How to apply new echocardiographic methods in management of heart failure

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Conflicts of interest

- There are no conflicts of interest to disclose

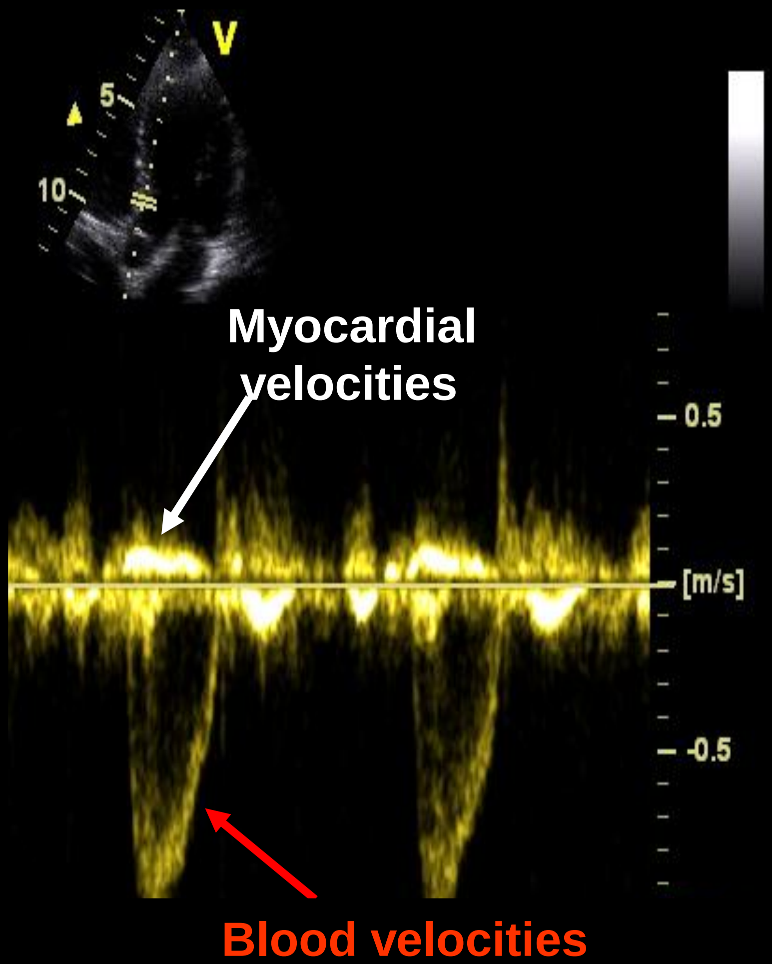
Evaluation of Left Ventricular Function

- ✓ Systolic function
- ✓ Diastolic function

Which methods?

- ✓ Myocardial velocities by tissue Doppler echocardiography
- ✓ Myocardial strain by speckle tracking echocardiography

Myocardial velocities by tissue Doppler



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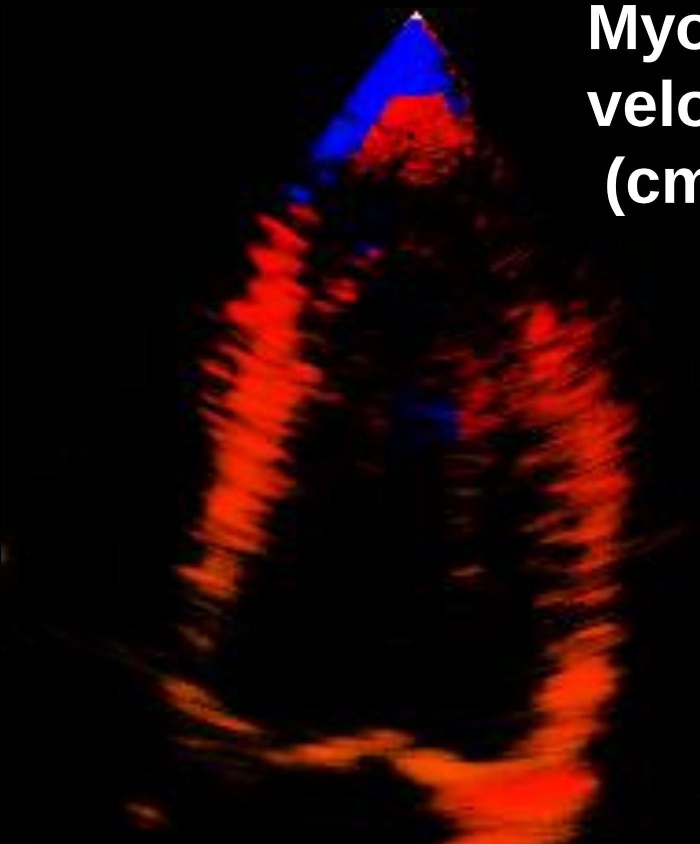
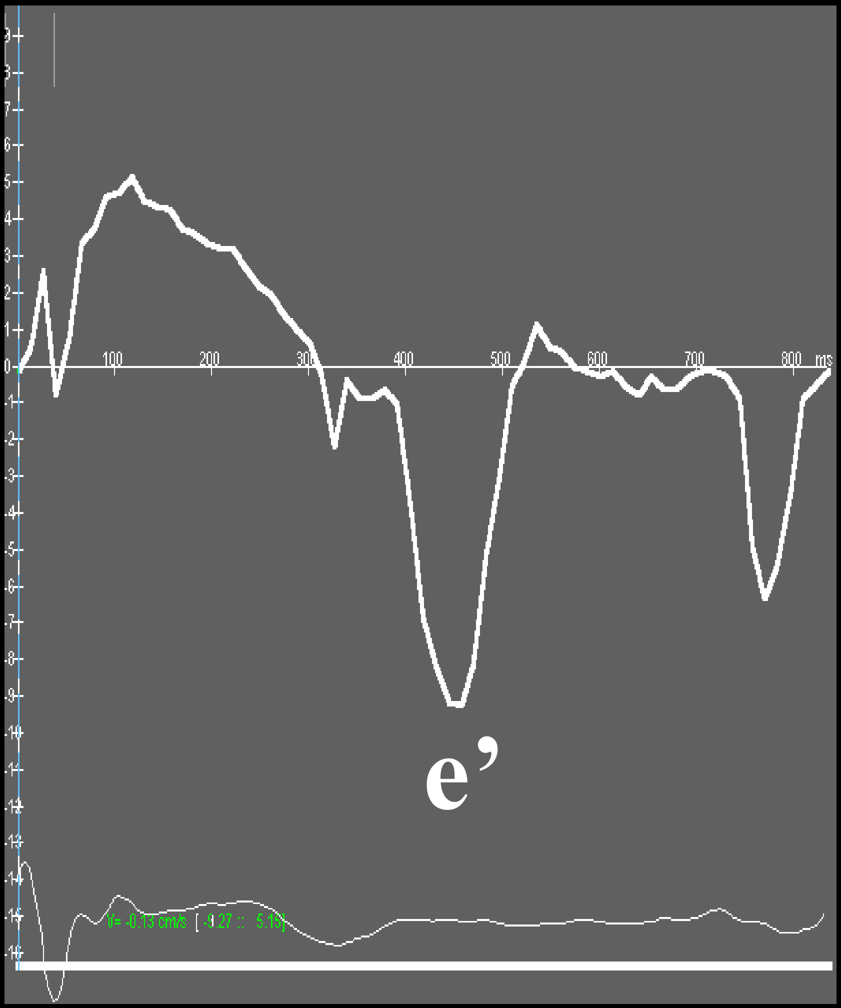
LV early-diastolic lengthening velocity (e’)



Myocardial velocities (cm/s)

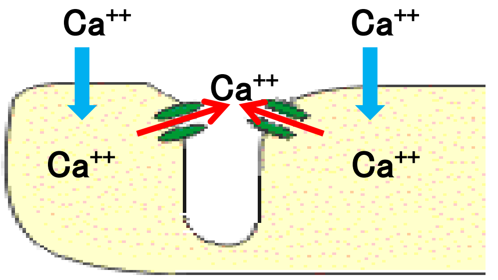


ECG

Smiseth 2013

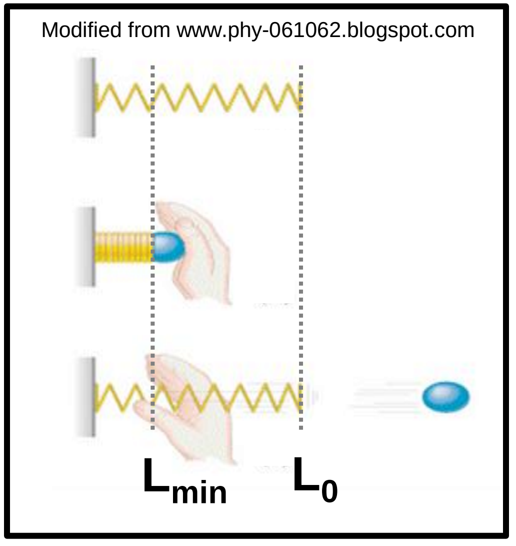
Determinants of LV lengthening velocity (e')

LV relaxation



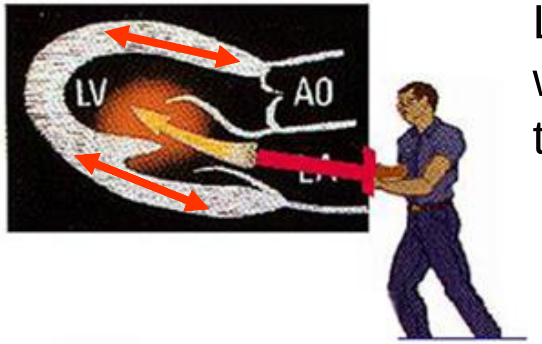
Decay in active fibre force

Restoring forces



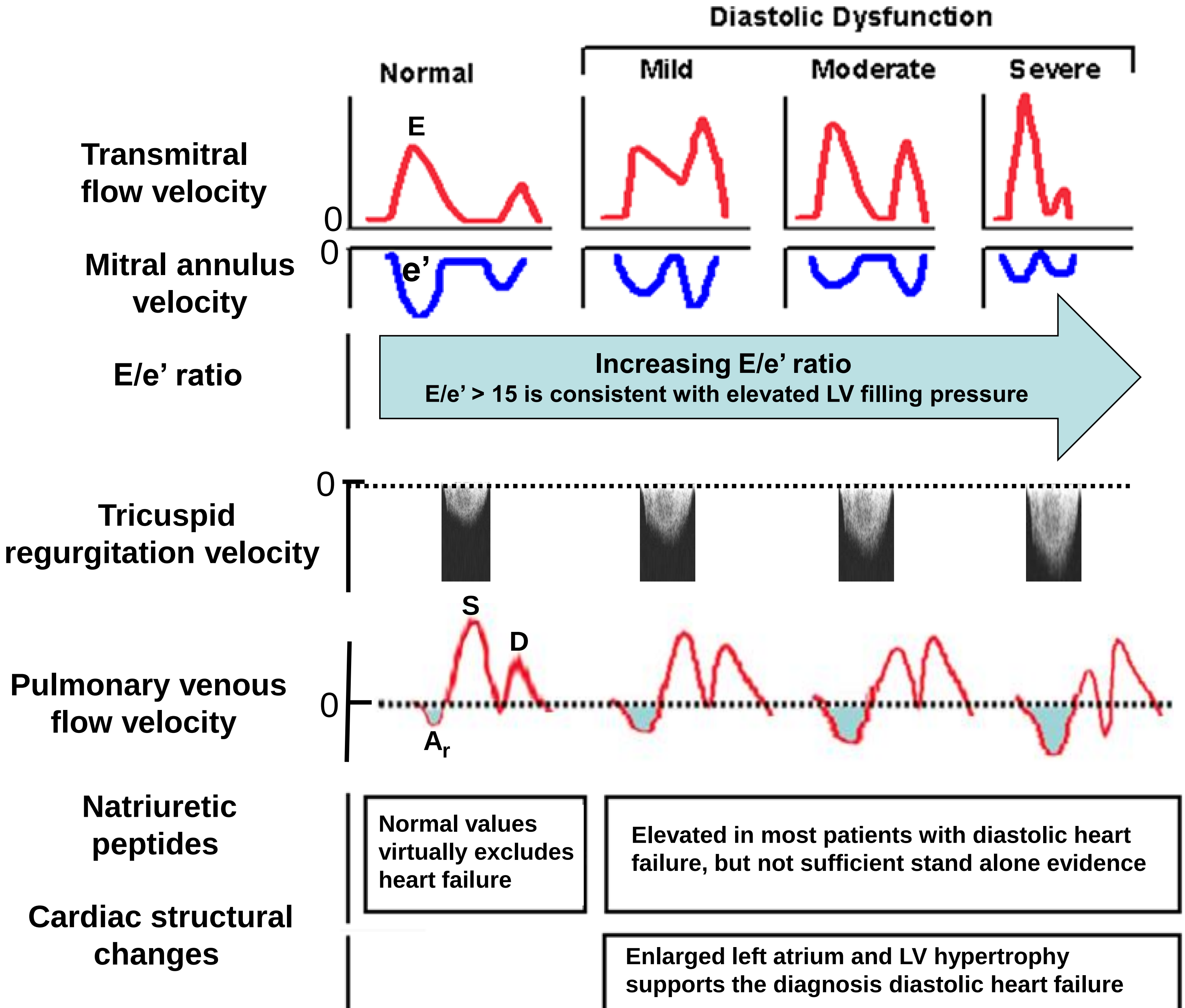
Analogous to a compressed spring which recoils passively.

