INTEGRATING MYOCARDIAL STRAIN INTO CLINICAL PRACTICE: ALL THE PATTERNS

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NO DISCLOSURES

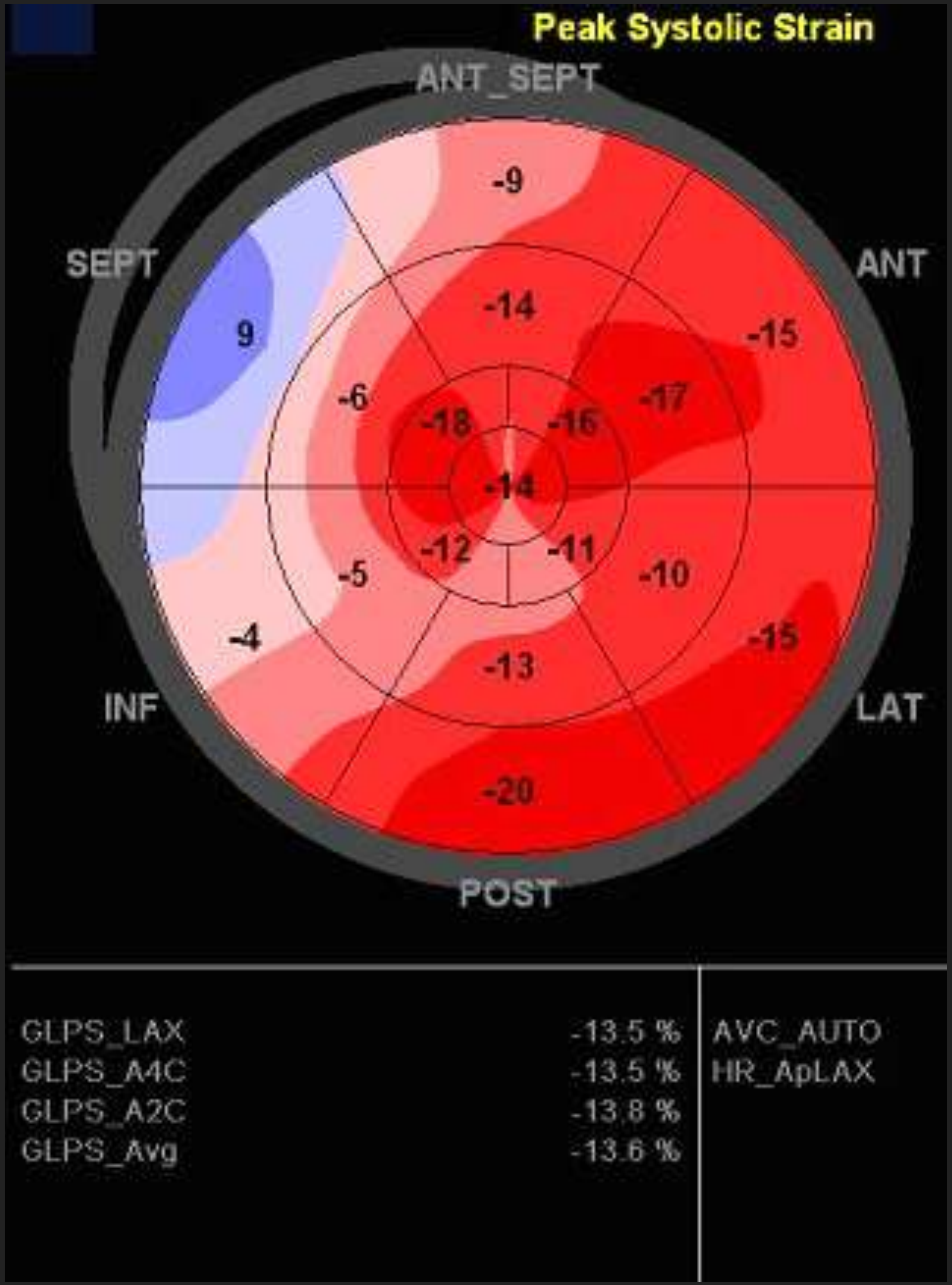

THERE IS NO
SUBSTITUTE
ARNOTT'S
TimTam
Original

- Strain Echocardiography is another arrow in our clinical critical thinking quiver
- Strain echocardiography is an easy application sonographers can use to access more data from our standard images

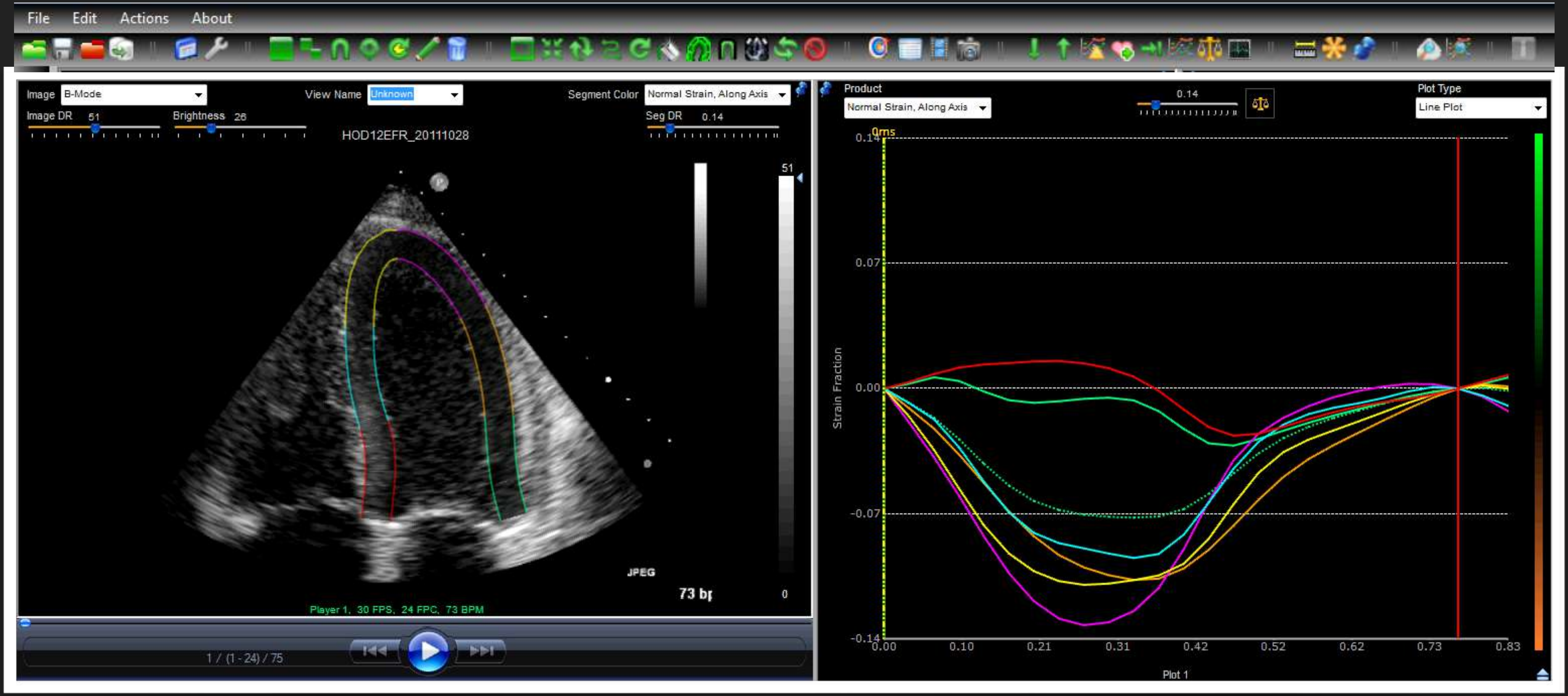
Image adapted from https://cdn.pixabay.com

OBJECTIVES

- Extend knowledge of speckle tracking and technical factors with the use of strain echocardiography
- Demonstrate knowledge of application and assessment using strain echocardiography
- Recognize abnormalities (**Patterns**) in common pathologies seen in echocardiography



Strain Imaging



EXPERT CONSENSUS STATEMENT

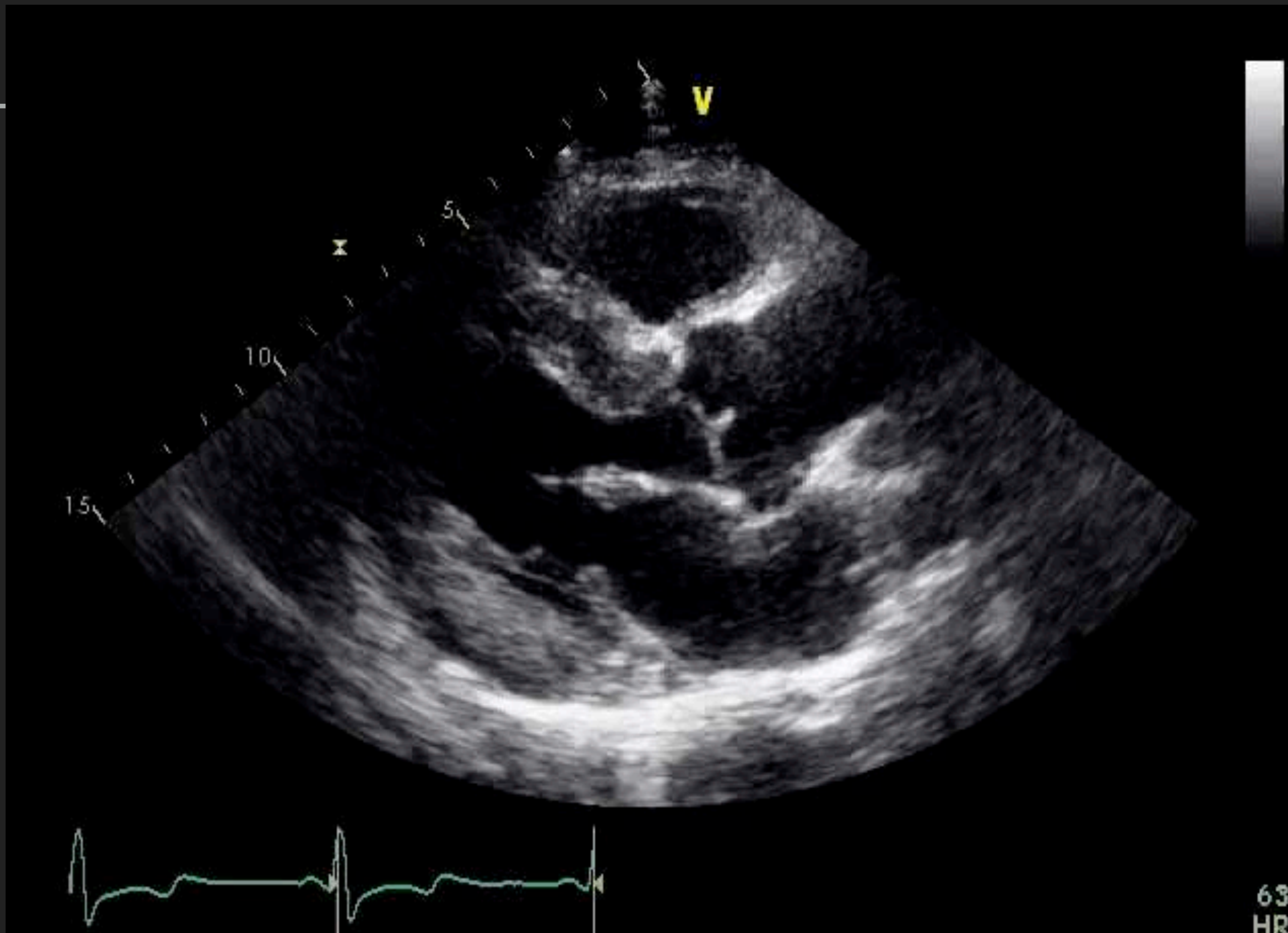
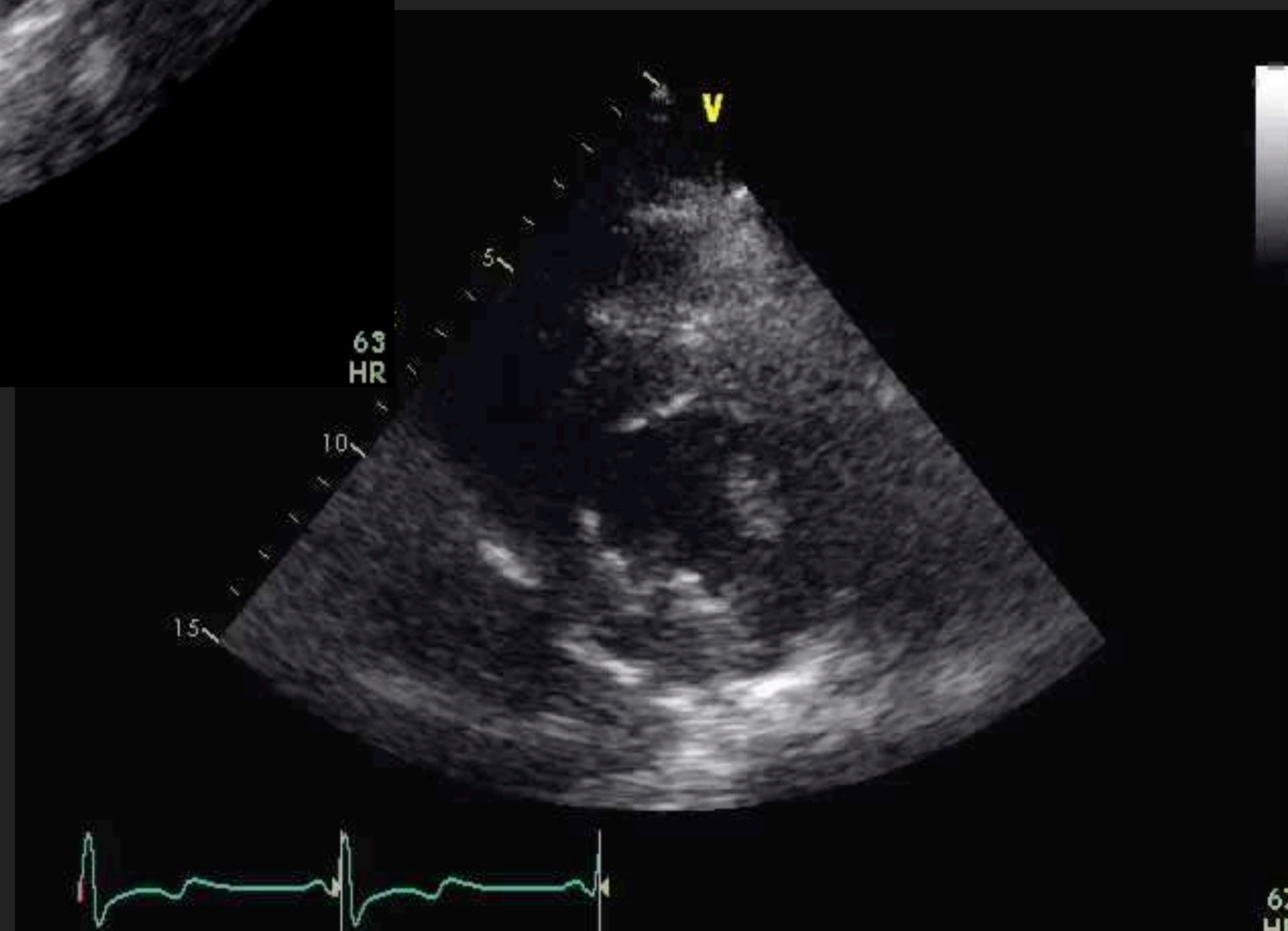
Current and Evolving Echocardiographic Techniques for the Quantitative Evaluation of Cardiac Mechanics: ASE/EAE Consensus Statement on Methodology and Indications

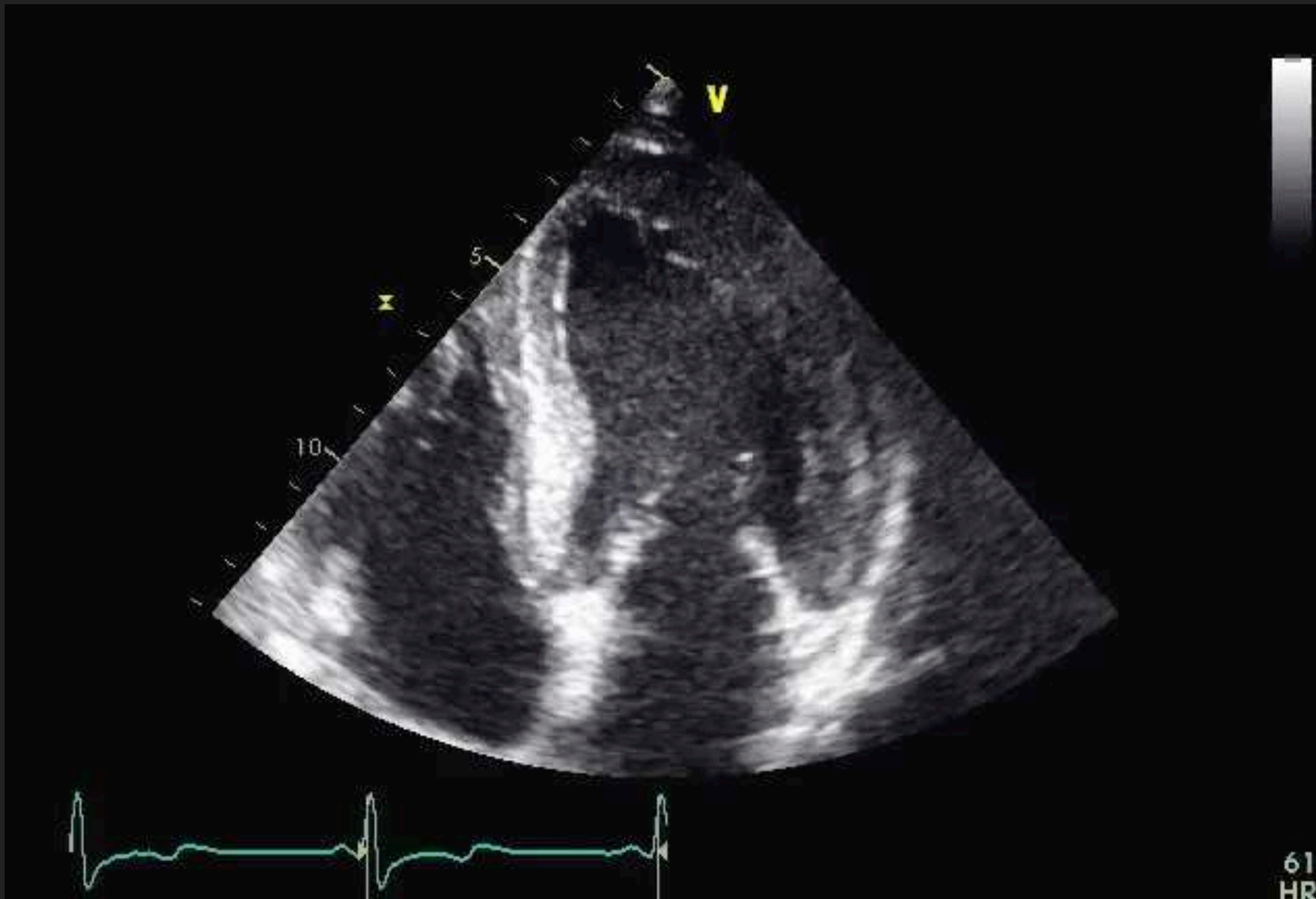
Endorsed by the Japanese Society of Echocardiography

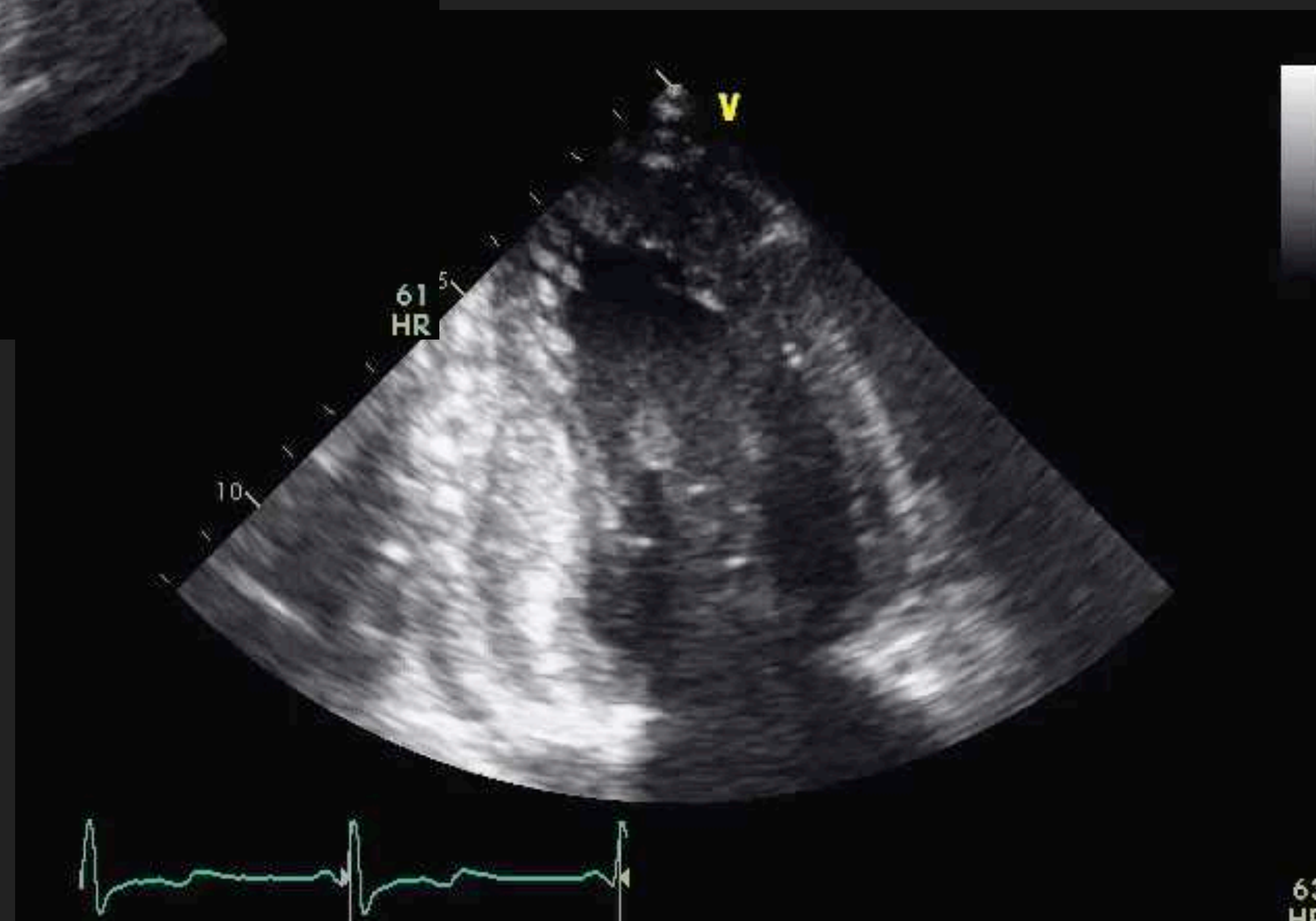
Victor Mor-Avi, PhD, FASE,* Roberto M. Lang, MD, FASE,† Luigi P. Badano, MD, FESC, Marek Belohlavek, MD, PhD, FESC, Nuno Miguel Cardim, MD, PhD, FESC, Geneviève Derumeaux, MD, PhD, FESC, Maurizio Galderisi, MD, FESC, Thomas Marwick, MBBS, PhD, Sherif F. Nagueh, MD, FASE, Partho P Sengupta, MBBS, FASE, Rosa Sicari, MD, PhD, FESC, Otto A. Smiseth, MD, PhD, FESC, Beverly Smulevitz, BS, RDCS, Masaaki Takeuchi, MD, PhD, FASE, James D. Thomas, MD, FASE, Mani Vannan, MBBS, Jens-Uwe Voigt, MD, FESC, and José Luis Zamorano, MD, FESC†, *Chicago, Illinois; Padua, Naples, and Pisa, Italy; Scottsdale, Arizona; Lisbon, Portugal; Lyon, France; Cleveland and Columbus, Ohio; Houston, Texas; Irvine, California; Oslo, Norway; Kitakyushu, Japan; Leuven, Belgium; Madrid, Spain*

(J Am Soc Echocardiogr 2011;24:277-313.)

Keywords: Ventricular function, Myocardial strain, Tissue Doppler, Myocardial Doppler, Tissue tracking, Speckle tracking, Integrated backscatter


V
5
10
15
63
HR

V
5
10
15
67
HR


V
5
10


V
61
HR
5
10
63
HR

NORMAL SYSTOLIC FUNCTION ??

- YES
- NO

European Heart Journal – Cardiovascular Imaging (2015) **16**, 1–11
doi:10.1093/ehjci/jeu184

CONSENSUS PAPER

Definitions for a common standard for 2D speckle tracking echocardiography: consensus document of the EACVI/ASE/Industry Task Force to standardize deformation imaging

Jens-Uwe Voigt[1†], Gianni Pedrizzetti[2,3†], Peter Lysyansky[4†], Tom H. Marwick[5], Helen Houle[6], Rolf Baumann[7], Stefano Pedri[8], Yasuhiro Ito[9], Yasuhiko Abe[10], Stephen Metz[11], Joo Hyun Song[12], Jamie Hamilton[13], Partho P. Sengupta[3], Theodore J. Kolias[14], Jan d'Hooge[1], Gerard P. Aurigemma[15], James D. Thomas[16‡], and Luigi Paolo Badano[17‡*]

[1]Department of Cardiovascular Diseases, University Hospital Gasthuisberg, Catholic University Leuven, Leuven, Belgium; [2]Department of Engineering and Architecture, University of Trieste, Trieste, Italy; [3]Zena and Michael A. Wiener Cardiovascular Institute, Mount Sinai School of Medicine, New York, NY, USA; [4]GE Healthcare, Haifa, Israel; [5]Menzies Research Institute of Tasmania, Hobart, Australia; [6]Siemens Medical Solutions, Ultrasound Division, Mountain View, CA, USA; [7]Tomtec Imaging Systems, Unterschleissheim, Germany; [8]Esaote S.p.A., Genova, Italy; [9]Hitachi Aloka Medical Ltd, Mitaka-shi, Tokyo, Japan; [10]Toshiba Medical Systems Corporation, Otawara-shi, Tochigi-ken, Japan; [11]Philips Healthcare, Ultrasound, Andover, MA, USA; [12]SamsungMedison, Seoul, Korea; [13]Epsilon Imaging, Inc., Ann Arbor, MI, USA; [14]Division of Cardiology, University of Michigan, Ann Arbor, MI, USA; [15]University of Massachusetts Medical School, Worcester, MA, USA; [16]Cardiovascular Imaging Center, Department of Cardiology, Cleveland Clinic Foundation, Cleveland, OH, USA; and [17]Department of Cardiac, Thoracic and Vascular Sciences, University of Padova, School of Medicine, Via Giustiniani 2, Padova 35128, Italy

