New modalities in clinical cardiac imaging

Speckle Tracking

olvg

Symposium 2009 Hartcentrum OLVG

L. Spallanzani (1729 – 1799)

Demonstrates in 1793 the use of echo-reflection by bats

The *supersonic* reflectoscope

FIG. 4. Type A sweeping and timing system. This is the pattern which appears on the screen when the crystal is not being energized. It consists essentially of a time scale which is formed by the green spot of the oscilloscope traveling along the zigzag path *A*, *B*, *C*, *D*, etc. Each microsecond the spot is deflected slightly upward so as to notch the line and thereby form a timing scale. Every eighth notch is made higher in order to assist in counting. There are eight of these higher marks per zigzag so that it requires 64 microseconds to traverse one zigzag.

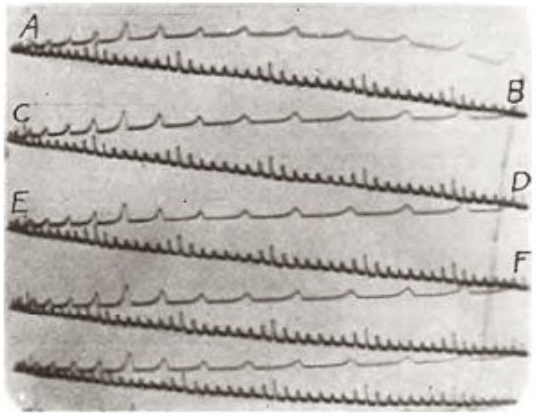


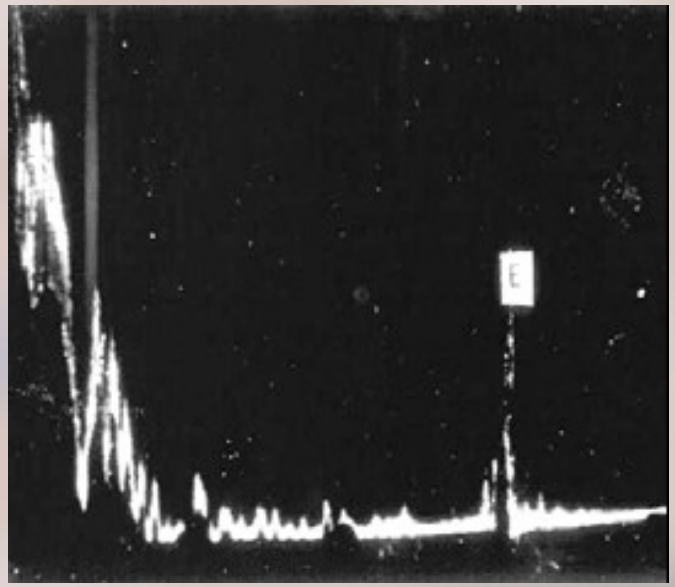
FIG. 2a. Type A supersonic reflectoscope.

Malmö, May 1953

Kockum's Shipbuilding Cie

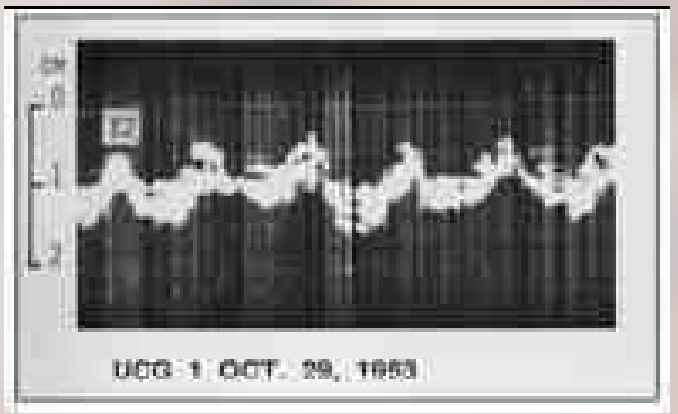
Malmö, May 1953

C.H. Hertz (1920– 1990)

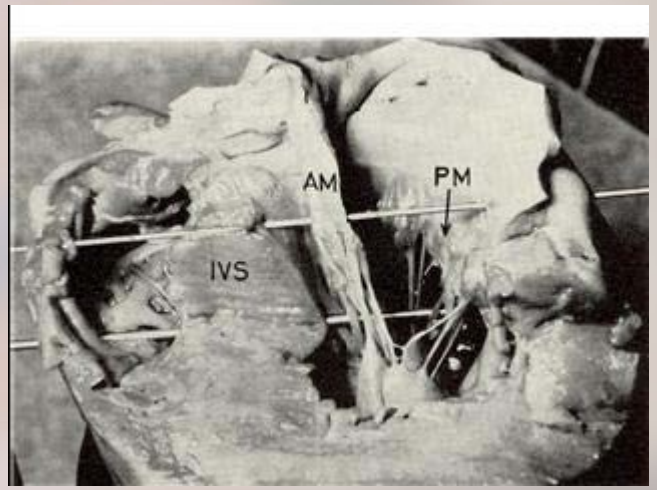


First steps in cardiac evaluation

First M-mode cardiogram



Structure identification



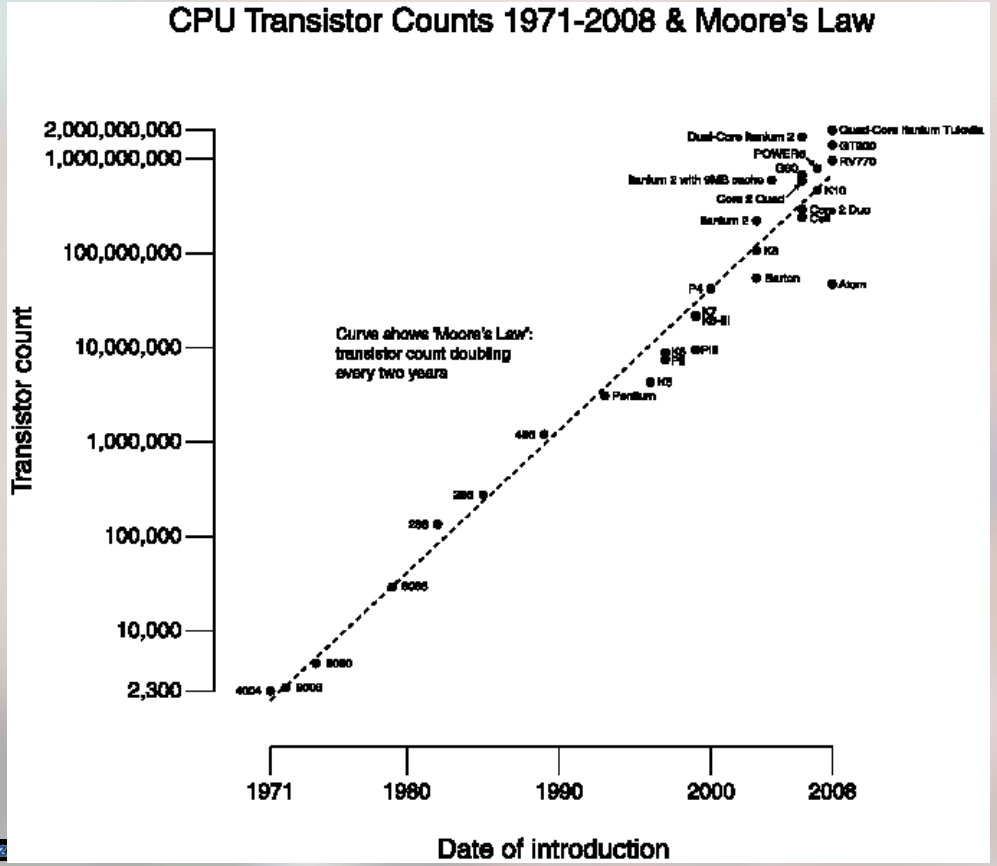
I. Edler, H. Hertz

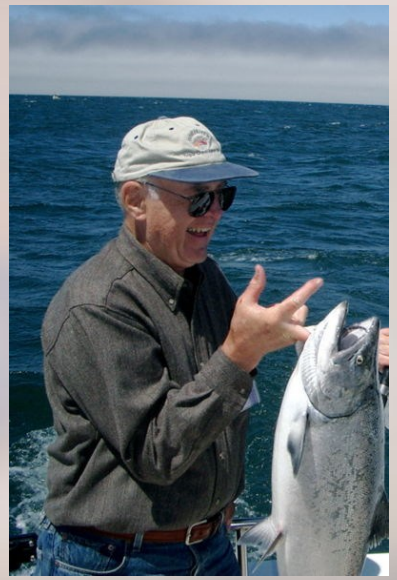
Edler I. Ultrasoundcardiography. Suppl to Acta Med Scand, 1961;170

Dynamic two-dimensional echocardiography (1971)

Bom N et al. Biomed-Engng 1971; 6: 500-3

Moore’s Law





Gordon Moore

Electronics, 1965:38:8

New modalities

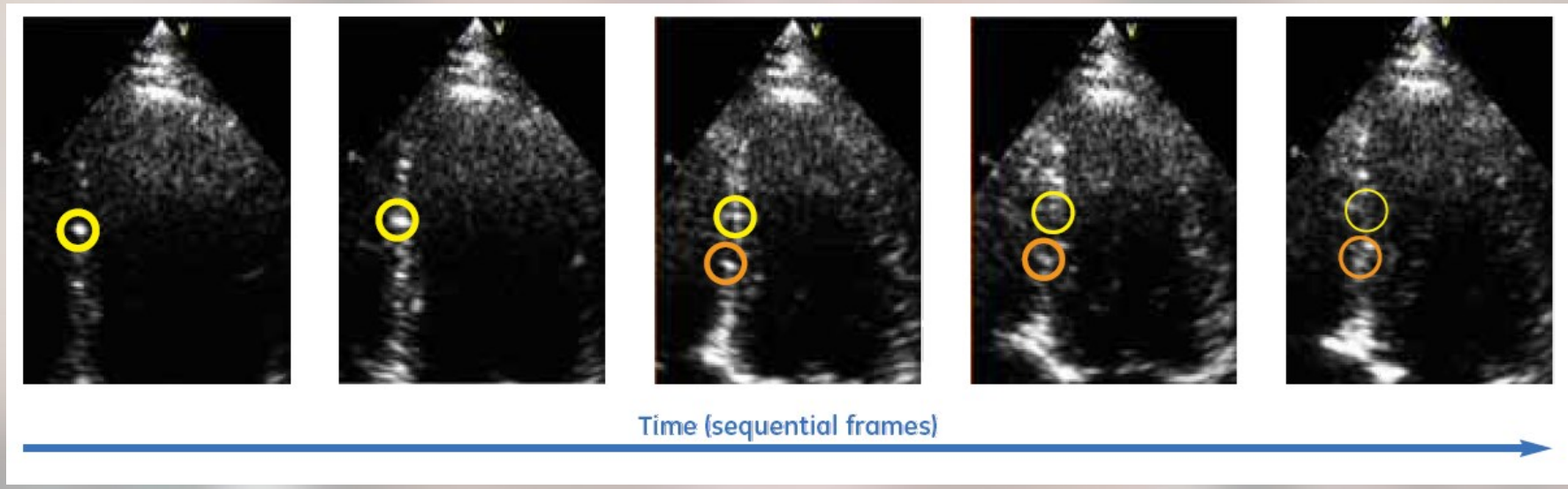
- 2D Strain imaging
  - Speckle tracking
- 3D echocardiography
  - 3D EF
  - Valve pathology
  - 3D TEE

Constellations

Speckle Tracking

2D strain
Non-doppler strain
Tissue deformation

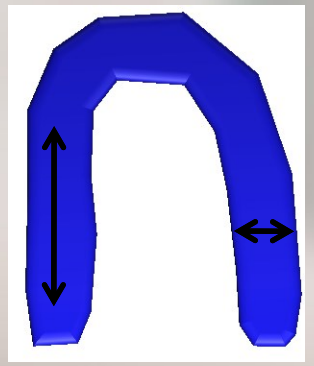
"natural acoustic tagging"
Speckle tracking pattern recognition algorithm



