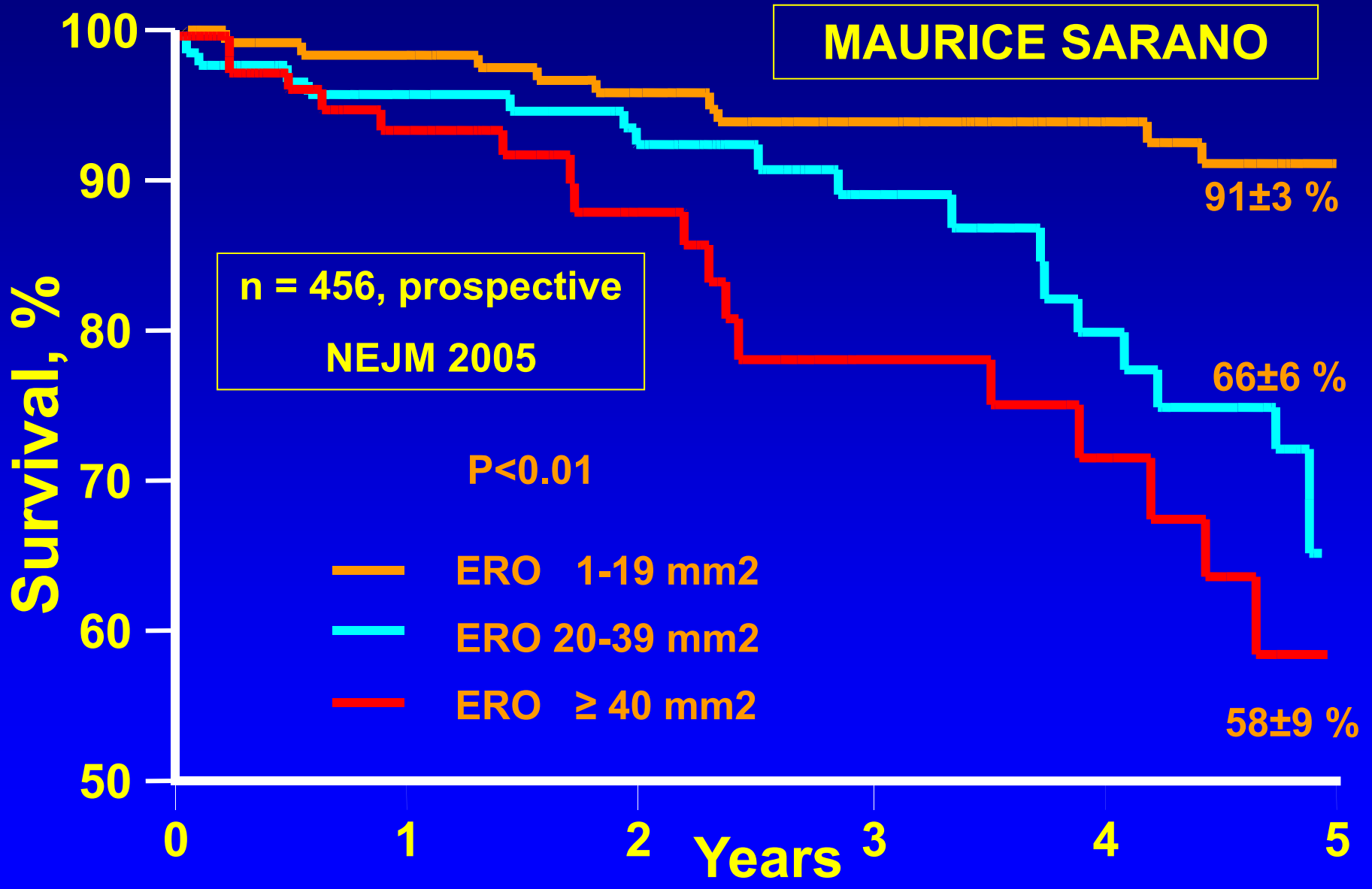
THE CHALLENGE OF ECHOCARDIOGRAPHIC ASSESSMENT OF MR SEVERITY

Robert A. Levine, MD
Massachusetts General Hospital, Boston
Israel Heart Society 2013

No conflicts of interest

Asymptomatic MR: Natural History



CHALLENGES IN ASSESSING MR

- Severity is multi-faceted
- Multiplicity of measures
- Greater clarity through advanced technology
- Persistent limitations – lesion dynamics and physiology

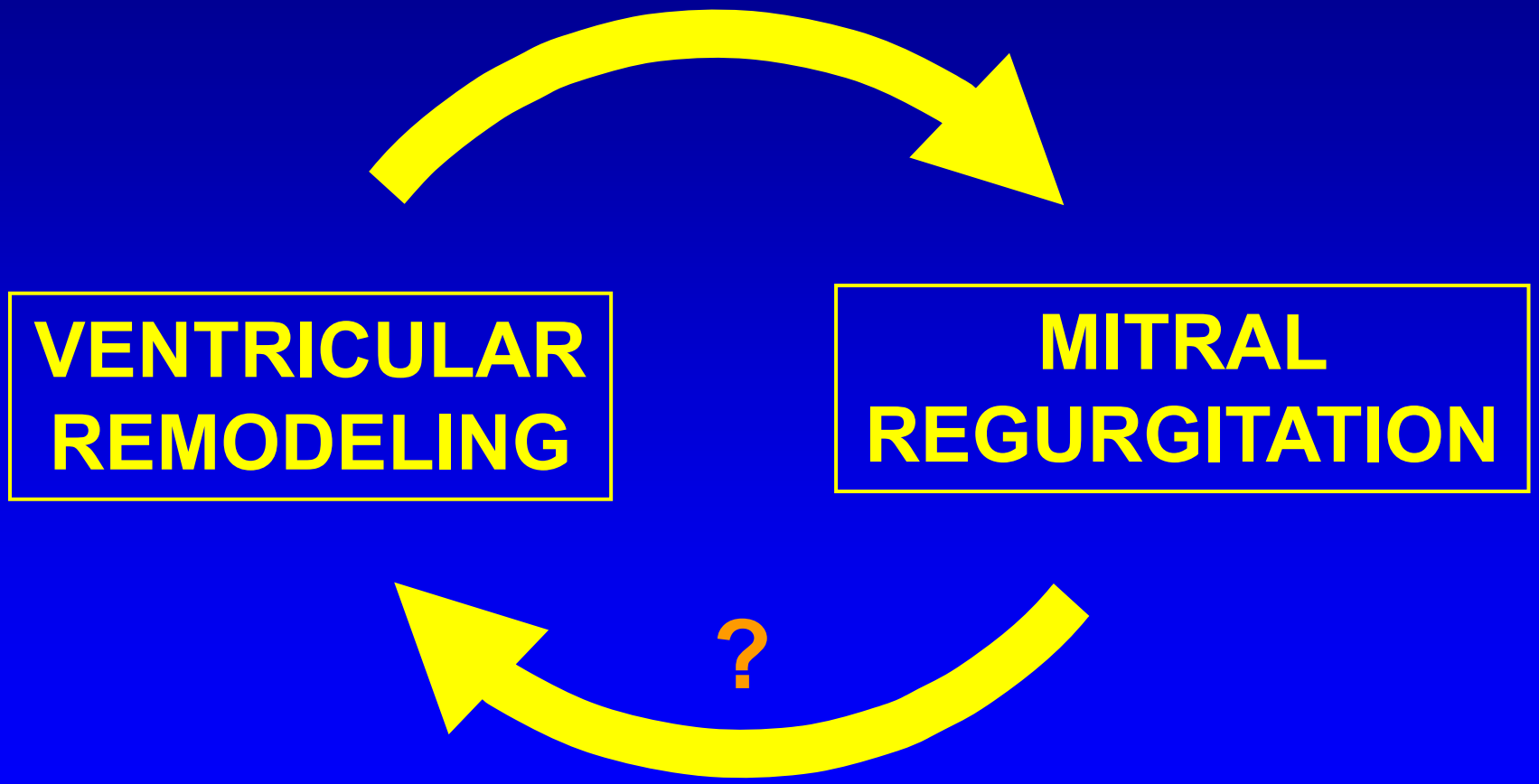
MR SEVERITY IS MULTI-FACETED

- The lesion itself
- Impact on left heart remodeling
- Impact on the pulmonary circulation and right heart
- Impact on exercise capacity

MR SEVERITY IS MULTI-FACETED

- The lesion itself
- Impact on left heart remodeling
- Impact on the pulmonary circulation and right heart
- Impact on exercise capacity

REMODELING AND MR: A VICIOUS CYCLE



In ischemic (post-infarction) MR, how can we separate the effects of MR and MI on the LV?

RONEN BEERI

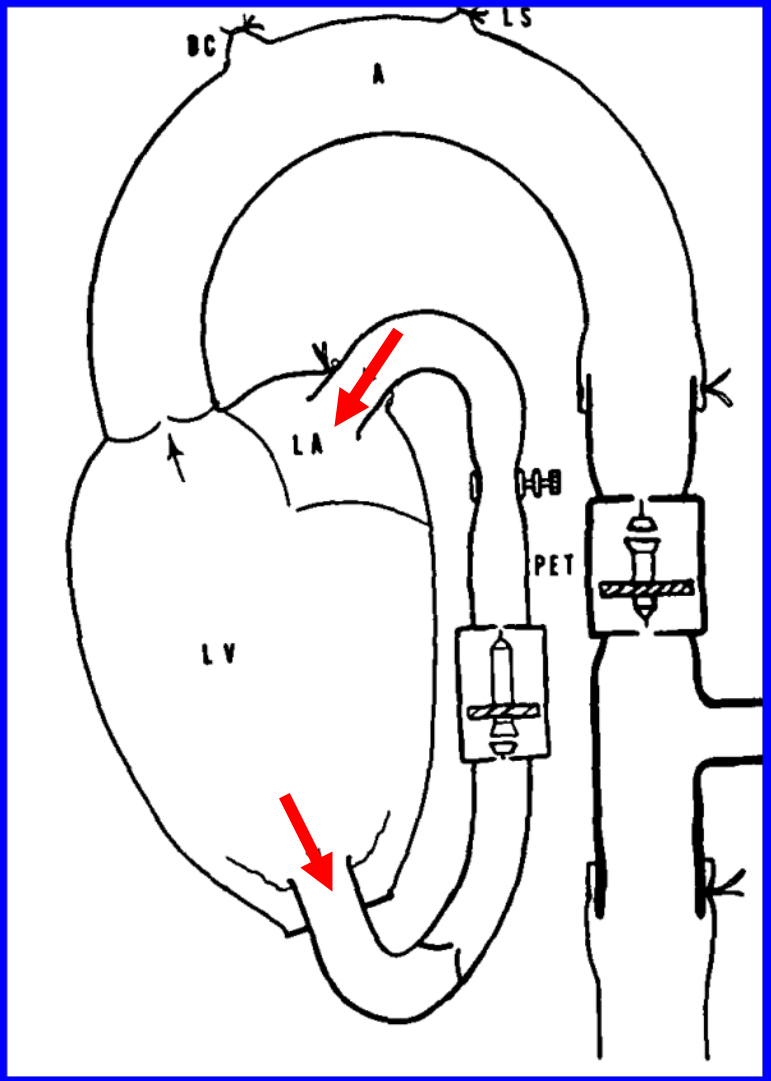
Circulation 2007; JACC 2008

Hadassah-Hebrew University Hospital
Massachusetts General Hospital

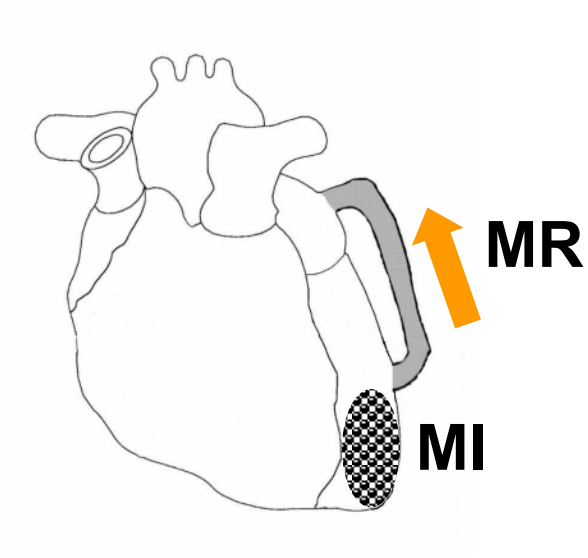
Hemodynamic Effects of Quantitatively Varied Experimental Mitral Regurgitation

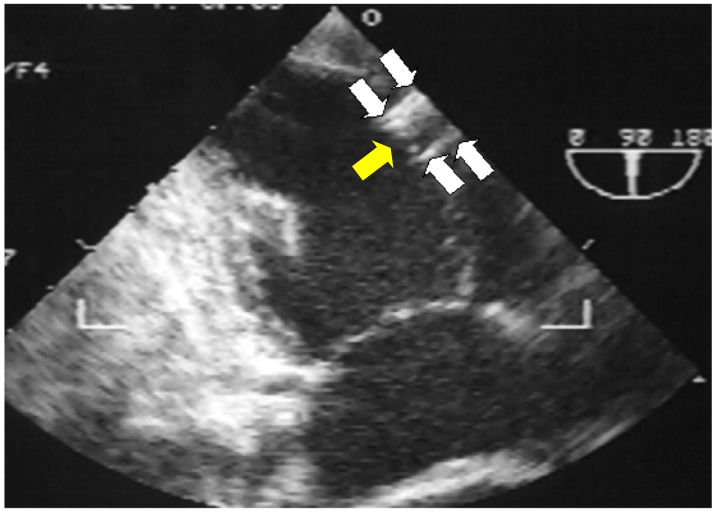
By Eugene Braunwald, M.D., George H. Welch, Jr., M.D., and Stanley J. Sarnoff, M.D.

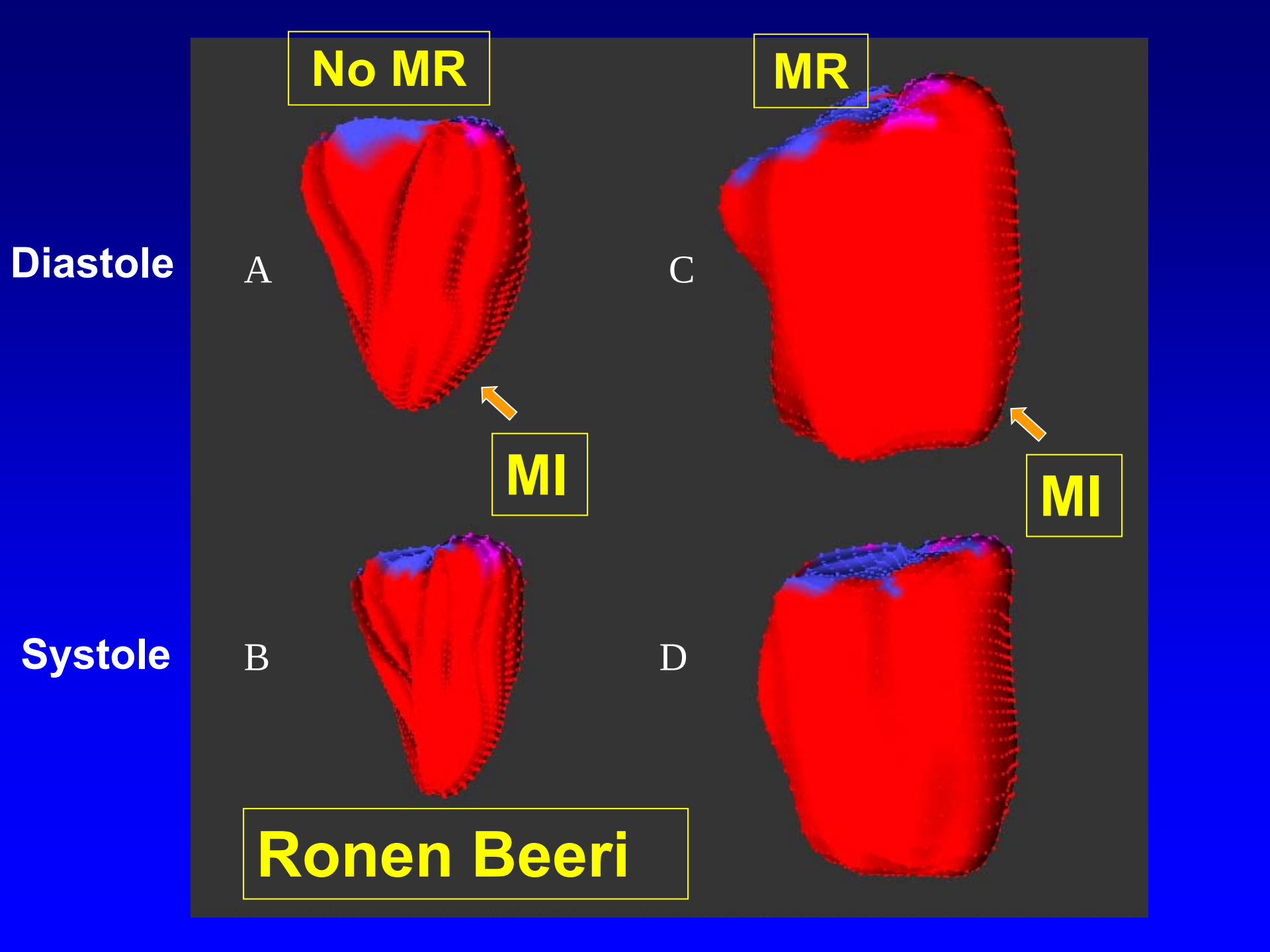
Circ Res. 1957;5:539-545



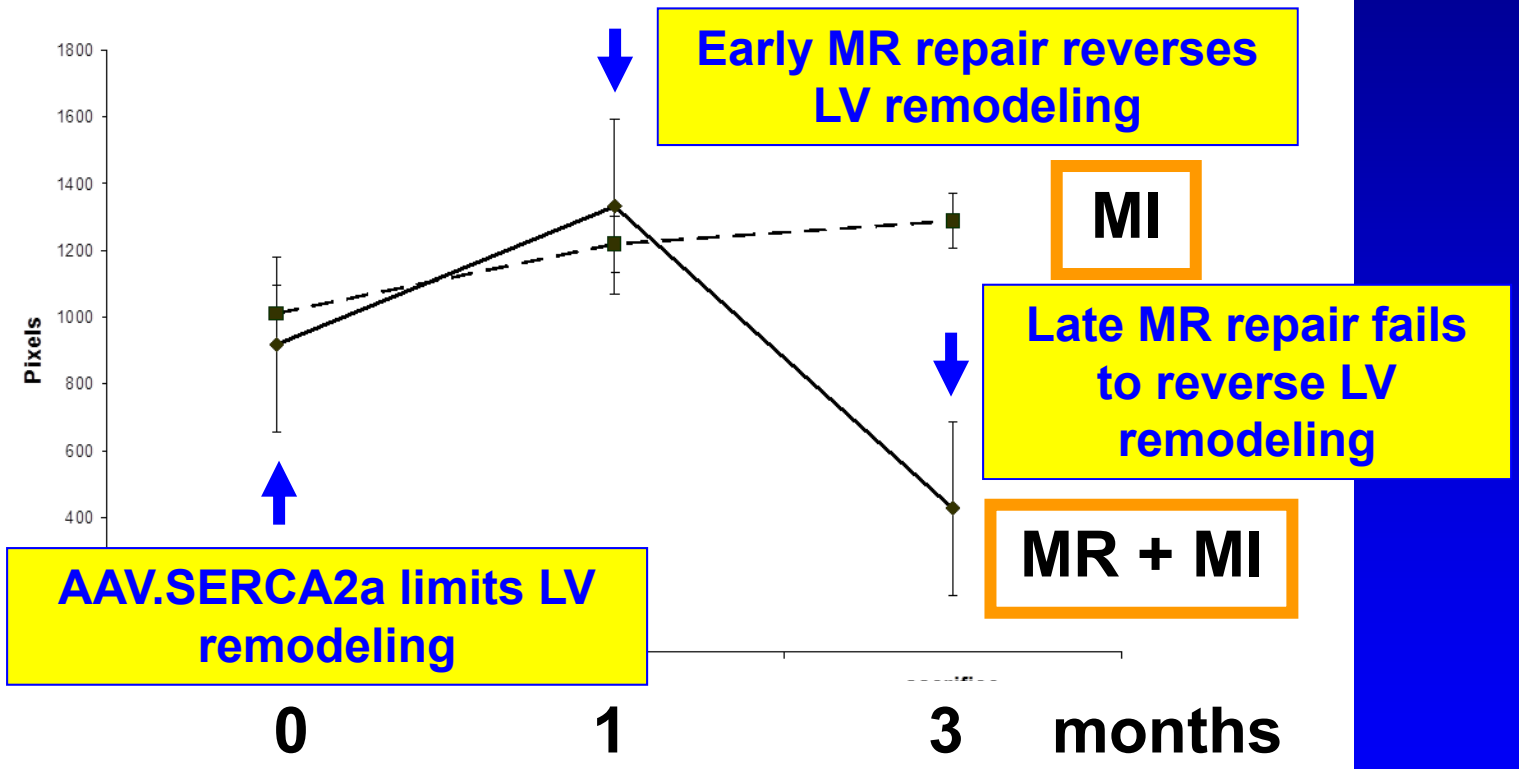
INDEPENDENT MR AND MI: APICAL MI AND LV-TO-LA SHUNT






No MR
MR
Diastole
A
C
MI
MI
Systole
B
D
Ronen Beeri

Akt: Anti-apoptotic signal

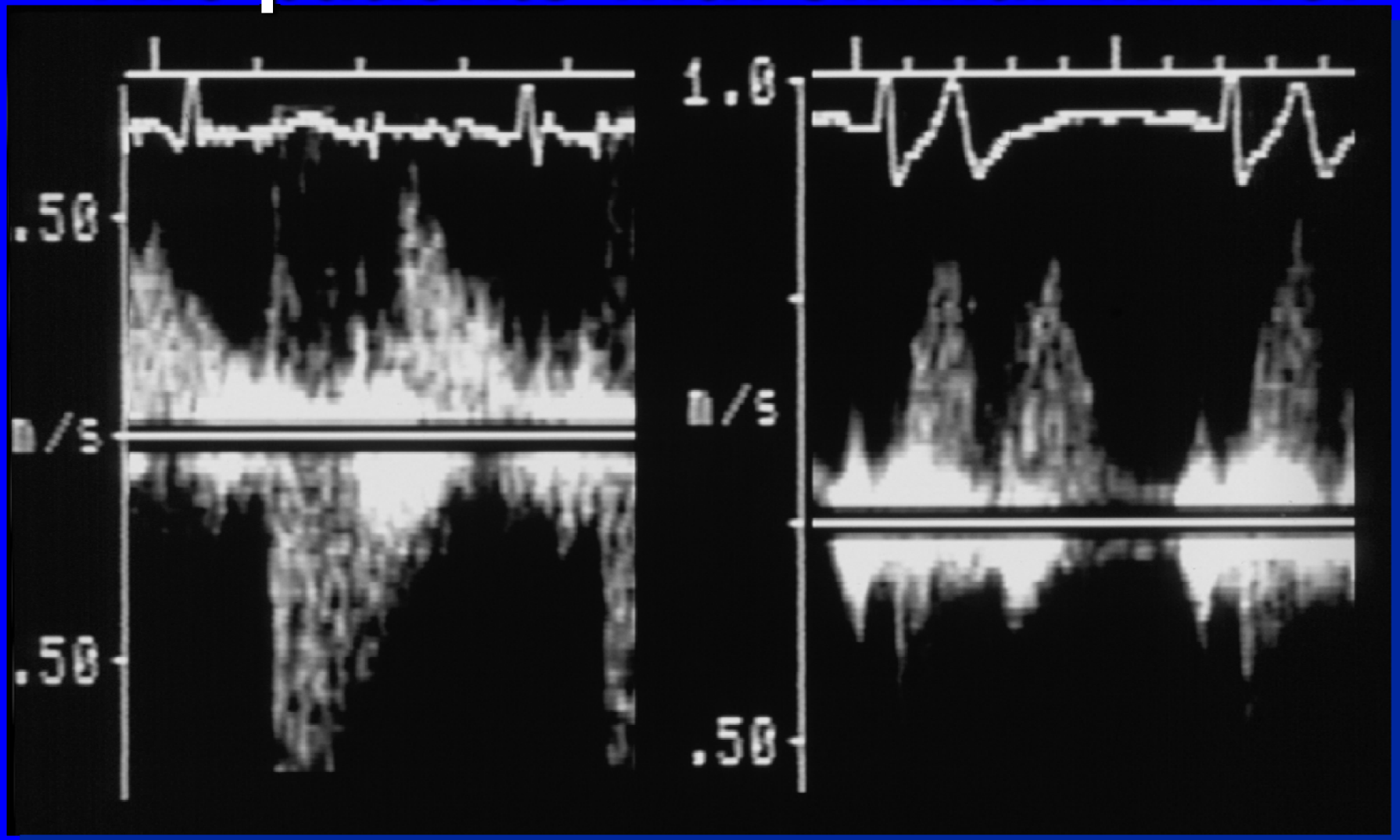


MR SEVERITY IS MULTI-FACETED

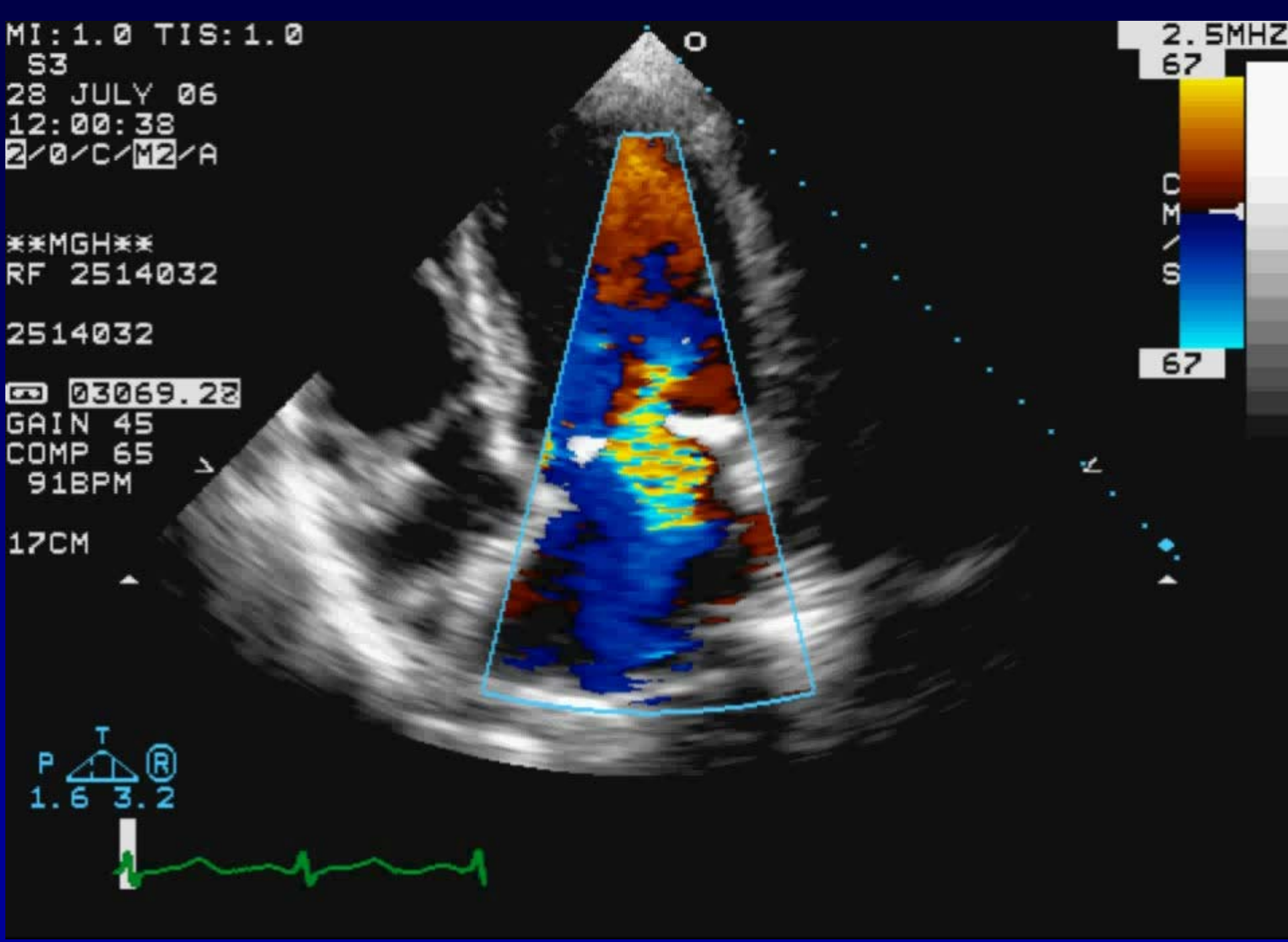
- The lesion itself
- Impact on left heart remodeling
- PV flow as a window into the impact of MR on LA and PA pressures

