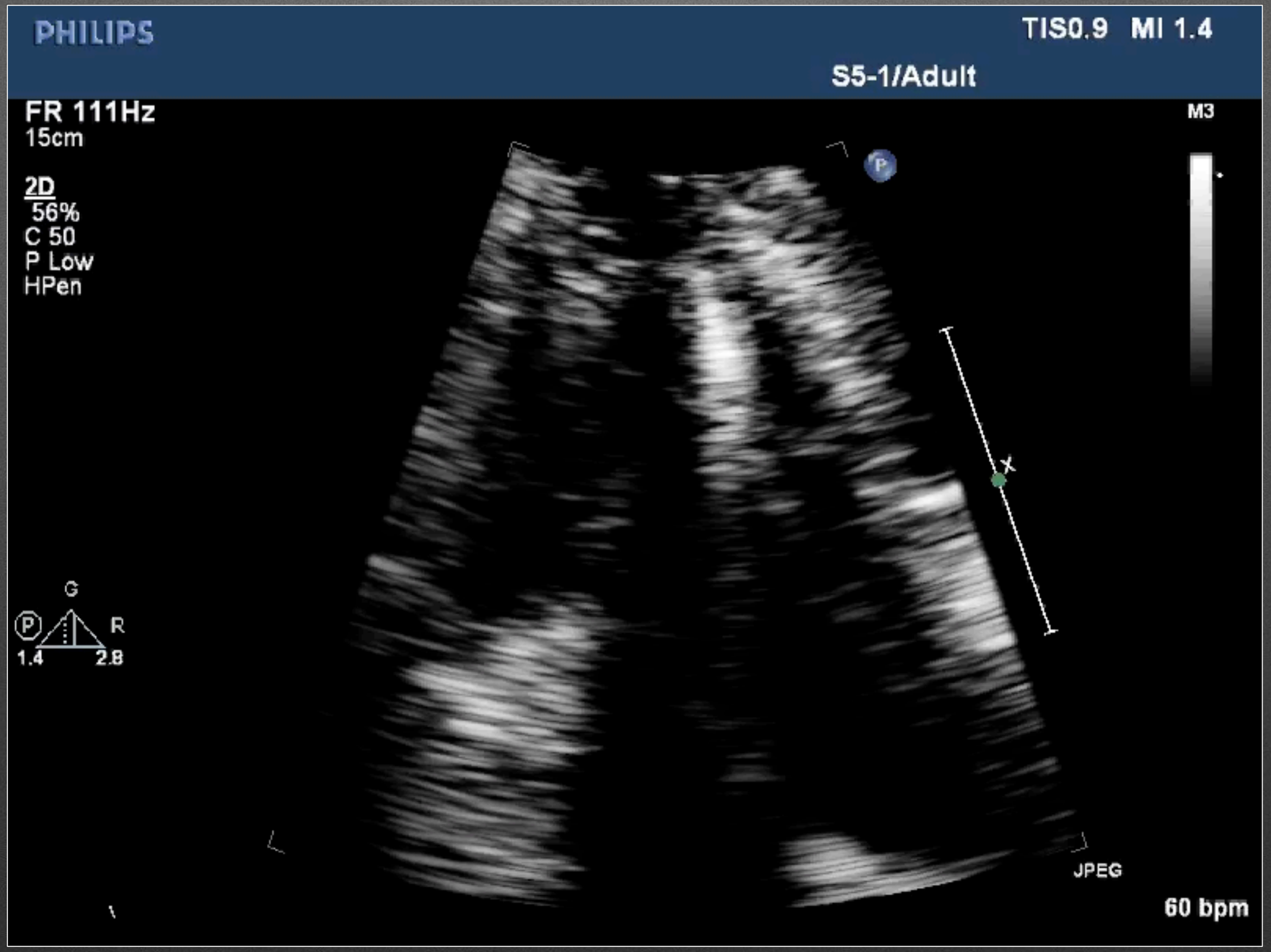

PHILIPS
TIS0.8 MI 1.4
S5-1/Adult
FR 47Hz
17cm
2D
62%
C 50
P Low
HGen
M3
G
P
R
1.7
3.4
JPEG
60 bpm

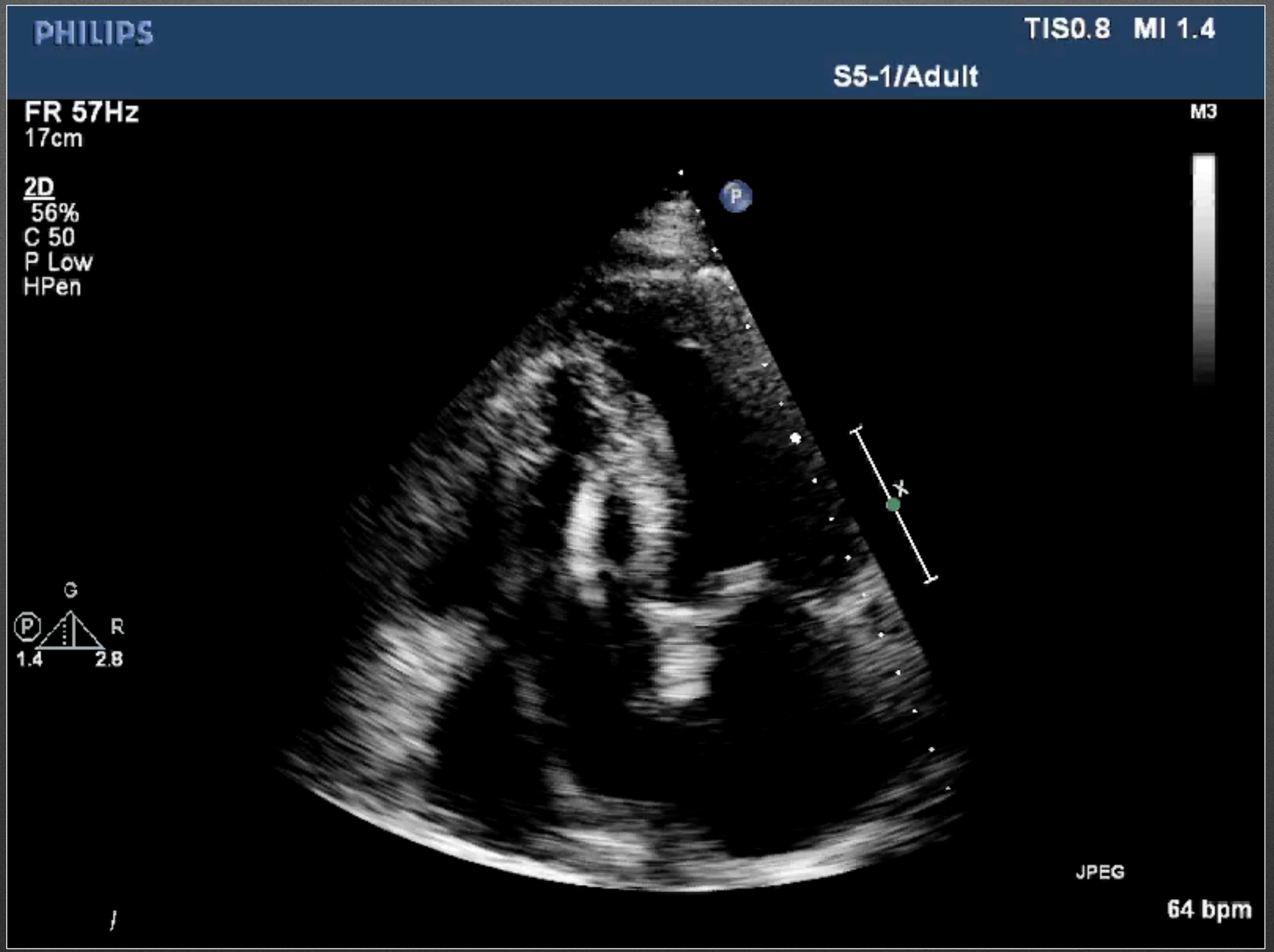

PHILIPS
TIS2.1 MI 1.3
S5-1/Adult
FR 18Hz
17cm
2D
54%
C 50
P Low
HGen
CF
66%
2.5MHz
WF High
Med
M3 M4
+50.1
-50.1
cm/s
JPEG
bpm