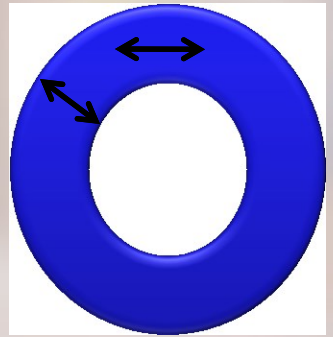
Peter Lysyansky and Zvi Friedman

2D Strain

$$\varepsilon = \frac{L - L_0}{L_0} = \frac{\Delta L}{L_0}$$



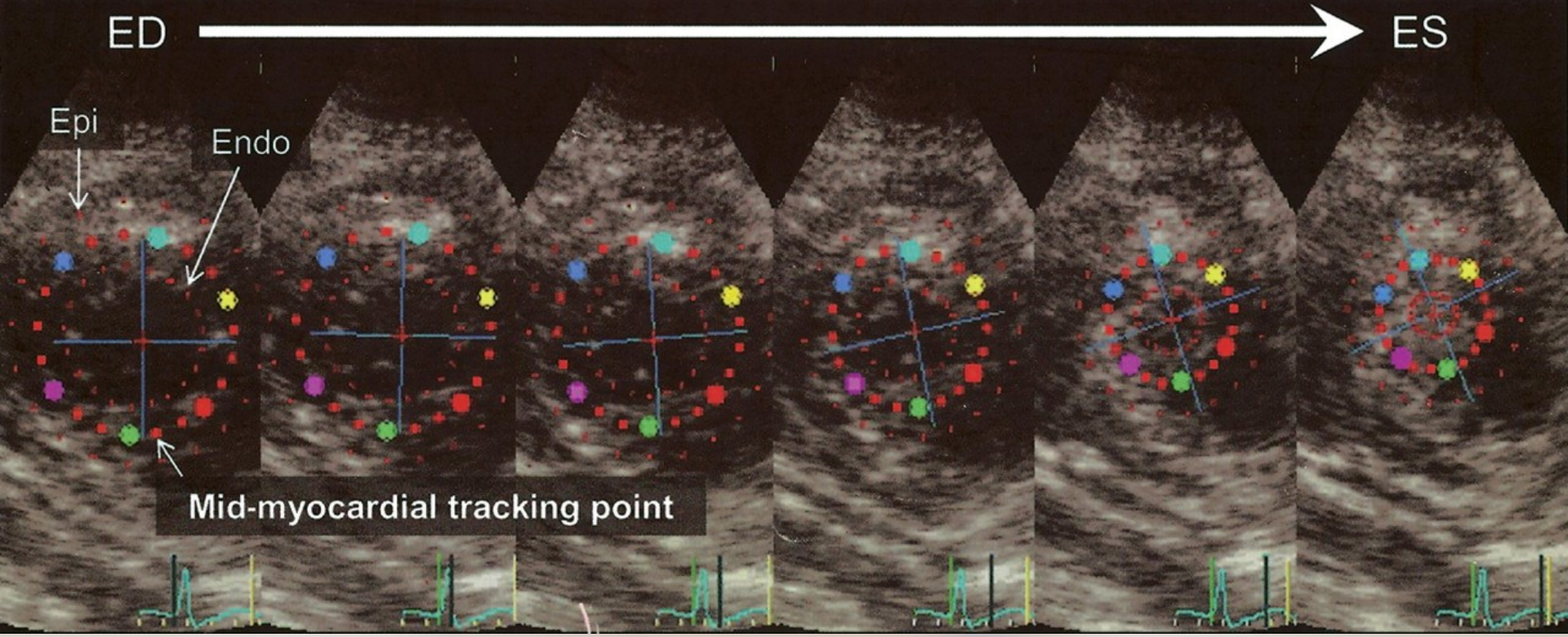
Apical



PSSAX

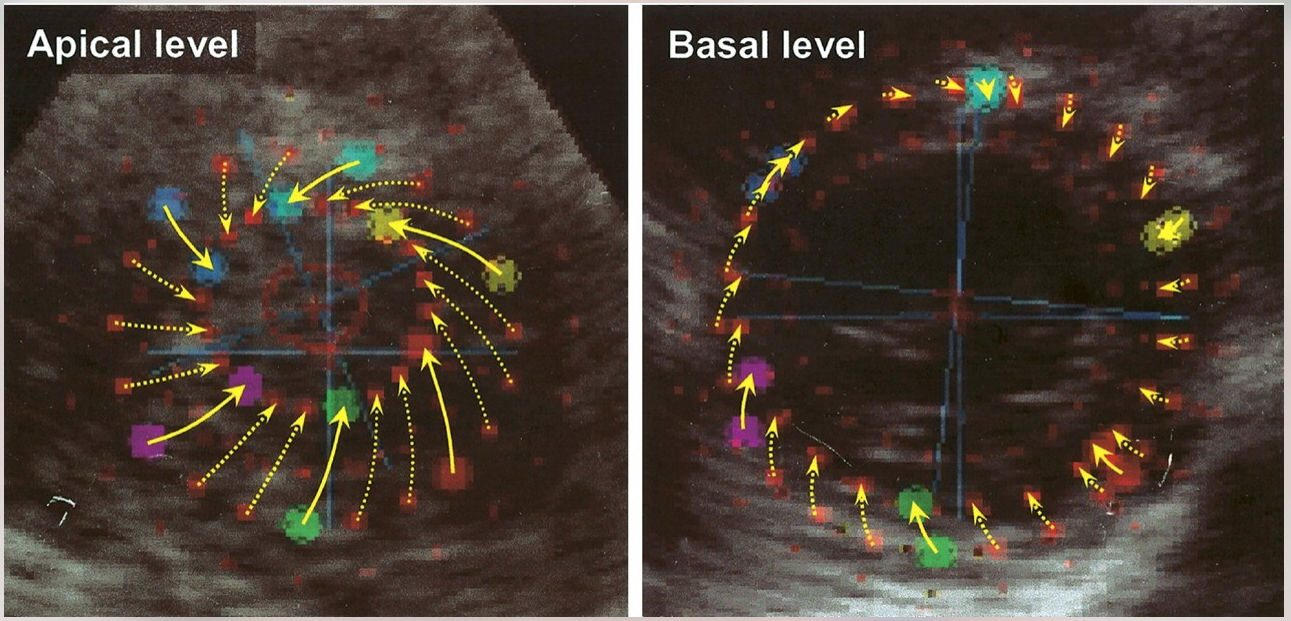
Strain can be evaluated as

- Longitudinal
- Transversal
- Radial
- Circumferential



Speckle tracking of successive two-dimensional images

Notomi, Y. et al. J Am Coll Cardiol 2005;4:2034-2041

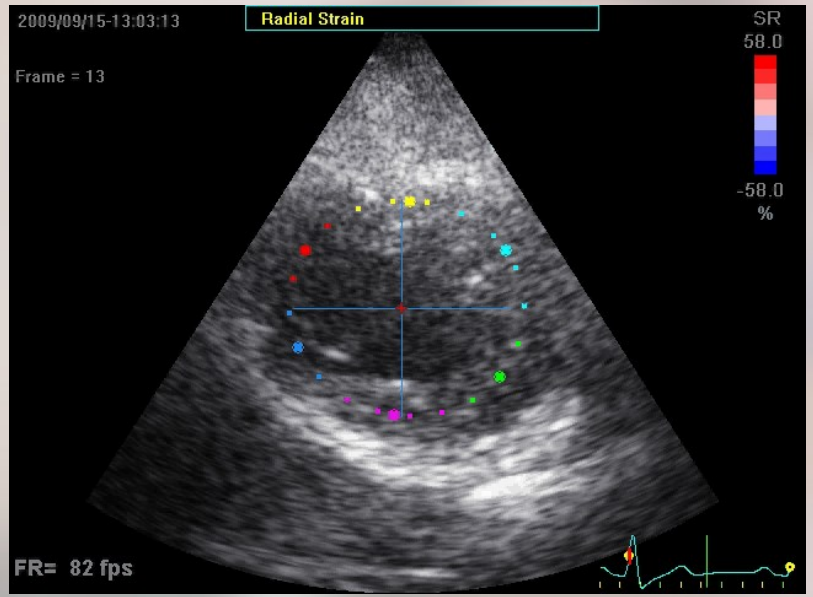


Left ventricular rotation (LVrot) at apical and basal levels during systole

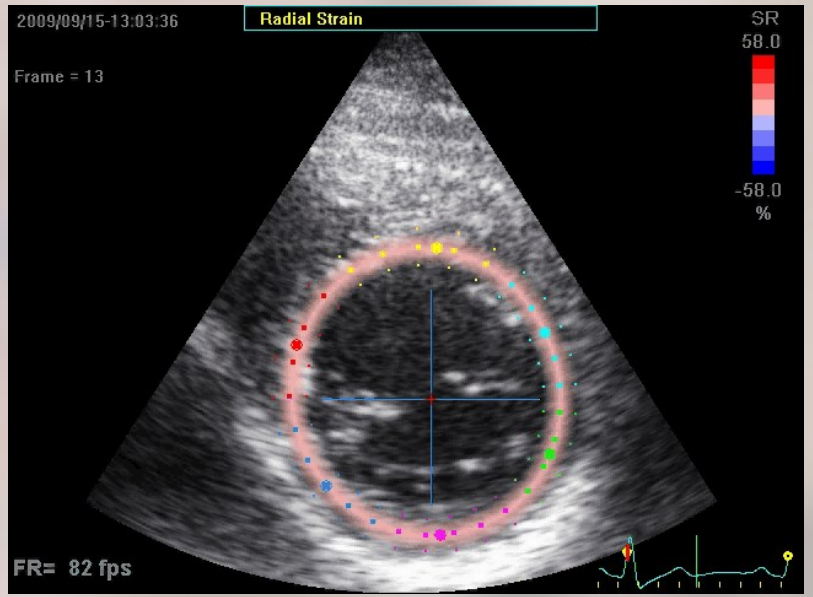
Notomi, Y. et al. J Am Coll Cardiol 2005;45:2034-2041

In practice

Apical level

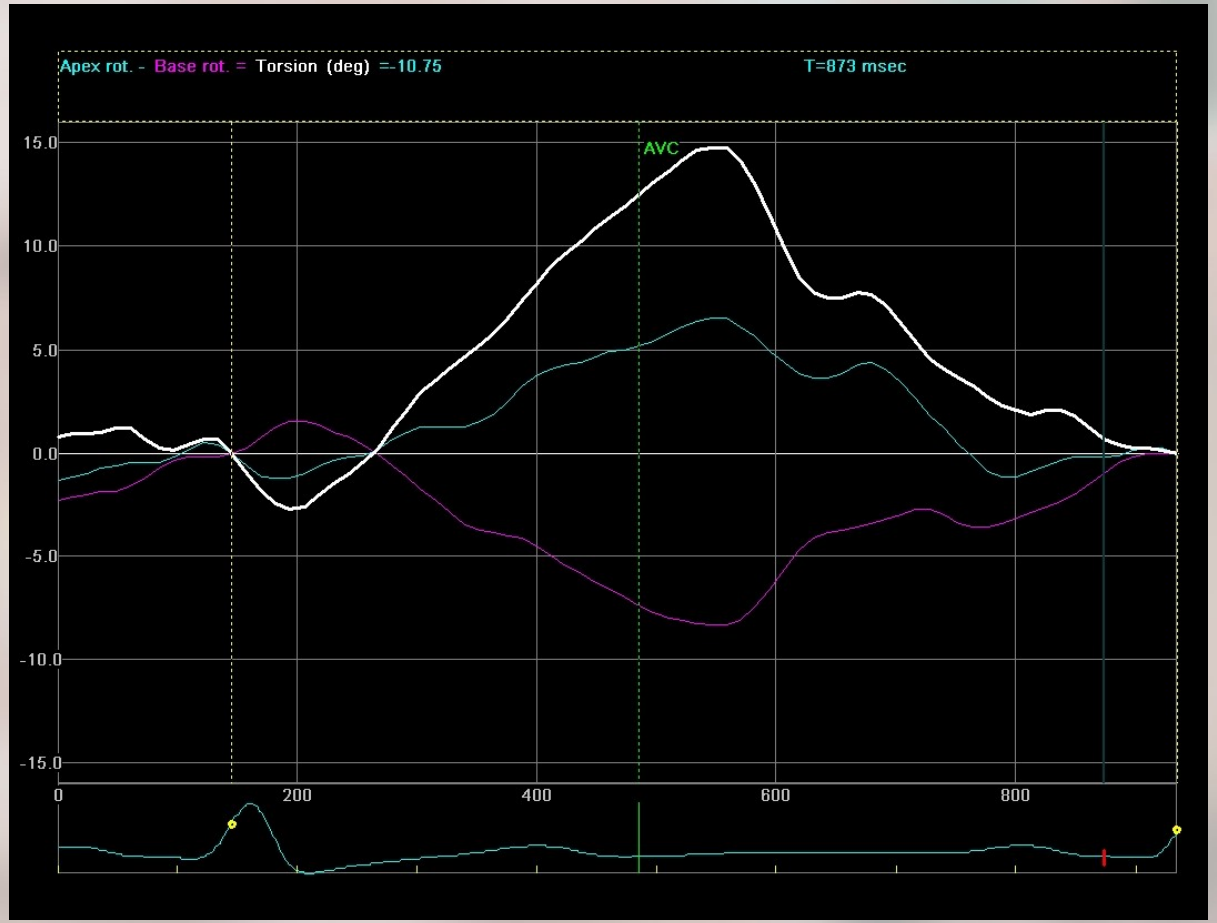


Basal Level



Torsion


apex
base


Apex rot. - Base rot. = Torsion (deg) =-10.75
T=873 msec
AVC
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
0
200
400
600
800

