EAE Teaching Course
Sofia, 2012

Myocardial Function Imaging:
How to do it in the clinic?

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Myocardial Function Imaging

Why to Quantify Myocardial Function ?

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Assessment of Myocardial Function

conventional echo:

- **wall thickening**
- **endocardial motion**

- **longitudinal shortening ?**
- **timing of events ?**

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Assessment of Myocardial Function

conventional echo:

- **visual, subjective**
- **semi-quantitative**
- **poor temporal resolution**
- **image quality dependent**

We need to objectify echocardiography !

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Myocardial Function Imaging

How to Measure Myocardial Function ?

Tissue Doppler & Tracking

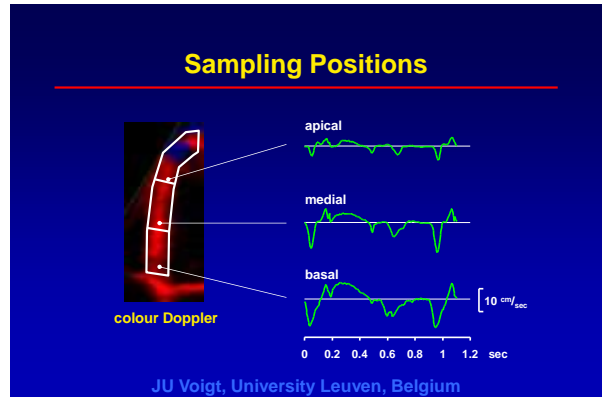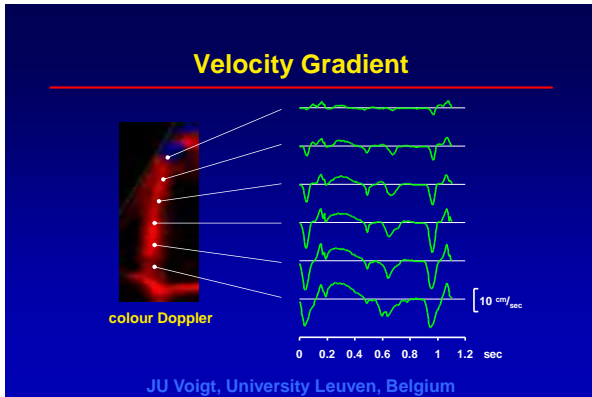JU Voigt, University Leuven, Belgium

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Tissue Doppler

myocardial velocity measurement

Systole   Diastole

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Velocity Gradient

colour Doppler

10 cm/sec

0   0.2 0.4 0.6 0.8   1   1.2 sec

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Sampling Positions

apical

medial

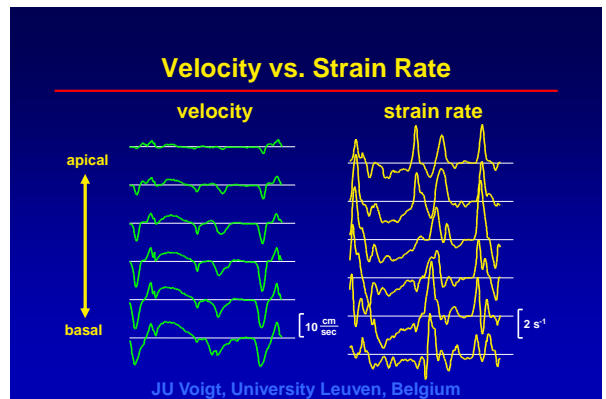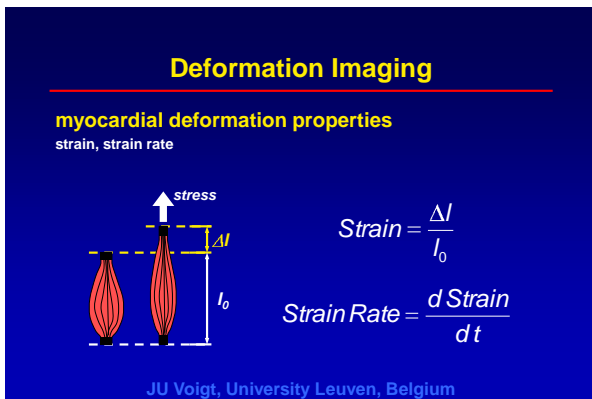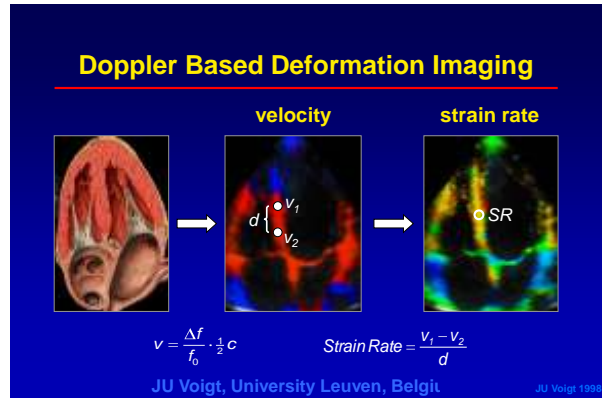basal

