Summer School
July 18-22 2011

Modern imaging techniques (3D echo, CT, MR) in the medical curriculum II.

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Teaching cardiology

- General skills
  - history taking, physical examination
- Cardiology methods
  - Routine techniques
  - Advanced imaging methods
- Decision making plans

Cardiology diagnostics

1970

Cardiology diagnostics

1970

History
Physical diagnostics

Cardiology diagnostics

1970

History
Physical diagnostics
ECG

Cardiology diagnostics

1970

History
Physical diagnostics

ECG

Chest X-ray

Cardiology diagnostics

1970

History
Physical diagnostics
ECG

Chest X-ray

Heart catheterization

Cardiology diagnostics

1970 XXI.

History
Physical diagnostics
ECG
Chest X-ray
Heart catheterization

Cardiology diagnostics

1970	XXI.
History Physical diagnostics	History Physical diagnostics
ECG	
Chest X-ray	
Heart catheterization	

Cardiology diagnostics

1970	XXI.
History Physical diagnostics	History Physical diagnostics
ECG	ECG, Holter
Chest X-ray	
Heart catheterization	

Cardiology diagnostics

1970	XXI.
History Physical diagnostics	History Physical diagnostics
ECG	ECG, Holter
Chest X-ray	Imaging (Echo, CT, MR)
Heart catheterization	

Cardiology diagnostics

1970	XXI.
History Physical diagnostics	History Physical diagnostics
ECG	ECG, Holter
Chest X-ray	Imaging (Echo, CT, MR)
Heart catheterization	Coronarography, (PCI)

Imaging techniques

- A diagnostic test
  - answer clinical questions
  - guide treatments
  - help in decision making

Choosing a diagnostic test

- Invasive - non-invasive
- No radiation exposure
  - ECG, echocardiography, MR
- Radiation exposure
  - X-ray, coronarography, CT, nuclear imaging, PET
- Imaging - non-imaging

Echocardiography

- One of the most frequently used imaging method
- Able to detect all cardiology malformations
  - Valvular heart disease
  - Myocardial disease
  - except for coronary disease
- For teaching purposes multiple examples needed

Echocardiography

- Noninvasive
- Repeatable unlimitedly
- Bedside
- Complete evaluation of the heart and the great vessels

Echocardiography

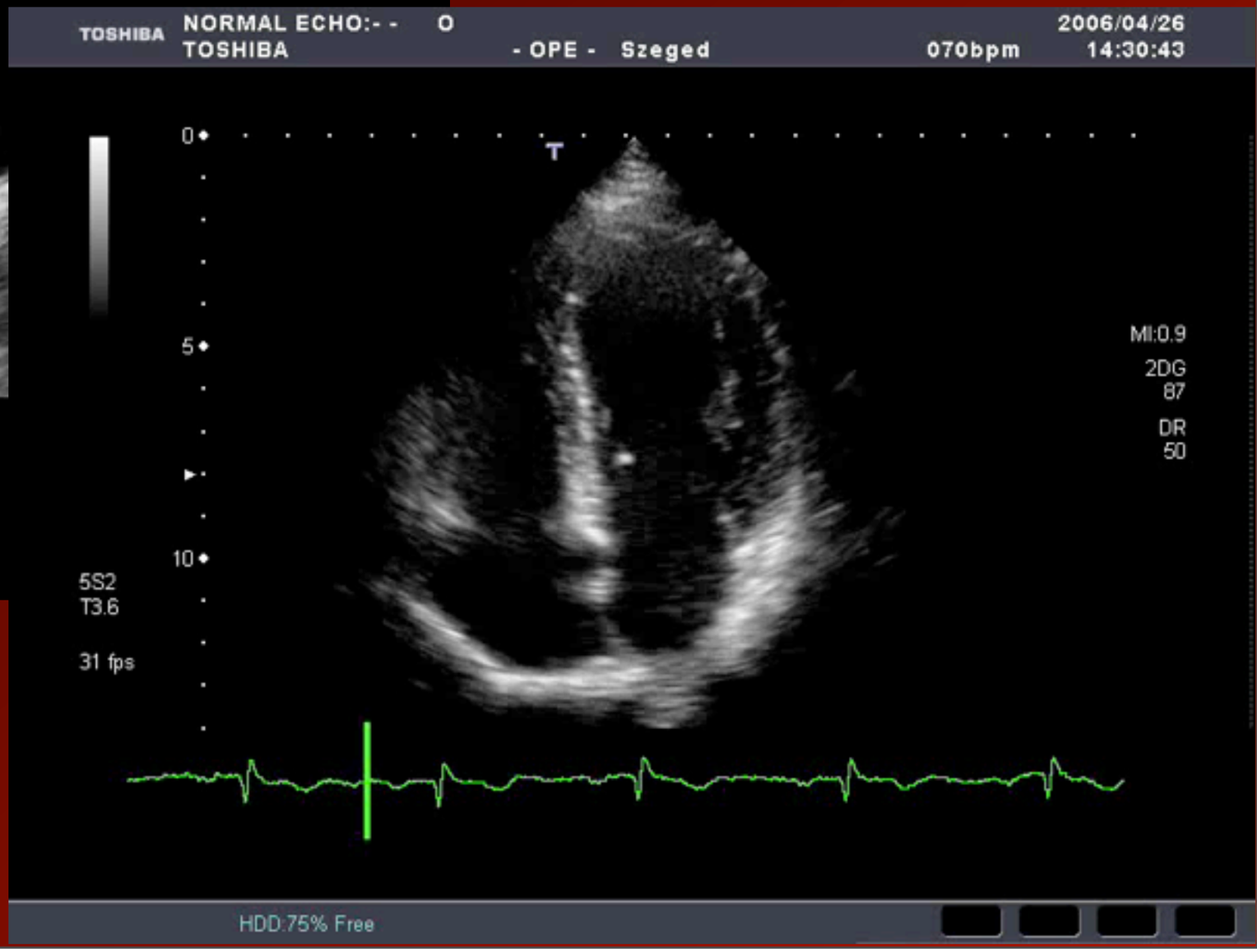
- M-mode
- 2-dimensional
- Doppler
  - Pulsed-wave
  - Continuous-wave
  - Colour-coded

2-dimensional echocardiography

- Morphology
- Heart chamber size
- Valves
- Myocardial function
  - global
  - regional
- Pericardial fluid
- Guiding procedures