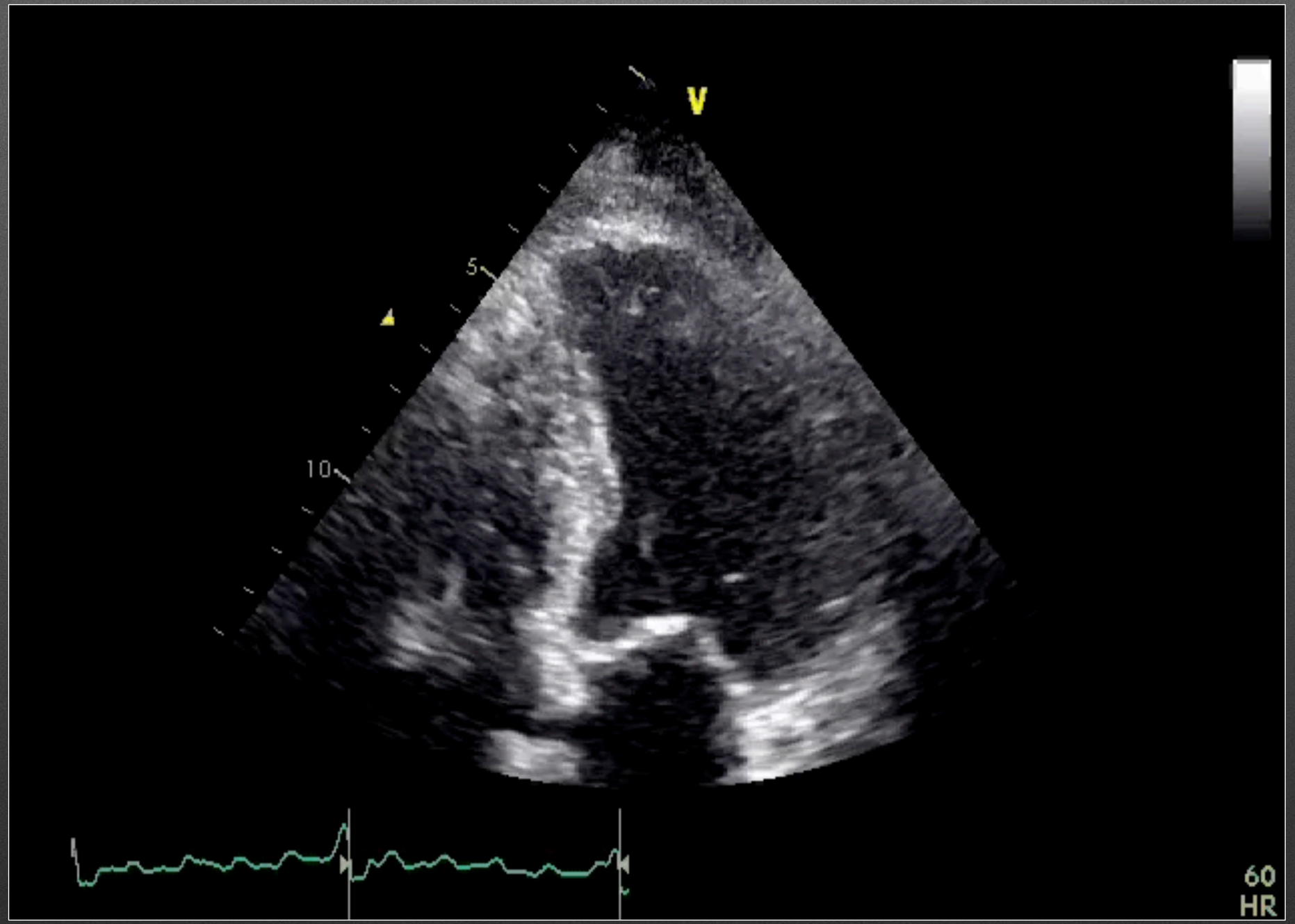

V
5
10
60
HR

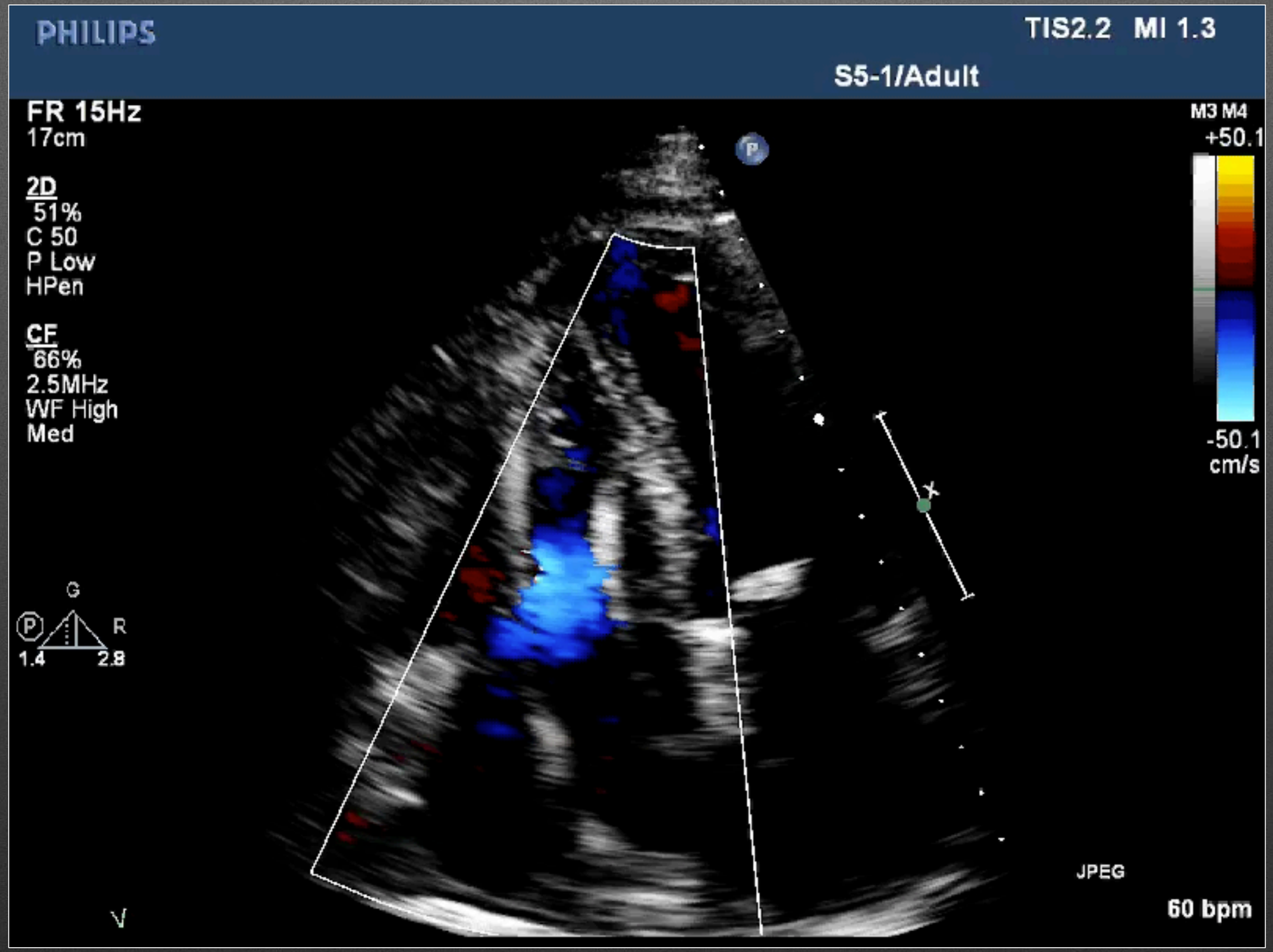

PHILIPS
TIS0.8 MI 1.4
S5-1/Adult
FR 55Hz
17cm
2D
56%
C 50
P Low
HGen
M3
P
G
P
R
1.7
3.4
JPEG
60 bpm

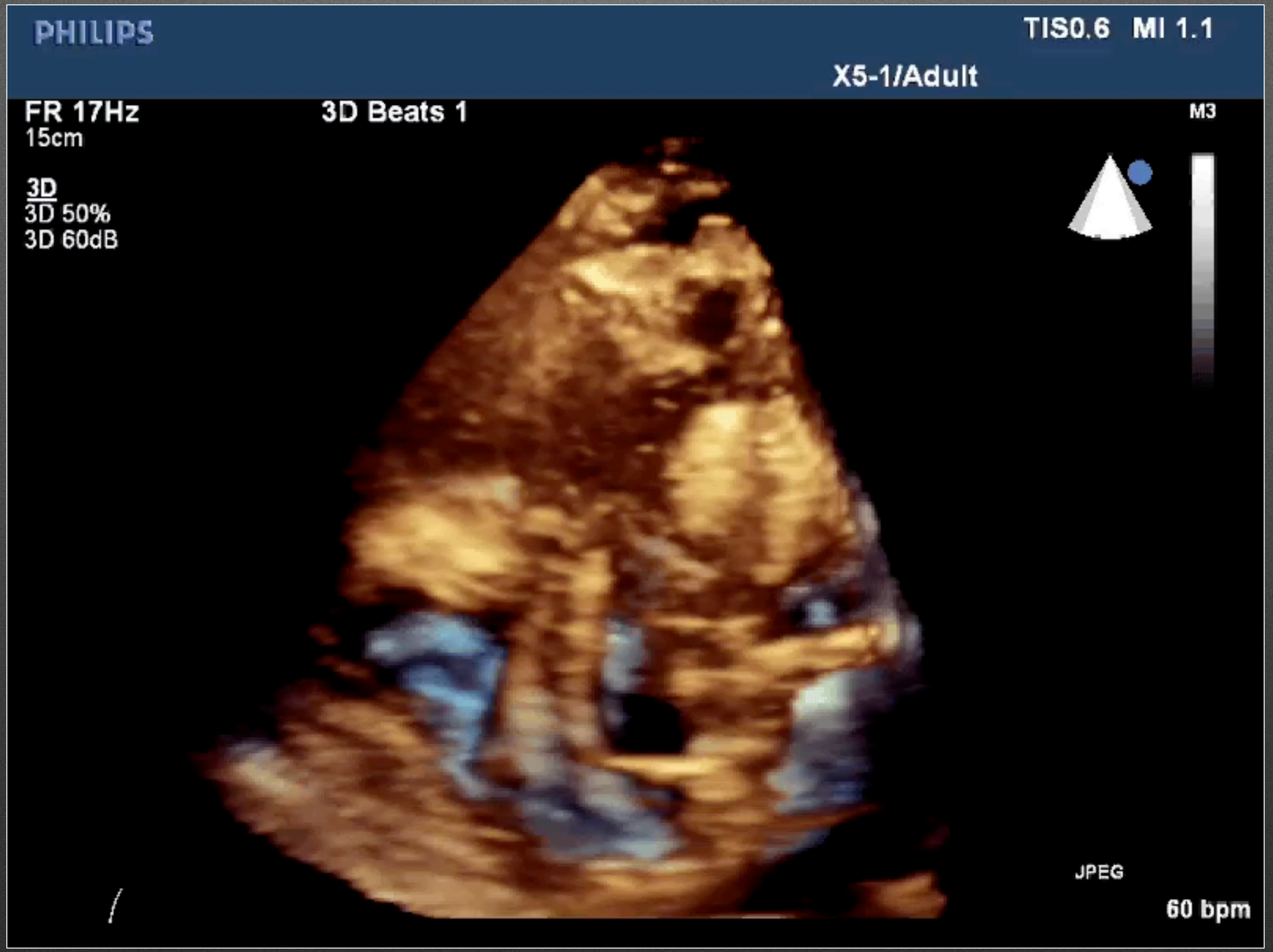

PHILIPS
TIS2.0 MI 1.2
S5-1/Adult
FR 19Hz
17cm
2D
51%
C 50
P Low
HPen
CF
66%
2.5MHz
WF High
Med
M3 M4
+56.2
-56.2
cm/s
G
P
R
1.4
2.8
JPEG
60 bpm


PHILIPS
TIS0.9 MI 1.4
S5-1/Adult
FR 111Hz
15cm
2D
56%
C 50
P Low
HPen
M3
G
P
R
1.4
2.8
JPEG
60 bpm

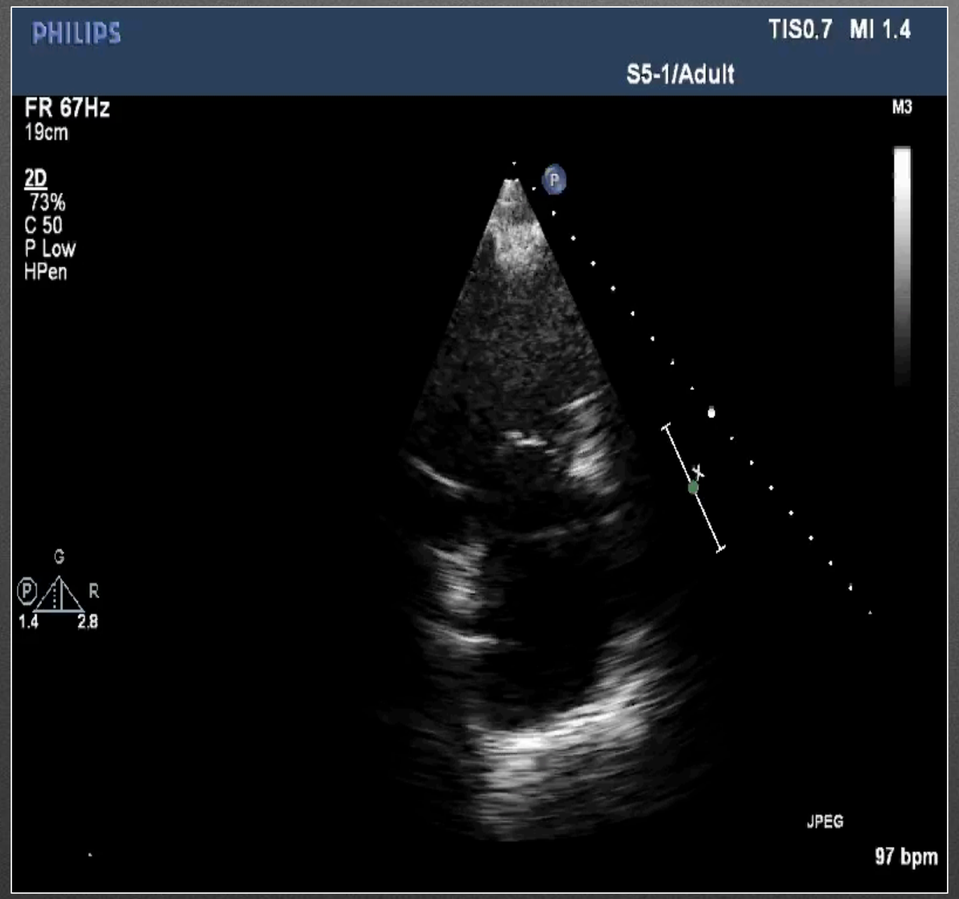

PHILIPS
TIS0.8 MI 1.4
S5-1/Adult
FR 57Hz
17cm
2D
56%
C 50
P Low
HPen
M3
G
R
1.4
2.8
JPEG
64 bpm


V
5
10
60
HR


PHILIPS
TIS2.2 MI 1.3
S5-1/Adult
FR 15Hz
17cm
2D
51%
C 50
P Low
HPen
CF
66%
2.5MHz
WF High
Med
M3 M4
+50.1
-50.1
cm/s
G
P
R
1.4
2.8
JPEG
60 bpm

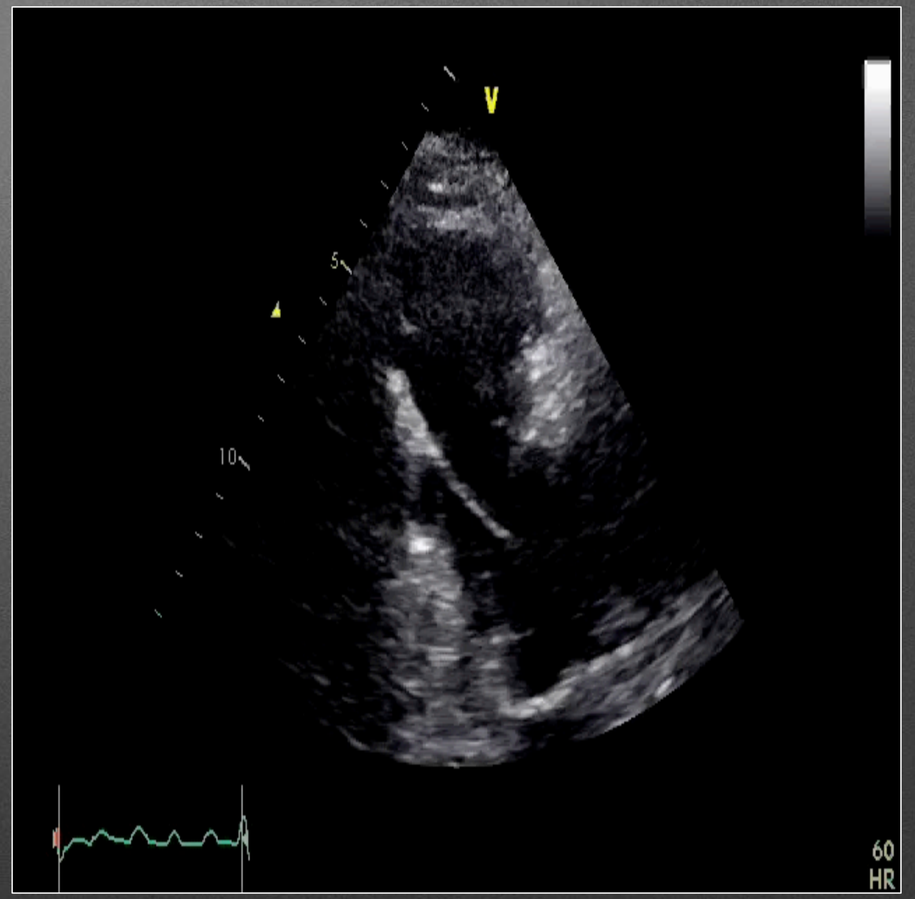

PHILIPS
TIS0.6 MI 1.1
X5-1/Adult
FR 17Hz
15cm
3D Beats 1
M3
3D
3D 50%
3D 60dB
JPEG
60 bpm