LV lengthening load



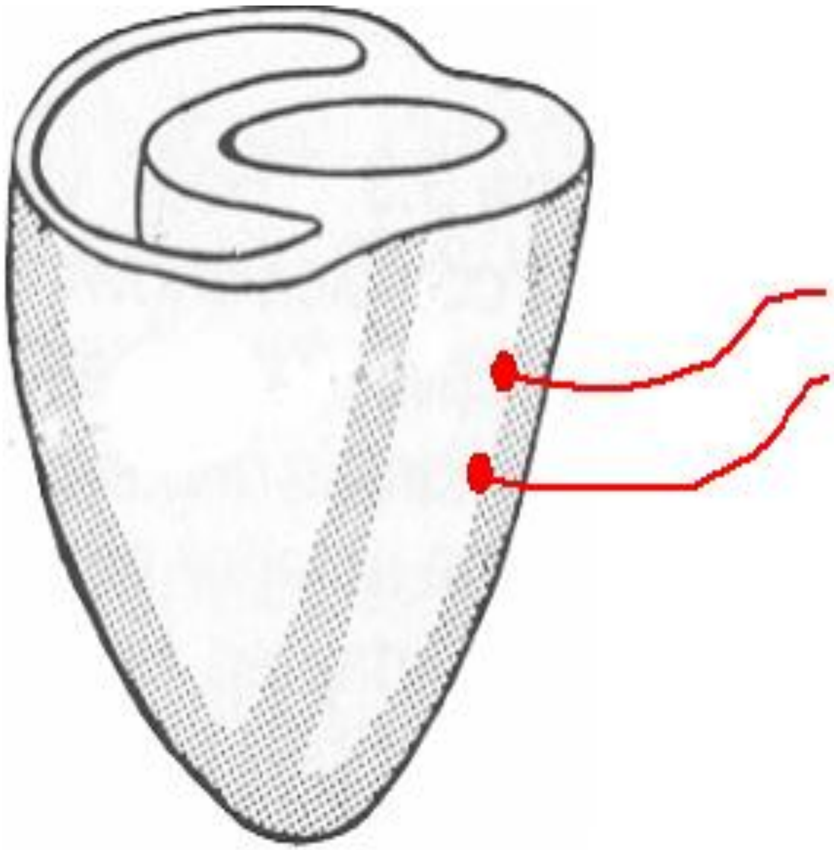
Left atrial pressure represents a force which pushes blood into the ventricle, thereby causing LV lengthening.

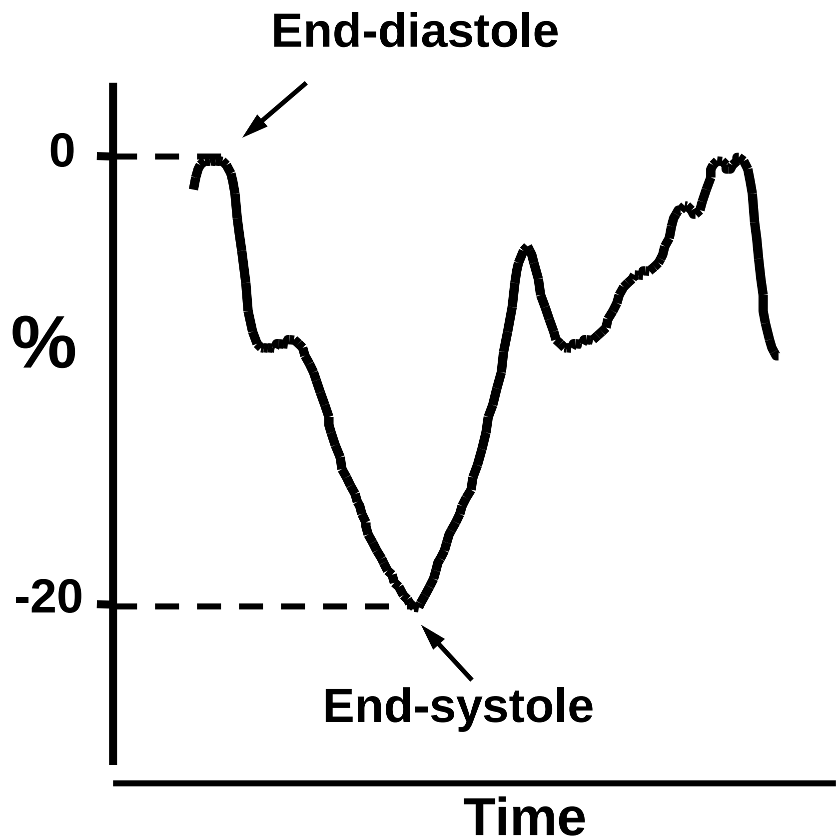
Based upon Opdahl/Smiseth et al., Circulation. 2009;119:2578-2586.



Smiseth et al., European Cardiology 2012

What is ”strain”?

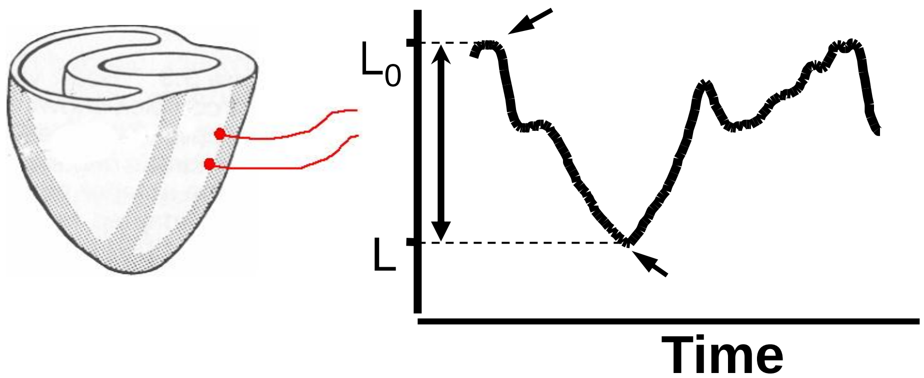




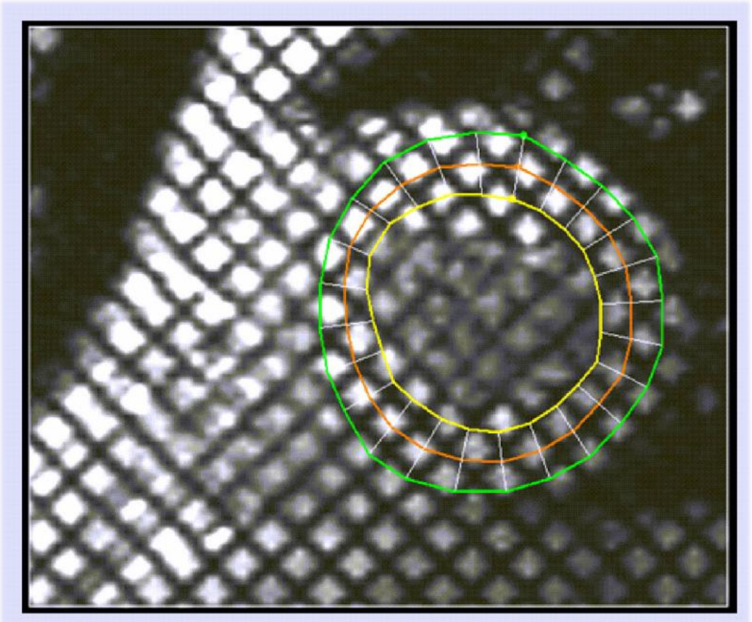
OA Smiseth, 2013

Strain methodologies

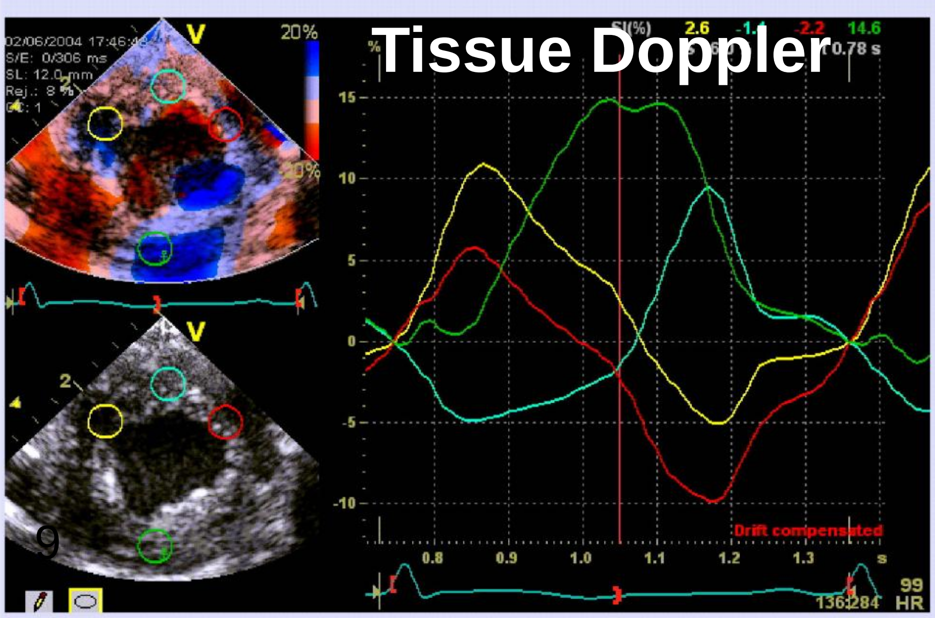
Dimension crystals
(experimental studies)