colour Doppler

10 cm/sec

0   0.2 0.4 0.6 0.8   1   1.2 sec
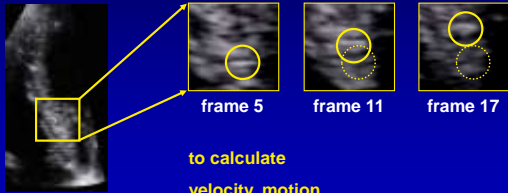
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Assessing Myocardial Function

How

far / fast

does the myocardium

move ?

How

much / fast

does the myocardium

deform ?

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Doppler Based Deformation Imaging

velocity   strain rate

$d \{ \begin{matrix} v_1 \\ v_2 \end{matrix}$ SR

$$v = \frac{\Delta f}{f_0} \cdot \tfrac{1}{2} c \qquad Strain\,Rate = \frac{v_1 - v_2}{d}$$

JU Voigt, University Leuven, Belgium   JU Voigt 1998

Deformation Imaging

myocardial deformation properties
strain, strain rate

stress

Δl

l_0

$$Strain = \frac{\Delta l}{l_0}$$

$$Strain\,Rate = \frac{d\,Strain}{d\,t}$$

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Velocity vs. Strain Rate

velocity   strain rate

apical

basal

$10 \frac{cm}{sec}$ $2\,s^{-1}$

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Tracking Based Deformation Imaging

following patterns in the image
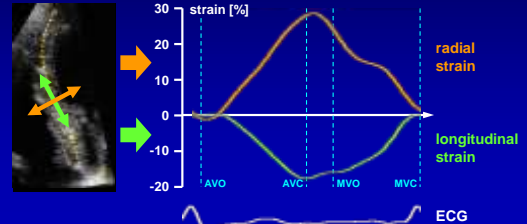
frame 5   frame 11   frame 17

to calculate

velocity, motion, deformation, (deformation rate)

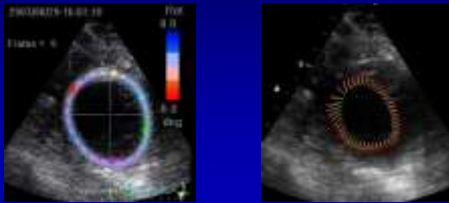JU Voigt, University Leuven, Belgium

Tracking Based Deformation Imaging

longitudinal and radial strain

strain [%]

radial strain

longitudinal strain

AVO   AVC   MVO   MVC

ECG

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Tracking Based Deformation Imaging

different solutions

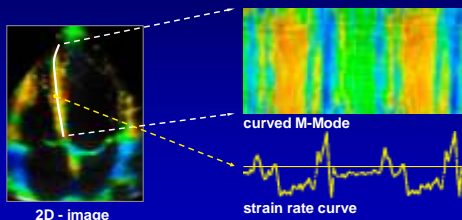JU Voigt, University Leuven, Belgium

Deformation Imaging

How to interpret data?

... normal patterns

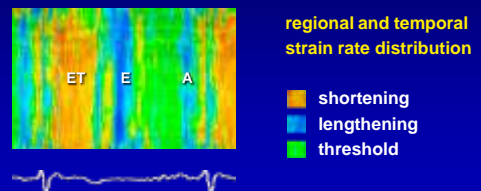JU Voigt, University Leuven, Belgium

Deformation Imaging

tissue Doppler based deformation analysis

curved M-Mode

strain rate curve

2D - image

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Deformation Imaging

strain rate curved M-Mode

ET   E   A

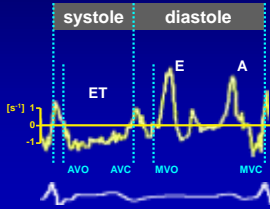**regional and temporal strain rate distribution**

- shortening
- lengthening
- threshold

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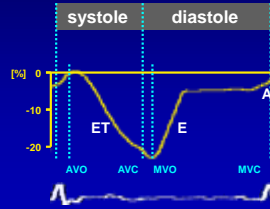**Deformation Imaging** — strain rate curve

amplitude and time course of regional strain rate

(-) shortening
(+) lengthening

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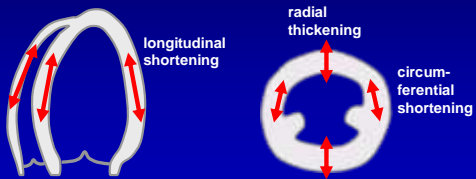