CASE 4



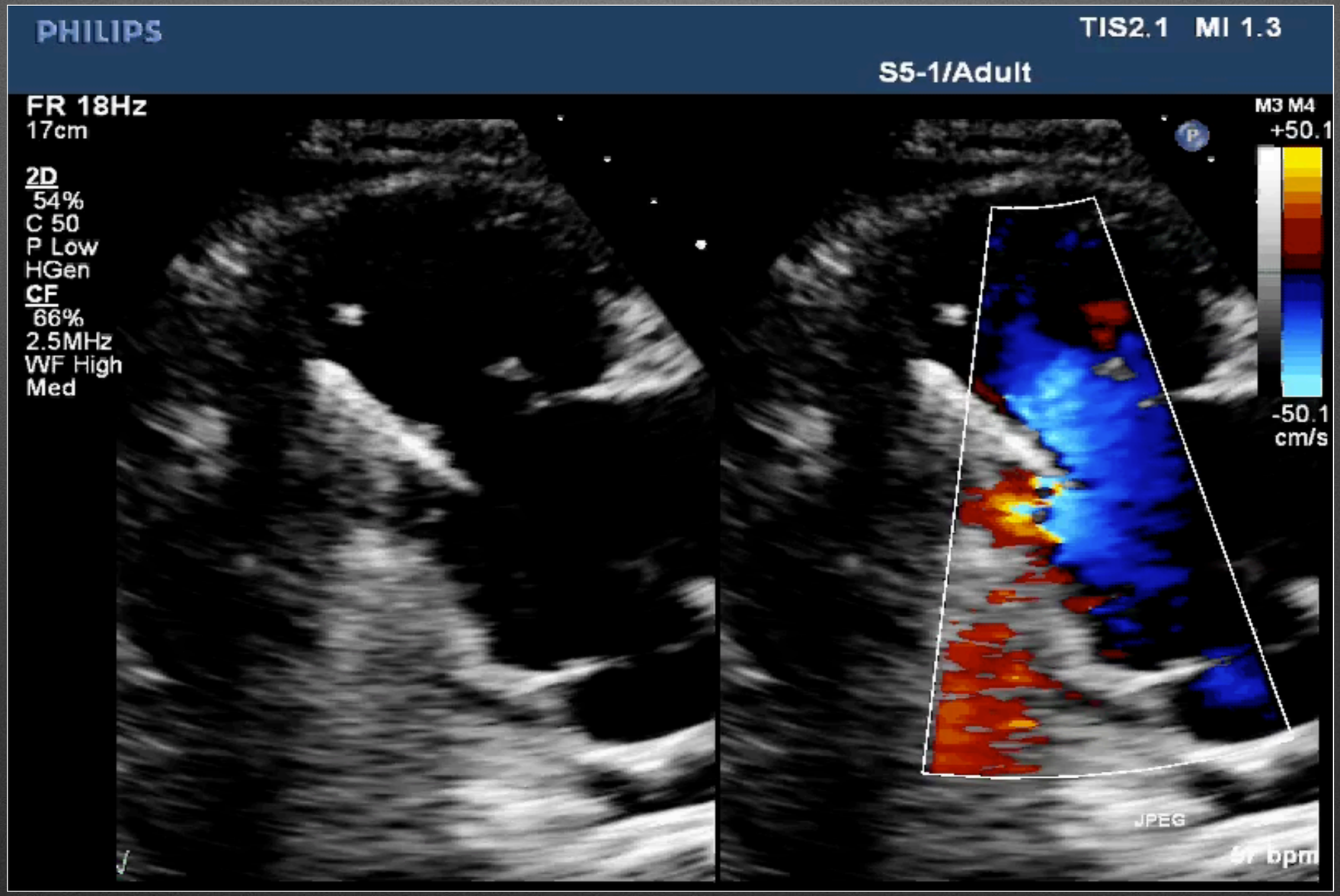
Entrapment or not?

CASE 5



Entrapment or not?

CASE 5


PHILIPS
TIS2.1 MI 1.3
S5-1/Adult
FR 18Hz
17cm
2D
54%
C 50
P Low
HGen
CF
66%
2.5MHz
WF High
Med
M3 M4
+50.1
-50.1
cm/s
JPEG

Address for correspondence:
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Cardiac Catheterization Laboratory

Tricus
Pacem
Defibr

Rasha Al-Ba
Justin Dunn,
Samir R. Ka
Department I
(Krishnaswar
Cleveland, Oh

Reviews

Tricuspid Regurgitation in Patients With Pacemakers and Implantable Cardiac Defibrillators: A Comprehensive Review

Rasha Al-Bawardy, MD; Amar Krishnaswamy, MD; Mandeep Bhargava, MD; Justin Dunn, MD; Oussama Wazni, MD; E. Murat Tuzcu, MD; William Stewart, MD; Samir R. Kapadia, MD

Department Internal Medicine (Al-Bawardy) and the Department of Cardiovascular Medicine (Krishnaswamy, Bhargava, Dunn, Wazni, Tuzcu, Stewart, Kapadia), Cleveland Clinic Foundation, Cleveland, Ohio

ABSTRACT

Introduction

Tricuspid regurgitation (TR) is a common valvular lesion, with 1.6 million people in the United States affected by moderate or severe TR.[1] The pathophysiology is divided into 2 major categories: functional (associated with left or right heart pathology) and structural (from primary leaflet abnormalities). Functional tricuspid regurgitation often results from left-sided heart valve disease.[1] The incidence of TR may be increasing in frequency coincident with the use of implanted cardiac devices, such as implantable cardioverter-defibrillators (ICDs) and permanent pacemakers (PPMs). This association was first described by Gibson and colleagues in 1980.[2] The current literature regarding symptomatic, lead-related TR following ICD or PPM is based mainly on case reports and observational studies.[3] In this article, we provide a comprehensive review of the incidence, diagnosis, mechanism, and outcomes of TR in patients with cardiac devices.

($P < 0.05$).[4,5] Numerous authors have found worsening of preexisting TR by 1 or 2 grades in 11% to 25% of patients, over a period of 1 to 827 days after PPM or ICD placement [6–10] (Table 1). Tricuspid regurgitation may worsen, or new TR may develop after up to 7 years of device implantation.[4–10]

Evidence Supporting an Increase in TR After Cardiac Device Implantation: Paniagua and colleagues retrospectively evaluated 374 patients who were studied with echocardiography after pacemaker implantation, and reported an increase in the prevalence of moderate–severe TR (25% vs 12%, odds ratio [OR]: 4.75).[4] De Cock and colleagues prospectively compared 48 patients with PPM, followed them over a mean of 7.4 years, with age-matched controls without PPM. The prevalence of TR was 29% compared to 13.5% in the control group ($P < 0.05$).[5] However, they did not look at preimplantation tricuspid valve function.

Kim and colleagues studied 248 patients with either an ICD or PPM, with pre- and postimplantation echocardiograms.[10] Tricuspid regurgitation, based on jet area by color Doppler, worsened by at least 1 grade in 24.2%

Clin. Cardiol. 36, 5, 249–254 (2013)

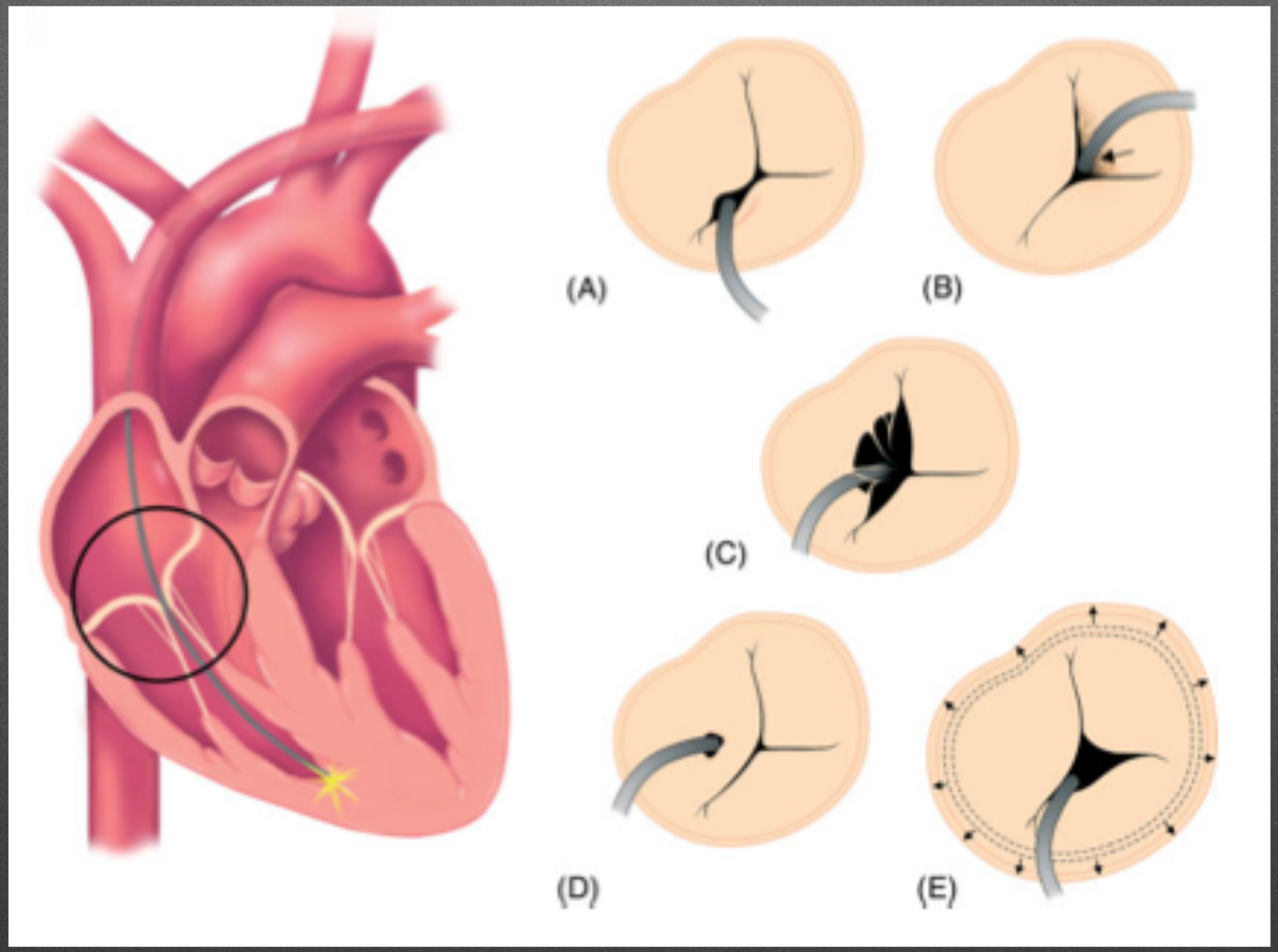


Figure 1. Mechanisms of mechanical tricuspid regurgitation in the setting of permanent pacemaker or implantable cardioverter-defibrillator leads. (a) Valve obstruction caused by lead placed in between leaflets. (b) Lead adherence due to fibrosis and scar formation to valve causing incomplete closure. (c) Lead entrapment in the tricuspid valve apparatus. (d) Valve perforation or laceration. (e) Annular dilatation.

Studies Assessing Prevalence of Lead-Related TR in Patients with PPM or ICD

Author of Study	No. of Patients	Median Age, y	ICD, %	Preprocedure Echo (Average Timing)	Postprocedure Echo (Average Timing)	Increase in Prevalence of TR by at Least 1 Grade, %	Statistical Significance of Difference in Prevalence (*P* Value)
De Cock et al[5]	48	62	0	No	Yes (7.4 years)	16[a]	<0.05
Paniagua et al[4]	745[b]	77.5	0	No	Yes (unknown)	13	<0.001
Leibowitz et al[9]	35	67	57	Yes (4.5 days)	Yes (1.2 days)	11	Unknown
Kucukarslan et al[8]	61	53	10	Yes (3 days)	Yes (1 day)	13	Unknown
Webster et al[7]	123	16	55	Yes (unknown)	Yes (242 days and 827 days)	25[c]	<0.05
Kim et al[10]	248	75.4	30	Yes (7 days)	Yes (93 days)	24	<0.05
Klutstein et al[6]	410	72-77	0	Yes (75 days)	Yes (113 days)	18	<0.001

Abbreviations: ICD, implantable cardiac defibrillator; PPM, permanent pacemaker; TR, tricuspid regurgitation.
[a]Unknown grade. [b]Paniagua et al. studied 374 patients but the prevalence of TR in the PPM group was reported out of the 745 patients. [c]At second postimplantation echocardiogram.

Compared to control which TR was 12-13%, TR prevalence in between 25% - 29% of patients with PM. TR may worsen or new TR may develop up to 7 years after device implant.

Studies Assessing PM TR with 1 Ventricular Lead vs 2 leads

Author of Study	No. of Patients	Median Age, y	ICD, %	Preprocedure Echo	Postprocedure Echo (Average Timing)	Prevalence of TR (Grade), %	Statistically Significant Difference Between the Groups With 1 and 2 Leads (*P* Value)
Celiker et al[14]							
1-lead group	22	69	0	No	Yes (2433 days)	18.2 (moderate), 59.1 (mild)	NS
2-lead group	18	67	0	No	Yes (1186 days)	22.2 (moderate), 61.1 (mild)	
Postaci et al[15]							
1-lead group	32	61	0	No	Yes (2 years)	9.4 (grade 2)	<0.05
2-lead group	18	61	0	No	Yes (2 years)	55.6 (grade 2)	

Abbreviations: ICD, implantable cardiac defibrillator; NS, not significant; TR, tricuspid regurgitation.