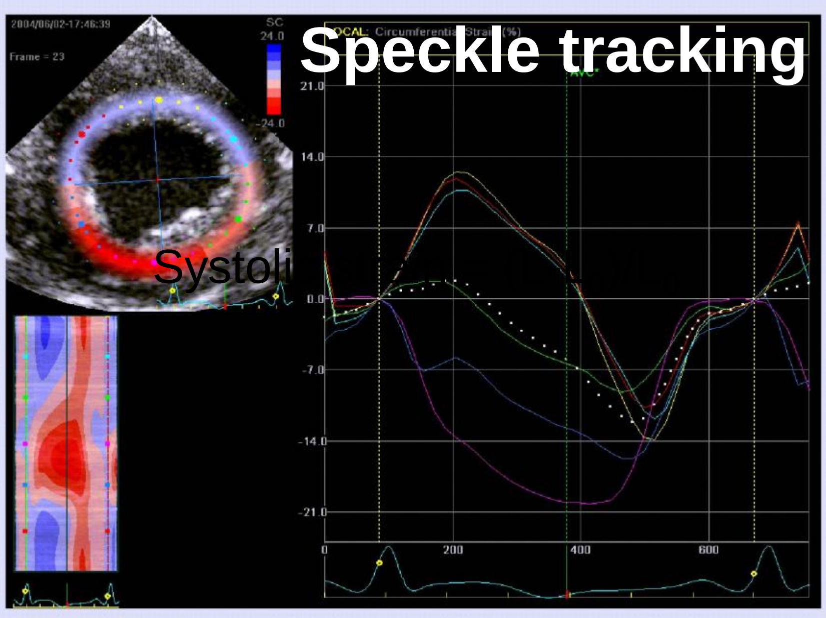
MRI-tissue tagging



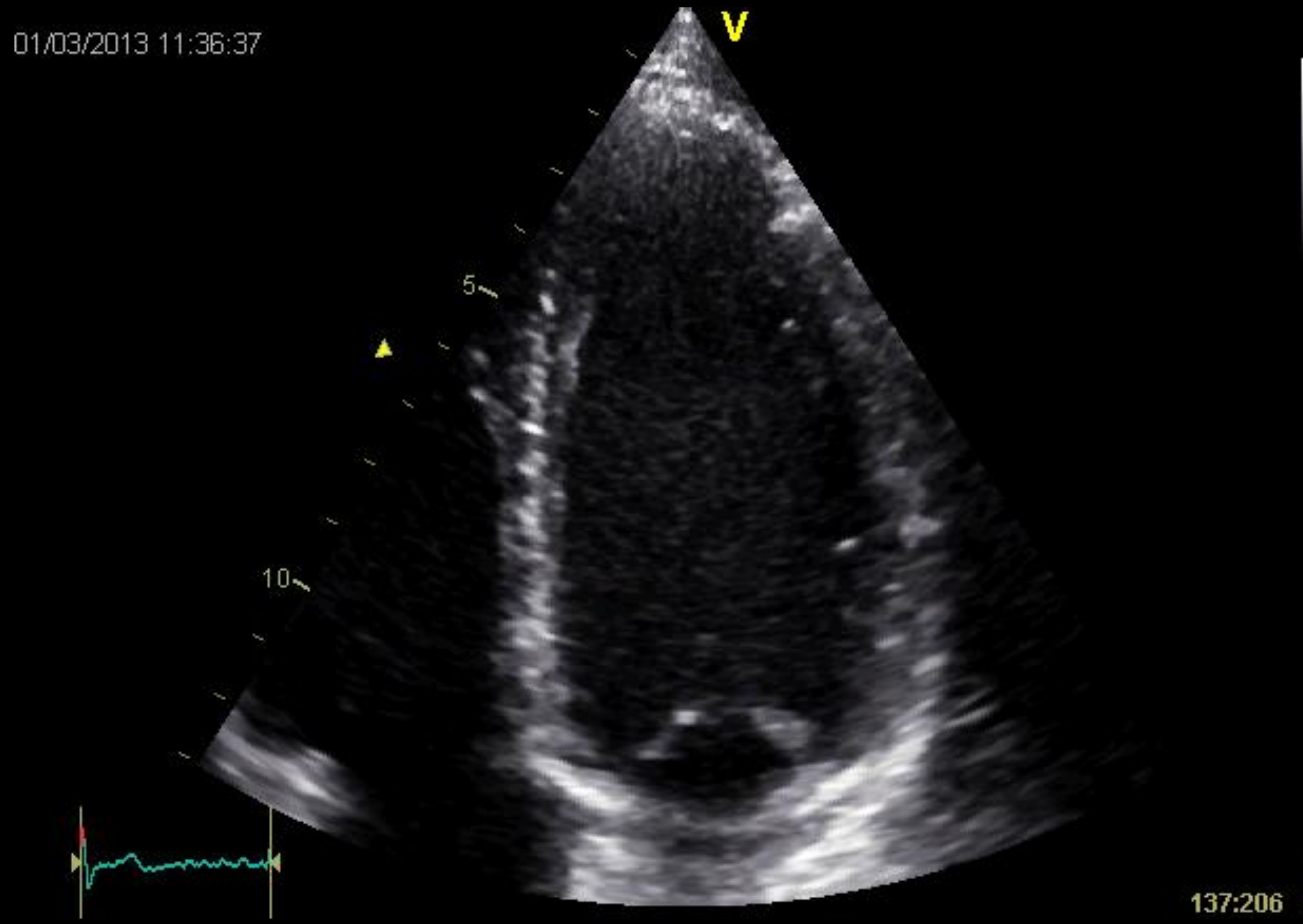
Tissue Doppler



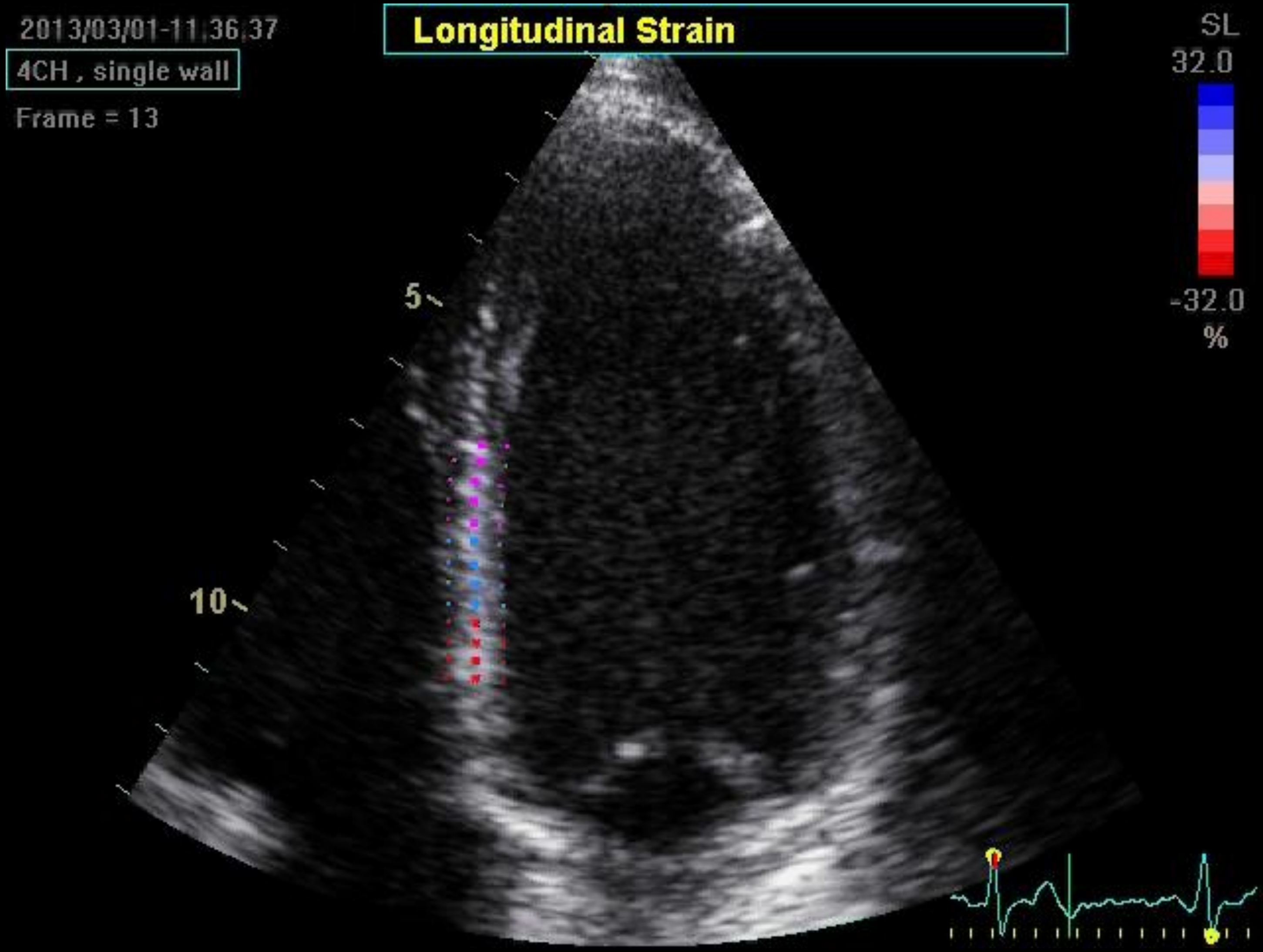
Speckle tracking



Speckle tracking

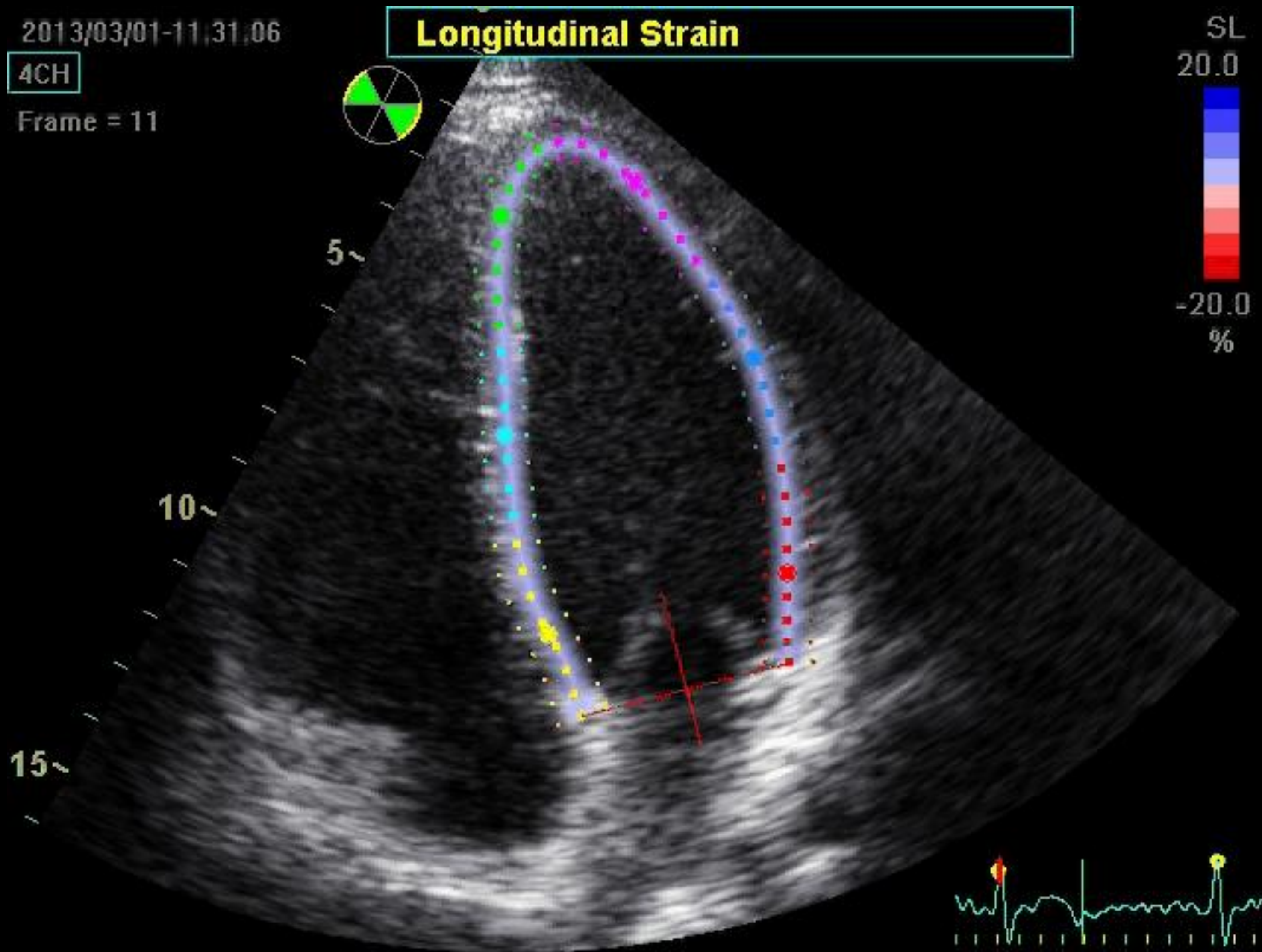


Speckle tracking echocardiography

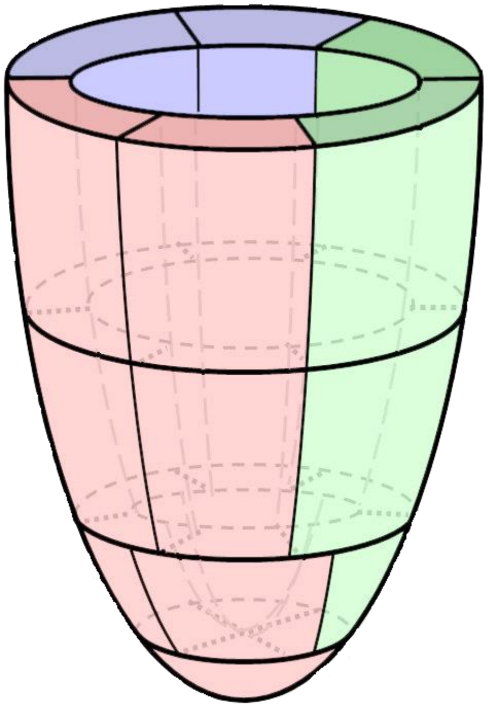


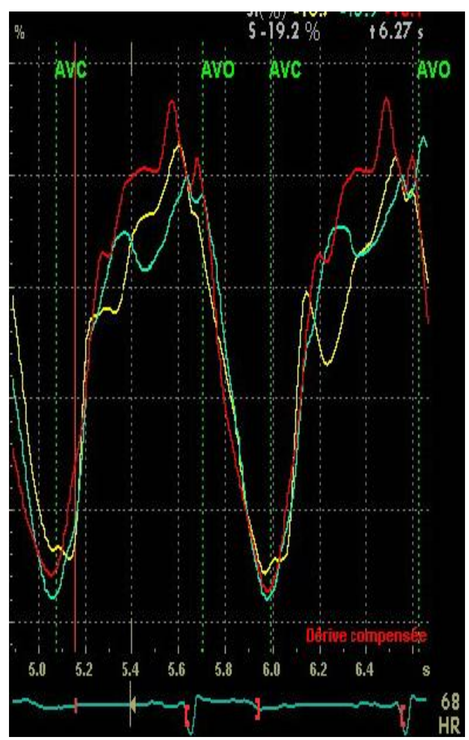
Courtesy of Thomas Helle-Valle

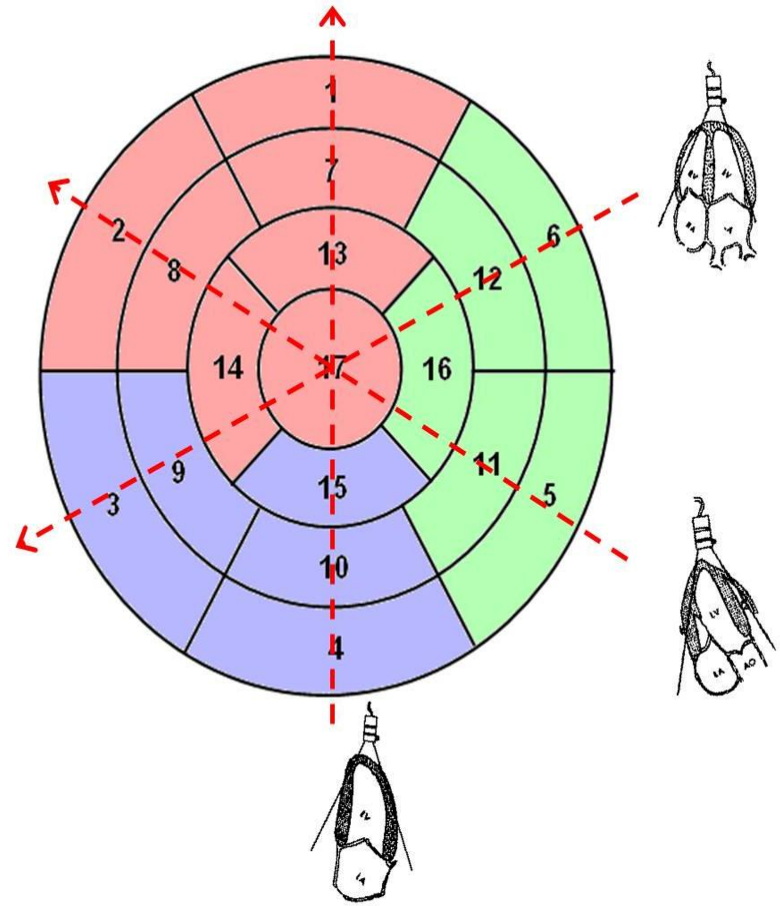
Strain by speckle tracking echocardiography