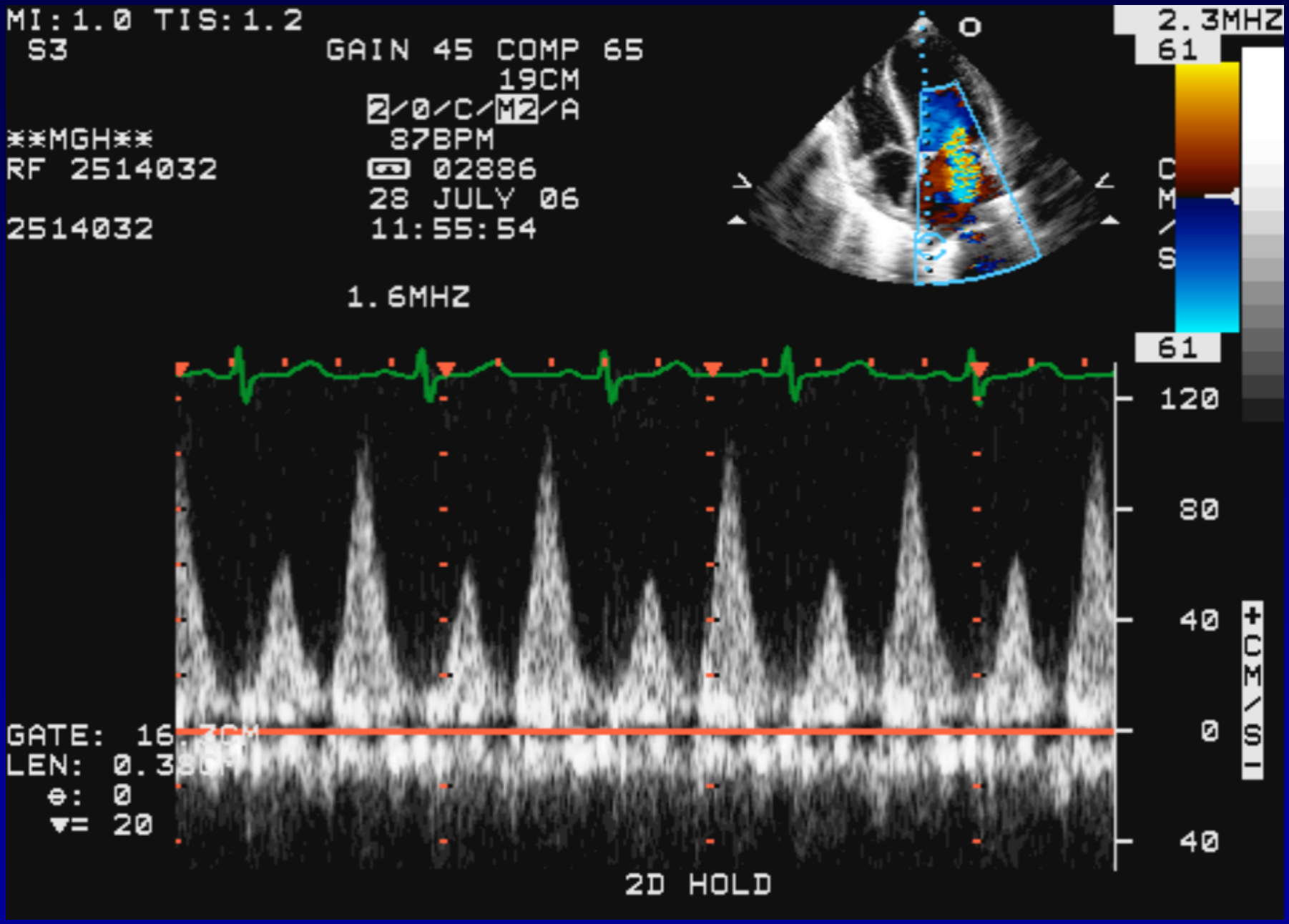
Pulmonary Venous Flow

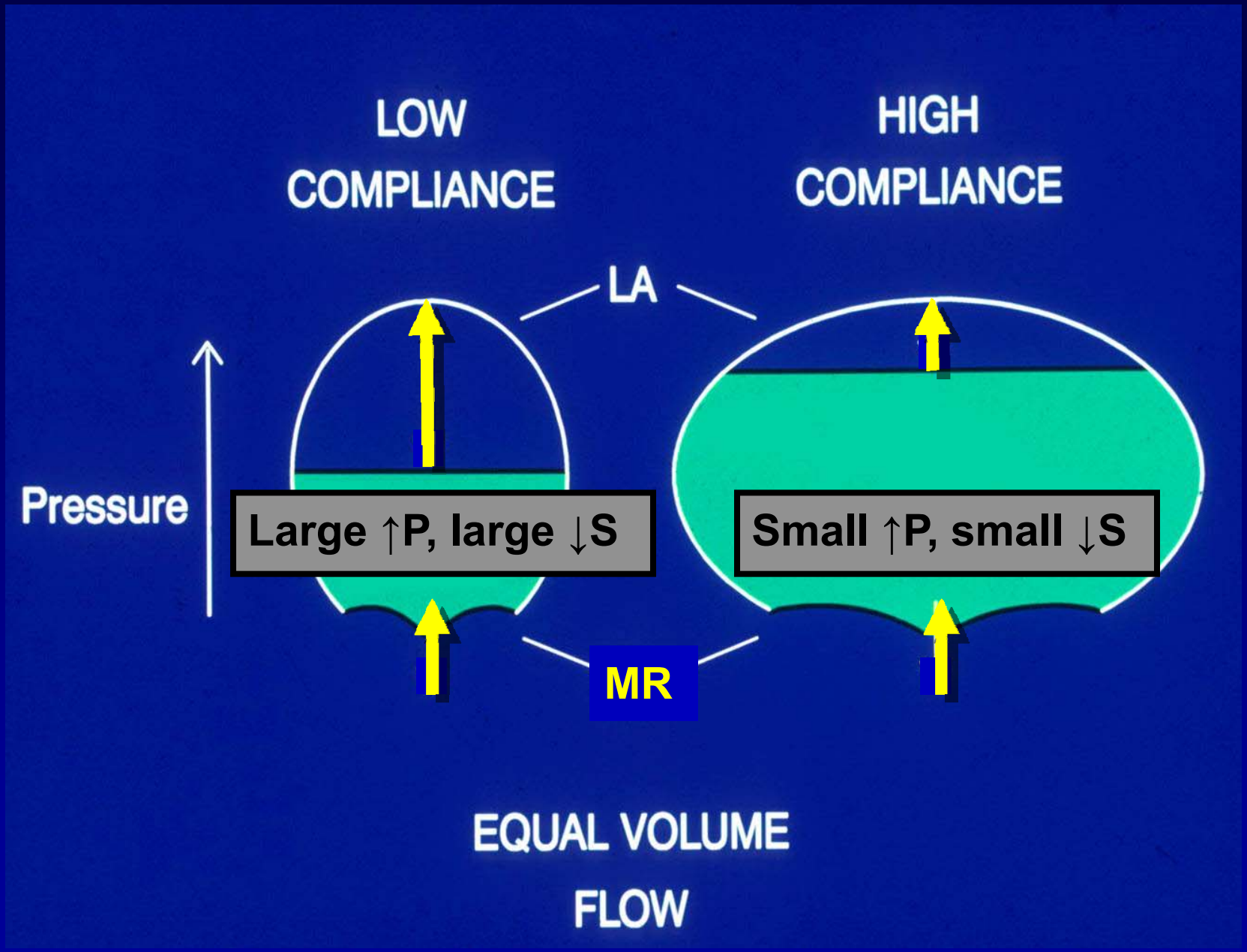
Two patients with similar MR Vol

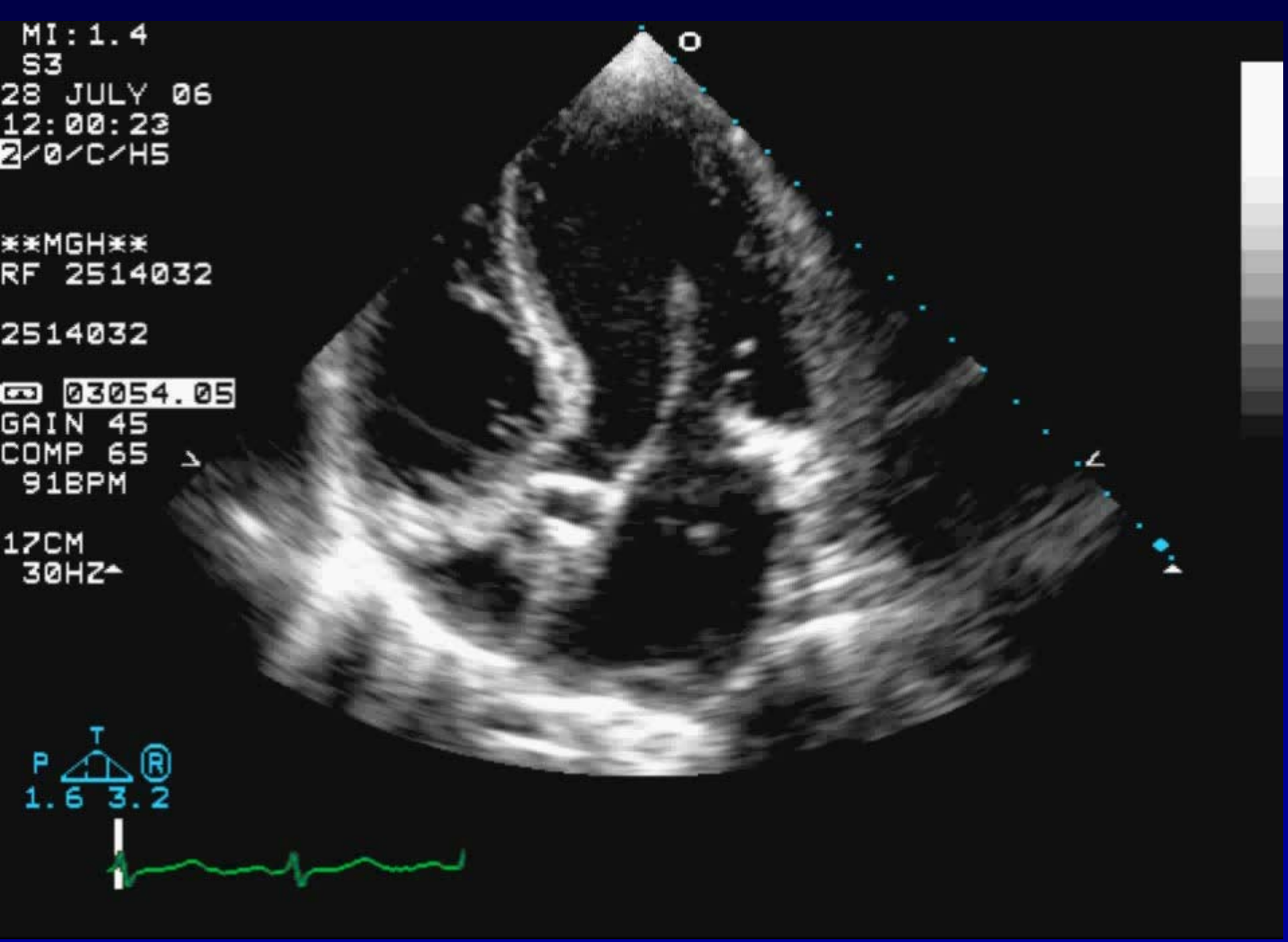


Maurice Enriquez-Sarano


MI:1.0 TIS:1.0
S3
28 JULY 06
12:00:38
2/0/C/M2/A
MGH
RF 2514032
2514032
03069.22
GAIN 45
COMP 65
91BPM
17CM
2.5MHZ
67
CM/S
67
T
P
R
1.6 3.2


MI:1.0 TIS:1.2
S3
GAIN 45 COMP 65
19CM
2/0/C/M2/A
87BPM
02886
28 JULY 06
11:55:54
MGH
RF 2514032
2514032
1.6MHZ
2.3MHZ
61
CM/S
61
120
80
40
0
40
+CM/S
GATE: 16
LEN: 0.3
2D HOLD


LOW
COMPLIANCE
HIGH
COMPLIANCE
LA
Pressure
Large ↑P, large ↓S
Small ↑P, small ↓S
MR
EQUAL VOLUME
FLOW


MI:1.4
S3
28 JULY 06
12:00:23
2/0/C/H5
MGH
RF 2514032
2514032
03054.05
GAIN 45
COMP 65
91BPM
17CM
30HZ
T
P
R
1.6 3.2

The Syndrome of Severe Mitral Regurgitation with Normal Left Atrial Pressure

By EUGENE BRAUNWALD, M.D., AND WILLIAM C. AWE, M.D.

Circulation. 1963;27:29-35

It is suggested that long-standing MR may modify the mechanical characteristics of the atrial wall and that the presence of a normal left atrial pressure must not be assumed to exclude the presence of severe MR.

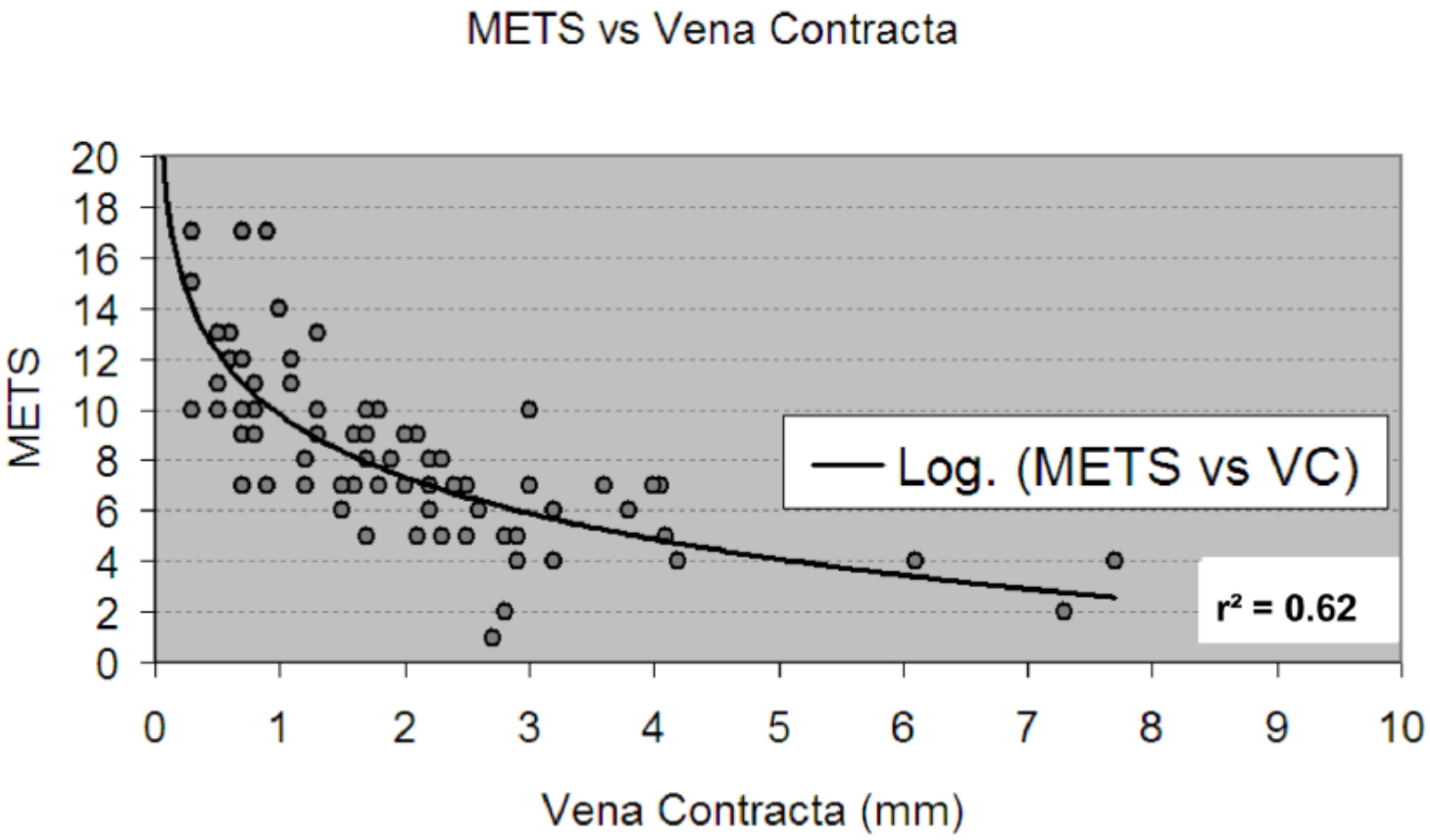
Limitations of PV versus Quantitative Measures

- Misses 40% of severe MR: May be absent with compliant LA – Maurice Enriquez-Sarano, AJC 1999
- May be exaggerated by stiff LA
- S wave blunted in AFib

MR SEVERITY IS MULTI-FACETED

- The lesion itself
- Impact on left heart remodeling
- Impact on the pulmonary circulation and right heart
- Impact on exercise capacity

IMPACT OF ISCHEMIC MR ON EXERCISE CAPACITY
Szymanski C, Hung J, AJC 2011



MR SEVERITY IS MULTI-FACETED

- The lesion itself
- Impact on left heart remodeling
- Impact on the pulmonary circulation and right heart
- Impact on exercise capacity

MR SEVERITY IS MULTI-FACETED

- The lesion itself
- Impact on left heart remodeling
- Impact on the pulmonary circulation and right heart
- Impact on exercise capacity

CHALLENGES IN ASSESSING MR

- Severity is multi-faceted
- Multiplicity of measures
- Greater clarity through advanced technology
- Persistent limitations – lesion dynamics and physiology

"If many methods are used to evaluate a disorder, none are sufficient."

- Sir William Osler (paraphrase)

GOAL: Confident quantification, correlated with outcome, can improve decision making.

ASE Consensus Report on Valvular Regurgitation

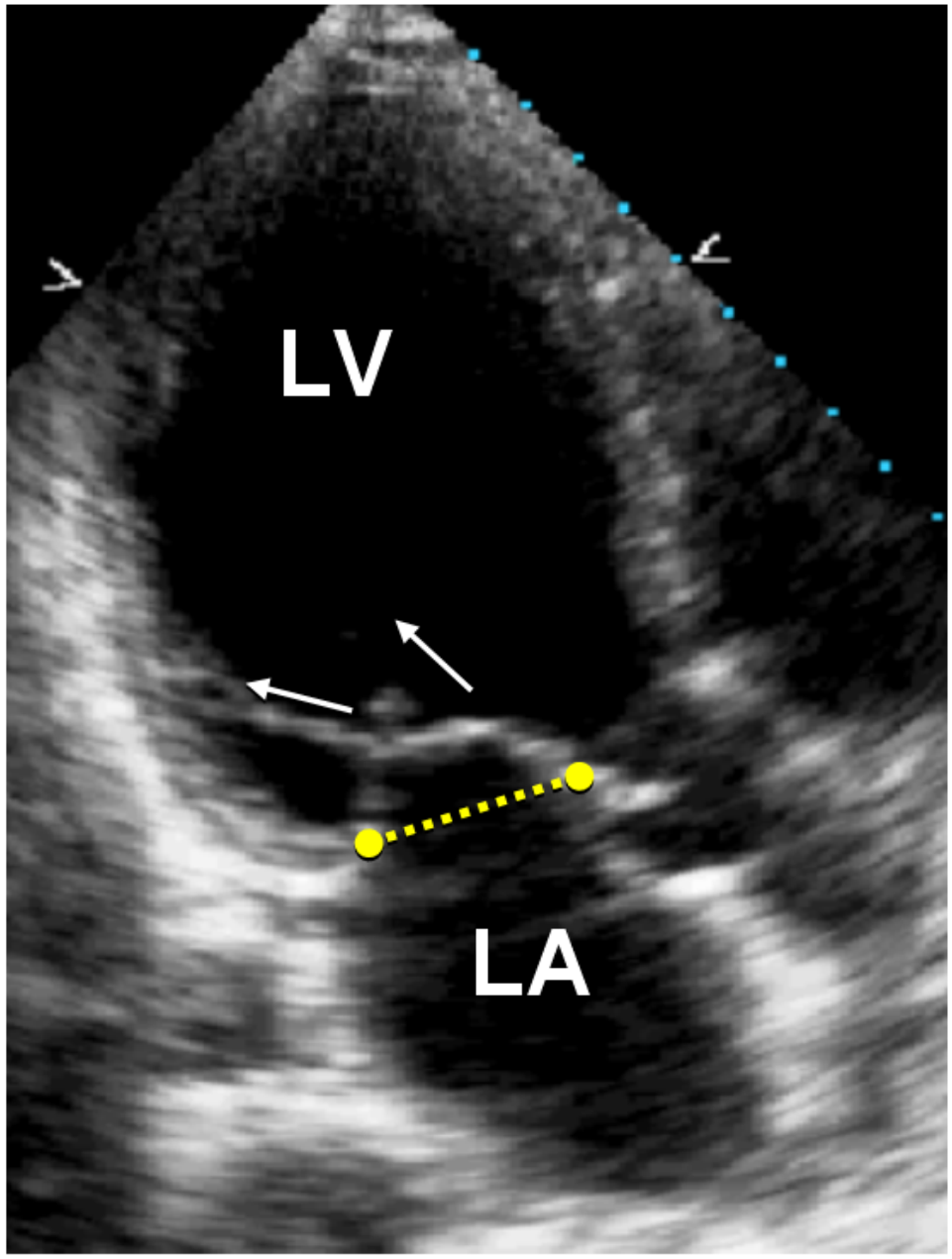
William A. Zoghbi, Chair

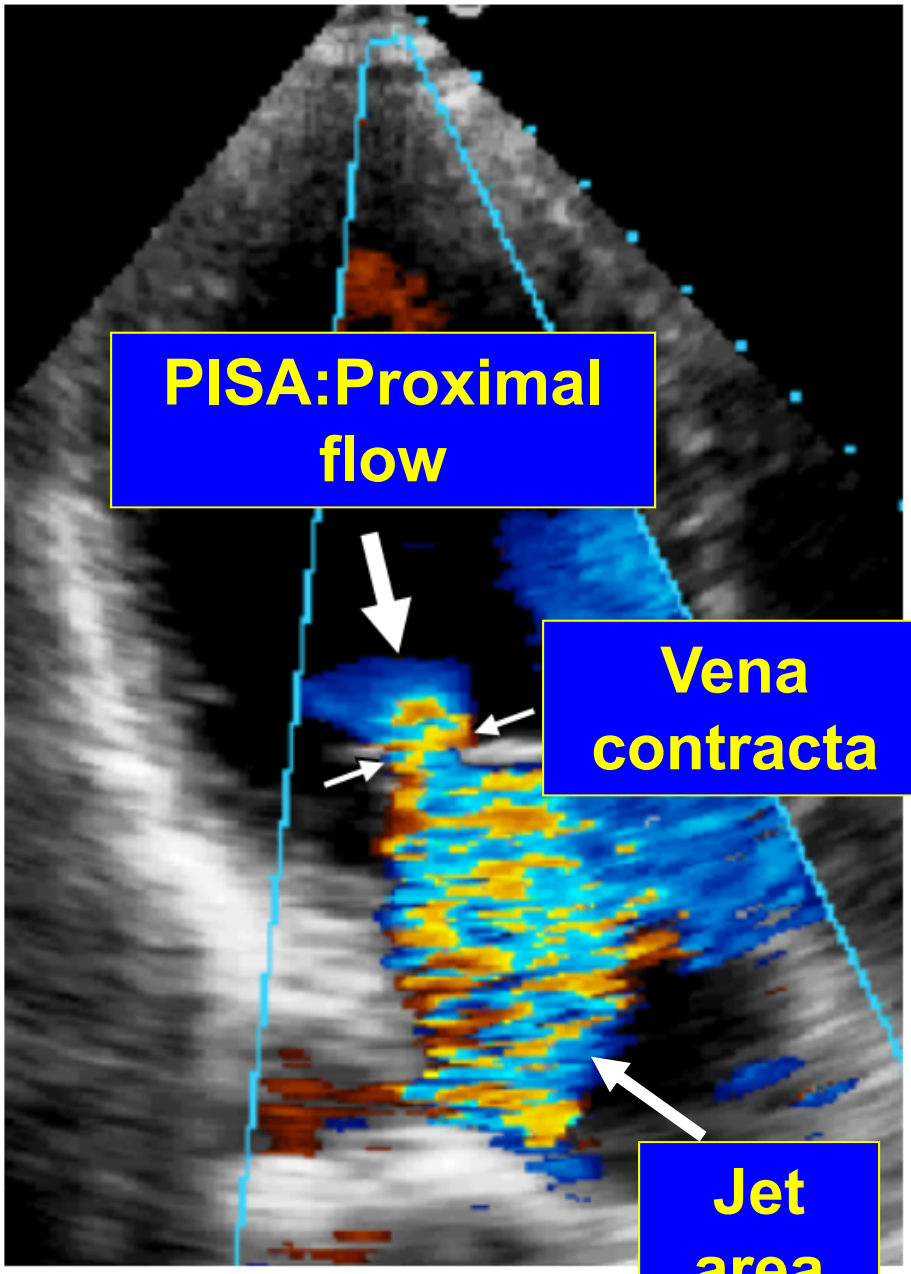
Maurice Enriquez-Sarano, Elyse Foster,
Paul A. Grayburn, Carol P. Kraft,
Robert A. Levine, Petros Nihoyannopoulos,
Catherine C. Otto, Miguel A. Quinones,
Harry Rakowski, William J. Stewart,
Alan Waggoner, Neil J. Weissman

JASE 2003

ACHIEVING CONSENSUS

ACHIEVING CONSENSUS


LV
LA


PISA:Proximal flow
Vena contracta
Jet area

MYTH: Jet size cannot be used at all to quantify valvular regurgitation.