2D-echocardiography

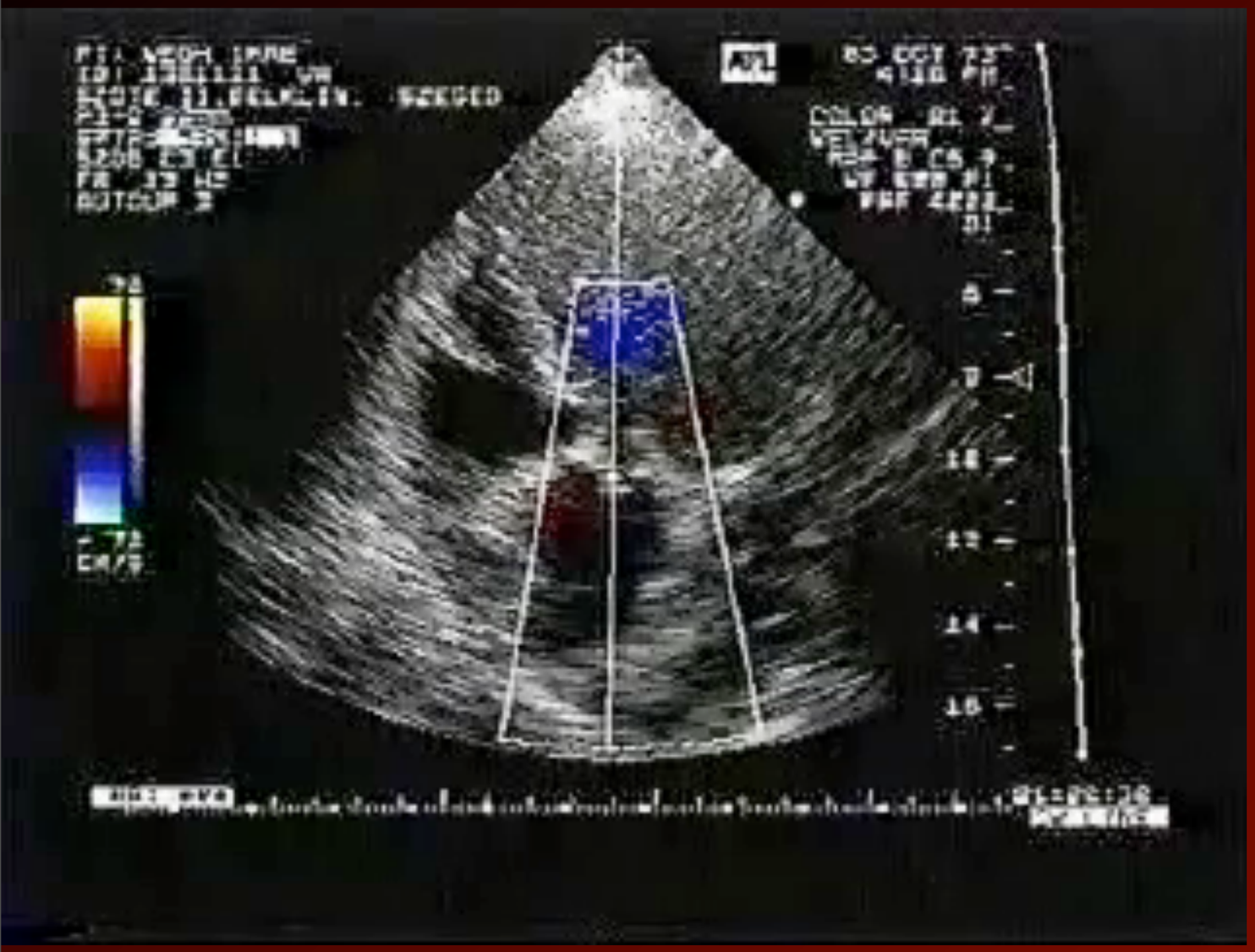
2D-echocardiography



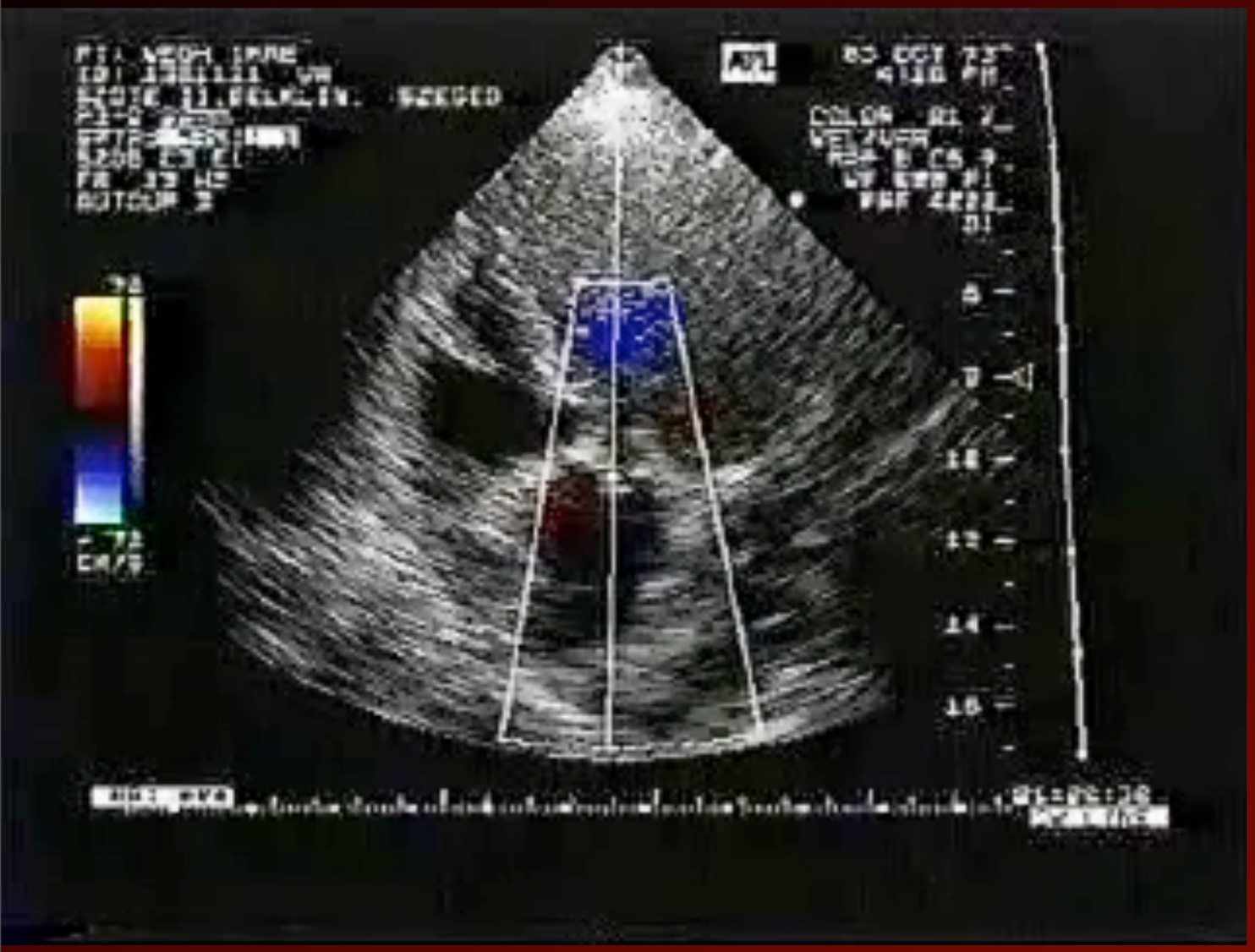
Doppler echocardiography

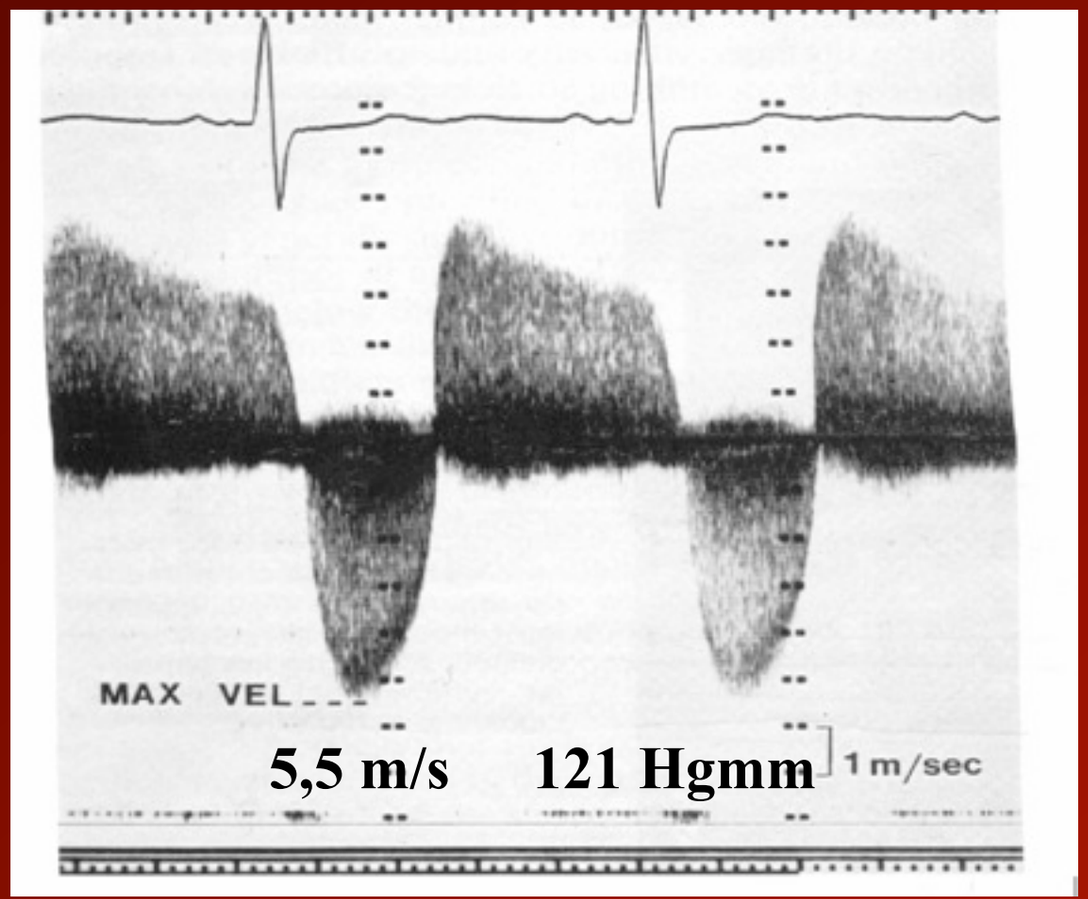
- Pulsed-wave Doppler
  - Diastolic function
  - Cardiac output
- Continuous-wave Doppler
  - Valvular gradients, valve area
  - Pulmonary systolic pressure
  - Contractility
- Colour Doppler
  - Differentiation of normal and abnormal flows
  - Assessing valvular regurgitations
  - Unexpected flows