Global Systolic Strain



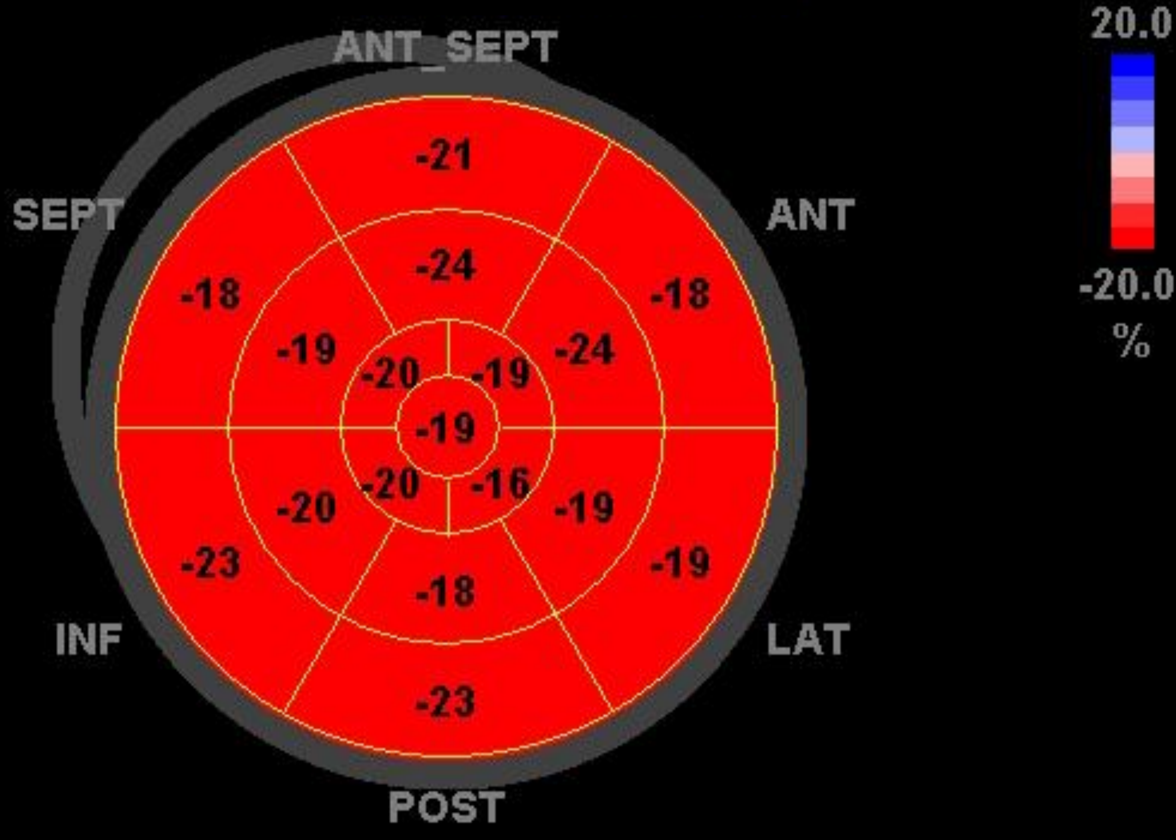




Global strain = average of all segmental strain values

Modified from Ola Gjesdal

Global Strain in a Normal Heart



Global strain = average of all segmental strain values

Global strain= -20 %

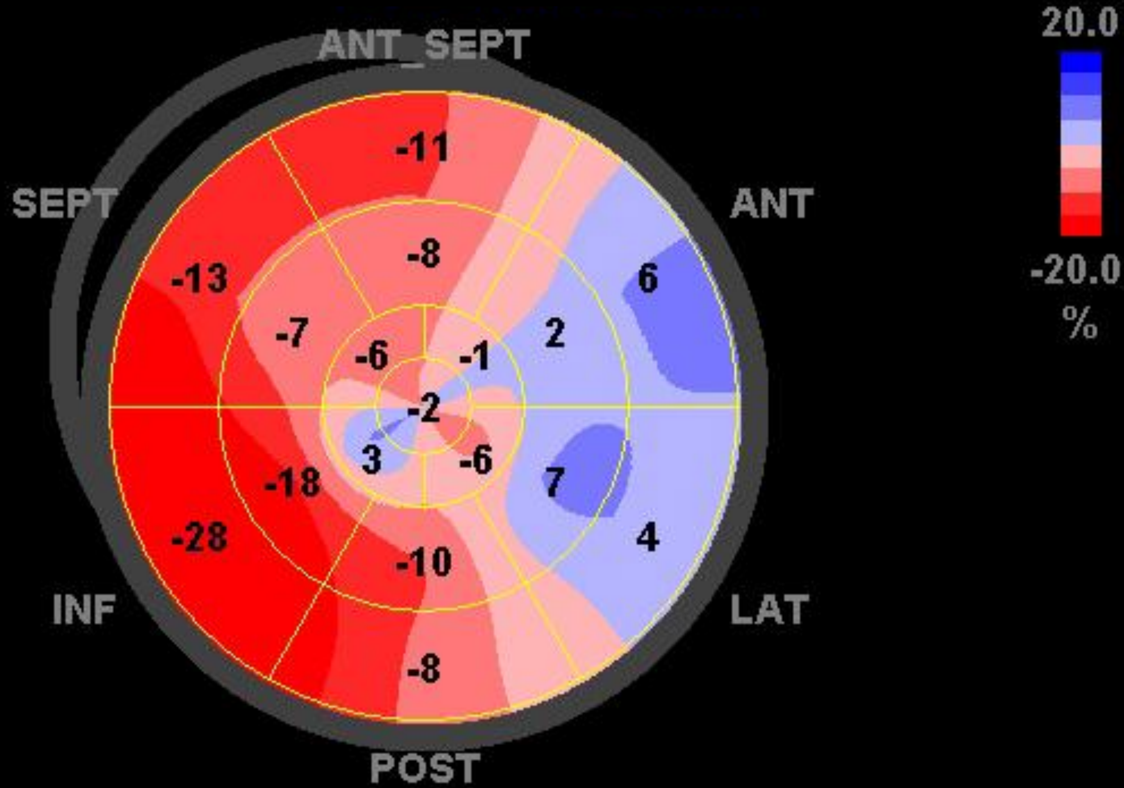
Normal ranges of global left ventricular longitudinal strain

A meta-analysis: 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%).

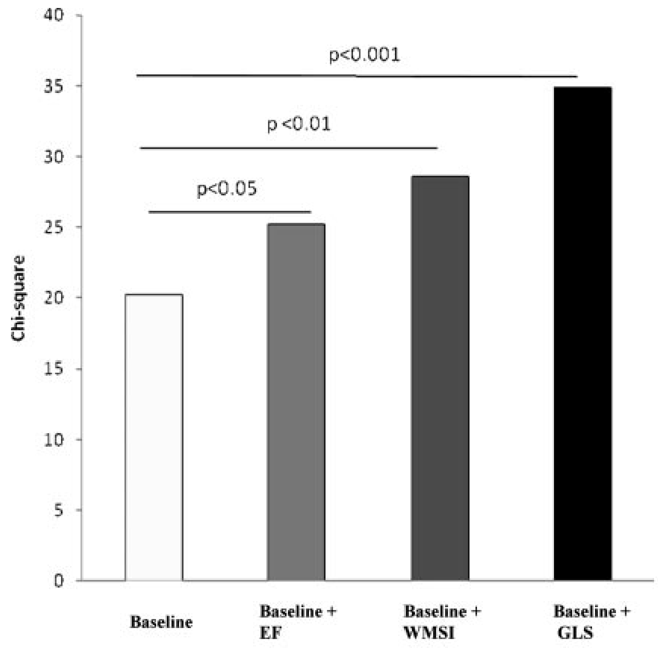
Yingchoncharoen **T, Agarwal S, Popović ZB, Marwick TH.**
J Am Soc Echocardiogr. **2013 Feb;26(2):185-91.**

Global Strain - LAD Infarct



Global strain = average of all segmental strain values

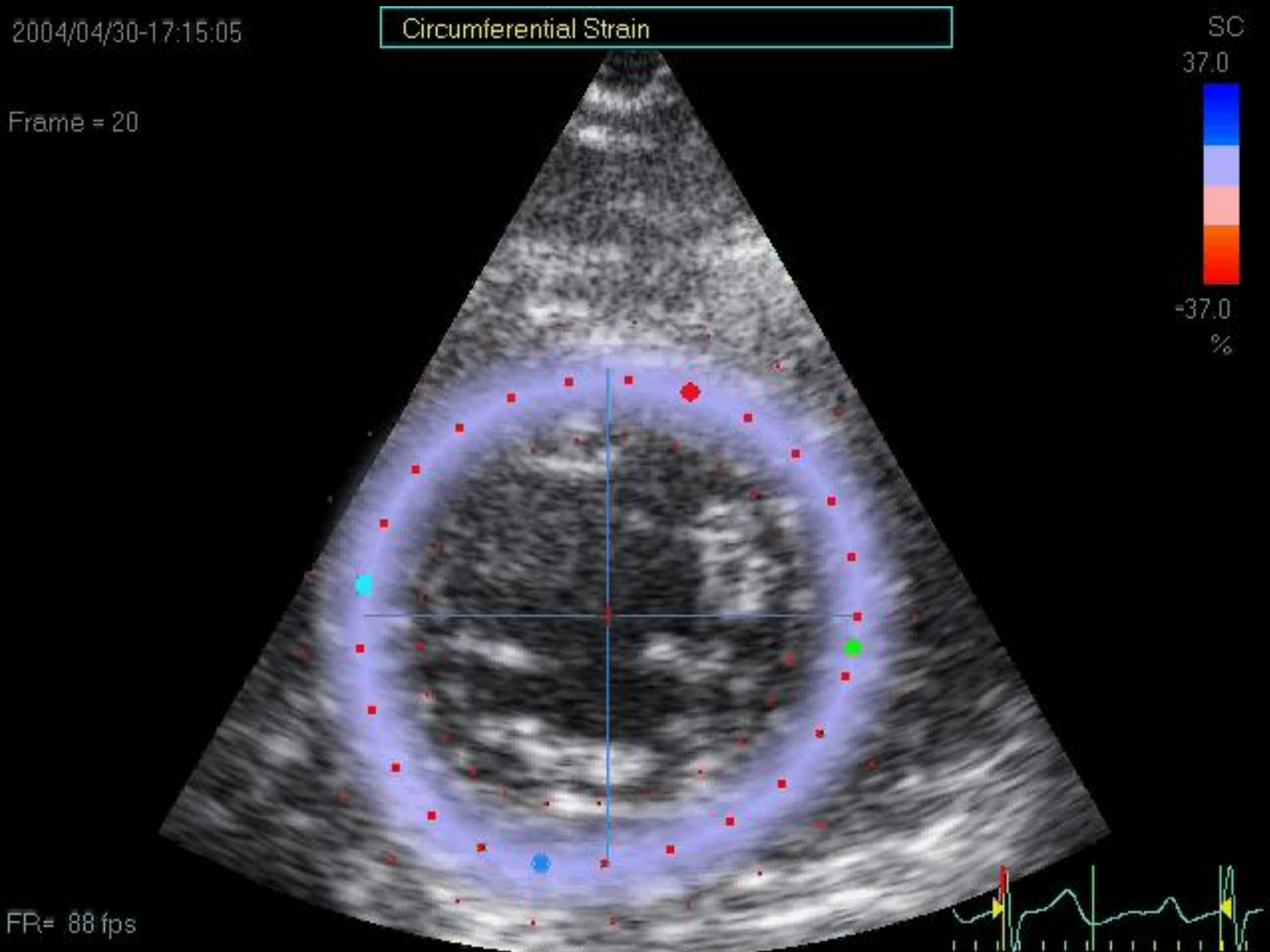
Global strain = -9 %



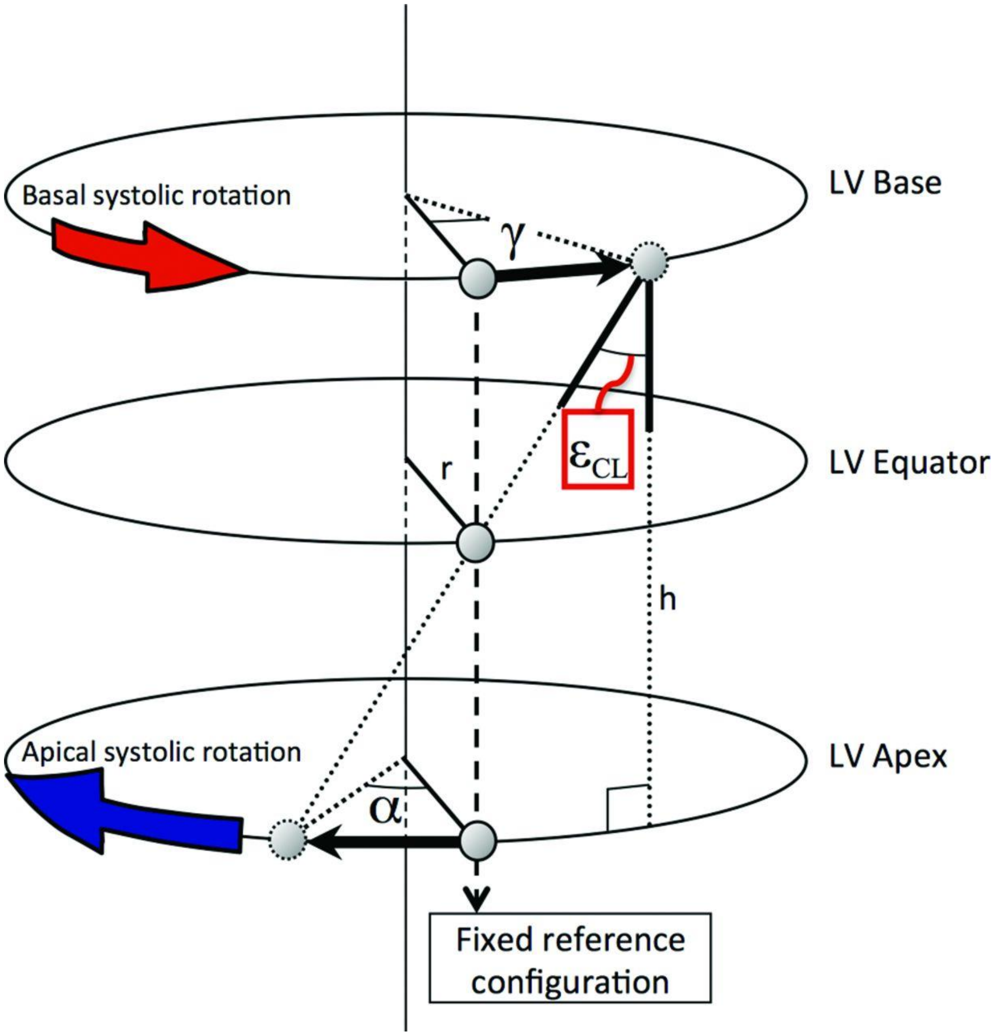
”Global longitudinal strain measurement by 2DS was superior to EF and WMSI for the prediction of outcome and may become the optimal method for assessment of global LV systolic function. Guidelines incorporating measures of LV function may need to be revised to incorporate global longitudinal strain in light of this finding.”