ASSUMPTION: Jet area is proportional to regurgitant volume.

REALITY: Jet area is proportional to regurgitant volume x driving pressure. (JD Thomas, Circ 1990).

OR

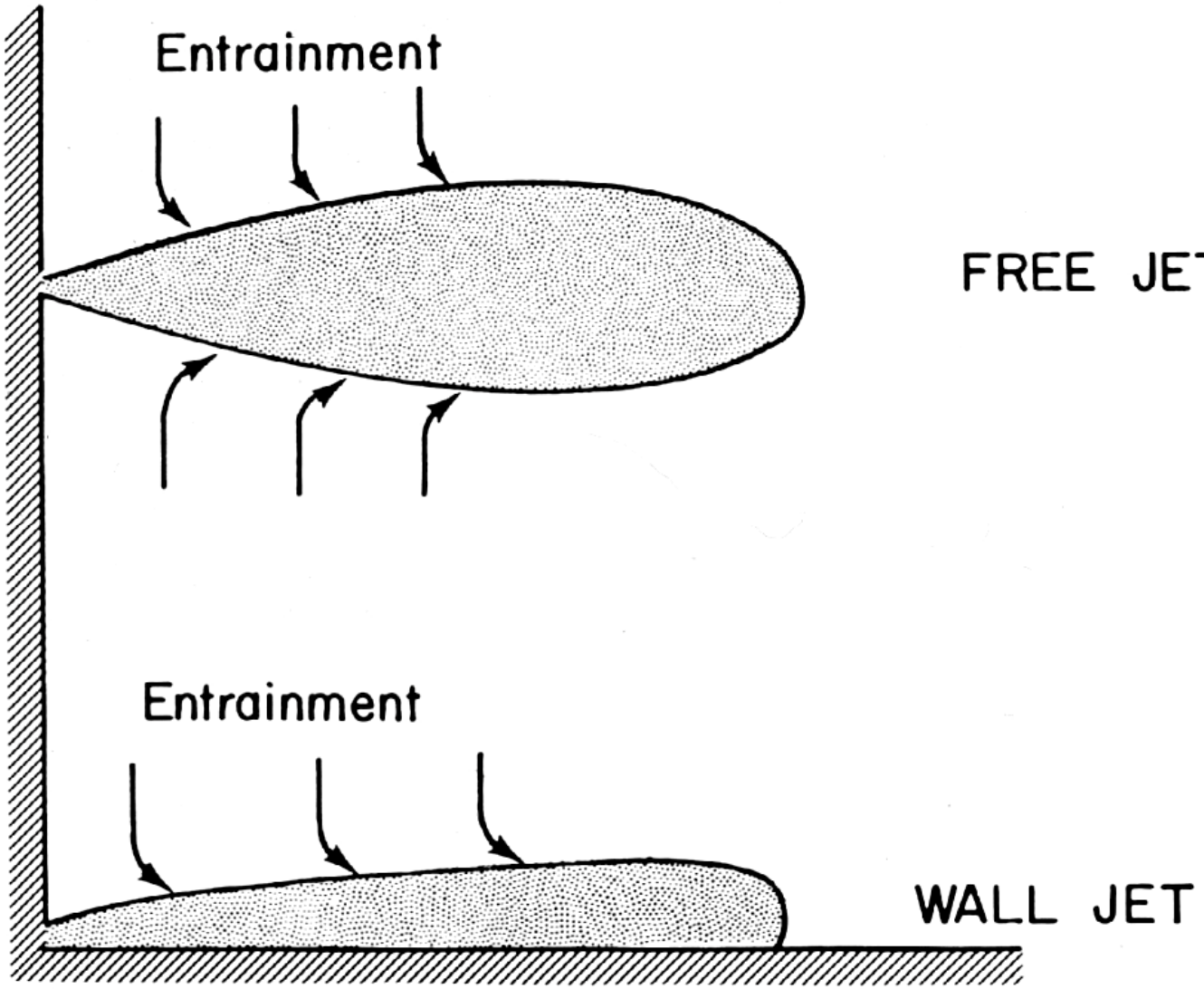
50 yo man

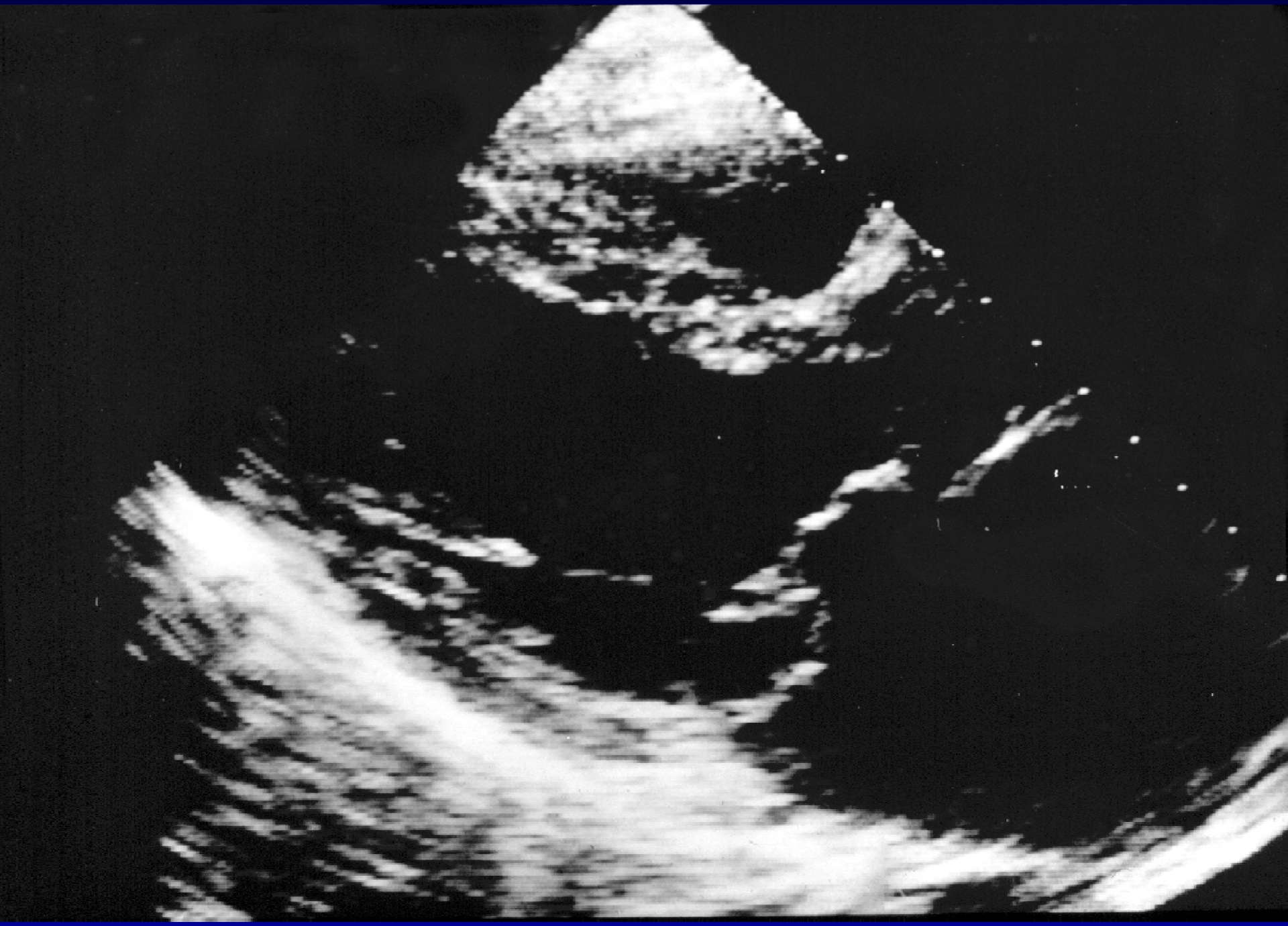
SOB 6 months

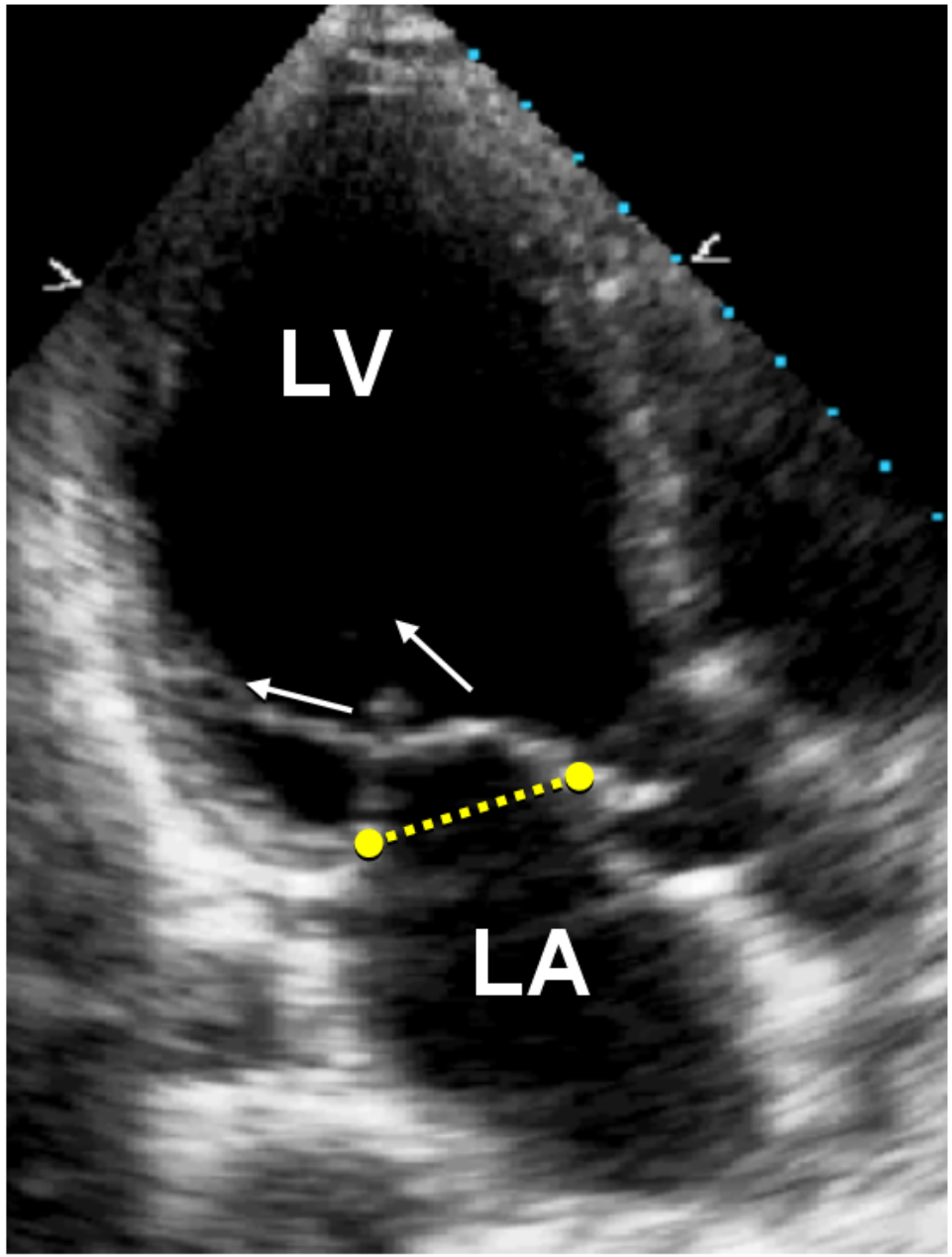
MVP repair

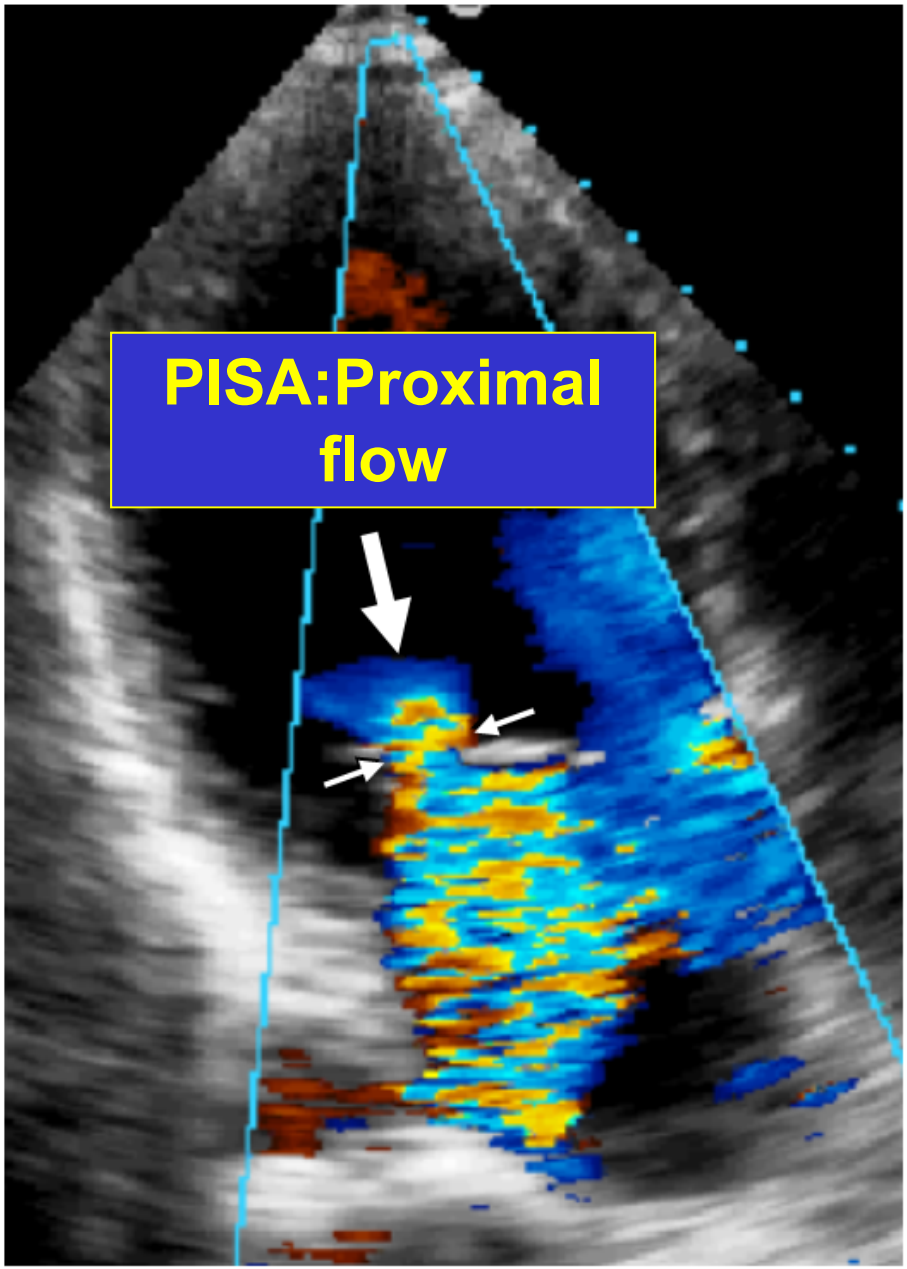
Severe MR

Asx after repair

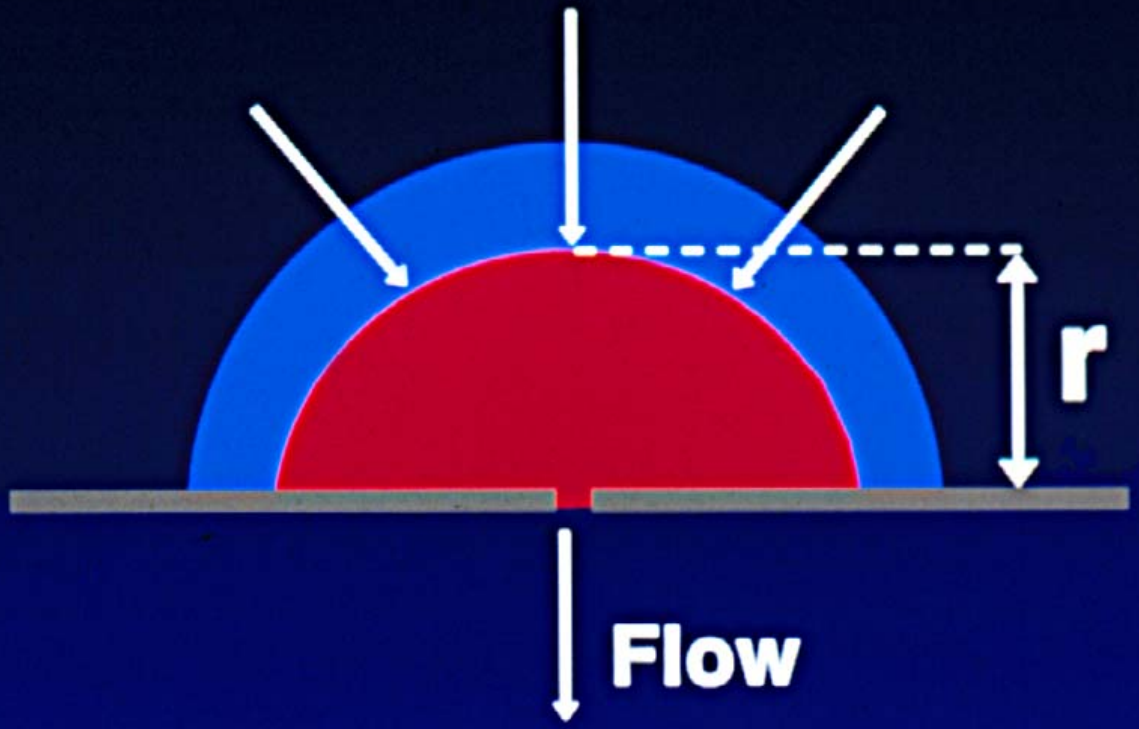

Entrainment
FREE JET
Entrainment
WALL JET
No Entrainment




LV
LA


PISA:Proximal flow

PRINCIPLE OF FLOW CONVERGENCE

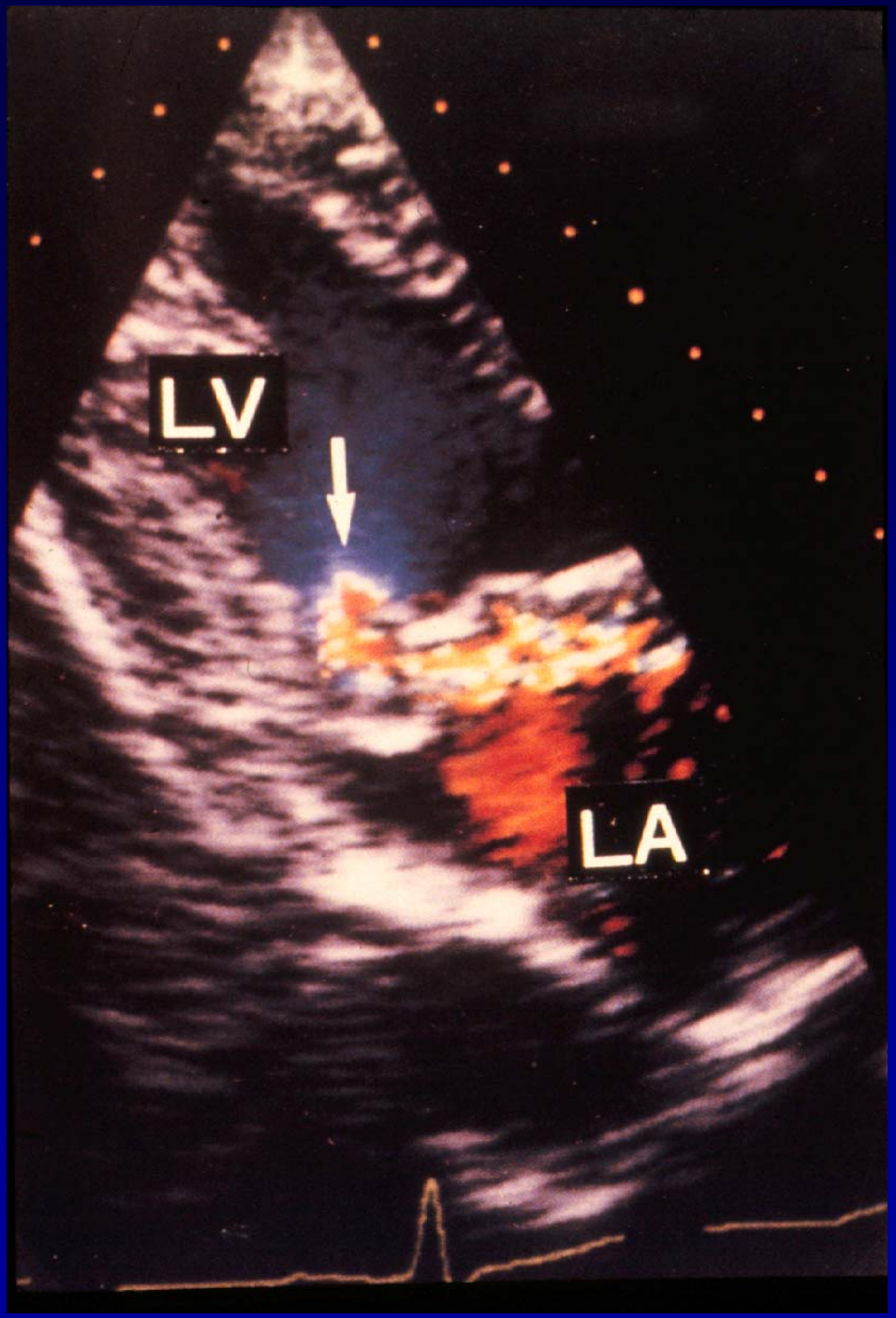


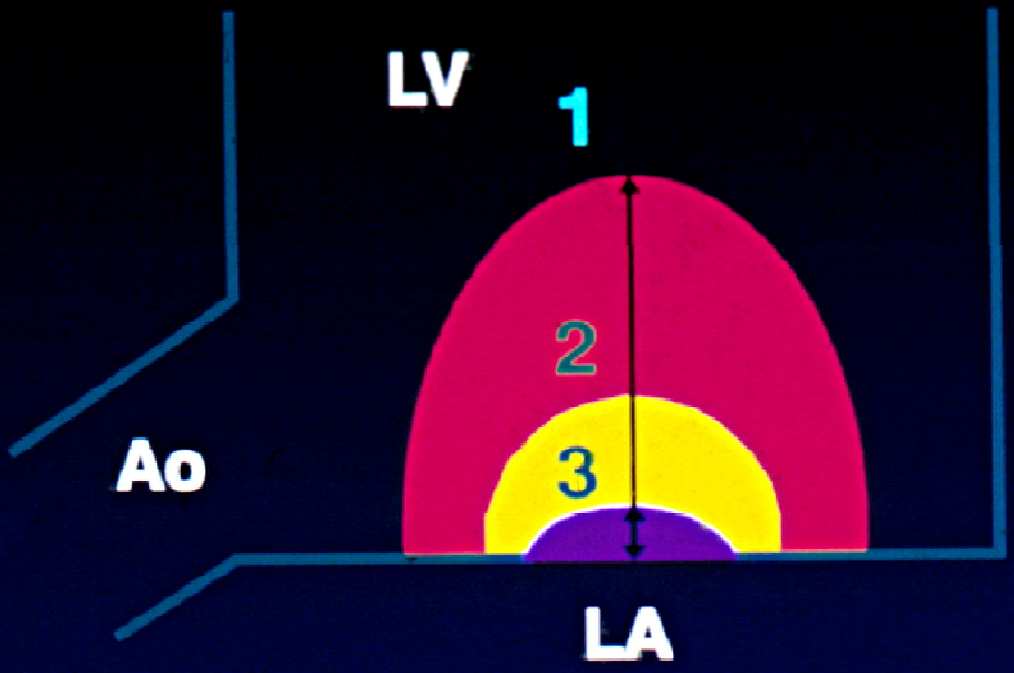
Flow through the orifice
= flow through the isovelocity surface
= $2\pi r^2$ x alias velocity

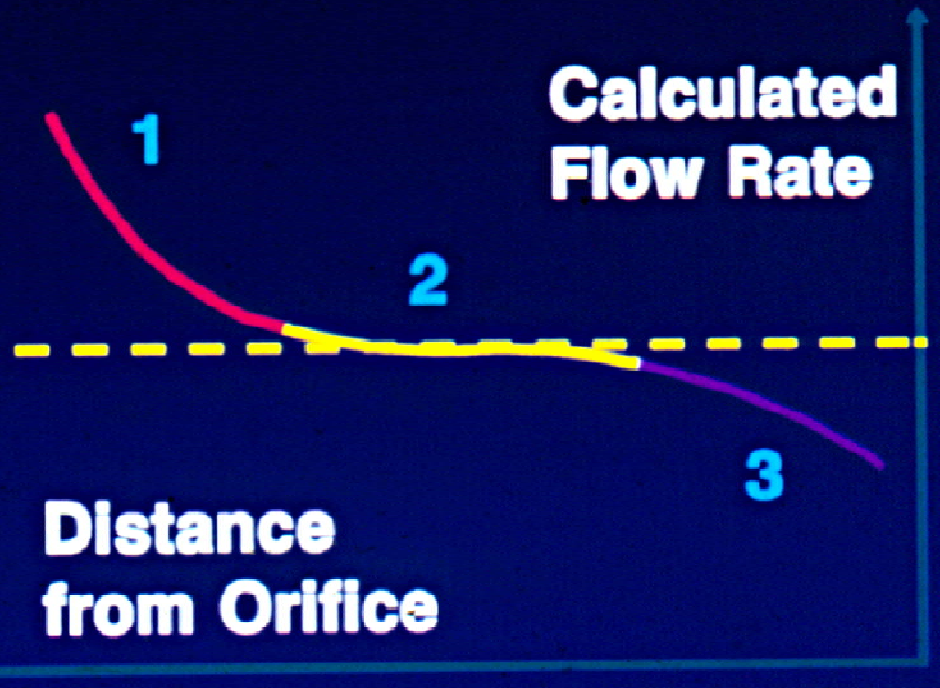
PISA

"Care must be taken to use the velocity at which the hemispheric formula applies best."