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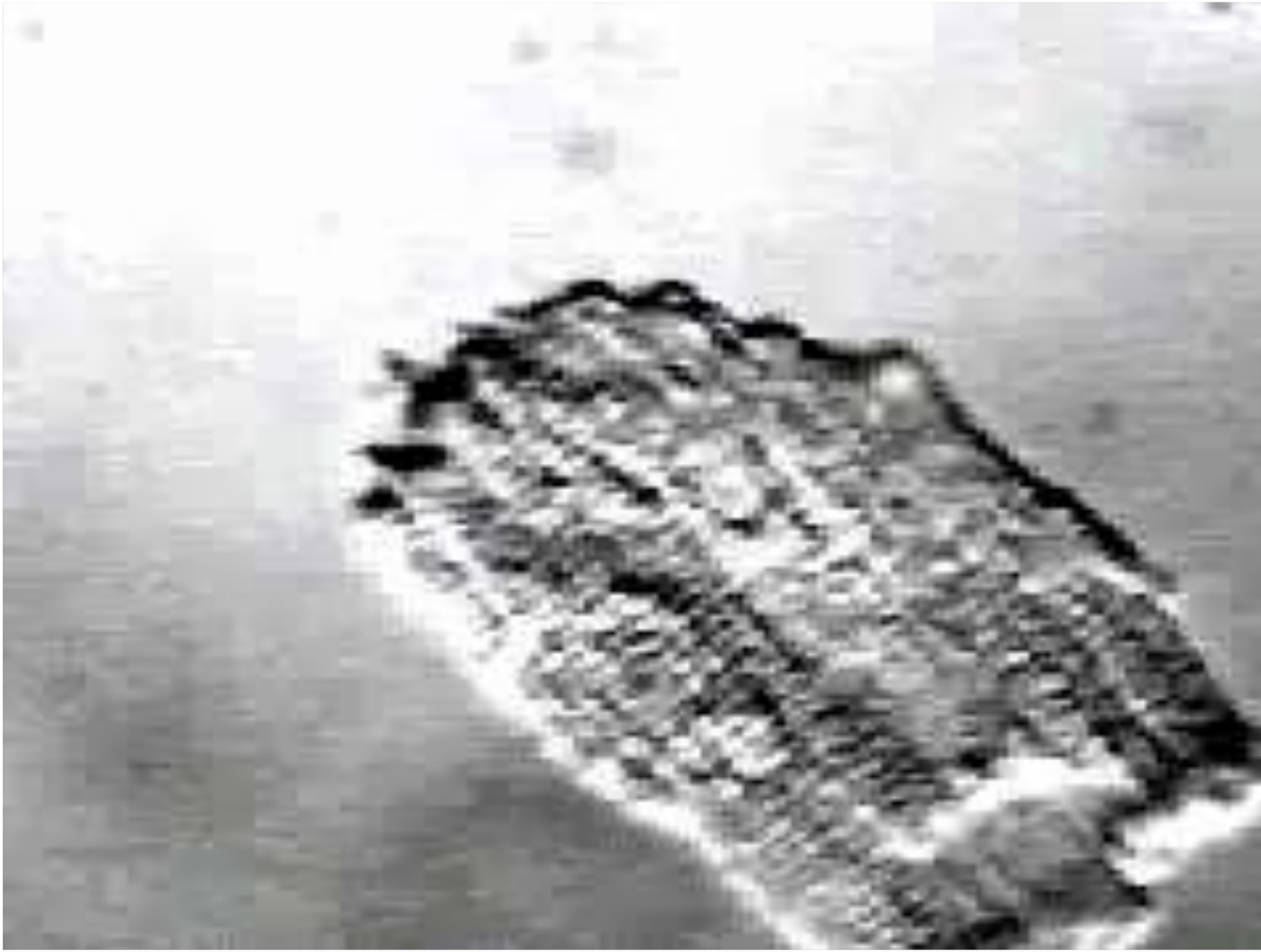
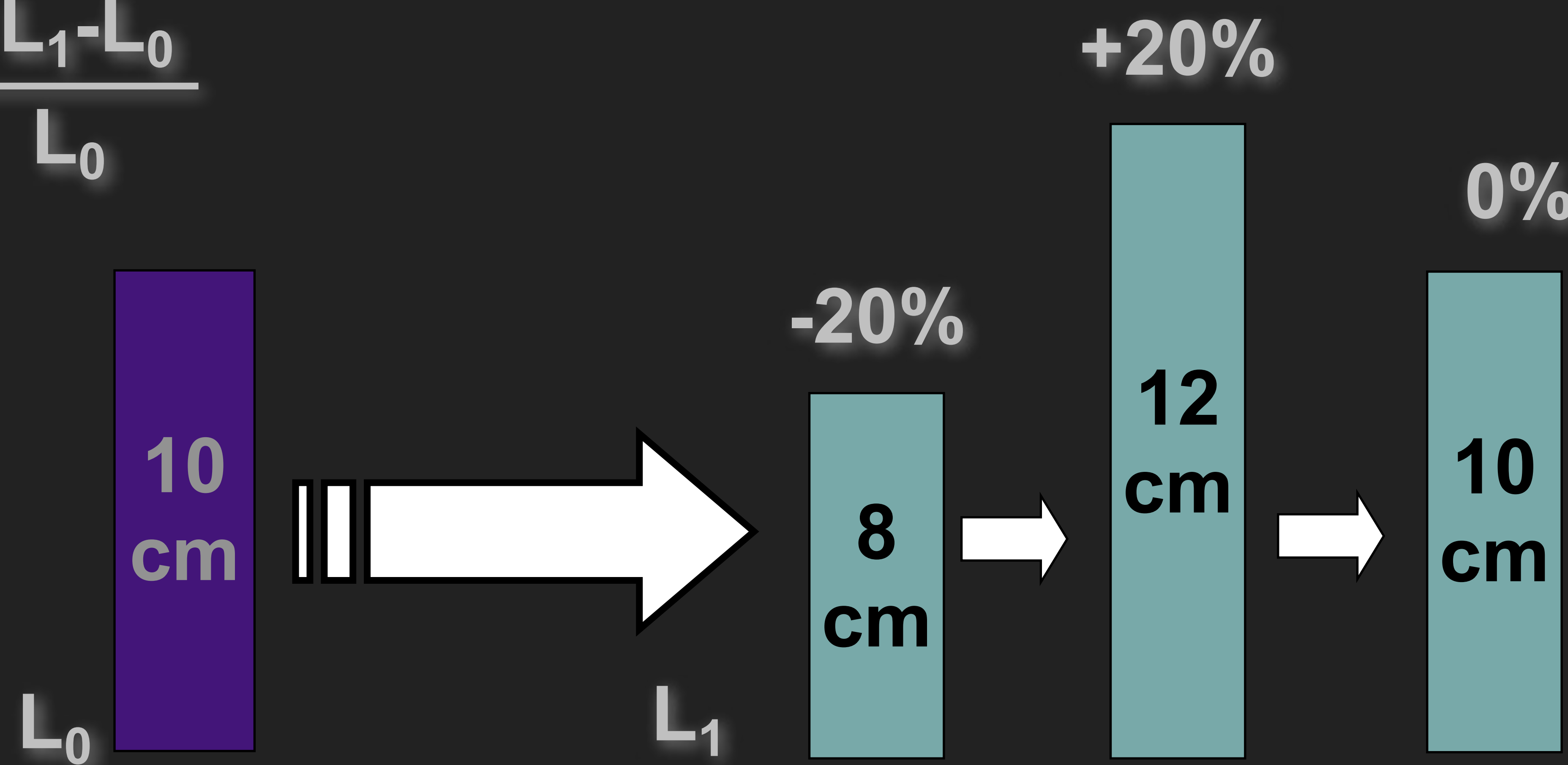


MYOCARDIAL STRAIN

$$GLS(\%) = \frac{(MLs - MLd)}{MLd}$$

$$\text{Strain } (\varepsilon) = \frac{L_1 - L_0}{L_0}$$

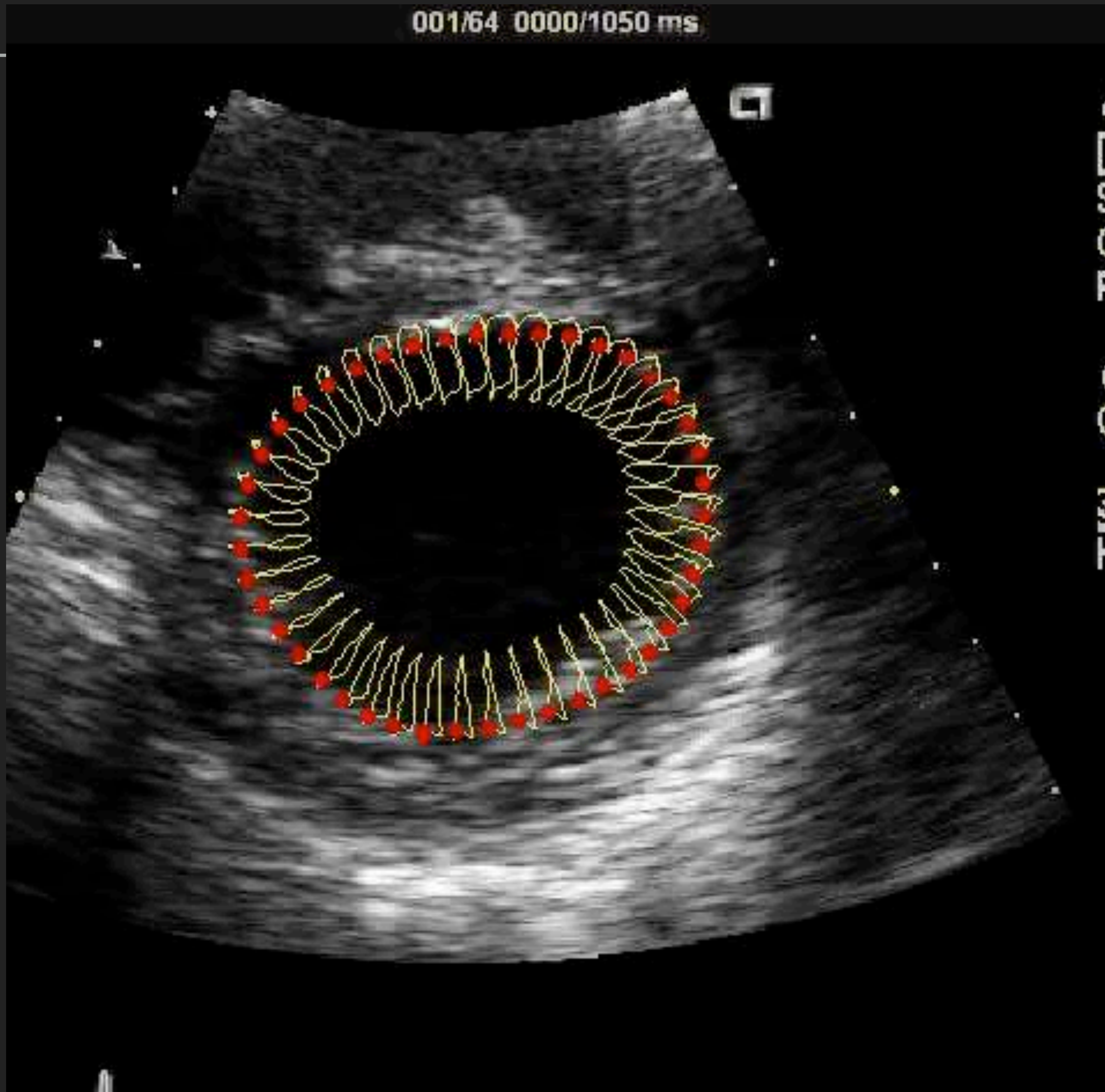


Strain = % of change

L_0 = Original Length L_1 = Final Length

SPECKLE TRACKING

- Method of quantifying myocardial motion
- *Physics:* Reflection, scattering, interference of the beam produce a speckle formation
- Speckle patterns are tracked frame by frame throughout cardiac cycle
- Allows to look at torsion and twist
- Not angle dependent


001/64 0000/1050 ms

NORMAL STRAIN VALUES

Normal Ranges of Left Ventricular Strain: A Meta-Analysis

Teerapat Yingchoncharoen, MD, Shikhar Agarwal, MD, MPH, Zoran B. Popović, MD, PhD, and Thomas H. Marwick, MD, PhD, MPH, *Cleveland, Ohio*

Background: The definition of normal values of left ventricular global longitudinal strain (GLS), global circumferential strain, and global radial strain is of critical importance to the clinical application of this modality. The investigators performed a meta-analysis of normal ranges and sought to identify factors that contribute to reported variations.

Methods: MEDLINE, Embase, and the Cochrane Library database were searched through August 2011 using the key terms "strain," "speckle tracking," "left ventricle," and "echocardiography" and related phrases. Studies were included if the articles reported left ventricular strain using two-dimensional speckle-tracking echocardiography in healthy normal subjects, either in the control group or as a primary objective of the study. Data were combined using a random-effects model, and effects of demographic, hemodynamic, and equipment variables were sought in a meta-regression.

Results: The search identified 2,597 subjects from 24 studies. Reported normal values of GLS varied from −15.9% to −22.1% (mean, −19.7%; 95% CI, −20.4% to −18.9%). Normal global circumferential strain varied from −20.9% to −27.8% (mean, −23.3%; 95% CI, −24.6% to −22.1%). Global radial strain ranged from 35.1% to 59.0% (mean, 47.3%; 95% CI, 43.6% to 51.0%). There was significant between-study heterogeneity and inconsistency. The source of variation was sought between studies using meta-regression. Blood pressure, but not age, gender, frame rate, or equipment, was associated with variation in normal GLS values.

Conclusions: The narrowest confidence intervals from this meta-analysis were for GLS and global circumferential strain, but individual studies have shown a broad range of strain in apparently normal subjects. Variations between different normal ranges seem to be associated with differences in systolic blood pressure, emphasizing that this should be considered in the interpretation of strain. (J Am Soc Echocardiogr 2013;26:185-91.)

Keywords: Strain, Meta-analysis, Normal range, Echocardiography

NORMAL RANGES

- The search identified 2,597 subjects from 24 studies.
- **Global longitudinal strain (GLS)** varied from 15.9% to 22.1% (mean, **19.7%**; 95% CI, 20.4% to 18.9%).
- **Global circumferential strain** varied from 20.9% to 27.8% (mean, **23.3%**; 95% CI, 24.6% to 22.1%).
- **Global radial strain (GRS)** ranged from 35.1% to 59.0% (mean, **47.3%**; 95% CI, 43.6% to 51.0%).
- * CI = confidence intervals

STRAIN %

Supplemental Table 6 Normal LV strain values from meta-analysis and individual recent publications using specific vendors' equipment and software

vendor	Software	n	Mean	SD	LLN	Reference from list below
Varying	Meta-analysis	2597	−19.7%		NA	1
GE	EchoPAC BT 12	247	−21.5%	2.0%	−18%	2
	EchoPAC BT 12	207	−21.2%	1.6%	−18%	3
	EchoPAC BT 12	131	−21.2%	2.4%	−17%	4
	EchoPAC 110.1.3	333	−21.3%	2.1%	−17%	5
Philips	QLAB 7.1	330	−18.9%	2.5%	−14%	5
Toshiba	Ultra Extend	337	−19.9%	2.4%	−15%	5
Siemens	VVI 1.0	116	−19.8%	4.6%	−11%	6
	VVI 1.0	82	−17.3%	2.3%	−13%	7
Esaote	Mylab 50	30	−19.5%	3.1%	−13%	8

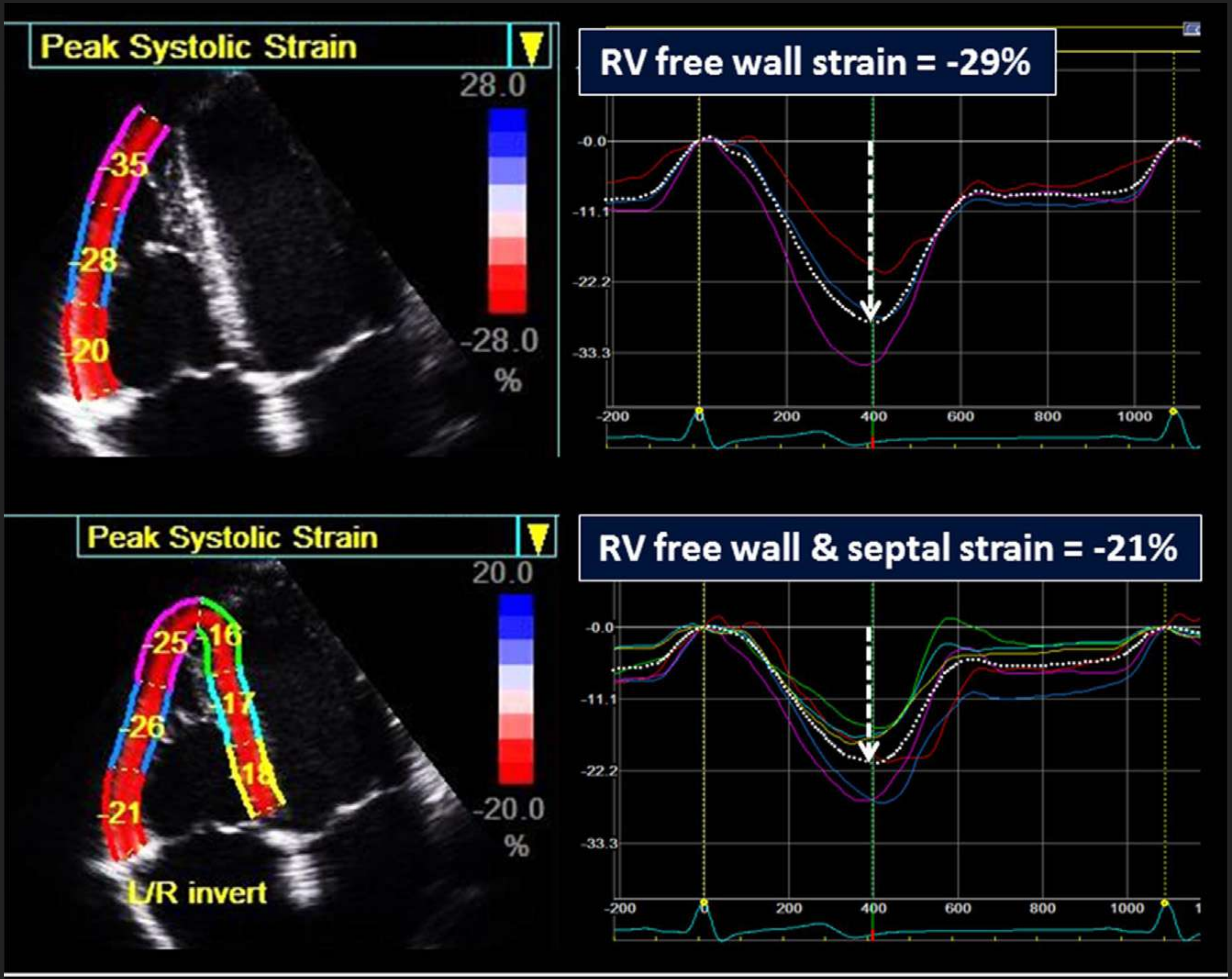
Adapted from Lang R, et al. ASE Chamber Quantification Guidelines 2015

TECHNICAL COMPONENTS

TECHNICAL COMPONENTS

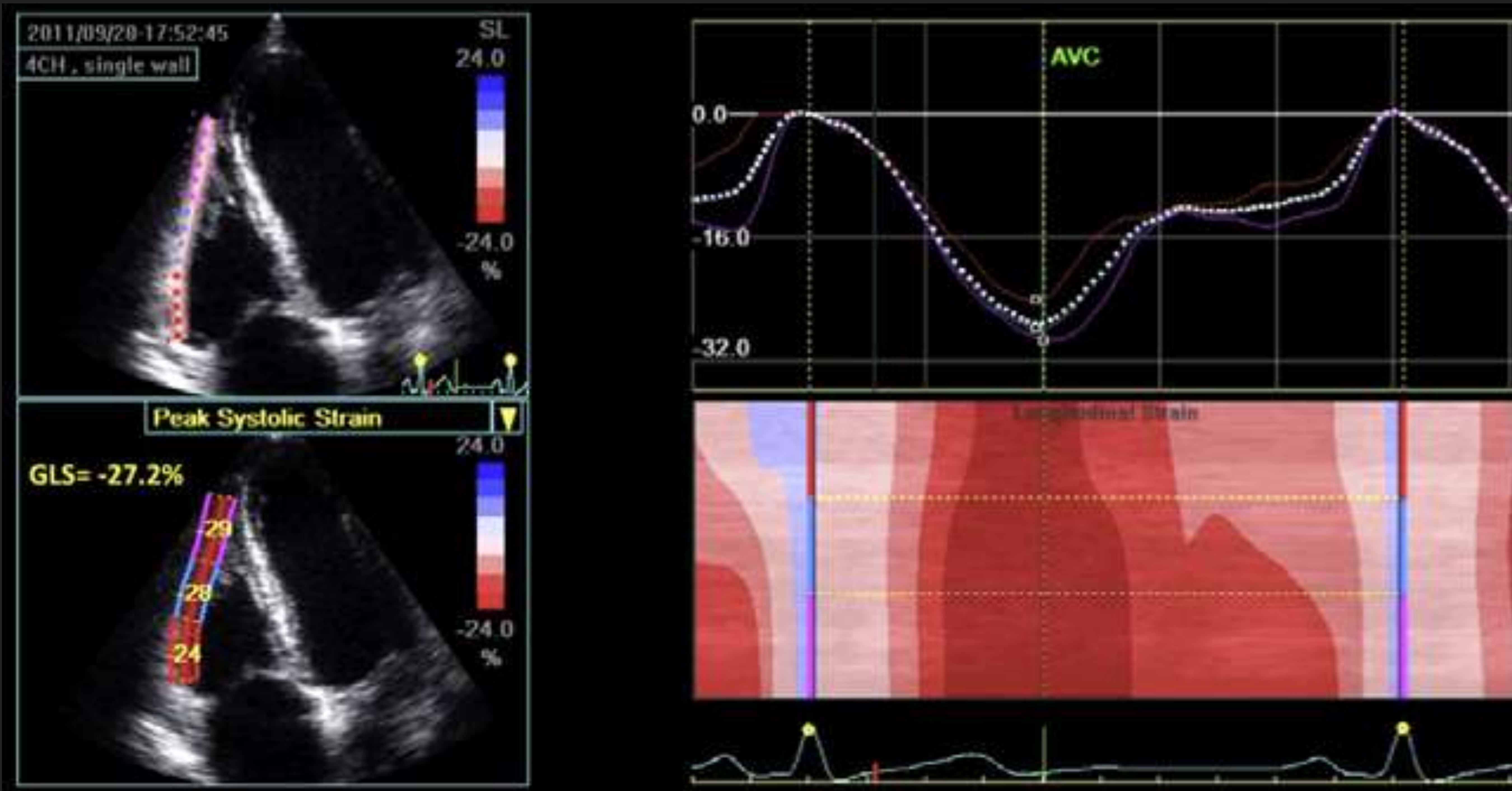
- Good 2D image quality
- Can use protocol images (4ch, 2ch, ALAX)
- Frame rate
  - 40-80 fps
  - Sector/Depth -> Increase Frame Rate; decrease line density
- Aortic valve seen
- ROI set, Automated vs Sonographer traced

RV STRAIN



Adapted from Lang R, et al. ASE Chamber Quantification Guidelines 2015

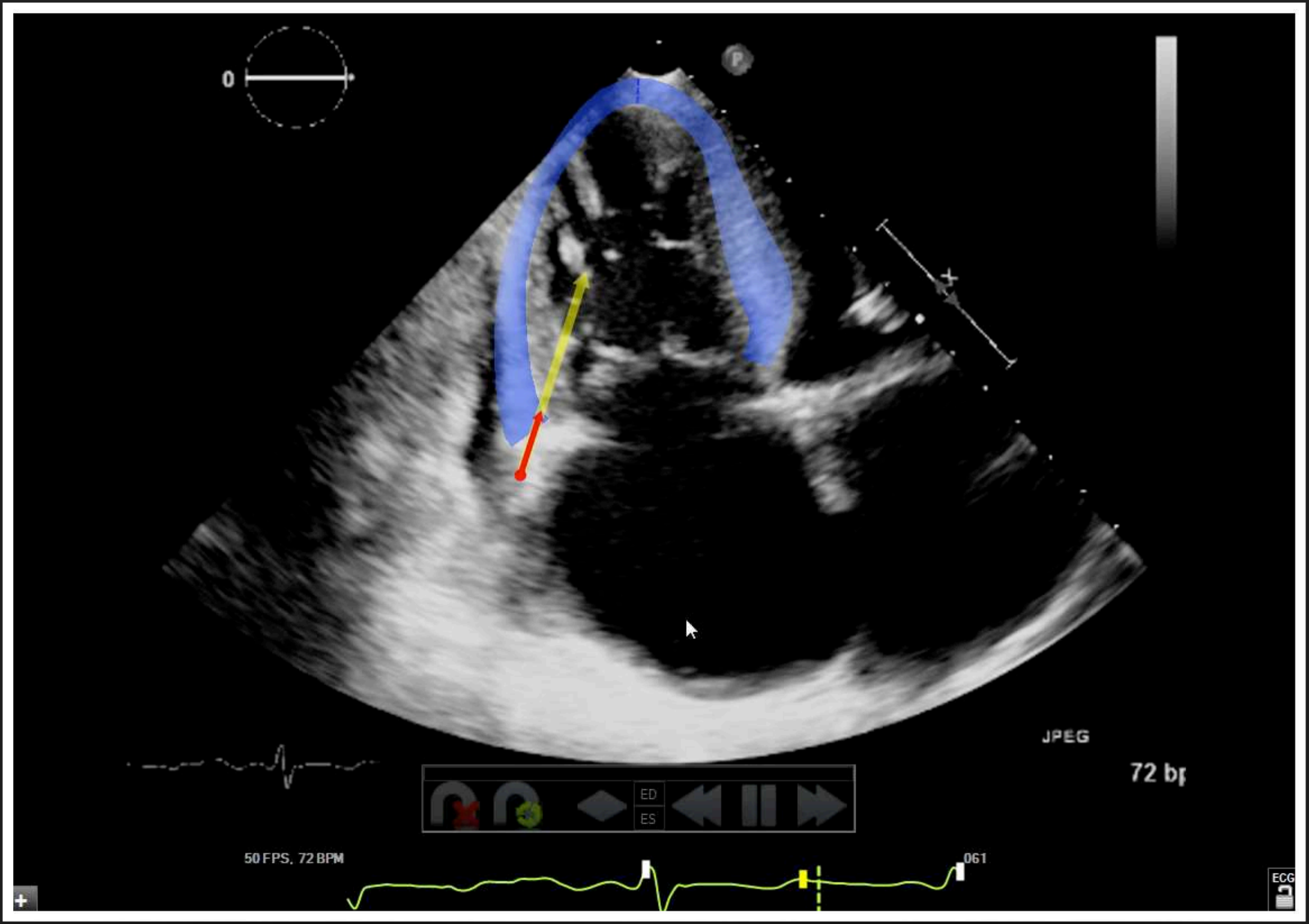
RV GLS Normal value >-20%



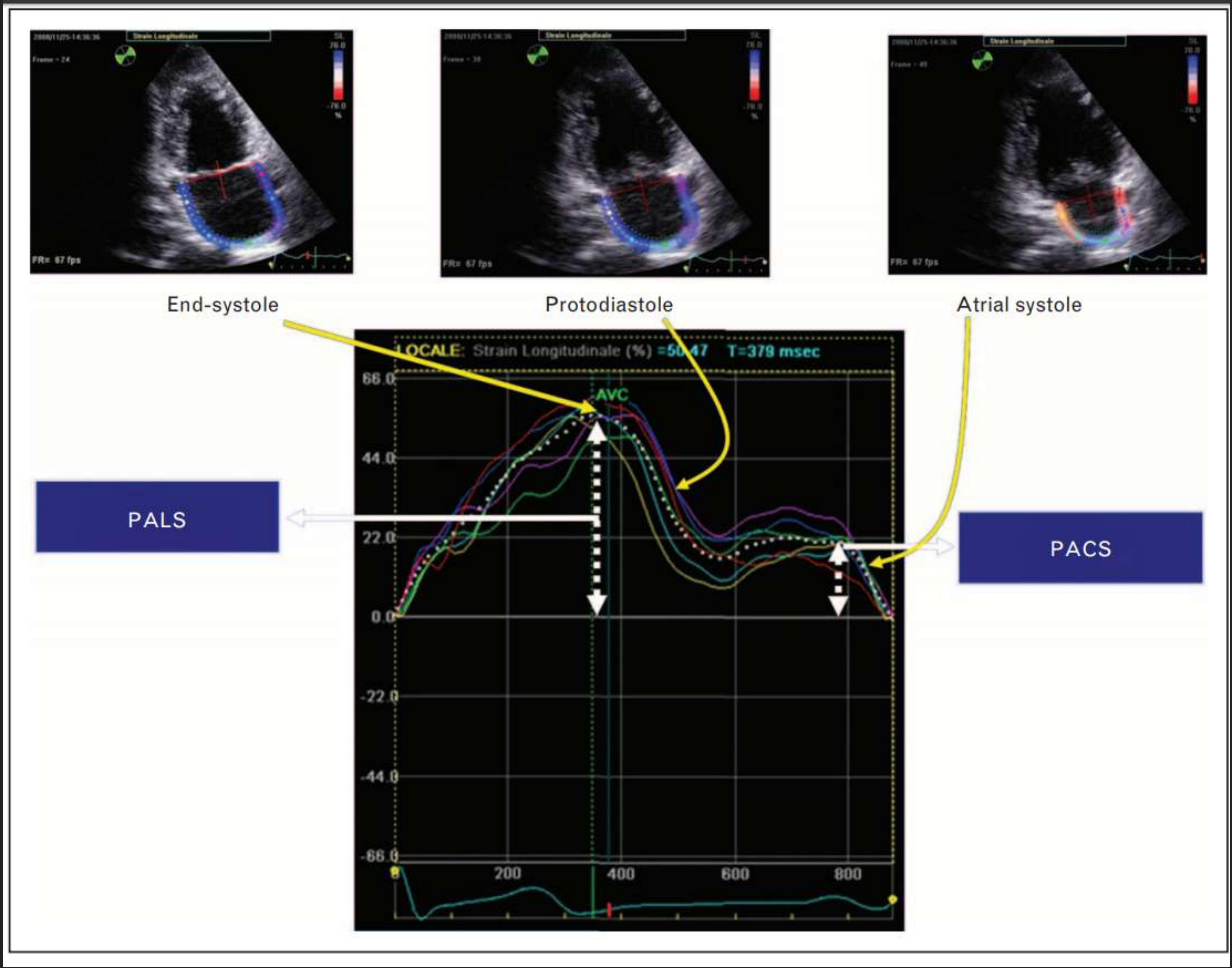
Adapted from Lang R, et al. ASE Chamber Quantification Guidelines 2015

RV STRAIN

- Peak value of 2D longitudinal speckle tracking derived strain, averaged over the three segments of the RV free wall in RV-focused apical four-chamber view (%)
- Advantage:
  - Angle independent
  - Established prognostic value
- Disadvantage:
  - Vendor dependent

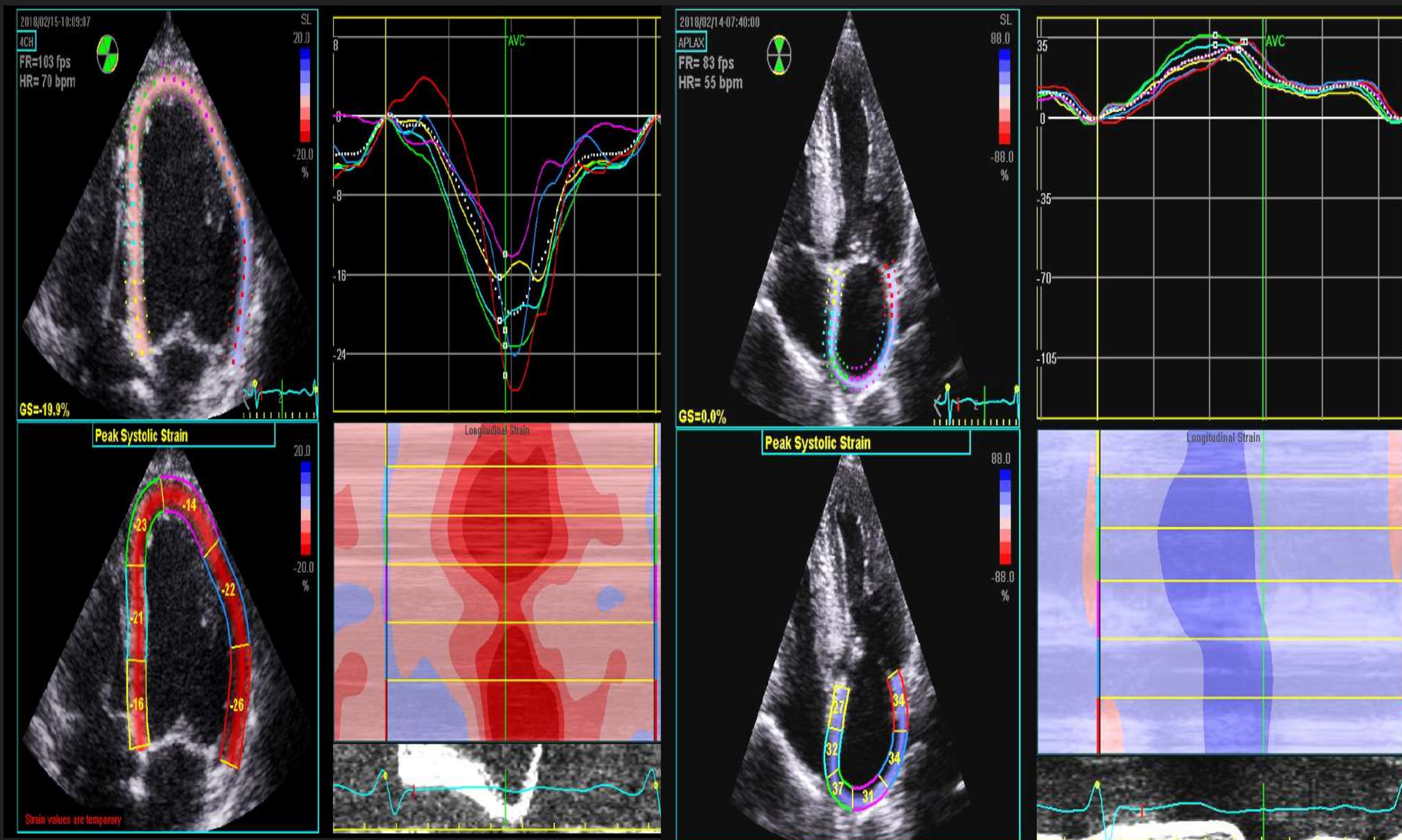

0
P
JPEG
72 bp
ED
ES
50 FPS, 72 BPM
061
ECG

LA STRAIN



Slides courtesy from Kelly Pesek and McKenzie Schweitzer

LV vs. LA Strain Pattern



Slides courtesy from Kelly Pesek and McKenzie Schweitzer

Uses of LA strain

–Diatolic Function
–Heart failure w/ preserved LV systolic function
–Hypertension
–Atrial fibrillation
–Aortic stenosis
–Chronic mitral regurgitation
–Constrictive pericarditis
–Cardiomyopathies
–Athlete’s Heart
–Infiltrative diseases