Stanton T et al. Circ Cardiovasc Imaging 2009;2:356-364

Twisting motion



Determinants of LV untwisting rate

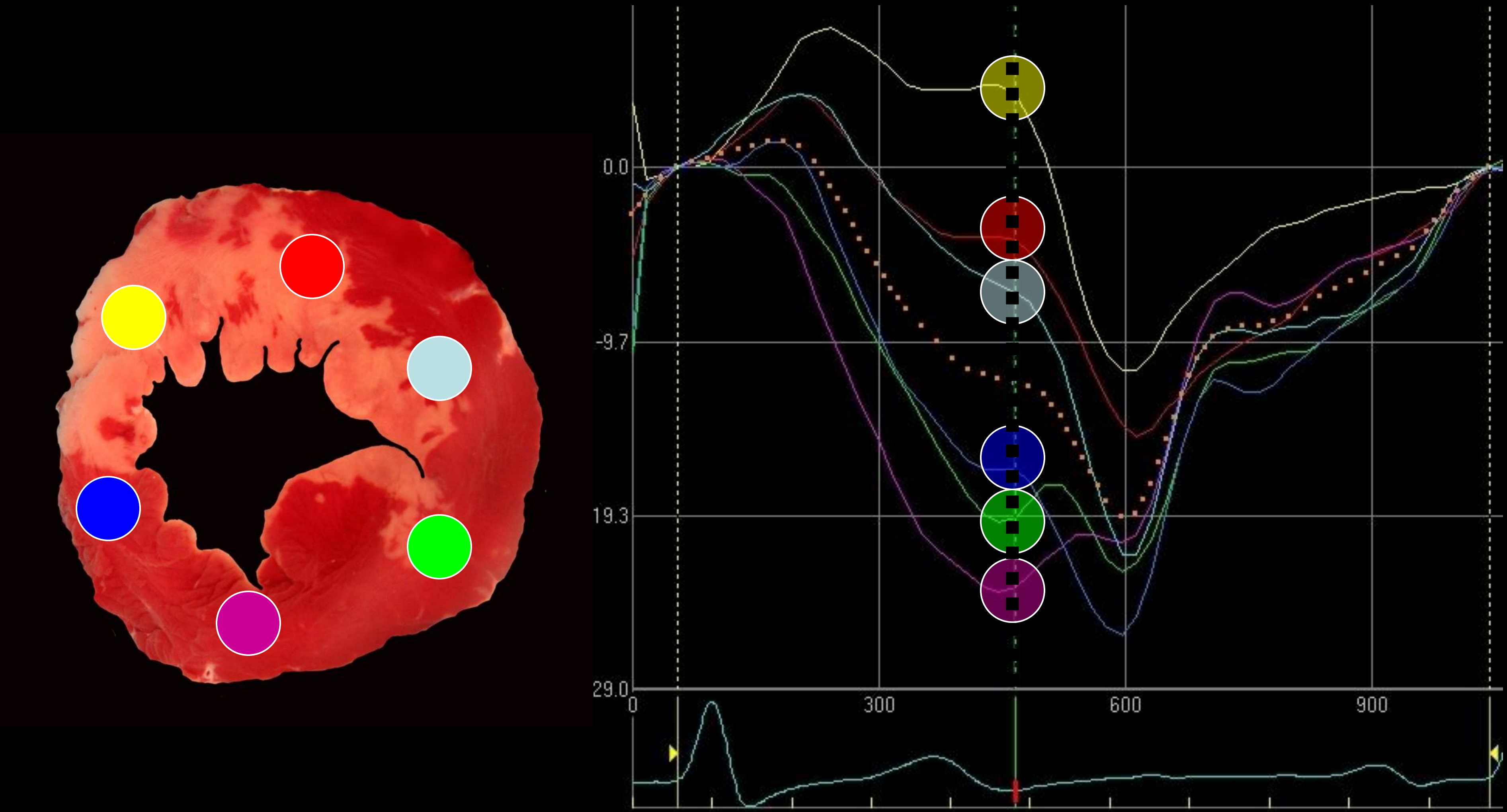


A Opdahl/OA Smiseth et al. Circulation 2012;126:1441-1451

Important features of the strain trace

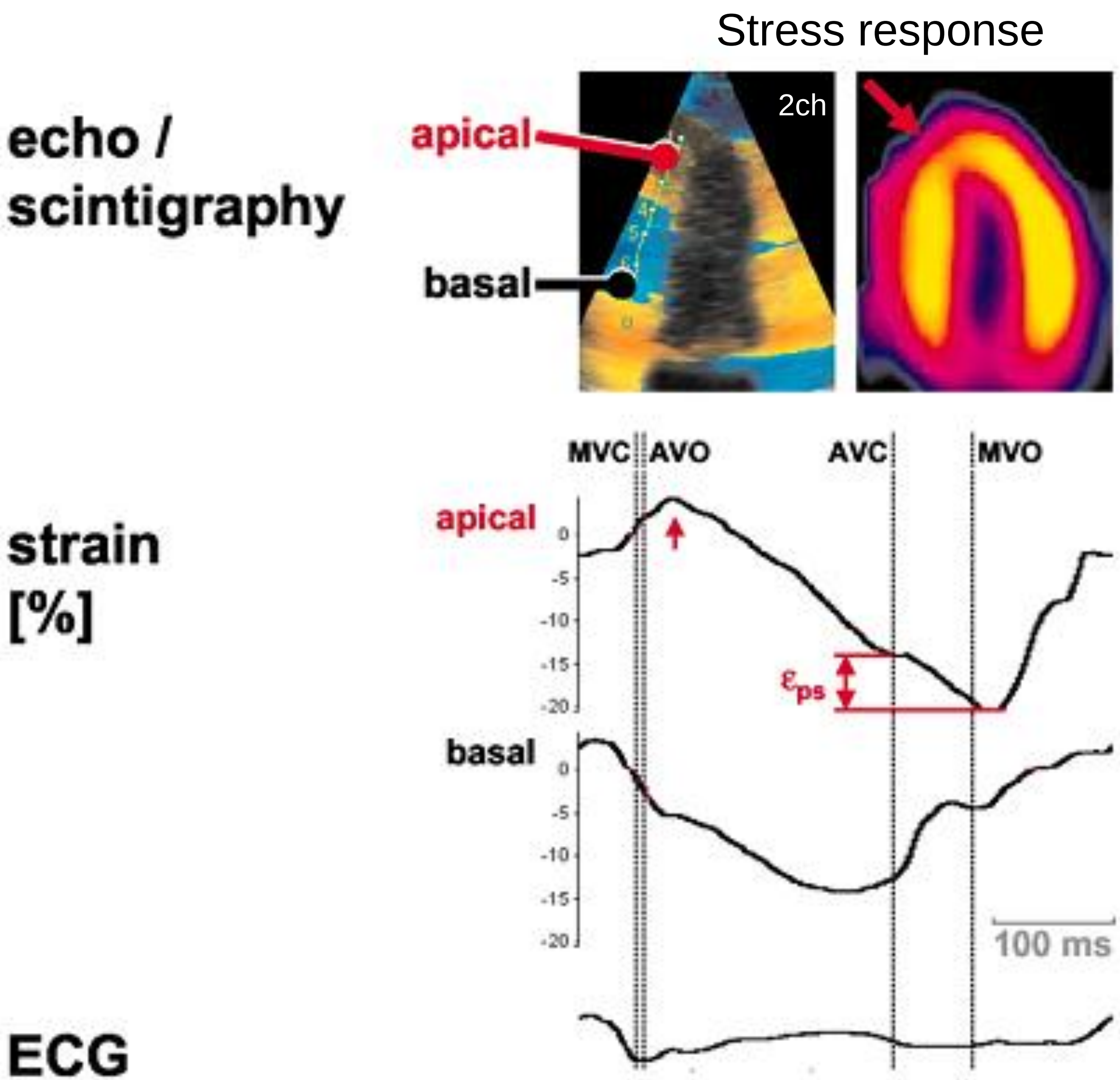
- Peak strain
- Post-systolis shortening

Distribution of circumferential strain in the ischemic LV



Courtesy of Thomas Helle-Valle

Post-systolic shortening in ischemic myocardium



Modified from Voigt J et al. Circulation 2003;107:2120-2126

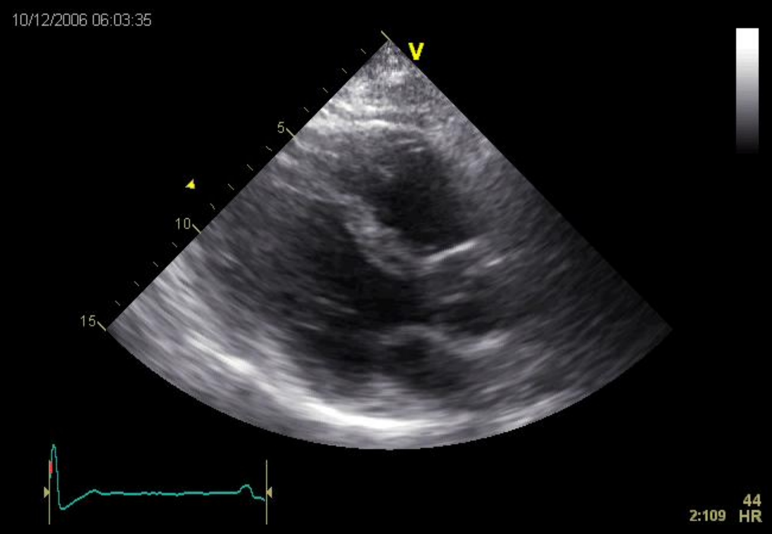
Case 1

61 yr. old male

Previously healthy

Admitted after midnight, general discomfort and nausea

ECG non-conclusive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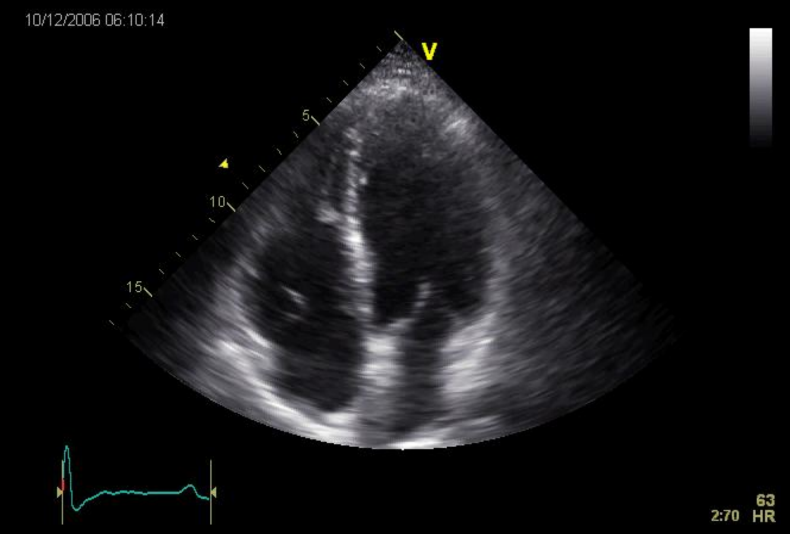
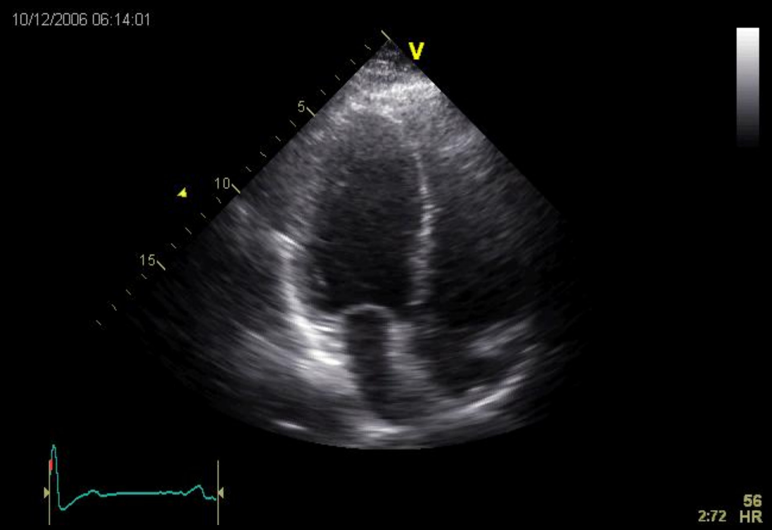
V
5
10
15
44
2:109 HR


10/12/2006 06:10:14
V
5
10
15
63
2:70 HR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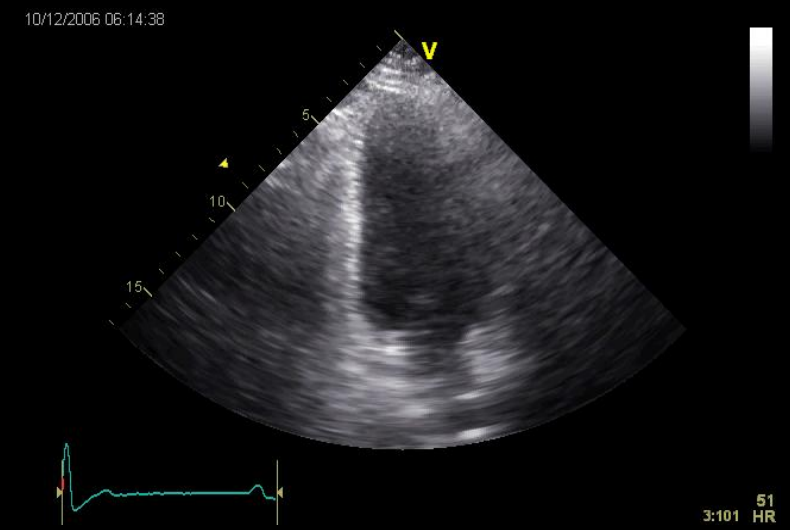
V
5
10
15
56
2:72 HR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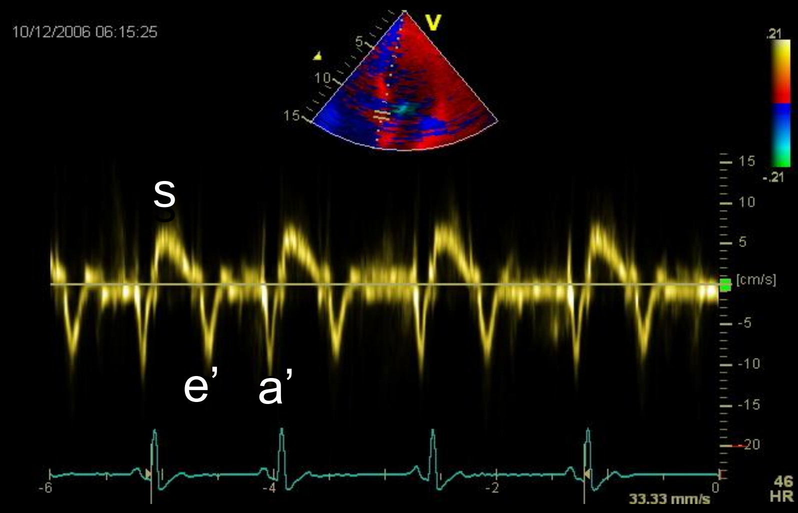
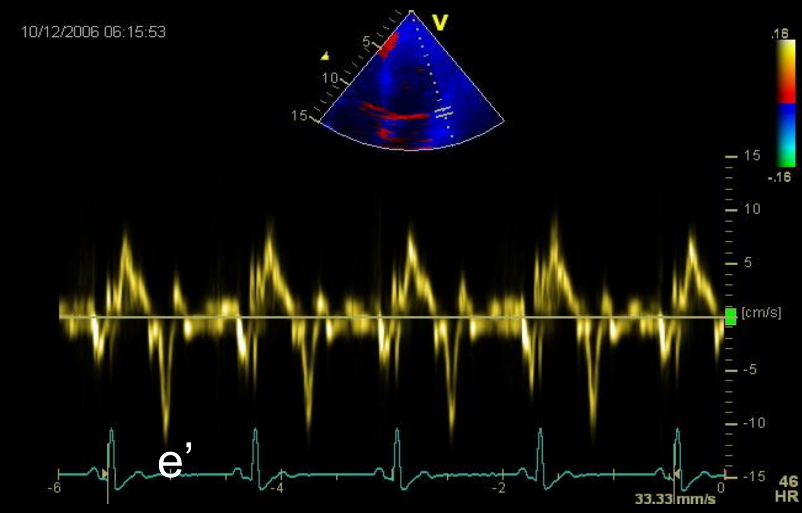
V
5
10
15
51
3:101 HR

