EAE Teaching Course
Sofia, 2012

Flow Pattern Analysis Inside the Heart

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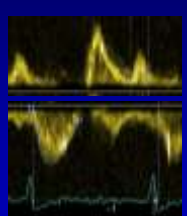
Cardiac Enegetics

How to Describe Intracardiac Flow ?

Assessment of Cardiac Flow

conventional echo

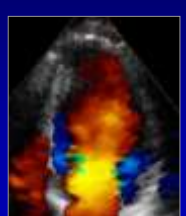


Doppler

... only for valve assessment

Assessment of Cardiac Flow

conventional echo



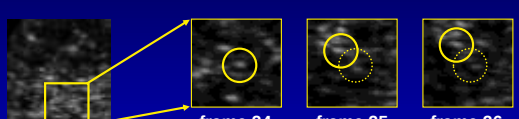
Doppler

... only for valve assessment

... cannot display complex 2D/3D blood motion patterns

Particle Imaging Velocimetry

by echo: following speckles in the blood



to estimate
velocity, direction and pattern
of blood flow

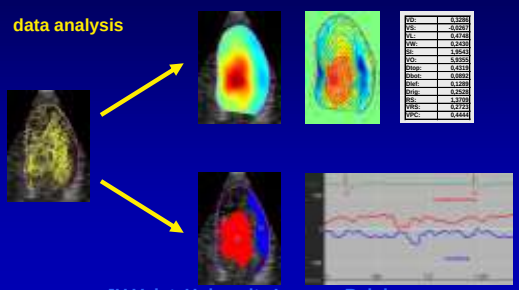
Particle Imaging Velocimetry

contrast echo

flow vectors

Particle Imaging Velocimetry

data analysis



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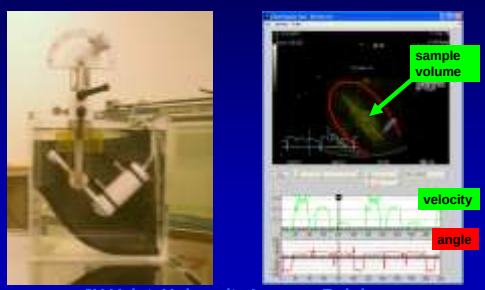
PIV - Phantom Validation



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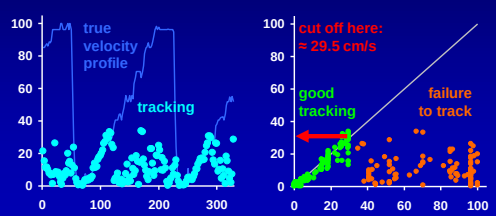
Phantom Measurements

estimated vs. true velocity



C. Prinz, R. Faludi, et al., JASE (submitted)

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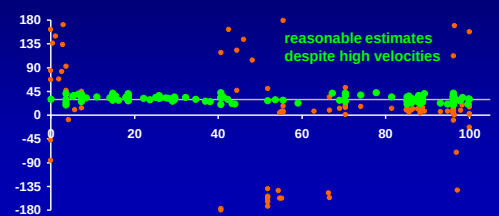
Phantom Measurements

angle estimate vs. true velocity



C. Prinz, R. Faludi, et al., JASE (submitted)

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Assessment of Cardiac Function

Normal LV Flow Patterns

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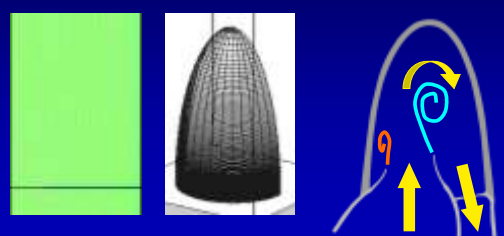
Vortical Flow in the Heart

simulation

flow re-direction



courtesy: G Pedrezzetti

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Energy Storage by Vortices

effective re-direction of blood flow

Tonti

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Energy Storage by Vortices

mid-ventricular main vortex

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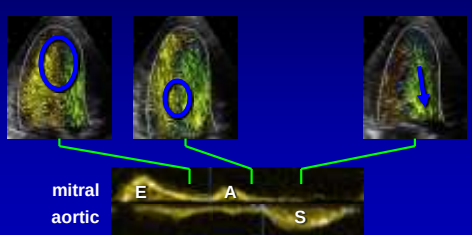
Intracavitary Flow Patterns

time sequence



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Assessment of Cardiac Function