Predictors of TR after implant are not well understood. Placement of more than one lead may or may not worsen TR, conflicting data.

Echo Imaging Diagnosis

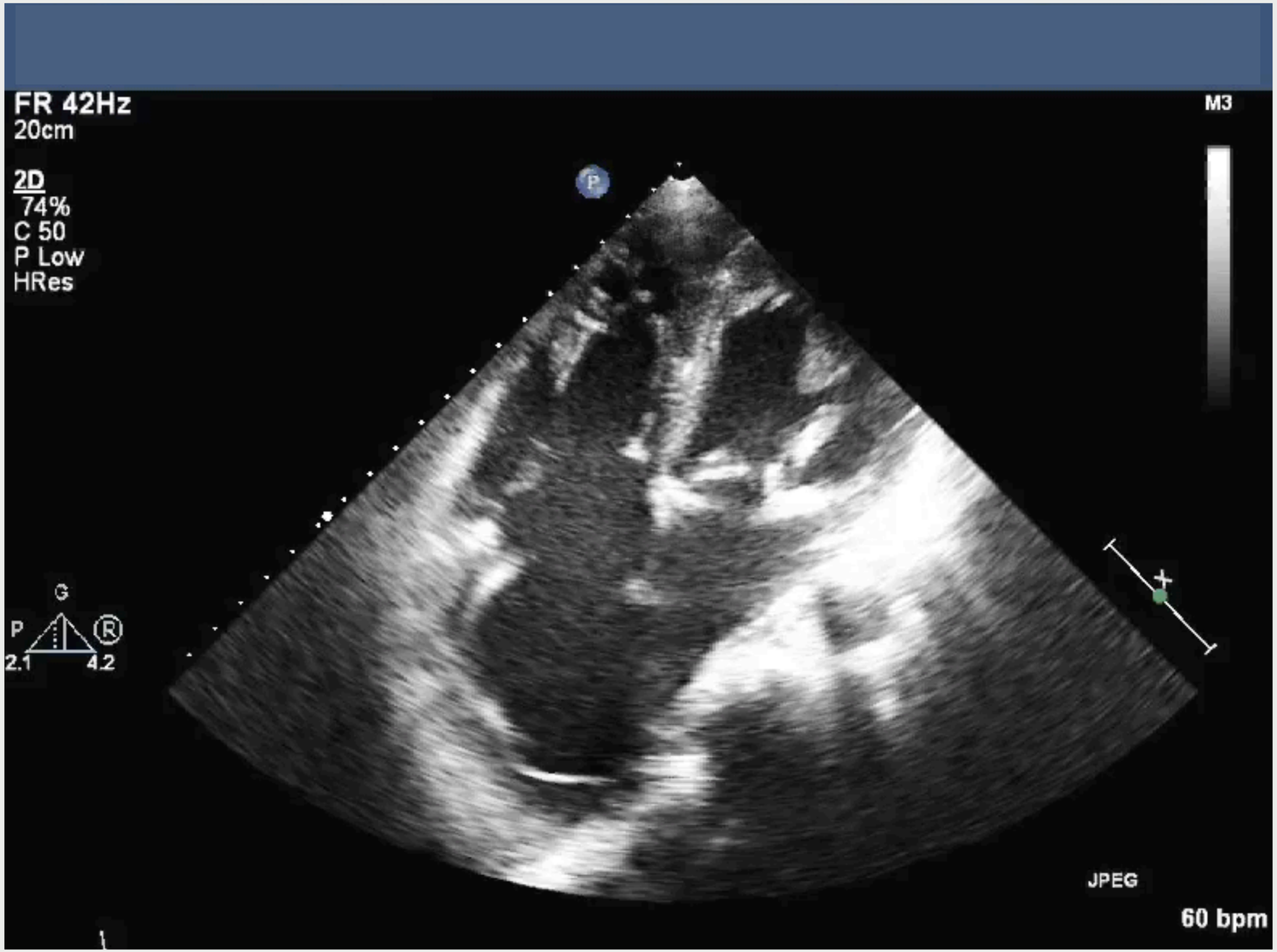
- 2D and Color flow Doppler are essential
- Increasing role of 3D
  - Viewing posterior TV leaflet
  - Visualize 2 leads
    - Could be missed on single 2D plane
- Use multiple acoustic windows
  - PM shadowing could lead to suboptimal visualization

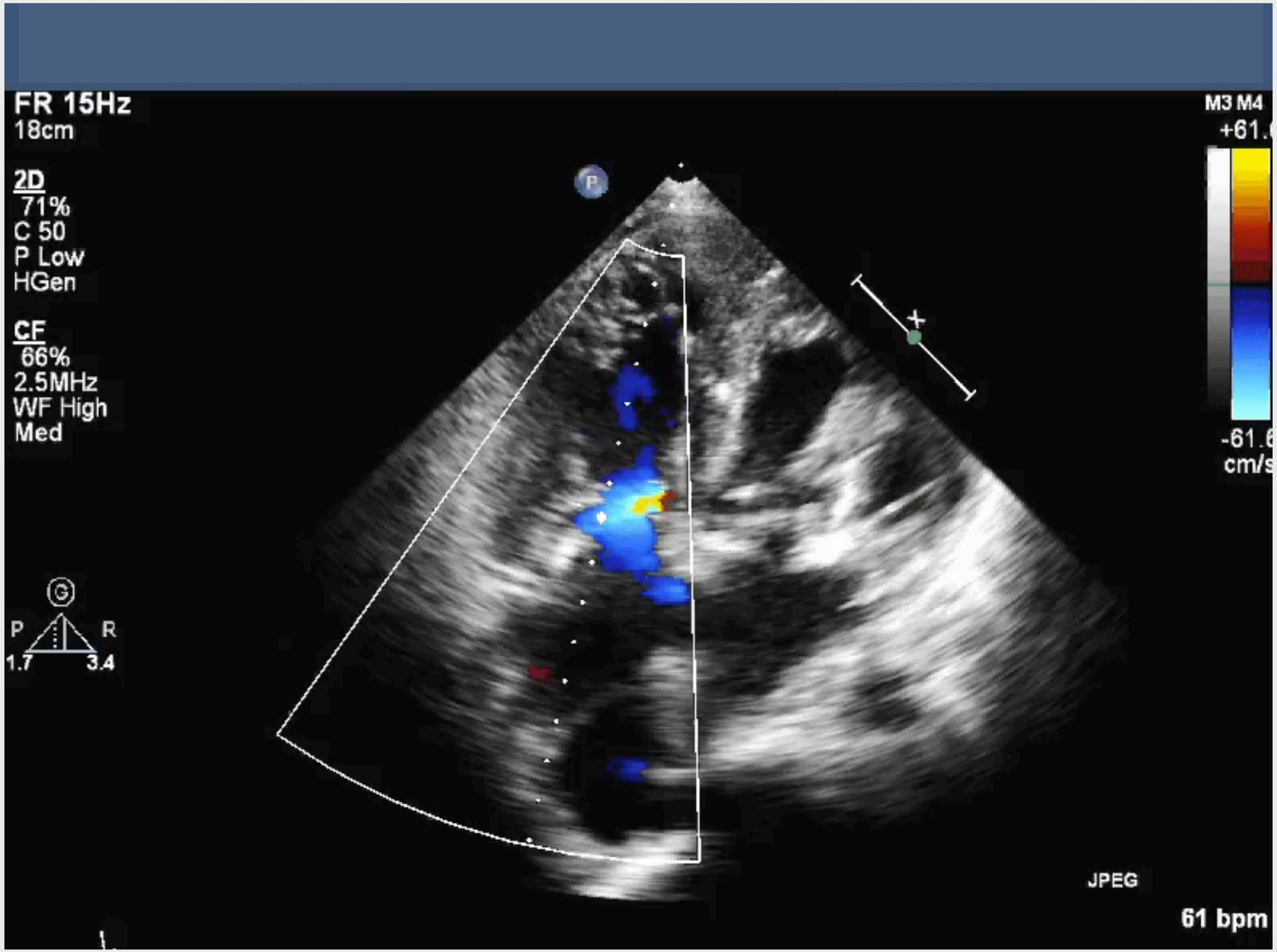
Sonographer “Soap-box”

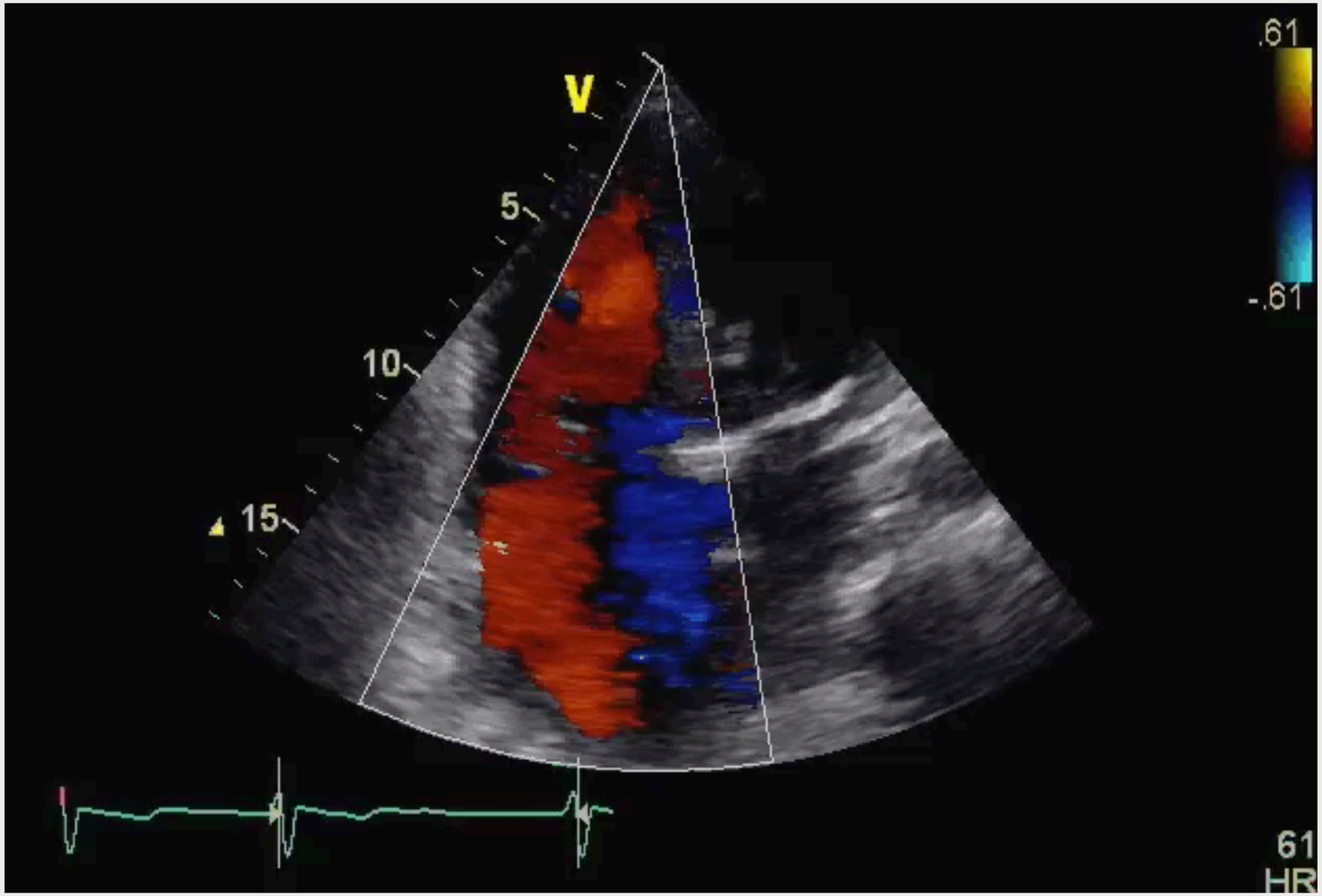
- Become a detective
- Look for mechanism of TR
  - Primary (organic) or Secondary (functional)
  - Pacemaker Entrapment, Adherence, Perforation
- Visualize all three leaflets
  - Septal and posterior leaflets