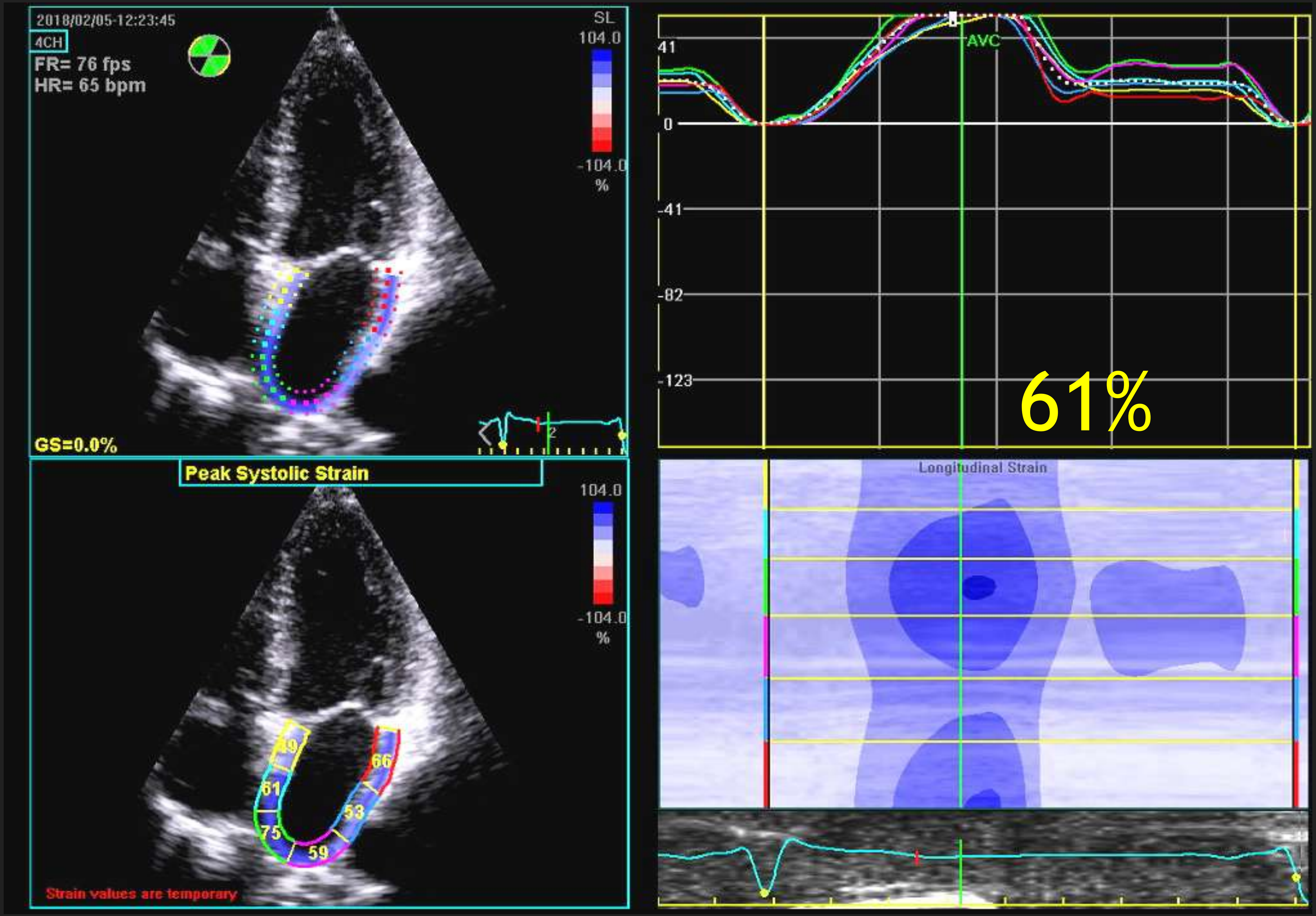
Slides courtesy from Kelly Pesek and McKenzie Schweitzer

Normal LA Strain Value

- Reservoir strain (ventricular systole) is what is most commonly reported
- ≥40% is considered normal
- In both the 4 chamber and 2 chamber views average the 6 segments

Normal Heart

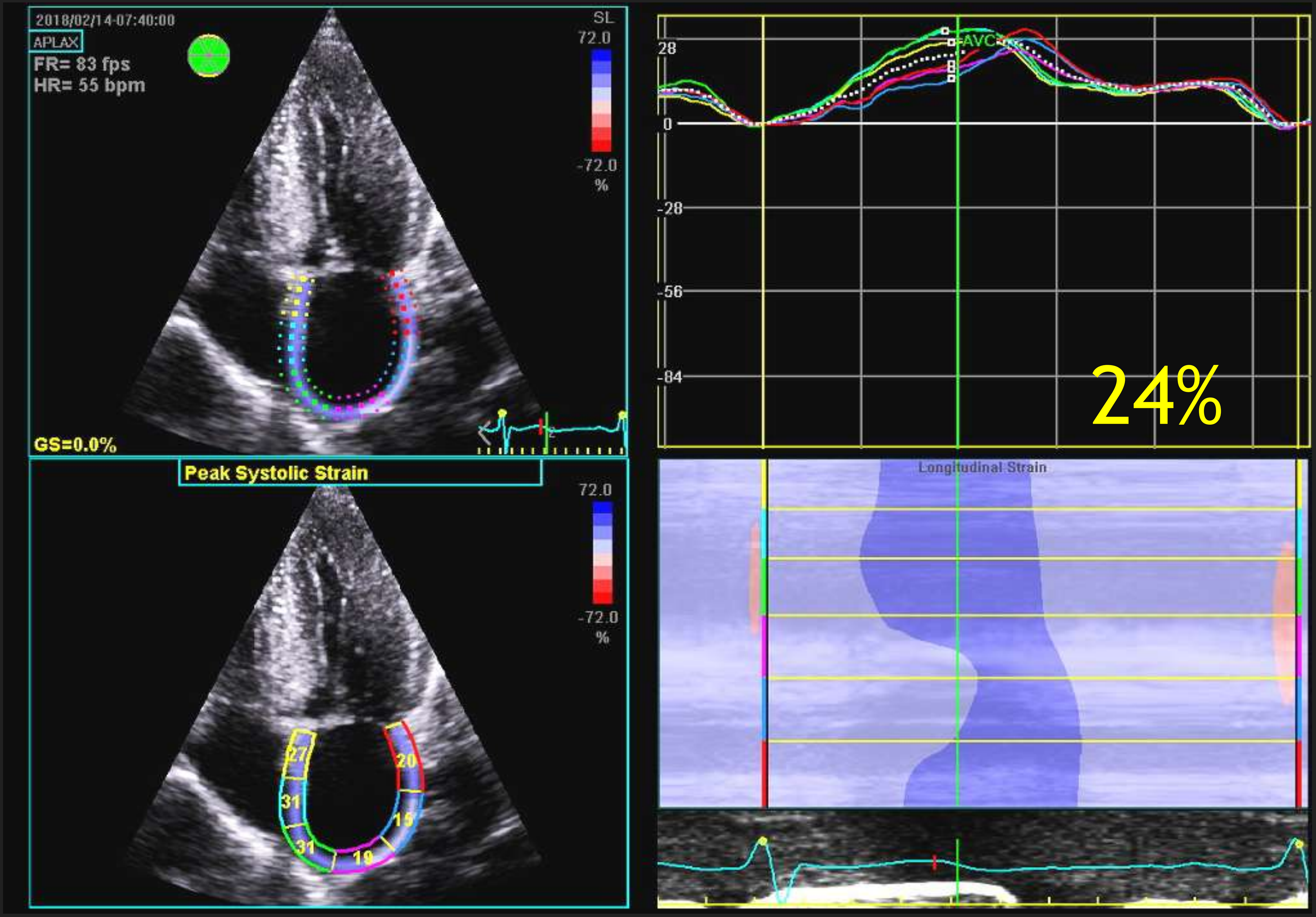
End Systole (ventricular)



Slides courtesy from Kelly Pesek and McKenzie Schweitzer

HCM

End Systole (ventricular)



Slides courtesy from Kelly Pesek and McKenzie Schweitzer

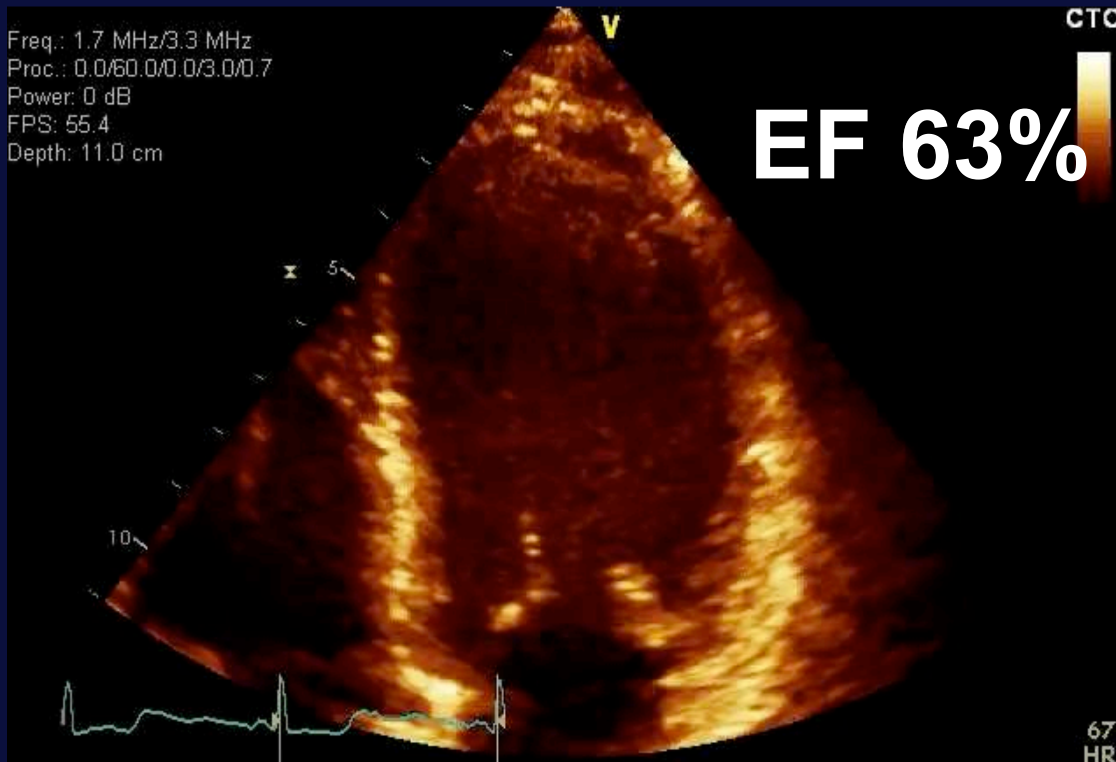
CHEMOTHERAPY

EXPERT CONSENSUS STATEMENT

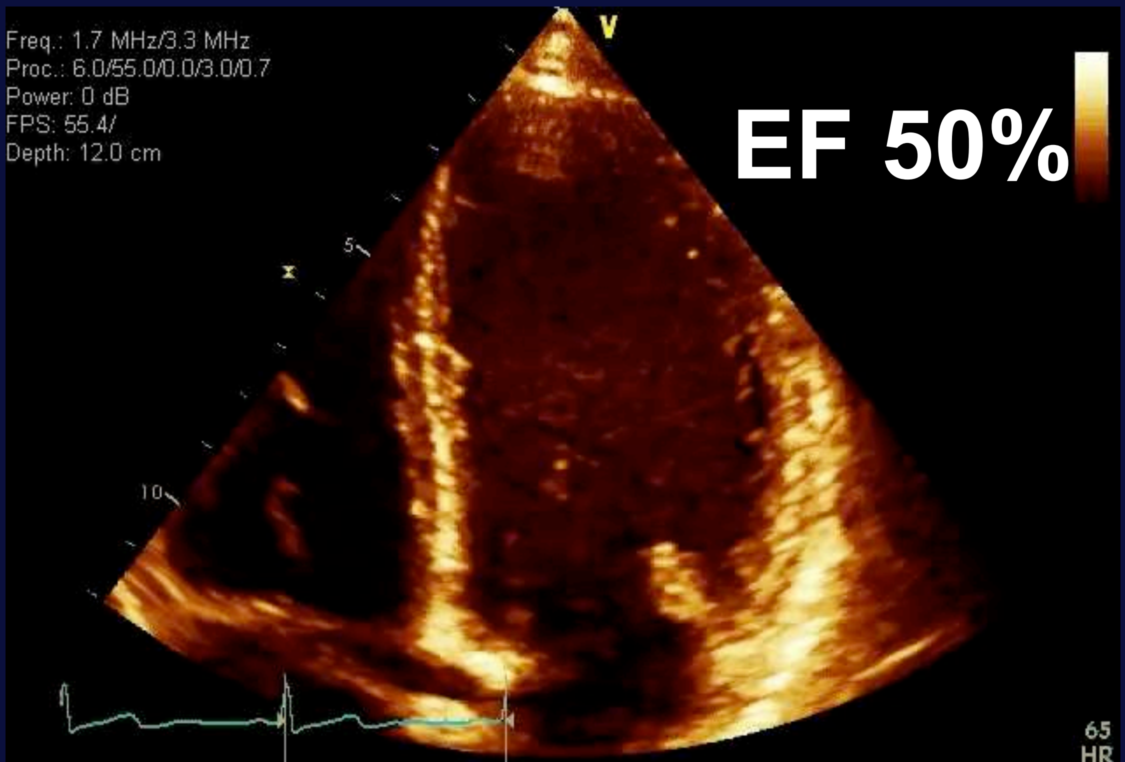
Expert Consensus for Multimodality Imaging Evaluation of Adult Patients during and after Cancer Therapy: A Report from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

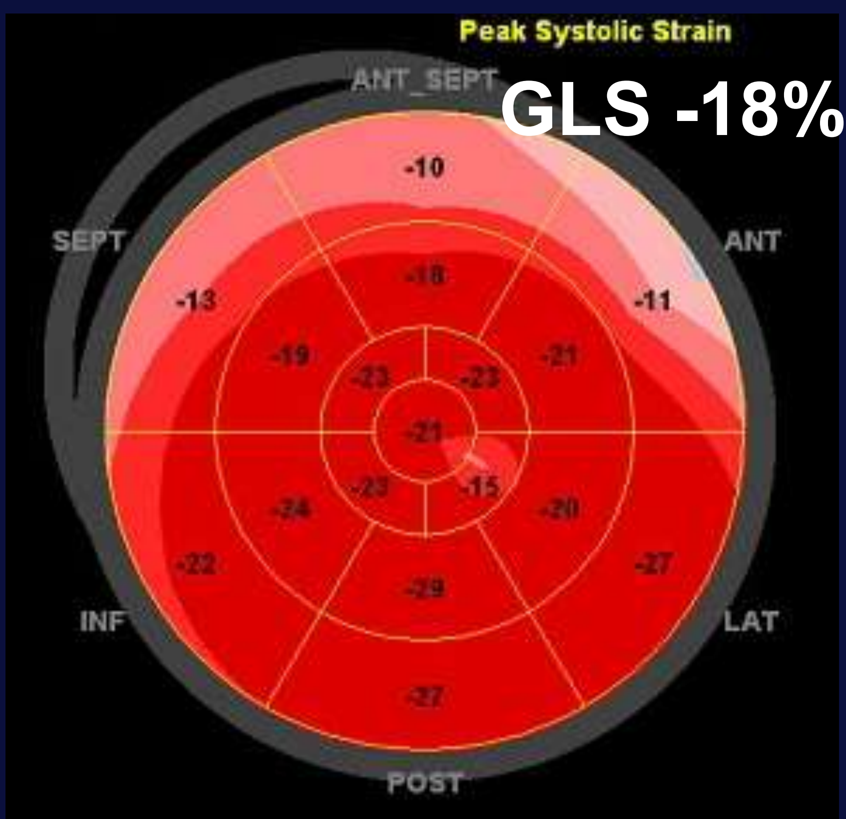
Juan Carlos Plana, MD, FASE, Chair, Maurizio Galderisi, MD, FESC, Co-Chair, Ana Barac, MD, PhD, Michael S. Ewer, MD, JD, Bonnie Ky, MD, FASE, Marielle Scherrer-Crosbie, MD, PhD, FASE, Javier Ganame, MD, PhD, FASE, Igal A. Sebag, MD, FASE, Deborah A. Agler, RCT, RDCS, FASE, Luigi P. Badano, MD, PhD, FESC, Jose Banchs, MD, FASE, Daniela Cardinale, MD, PhD, FESC, Joseph Carver, MD, Manuel Cerqueira, MD, Jeanne M. DeCara, MD, FASE, Thor Edvardsen, MD, PhD, FESC, Scott D. Flamm, MD, MBA, Thomas Force, MD, Brian P. Griffin, MD, Guy Jerusalem, MD, PhD, Jennifer E. Liu, MD, FASE, Andreia Magalhães, MD, Thomas Marwick, MBBS, PhD, MPH, Liza Y. Sanchez, RCS, FASE, Rosa Sicari, MD, PhD, FESC, Hector R. Villarraga, MD, FASE, and Patrizio Lancellotti, MD, PhD, FESC, *Cleveland, Ohio; Naples, Padua, Milan, and Pisa, Italy; Washington, District of Columbia; Houston, Texas; Philadelphia, Pennsylvania; Boston, Massachusetts; Hamilton, Ontario and Montreal, Quebec, Canada; Chicago, Illinois; Oslo, Norway; Liege, Belgium; New York, New York; Lisbon, Portugal; Hobart, Australia; Rochester, Minnesota*

Pre Chemo



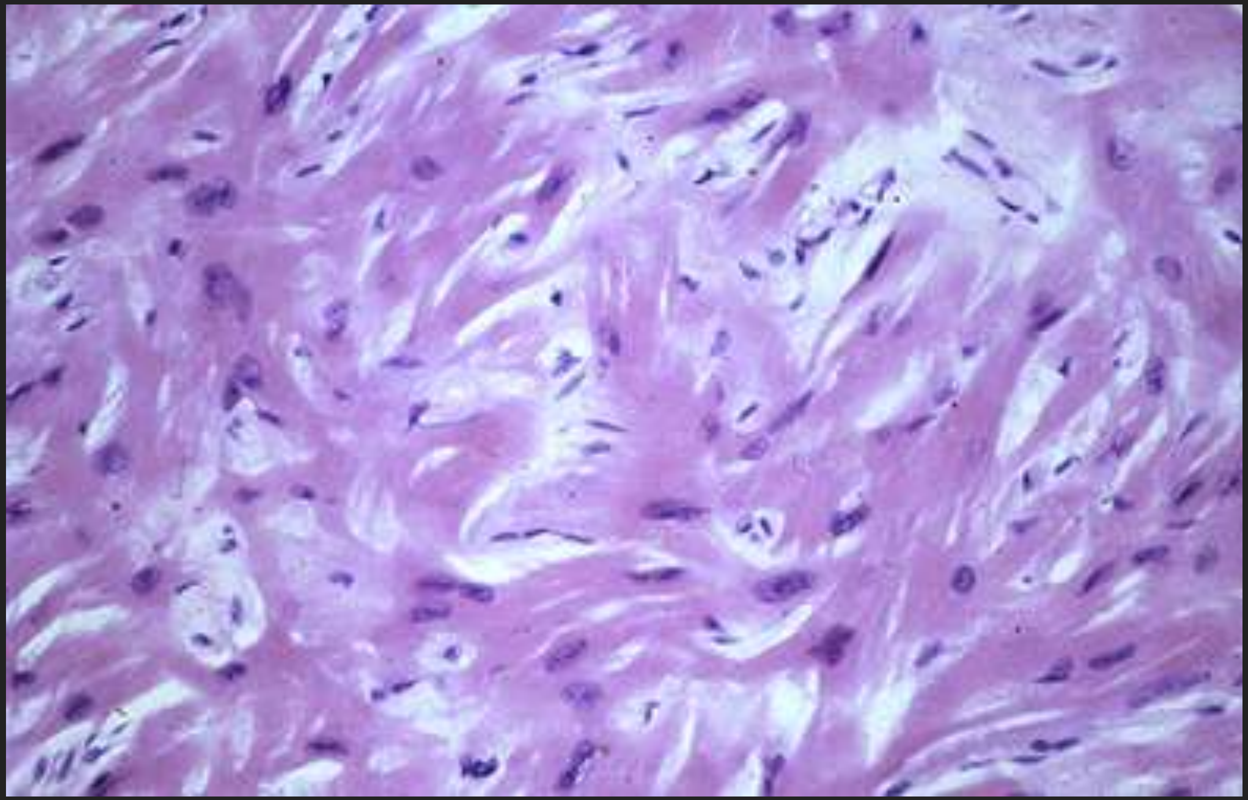
6 m f/u



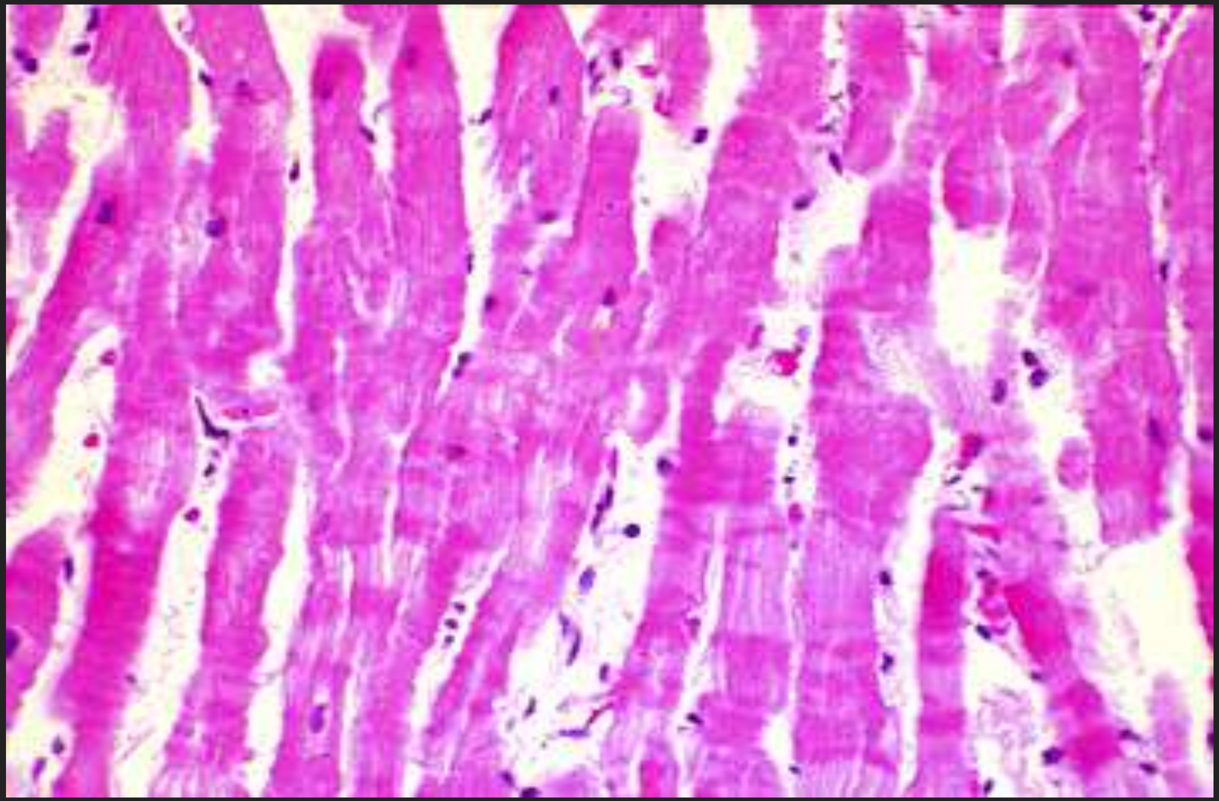


HYPERTROPHIC CARDIOMYOPATHY

Myocyte disarray in hypertrophic cardiomyopathy



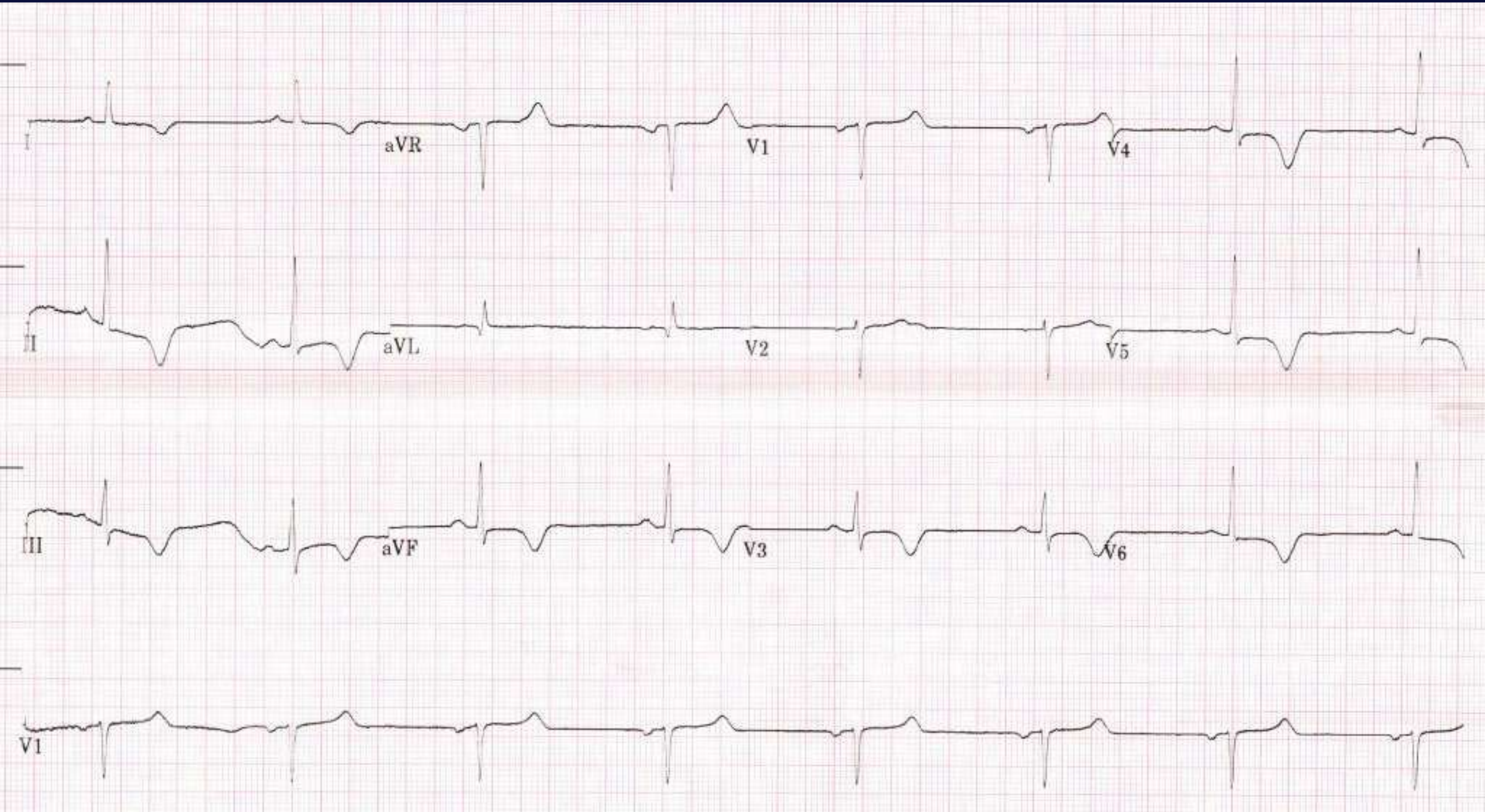
Normal endomyocardial biopsy



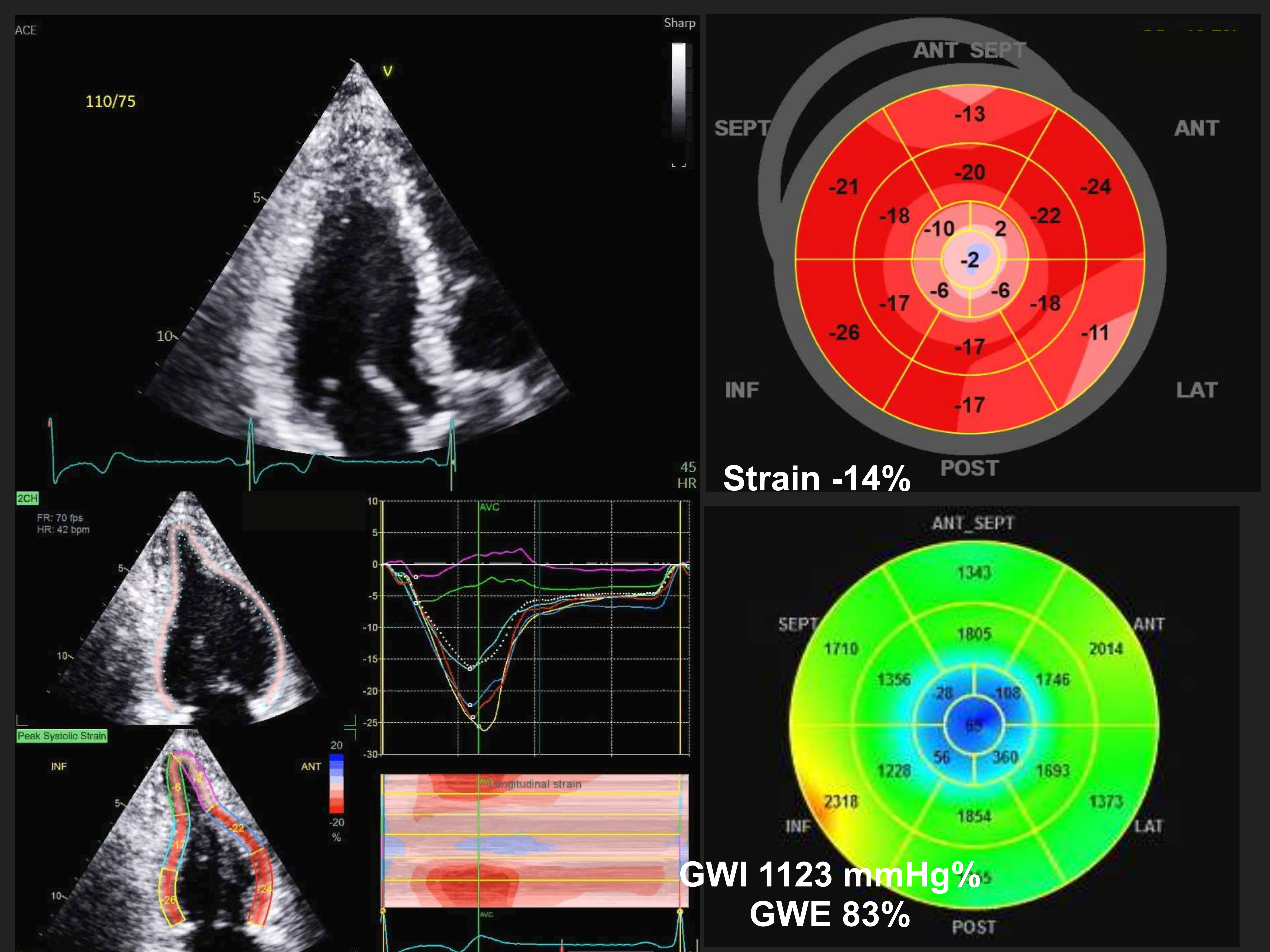
Adapted from UptoDate: Restrictive Cardiomyopathy