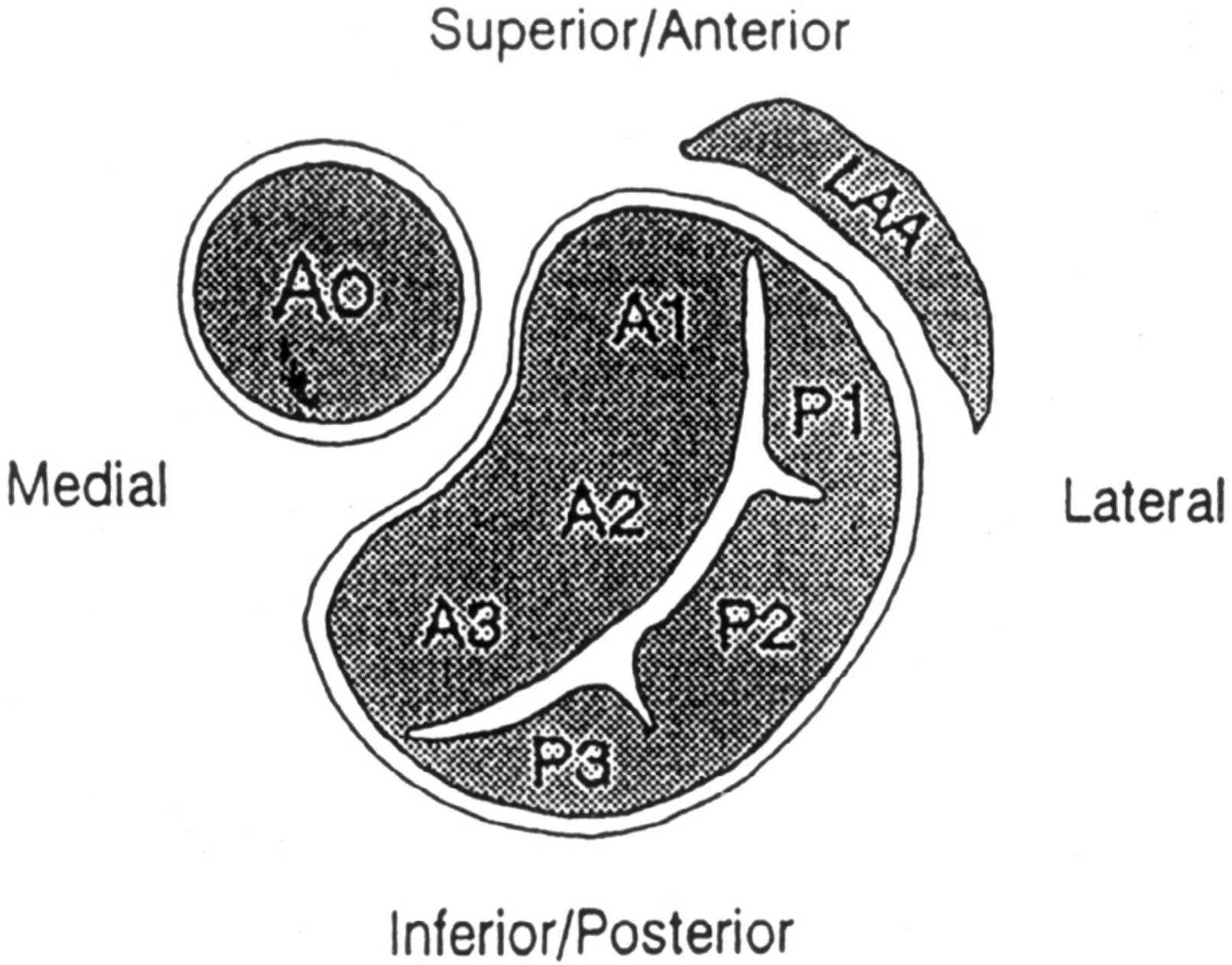
But is it really a hemisphere?

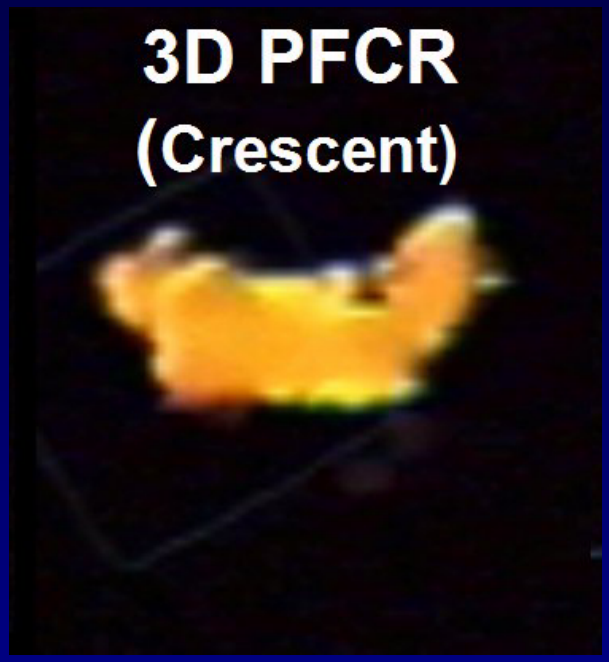

LV
LA



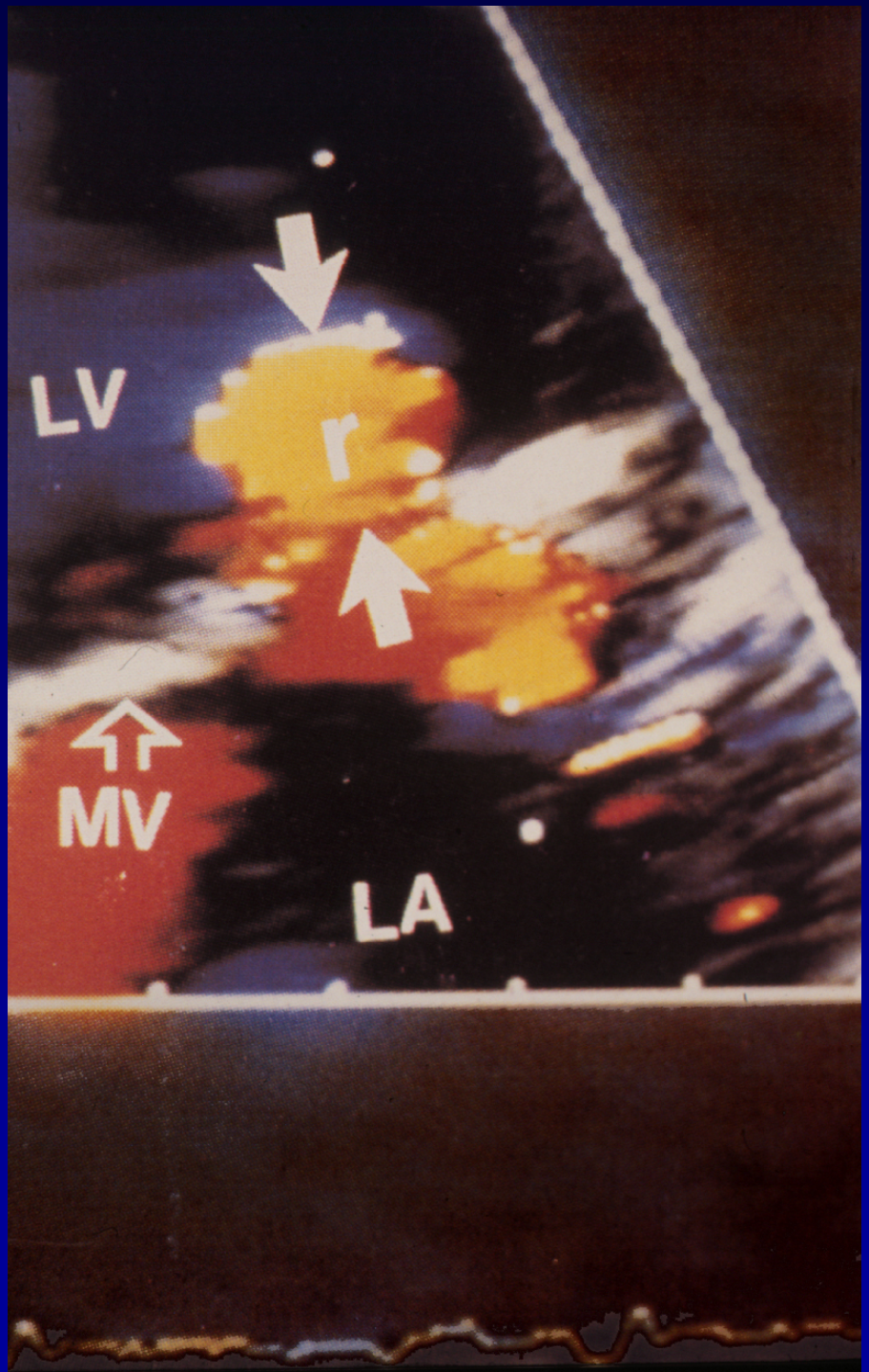


EHUD
SCHWAMMENTHAL
JACC 1996

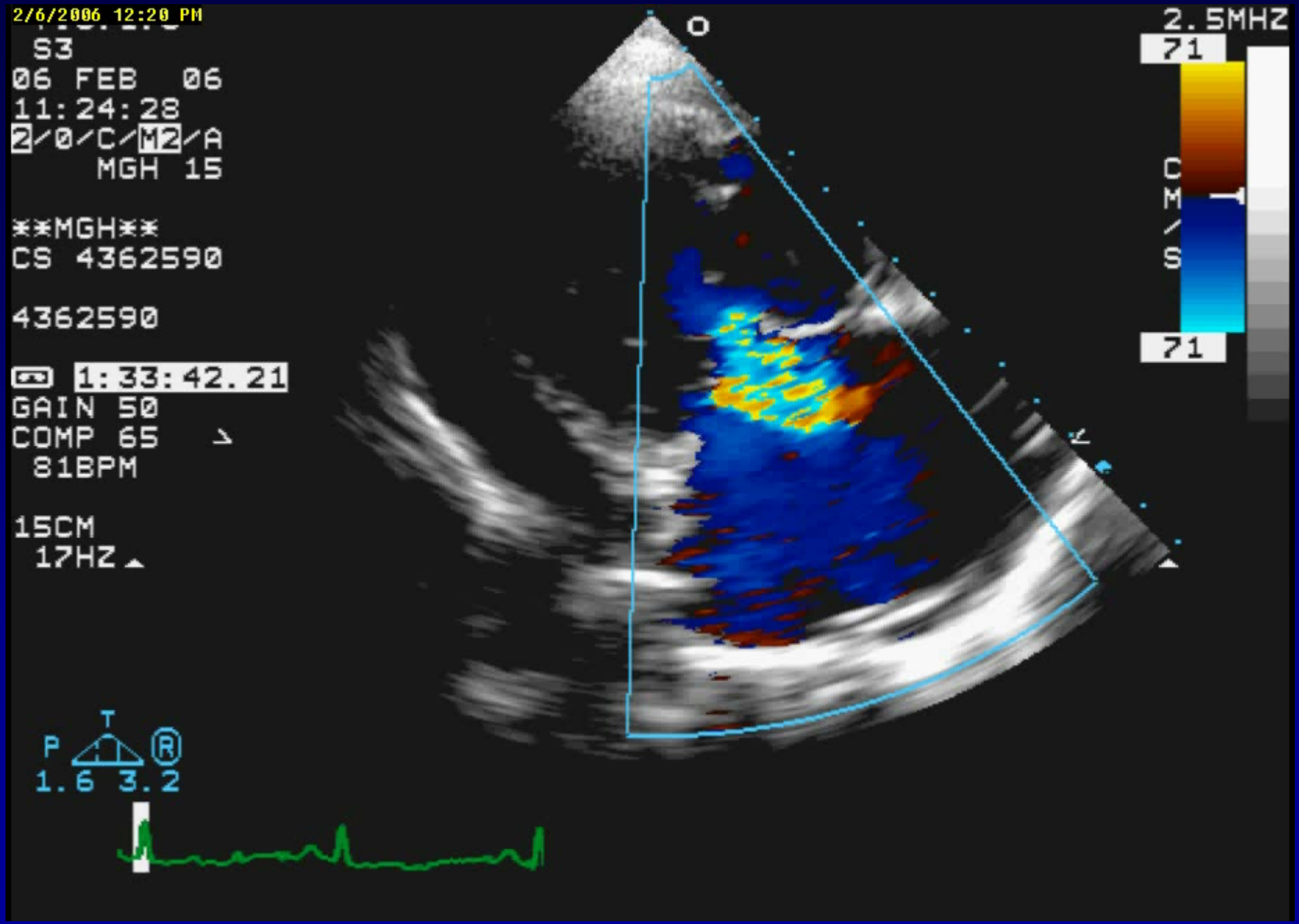

Superior/Anterior
LAA
A0
A1
P1
Medial
A2
Lateral
A3
P2
P3
Inferior/Posterior

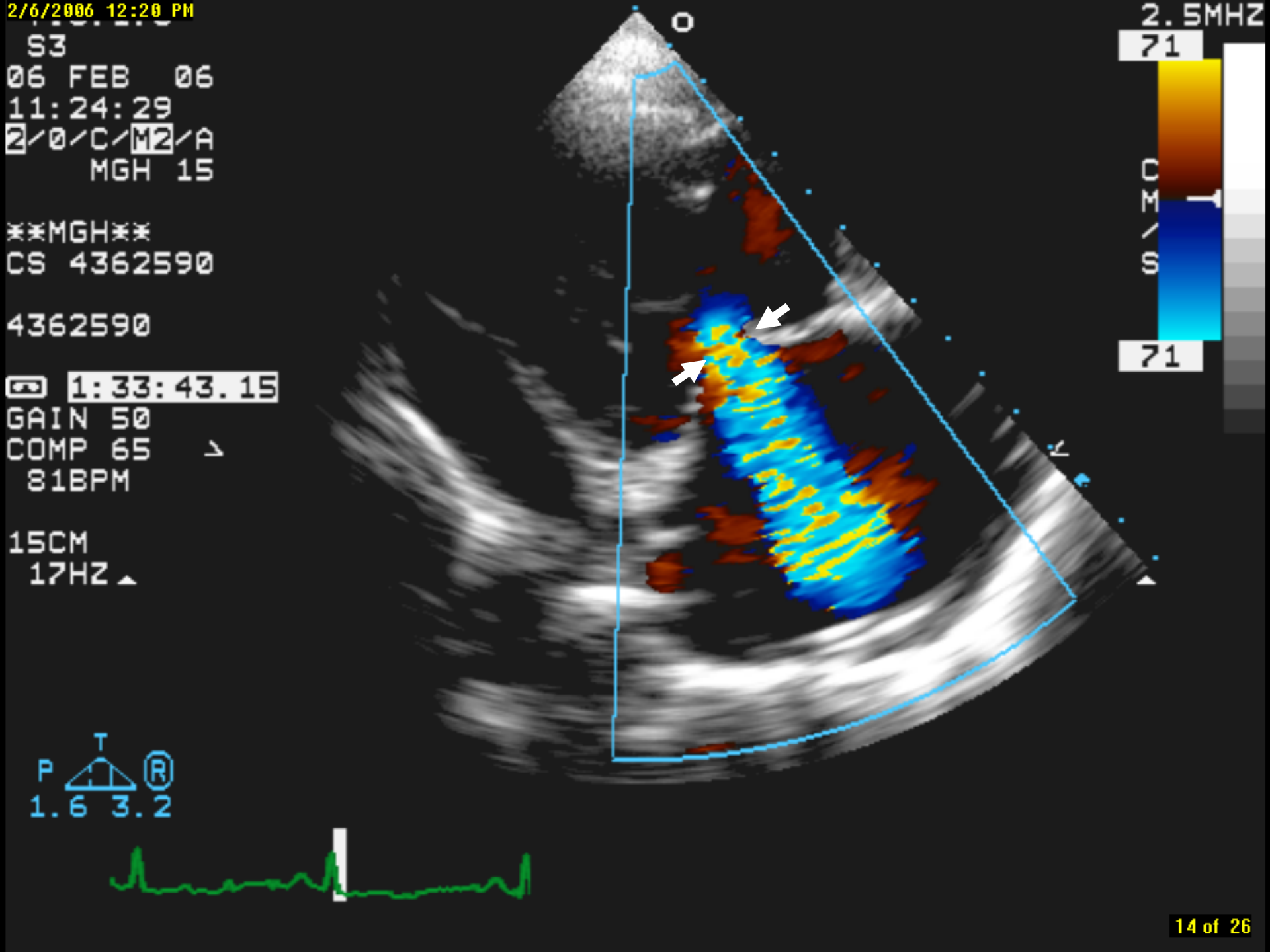


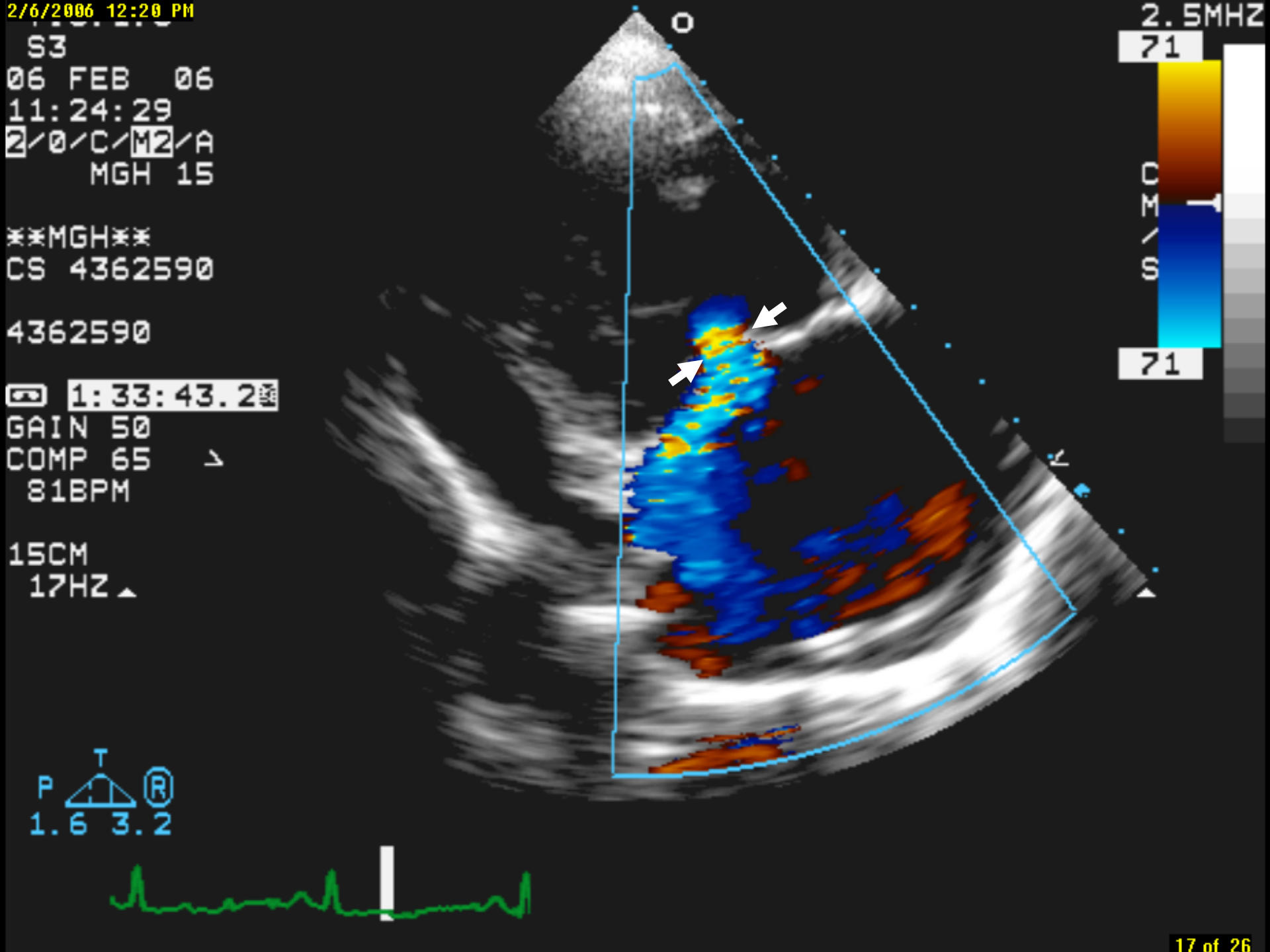
CHAIM YOSEFY
JUDY HUNG
XIN ZENG
JASE 2007; Circ CV Imag 2011


LV
r
MV
LA

THE MR PROXIMAL JET OR VENA CONTRACTA


2/6/2006 12:20 PM
S3
06 FEB 06
11:24:28
2/0/C/M2/A
MGH 15
MGH
CS 4362590
4362590
1:33:42.21
GAIN 50
COMP 65
81BPM
15CM
17HZ
2.5MHZ
71
CM/S
71
P
T
R
1.6 3.2


2/6/2006 12:20 PM
S3
06 FEB 06
11:24:29
2/0/C/M2/A
MGH 15
MGH
CS 4362590
4362590
1:33:43.15
GAIN 50
COMP 65
81BPM
15CM
17HZ
2.5MHZ
71
CM/S
71
T
P
R
1.6 3.2
14 of 26


2/6/2006 12:20 PM
S3
06 FEB 06
11:24:29
2/0/C/M2/A
MGH 15
MGH
CS 4362590
4362590
1:33:43.2
GAIN 50
COMP 65
81BPM
15CM
17HZ
2.5MHZ
71
CM/S
71
T
P
R
1.6 3.2
17 of 26

SPECIFIC SIGN:
THE VENA CONTRACTA
ASE – Zoghbi W JASE 2003

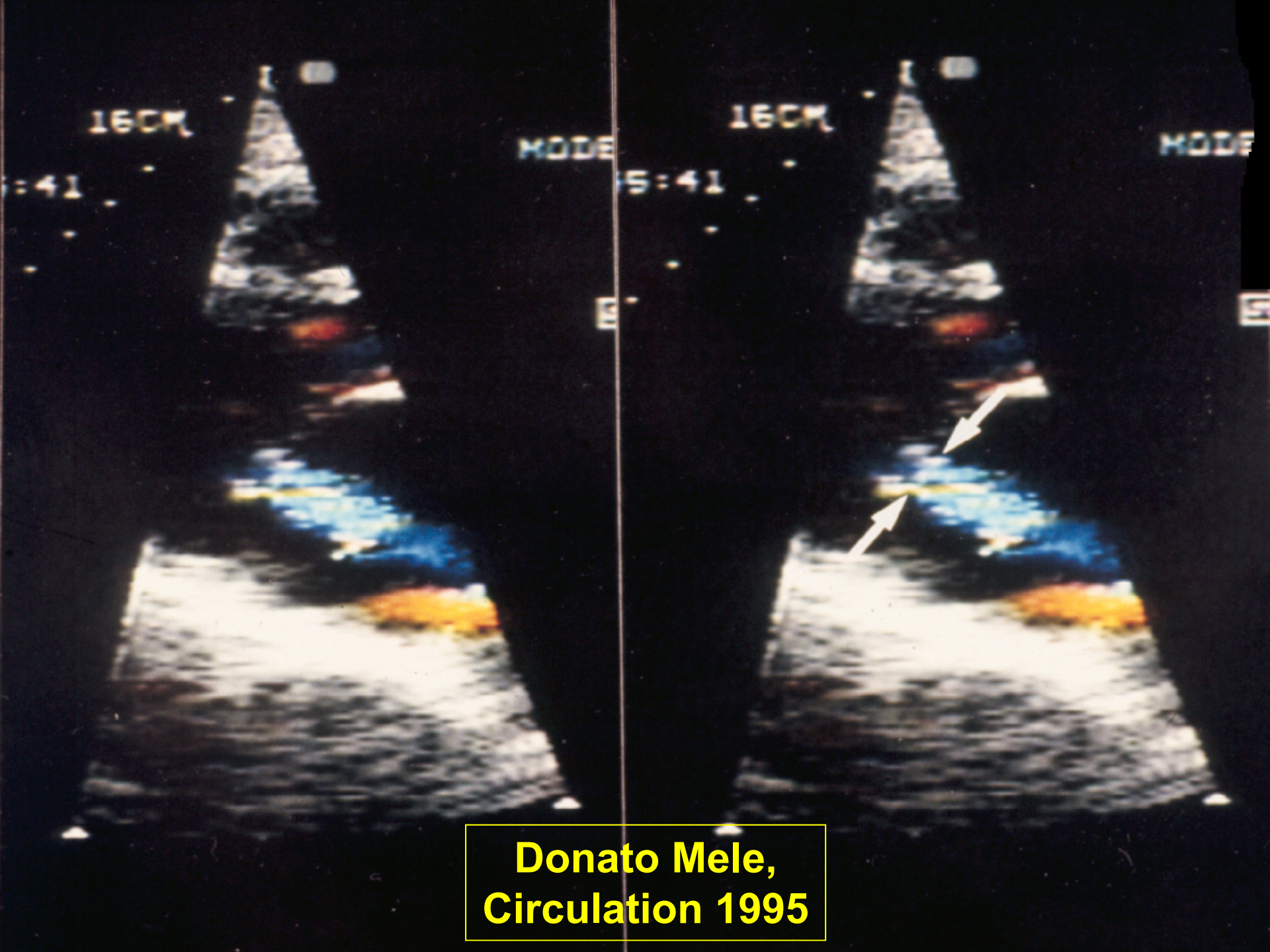
"The heart of the matter" (Paul Grayburn)