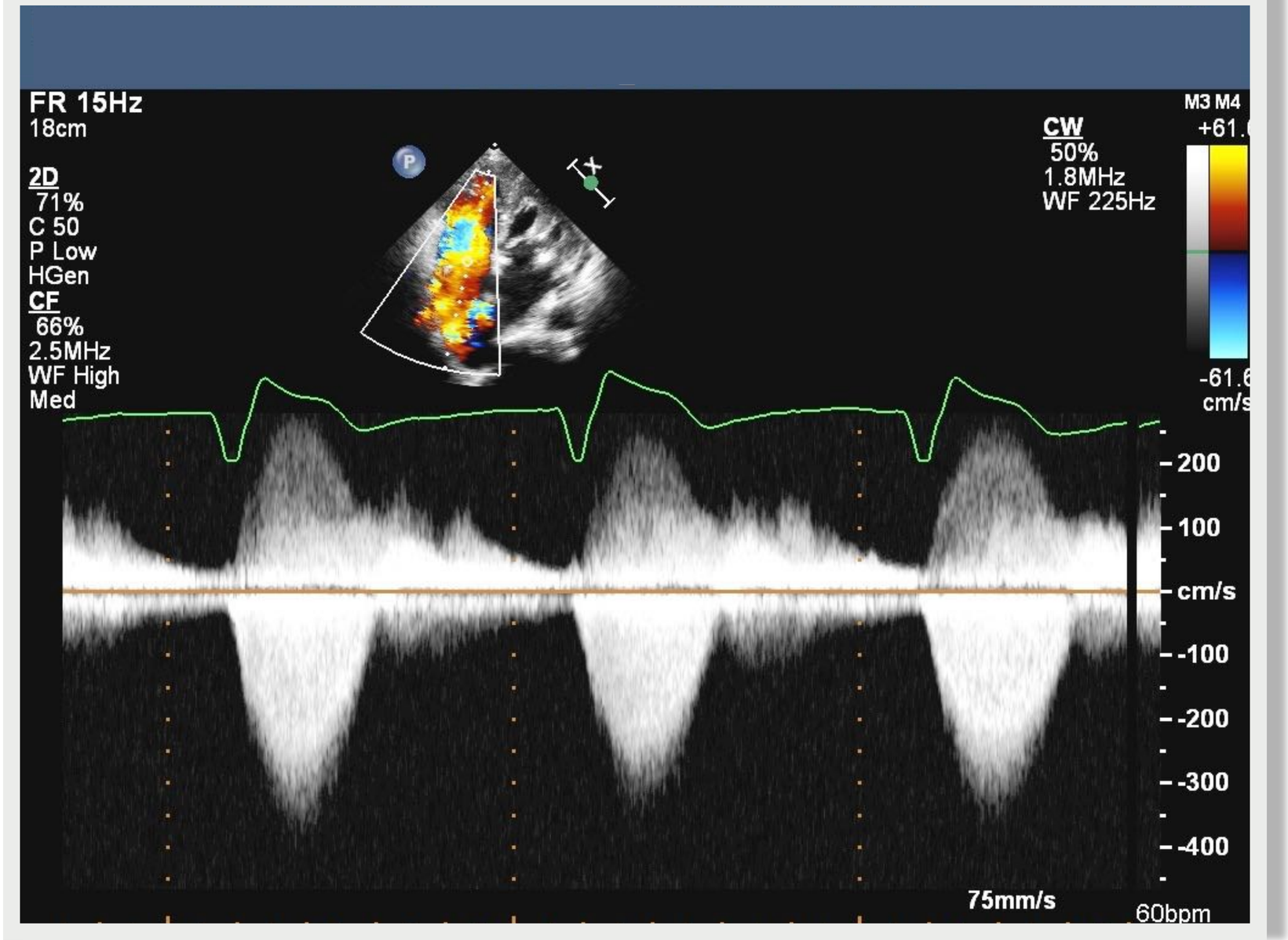
Case #6

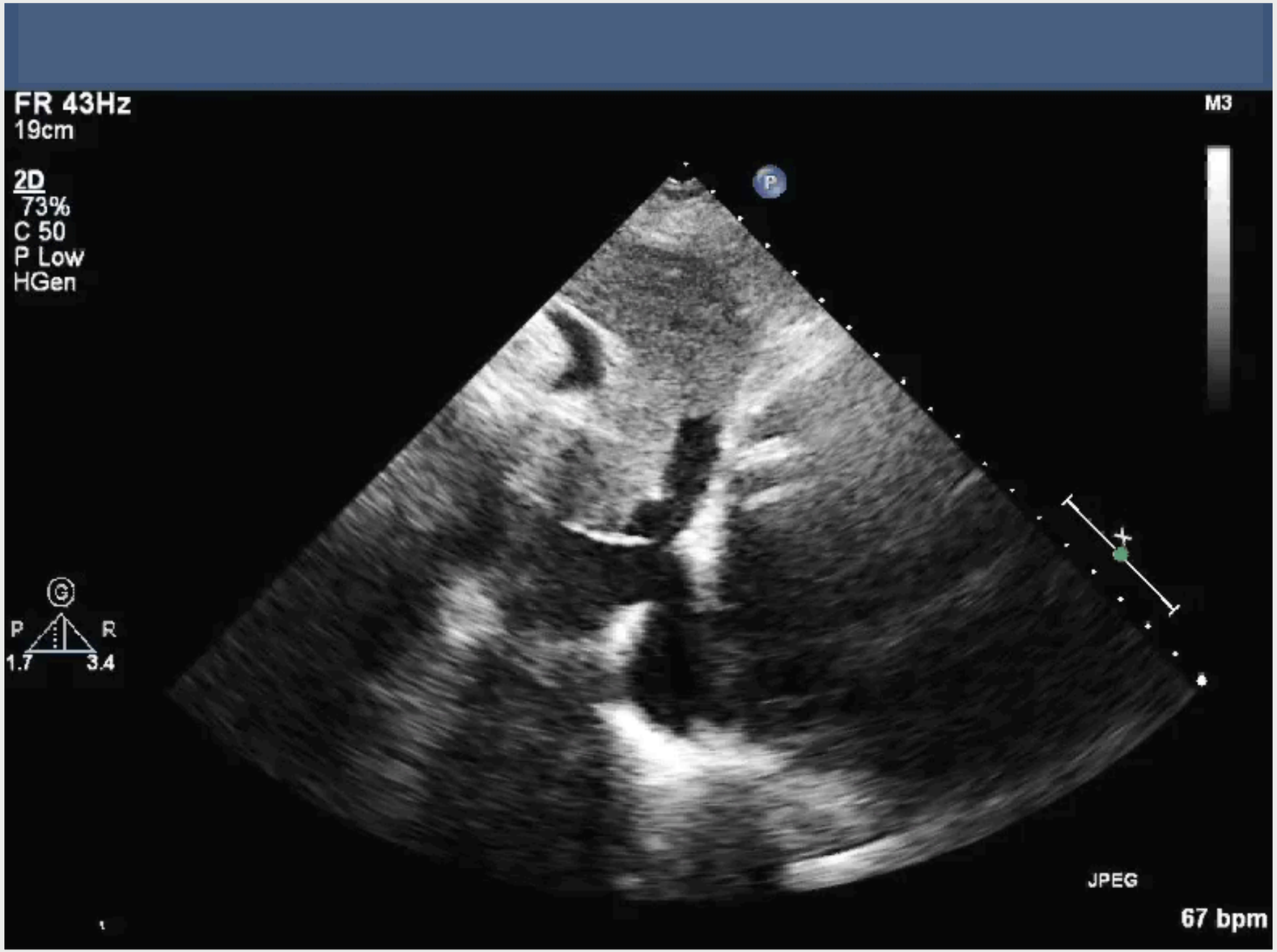
- 76 yr old Female
- Grade 4/6 systolic murmur
- PM implant 2008
- Fatigue
- SOB
- Lower extremity Edema
- Echo indication: Heart Failure

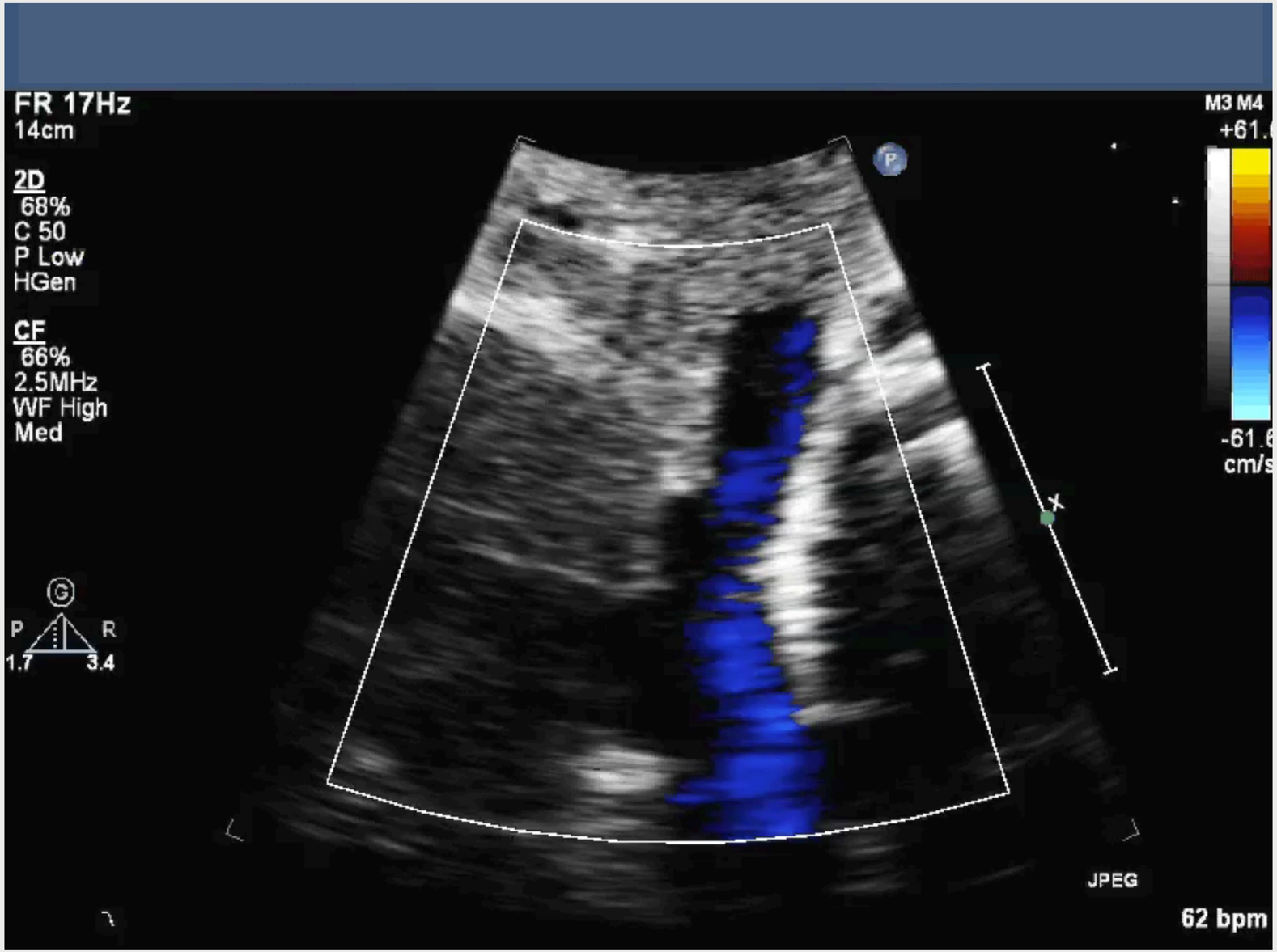

FR 42Hz
20cm
2D
74%
C 50
P Low
HRes
M3
P
G
P
R
2.1
4.2
JPEG
60 bpm

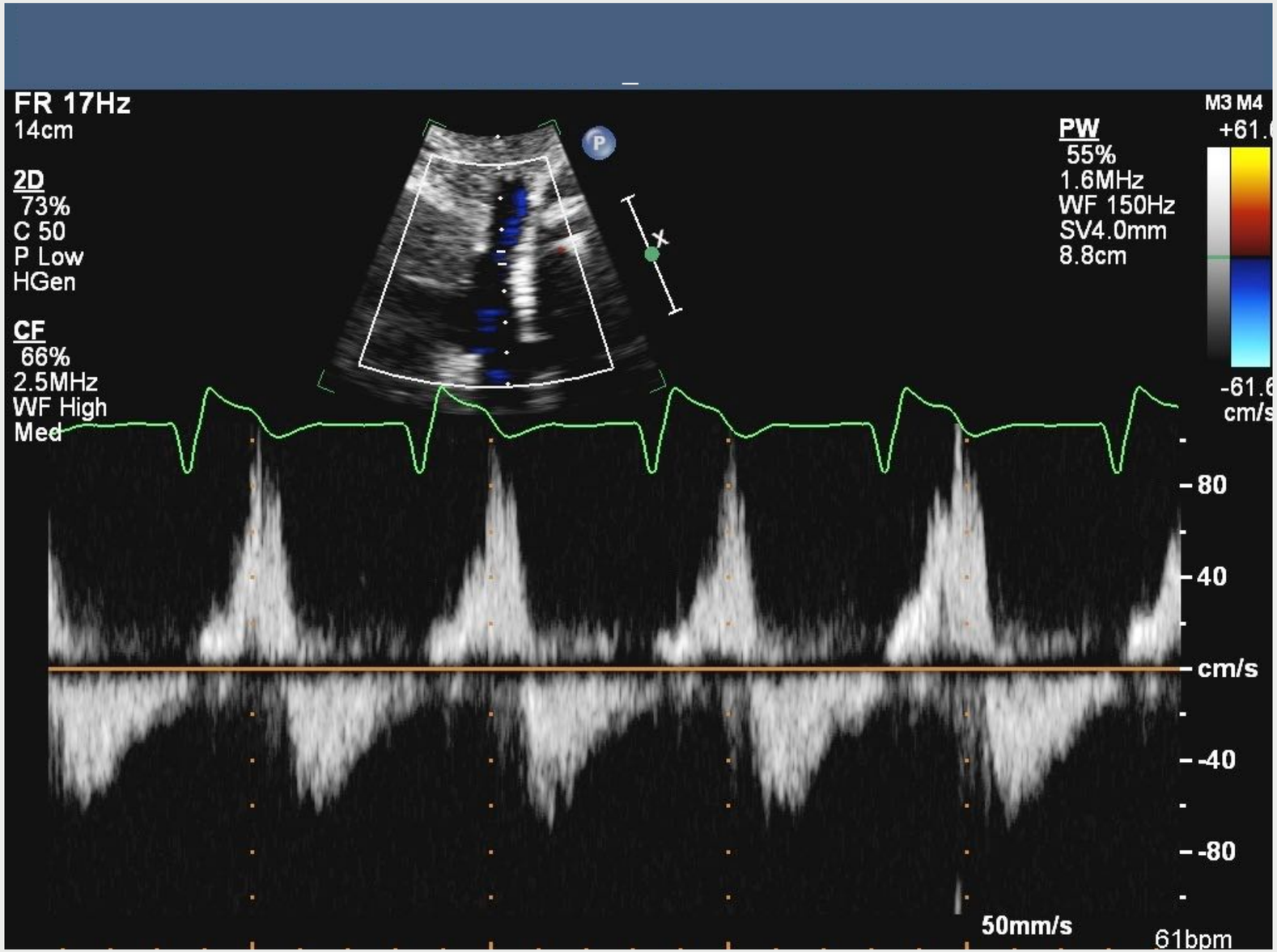

FR 15Hz
18cm
2D
71%
C 50
P Low
HGen
CF
66%
2.5MHz
WF High
Med
P
R
1.7
3.4
M3 M4
+61.
-61.6
cm/s
JPEG
61 bpm