CASE

- 73 year old female
- Went to ER in Montana due to palpitations
- EKG abnormal and mildly elevated troponin
- 2 days prior patient went on 2 long hikes

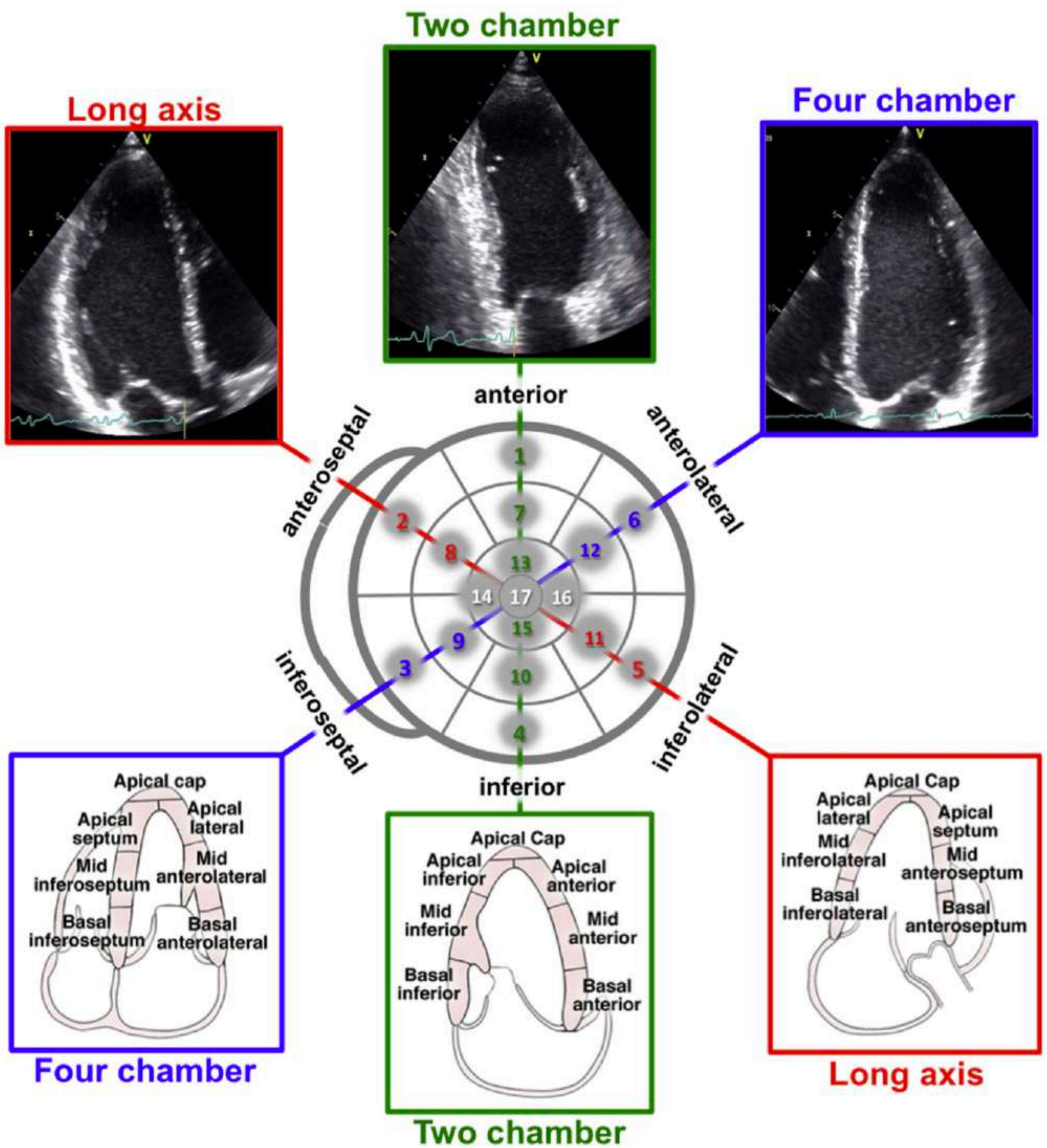


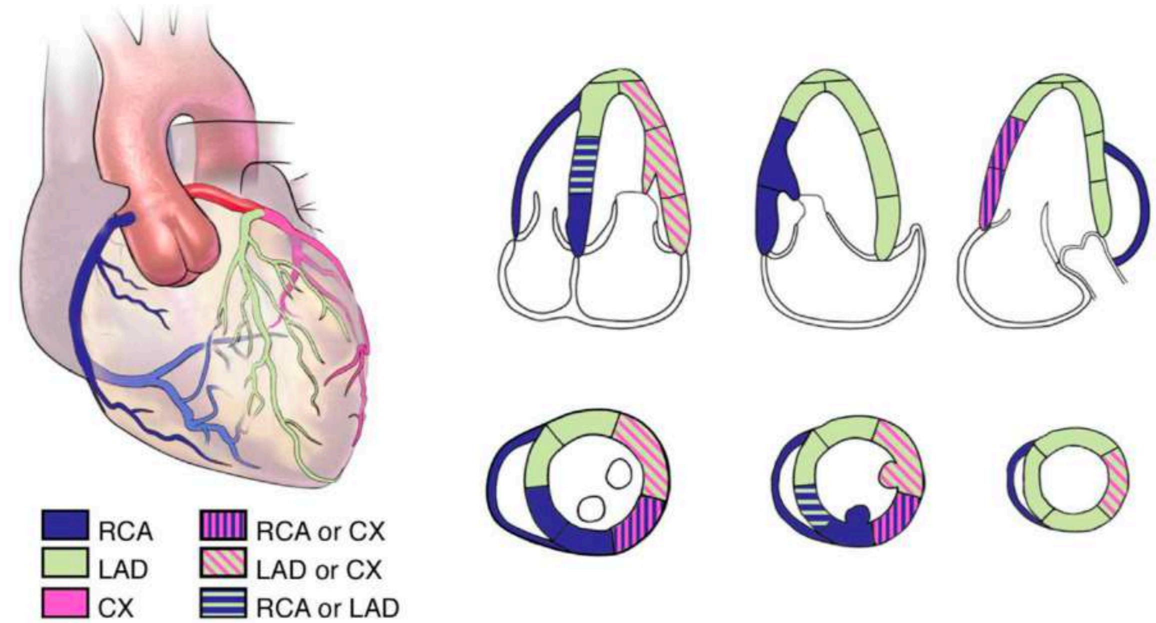
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1


ACE
Sharp
110/75
V
45
HR
2CH
FR: 70 fps
HR: 42 bpm
Peak Systolic Strain
INF
ANT
AVC
Longitudinal strain
ANT SEPT
SEPT
ANT
INF
LAT
POST
-13
-21
-20
-24
-18
-10
2
-22
-2
-6
-6
-17
-18
-26
-17
-11
-17
Strain -14%
ANT_SEPT
SEPT
ANT
INF
LAT
POST
1343
1710
1805
2014
1356
28
108
1746
56
360
1228
1693
2318
1854
1373
GWI 1123 mmHg%
GWE 83%

CAD

ASE GUIDELINE



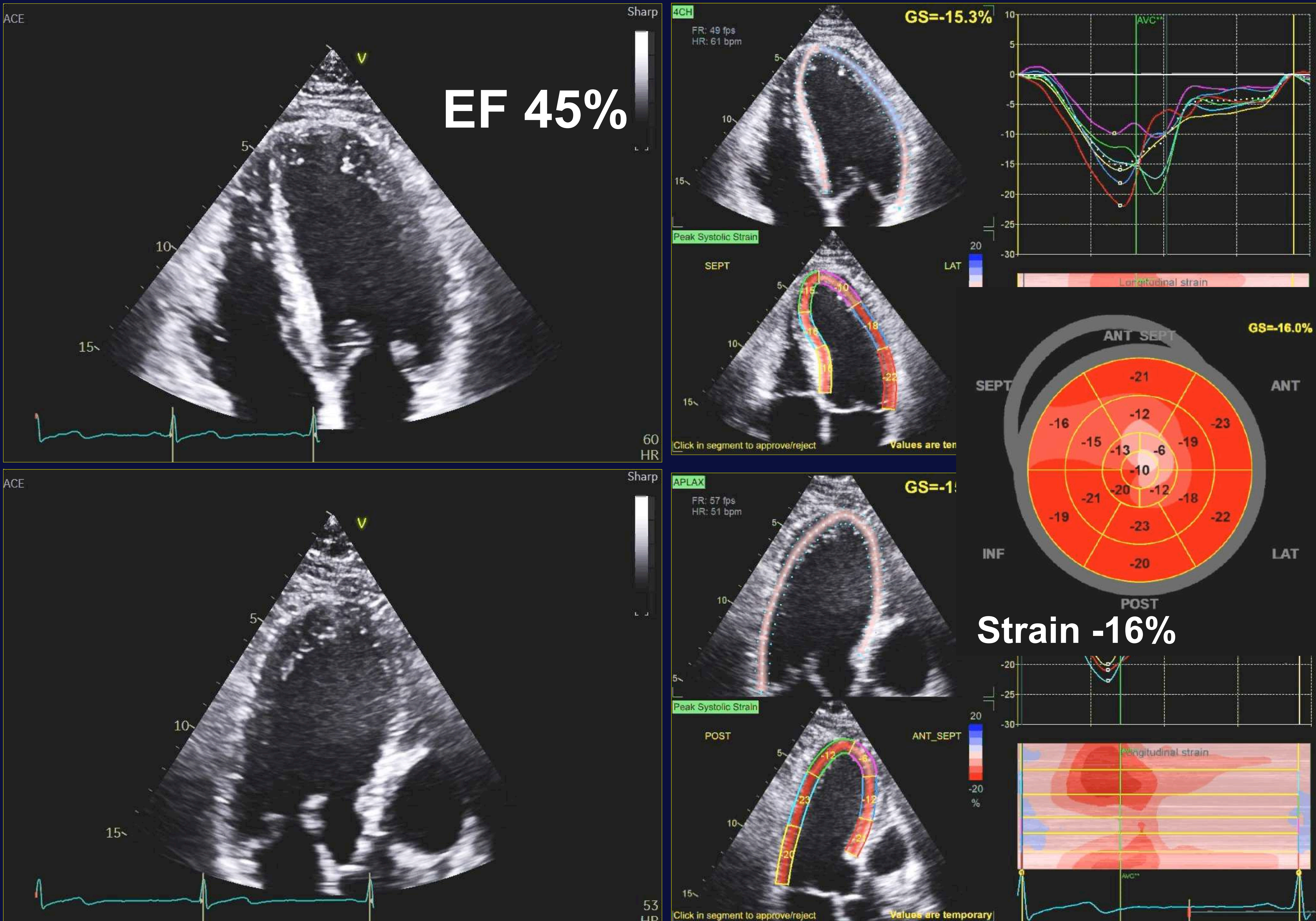


Wall Scoring Index	
1	Normal >40%
2	Hypokinetic <30%
3	Akinetic <10%
4	Dyskinetic
5	Aneurysmal

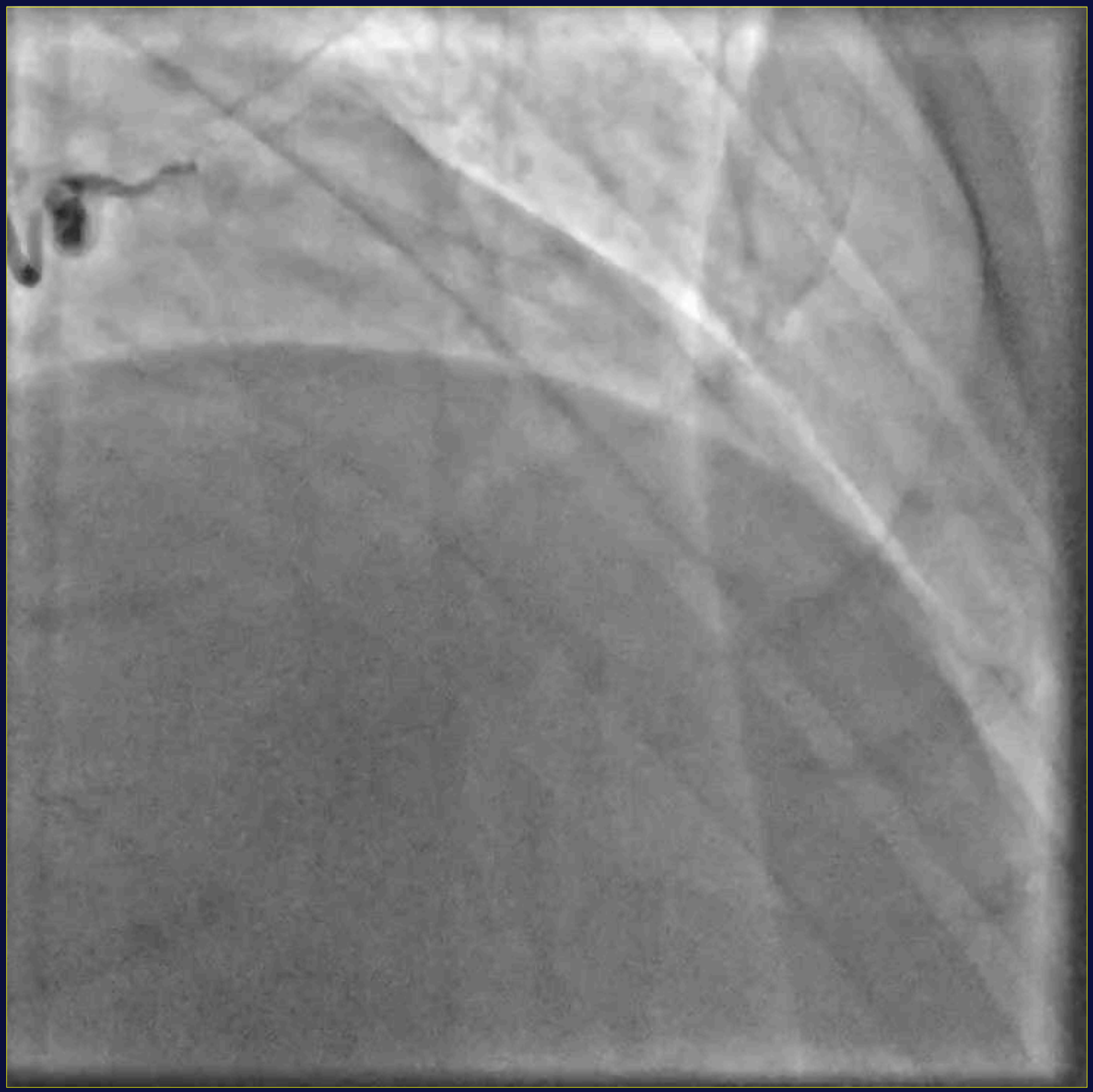
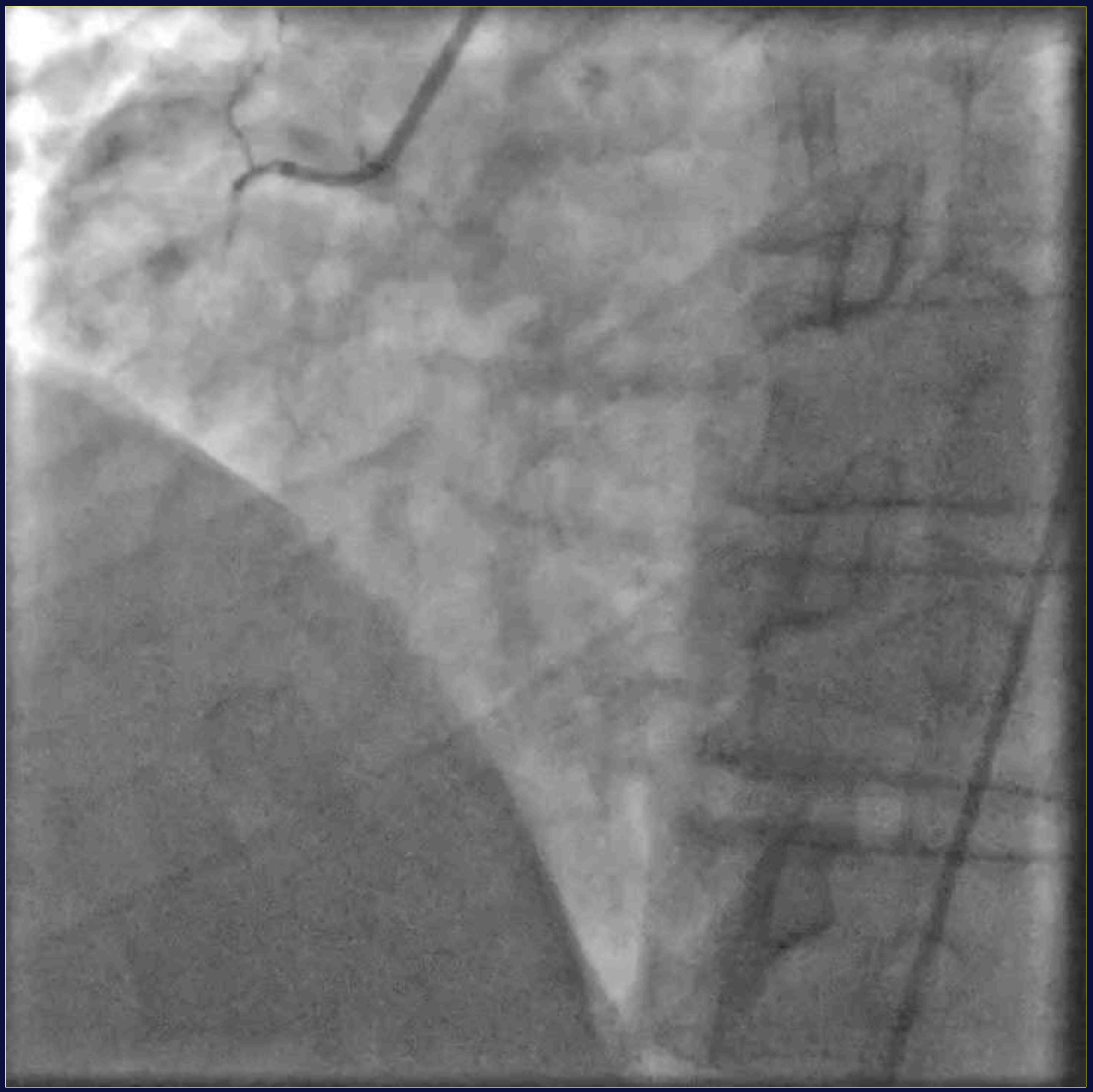
Adapted from Lang R, ASE Chamber Quantification Guideline 2015

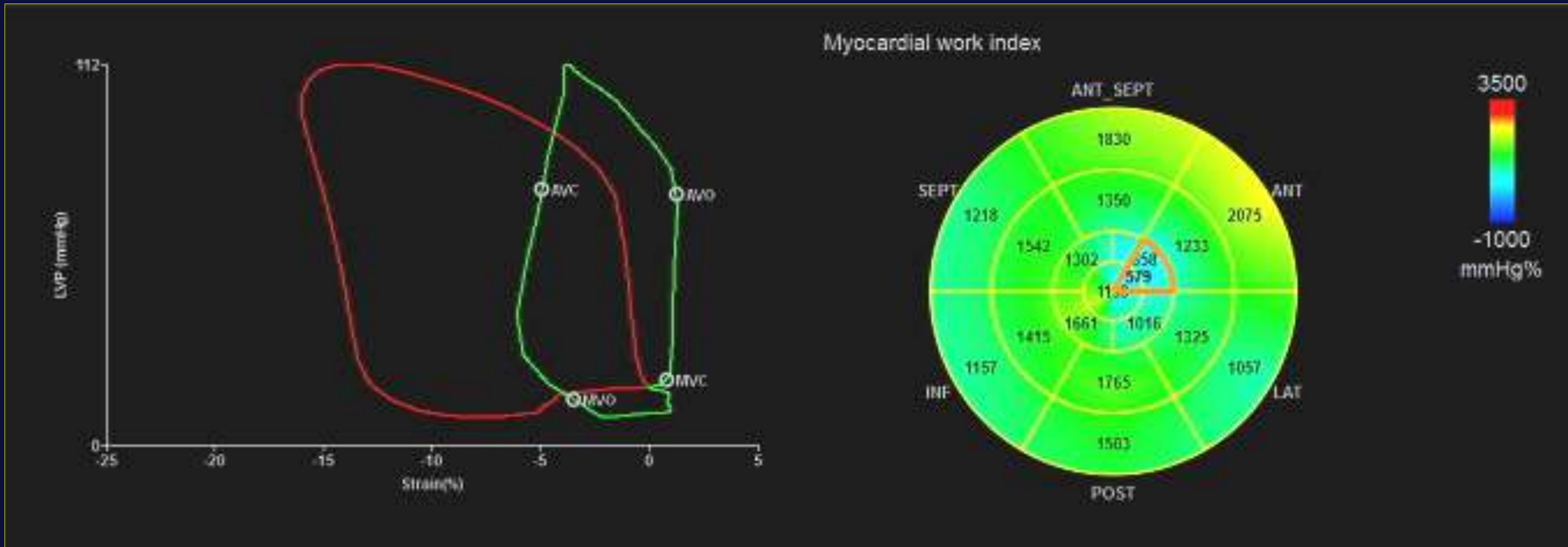
CASE

- 54 year old male
- Hx of CAD s/p PCI 2018 with mid LAD stent
- Chest pain, increasing DOE and exertion fatigue

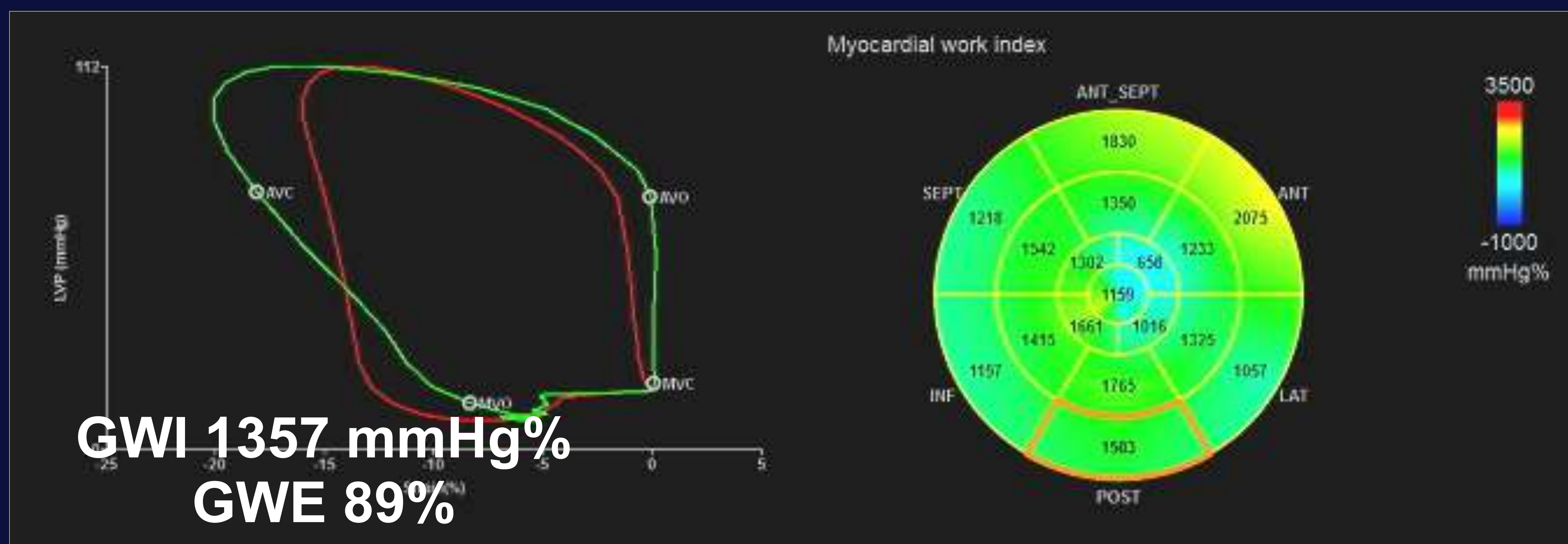


EF 45%
GS=-15.3%
4CH
FR: 49 fps
HR: 61 bpm
Peak Systolic Strain
SEPT
LAT
Click in segment to approve/reject
APLAX
FR: 57 fps
HR: 51 bpm
POST
ANT_SEPT
Values are temporary
Longitudinal strain
GS=-16.0%
ANT_SEPT
SEPT
ANT
INF
LAT
POST
-21
-16
-12
-23
-15
-13
-6
-19
-10
-21
-20
-12
-18
-19
-22
-23
-20
Strain -16%
60 HR
53 HR

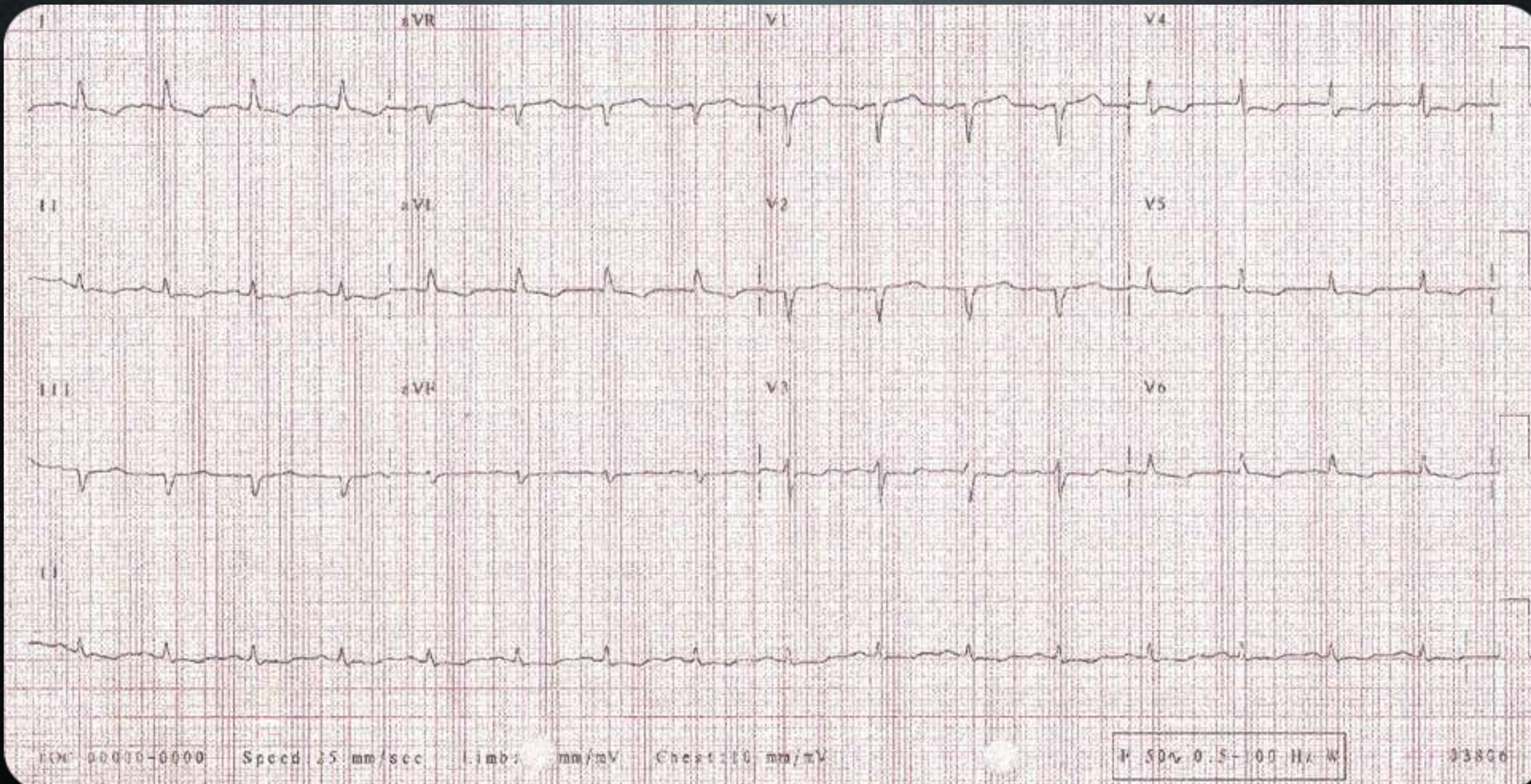


Myocardial work index
LVP (mmHg)
Strain(%)
AVC
AVO
MVC
MVO
ANT_SEPT
ANT
SEPT
INF
LAT
POST
1830
1350
1218
2075
1542
1233
1302
658
579
1661
1016
1415
1325
1157
1057
1765
1503
3500
-1000
mmHg%