Width <0.3cm	Mild
Width ≥0.7cm	Severe

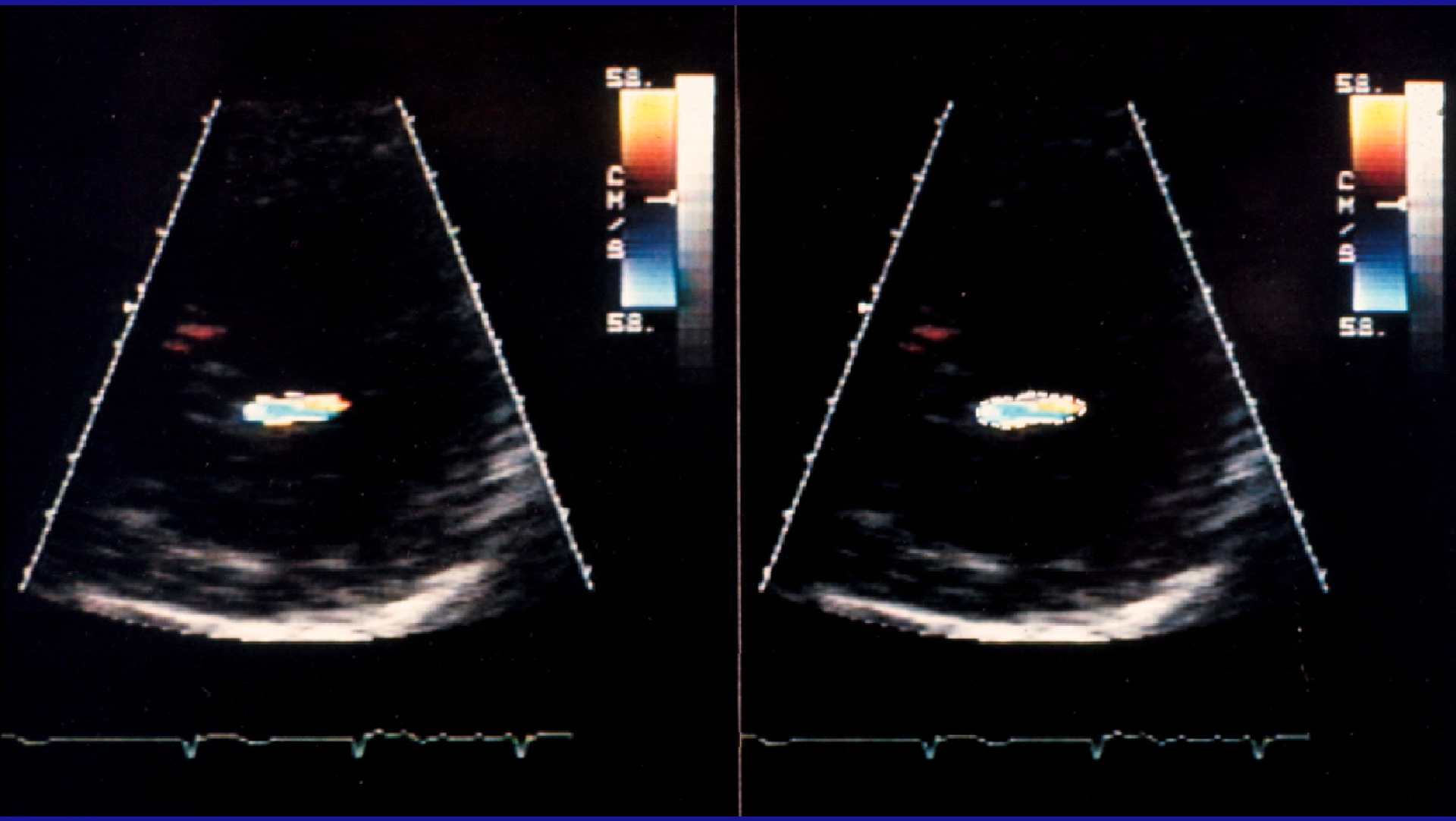
5 mm = moderate (Tribouilloy; Mele - Circulation 1992-5)

Use zoom mode for greatest accuracy

Christophe Tribouilloy, Circulation 1992



Donato Mele,
Circulation 1995



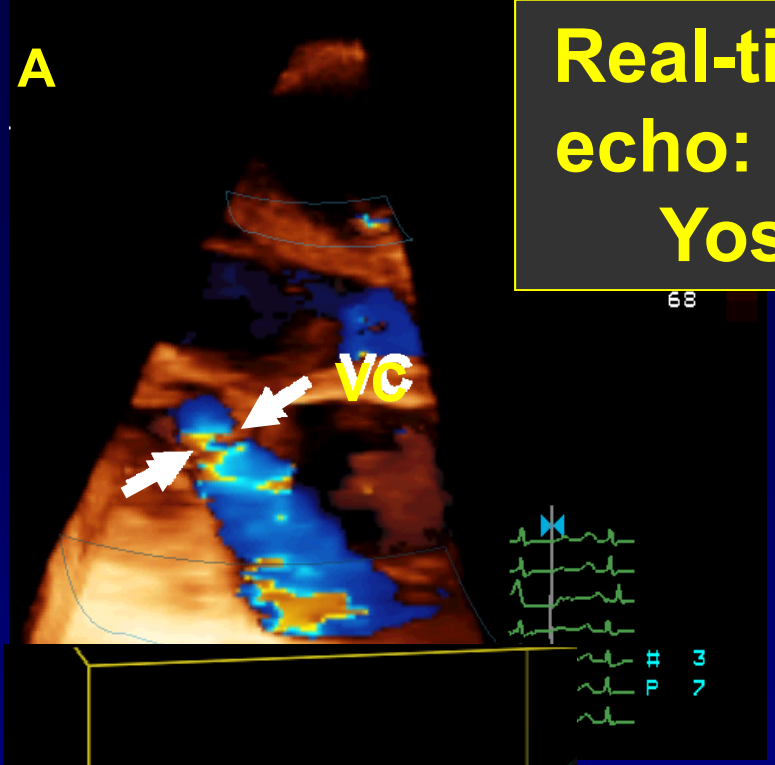
Mele, Circulation

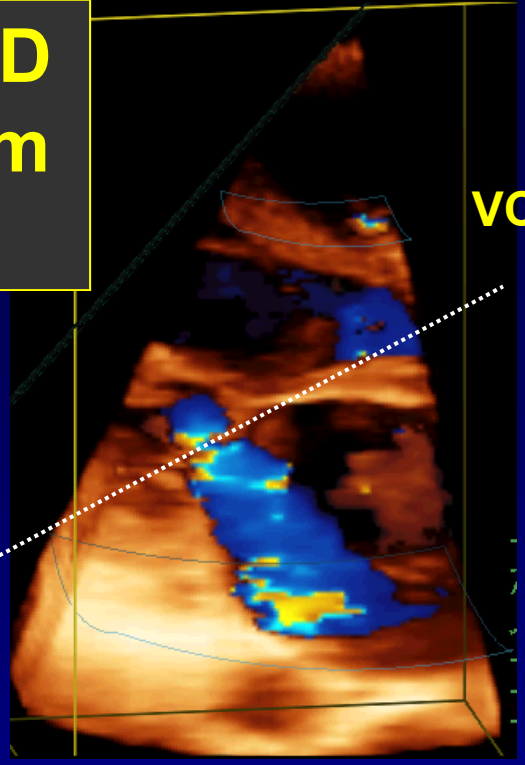
Improved quantification of the vena contracta by 3D echo

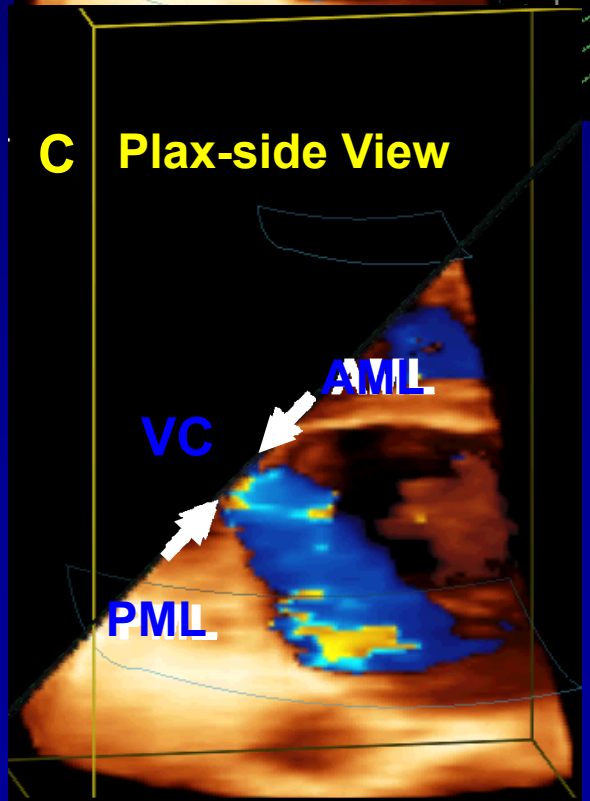
Chaim Yosefy, Robert Levine, Judy Hung

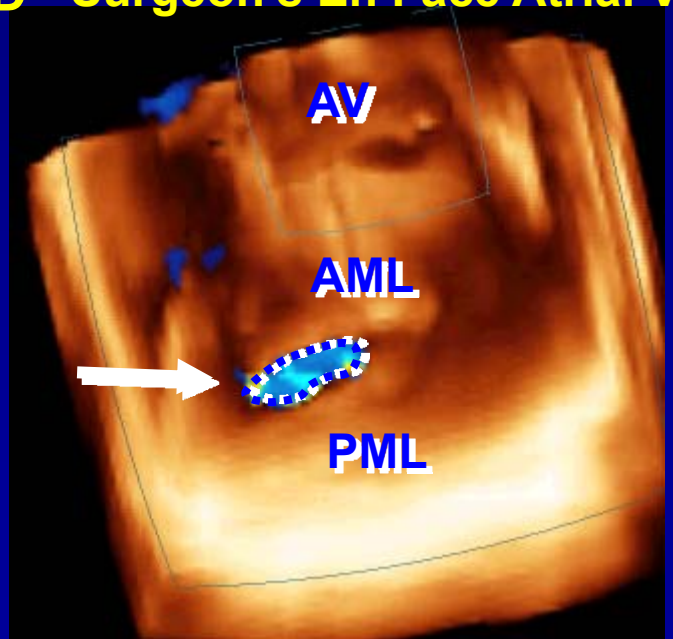
MGH
Barzilai Hospital, Ashkelon
Am J Cardiol 2009

Real-time 3D echo: Chaim Yosefy

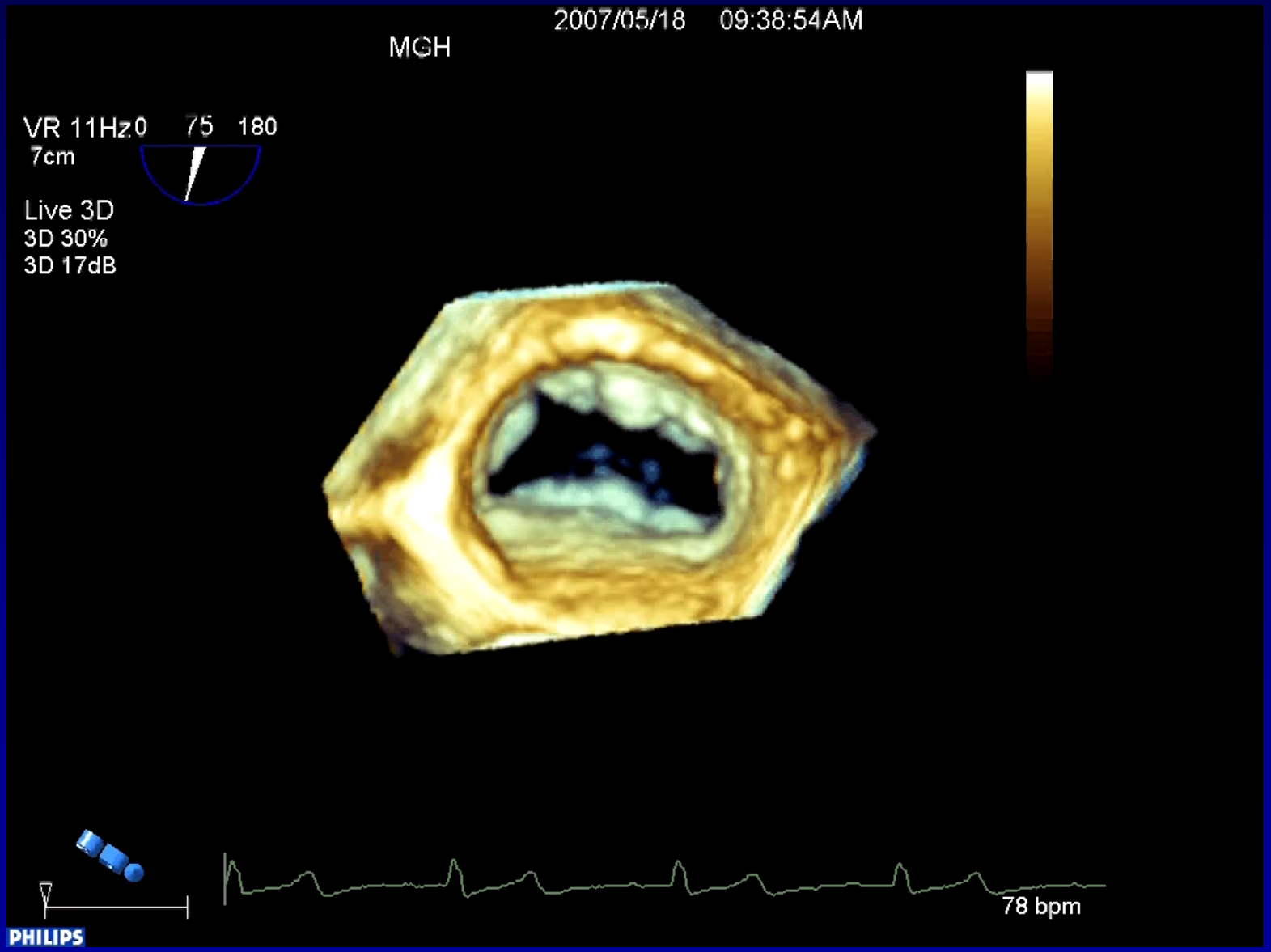




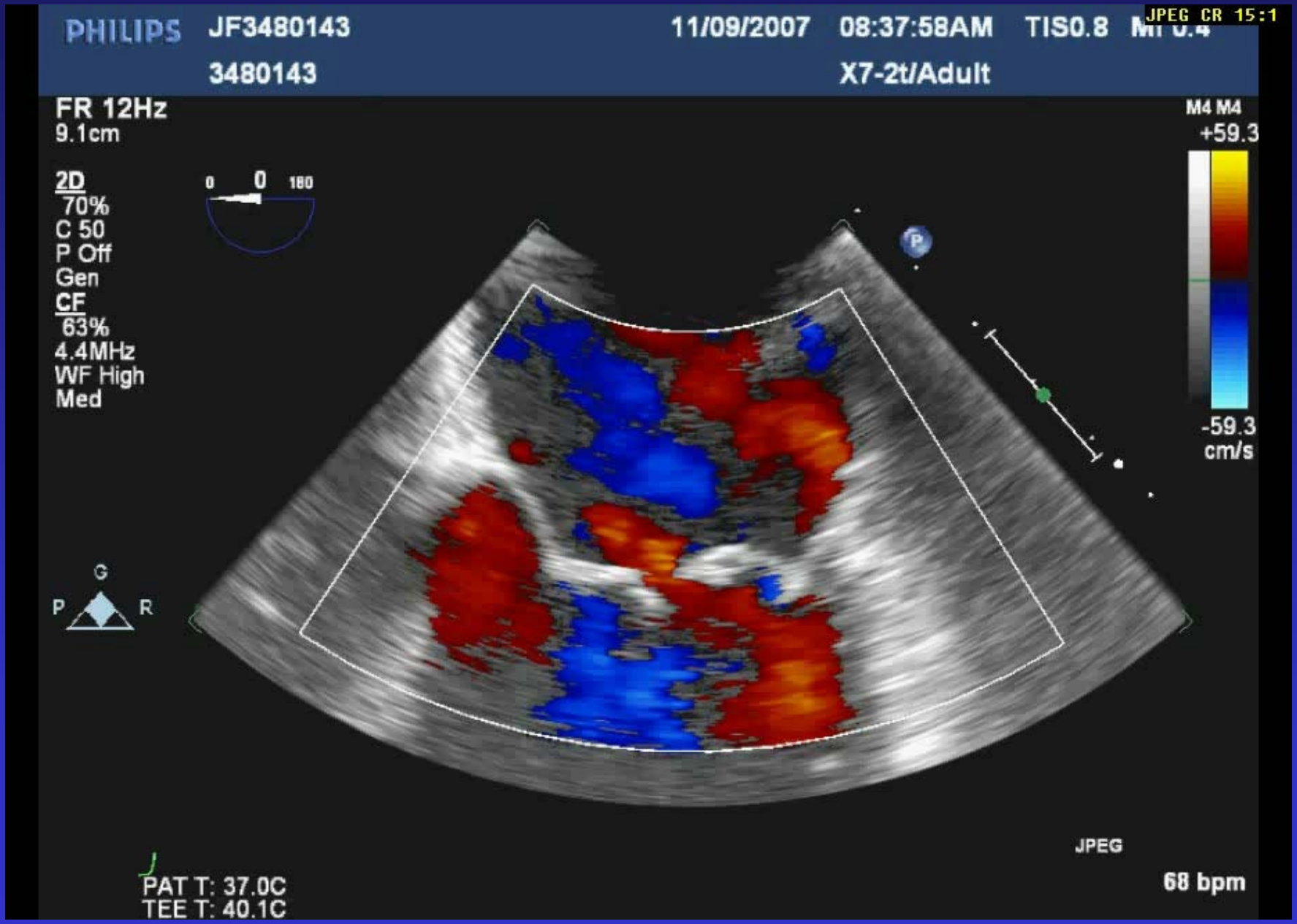




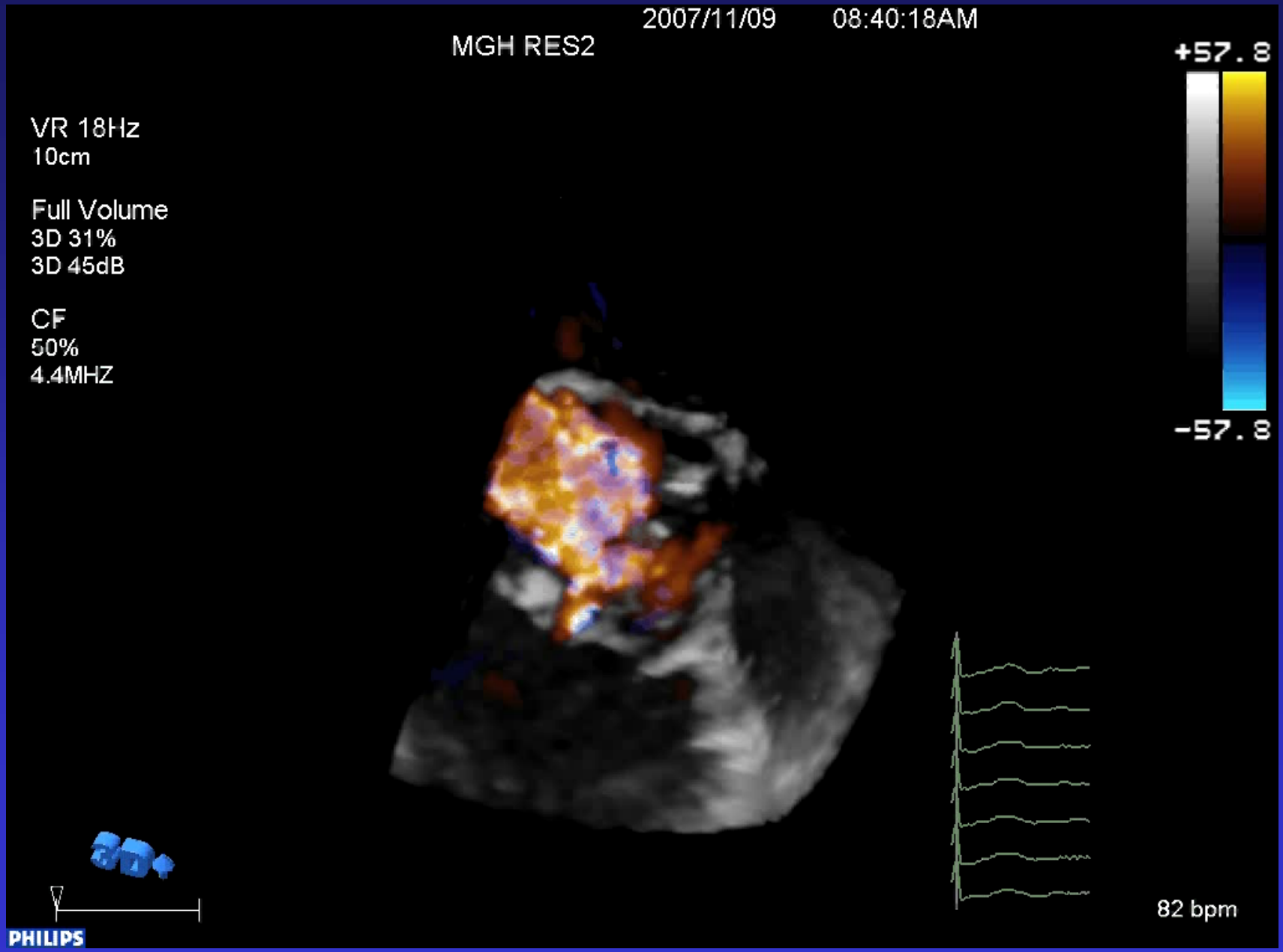
Real-time 3D TEE
Jonathan Passeri, MGH

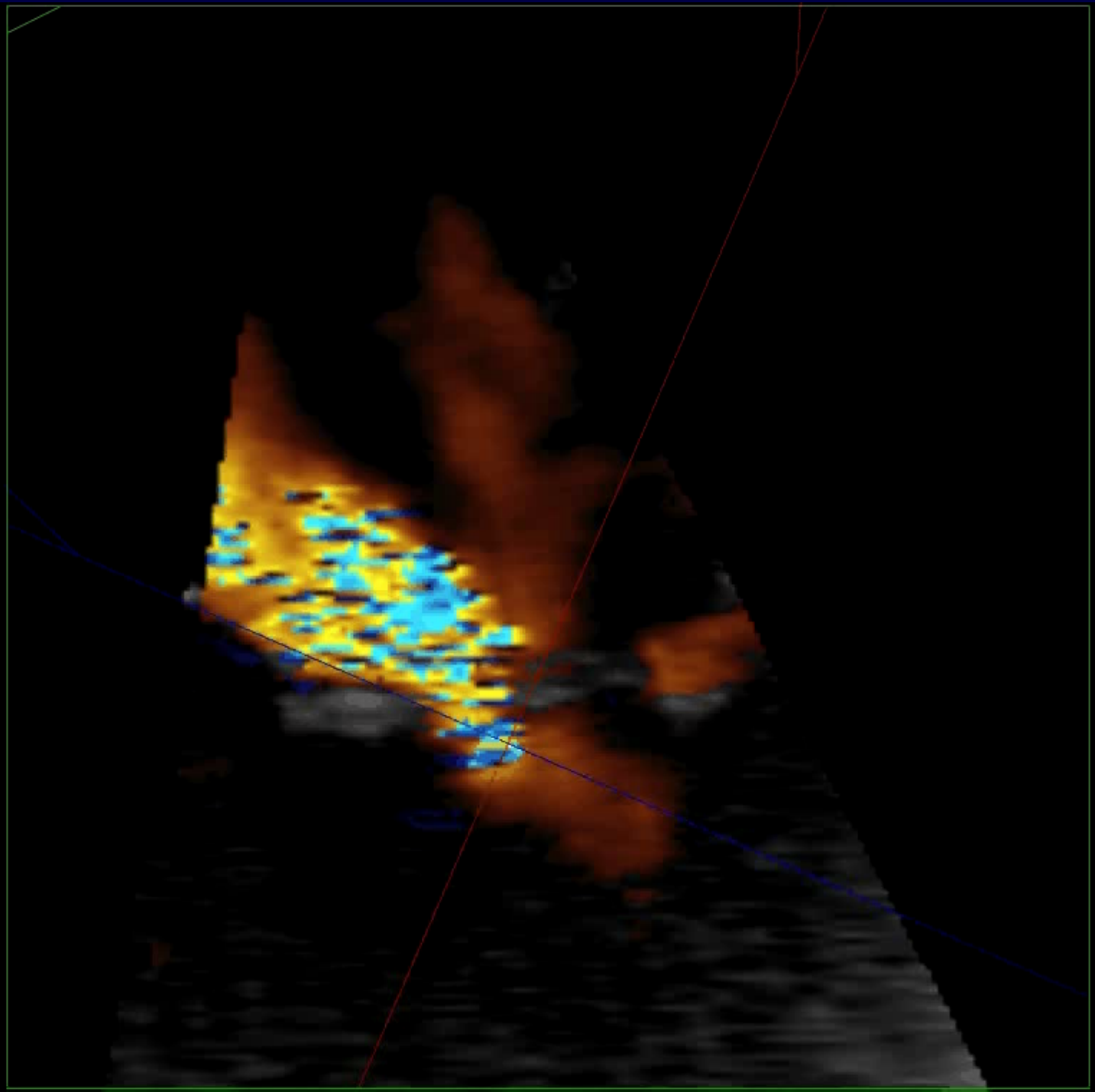


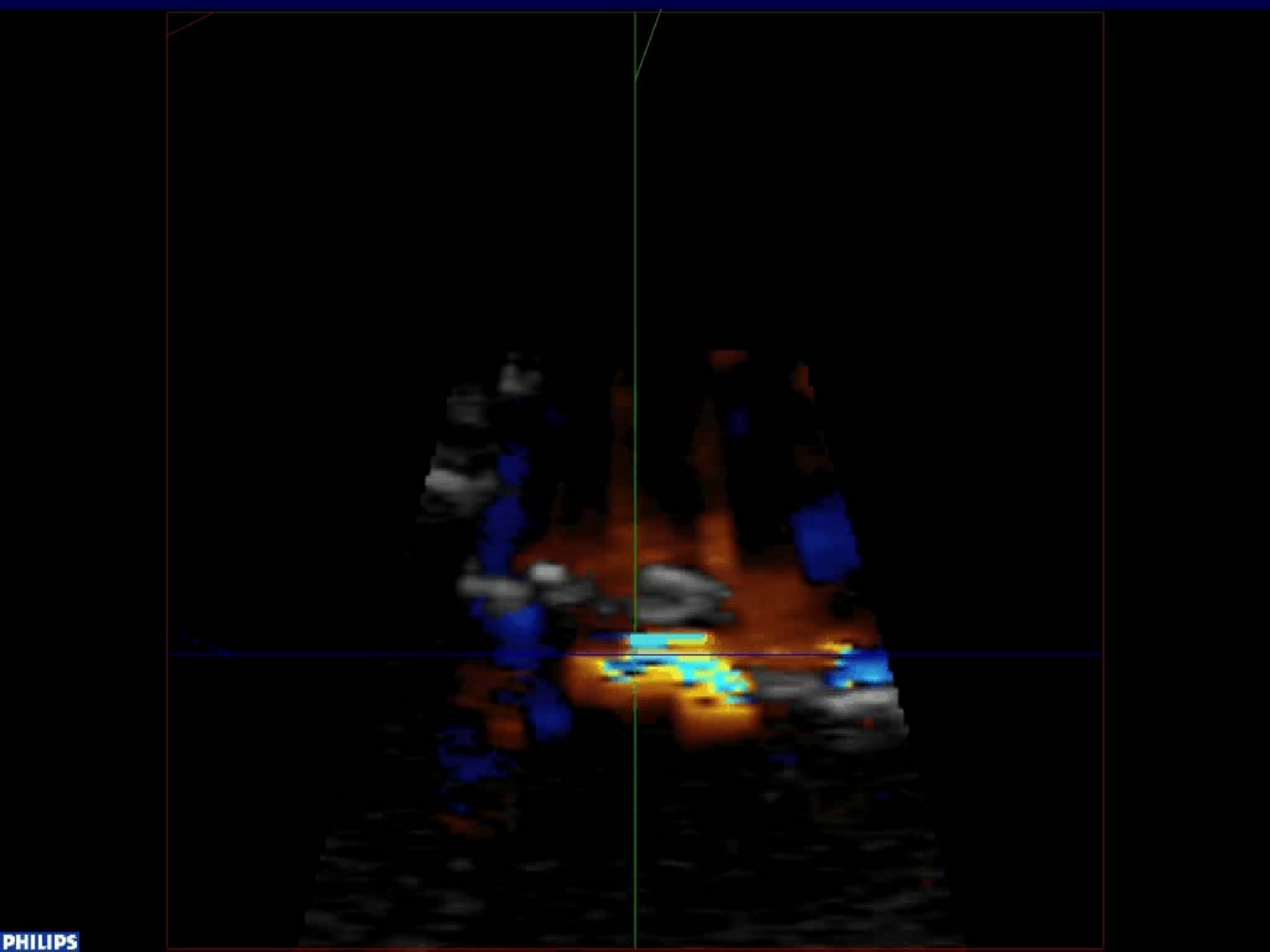
HOW EXTENSIVE IS THE LESION?