Doppler echocardiography

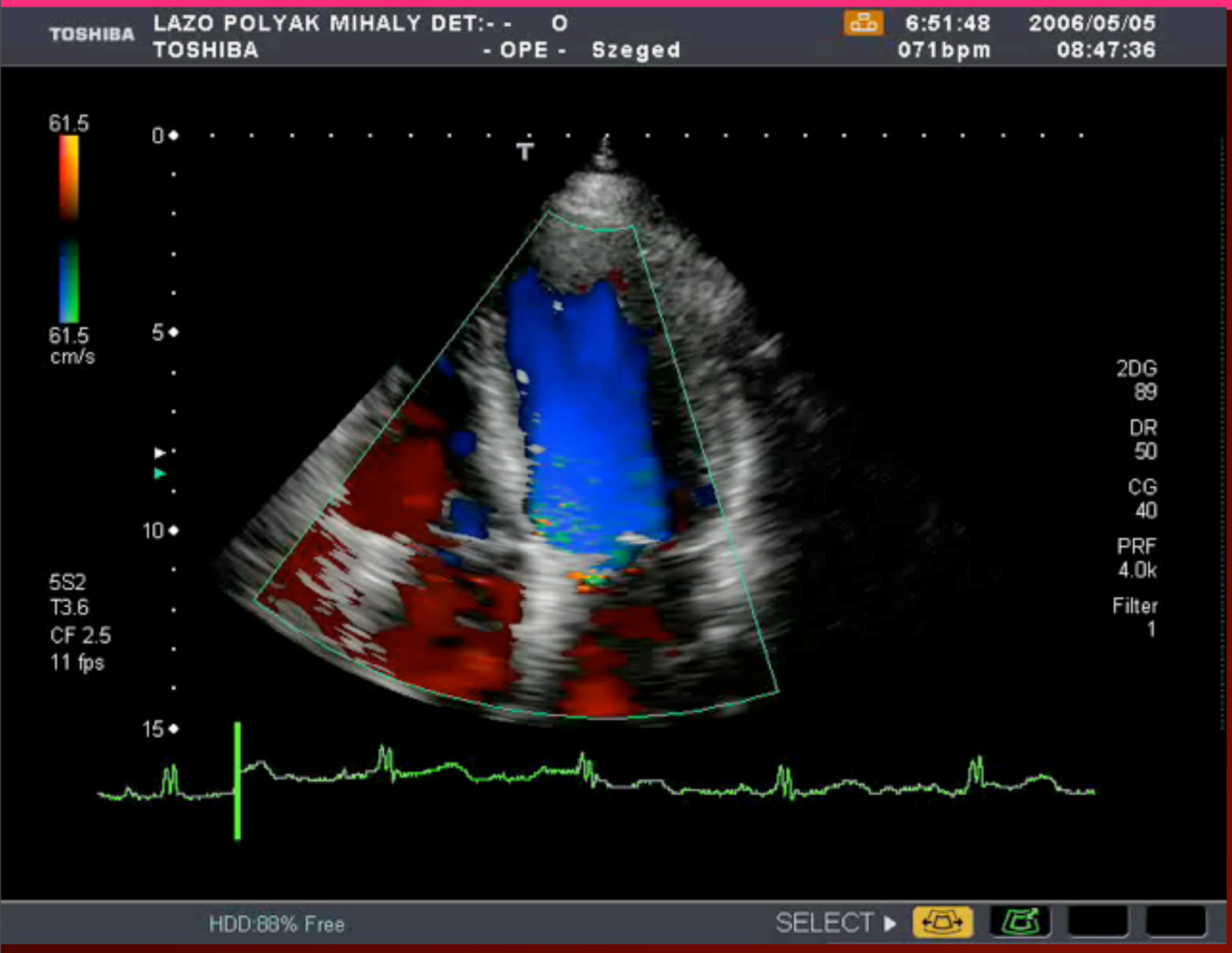


Doppler echocardiography

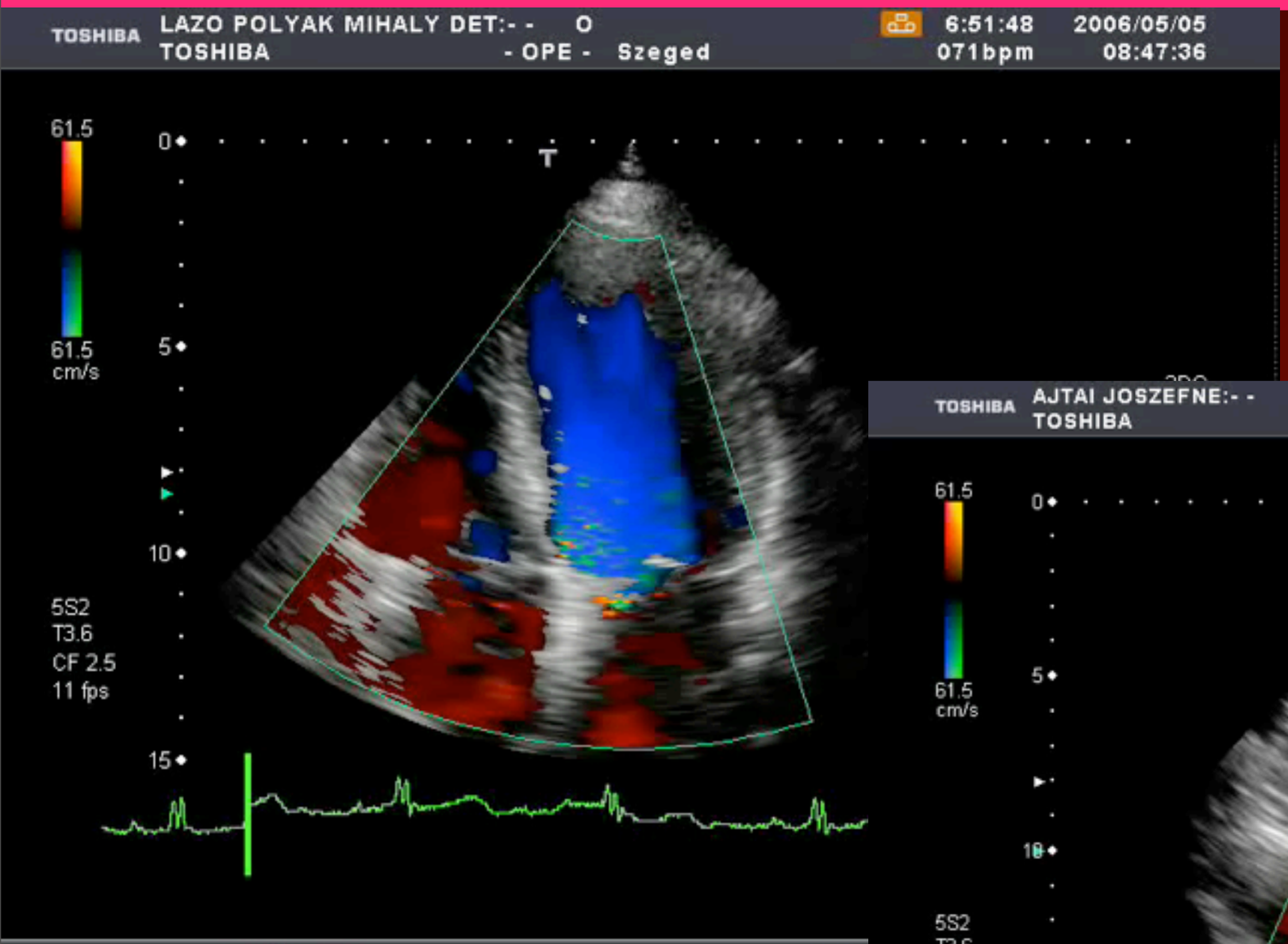


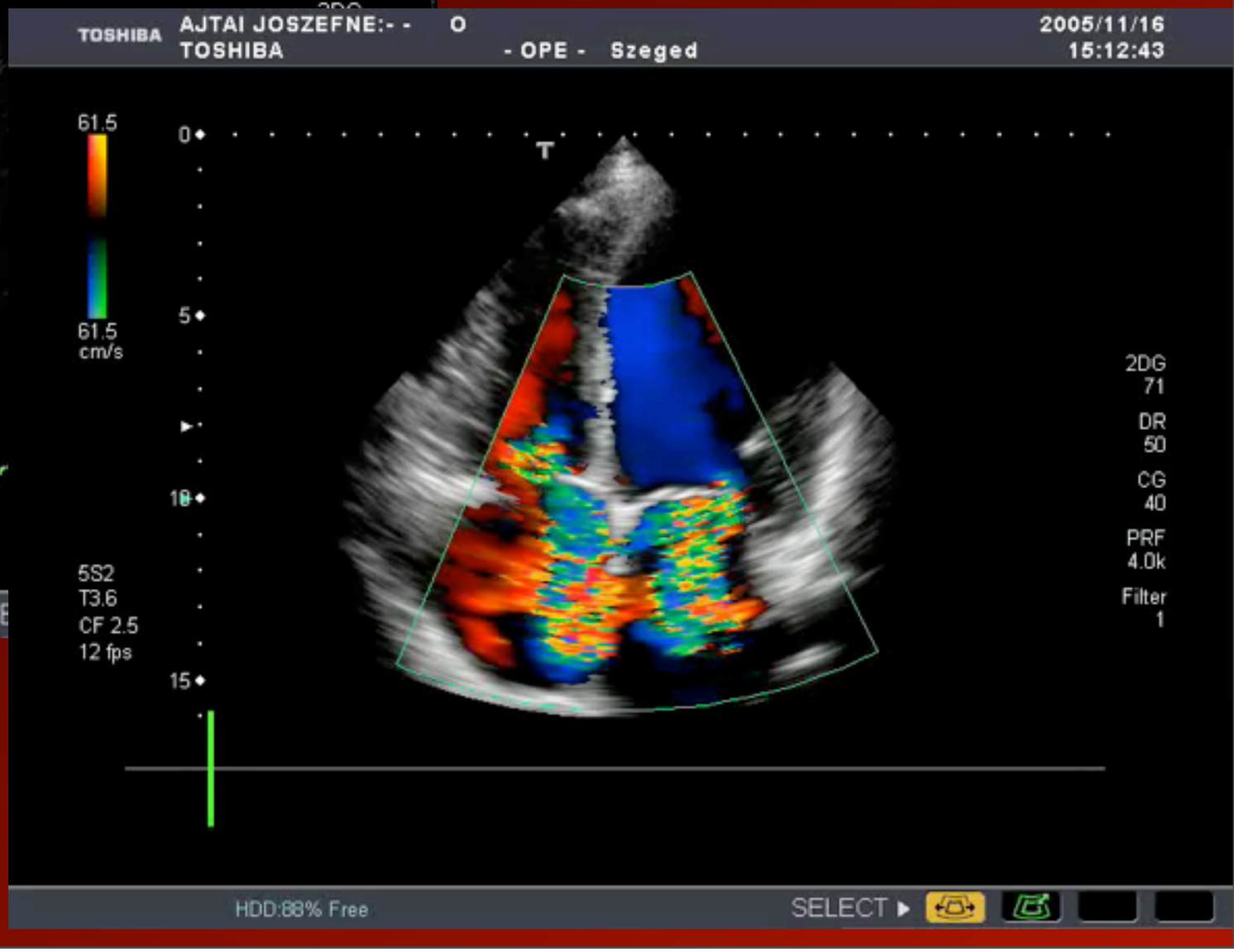


Colour Doppler



Colour Doppler





Transoesophageal echocardiography

- „New window” to the heart
- Higher transducer frequency
- Better resolution
- Mitral valve, prosthetic valve in the near-field
- Atrial septum, atrial thrombi
- Proximal coronary branches
- Aortic pathology

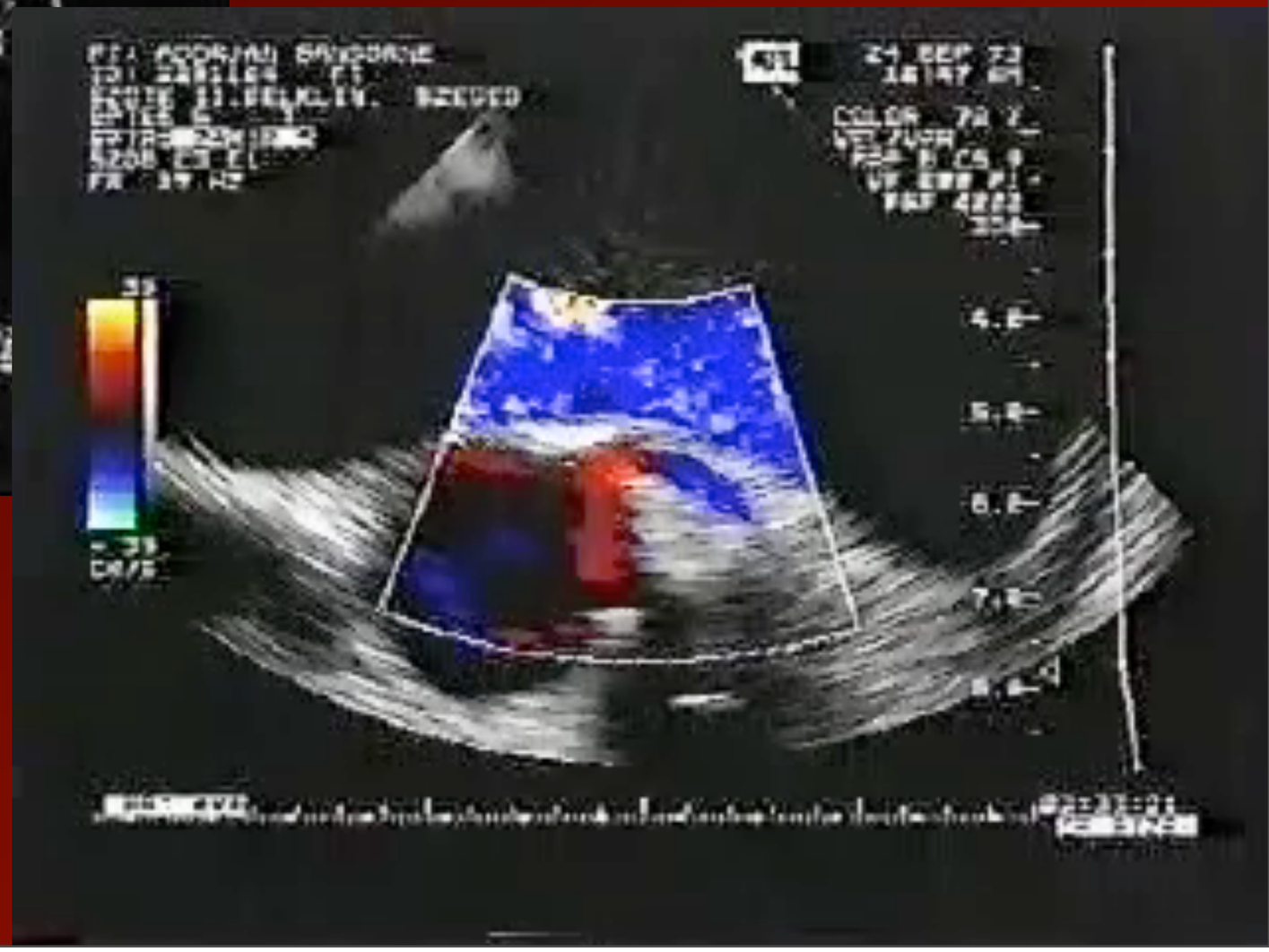
Transoesophageal echocardiography

Indications

- Detection of the source of emboli
- Infective endocarditis
- Aortic pathology
- Prosthetic valve function and dysfunction
- Anomalies of the atrial septum, complex cong. heart diseases
- Atrial tumors and masses
- Proximal coronary arteries
- Mitral insufficiency
- Suboptimal TTE echo quality

Transoesophageal echocardiography

Transoesophageal echocardiography



Stress echocardiography

- New, alternative stress type
- More precise
  - sensitivity - 80-85 %
  - specificity - 90 %
- Dipyridamole, dobutamine, (exercise)
- Complementary

Stress echocardiograpy

Indications

- Non-diagnostic stress ECG
- Detection of ischaemia
- Significance of coronary heart disease
- Effect of therapy (PTCA, CABG)
- Risk stratification (postmyocardial infarction, vascular surgery)
- Myocardial viability

Imaging approaching clinical practice

- New imaging techniques
- Improve diagnostic accuracy
- Availability is restricted
  - shortage of systems
  - shortage of operators
  - research tools
- Implementaion into clinical practice