Clinical applications of 2D Strain

- Coronary artery disease
- Stress testing
- Left ventricular dyssynchrony
- Cardiomyopathy

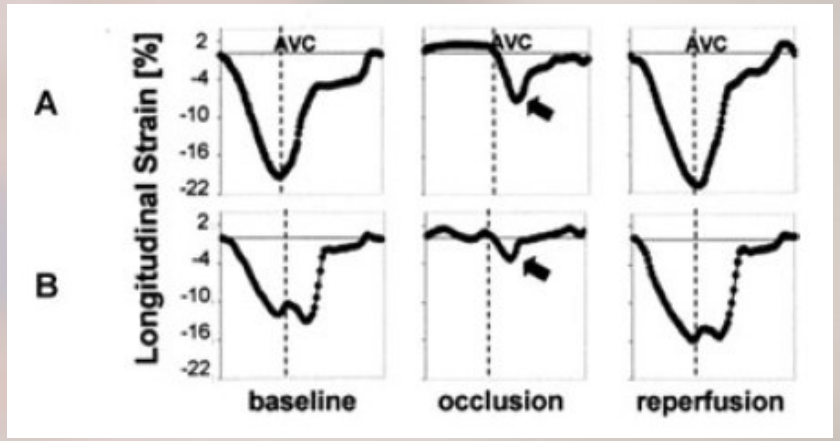
Evaluation of coronary artery disease

2D Strain

- Acuraat & reproduceerbaar
- Subtiele WBS
  - Kwantificatie
- Ontrafelen van complexe myocardiale contractie patronen:

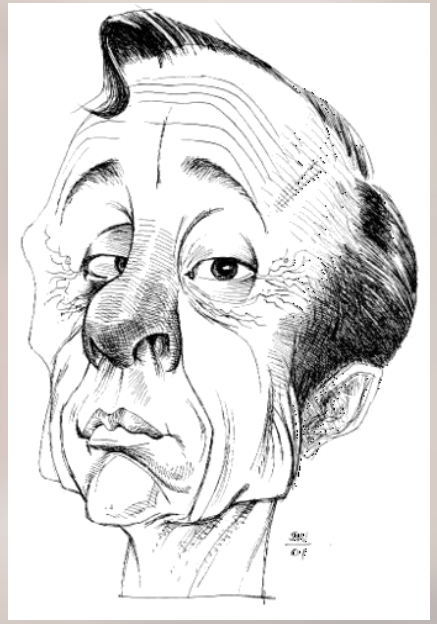
Akinesie	<6%
Hypokinesie	6-18%
Normokinesie	>18%
Hyperkinesie	>24%
Dyskinesie	stretching
Dyssynchronie	regional timing

Ischemic response



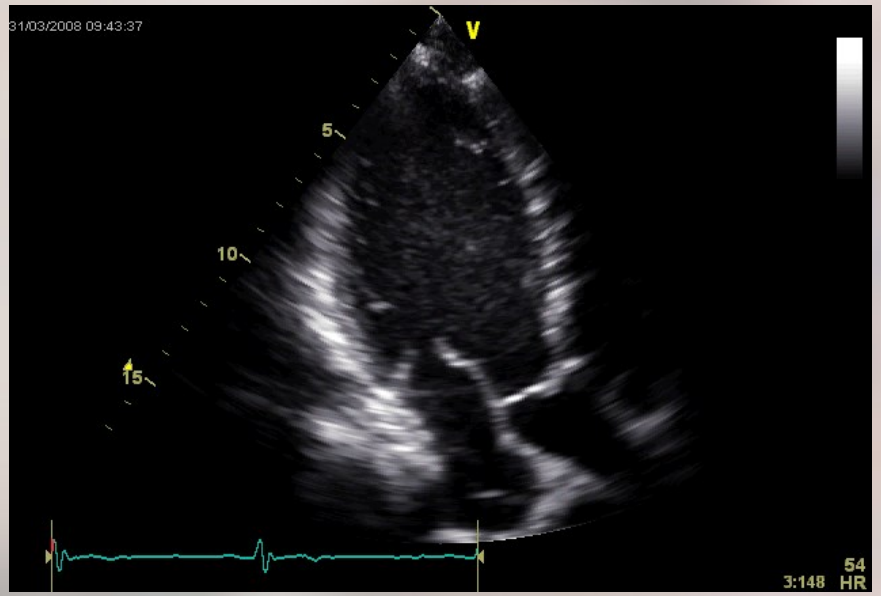
Echocardiography 2009;3:299-306

Ontrafelen van complexe contractie patronen

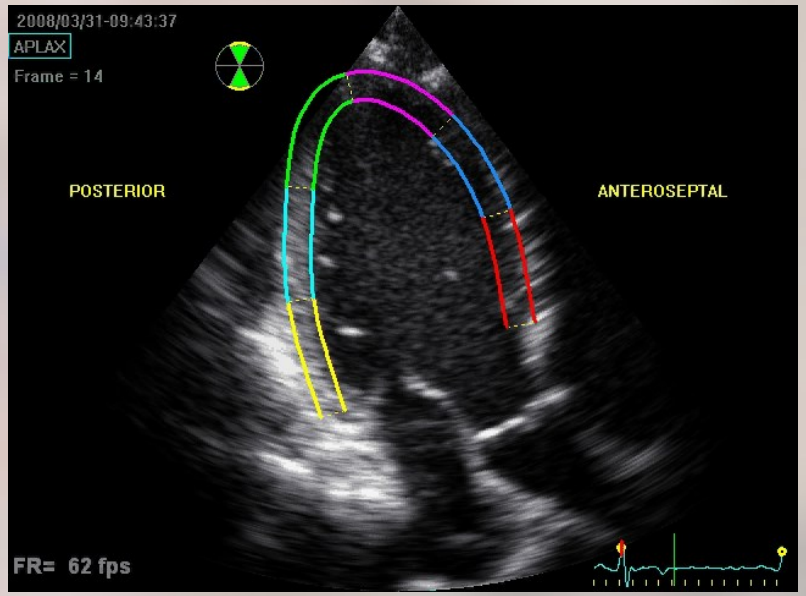


2D Strain in practice

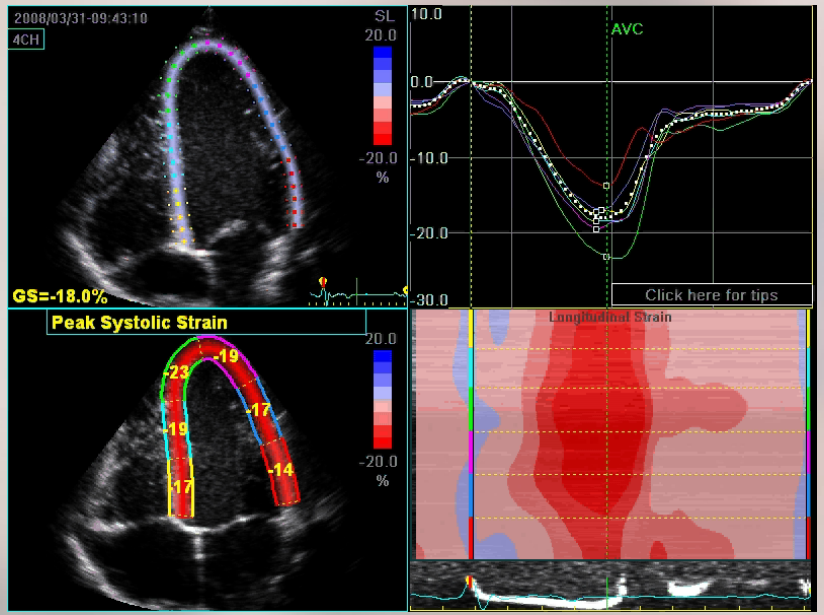
Plain 2D APLAX

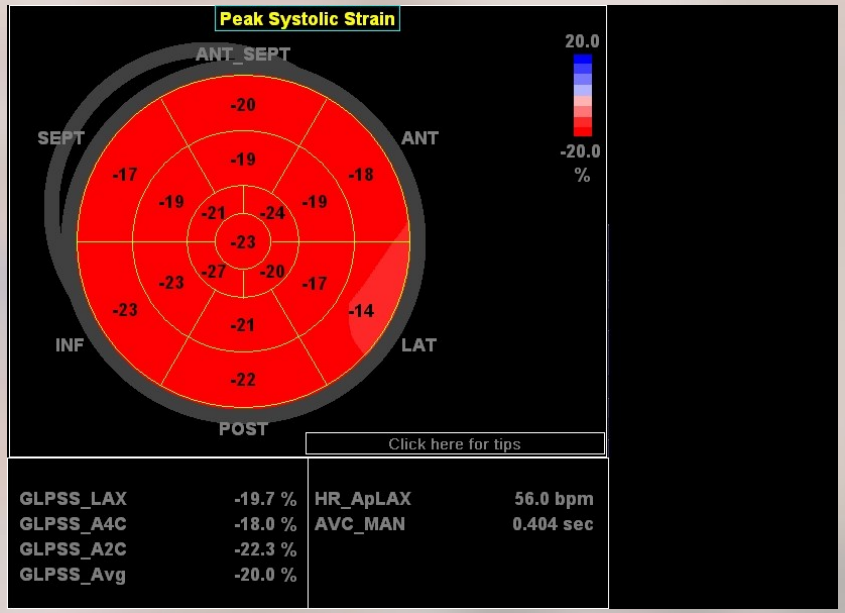


APLAX using 2D strain imaging



2D strain results

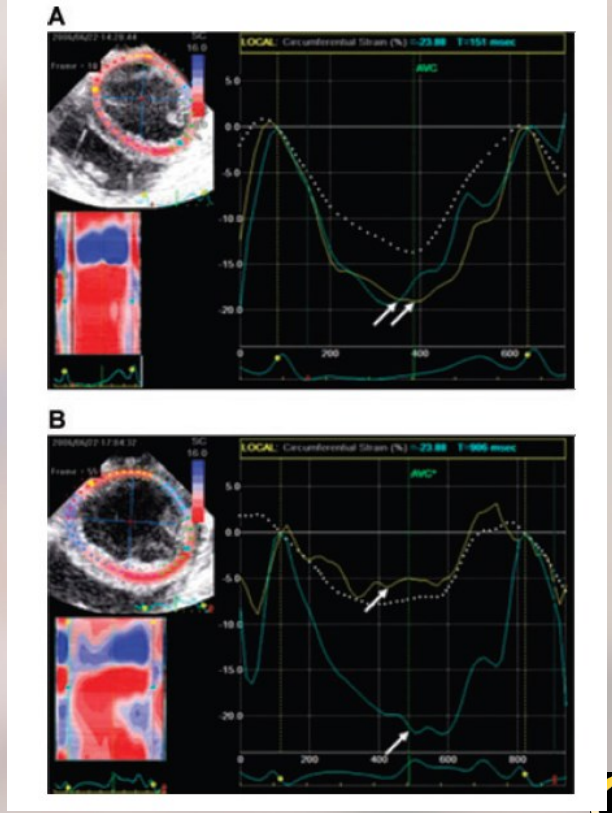




Stress testing

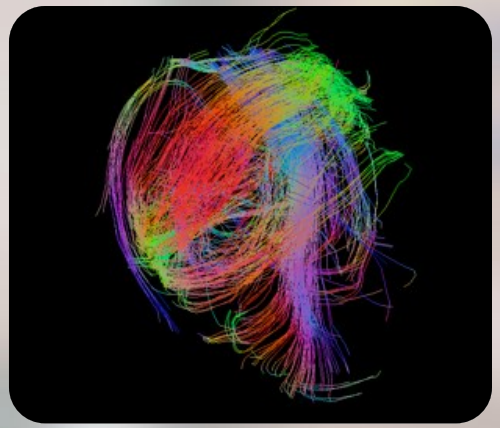
- Limitations stress echo:
  - Subjective interpretation
  - High level of expertise
  - Moderate reproducibility