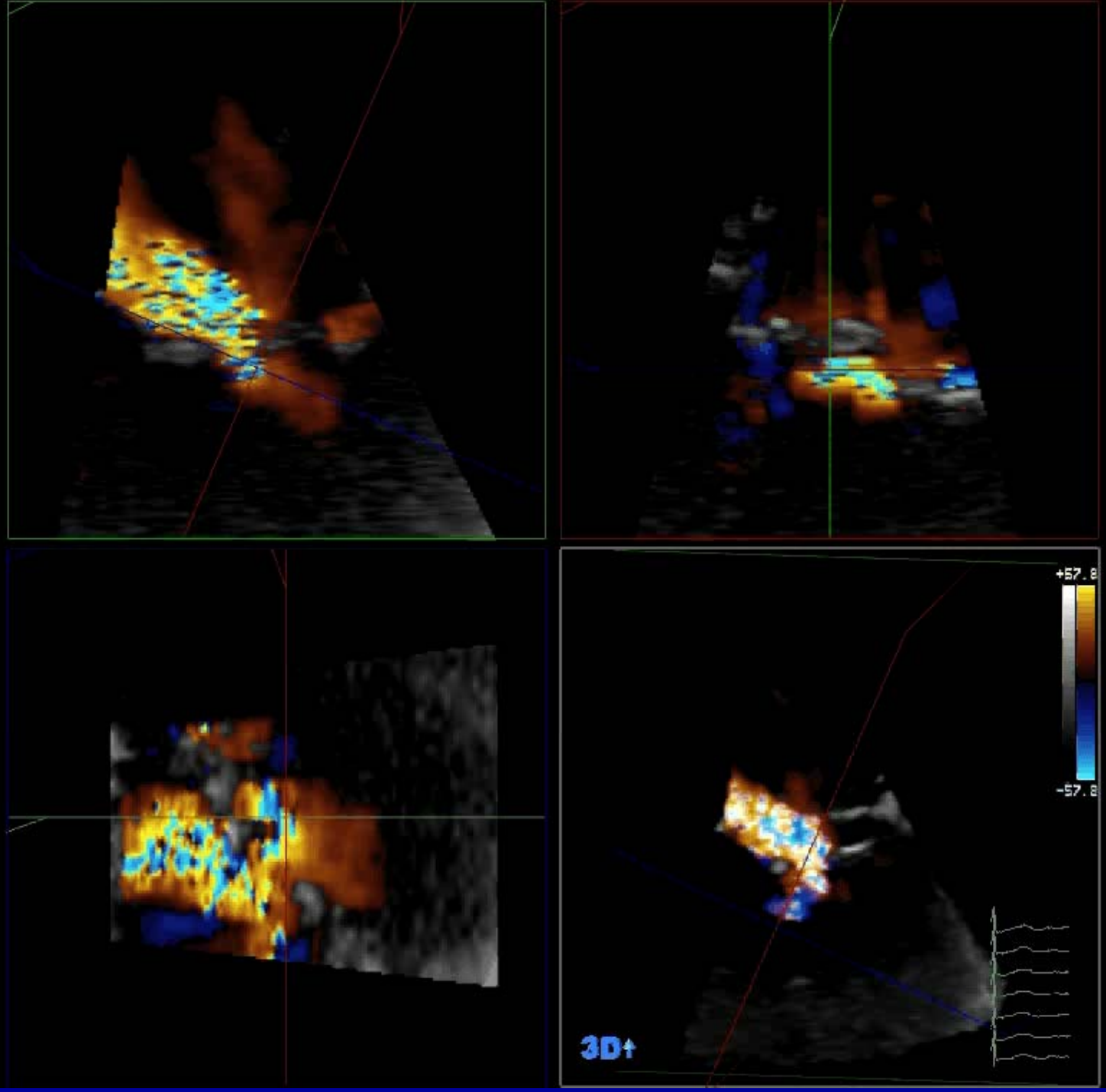


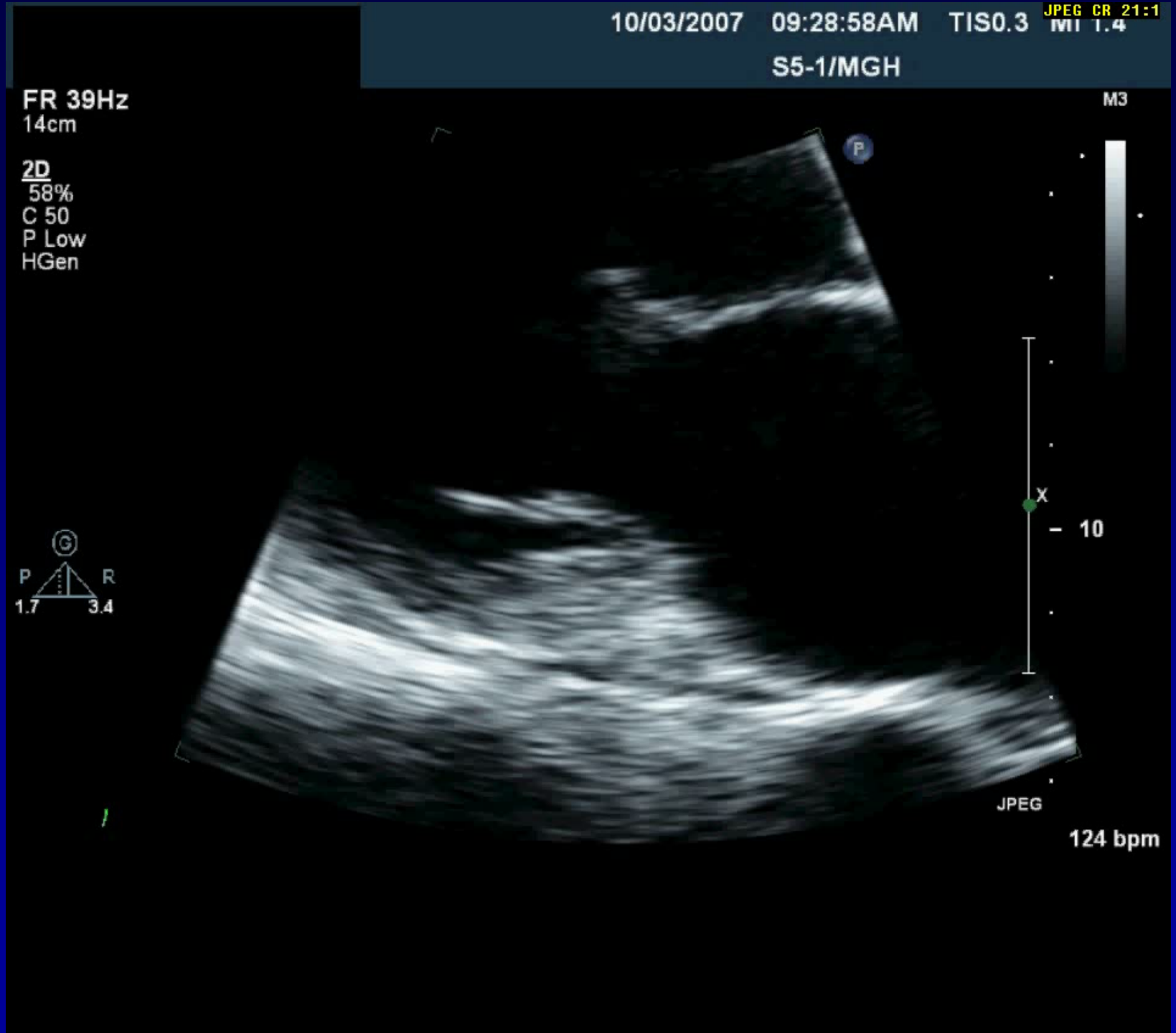
HOW EXTENSIVE IS THE LESION?

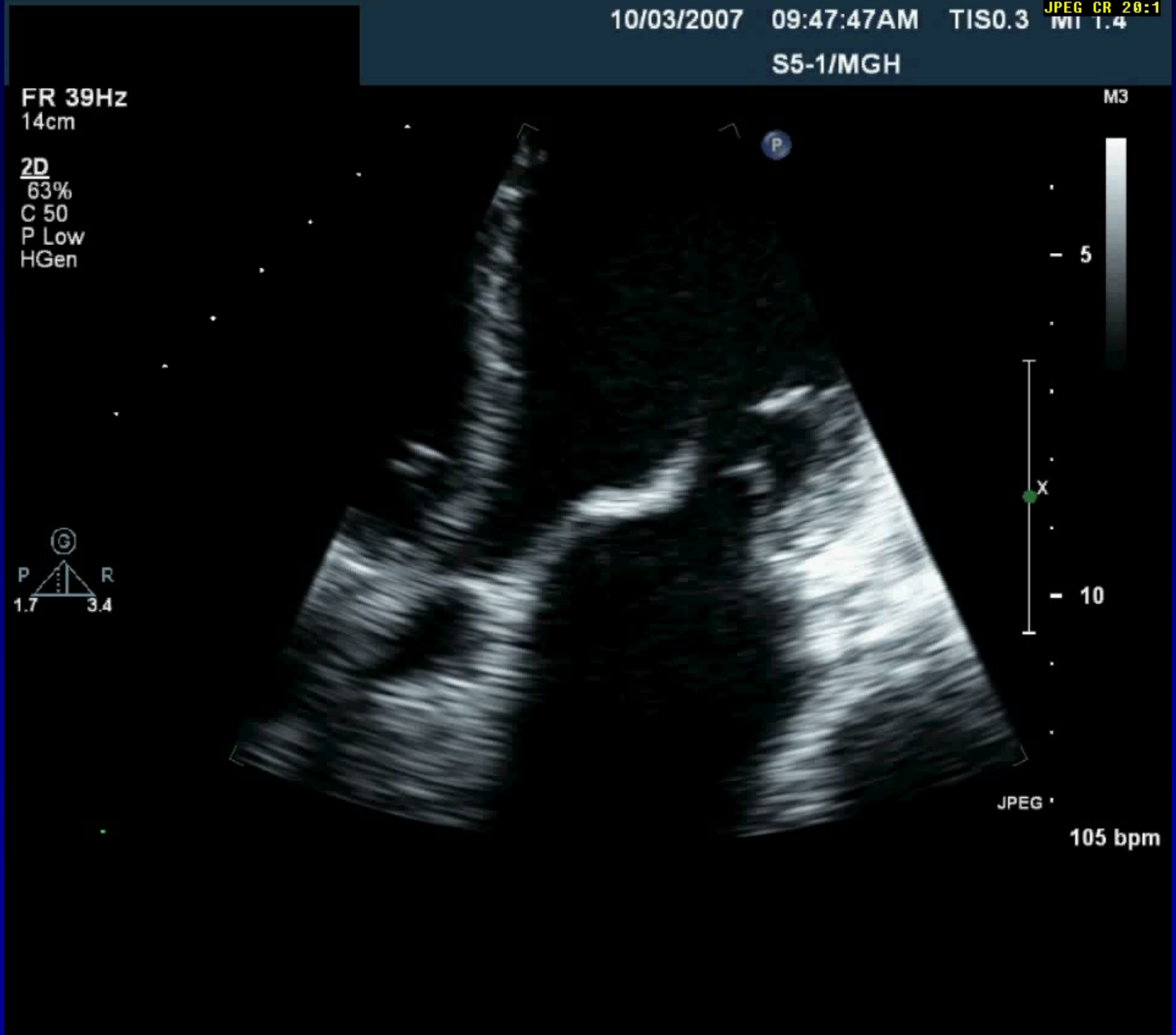


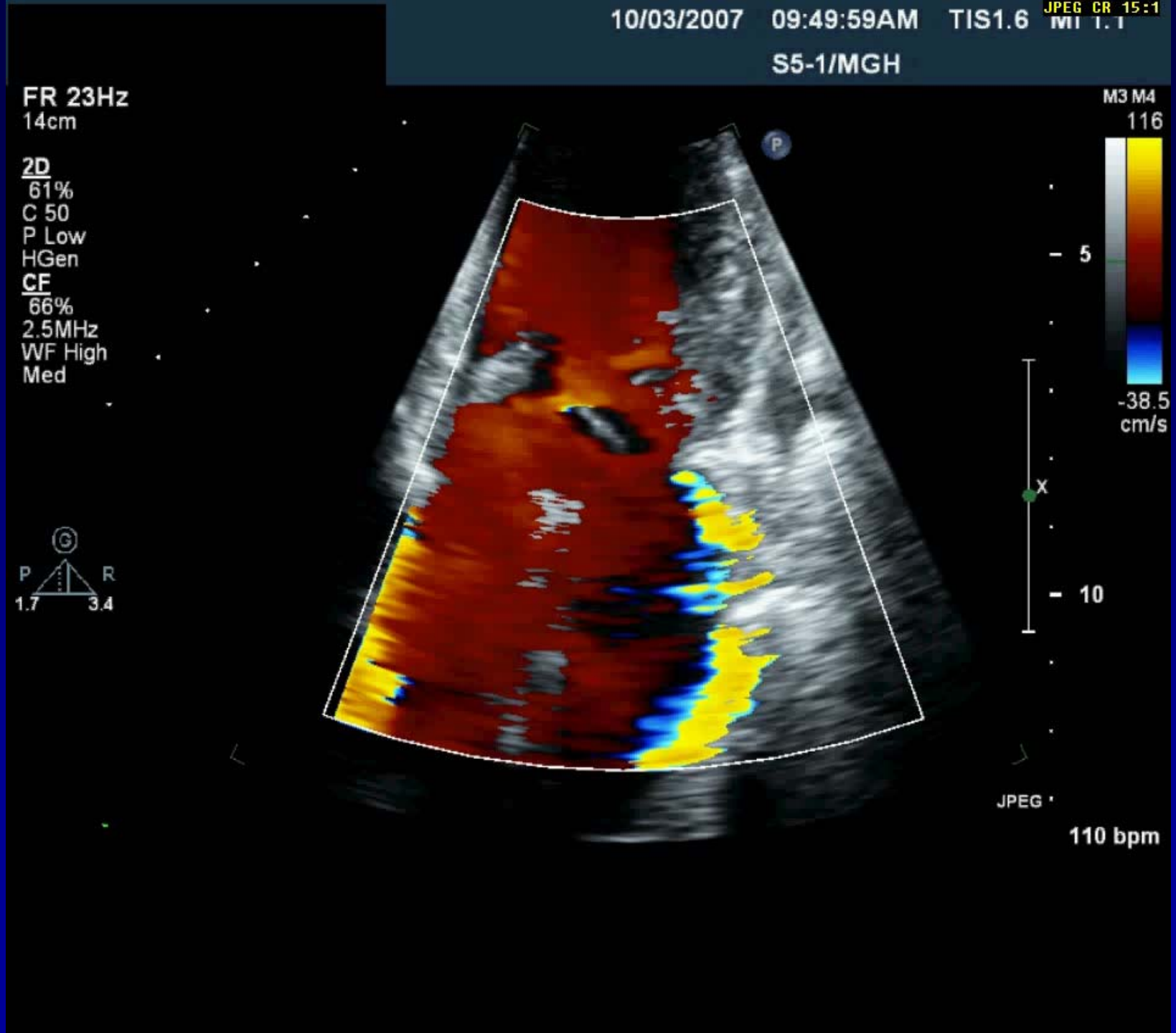

PHILIPS

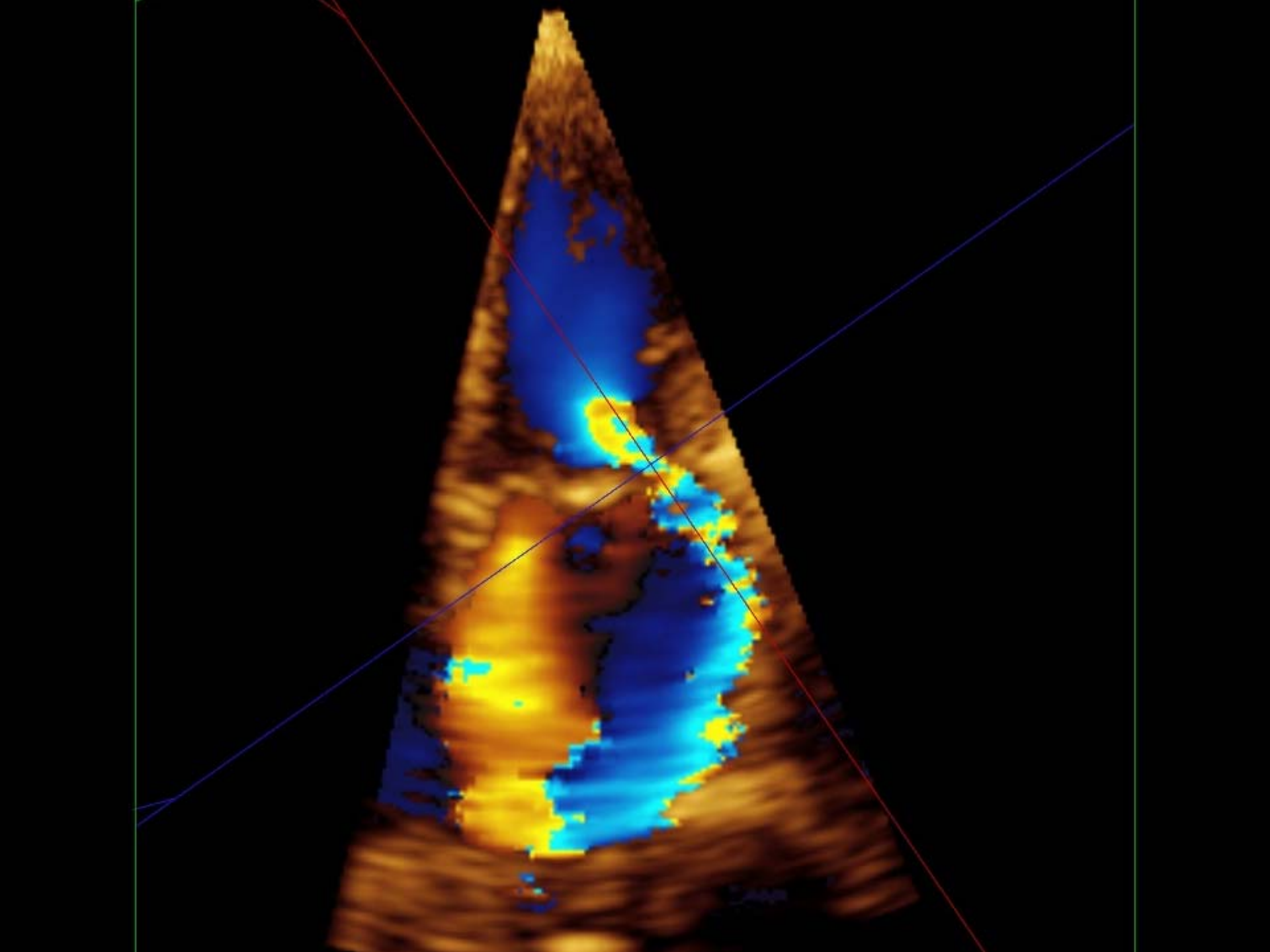

PHILIPS

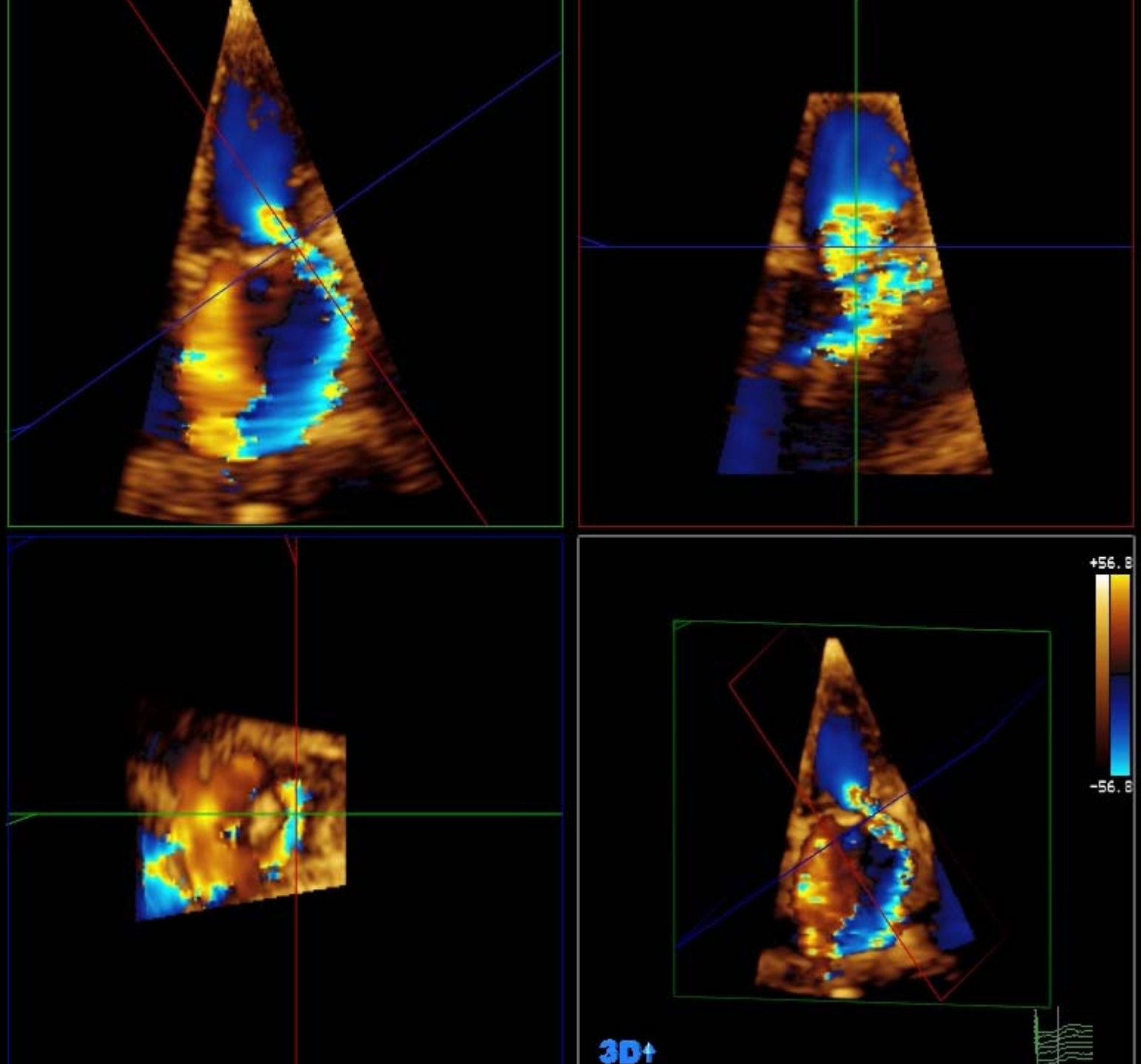

+57.8
-57.8
3D

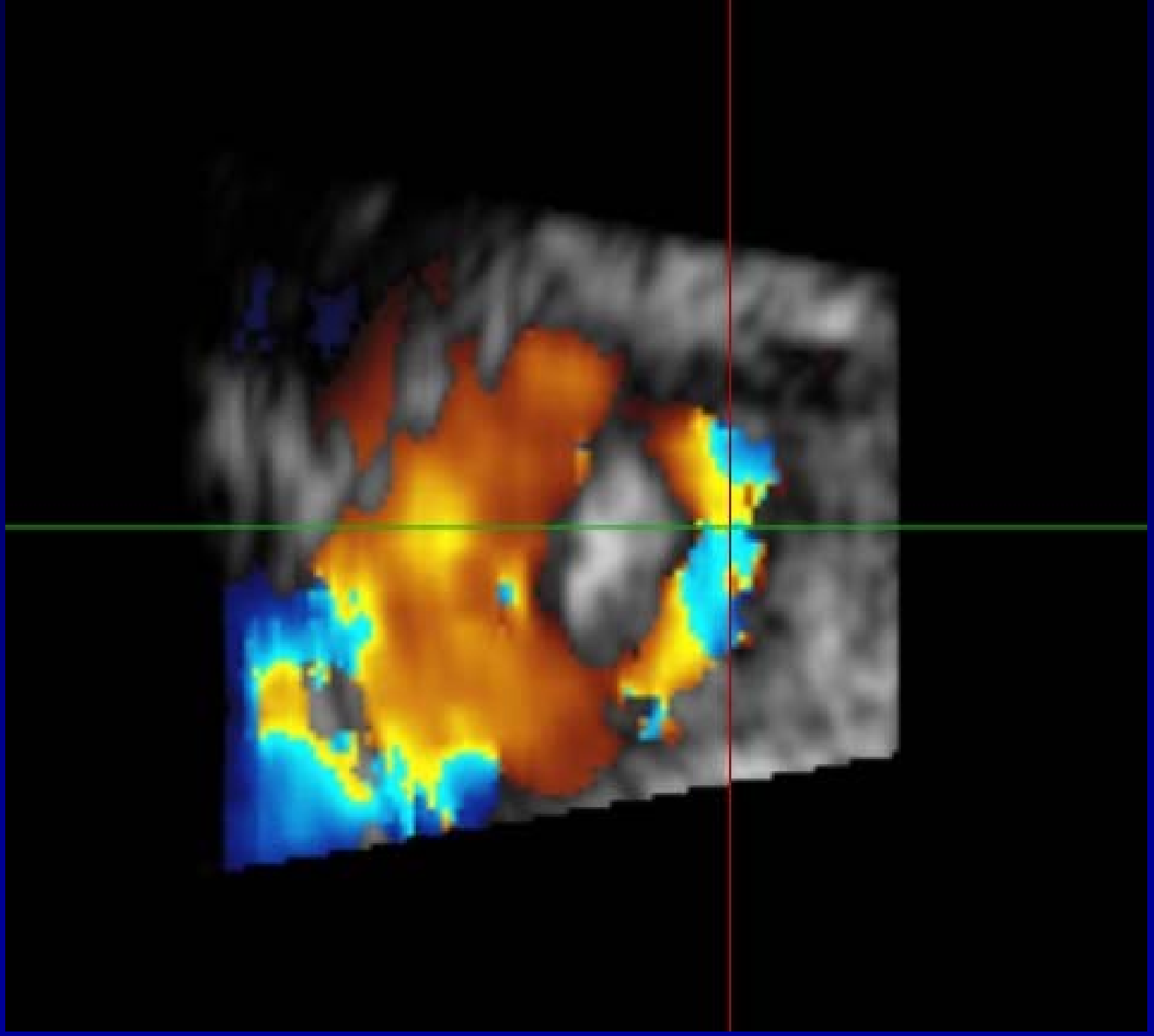

JPEG CR 21:1
10/03/2007 09:28:58AM TIS0.3 MI 1.4
S5-1/MGH
FR 39Hz
14cm
2D
58%
C 50
P Low
HGen
M3
P
X
10
G
P
R
1.7
3.4
JPEG
124 bpm