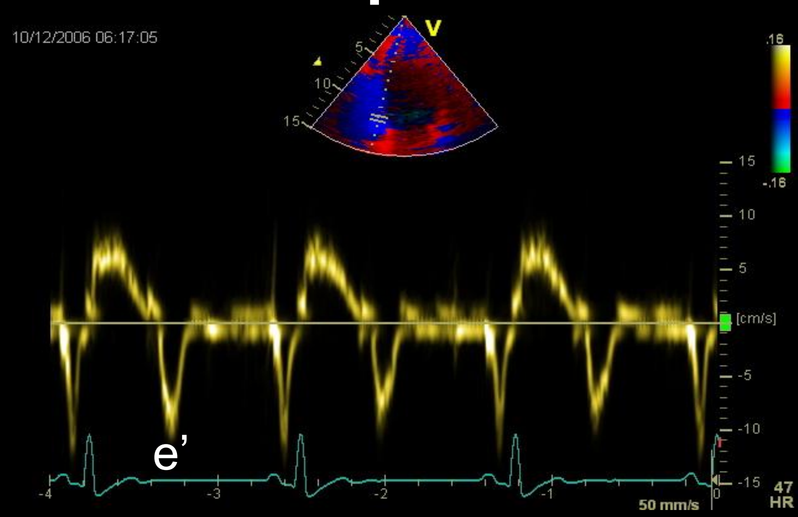
Tissue Doppler velocities (cm/s)



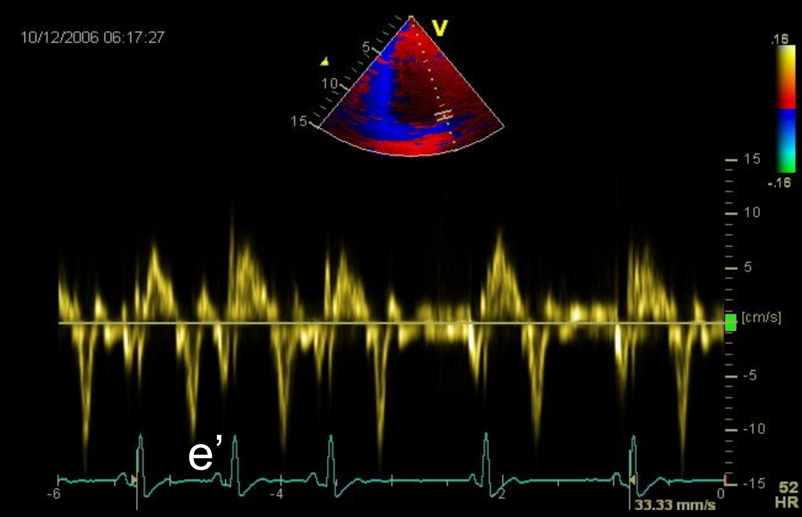
Septum



LV lateral wall

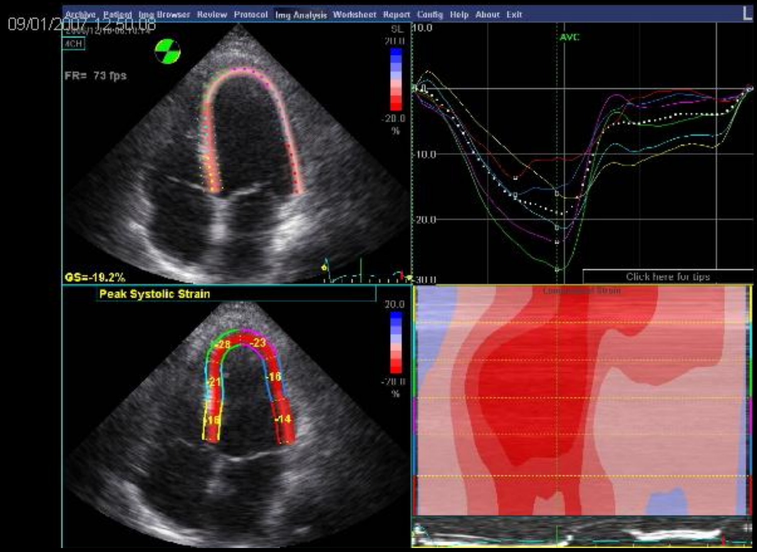


LV inferior wall



LV anterior wall

Strain



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FR= 73 fps
AVC
GS=-19.2%
Click here for tips
Peak Systolic Strain
-28
-23
-16
-21
-16
-14

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-20
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Peak Systolic Strain
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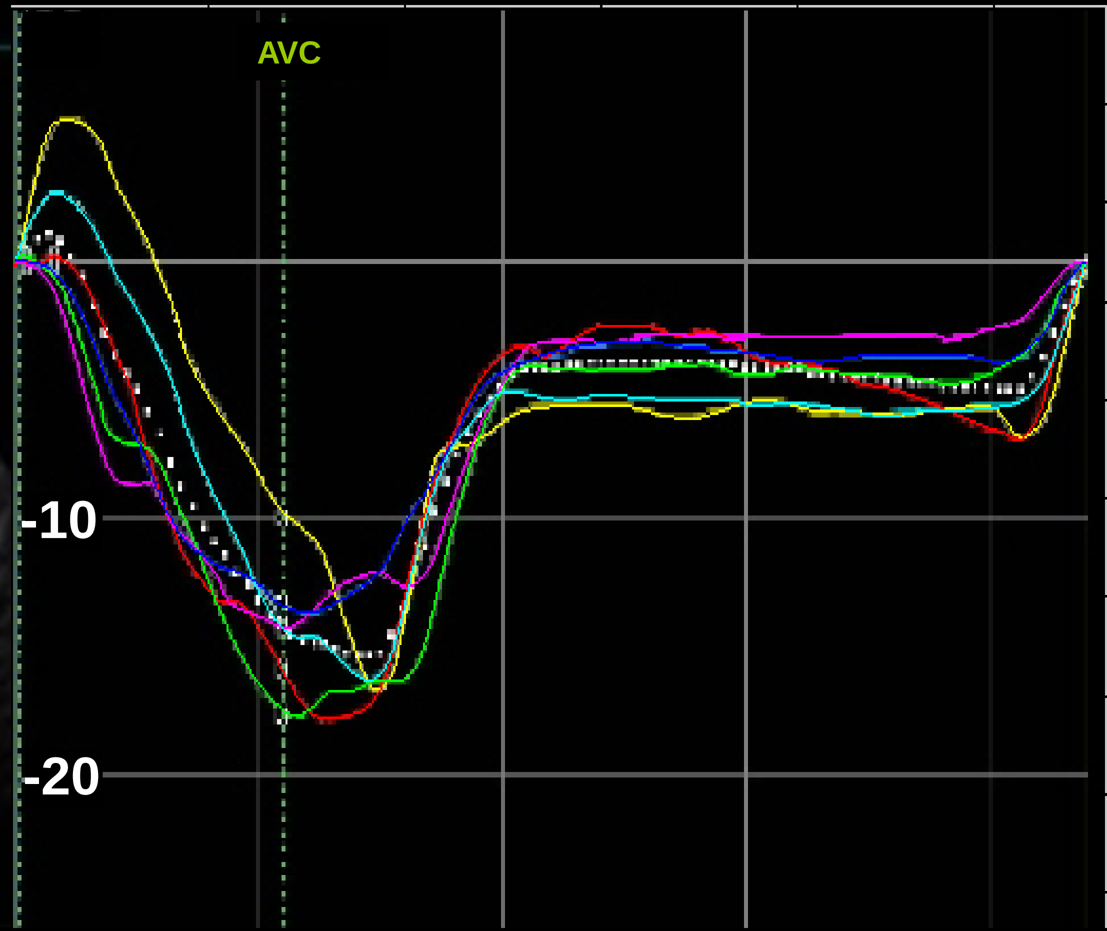
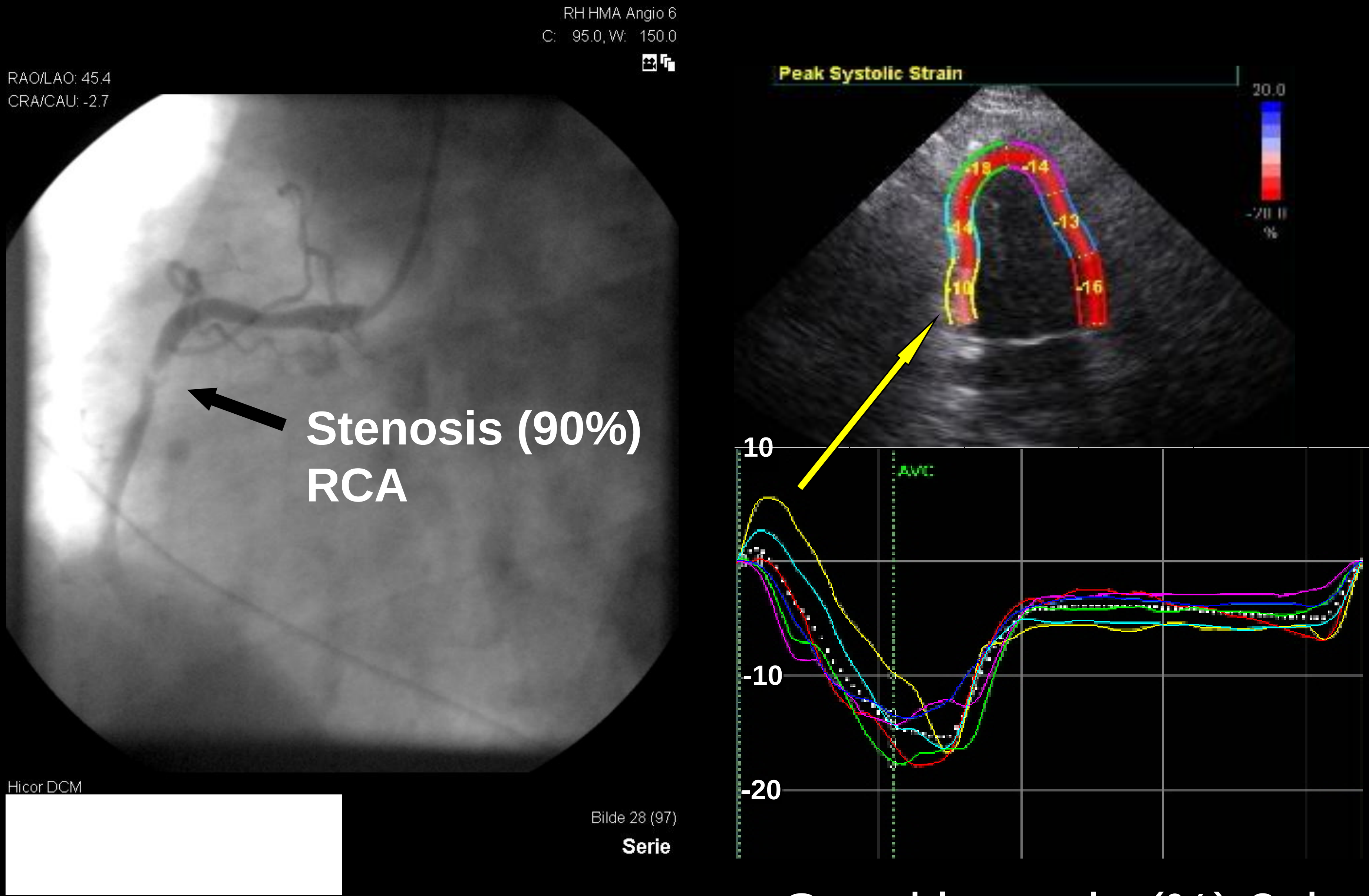
-14
-14
-13
-18
-16

2 chamber



Strain curves 2 chamber (%)



Speckle strain (%) 2ch

Case 2

Case 2

20 yr. old male

Chest pain.