- 2D strain:
  - Post processing
  - Longitudinal strain
  - Reliable measurements

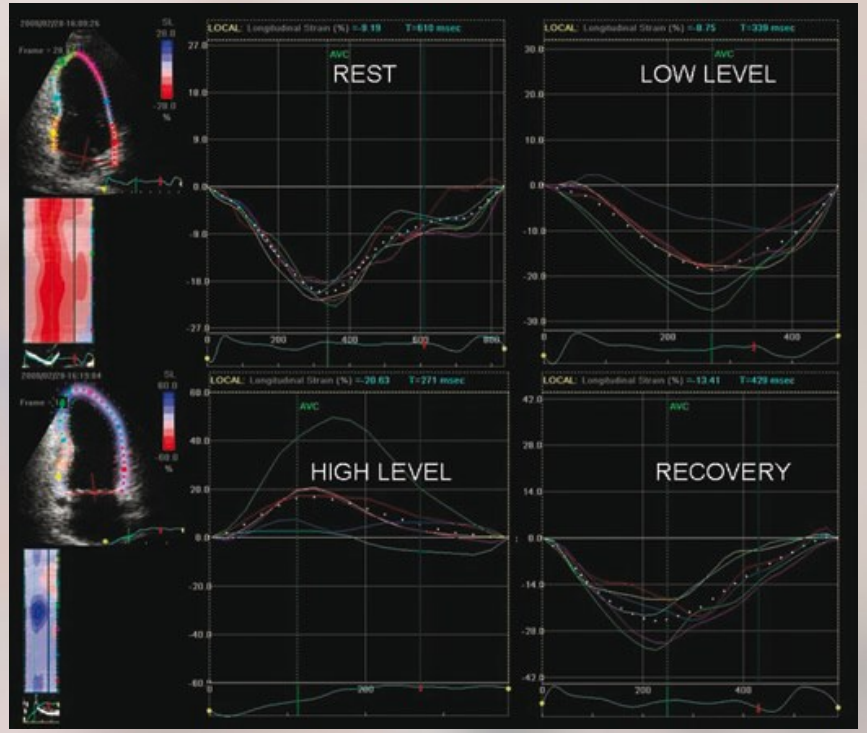


Stress testing

- Ischemic response
  - Longitudinal
  - Before radial
- Subendocardial fibers are oriented longitidinally

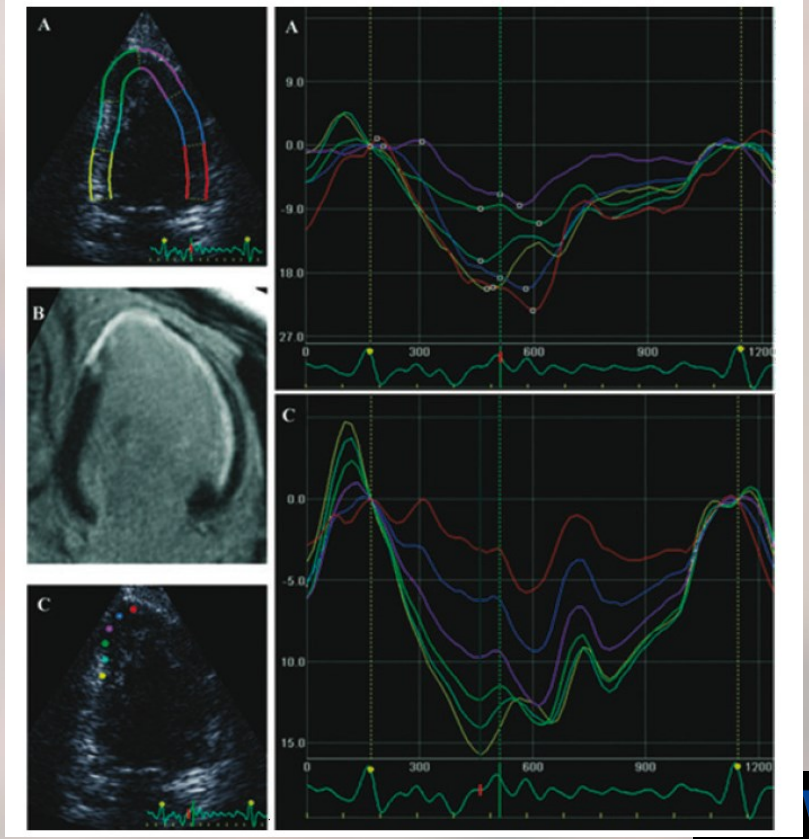


Diffusion Tensor Imaging (DTI)



Viability assessment

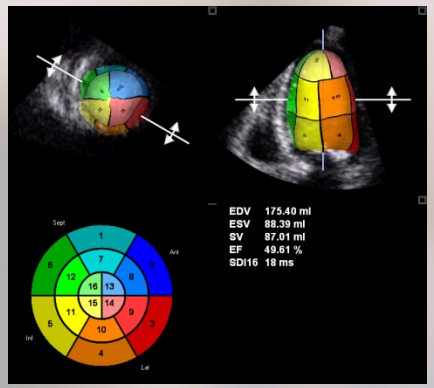
- Gradual decrease in strain with increasing transmurality of MI
- 2D strain:
  - Excellent prognostic value for functional recovery after revascularzation
- OLVG: confirmation study
  - 2D strain vs MRI



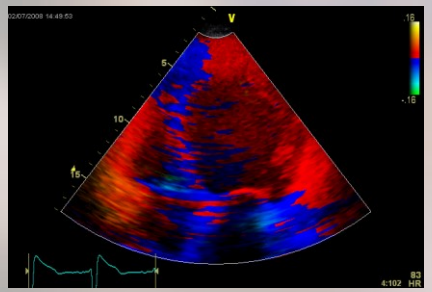
Left ventricular dyssynchrony

Methods

- RT3DE



- TDI



Disadvantages

- Limited availability
- Low spatial resolution

- Angle dependent
- Active vs passive
- High framerate (>130FPS)

Left ventricular dyssynchrony

Method

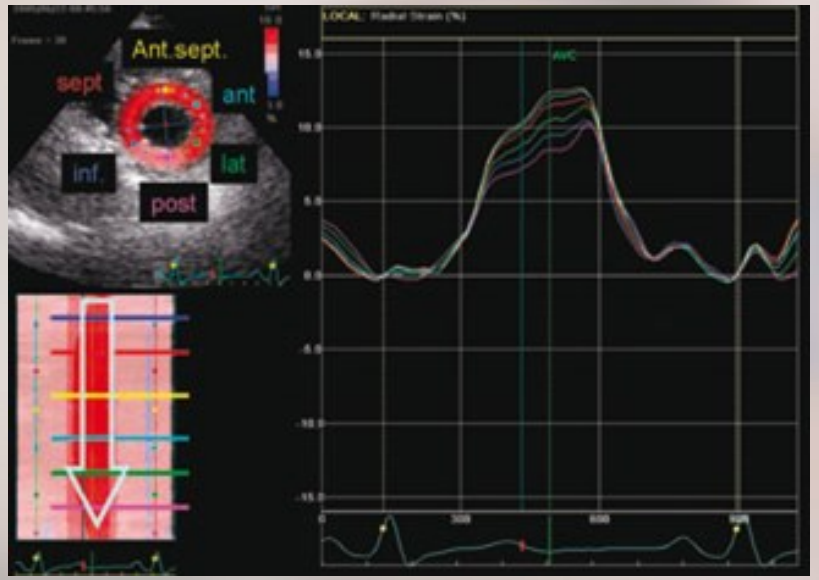
- 2D Strain

Advantages

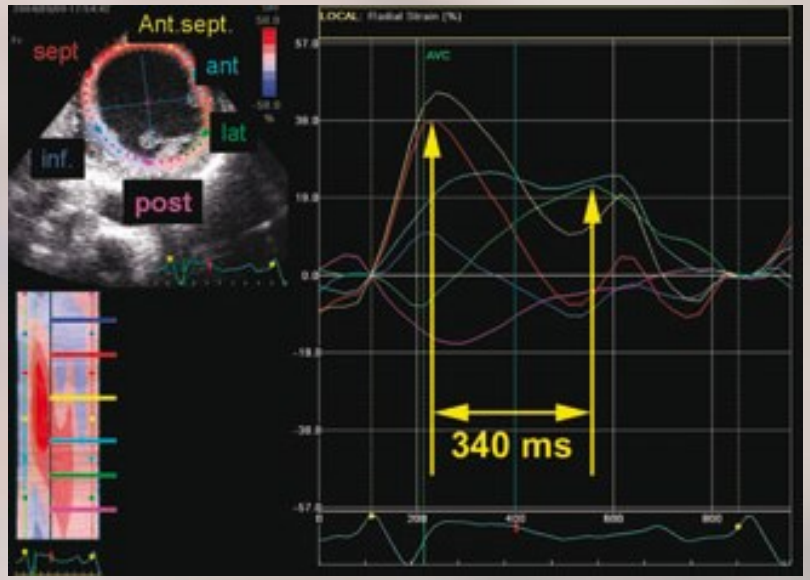
- Operator independent
- Less artifacts
- Not angle dependent
- Proper quantification
- Higher sensitivity and specificity regarding CRT responders