Newer imaging techniques

- Ultrasound technology
  - Contrast echocardiography
  - Tissue Doppler imaging
  - Real-time 3D-echocardiography
  - Intracardiac echocardiography (ICE)
  - IVUS, virtual histology, OCT
- MDCT
- Cardiac MR

Contrast echocardiography

- New „contrast agents” - passing the lung
- Application
  - improved endocardial definition
  - enhanced colour sensitivity
  - myocardial perfusion
- New techniques
  - „second harmonic”
  - intermittent imaging
  - „pulse inversion imaging”
  - power Doppler imaging

Myocardial contrast echo

Possible clinical applications

- Diagnosis of myocardial infarction
- Estimation of „area at risk”, success of reperfusion
- „no-reflow” phenomen

- Advantage
  - No radiation exposure

- Disadvantage
  - special equipment
  - price of contrast agents

Tissue Doppler Imaging

- Segmental analysis of myocardial function
- Resynchronization therapy
- E/E´ - diastolic function
  - < 8 – normal LVEDP
  - >12 – elevated LVEDP
- Angle dependant

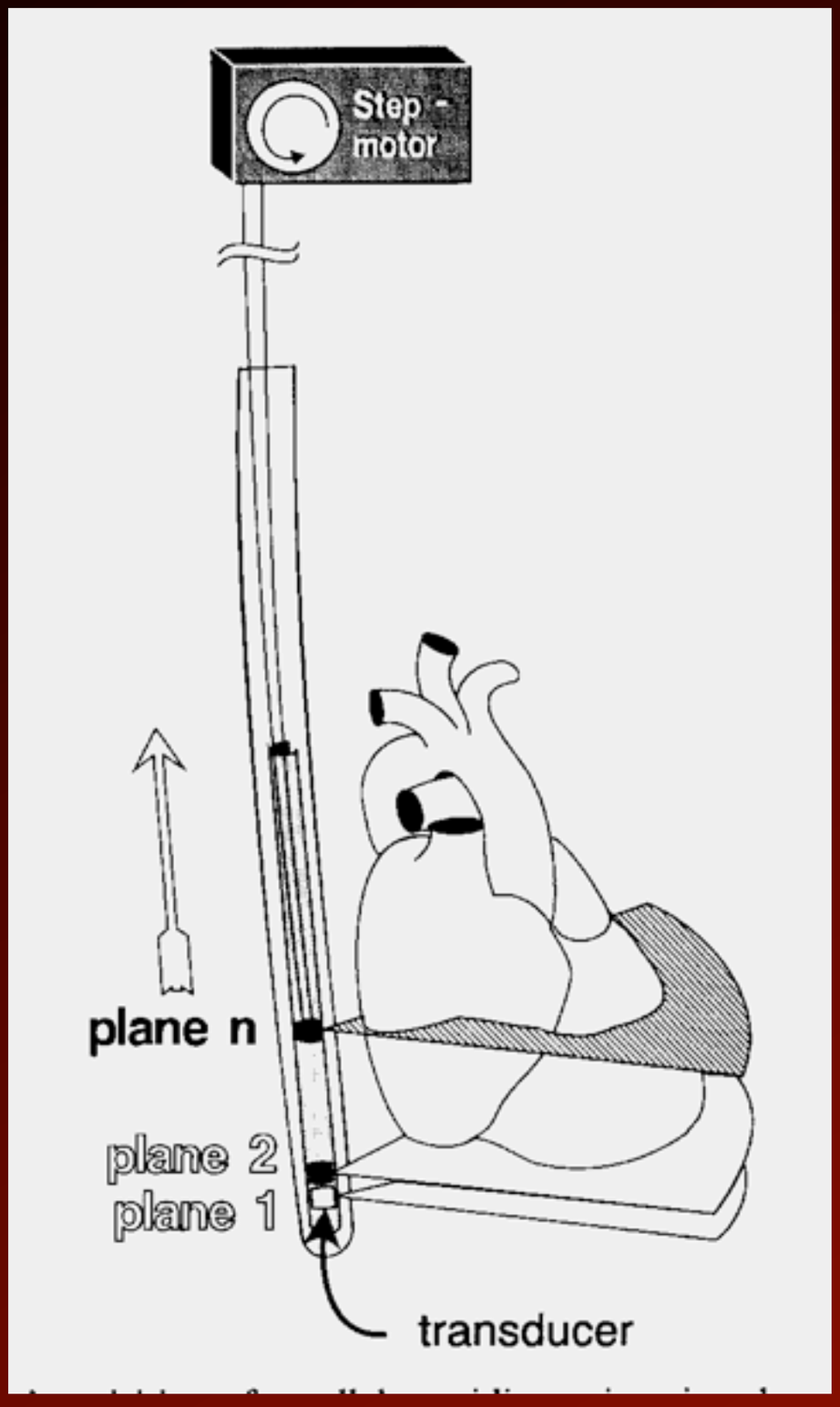
Intracardiac echocardiography (ICE)

- Catheter based technique - invasive
- Mainly during electrophysiology studies
- Intracardiac manipulations - e.g. transseptal puncture