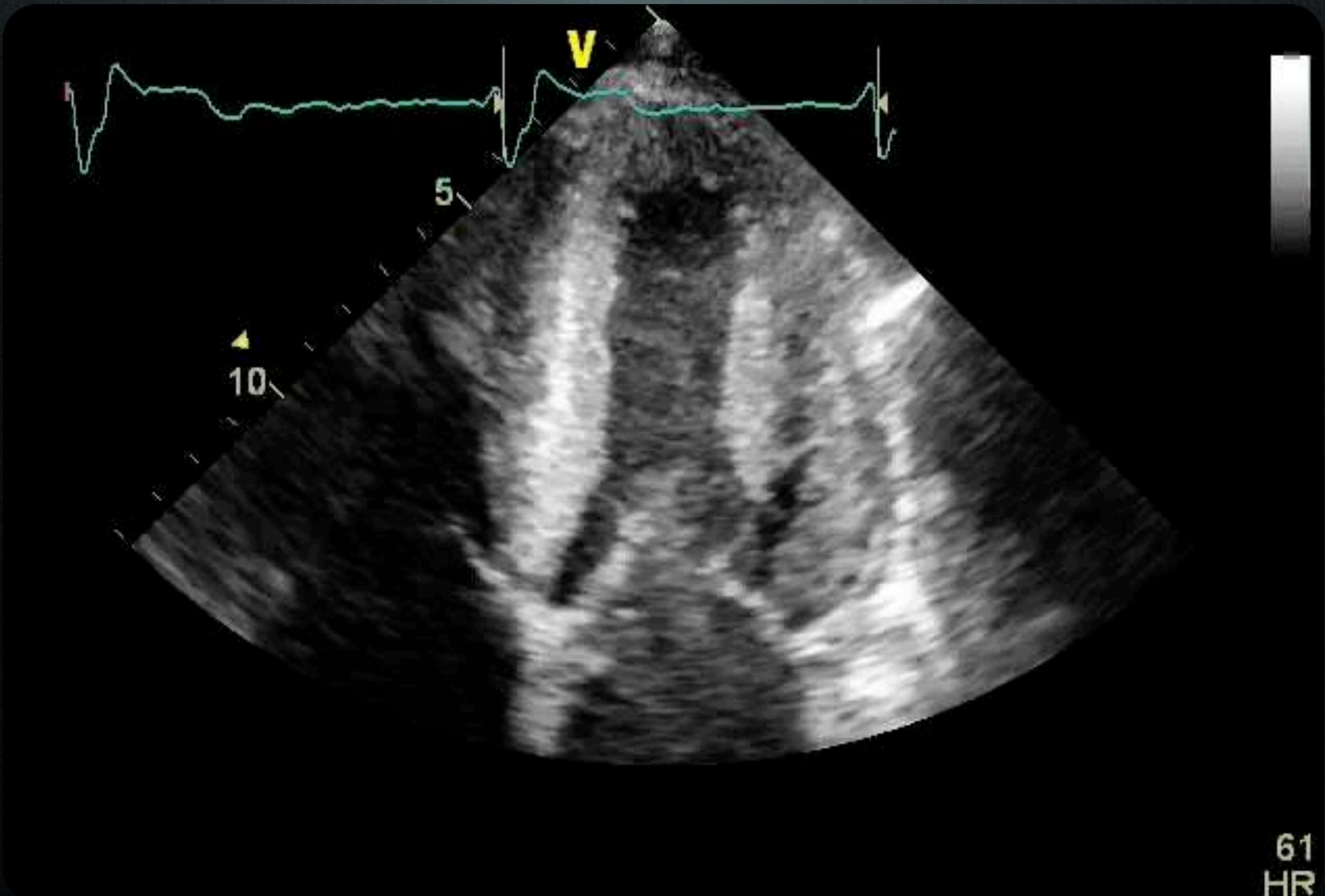


Myocardial work index
LVP (mmHg)
AVC
AVO
MVC
MVO
ANT_SEPT
ANT
SEPT
INF
LAT
POST
1830
1350
1218
2075
1542
1233
1302
658
1159
1661
1016
1415
1325
1157
1057
1765
1503
3500
-1000
mmHg%
GWI 1357 mmHg%
GWE 89%

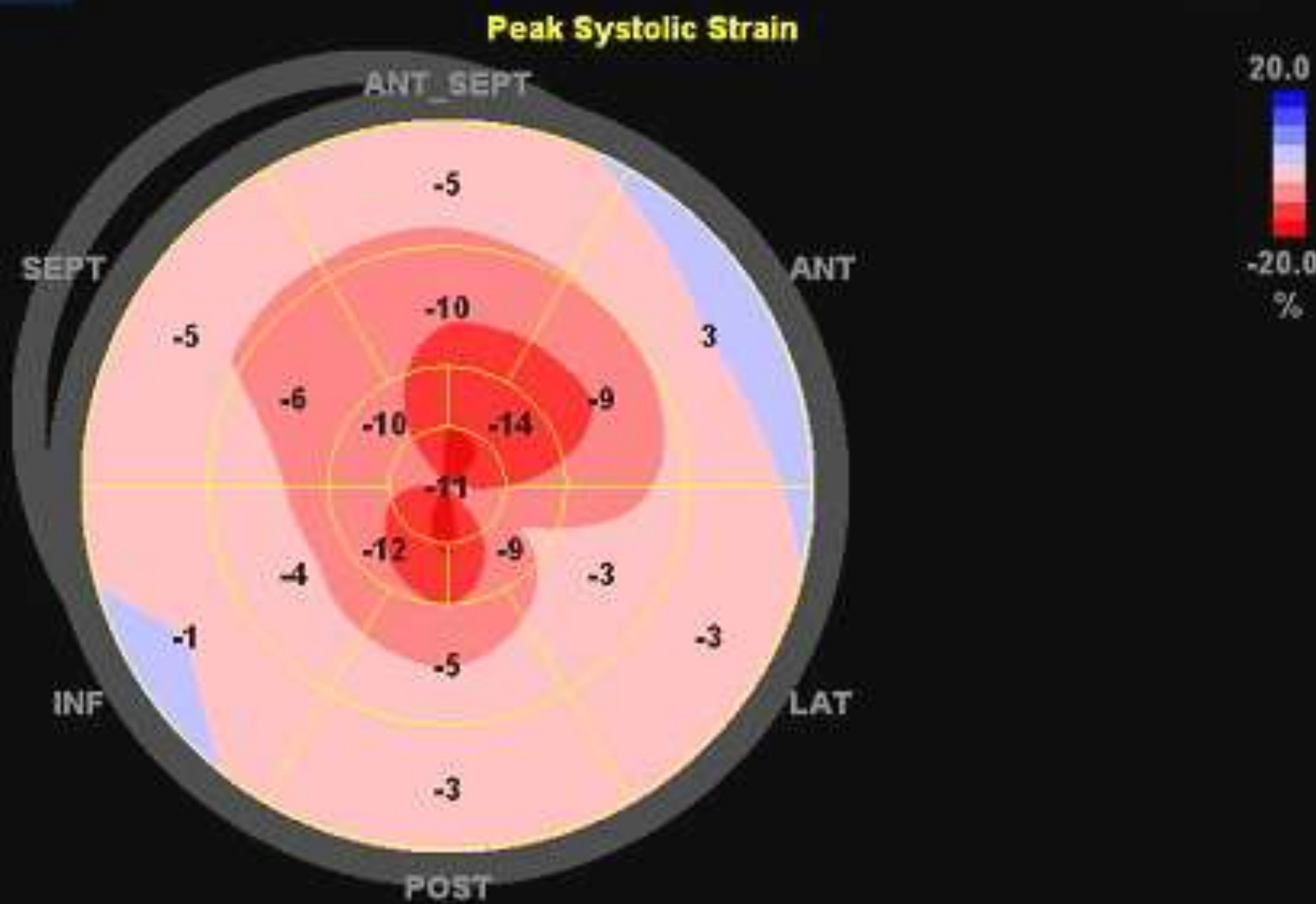
AMYLOIDOSIS



EKG

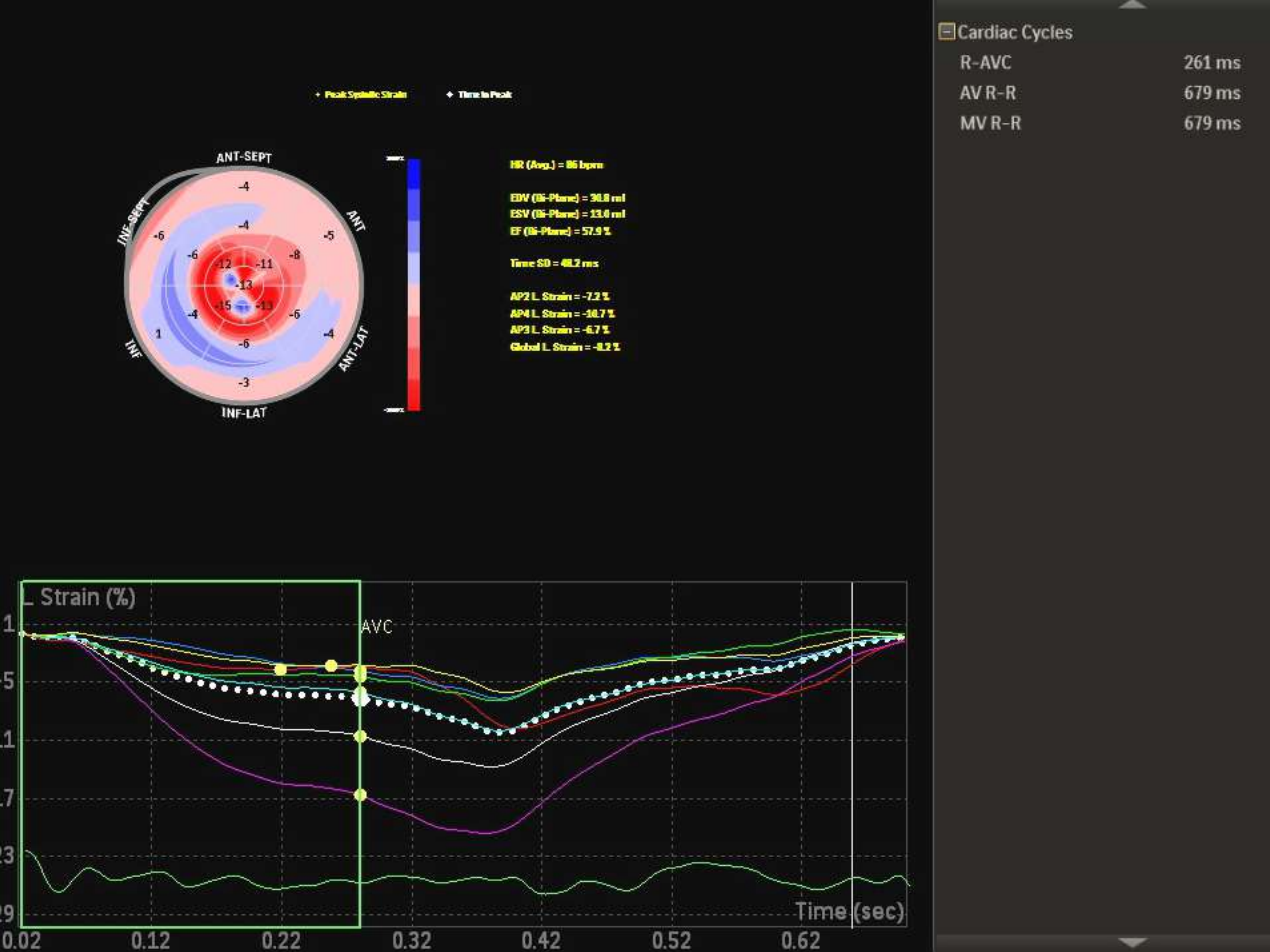


V
5
10
61
HR



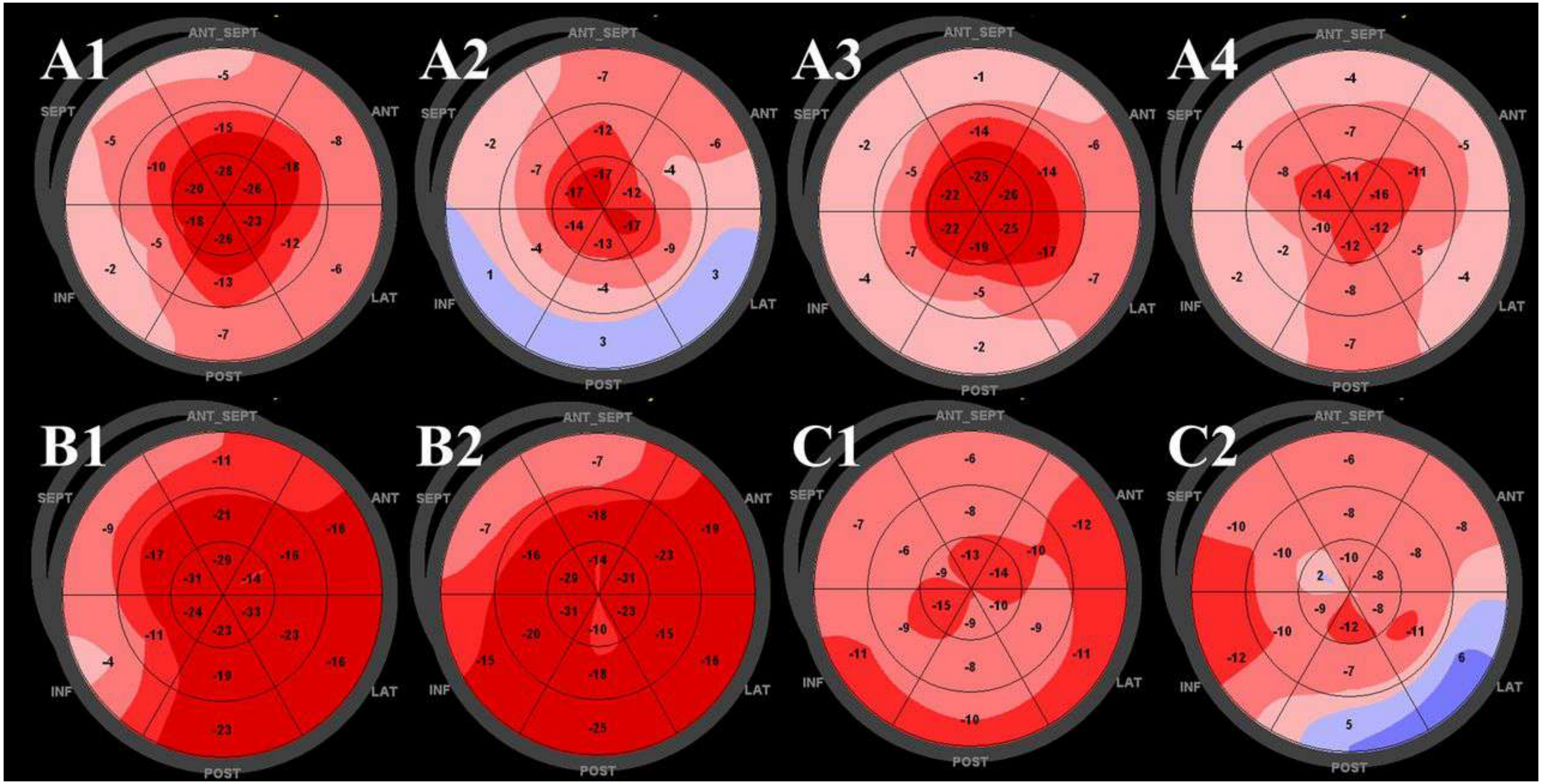
08/09/2014-12:11:29

GLPS_LAX	-8.8 %	AVC_AUTO	278 msec
GLPS_A4C	-4.3 %	HR_ApLAX	89 bpm
GLPS_A2C	-6.7 %	FR_min	50 fps
GLPS_Avg	-6.8 %		

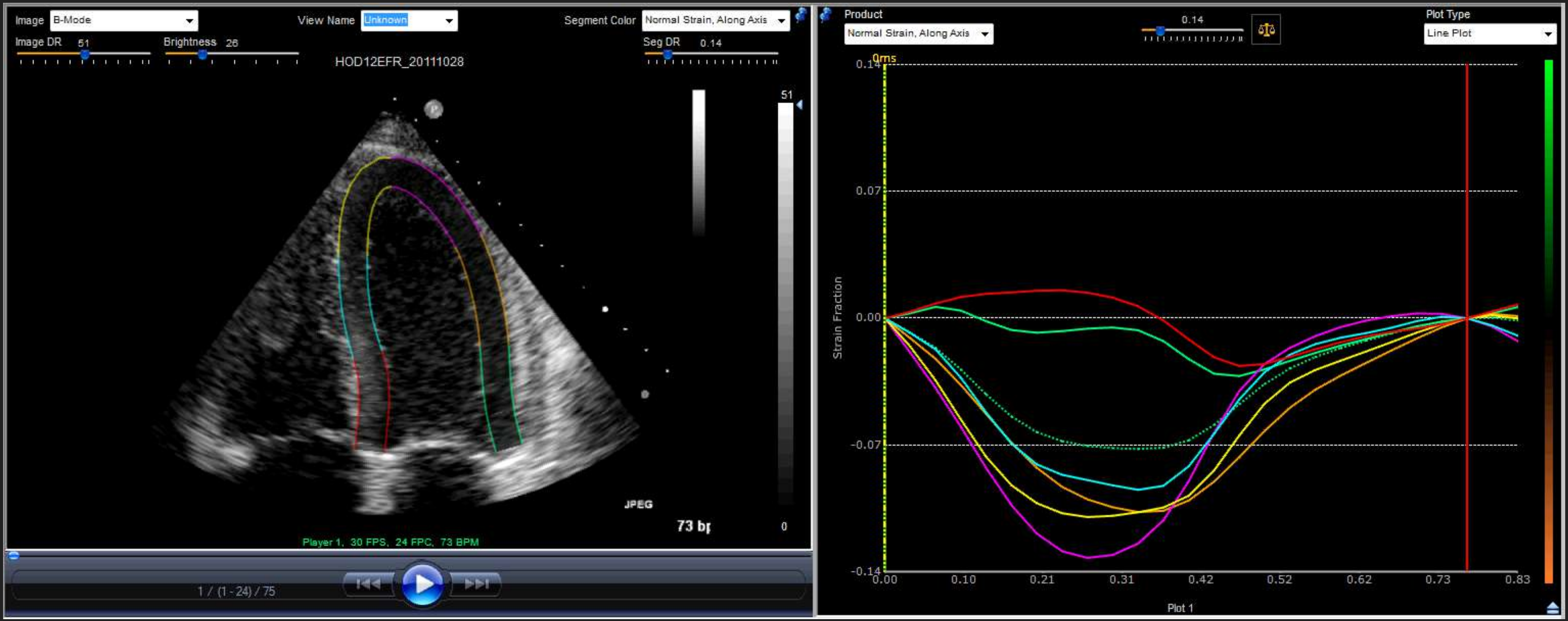


Cardiac Cycles
R-AVC 261 ms
AV R-R 679 ms
MV R-R 679 ms
ANT-SEPT
ANT
ANT-LAT
INF-LAT
INF
INF-SEPT
EDV (Bi-Plane) = 30.8 ml
ESV (Bi-Plane) = 13.0 ml
EF (Bi-Plane) = 57.9 %
AP2 L. Strain = -7.2 %
AP4 L. Strain = -10.7 %
AP3 L. Strain = -6.7 %
Global L. Strain = -8.2 %
L. Strain (%)
AVC
Time (sec)
0.02
0.12
0.22
0.32
0.42
0.52
0.62

Representative two-dimensional speckle-tracking longitudinal strain patterns (‘bull's eye plots’) for each subgroup.

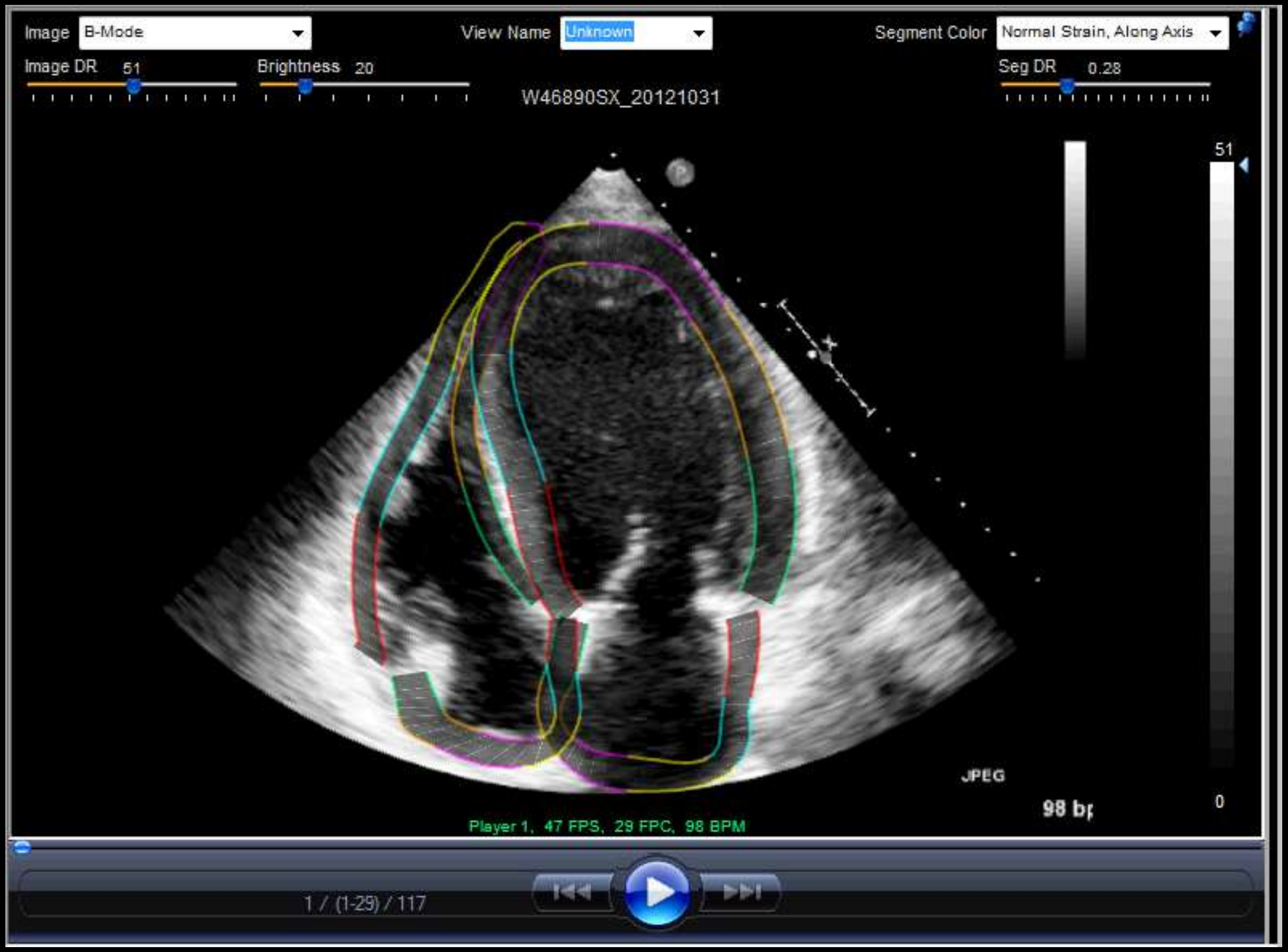


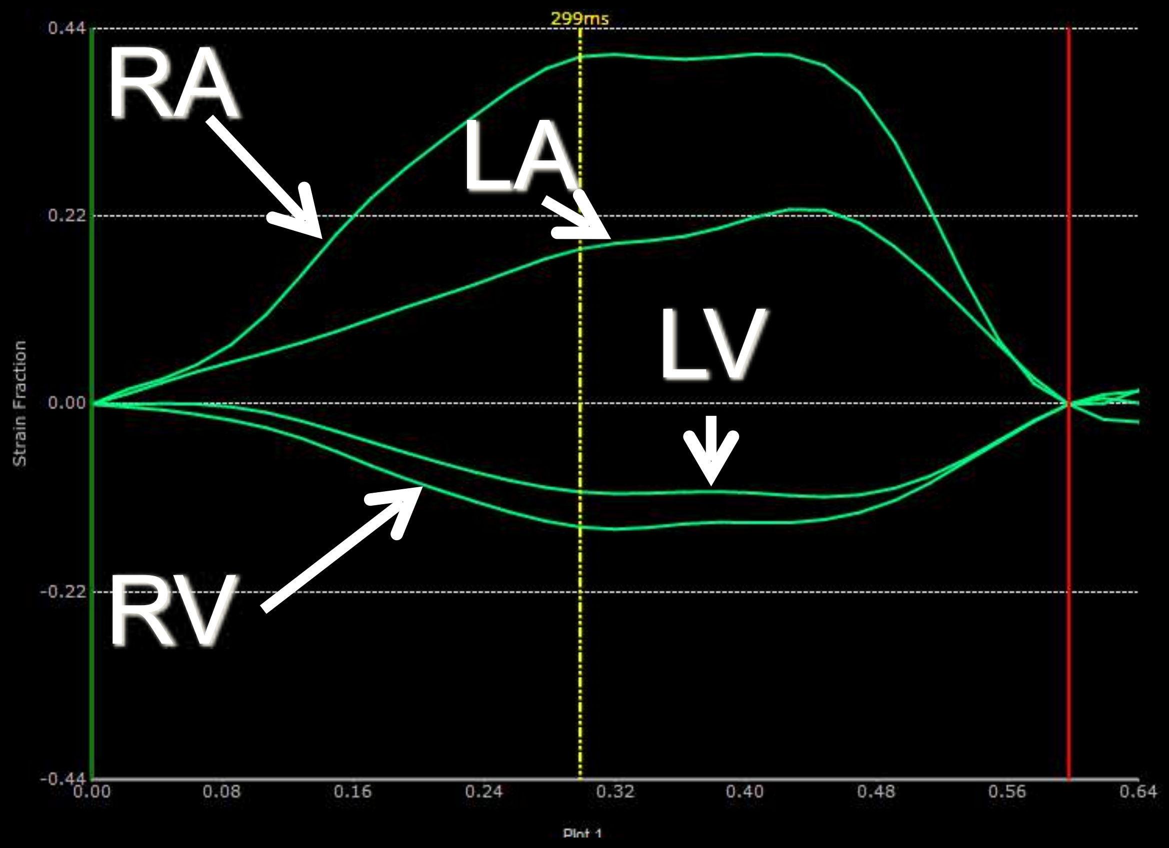
Dermot Phelan et al. Heart 2012;98:1442-1448



WHATS NEW AND UPCOMING IN STRAIN IMAGING?