Example of dyssynchrony

Synchroon

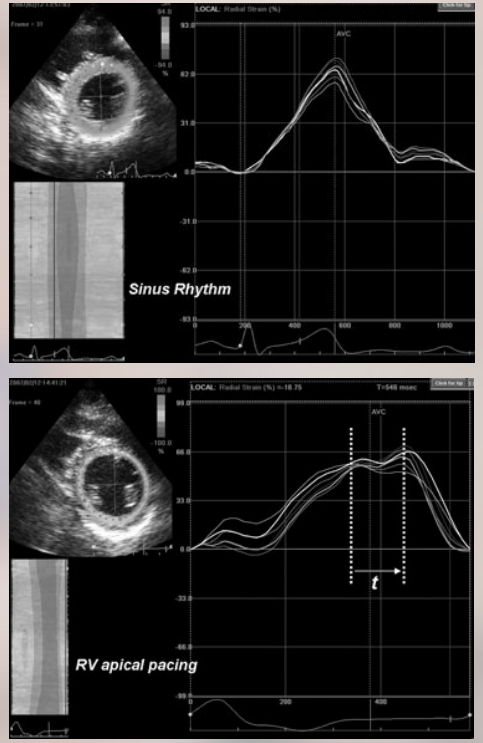


Dyssynchroon



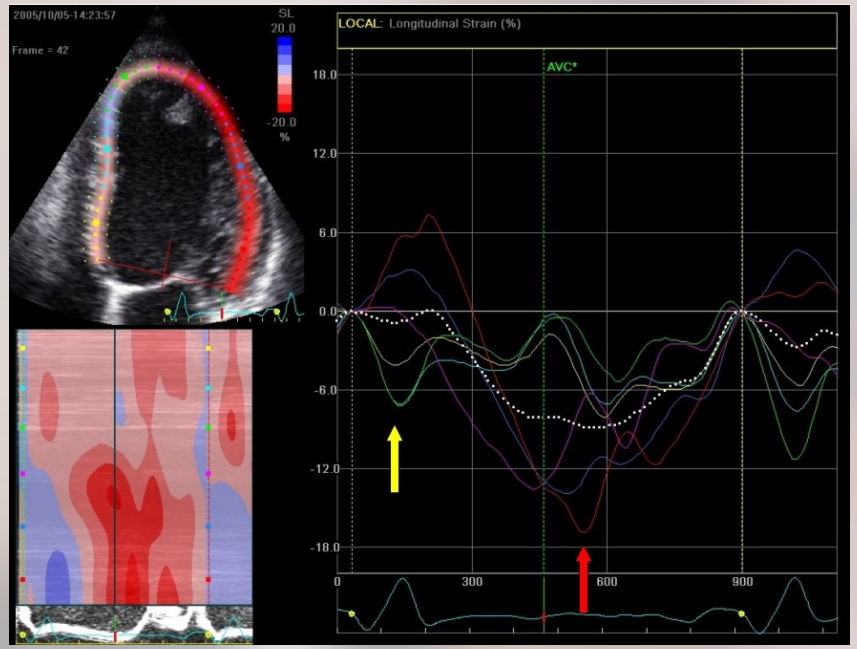
Left ventricular dyssynchrony

- Assessing dyssynchrony with 2D strain
  - Time-to-peak radial strain of 2 segments
    - ≥130ms
  - SD of time-to-peak longitudinal strain of 12 segments
    - ≥35ms

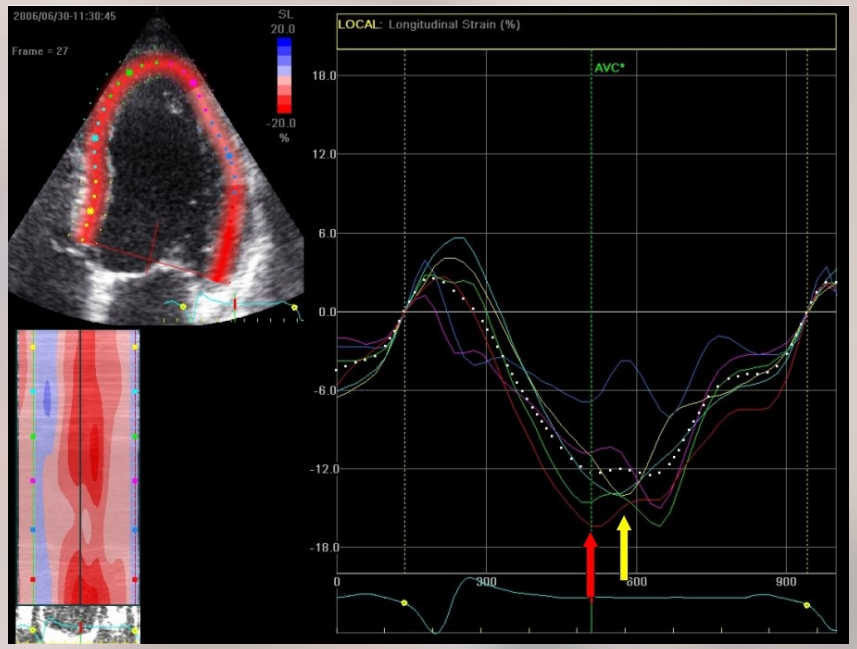


CRT optimalization

Voor CRT

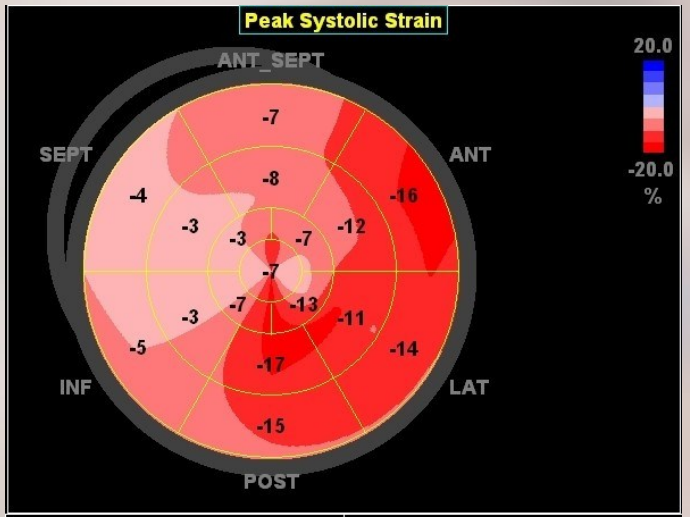


Na CRT



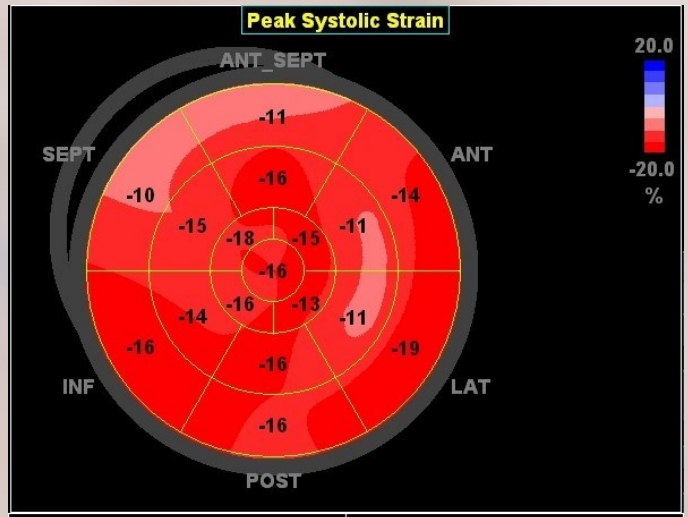
CRT optimalization

Voor CRT



GLPSS_LAX	-11.3 %	GLPSS_Avg	-10.1 %
GLPSS_A4C	-9.2 %	AVC_STORED	0.412 sec
GLPSS_A2C	-10.0 %		

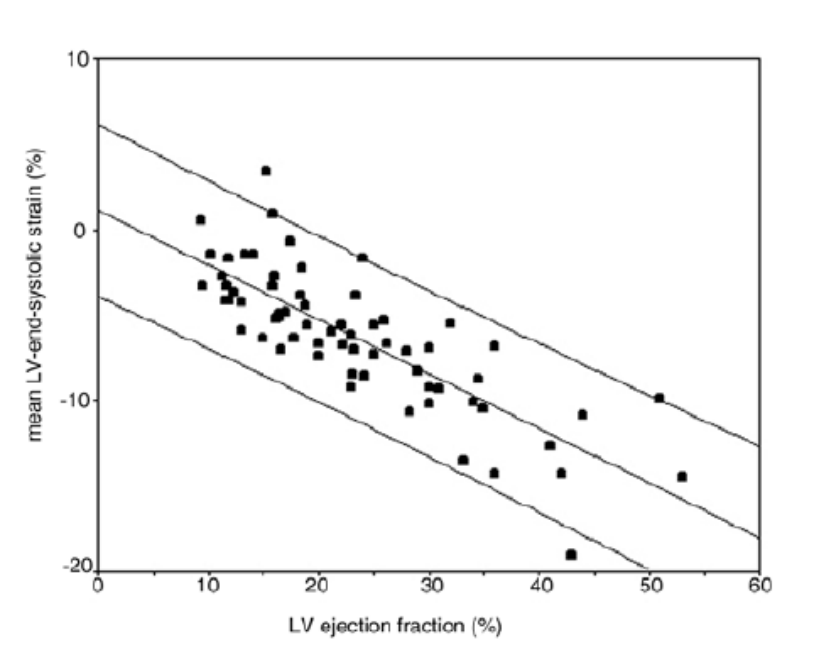
Na CRT



GLPSS_LAX	-14.3 %	GLPSS_Avg	-14.8 %
GLPSS_A4C	-14.7 %	AVC_MAN	0.408 sec
GLPSS_A2C	-15.3 %		

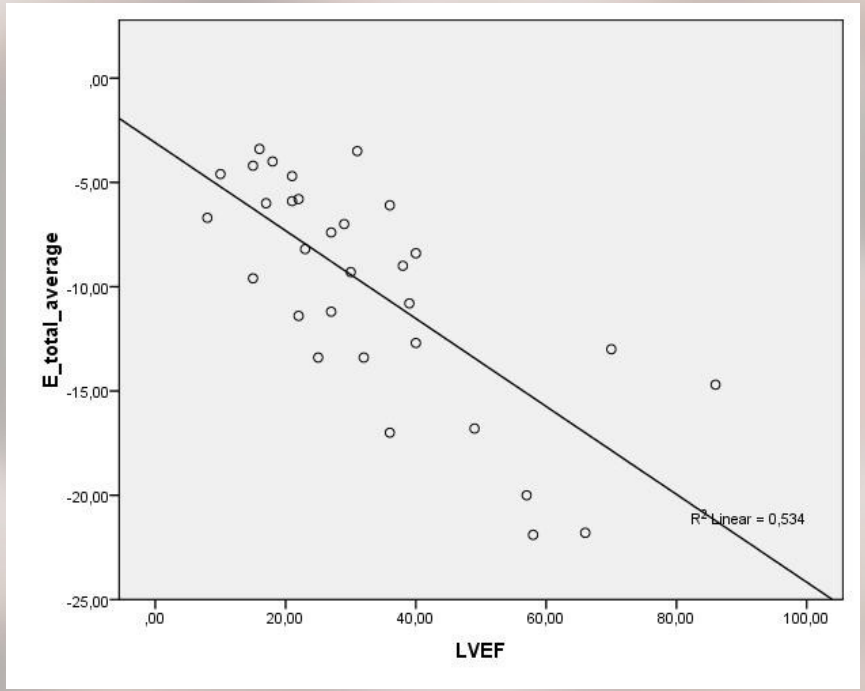
Cardiomyopathy

- LVEF
  - Simplistic approach
- 2D strain
  - Subtle dysfunction
  - Global vs. regional
  - Early identification