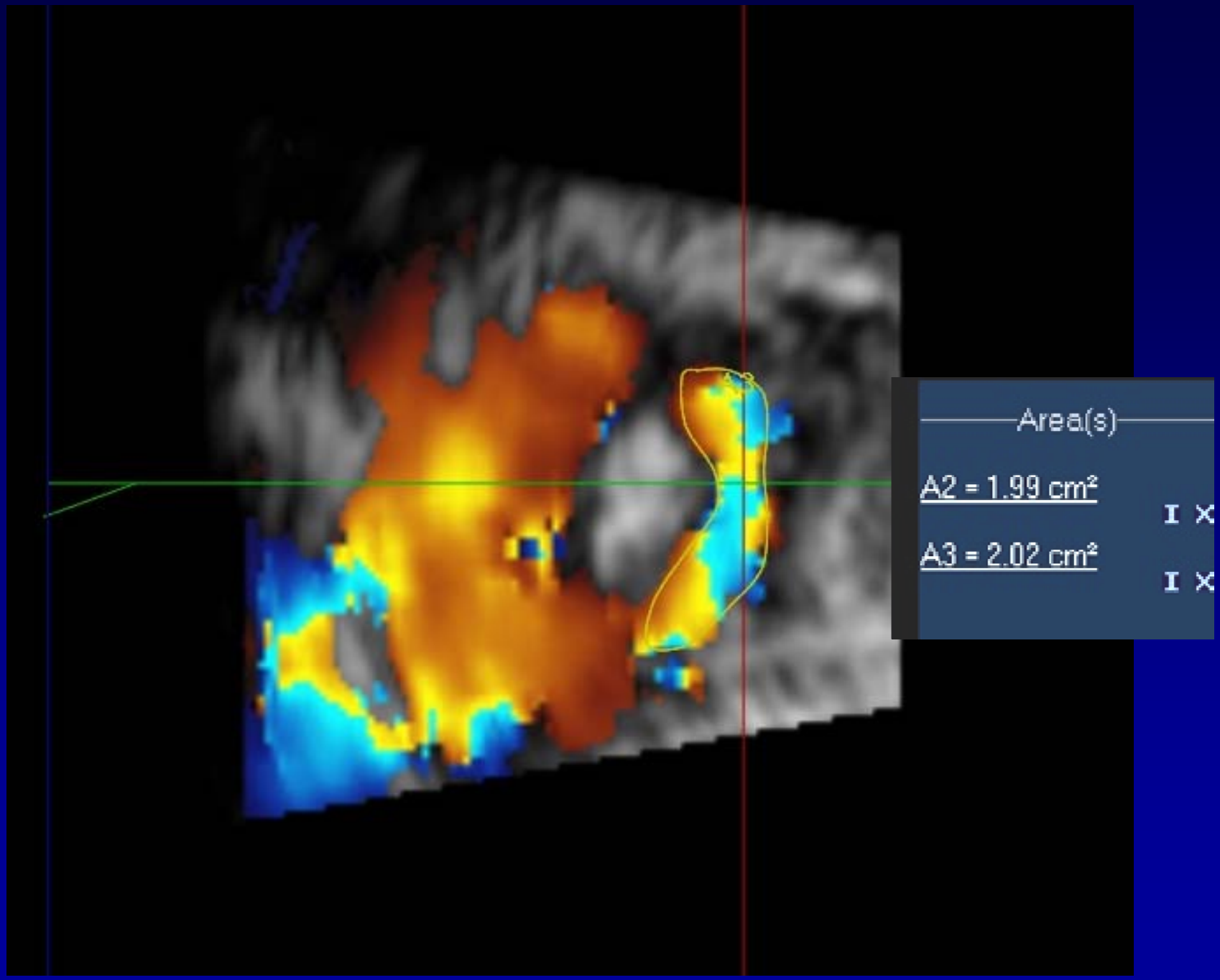

JPEG CR 20:1
10/03/2007 09:47:47AM TIS0.3 MI 1.4
S5-1/MGH
FR 39Hz
14cm
2D
63%
C 50
P Low
HGen
M3
5
10
P
R
1.7
3.4
JPEG
105 bpm

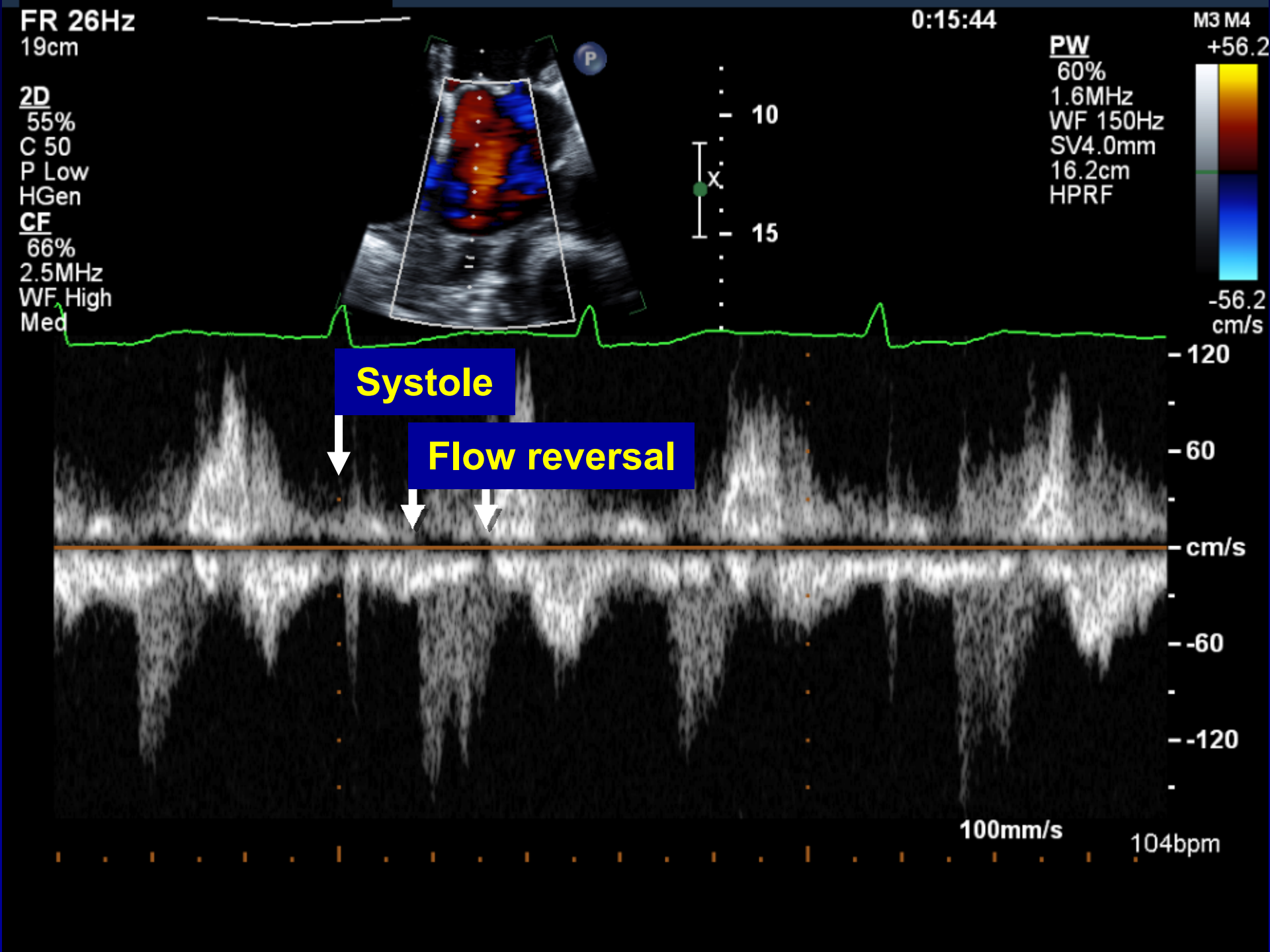

JPEG CR 15:1
10/03/2007 09:49:59AM TIS1.6 MI 1.1
S5-1/MGH
FR 23Hz
14cm
2D
61%
C 50
P Low
HGen
CF
66%
2.5MHz
WF High
Med
M3 M4
116
5
-38.5
cm/s
10
P
R
1.7
3.4
JPEG
110 bpm

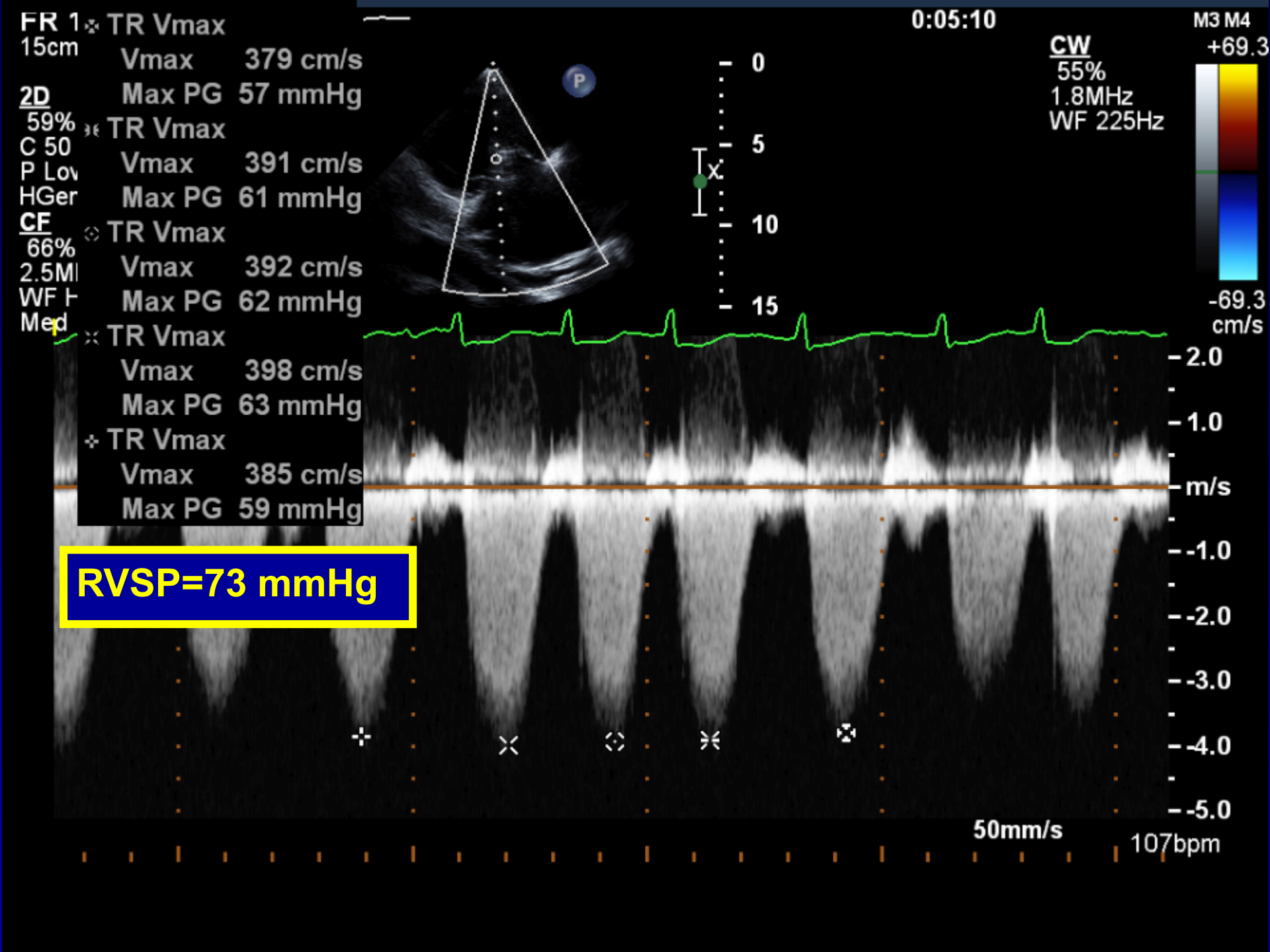



+56.8
-56.8
3D




Area(s)
A2 = 1.99 cm²
A3 = 2.02 cm²


FR 26Hz
19cm
2D
55%
C 50
P Low
HGen
CF
66%
2.5MHz
WF High
Med
0:15:44
PW
60%
1.6MHz
WF 150Hz
SV4.0mm
16.2cm
HPRF
M3 M4
+56.2
-56.2
cm/s
10
15
120
60
cm/s
-60
-120
Systole
Flow reversal
100mm/s
104bpm


FR 1
15cm
2D
59%
C 50
P Lov
HGer
CF
66%
2.5MI
WF H
Med
TR Vmax
Vmax 379 cm/s
Max PG 57 mmHg
TR Vmax
Vmax 391 cm/s
Max PG 61 mmHg
TR Vmax
Vmax 392 cm/s
Max PG 62 mmHg
TR Vmax
Vmax 398 cm/s
Max PG 63 mmHg
TR Vmax
Vmax 385 cm/s
Max PG 59 mmHg
RVSP=73 mmHg
0:05:10
CW
55%
1.8MHz
WF 225Hz
M3 M4
+69.3
-69.3
cm/s
0
5
10
15
2.0
1.0
m/s
-1.0
-2.0
-3.0
-4.0
-5.0
50mm/s
107bpm

3D-guided assessment of regurgitant orifice areas provides rapid, reliable and practical quantification

CHALLENGES IN ASSESSING MR

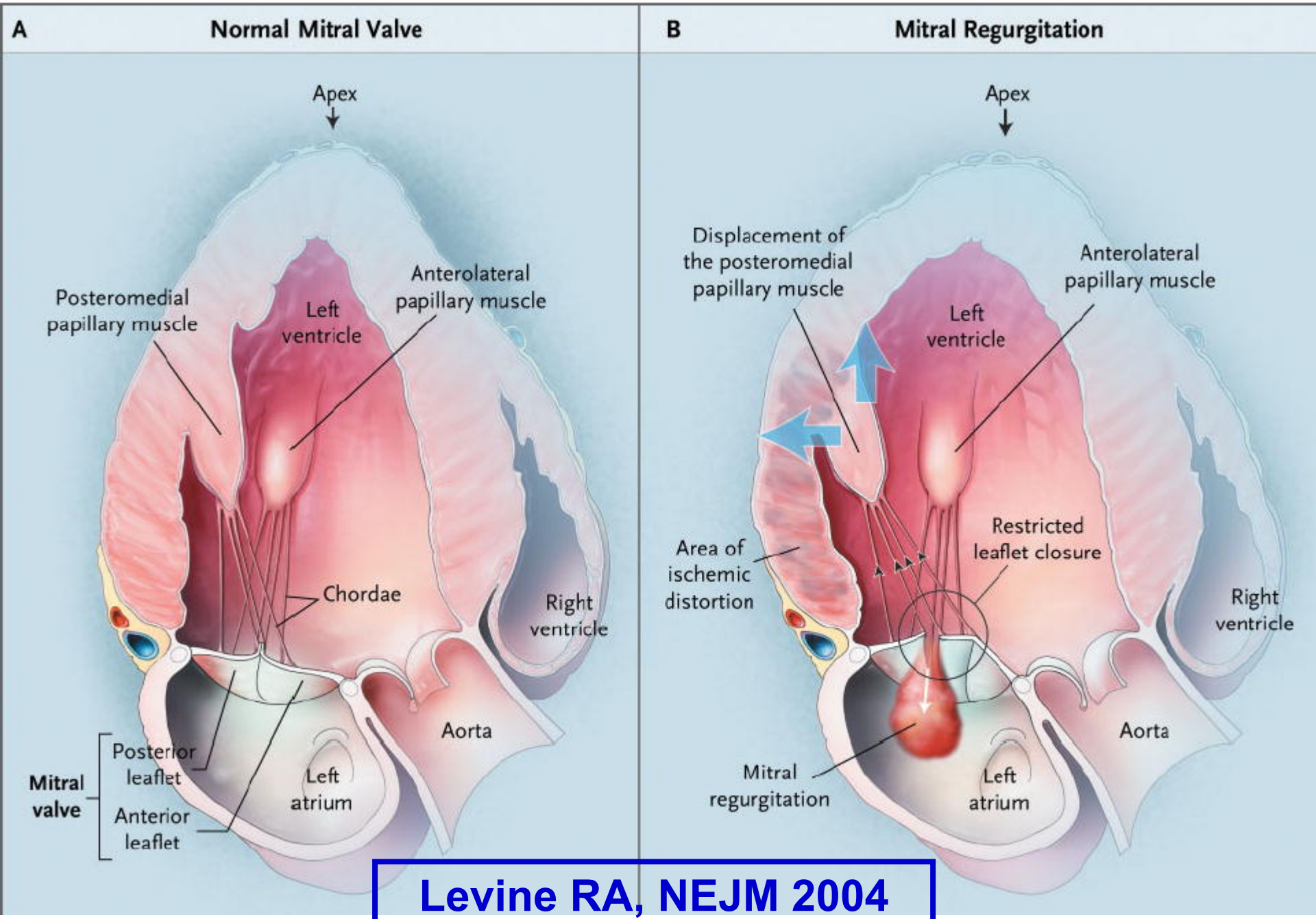
- Severity is multi-faceted
- Multiplicity of measures
- Greater clarity through advanced technology
- Persistent limitations – lesion dynamics and physiology

CHALLENGES IN ASSESSING MR

- Severity is multi-faceted
- Multiplicity of measures
- Greater clarity through advanced technology
- Persistent limitations – lesion dynamics and physiology

Hemodynamics play an important role:

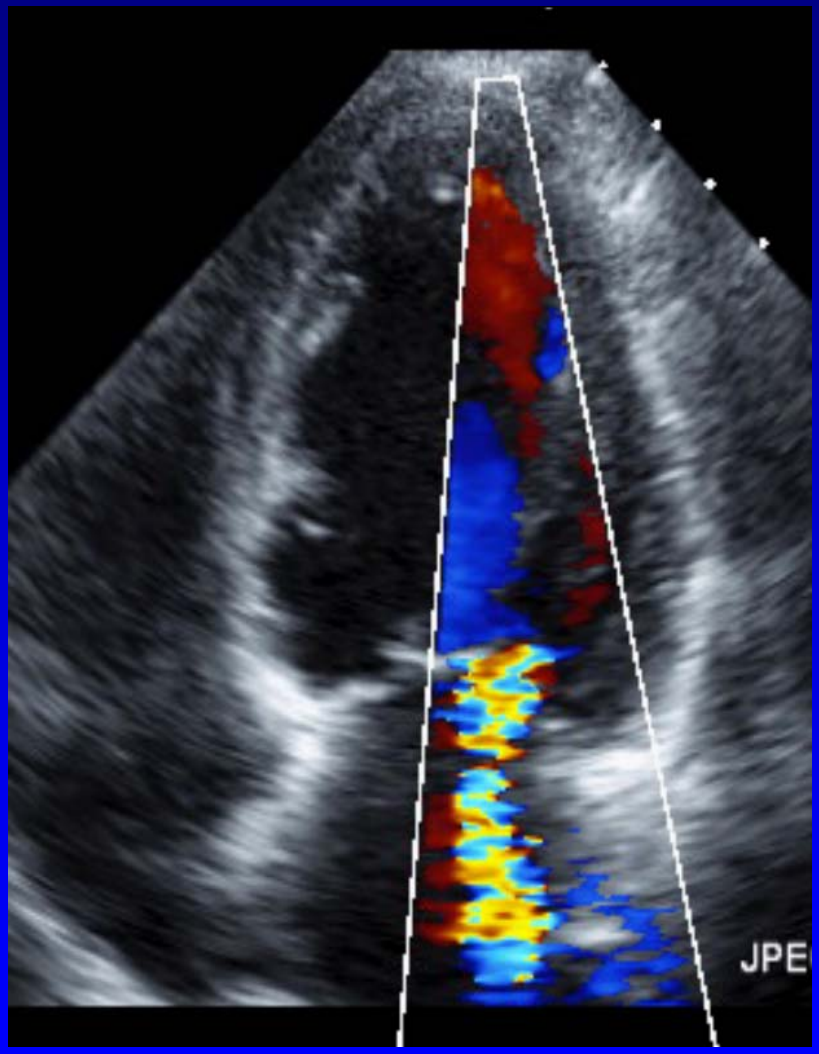
Vena contracta, like orifice area, can vary with loading in the OR and with exercise



Levine RA, NEJM 2004

RESTING

STRESS



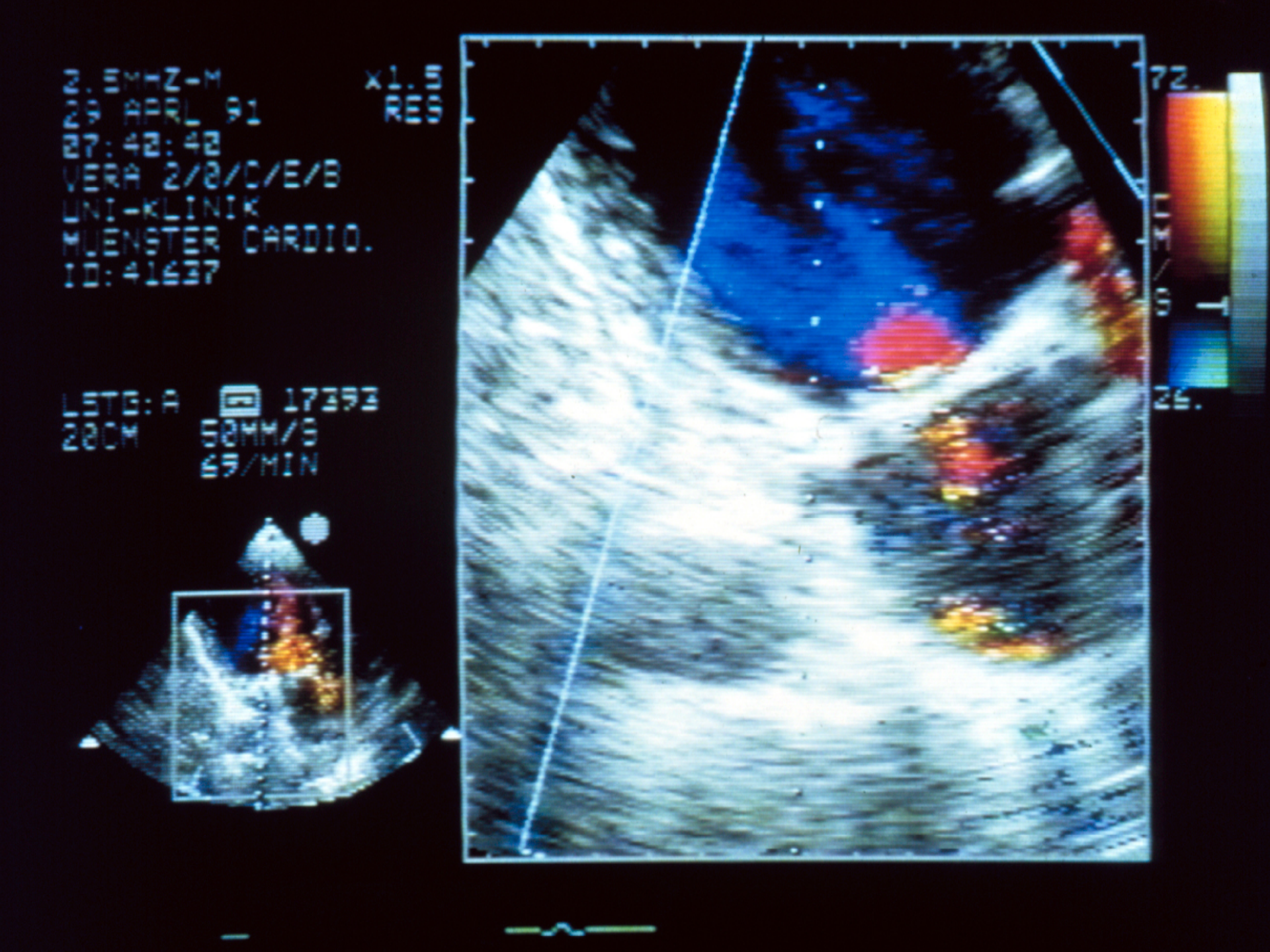
CHALLENGES IN ASSESSING MR

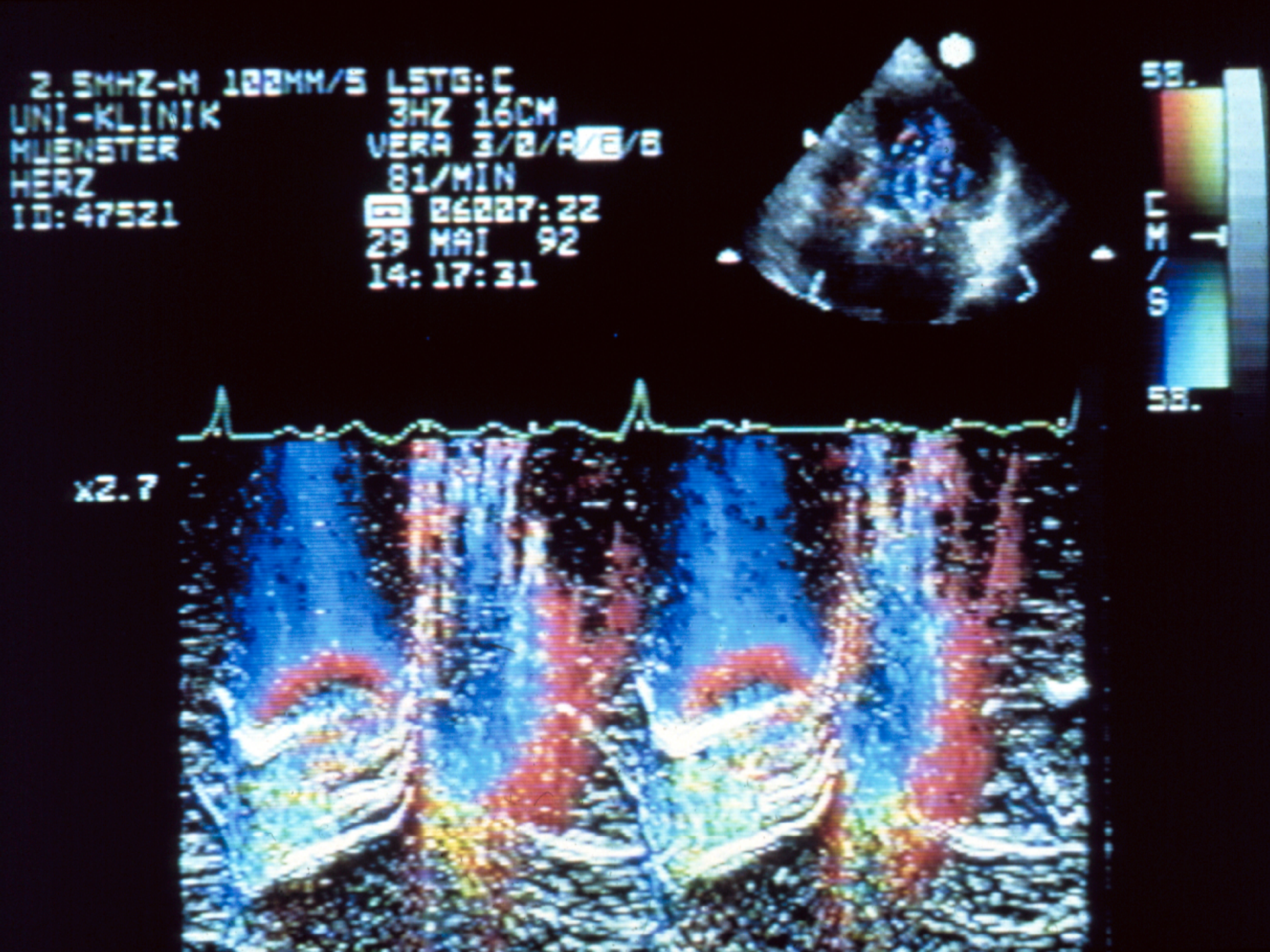
- Severity is multi-faceted
- Multiplicity of measures
- Greater clarity through advanced technology
- Persistent limitations – lesion dynamics and physiology