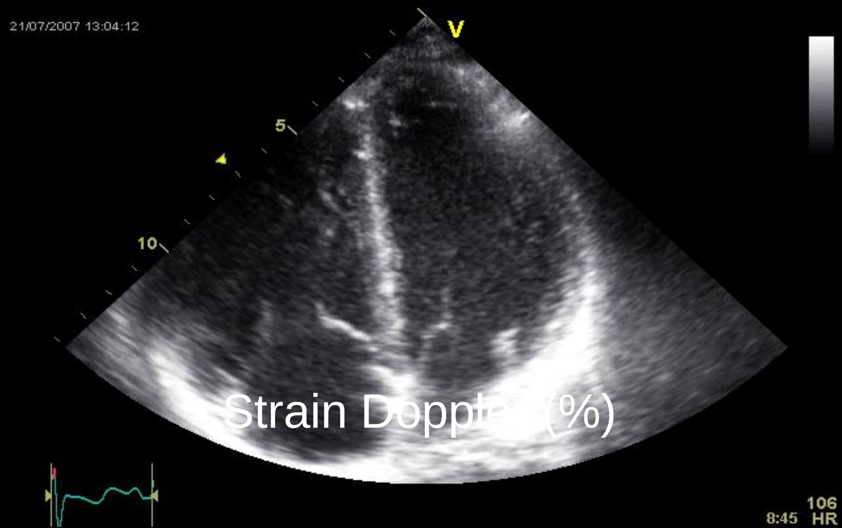
Hypotensive

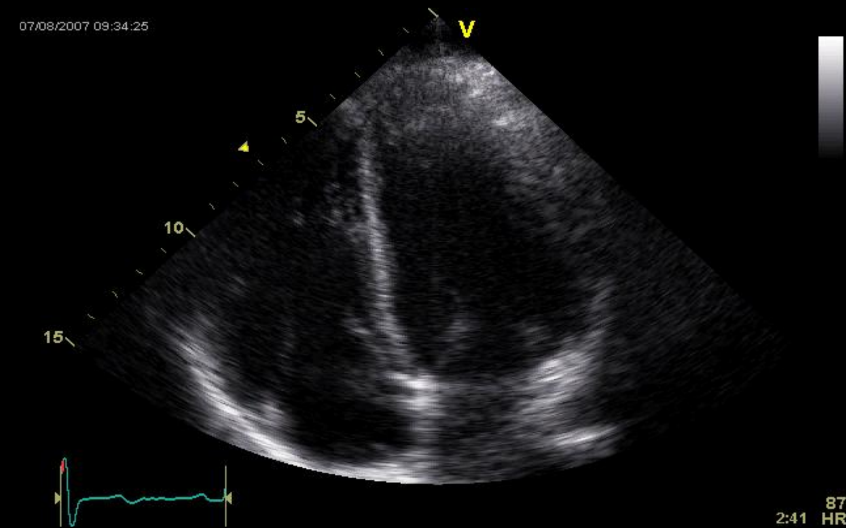
Suspected pulmonary embolism, confirmed by CT

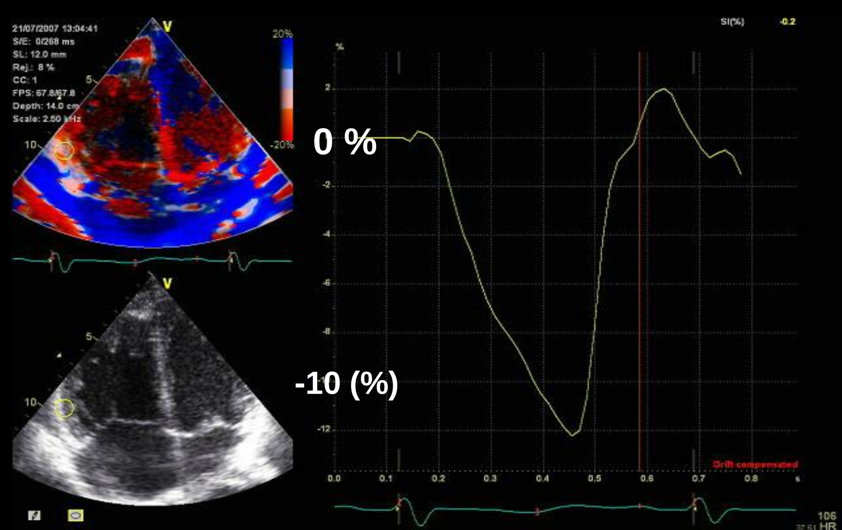
I.v. thrombolysis

ACUTE PULMONARY EMBOLISM

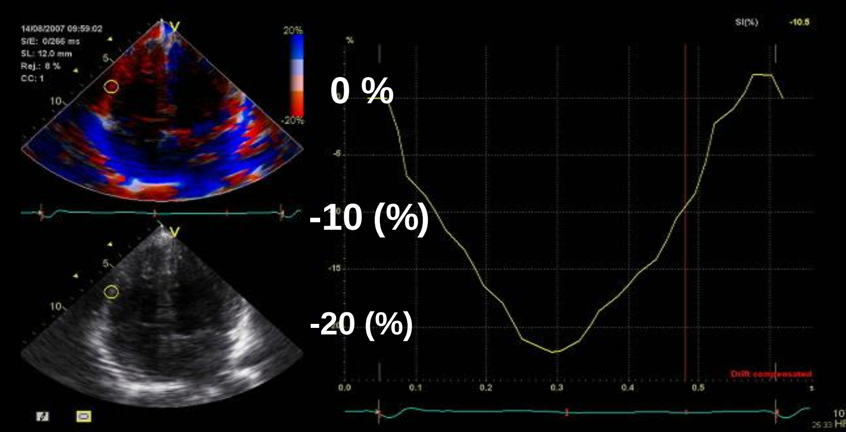
BASELINE | **THROMBOLYSIS**







Strain Doppler (%)

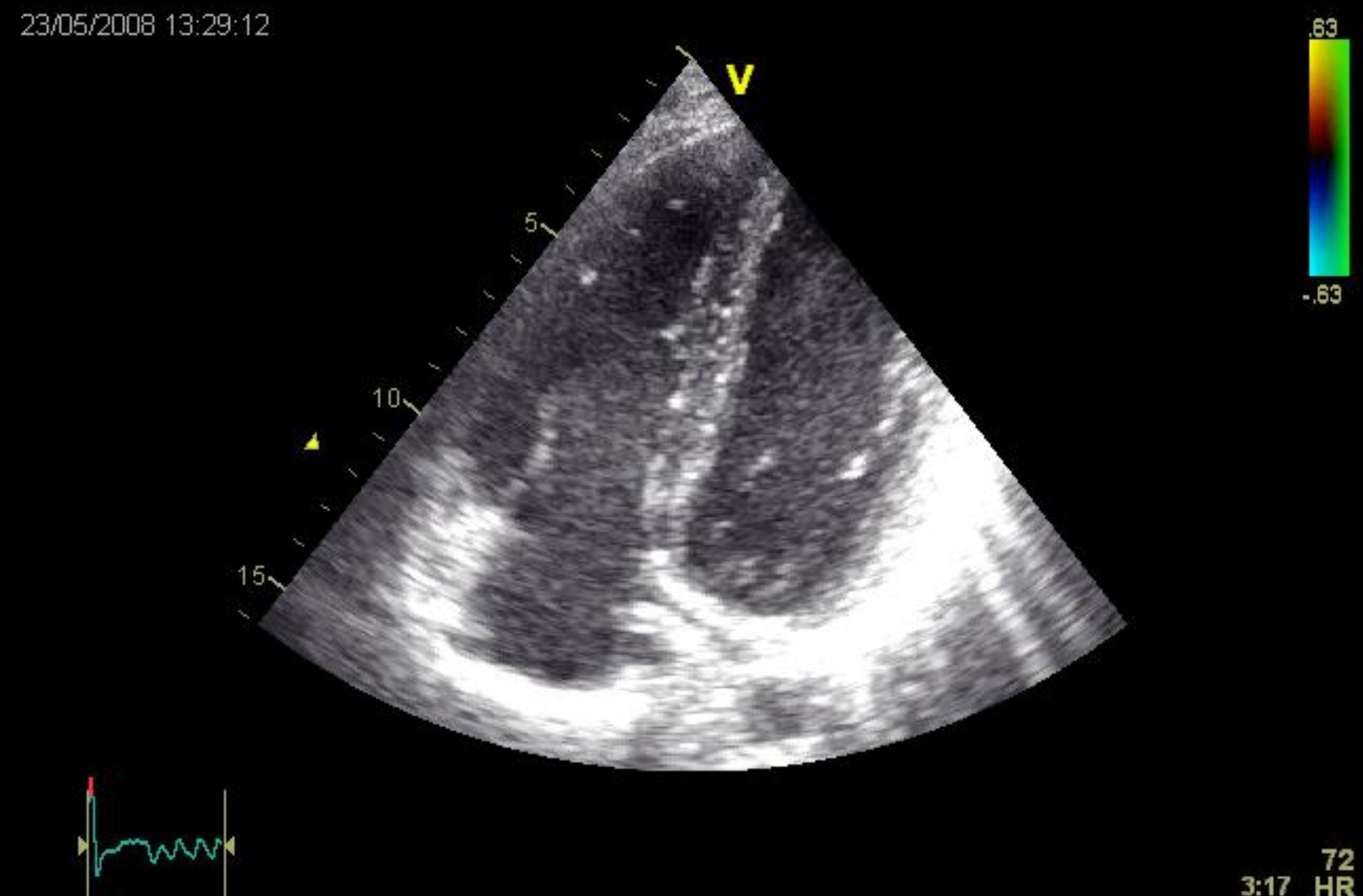


Strain Doppler (%)

Case 3

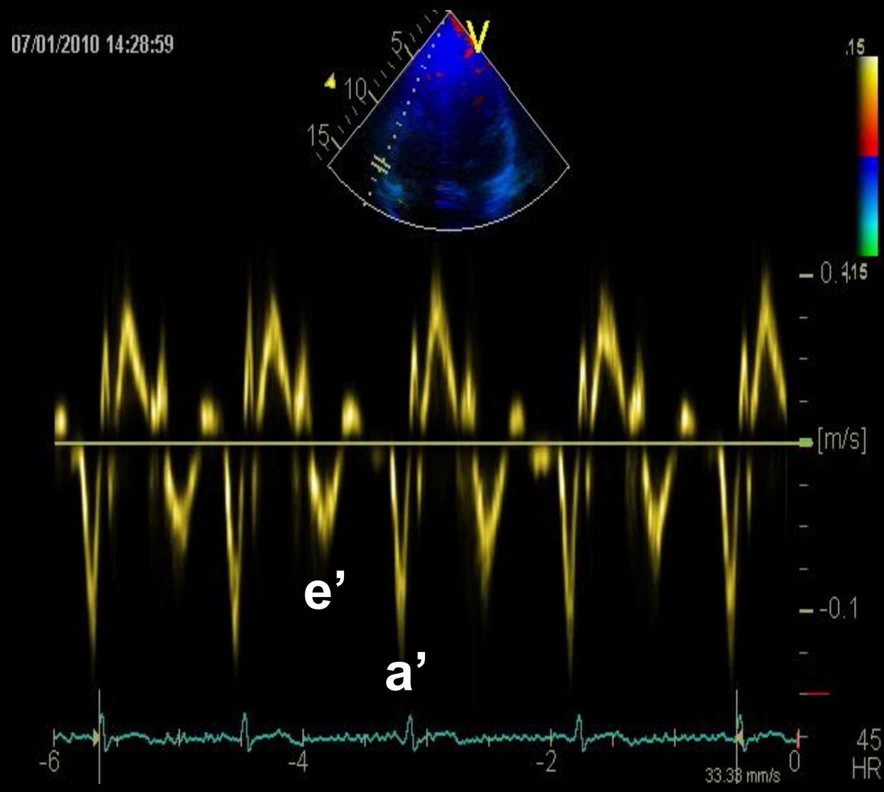
19 yr. old male

Fainted shortly after a soccer match



23/05/2008 13:29:12
V
5
10
15
.63
-.63
72
3:17 HR

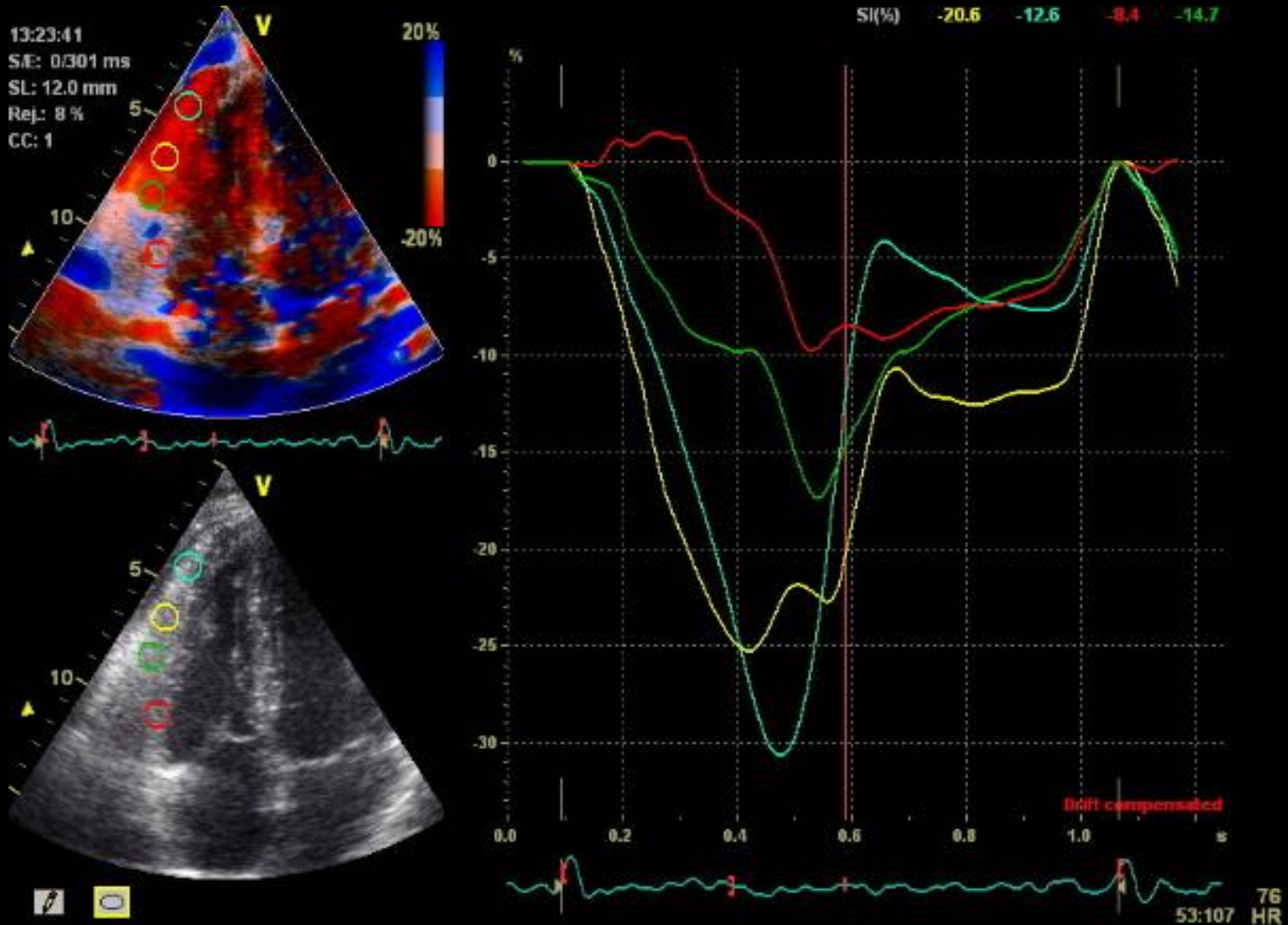
TISSUE DOPPLER



RIGHT VENTRICULAR FREE WALL

LEFT VENTRICULAR FREE WALL

Doppler strain RV free wall



Arrhythmogenic right ventricular cardiomyopathy and subclinical right ventricular dysfunction

	Healthy individuals ($n = 40$)	Asymptomatic mutation carriers ($n = 27$)	ARVC patients with arrhythmia ($n = 42$)	P-value Kruskal-Wallis
LVEF (%)	64(61,65)	61(60,65)	60(55,67)	0.16
LVGLS (%)	- 22(- 21,- 24)	- 20(- 18,- 21)*	- 17(- 16,- 19)*·**	<0.001
RV strain (%)	- 25(- 23,- 27)	- 22(- 20,- 24)*	- 19(- 16,- 21)*·**	<0.001
LV dispersion (ms)	20(16,25)	38(33,49)*	60(48,70)*·**	<0.001
RV dispersion (ms)	13(9,19)	35(23,47)*	52(41,63)*·**	<0.001
PSAX RVOT (mm)	28(26,30)	27(26,28)	31(29,37)*·**	<0.001
RVED area (cm^2)	22(20,24)	24(22,27)	29(25,36)*·**	<0.001
RVES area (cm^2)	12(11,14)	14(12,15)	18(15,25)*·**	<0.001
RVFAC (%)	44(39,48)	43(40,48)	38(27,43)*·**	<0.001

- *$P < 0.001$ compared with healthy individuals.
- **$P < 0.01$ compared with asymptomatic mutation carriers.