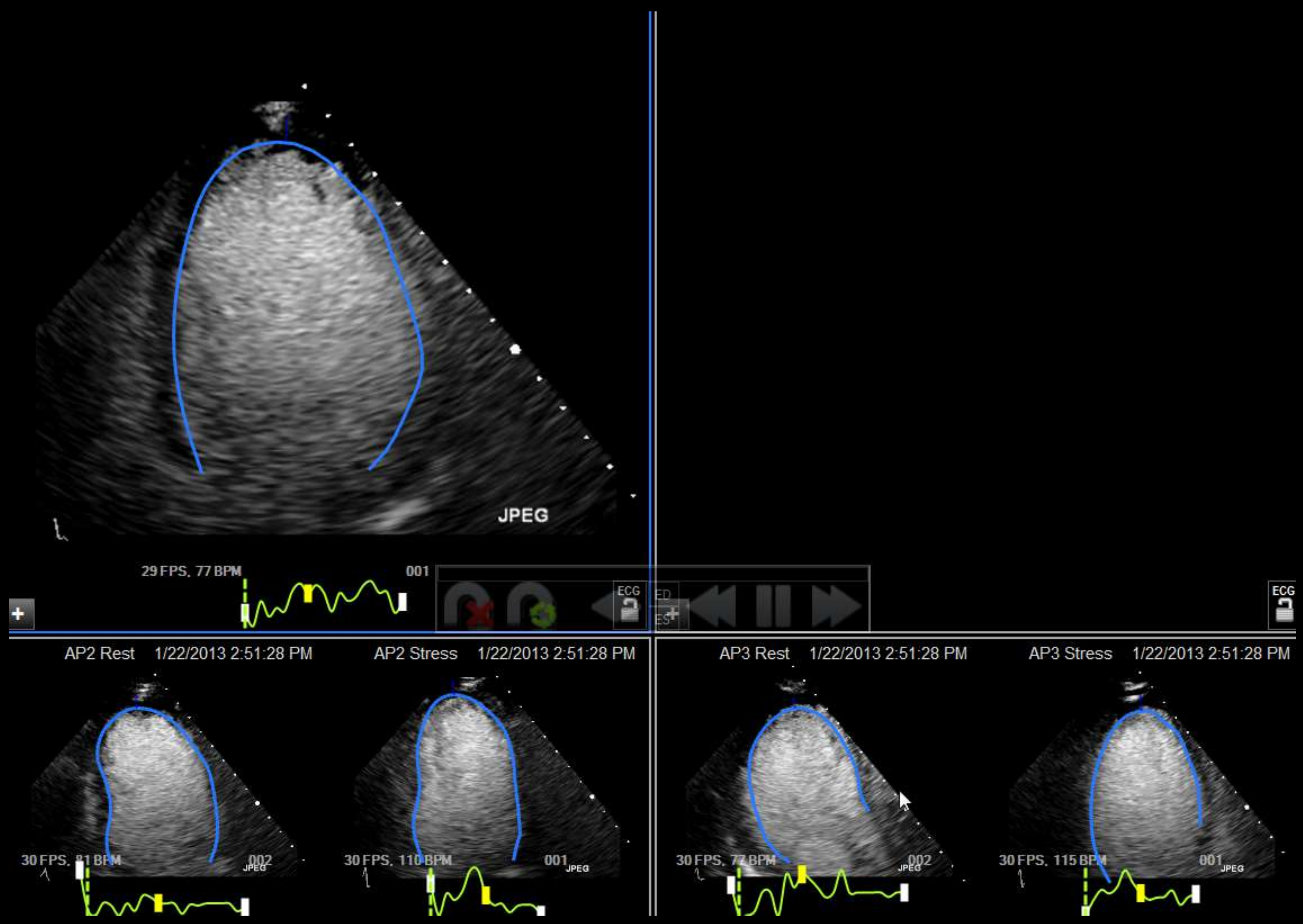
Total Heart Strain Imaging



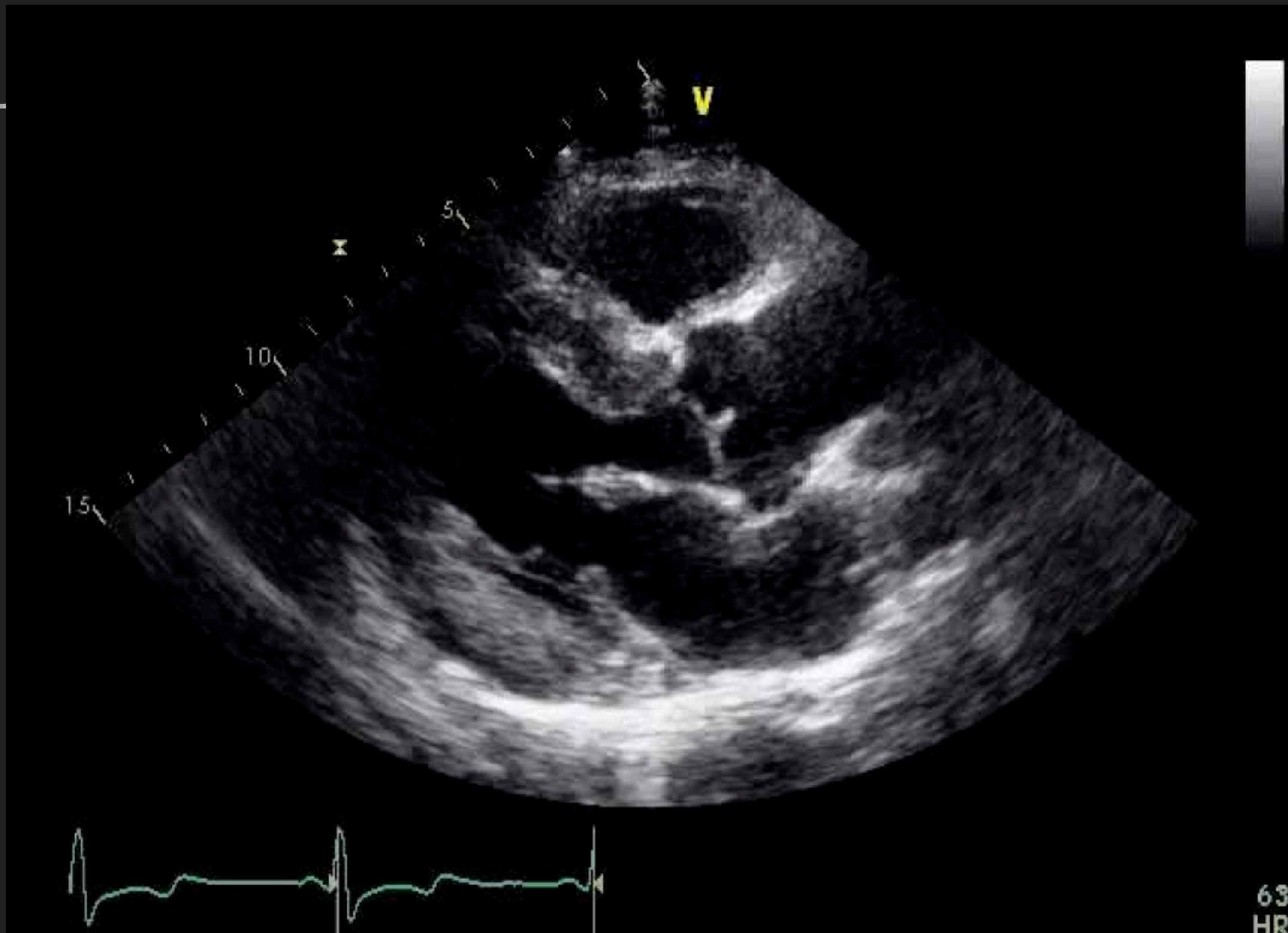


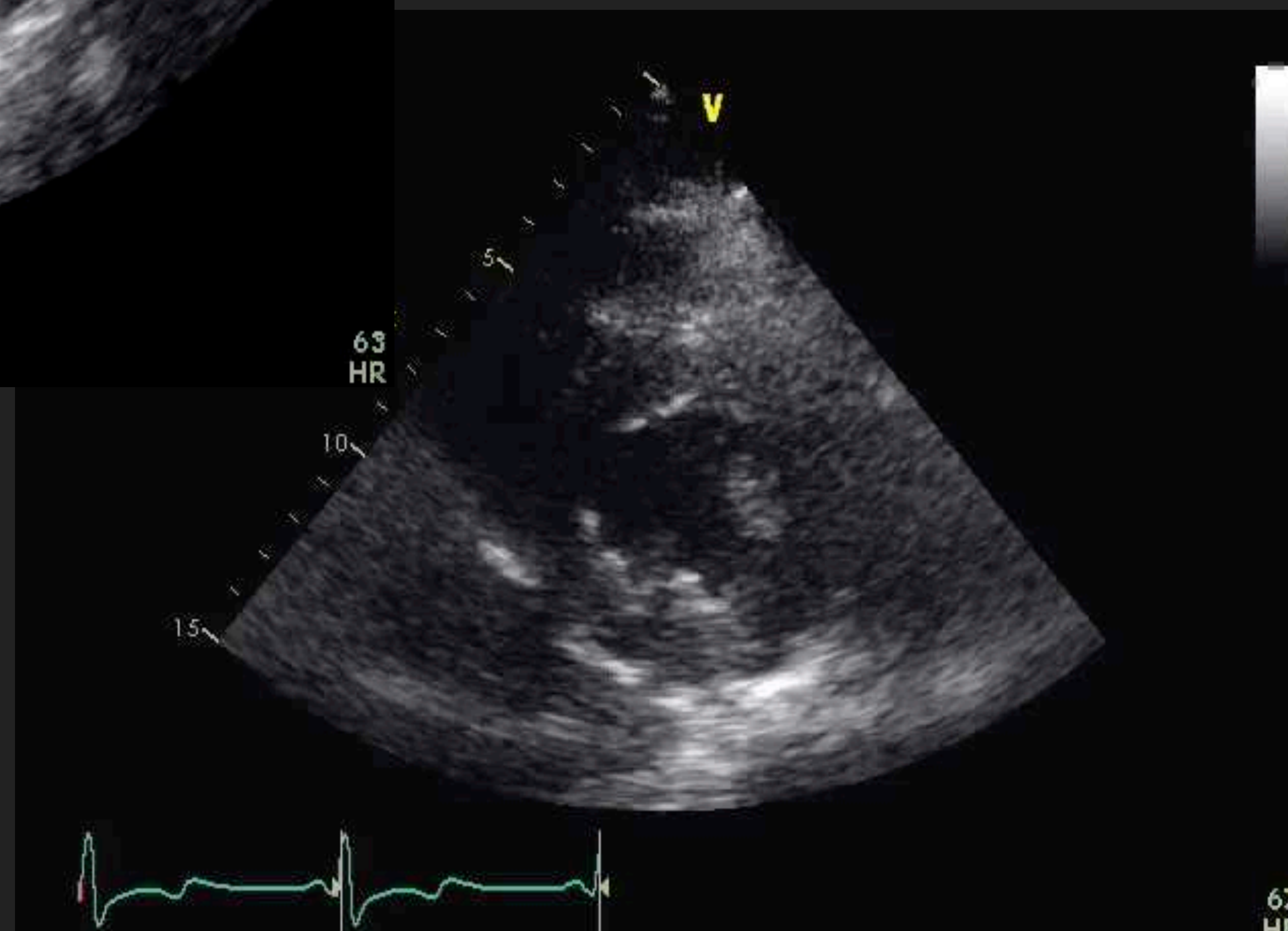
Contrast Stress Echo

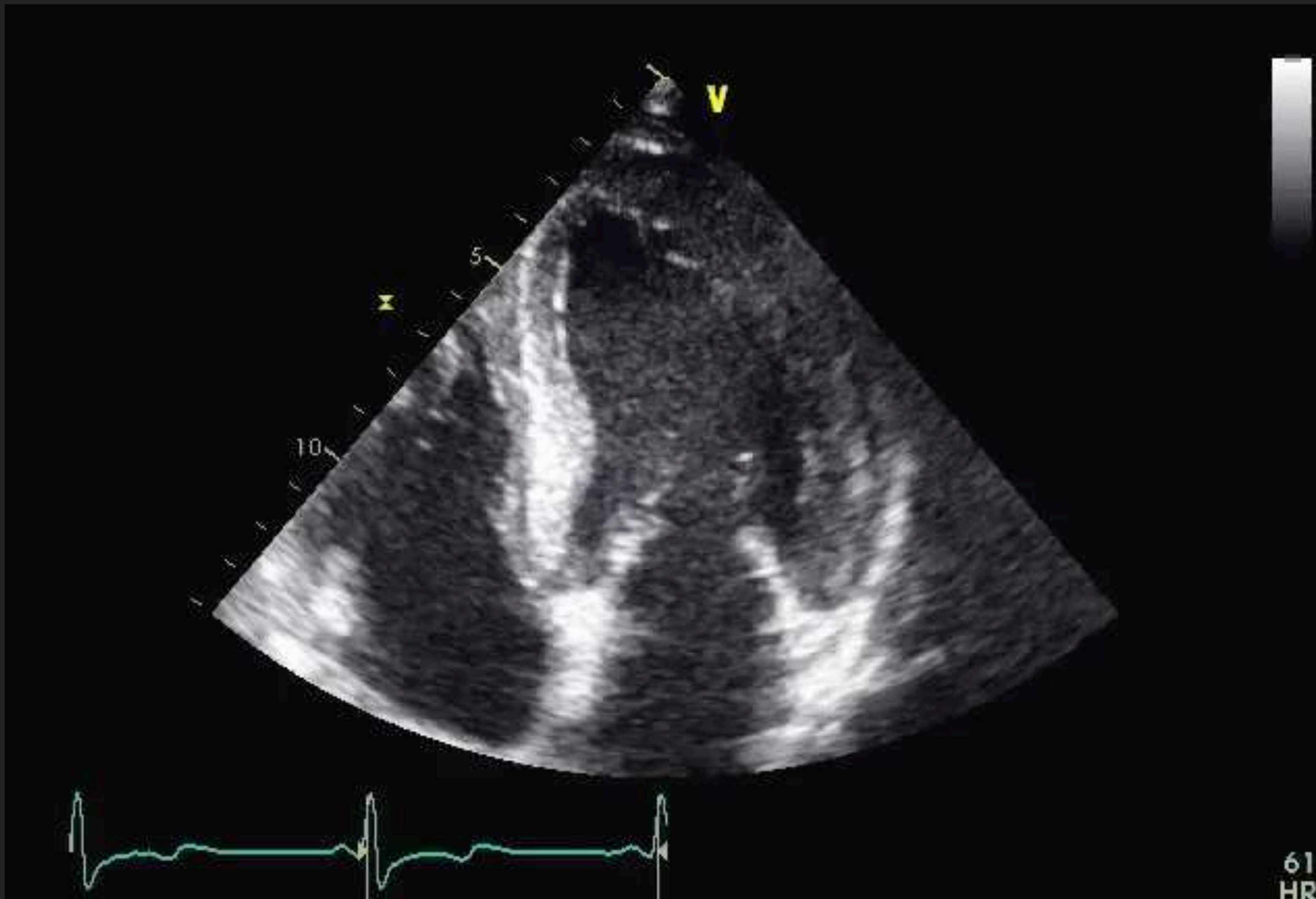
Baseline Peak

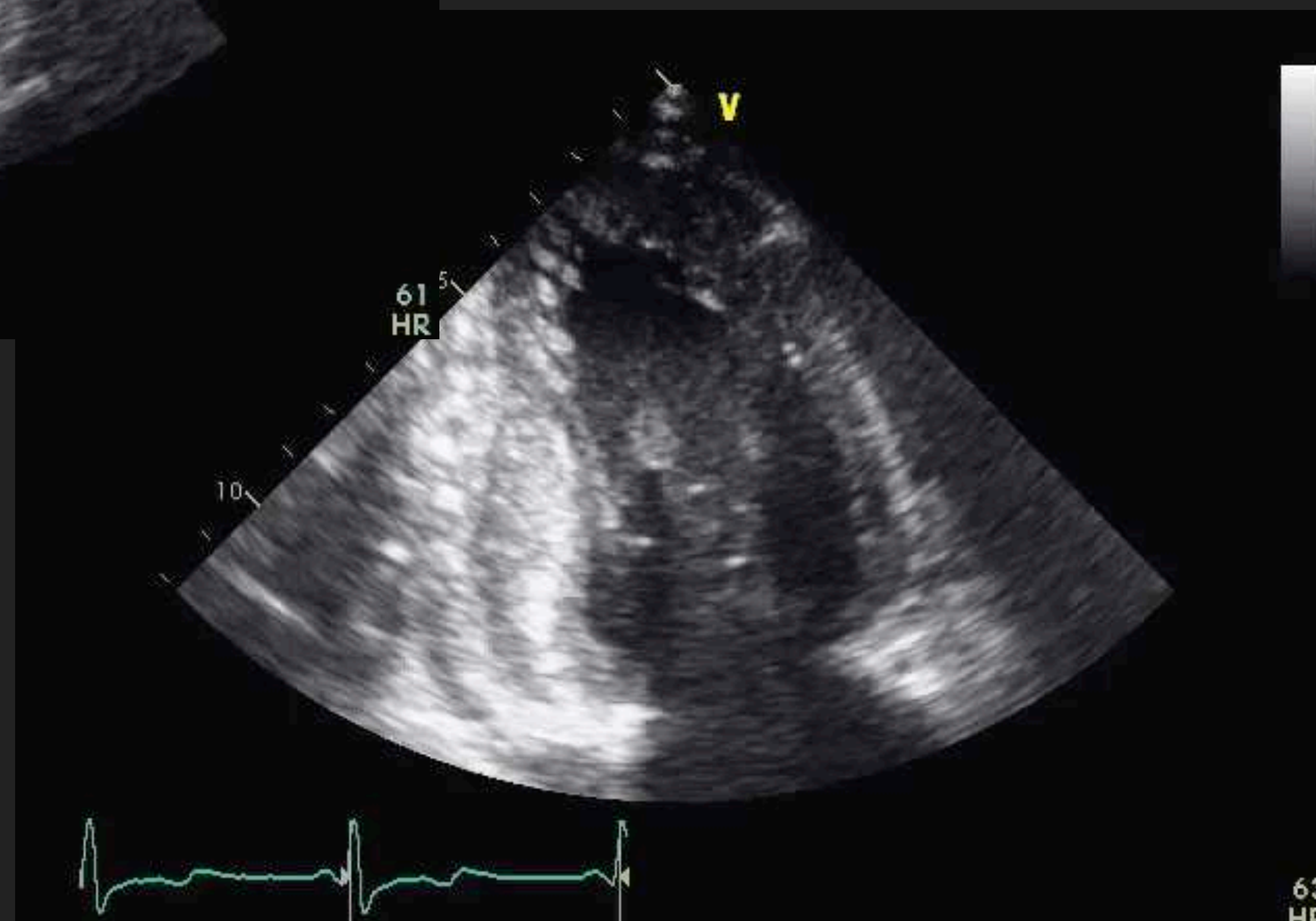


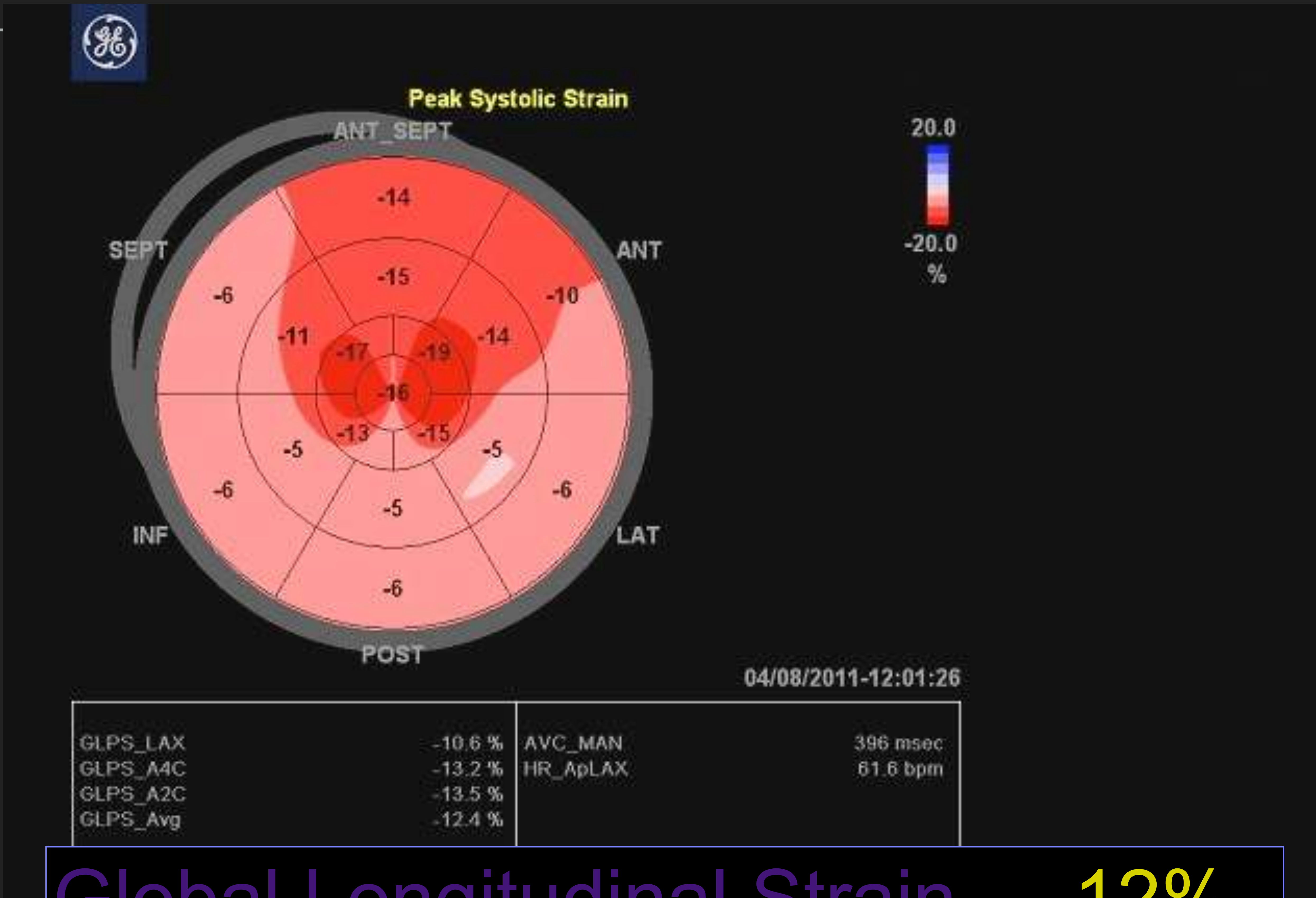
Baseline Peak


V
5
10
15
63
HR


V
5
10
15
67
HR


V
5
10


V
61
HR
5
10
63
HR

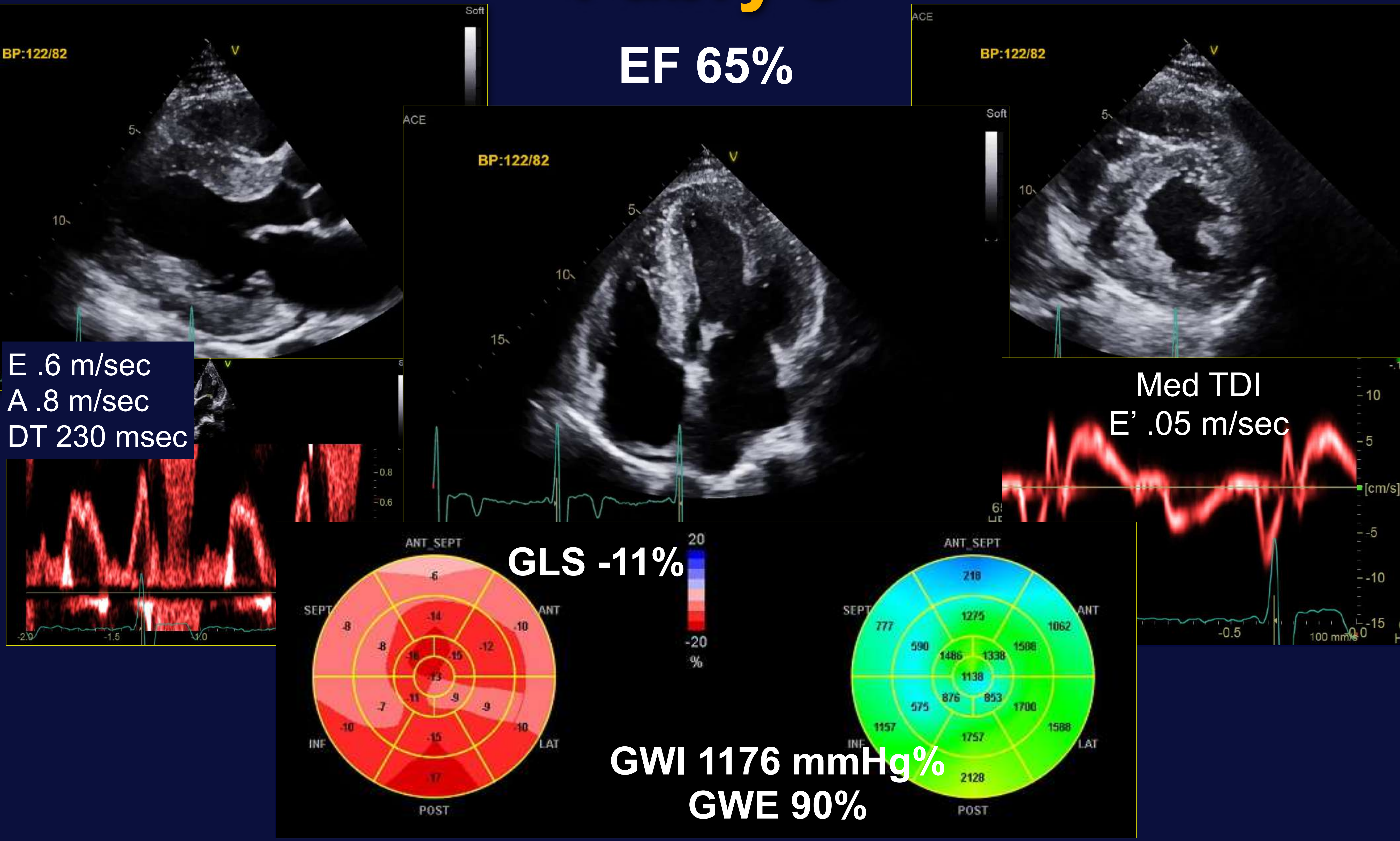


Global Longitudinal Strain -12%

CLINICAL CASES

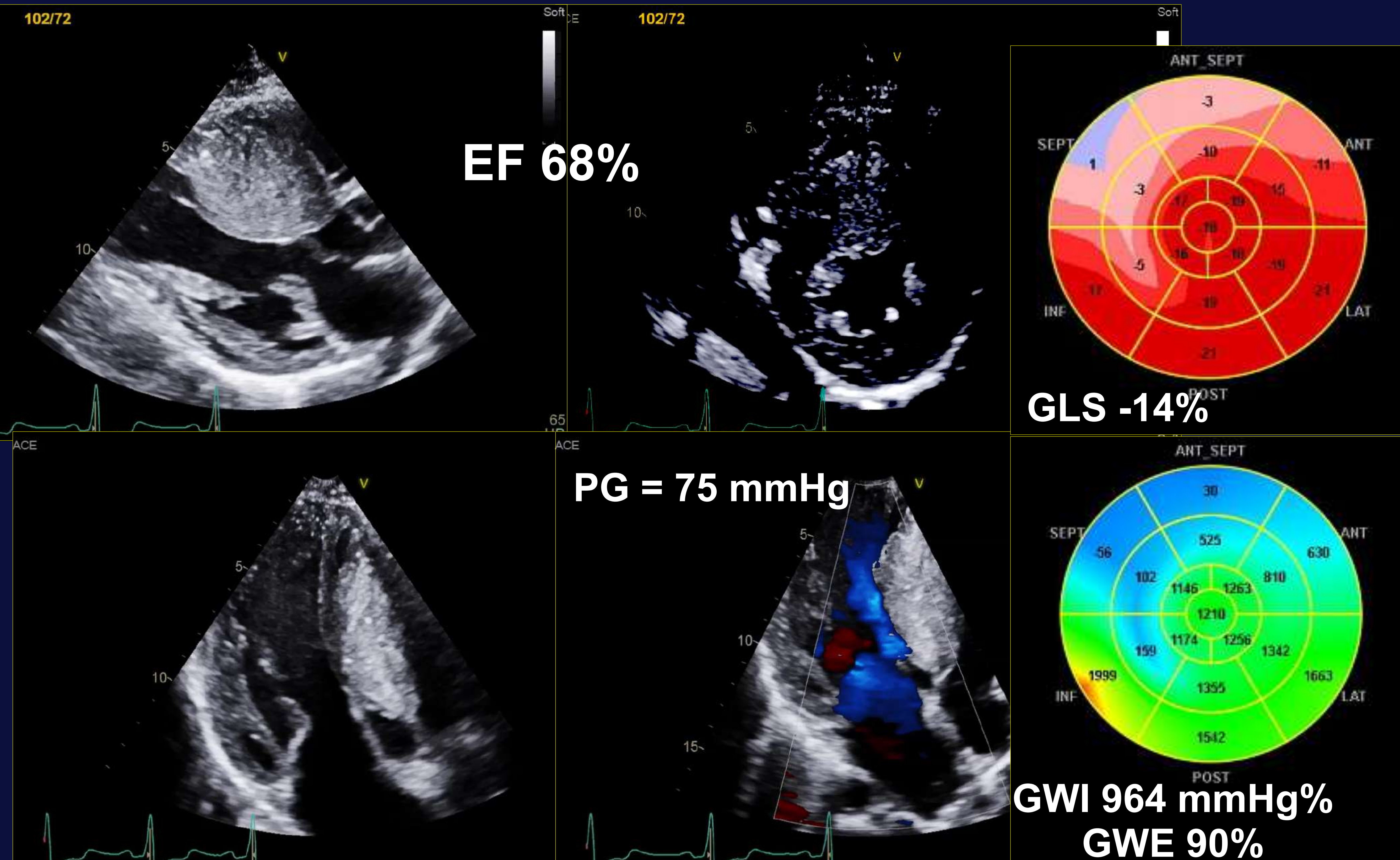
Fabry's

EF 65%

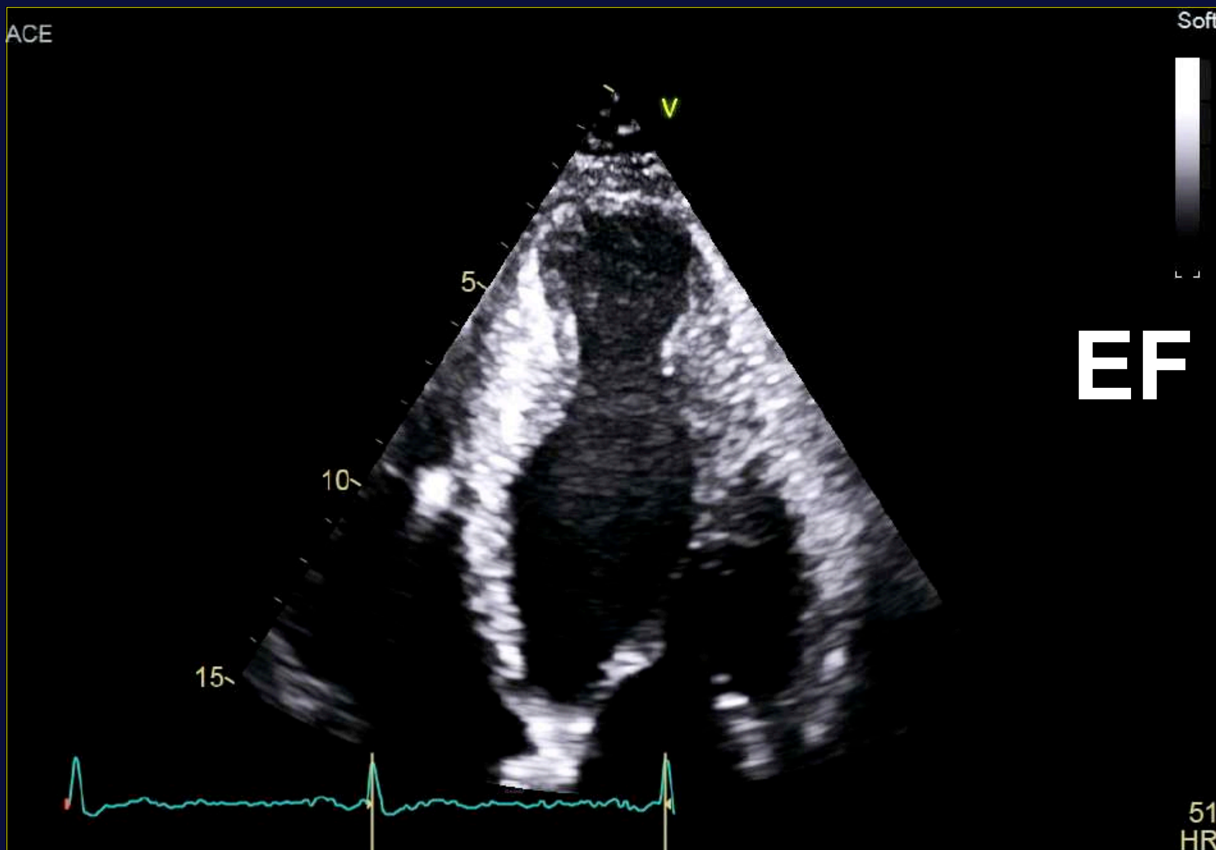


BP:122/82
E .6 m/sec
A .8 m/sec
DT 230 msec
Med TDI
E' .05 m/sec
GLS -11%
GWI 1176 mmHg%
GWE 90%
ANT_SEPT
SEPT
ANT
INF
LAT
POST