3D-echotomography

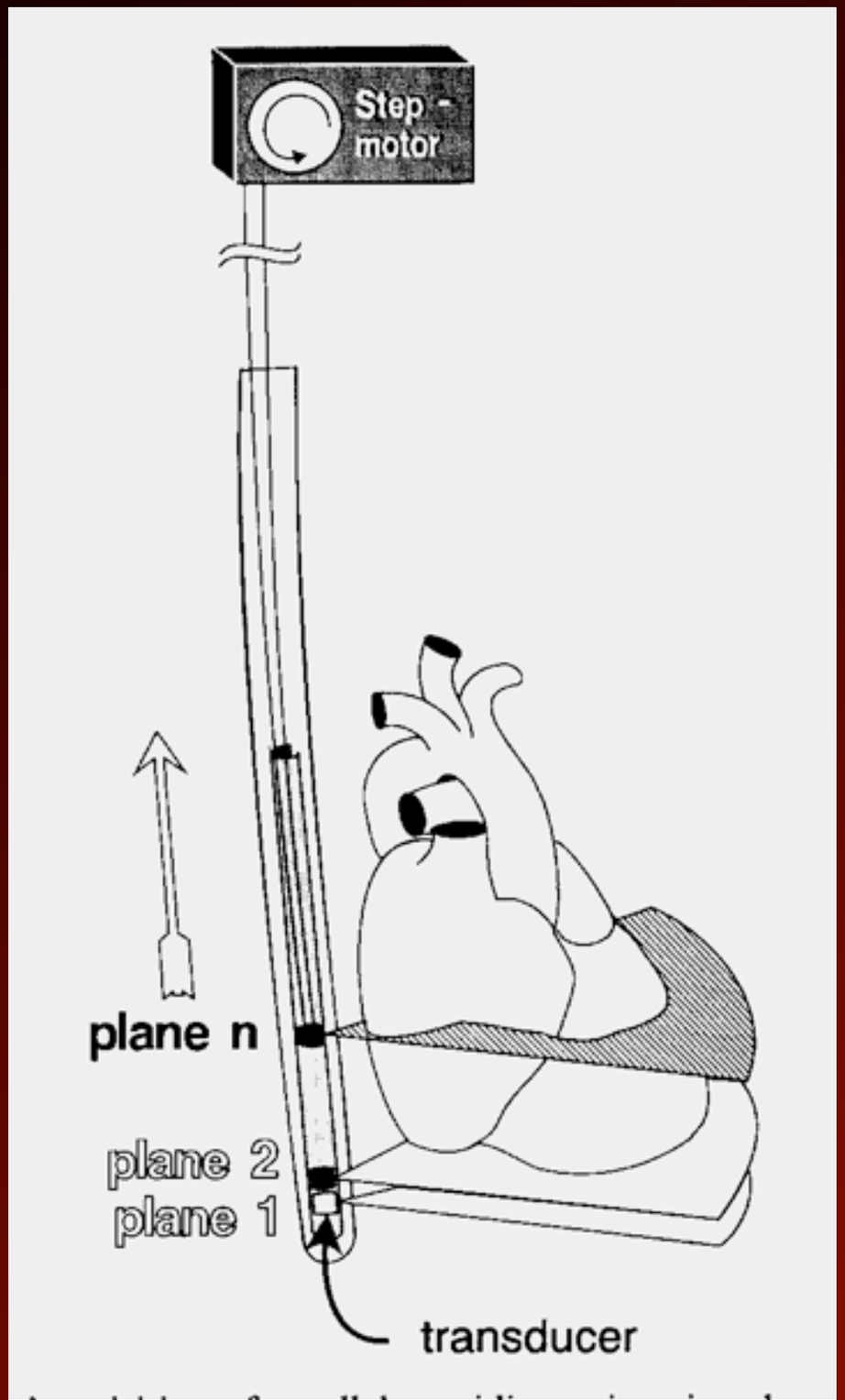
3D data acquisition

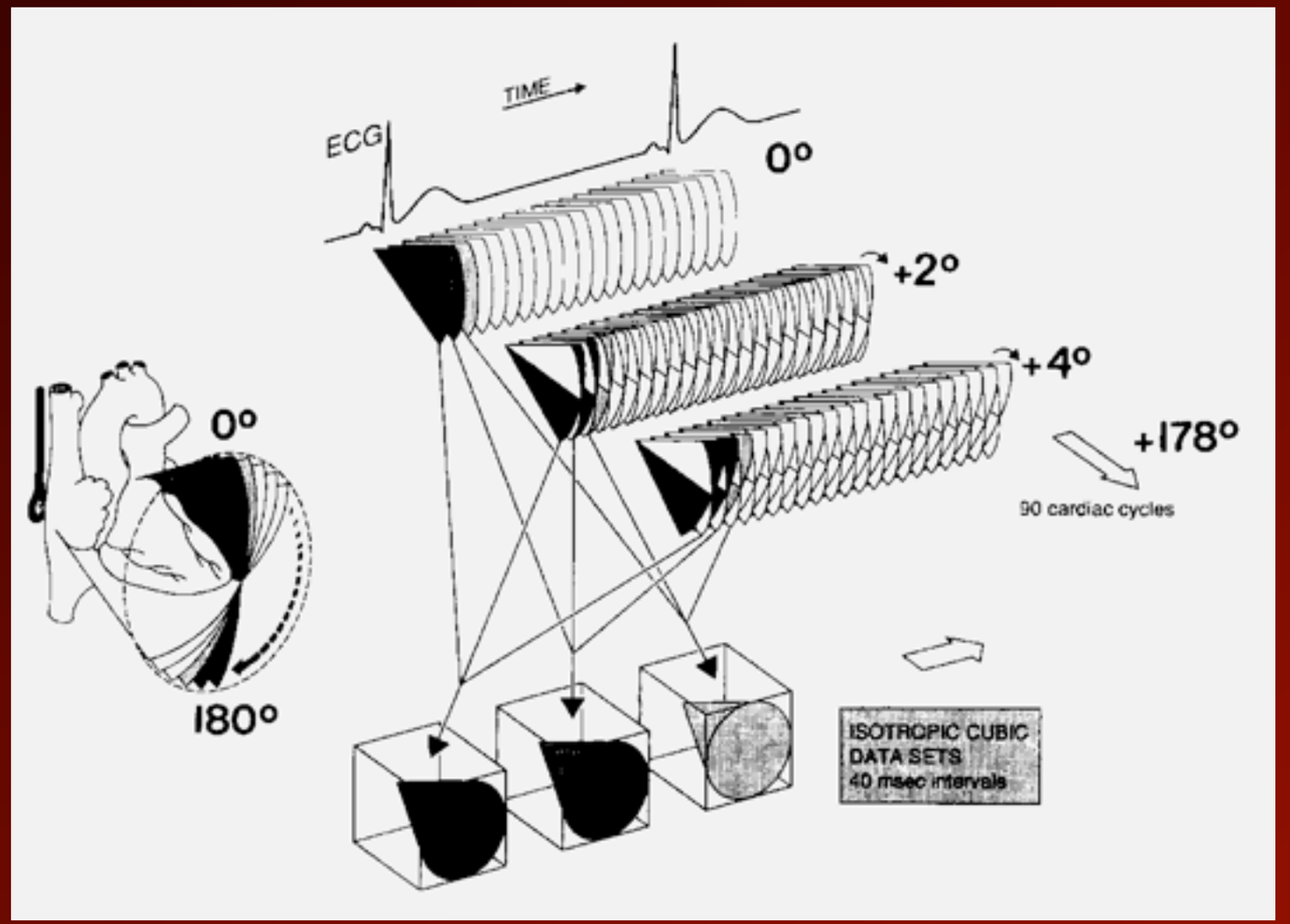
3D-echotomography



3D data acquisition