Flow Patterns in the RV

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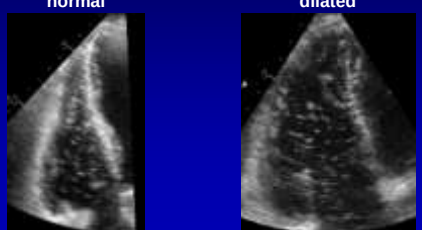
Flow Patterns in the RV

determined by ventricular size

normal dilated



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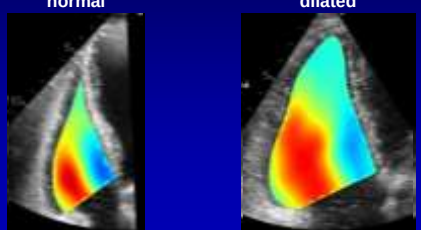
Flow Patterns in the RV

determined by ventricular size

normal dilated



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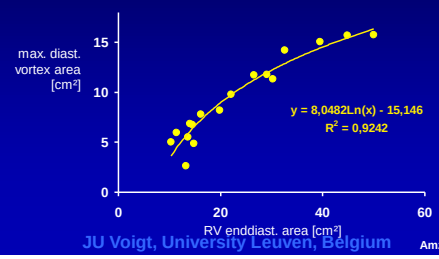
Determinants of Vortex Characteristics

ventricular size vs. vortex area



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Assessment of Cardiac Function

Abnormal Flow Patterns

Wall - Flow - Interaction

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Conduction Abnormalities

normal

LBBB

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Conduction Abnormalities

AAI stimulation

DDD stimulation

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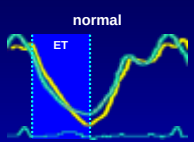
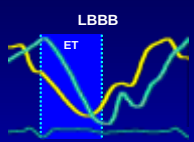
Conduction Abnormalities

Doppler strain

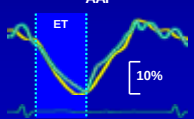
normal



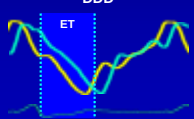
LBBB



AAI



DDD



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Conduction Abnormalities

AAI stimulation

DDD stimulation

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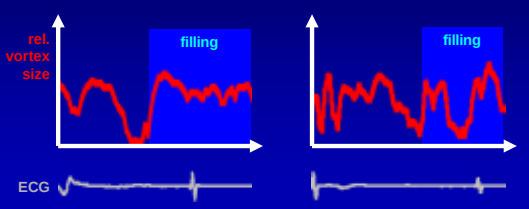
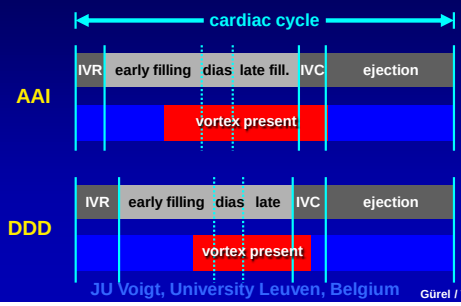
Relative Vortex Size

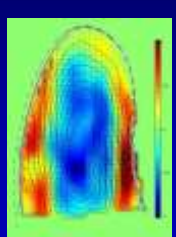


Time of Vortex Occurrence



Energy Storage by Votices

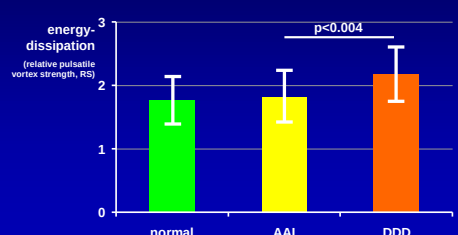
estimation of energy dissipation



$$RS = \frac{\int_{LV} \omega_1(x,y)\,dx\,dy}{\int_{Vortex} \omega_0(x,y)\,dx\,dy}$$