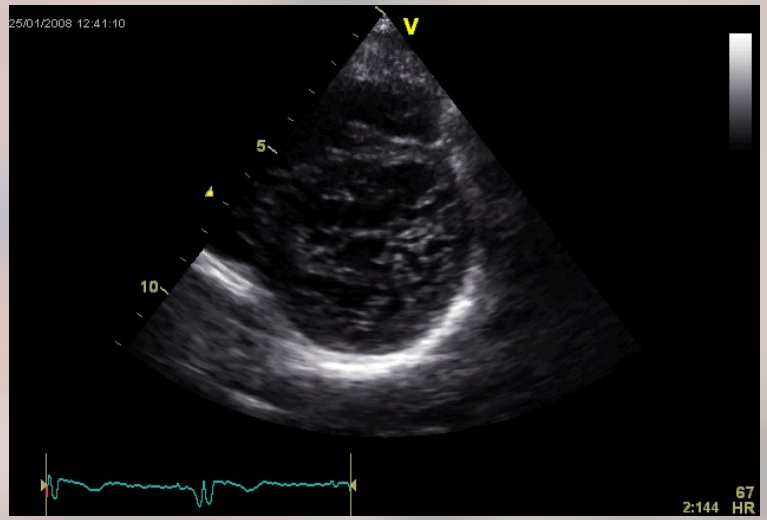
Cardiovascular ultrasound 2007;5:27

Confirmatie OLVG data

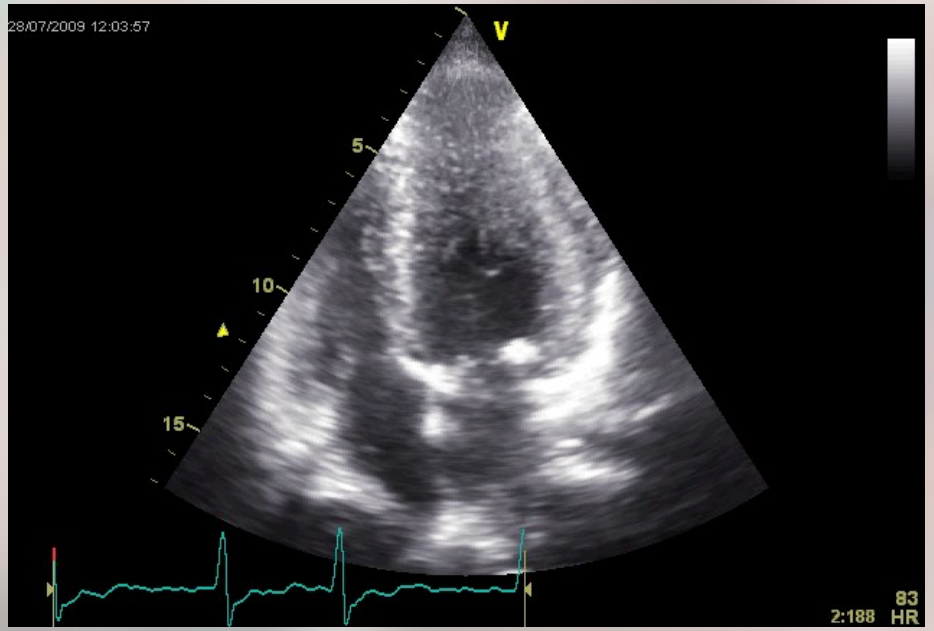


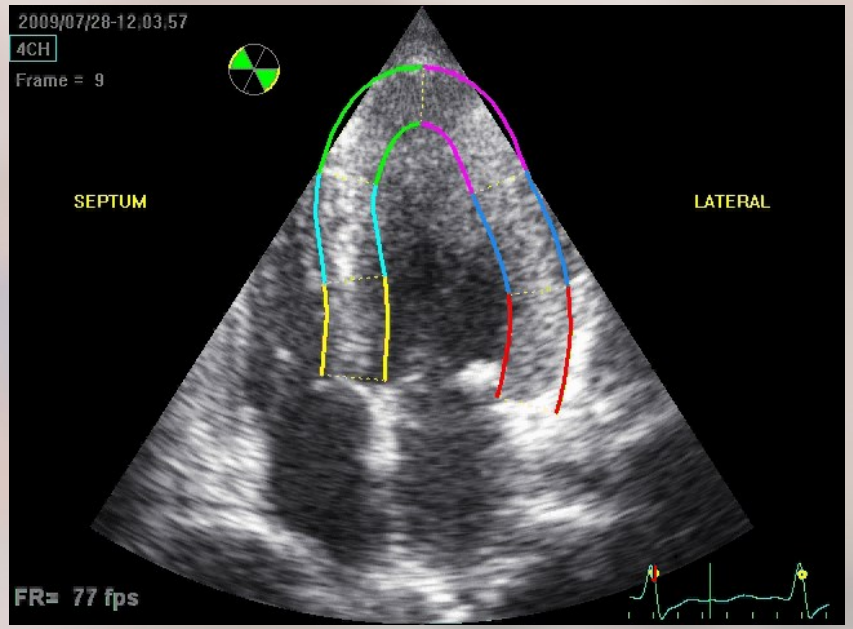
Subtiele afwijkingen

- Impaired longitudinal motion before ↓ EF.
  - Infiltratieve CM
  - NC CMP
  - HCM
  - HT CMP
  - ARVC