S. Sarvari et al., Eur Heart J (2011) 32 (9): 1089-1096.

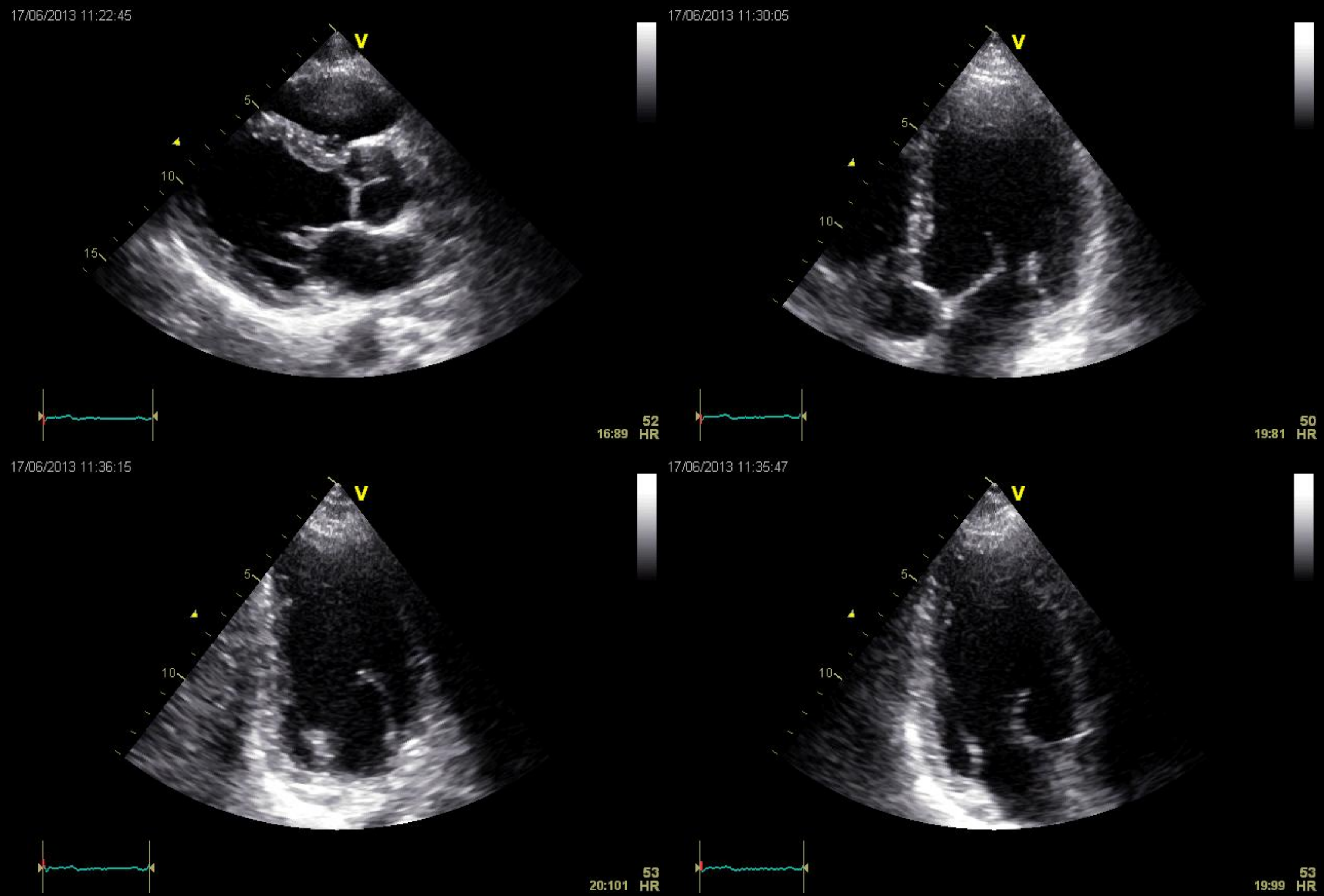
Case 4

- 50 yr. old male
- Highly active in sports
- No symptoms
- Referred due to SD in younger brother

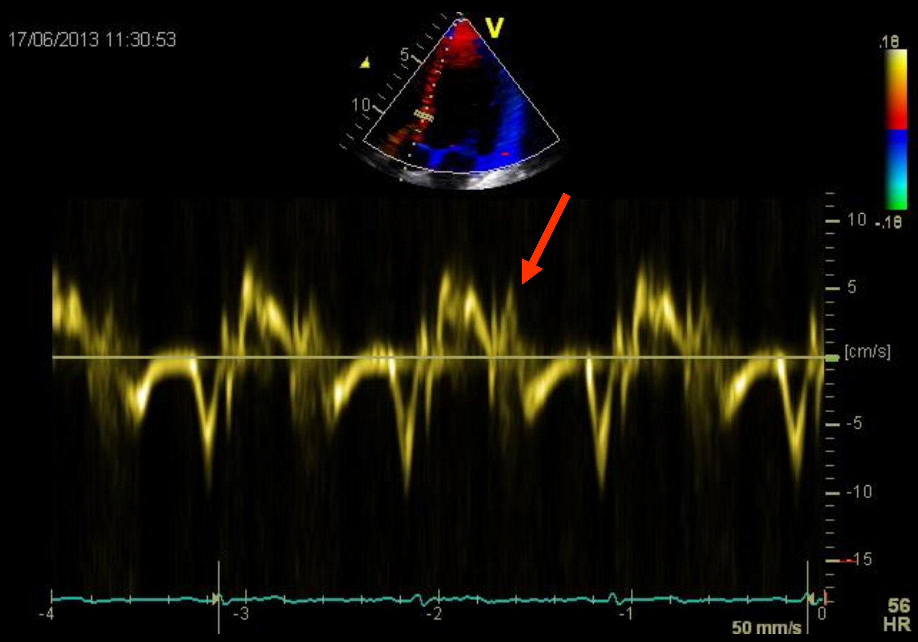
Case 4

- Echo: Bordeline LV
- Normal ECG and Holter
- Normal exercise stress test
- Normal scintigraphy

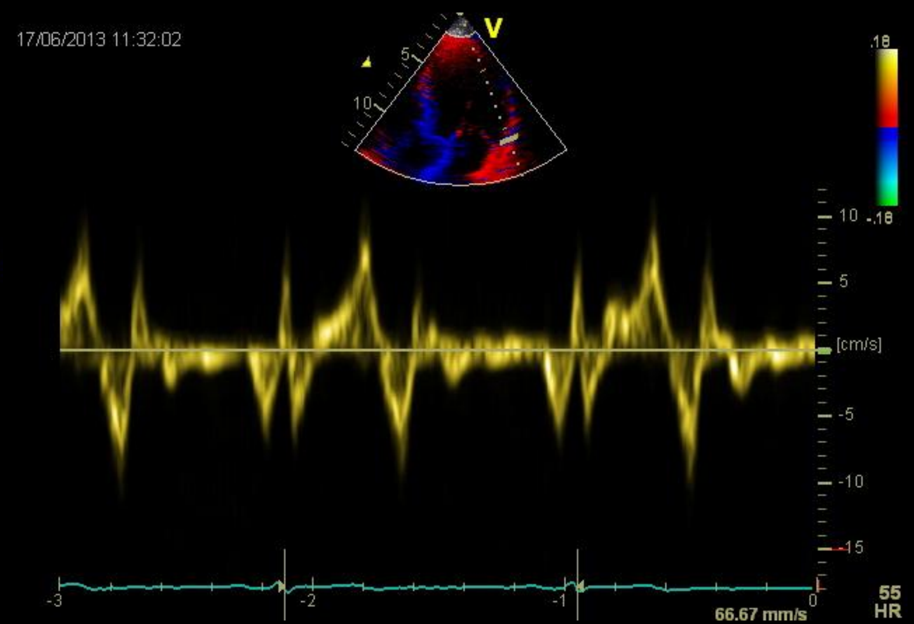
Slightly dilated LV, 6.2 cm



Tissue Doppler velocities (cm/s)

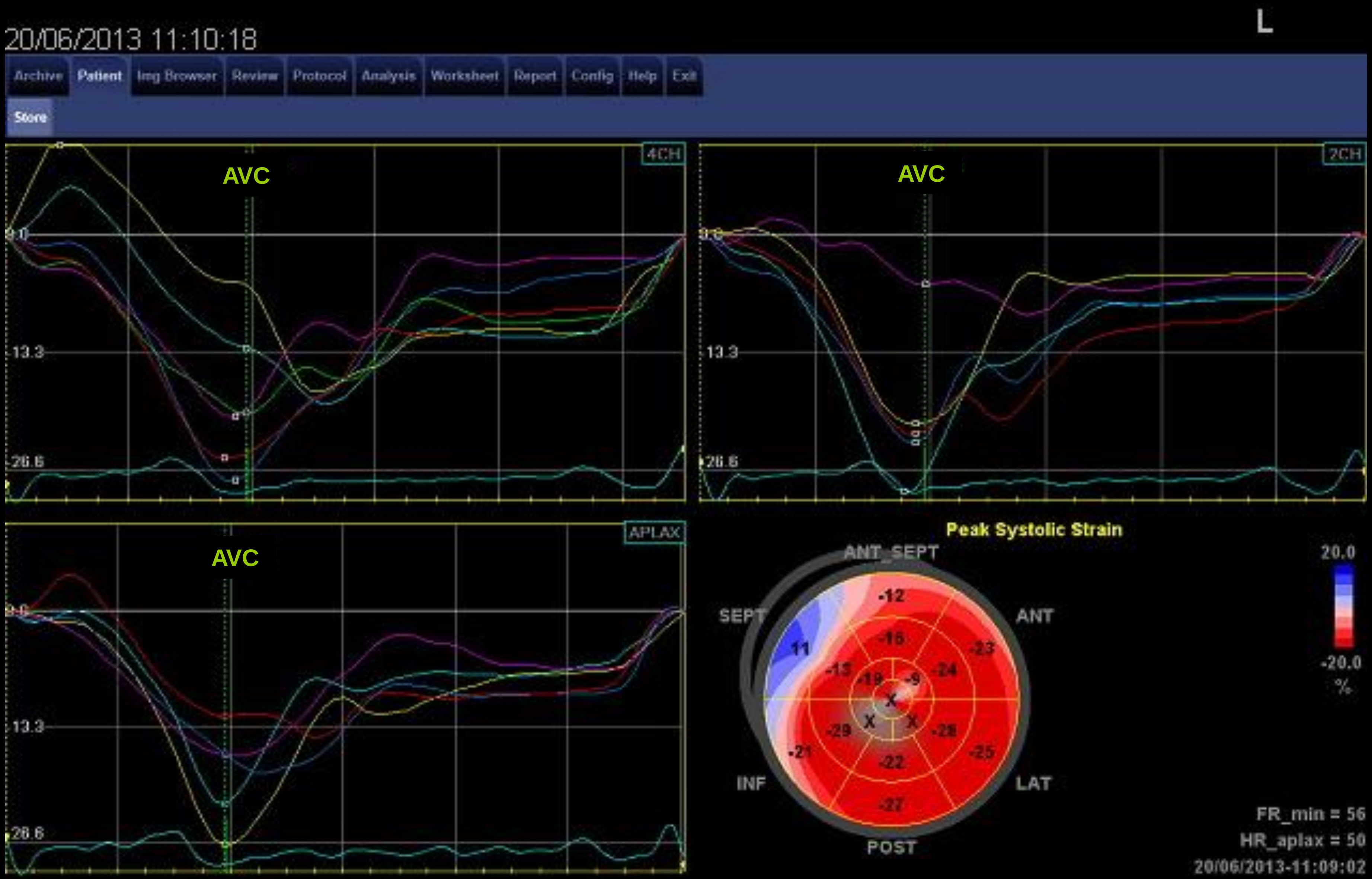


Septum



LV free wall

2D speckle strain (%)



Conclusions

- ✓ LV lengthening velocity (e’) by tissue Doppler should be used in evaluation of diastolic funcion.

- ✓ Global LV strain appear to be a sensitive measure of LV systolic function, but added clinical value not yet proven.

- ✓ In selected patients strain is clinically useful
  - In CAD
  - In CMP
  - In subclinical heart disease