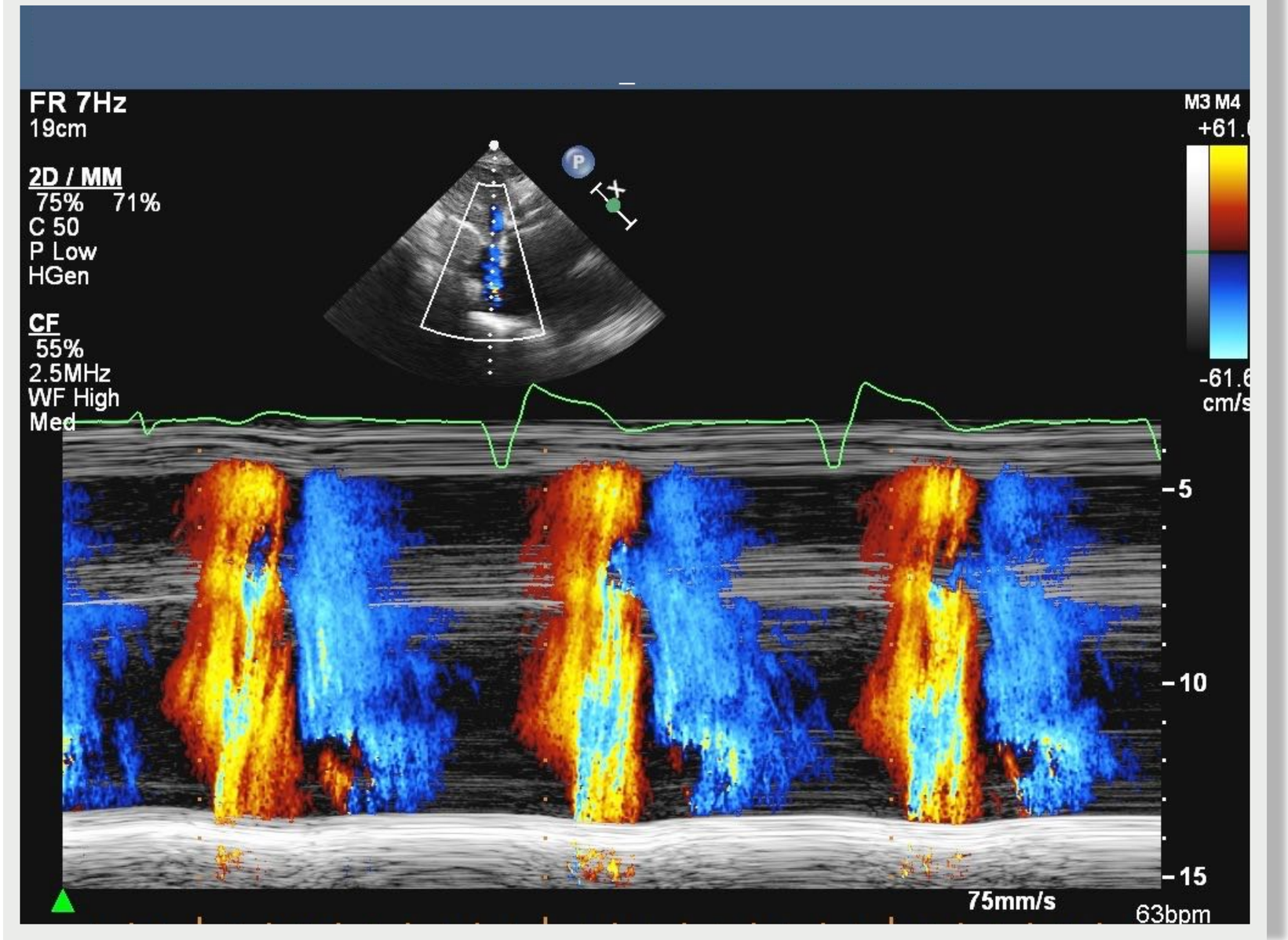

V
5
10
15
.61
-.61
61
HR

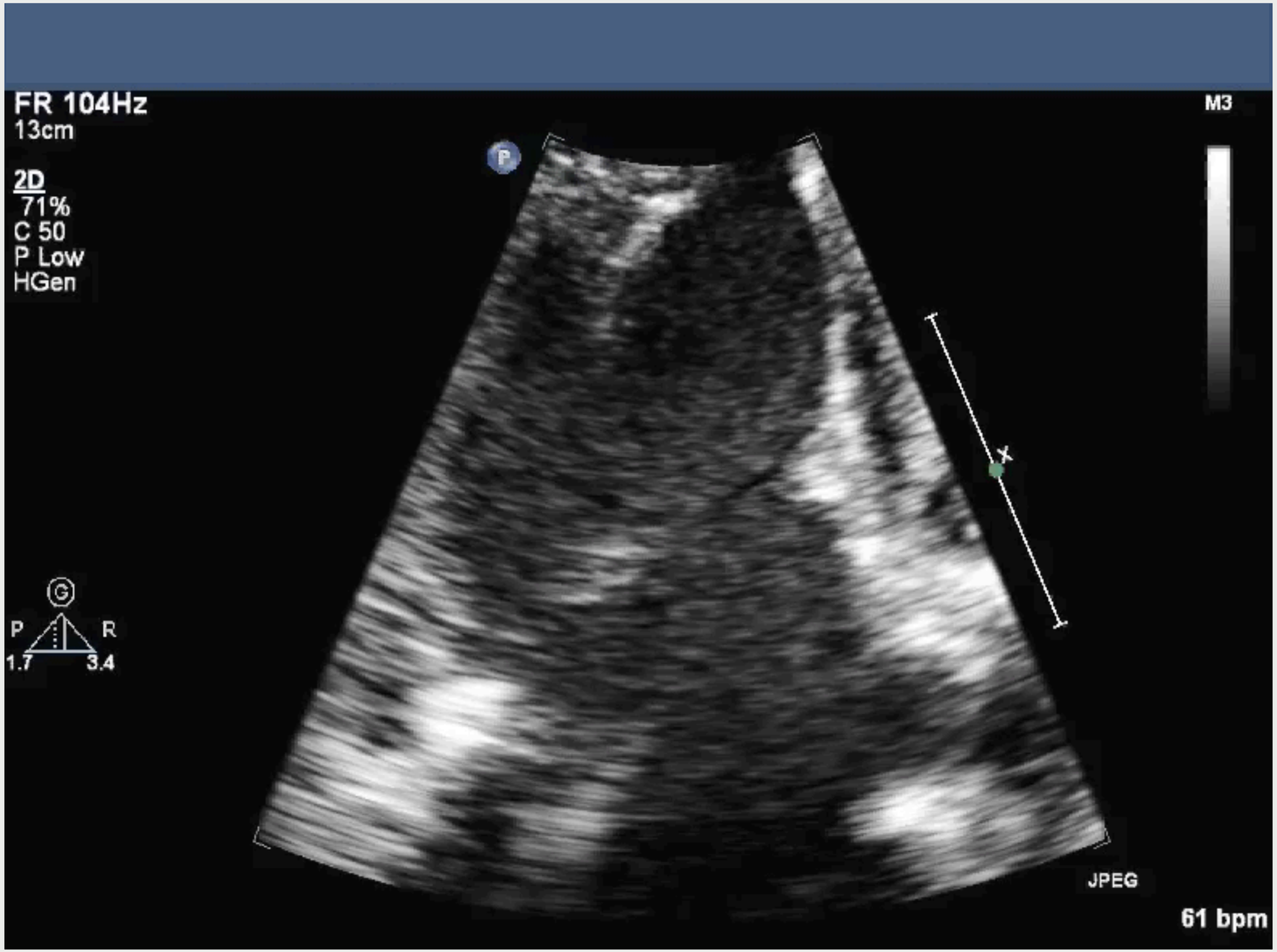

FR 15Hz
18cm
2D
71%
C 50
P Low
HGen
CF
66%
2.5MHz
WF High
Med
CW
50%
1.8MHz
WF 225Hz
M3 M4
+61.
-61.6
cm/s
200
100
cm/s
-100
-200
-300
-400
75mm/s
60bpm

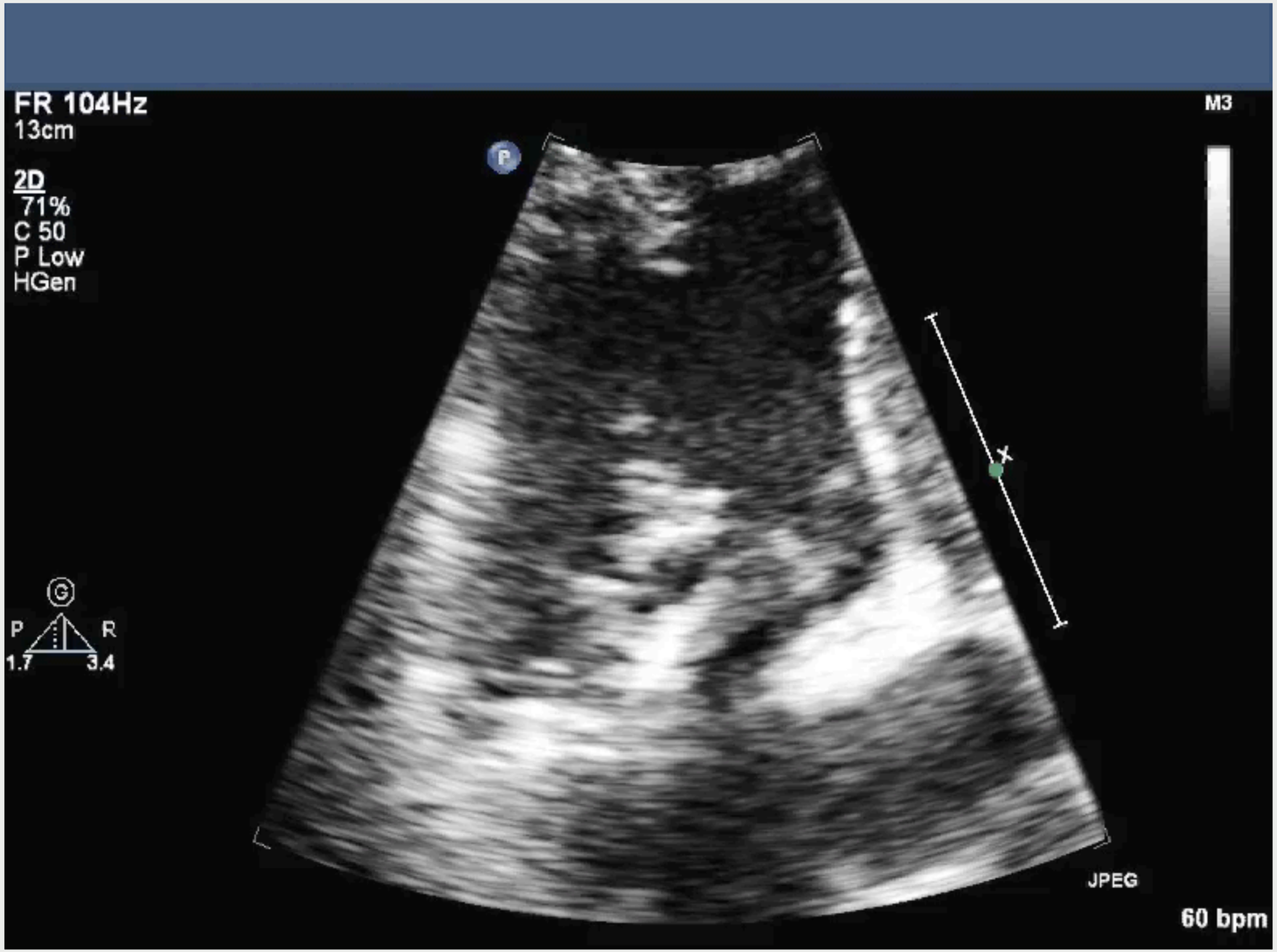

FR 43Hz
19cm
2D
73%
C 50
P Low
HGen
M3
P
G
P
R
1.7
3.4
JPEG
67 bpm


FR 17Hz
14cm
2D
68%
C 50
P Low
HGen
CF
66%
2.5MHz
WF High
Med
M3 M4
+61.
-61.6
cm/s
P
R
1.7
3.4
JPEG
62 bpm