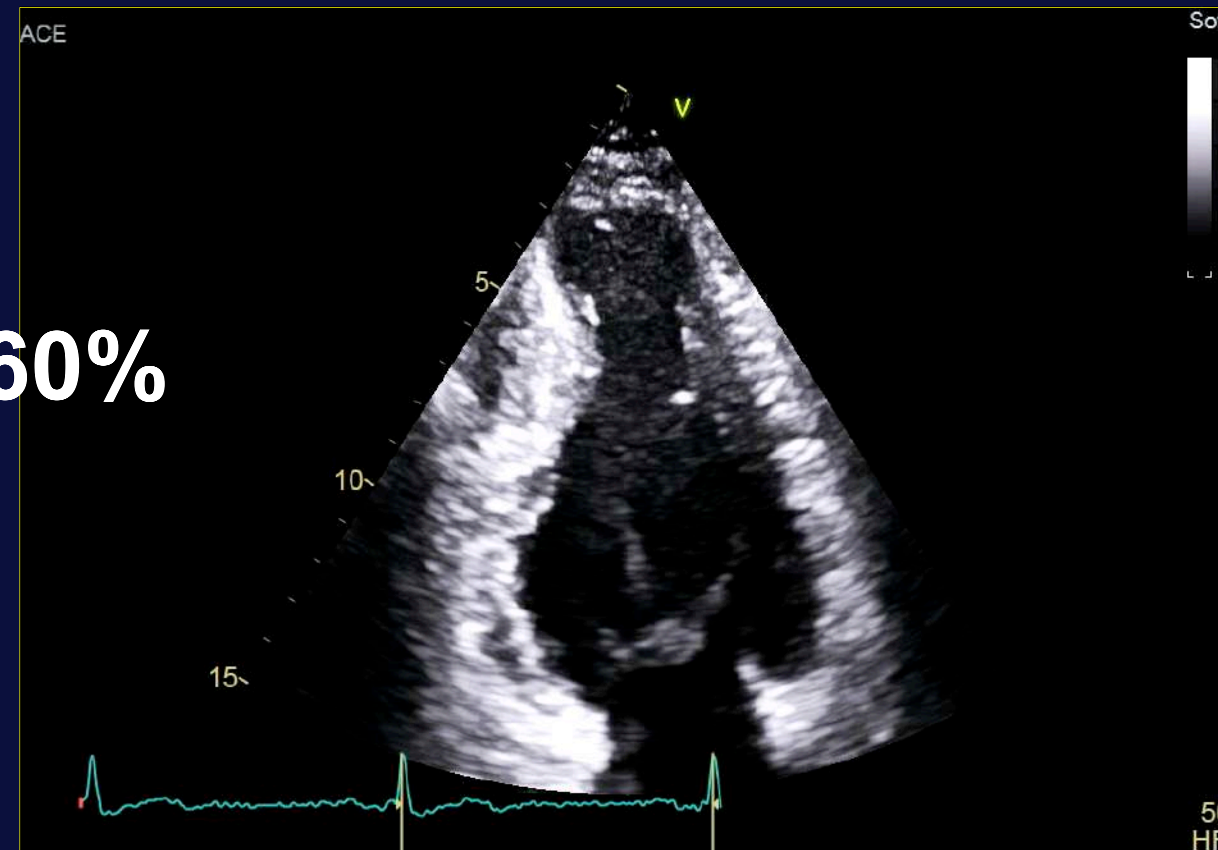
HCM - 20 y/o M, TTN, MYH7

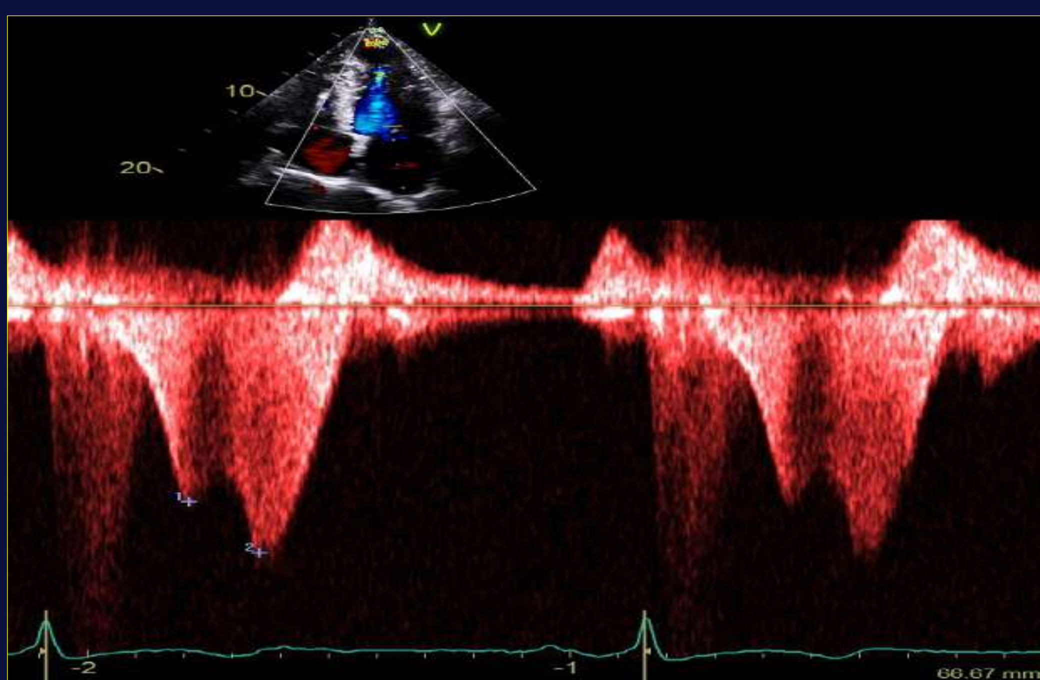


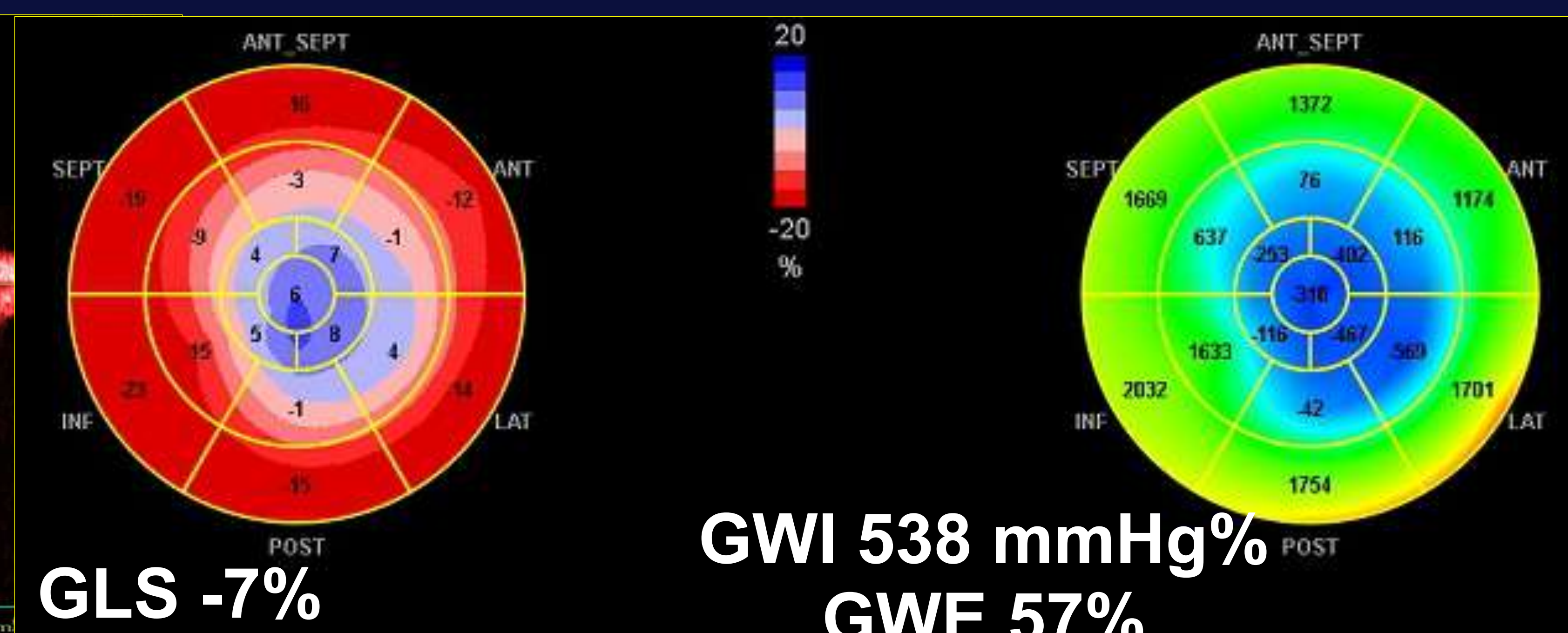
Apical HCM



EF 60%



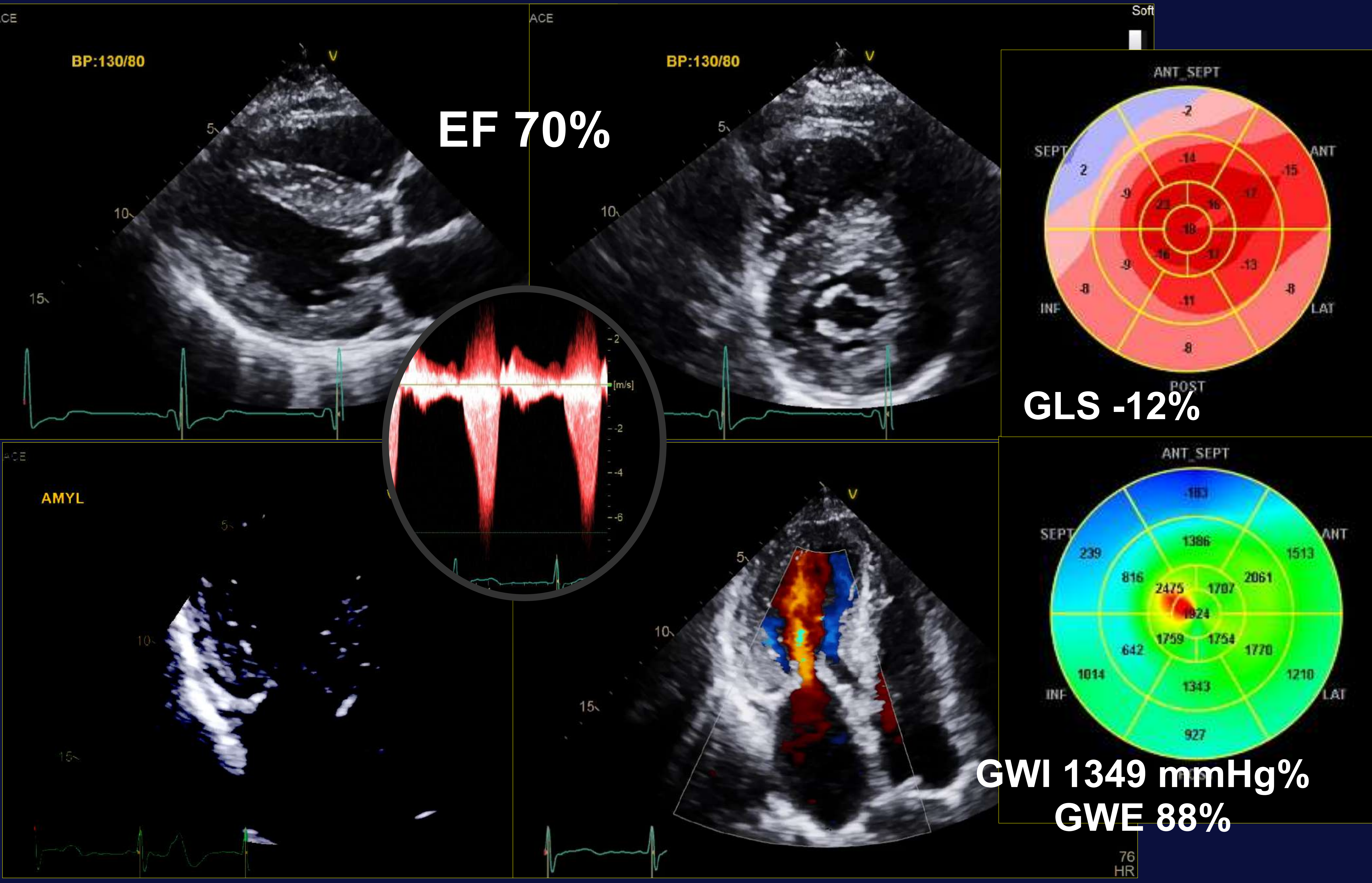




GLS -7%

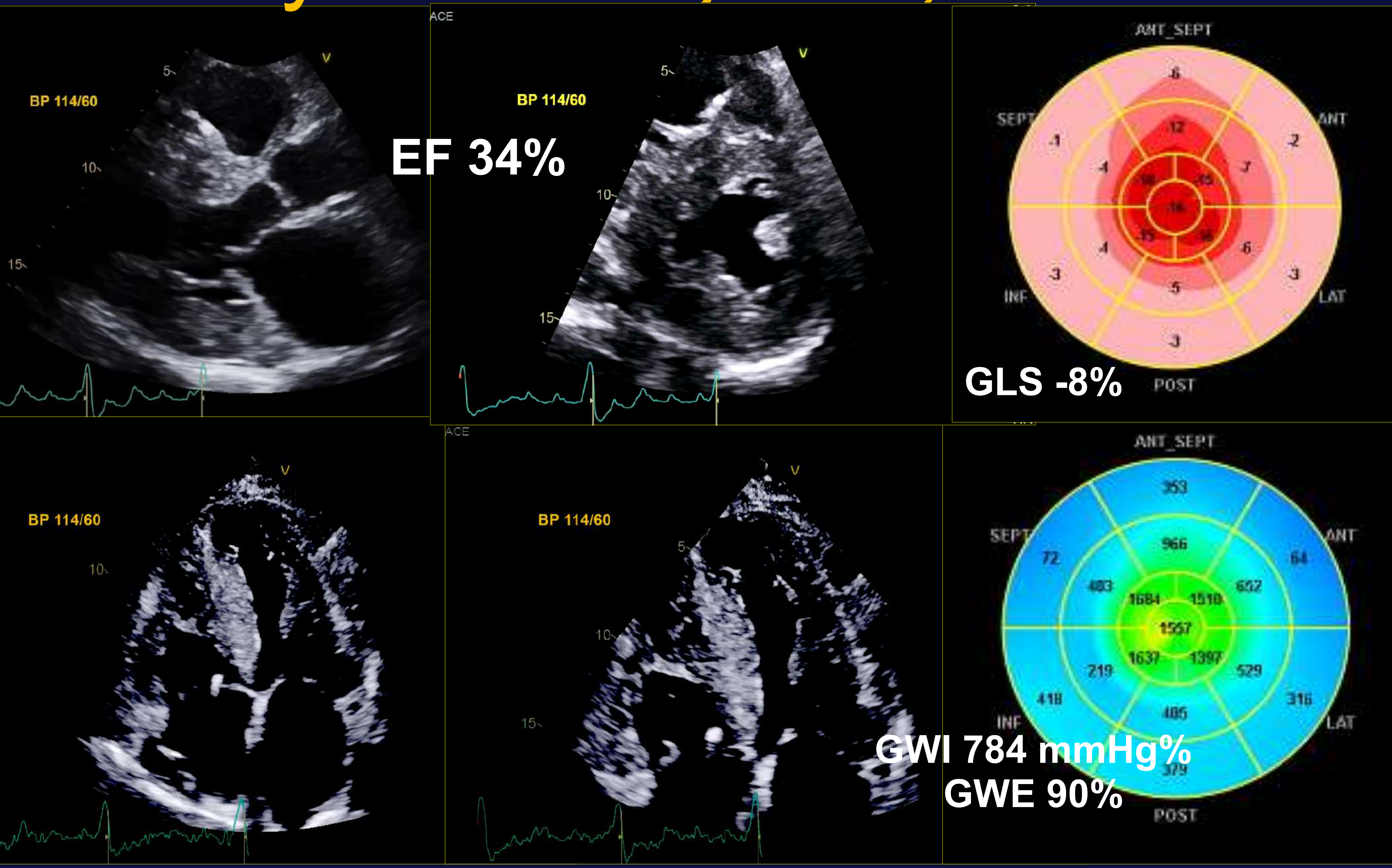
GWI 538 mmHg%
GWE 57%

HCM - 71 y/o F

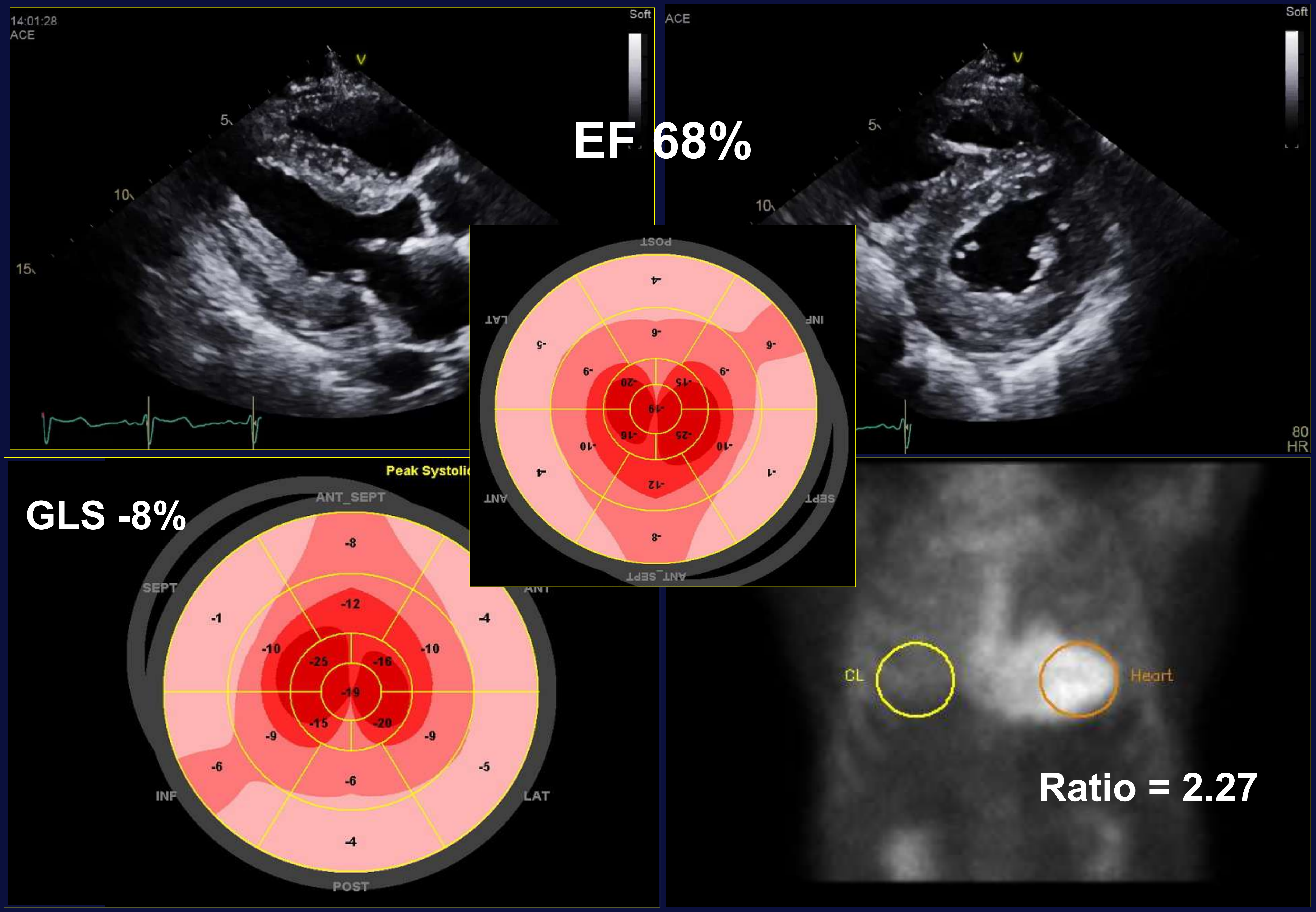


BP:130/80
BP:130/80
EF 70%
AMYL
ANT_SEPT
SEPT
ANT
INF
LAT
POST
GLS -12%
GWI 1349 mmHg%
GWE 88%
76
HR

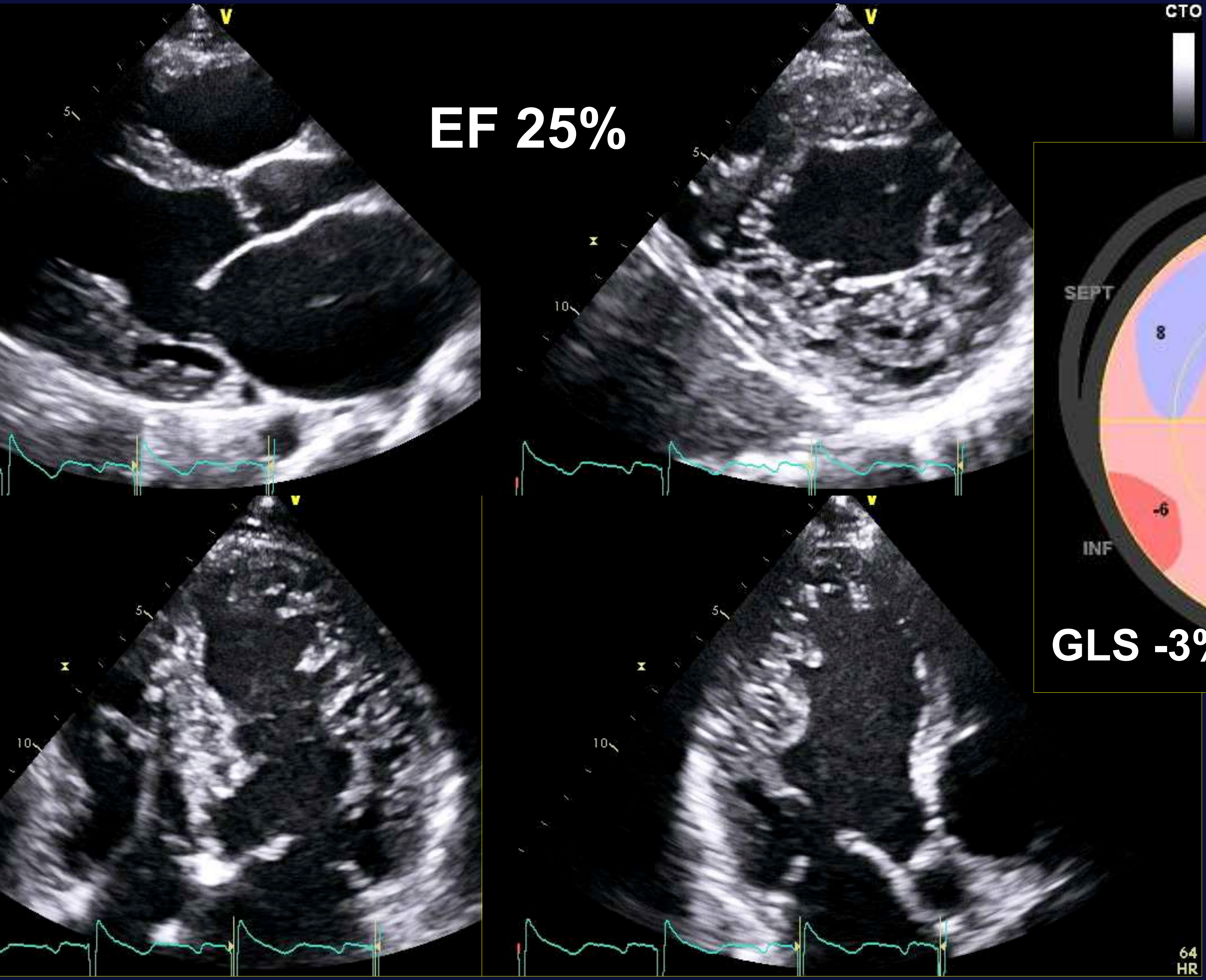
Amyloid - 75 y/o M, TTRw

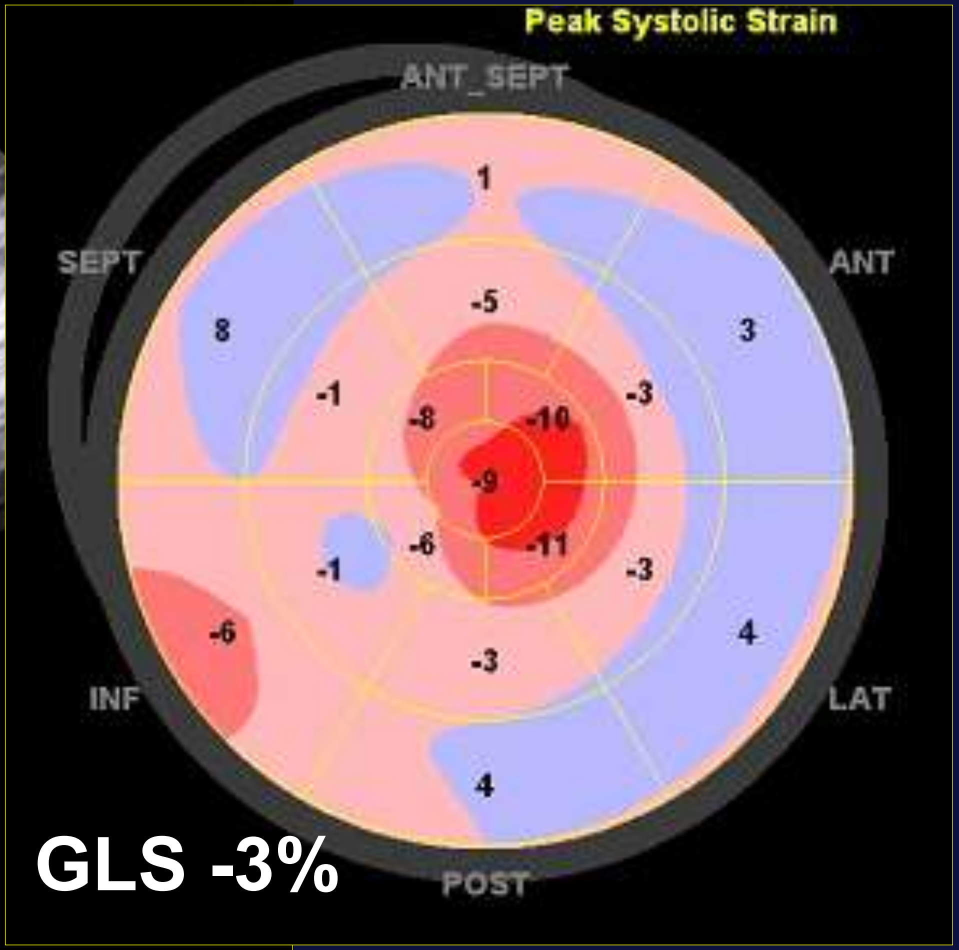


Amyloid - 76 y/o M

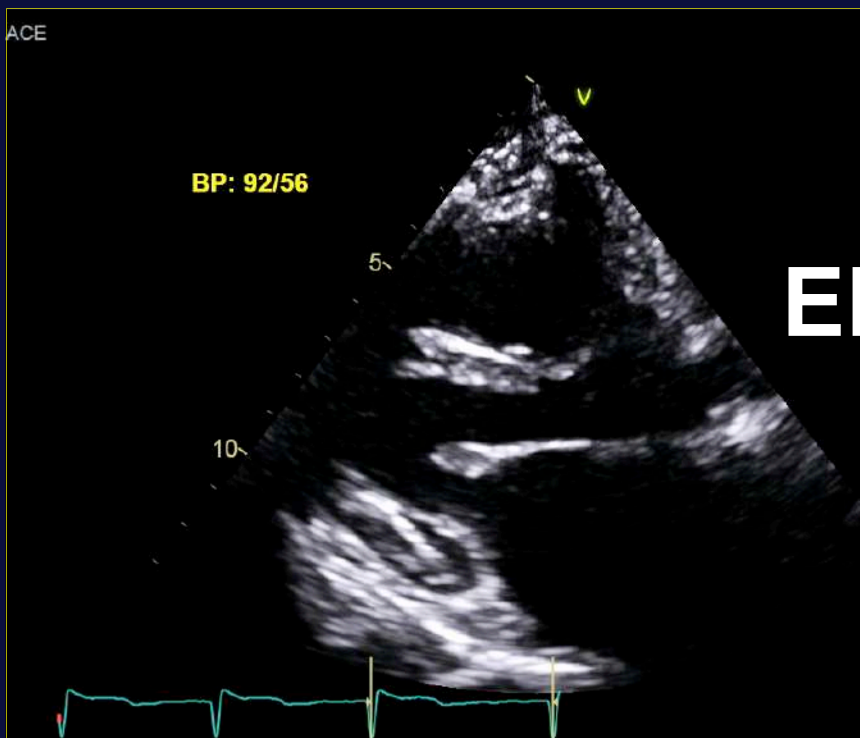


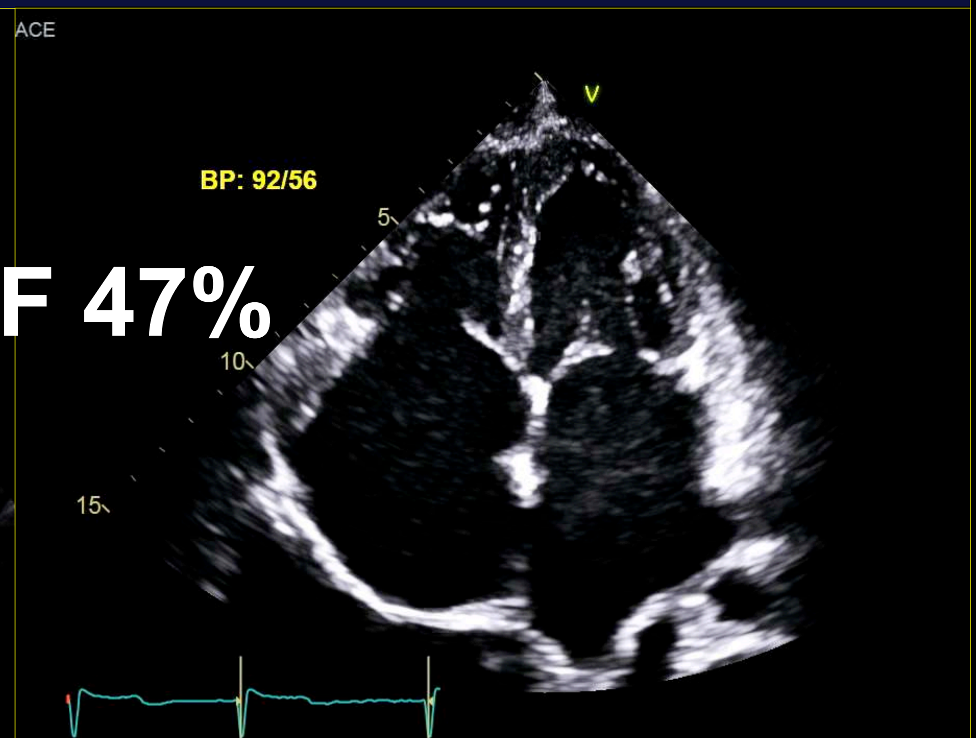
LVNC - 31 y/o M


EF 25%
CTO
64
HR

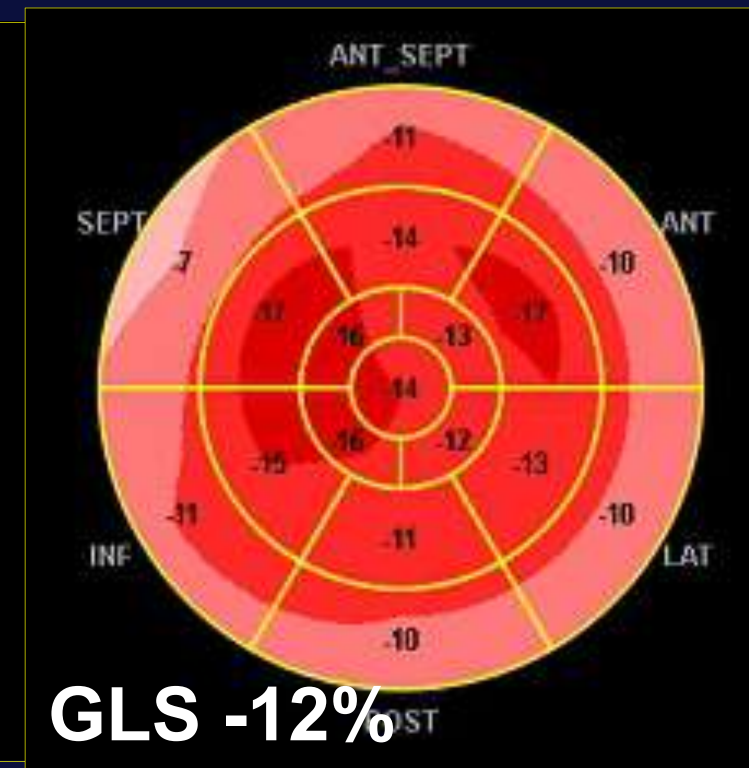

Peak Systolic Strain
ANT_SEPT
SEPT
ANT
INF
LAT
POST
1
8
3
-5
-1
-3
-8
-10
-9
-6
-11
-1
-3
-6
4
-3
4
GLS -3%