Deformation Imaging — strain curve

amplitude and time course of regional legth changes

downslope: shortening
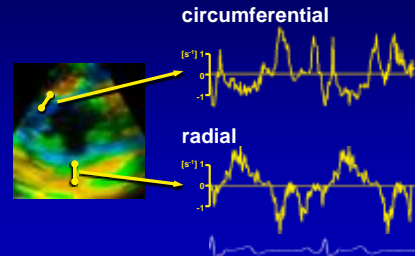upslope: lengthening

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Measurable Strain/-Rate Components

Doppler based measurements always along the ultrasound beam !

longitudinal shortening

radial thickening

circum-ferential shortening

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Measurable Strain Rate Components

circumferential
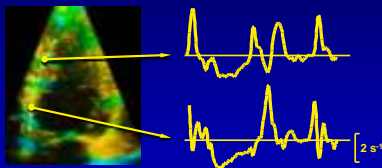
radial

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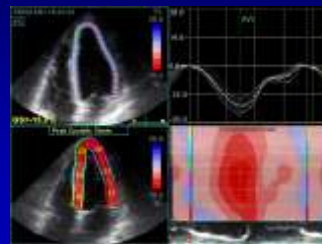

Measurable Strain Rate Components

longitudinal

2 s⁻¹

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Deformation Imaging

tracking provides additional information

parameters
velocity
motion
strain
strain rate
global strain

components
longitudinal
radial
circumferential
torsion

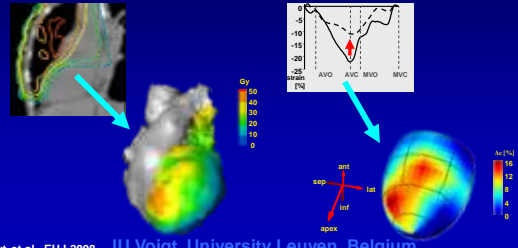JU Voigt, University Leuven, Belgium

Deformation Imaging

How to interpret data?

... pathologic patterns

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Pattern I: Reduced Strain Amplitude
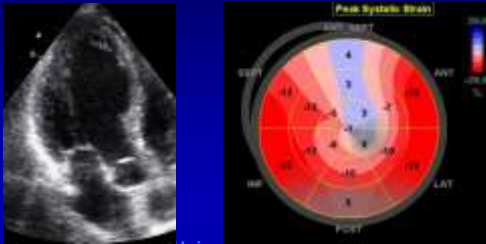
e.g. reduced longitudinal strain after radiotherapy

Jurcut et al., EHJ 2008   JU Voigt, University Leuven, Belgium

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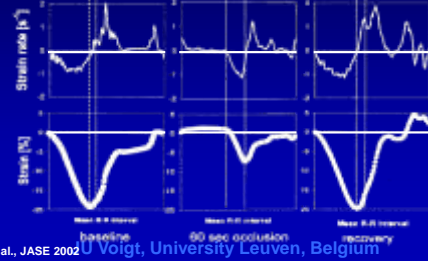## Pattern I: Reduced Strain Amplitude

e.g. reduced strain in infarct regions

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Pattern II: Altered Temporal Sequence

e.g. post-systolic shortening in acute ischemia

Kukulski et al., JASE 2002   JU Voigt, University Leuven, Belgium

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Myocardial Function Imaging

Is it difficult to do?

... a step-by-step approach

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„Deformation Imaging is Difficult !"

"... difficult to acquire ..."

"... time demanding post-processing ..."

"... tissue Doppler is better ..."

("... curves are noisy ...")

("... data are not reproducible ...")

You need to learn it !

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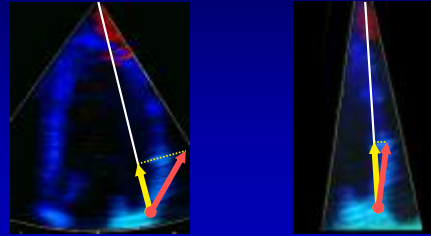## Is Data Acquisition Difficult ?