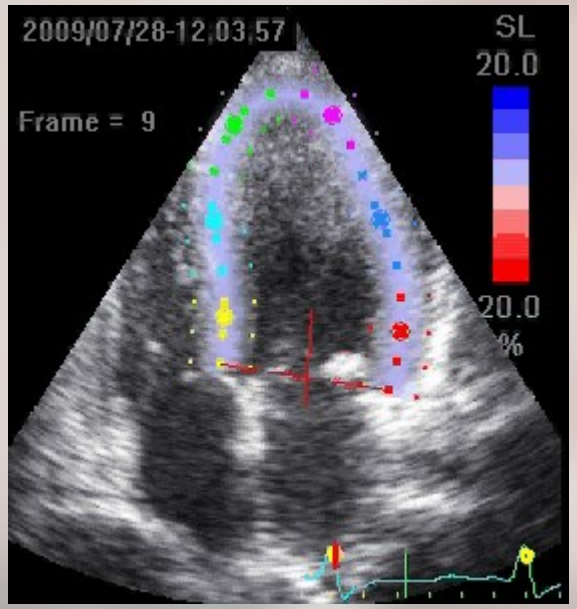


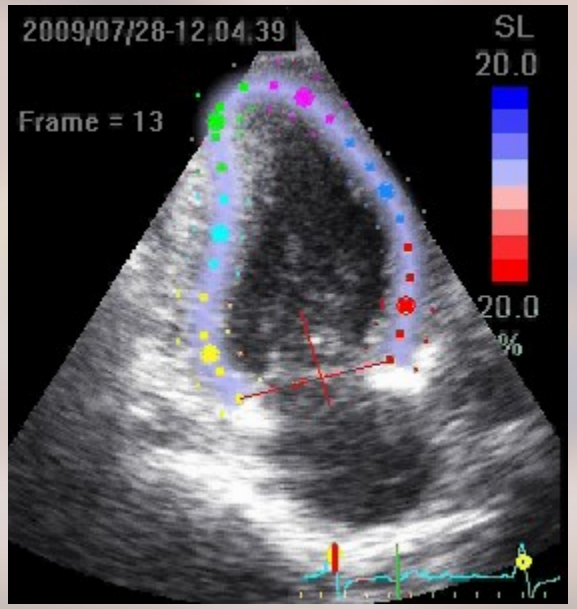
2D strain in cardiomyopathy

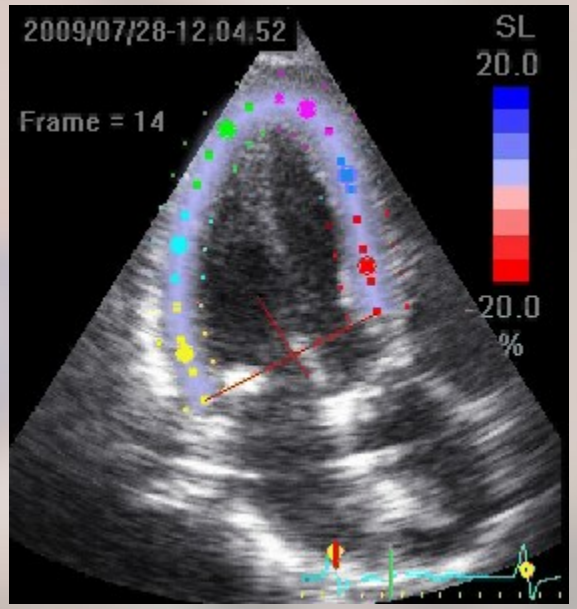




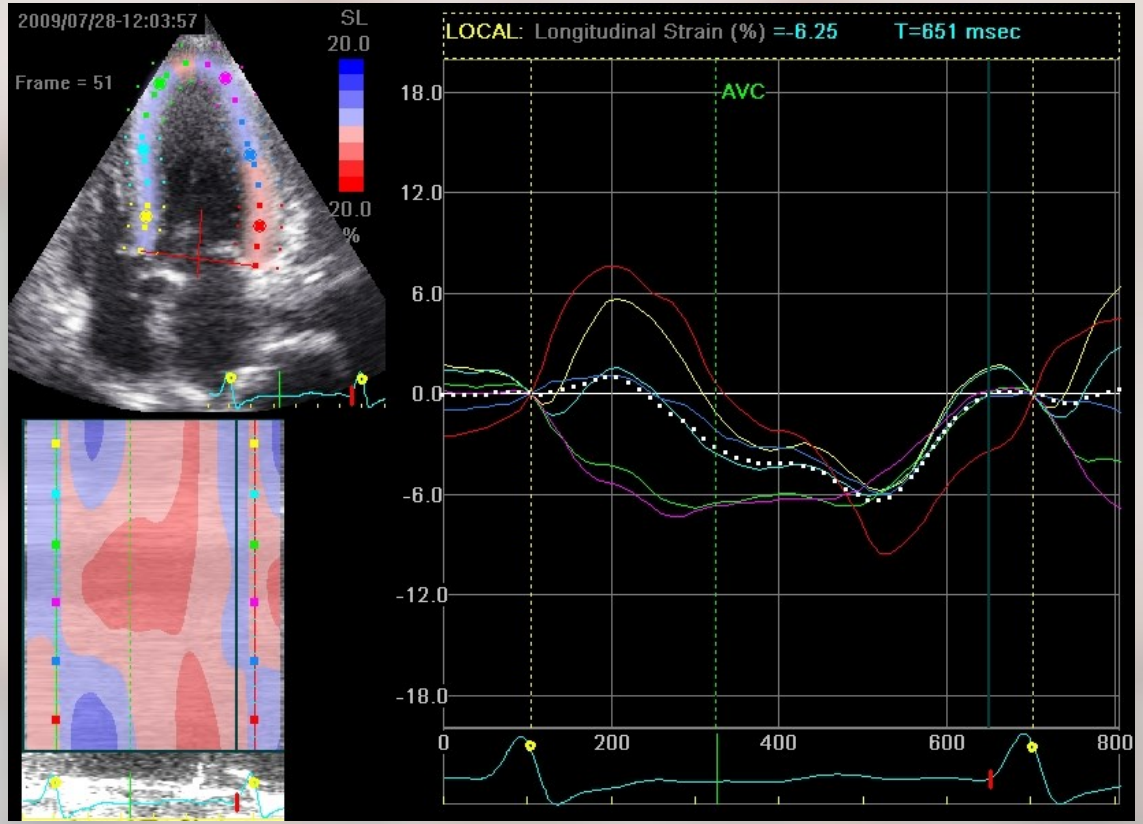
Offline 2D strain analysis





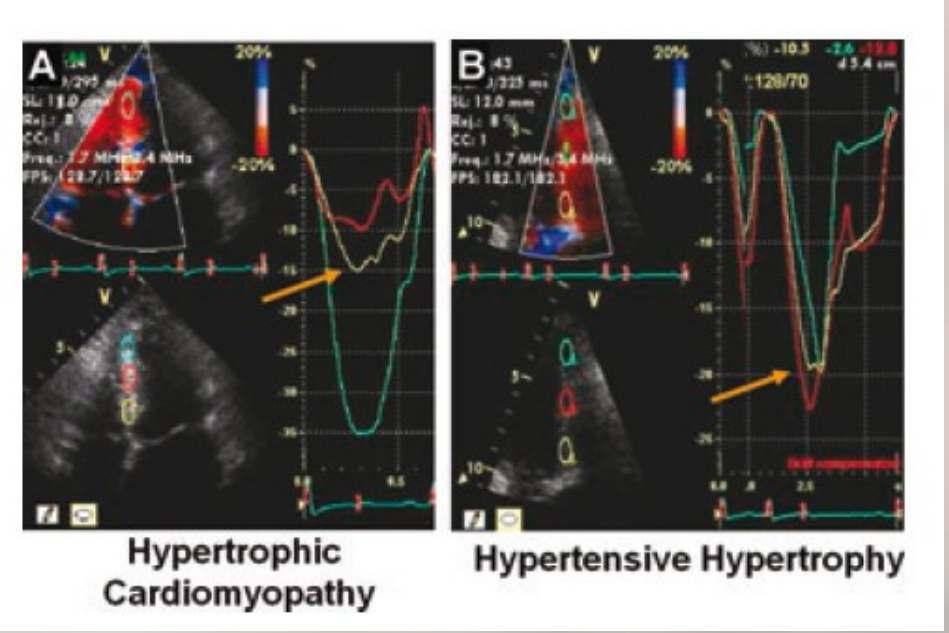


Morbus Fabry



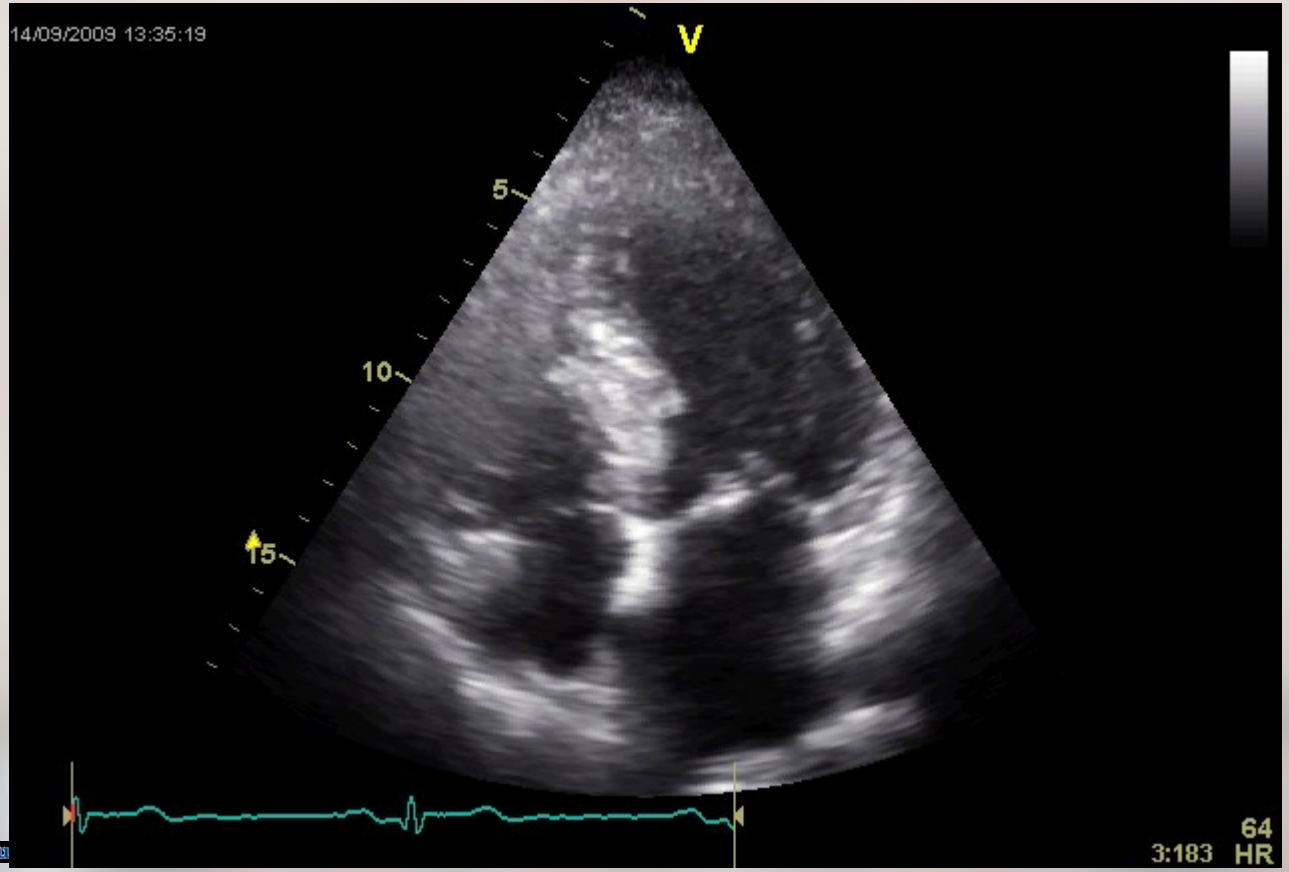
HCM vs LVH due to hypertension

- Differentiation by strain analysis
- HCM
  - Segmental abnormalities
    - Hypokinesie
    - Prestretching
    - Post-systolic shortening

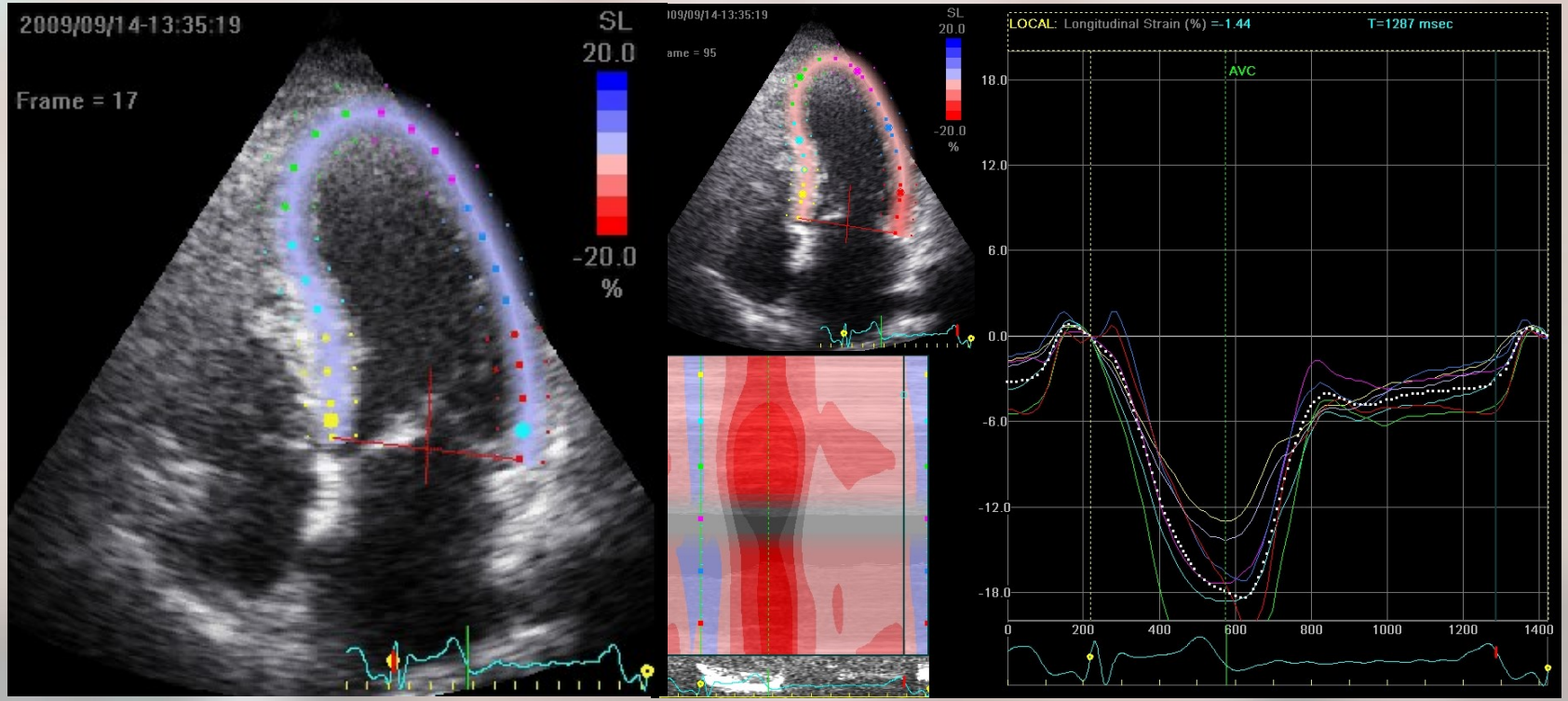


JASE 2003;16:233-239

HCM

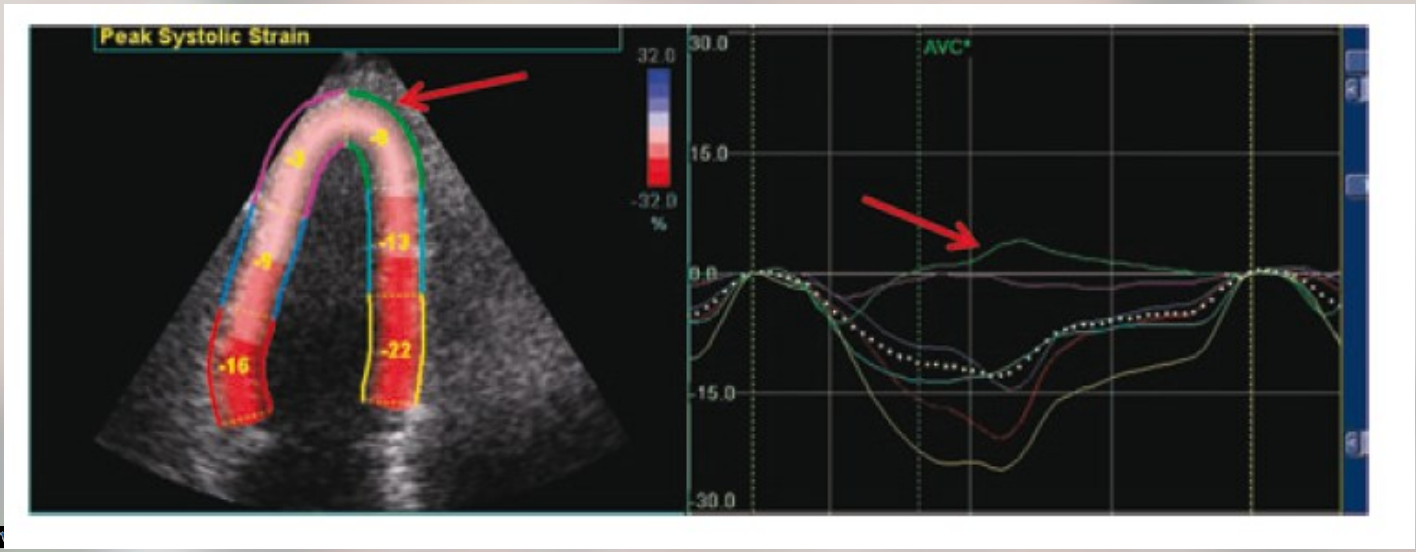


WMA's bij HCM

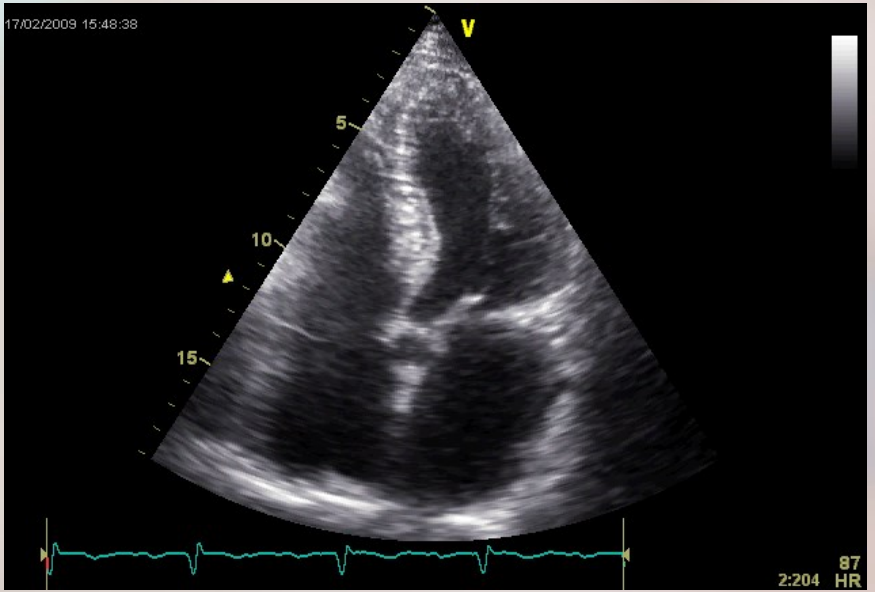

2009/09/14-13:35:19
Frame = 17
SL
20.0
-20.0
%
LOCAL: Longitudinal Strain (%) =-1.44
T=1287 msec
AVC
18.0
12.0
6.0
0.0
-6.0
-12.0
-18.0
0
200
400
600
800
1000
1200
1400