RCM - 54 y/o M

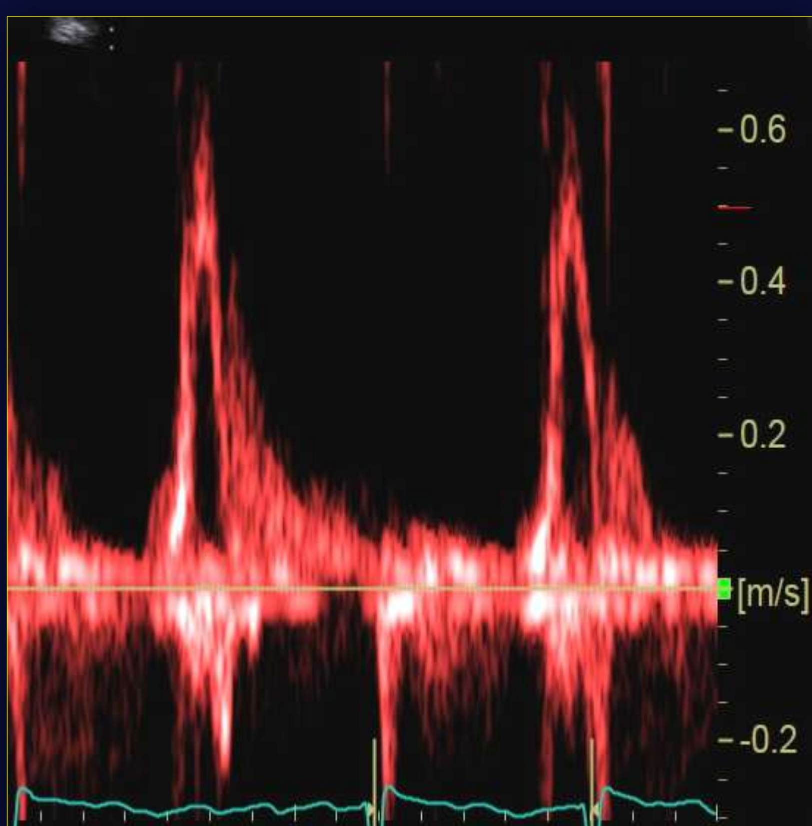


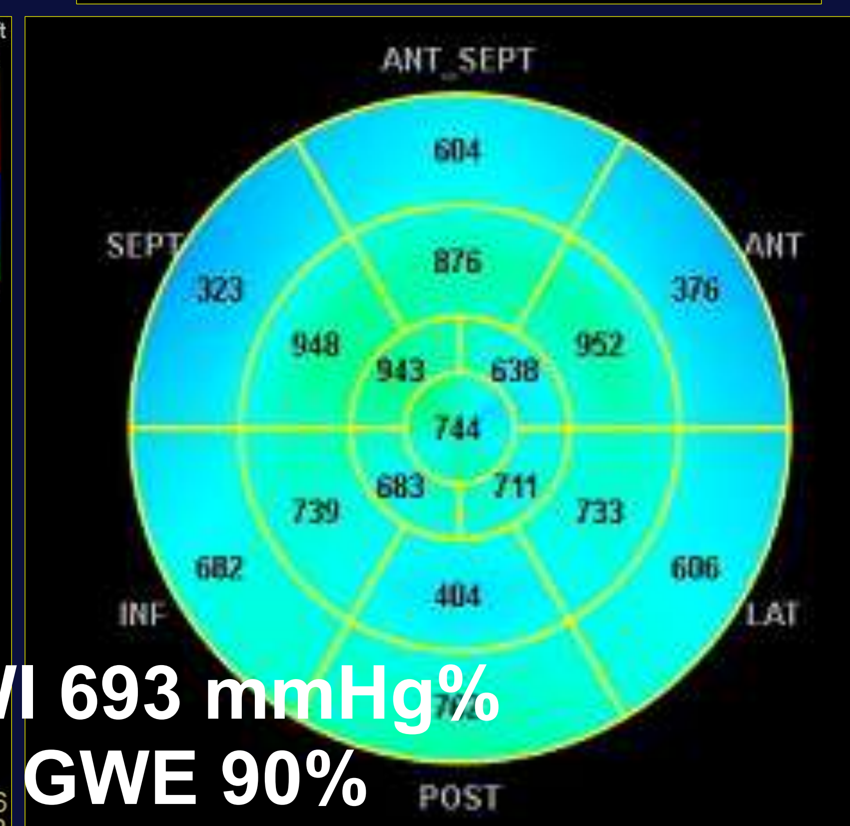


EF 47%

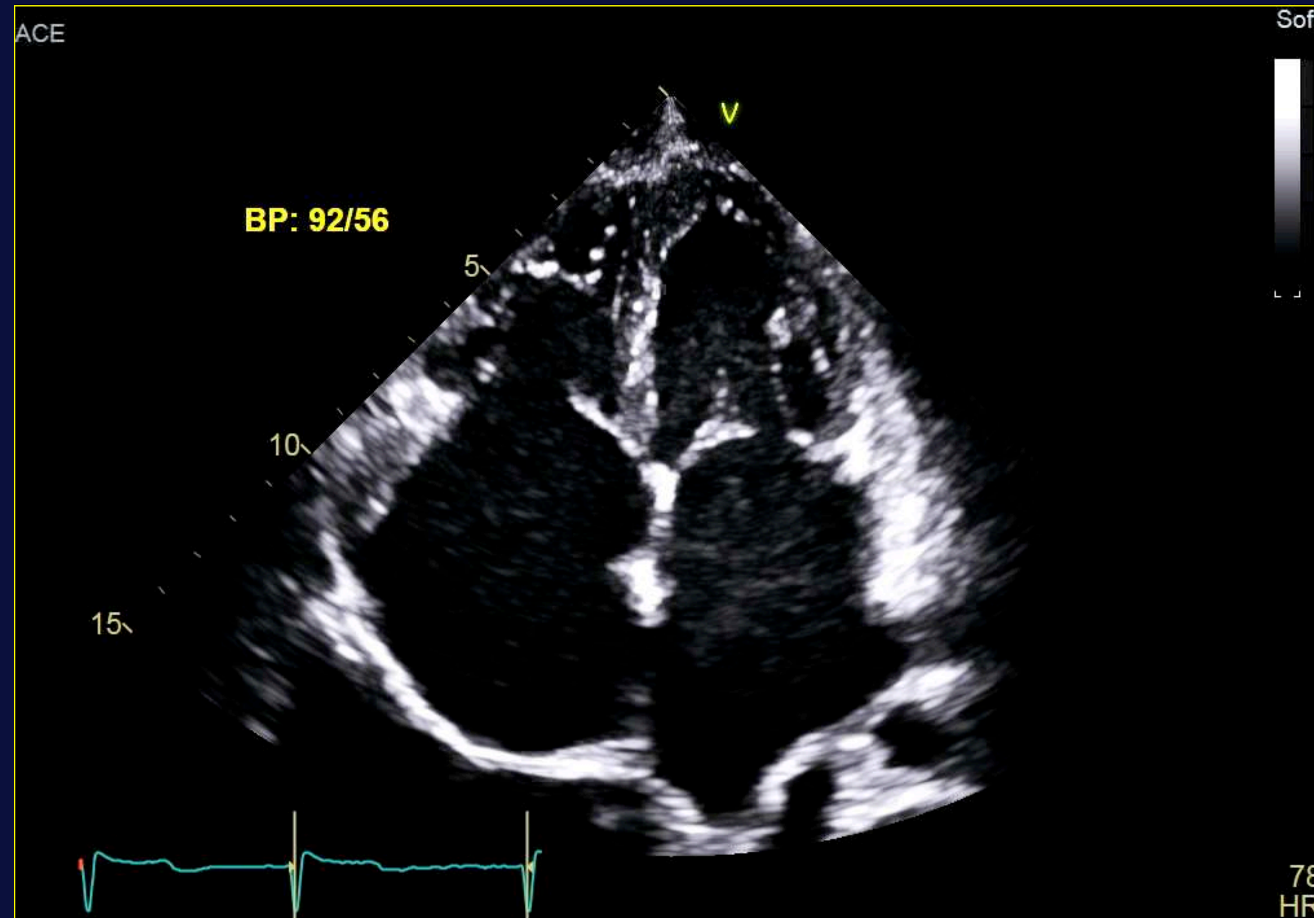


GLS -12%

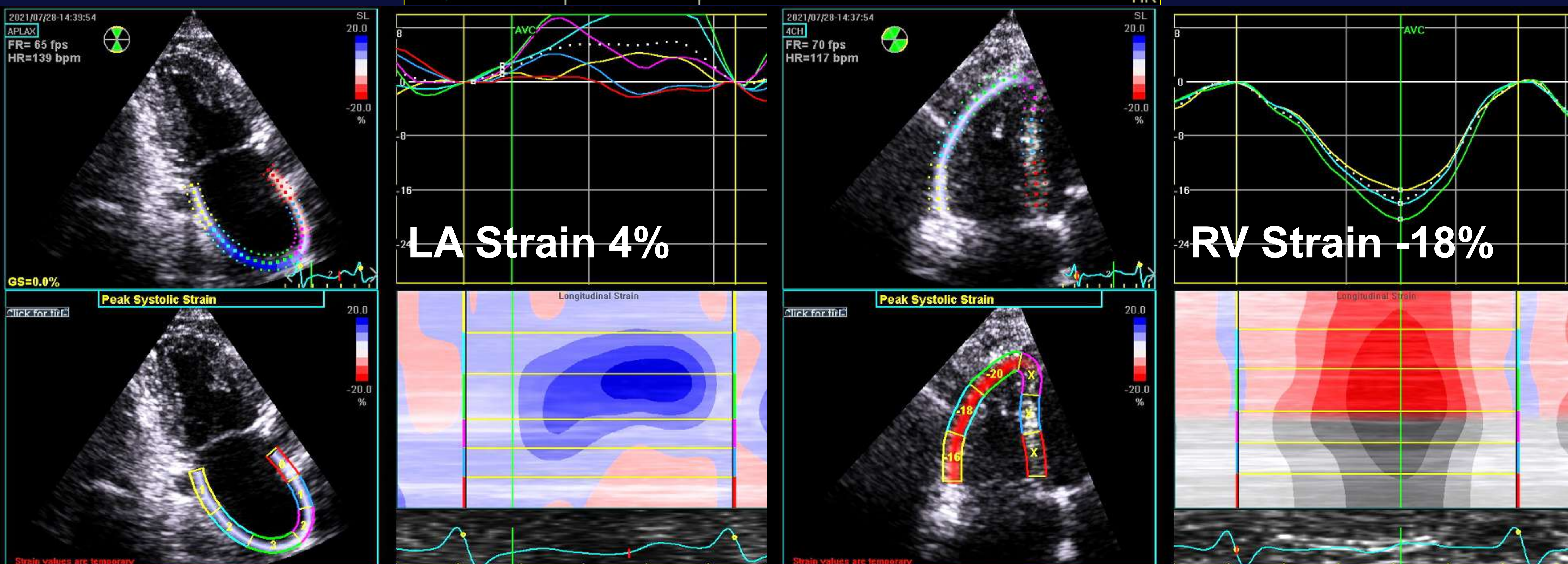




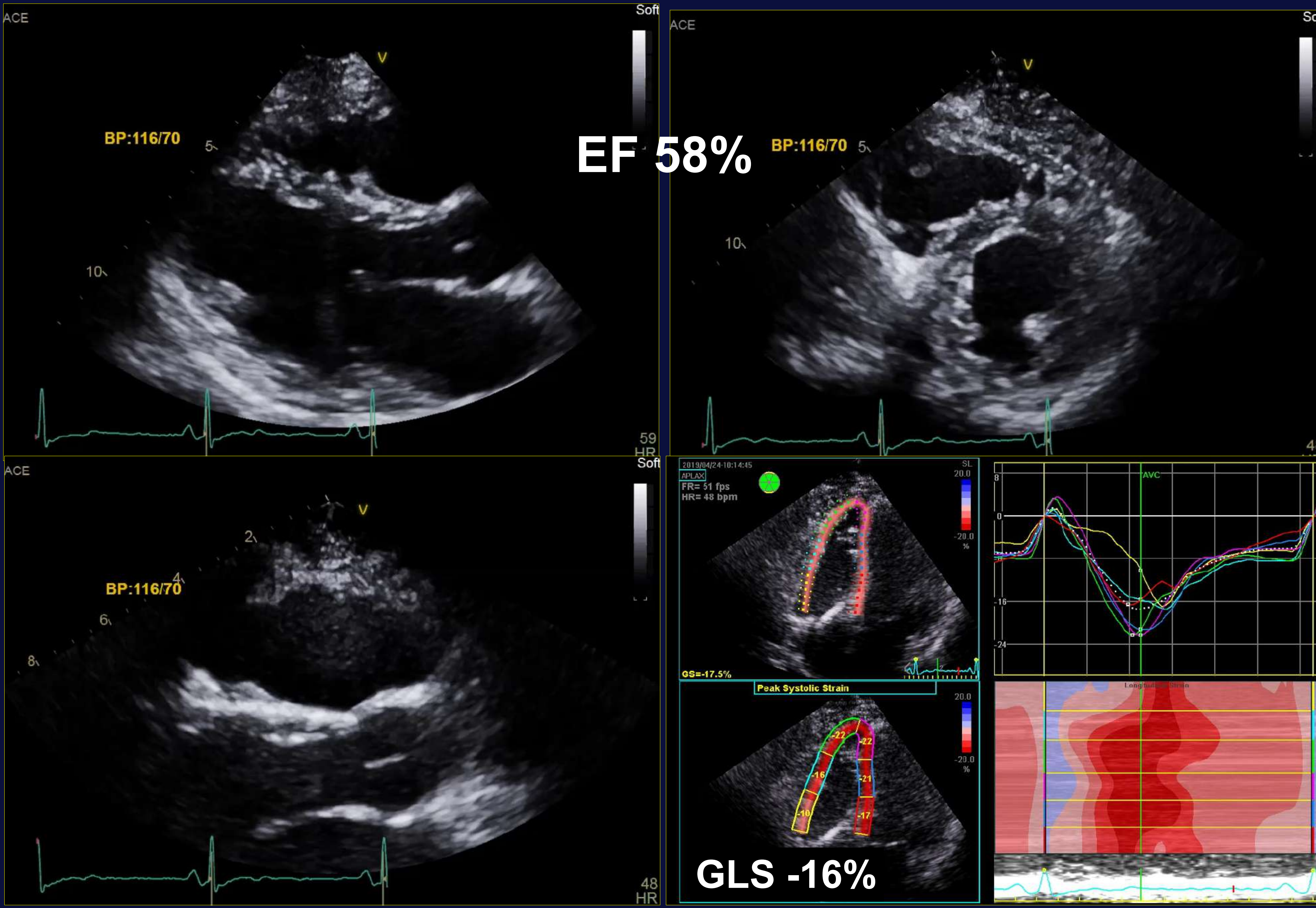
GWI 693 mmHg%
GWE 90%


ACE
Soft
BP: 92/56
V
5
10
15
78
HR

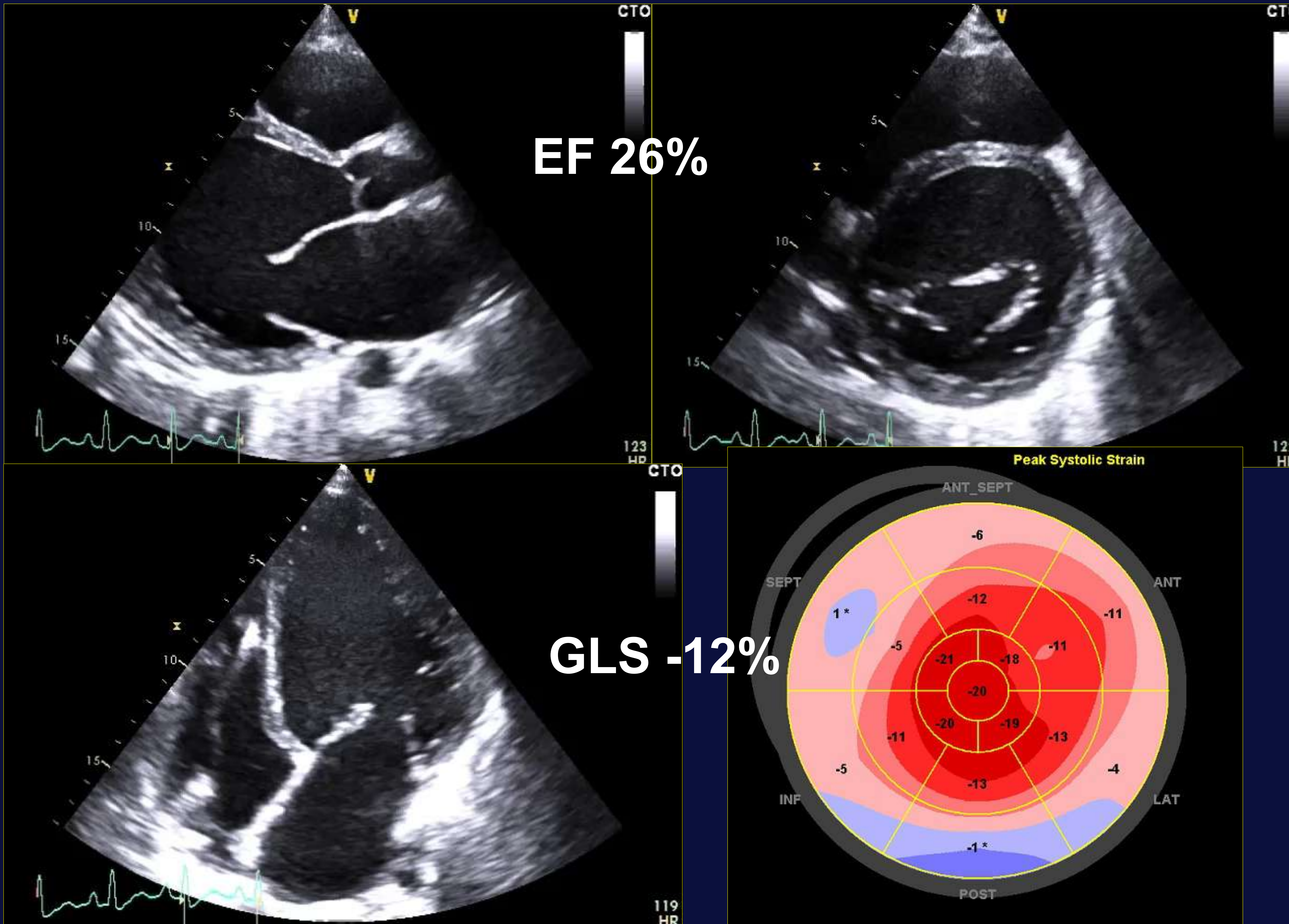
RCM


2021/07/28-14:39:54
APLAX
FR= 65 fps
HR=139 bpm
SL
20.0
-20.0
%
GS=0.0%
Peak Systolic Strain
Strain values are temporary
AVC
Longitudinal Strain
LA Strain 4%
2021/07/28-14:37:54
4CH
FR= 70 fps
HR=117 bpm
Peak Systolic Strain
-20
-18
-16
Strain values are temporary
RV Strain -18%

ARVC


EF 58%
BP:116/70
GLS -16%
Peak Systolic Strain
GS=-17.5%
APLAX
FR= 51 fps
HR= 48 bpm
AVC

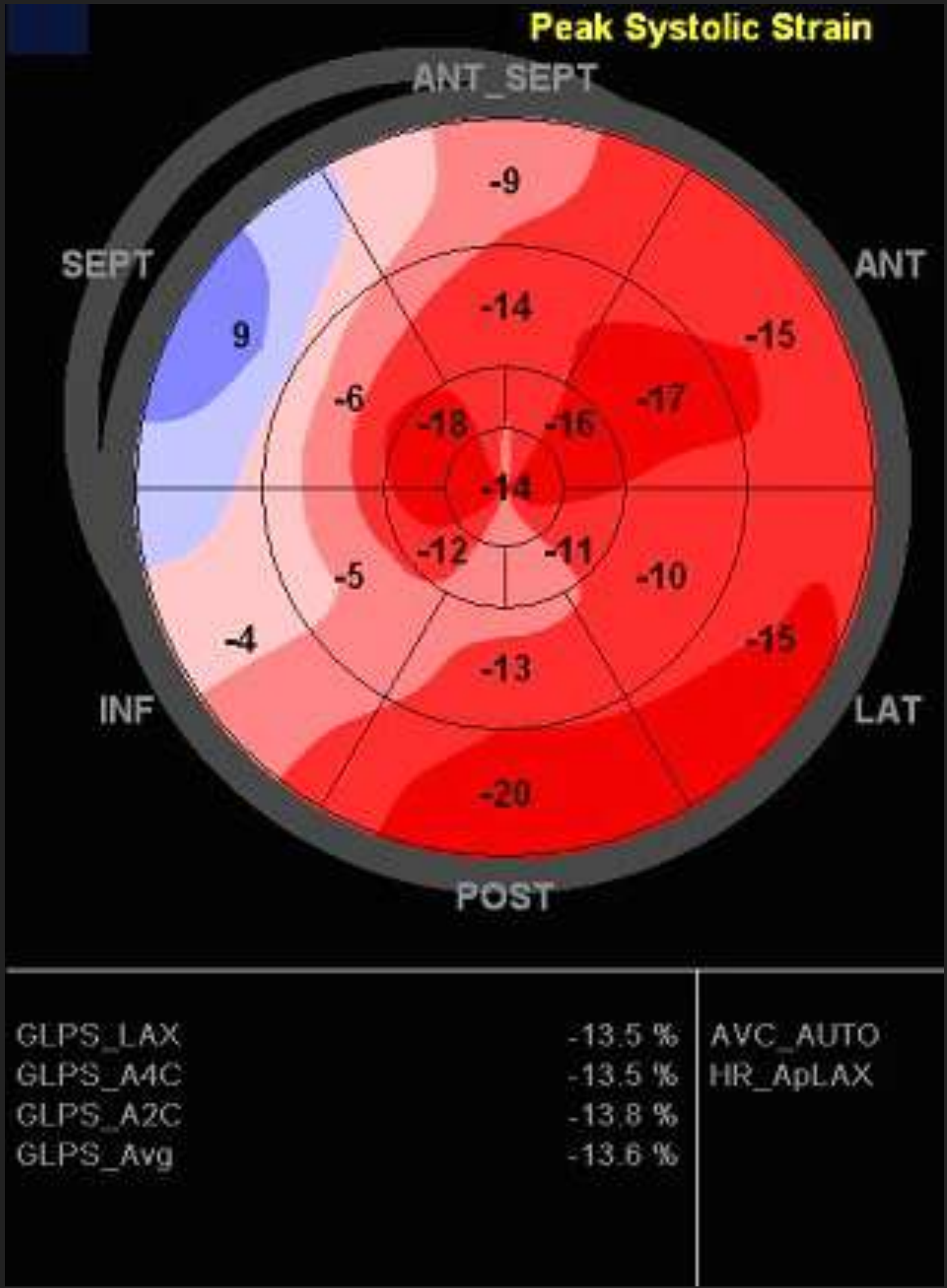
DCM



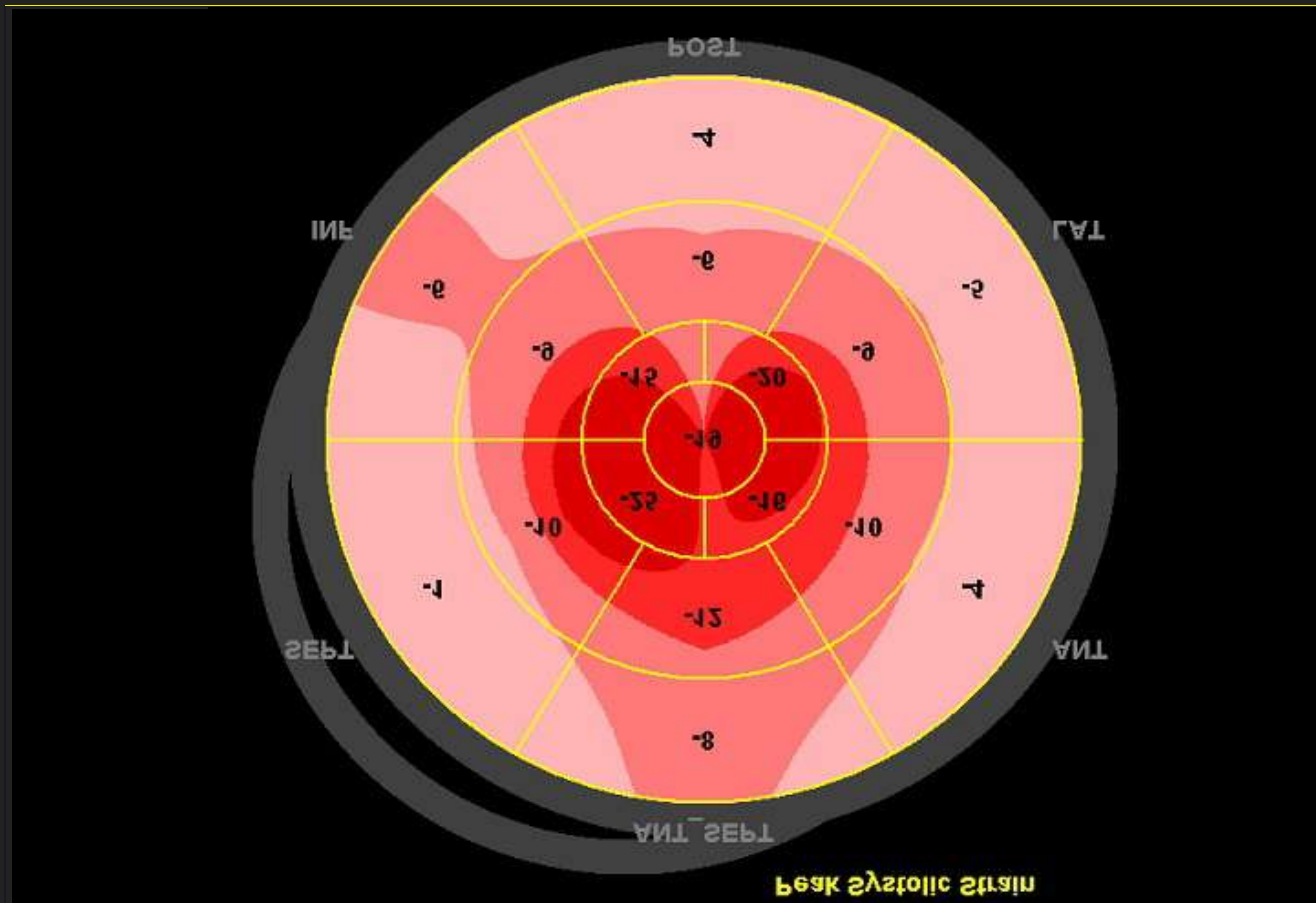
EF 26%
GLS -12%
Peak Systolic Strain
ANT_SEPT
SEPT
ANT
INF
LAT
POST
-6
-12
-11
1 *
-5
-21
-18
-11
-20
-20
-19
-11
-13
-5
-13
-4
-1 *
CTO
123 HR
122 HR
119 HR

CONCLUSION

- Technical factors: FR 40-80 fps, Standard Apical 2D images
- Recognize errors in tracking
- Recognize abnormalities in common pathologies
- Lastly, USE strain, practice-practice-practice, report avg GLS



THANK YOU



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