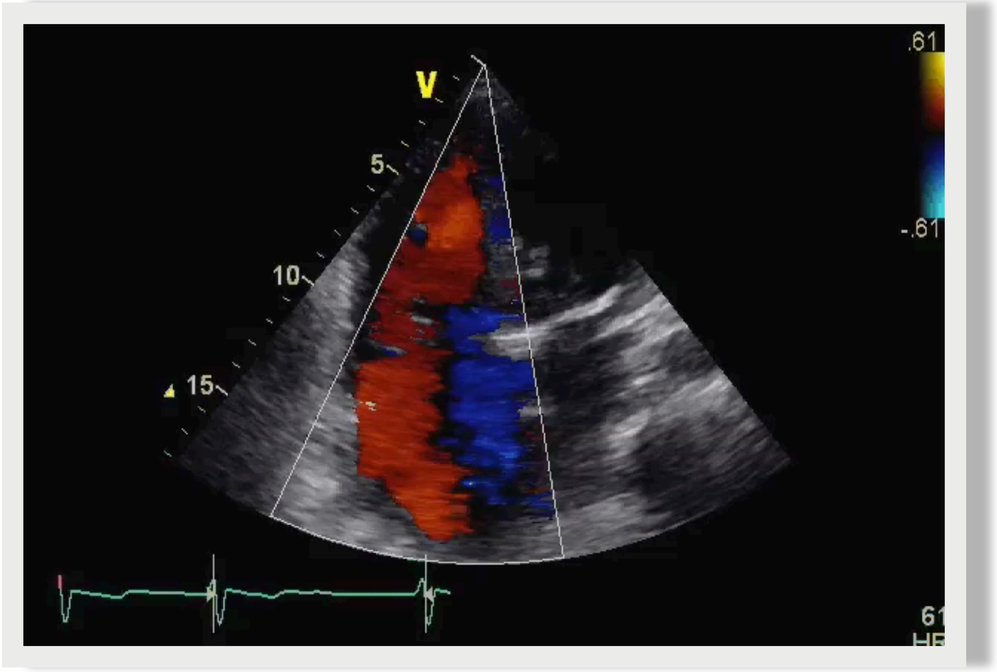

FR 17Hz
14cm
2D
73%
C 50
P Low
HGen
CF
66%
2.5MHz
WF High
Med
PW
55%
1.6MHz
WF 150Hz
SV4.0mm
8.8cm
M3 M4
+61.
-61.6
cm/s
80
40
cm/s
-40
-80
50mm/s
61bpm

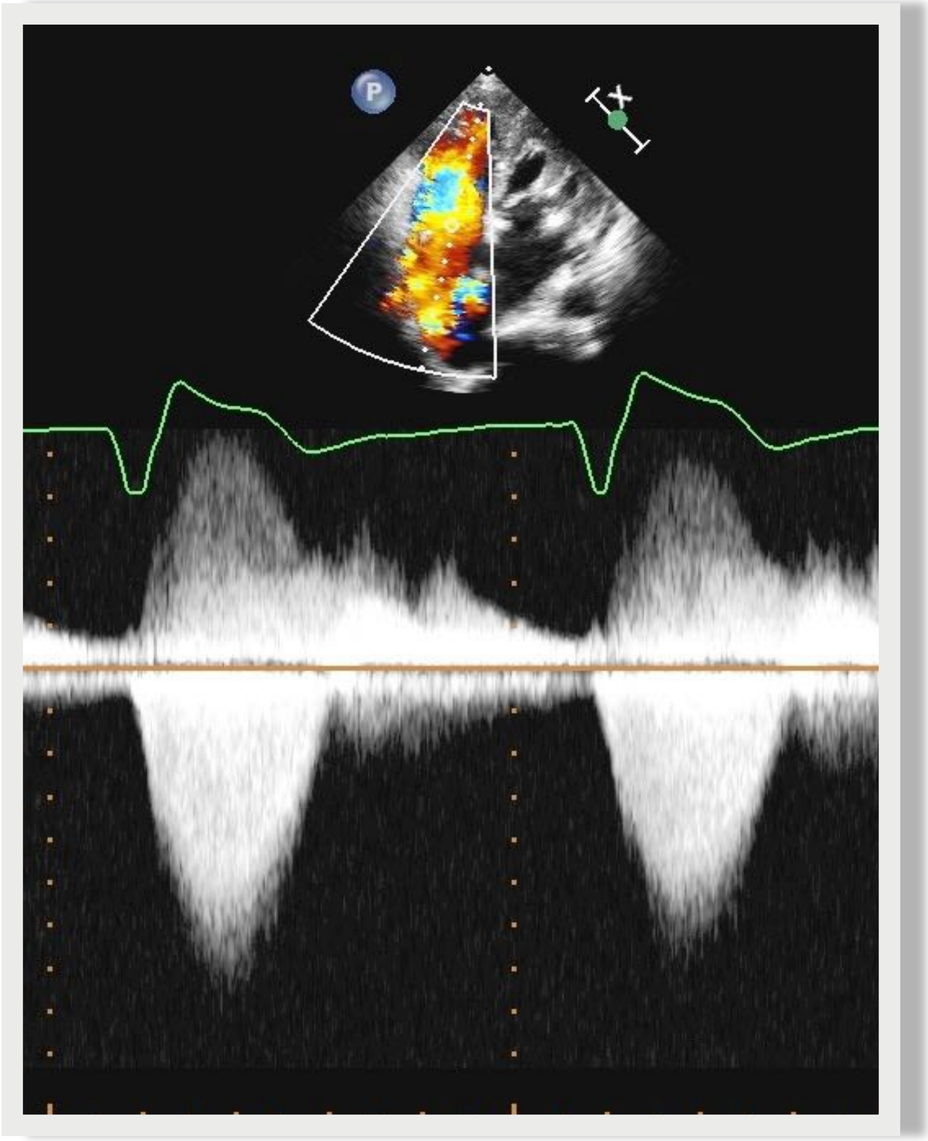

FR 7Hz
19cm
2D / MM
75% 71%
C 50
P Low
HGen
CF
55%
2.5MHz
WF High
Med
M3 M4
+61.
-61.6
cm/s
5
10
15
75mm/s
63bpm


FR 104Hz
13cm
2D
71%
C 50
P Low
HGen
M3
P
X
G
P
R
1.7
3.4
JPEG
61 bpm


FR 104Hz
13cm
2D
71%
C 50
P Low
HGen
M3
P
G
P
R
1.7
3.4
JPEG
60 bpm

Conclusion





- Multiple Windows… find the PM
- Look for the mechanism of TR
- 3D is a helpful tool
- Use alll other information…
- **Detect** the Severity

Tricuspid Stenosis

TRICUSPID STENOSIS
2D ECHO FEATURES

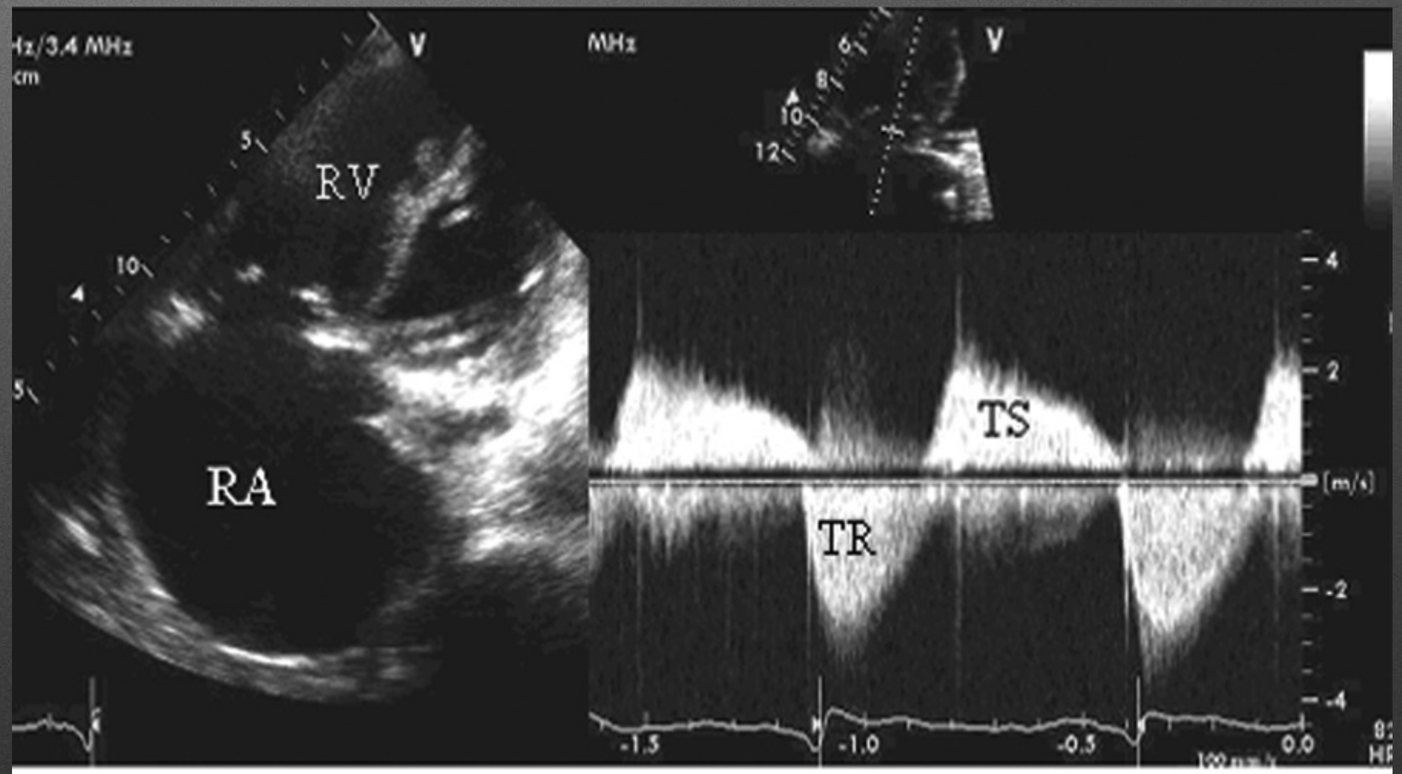
- Valve thickening *calcification
- Decreased mobility
  - Decreased leaflet separation in diastole
  - Frozen appearance *carcinoid involvement
- Diastolic doming of leaflets
- Dilated RA and IVC
- ? RV dilatation *presence of TR
- ? Other valve lesions

TRICUSPID STENOSIS
DOPPLER ECHO FEATURES

- Narrowing of the diastolic inflow jet
- Increase antegrade velocities
- Turbulent flow
- Tricuspid regurgitation

TRICUSPID STENOSIS QUANTIFICATION

- CW Doppler
  - Para-apical window



TVI = 60 cm; mean grad = 9 mmHg
*P*1/2*t* = 173 ms

ADAPTED FROM ASE GUIDELINES

TRICUSPID STENOSIS IMAGING GUIDELINES

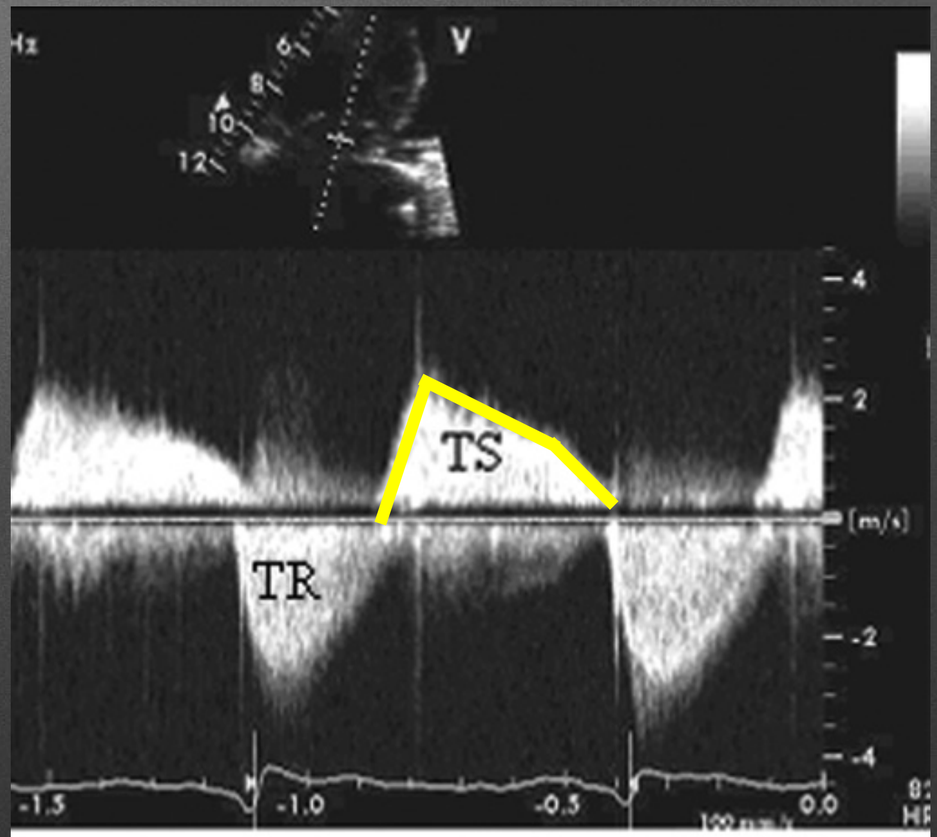
- Continuous wave
- Parallel to flow
- Sweep speed 100mm/s
- Atrial fibrillation
  - Average 5-10 cardiac cycles
- Avoid rapid heart rates