How to acquire good data.
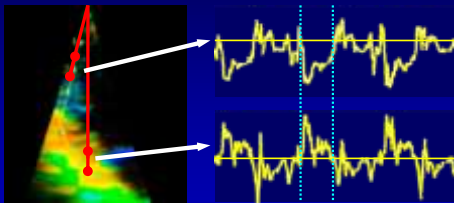
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Angle Dependence

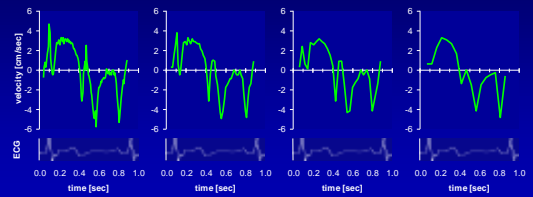**align beam to motion direction**

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Angle Dependence

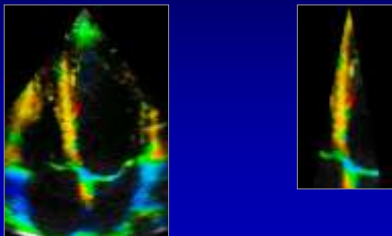JU Voigt, University Leuven, Belgium

Frame Rate Dependence

140 bps   **70 bps**   **35 bps**   **20 bps**

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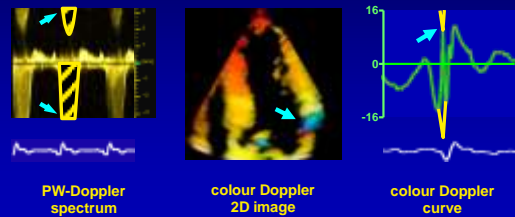## Optimizing Frame Rate

depth, sector, PRF

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Avoid Aliasing

velocity exceeds range

PW-Doppler
spectrum

colour Doppler
2D image

colour Doppler
curve
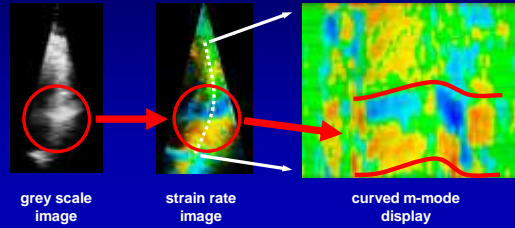
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Is Post-Processing Difficult ?

**Start with Doppler,
not with Tracking.**

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Doppler: Easy Quality Assessment

Strain Rate curved M-mode reveals artifacts
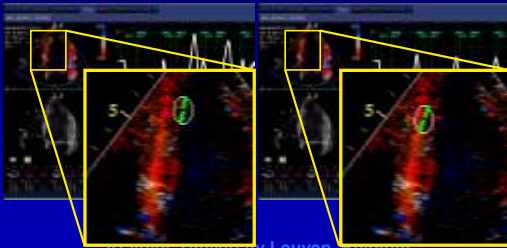

grey scale image   **strain rate image**   **curved m-mode display**

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Doppler: Easy Quality Assessment

bad curve   **good curve**

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Tracking: Curves Hide Problems

smoothing and drift compensation: on

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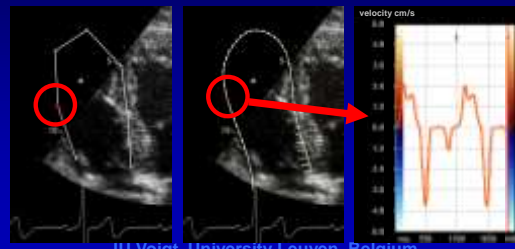## Tracking: Curves Hide Problems

smoothing and drift compensation: off

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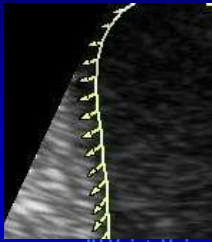## Tracking: Applying A-Priori Knowledge

generic   **a-priori: „LV long axis"**

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Tracking Problems

enddiastolic trace   **endsystolic trace**

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Myocardial Function Imaging

Can we use it
in the routine ?

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EAE Teaching Course
Organized with the Bulgarian Working Group
on Echocardiography

**NEW ECHOCARDIOGRAPHIC
TECHNIQUES** FOR
MYOCARDIAL FUNCTION IMAGING
With live demonstrations

5th - 7th April 2012
Inter Expo Center - **Sofia**, Bulgaria

Further Reading

**Current and Evolving Echocardiographic Techniques
for the Quantitative Evaluation of Cardiac Mechanics:**

**ASE/EAE Consensus Statement on
Methodology and Indications**

Mor-Avi, Lang, Badano, Belohlavek, Cardim, Derumeaux, Galderisi,
Marwick, Nagueh, Sengupta, Sicari, Smiseth, Smulevitz, Takeuchi,
Thomas, Vannan, Voigt, Zamorano

JU Voigt, University Leuven, Belgium **Eur J Echocardiogr 2011; 12(3):167-205**