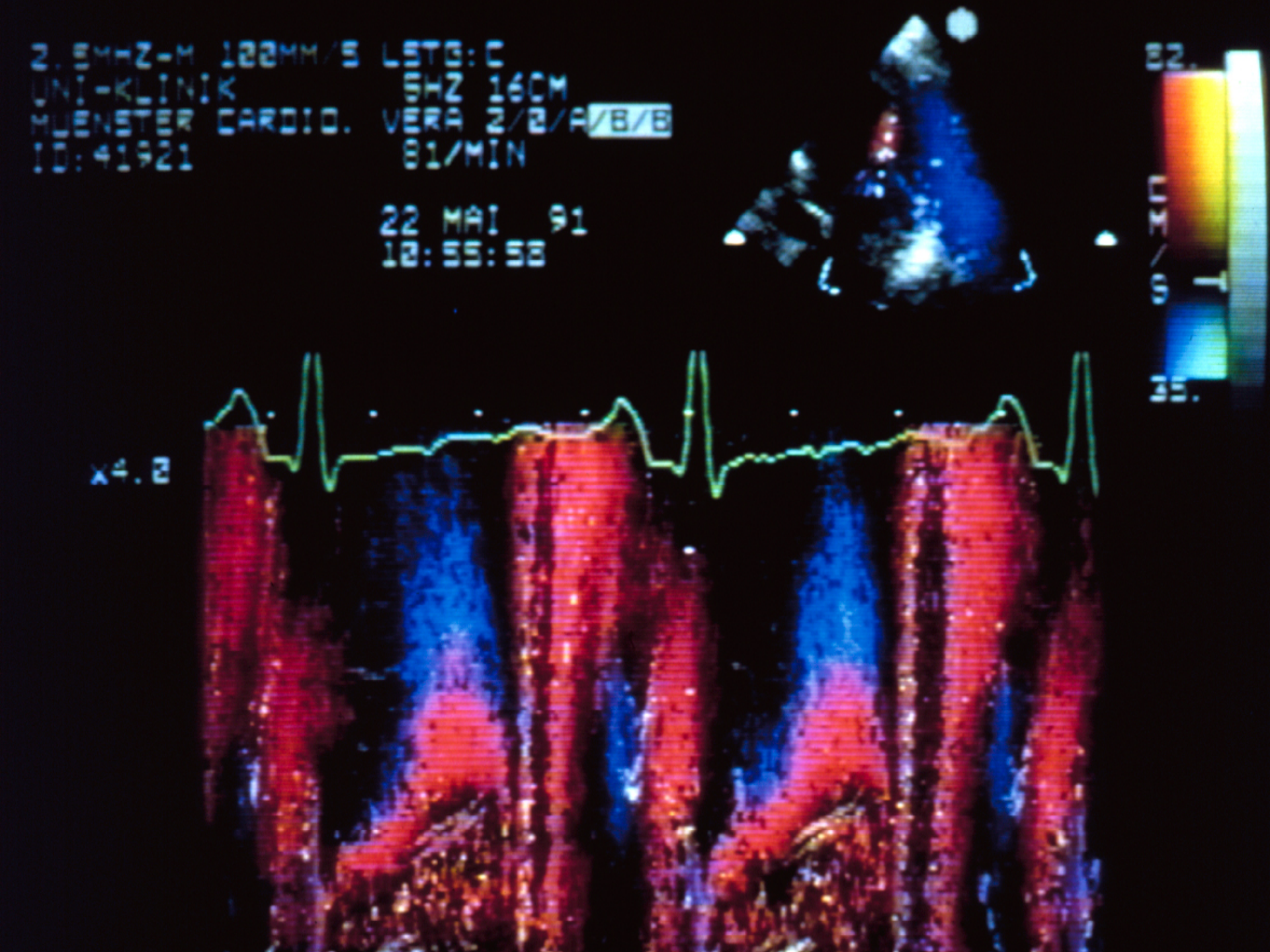
EHUD SCHWAMMENTHAL

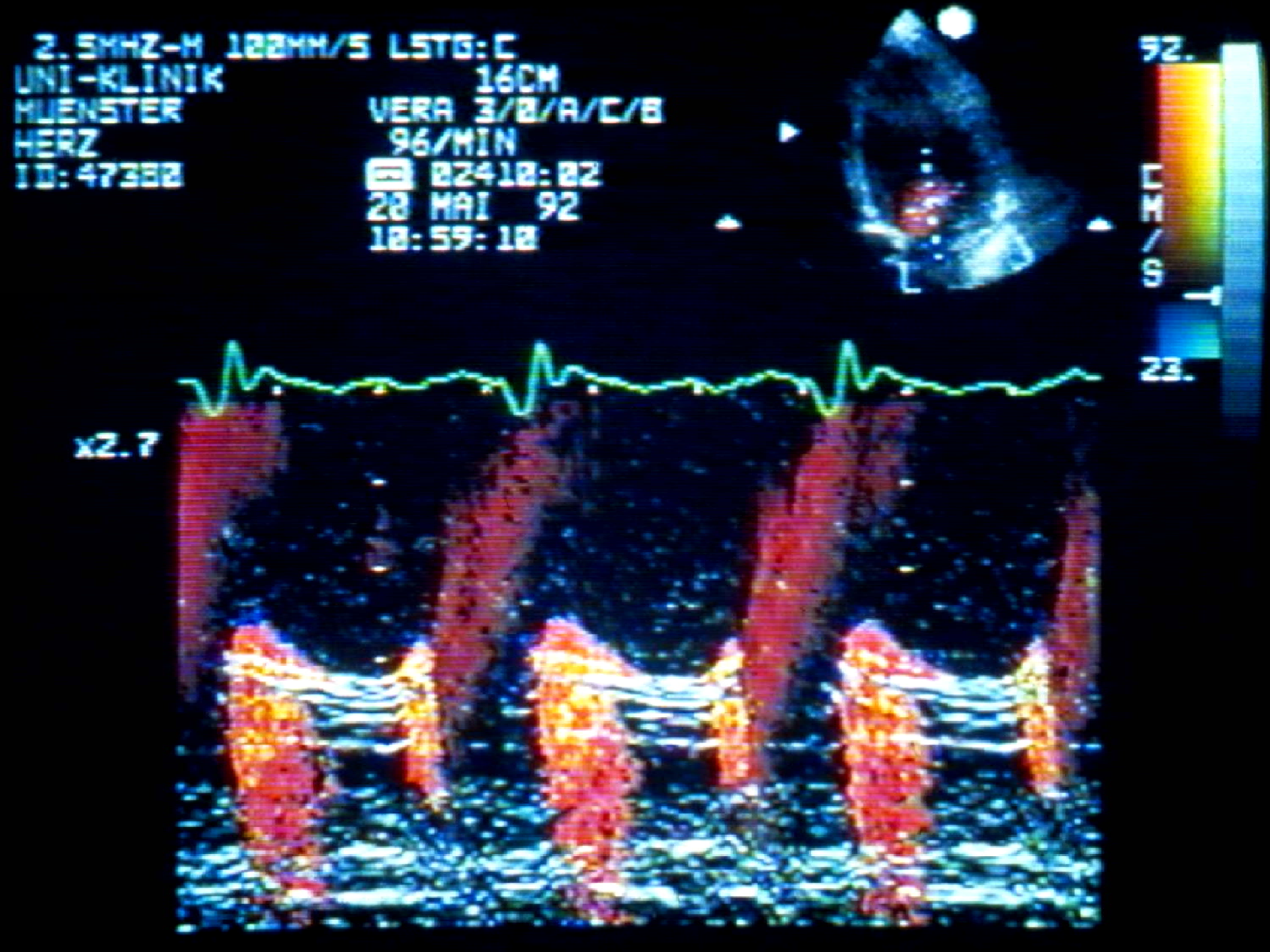
Chaim Sheba Medical Center
Tel Hashomer

Circulation 1994


2.5MHZ-M
x1.5
29 APRL 91
RES
07:42:42
VERA 2/0/C/E/B
UNI-KLINIK
MUENSTER CARDIO.
ID:41637
72.
CM/S
26.
LETB:A
17393
20CM
50MM/S
69/MIN

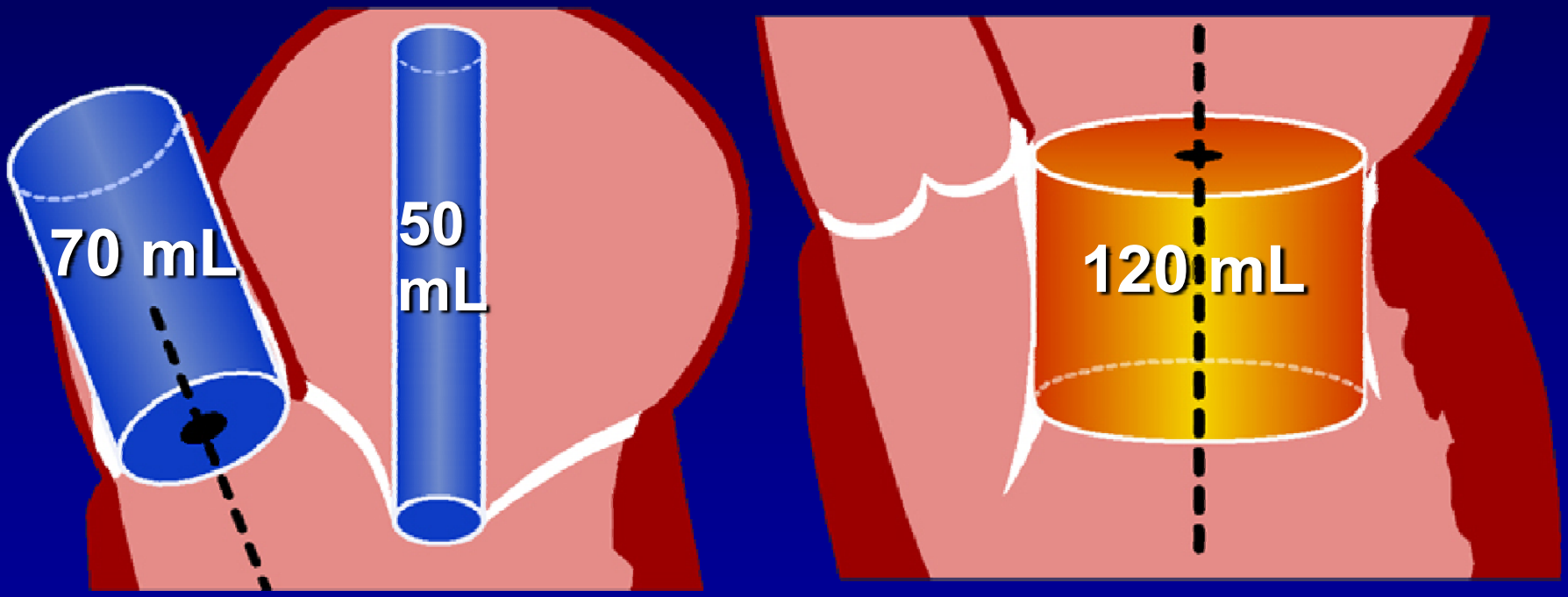

2.5MHZ-M 102MM/S
UNI-KLINIK
MUENSTER
HERZ
ID:47521
LSTG:C
3HZ 16CM
VERA 3/0/A/B/B
81/MIN
06207:22
29 MAI 92
14:17:31
58.
CM/S
58.
x2.7


2.5MHZ-M 100MM/S LSTG:C
UNI-KLINIK 5HZ 16CM
MUENSTER CARDIO. VERA 2/2/A/B/B
ID:41921 81/MIN
22 MAI 91
10:55:58
82.
CM/S
-1
35.
x4.2


2.5MHZ-M 122MM/S LSTG:C
UNI-KLINIK
MUENSTER
HERZ
ID:47332
16CM
VERA 3/0/A/C/8
96/MIN
02410:02
28 MAI 92
10:59:10
92.
CM/S
23.
x2.7

Quantitative Hemodynamics

Mitral Regurgitation



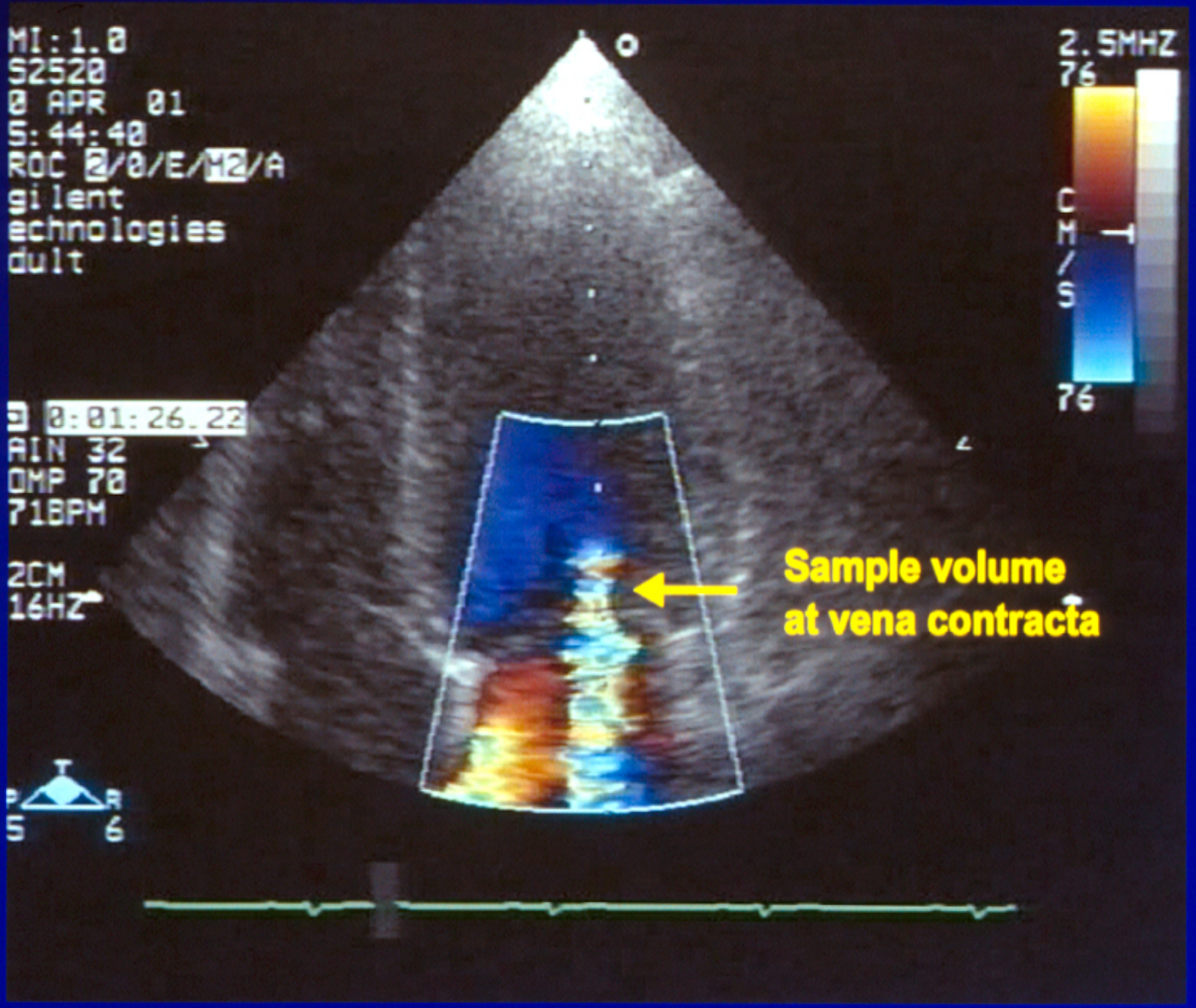
Maurice Sarano, Mayo Clinic

QUANTITATIVE PULSED DOPPLER

Mitral inflow minus aortic outflow

"This method is simple in theory but accurate results require individual training."

Translation: Practice makes (somewhat) perfect.


MI:1.0
S2520
0 APR 01
5:44:40
ROC 2/0/E/M2/A
gilent
echnologies
dult
0:01:26.22
AIN 32
OMP 70
71BPM
2CM
16HZ
2.5MHZ
76
CM/S
76
Sample volume
at vena contracta

THOMAS BUCK

Circulation 2000

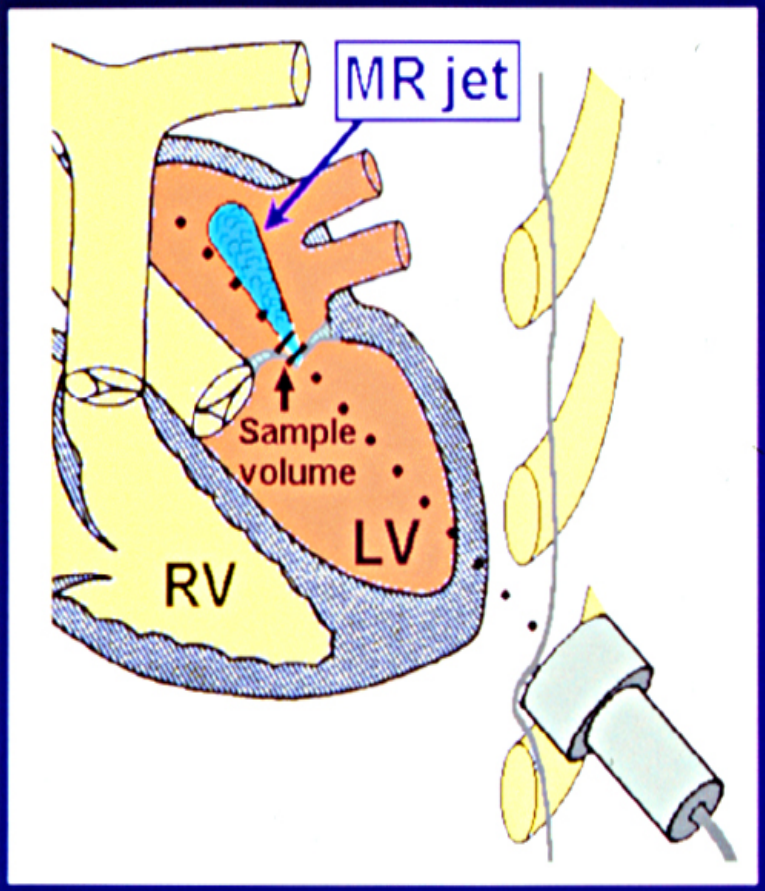
JACC 2005

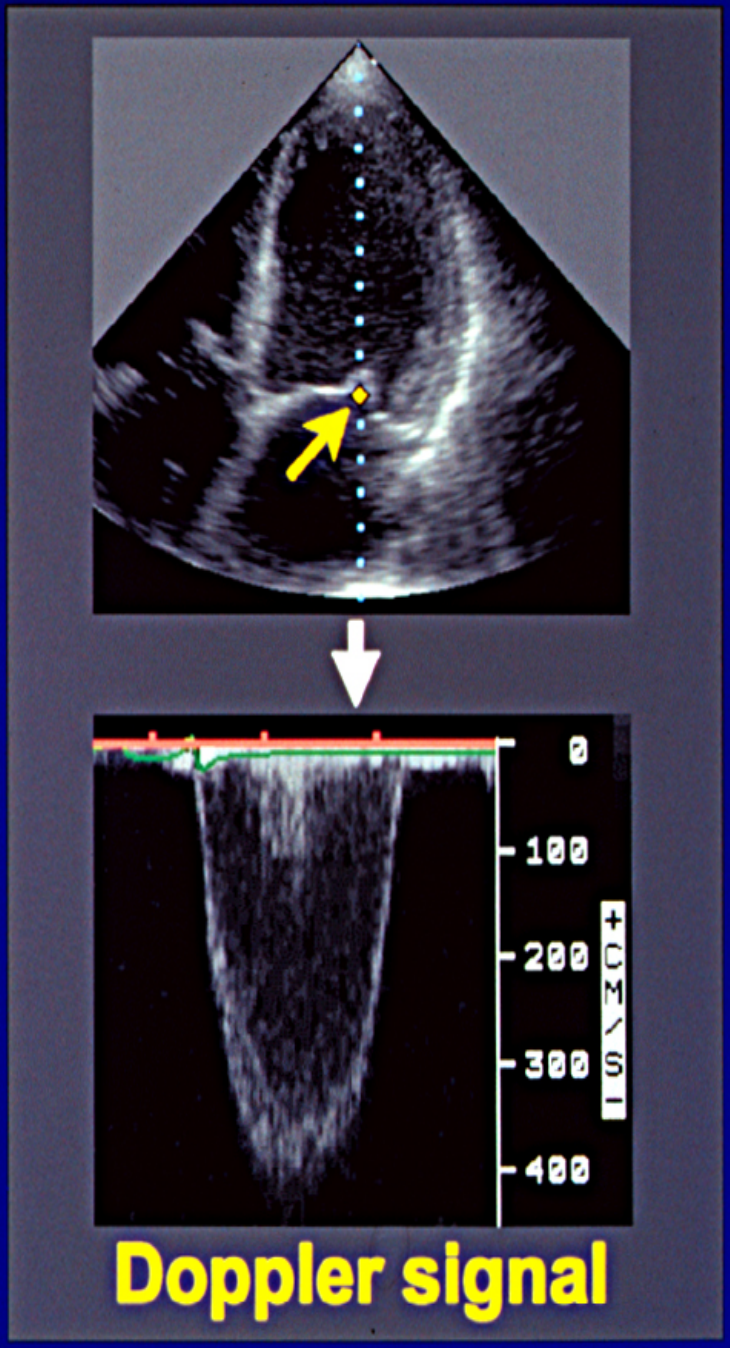
Basic Principle of Power Measurement

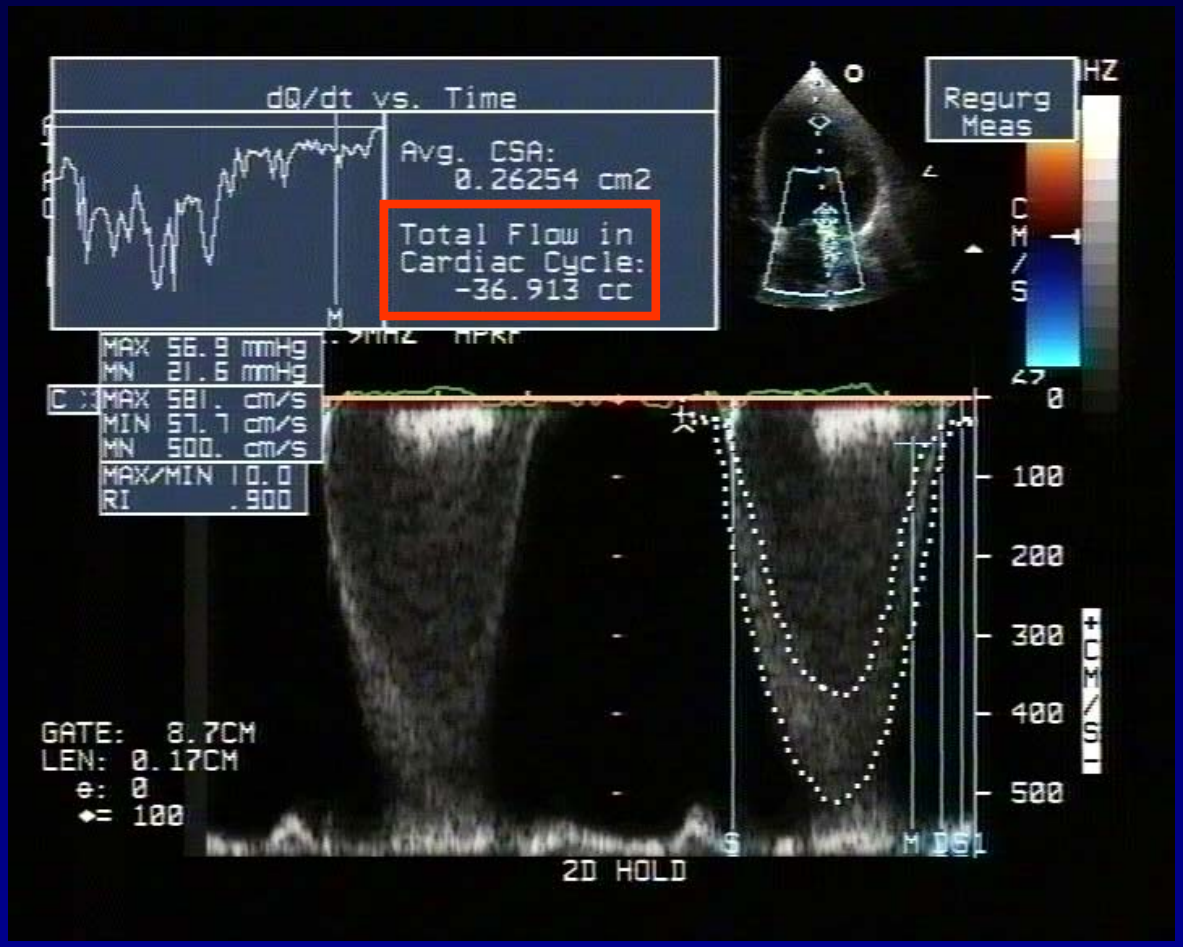
Velocity x Area ? = Flow rate ?

Velocity x Power = Flow rate

Patient Application







Power-Velocity Time Integral

Reg. Vol. = **36.91 ml**

Reg. Vol. by MRI = 36.3 ml

ASSESSMENT OF MITRAL REGURGITATION

IT IS IMPORTANT

BEST DONE BY VENA CONTRACTA

LESION DYNAMICS PROVIDE INSIGHTS INTO MECHANISMS

Thank you!