TRICUSPID STENOSIS QUANTIFICATION ANALYSIS

- Mean gradient
- TVI
- Pressure ½
- Valve area
  - Continuity equation
  - 3D Planimetry

TRICUSPDID STENOSIS
CW MEASUREMENTS

- Mean gradient
  - Trace TV inflow wave form
  - Simplified Bernouli's equation

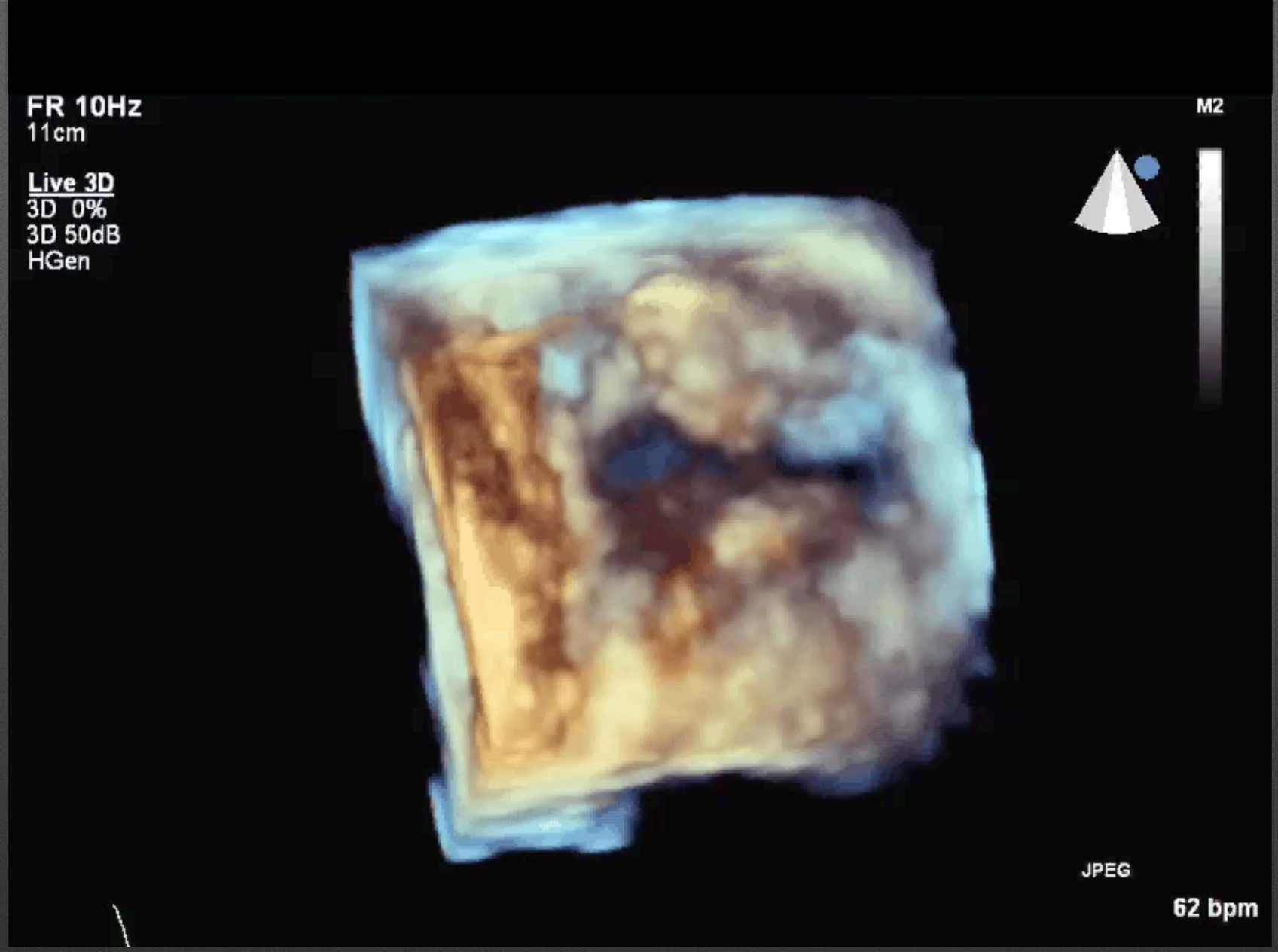


TVI = 60 cm; mean grad = 9 mmHg
*P*1/2*t* = 173 ms

TRICUSPDID STENOSIS
VALVE AREA

- Valve area
  - Continuity equation

    LVOT Stroke Volume / TV inflow TVI



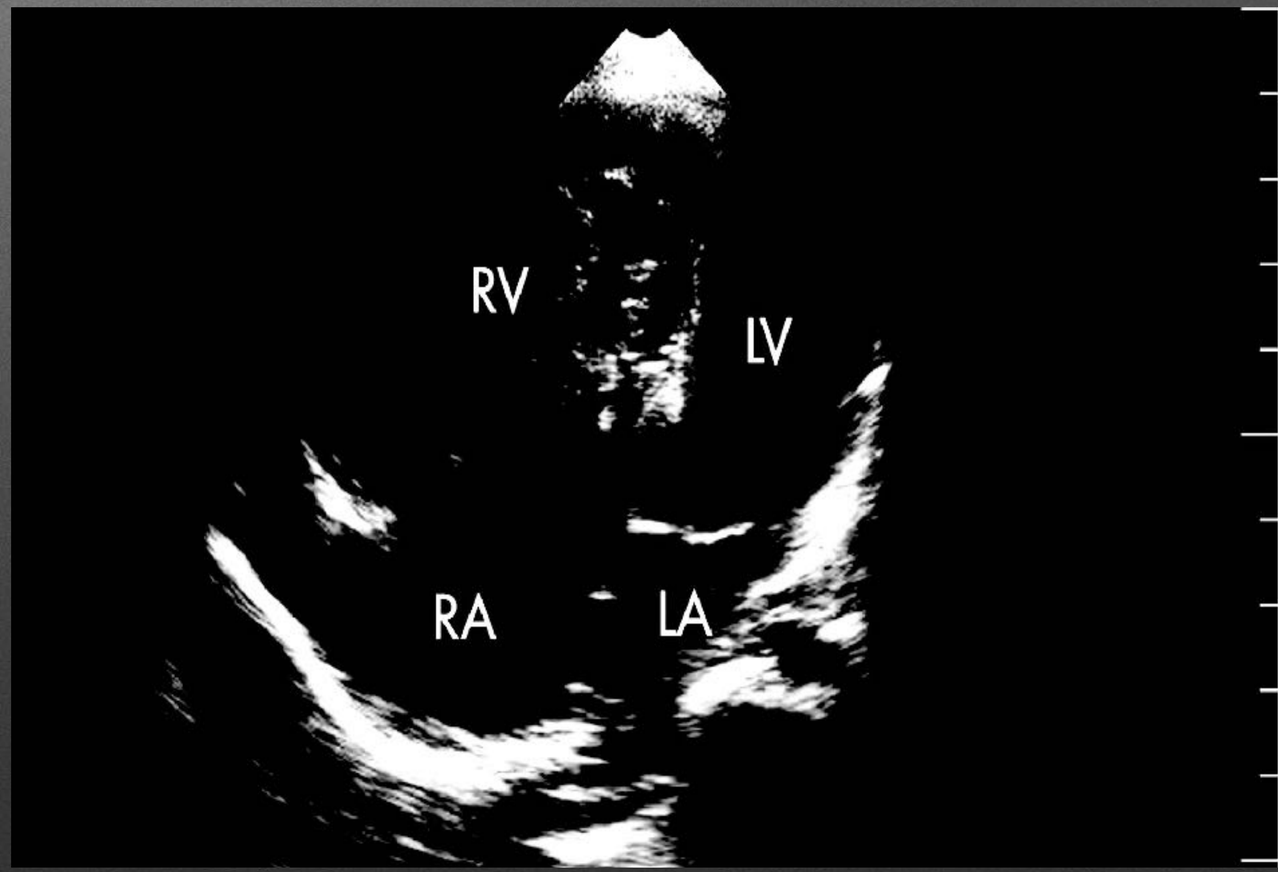
Planimetry 3D

TRICUSPID STENOSIS SEVERE

- Mean gradient
  - ≥ 5 mmHg
- TV inflow (TVI)
  - > 60 cm
- Pressure 1/2t
  - ≥ 190 ms
- TV Valve area
  - ≤ 1 cm^2

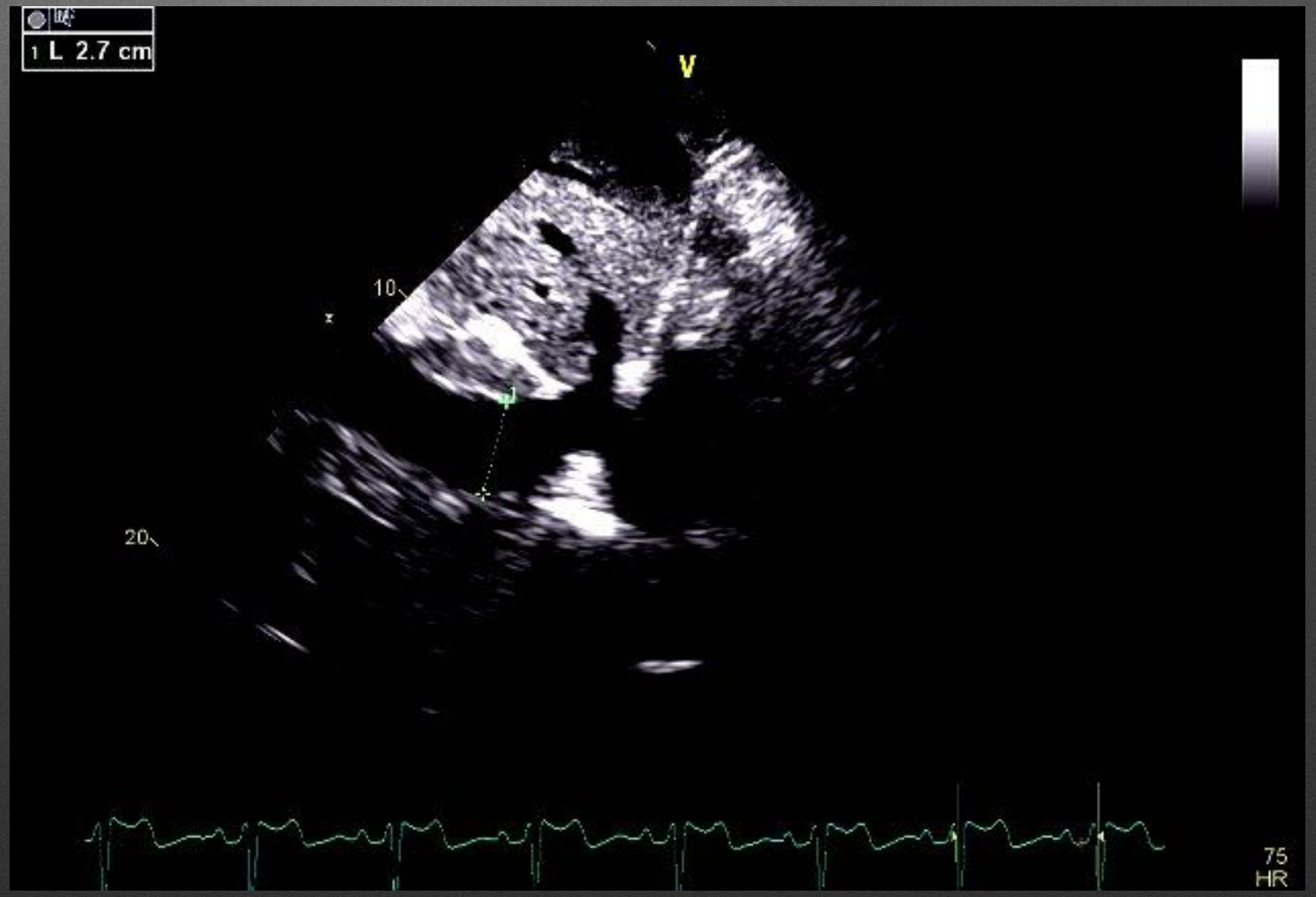
TRICUSPID STENOSIS SUPPORTIVE FINDINGS

- Right atrial enlargement



TRICUSPID STENOSIS SUPPORTIVE FINDINGS

- Dilated IVC



Thank You