Conduction Abnormalities

diastolic energie dissipation



Assessment of Cardiac Function

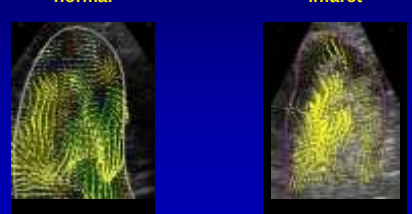
Abnormal Flow Patterns

Infarcts

Abnormal Flow Patterns

study: normals vs. apical infarcts

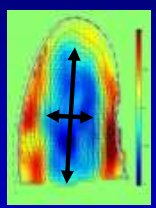
normal infarct



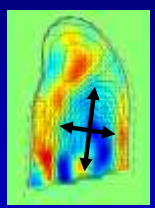
Abnormal Flow Patterns

study: normals vs. apical infarcts

normal



infarct



Abnormal Flow Patterns

study: post-infarct aneurysm & thrombus

Assessment of Cardiac Function

Abnormal Flow Patterns

Mitral Valve Replacement

Mitral Valve Replacement

normal

prosthesis

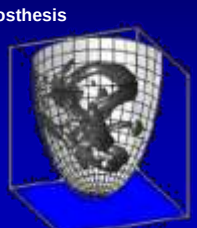
Pedrizzetti et al., Ann Biomed Eng 2010

Mitral Valve Replacement

numerical simulations

normal

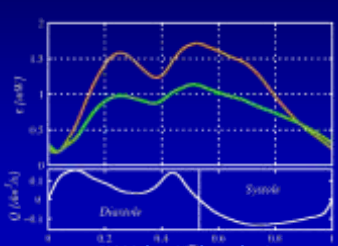
prosthesis



Pedrizzetti et al., Ann Biomed Eng 2010

Mitral Valve Replacement

numerical simulations



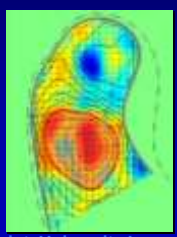
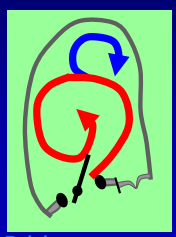
ca. 30% increased energy dissipation during 1 heart beat

- prosthesis
- normal

Pedrizzetti et al., Ann Biomed Eng 2010

Abnormal Flow Patterns

mitral valve prosthesis: tilt disc

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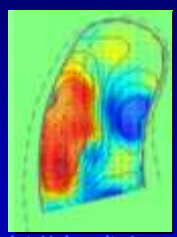
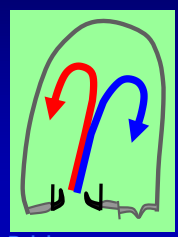
Faludi / Voigt, J Thor Cardiovasc Surg 2010

Abnormal Flow Patterns

mitral valve prosthesis: biologic (3CV)

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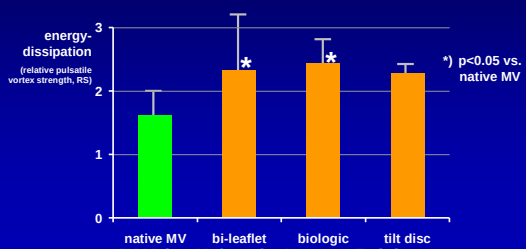
Mitral Valve Prosthesis

diastolic energie dissipation



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Faludi / Voigt, J Thor Cardiovasc Surg 2010

Summary

Modern speckle tracking technology allows to follow the motion of contrast enhanced blood in the heart.

Flow patterns can be displayed and quantified using parameters such as vorticity.

This echocardiographic particle imaging velocimetry (PIV) offers new insights into intraventricular hemodynamics and, thus, the energetics of cardiac function.

The clinical importance of this technique remains to be determined.

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