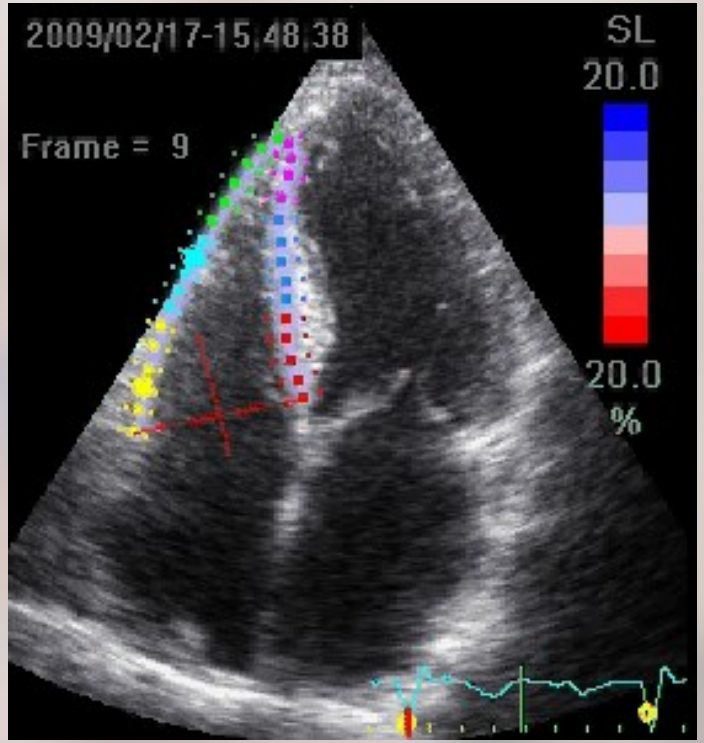
HCM

- Apical HCM; EF preserved
- Strain highlights the link between abnormality and systolic mechanics



Rechter ventrikel functie





Evaluatie RV

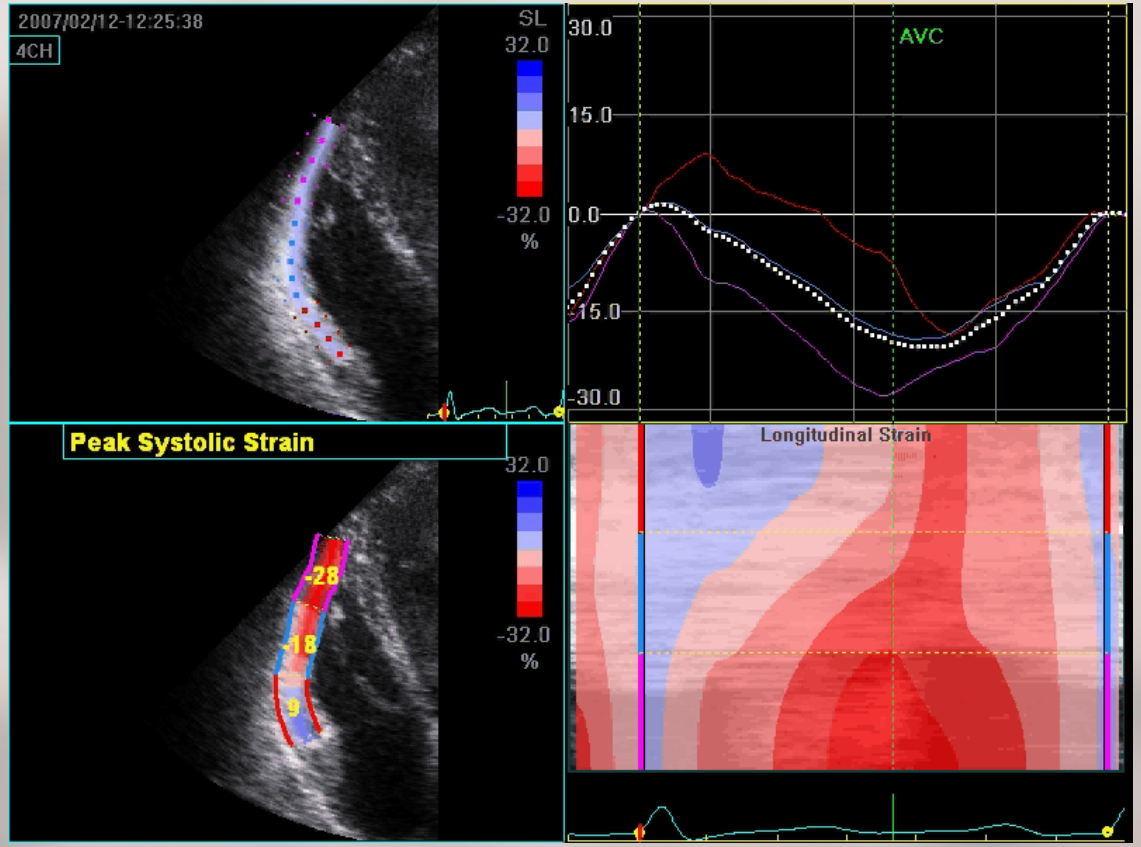
Motion independent deformation parameters (S, SR) appear superior in the accurate description of regional RV function.

Heart. Published Online First: 30 August 2009. doi:10.1136

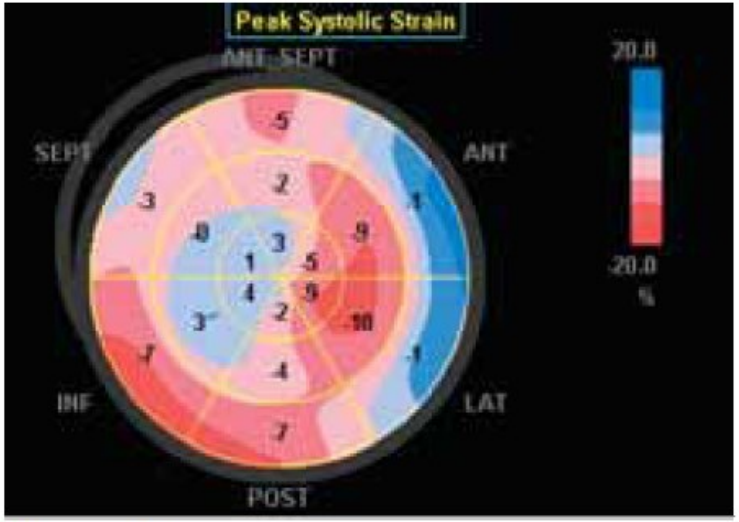
olvg

ARCV

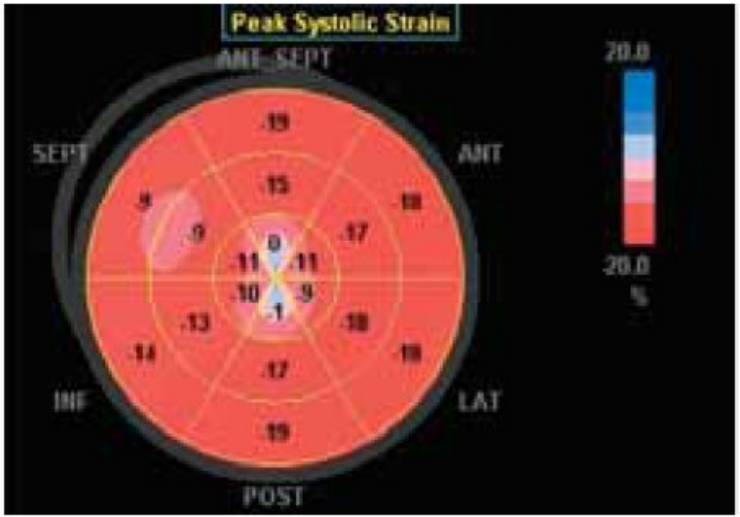
2D strain superieur aan TAPSE



Use 2D Strain for follow up



Myocarditis

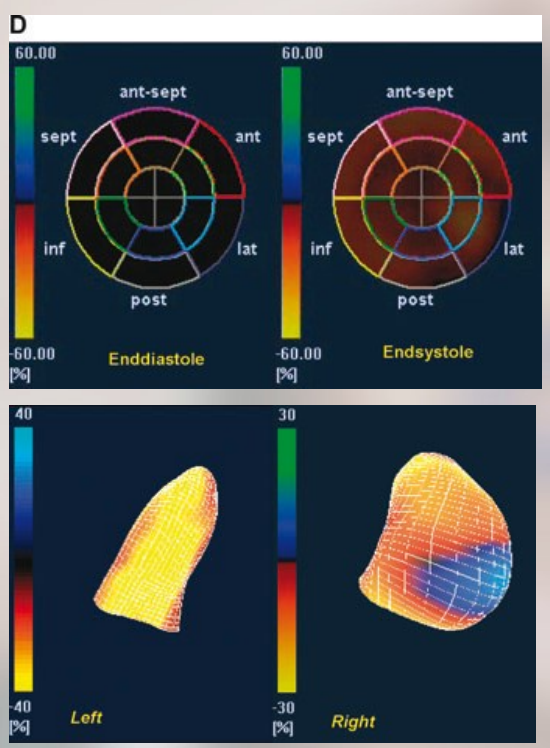


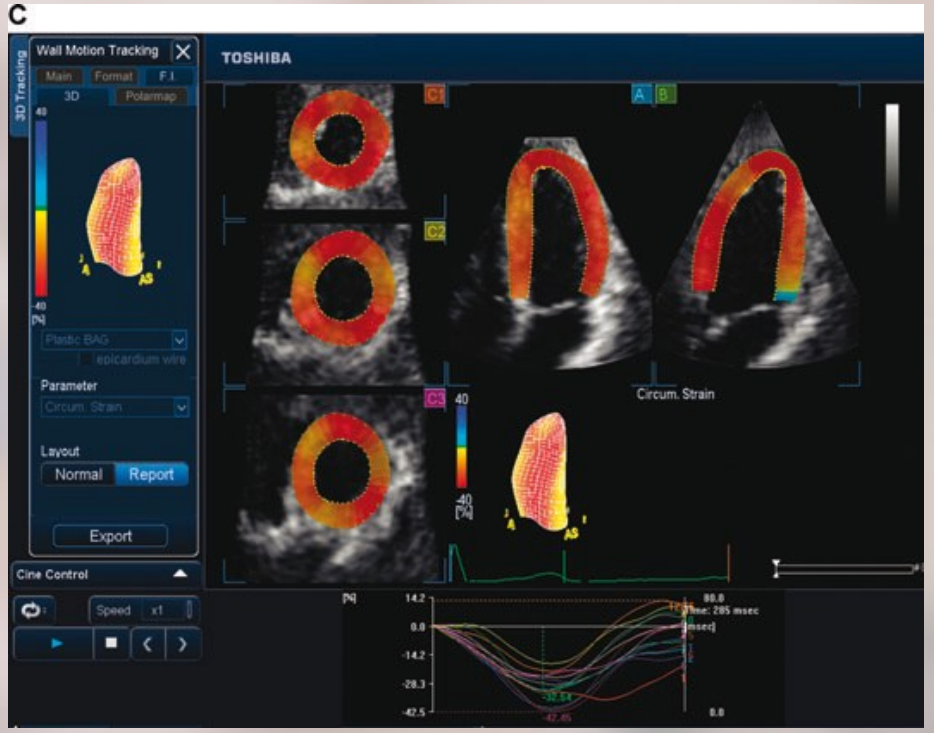
Recovery

Tips and Tricks

- Image quality: noice & near field clutter
- Frame rate (40-90 Hz)
- Region of interest (ROI): dikte vh myocard
- Endocardiac border tracing: Visual confirmation
- Check AVC settings

Future developments: 3D Strain





Jacc 2008;51 Suppl A, A116 (abstract)

Keep watching the speckles
There is more to come!