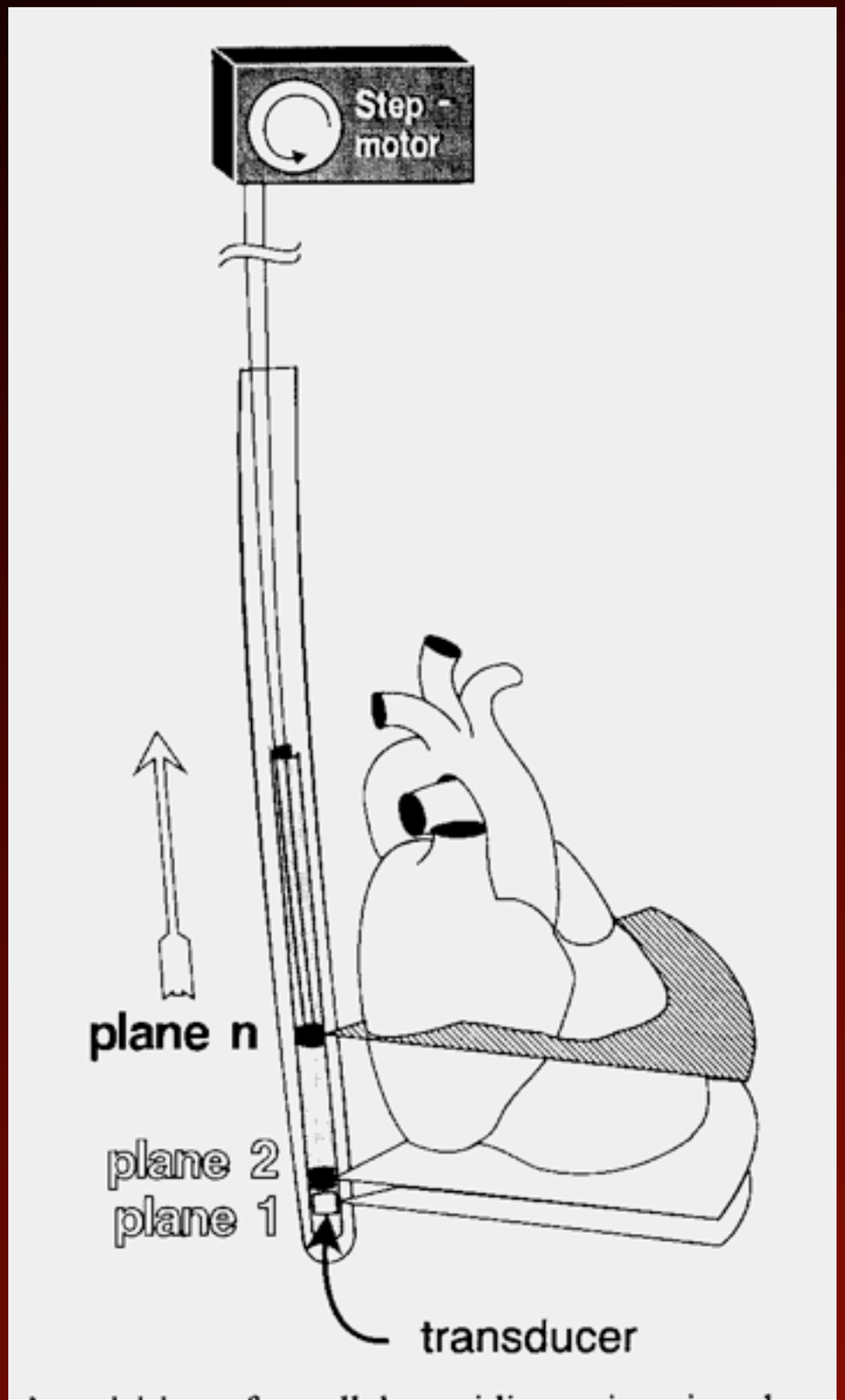
3D-echotomography

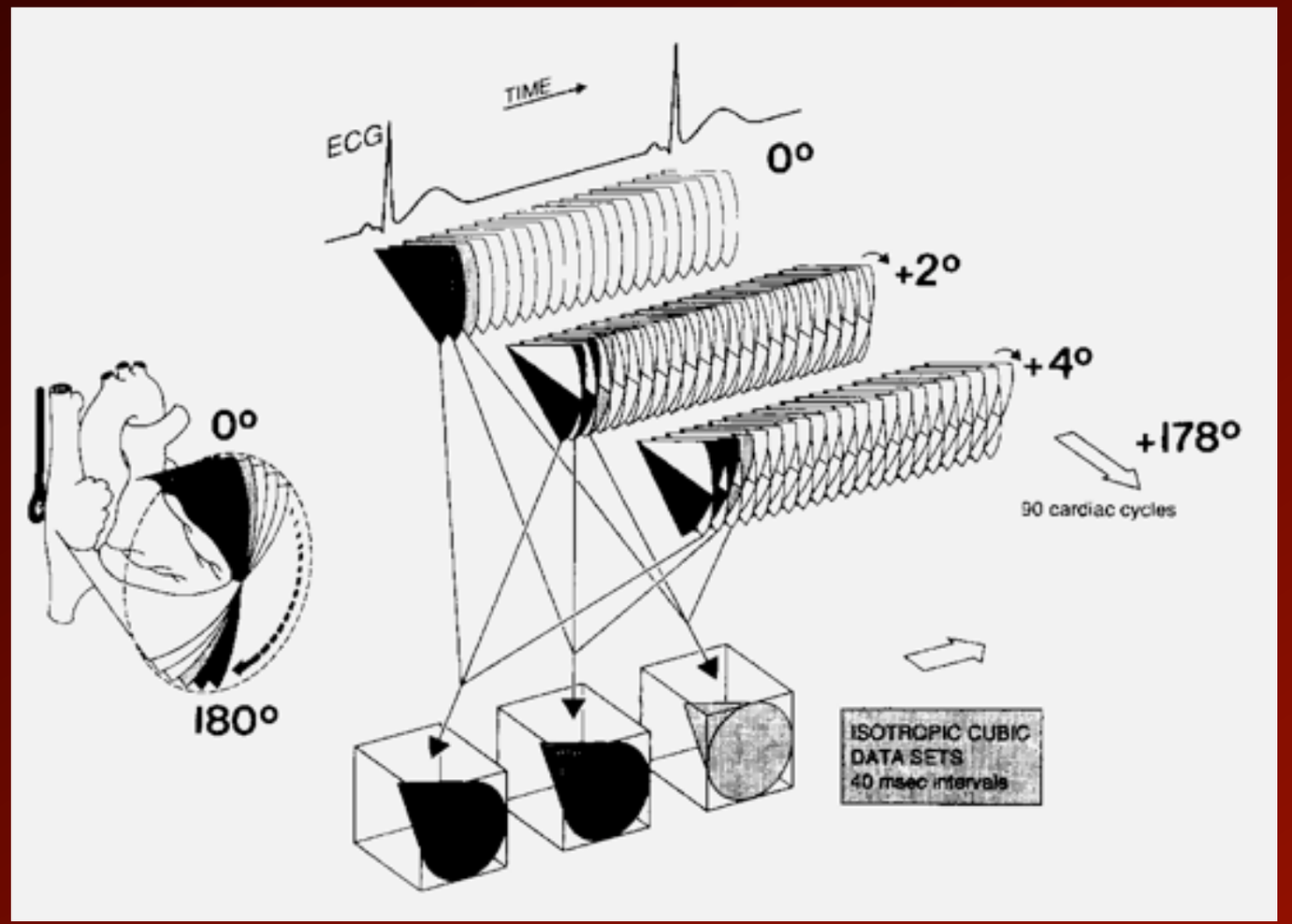




3D data acquisition

3D-echotomography

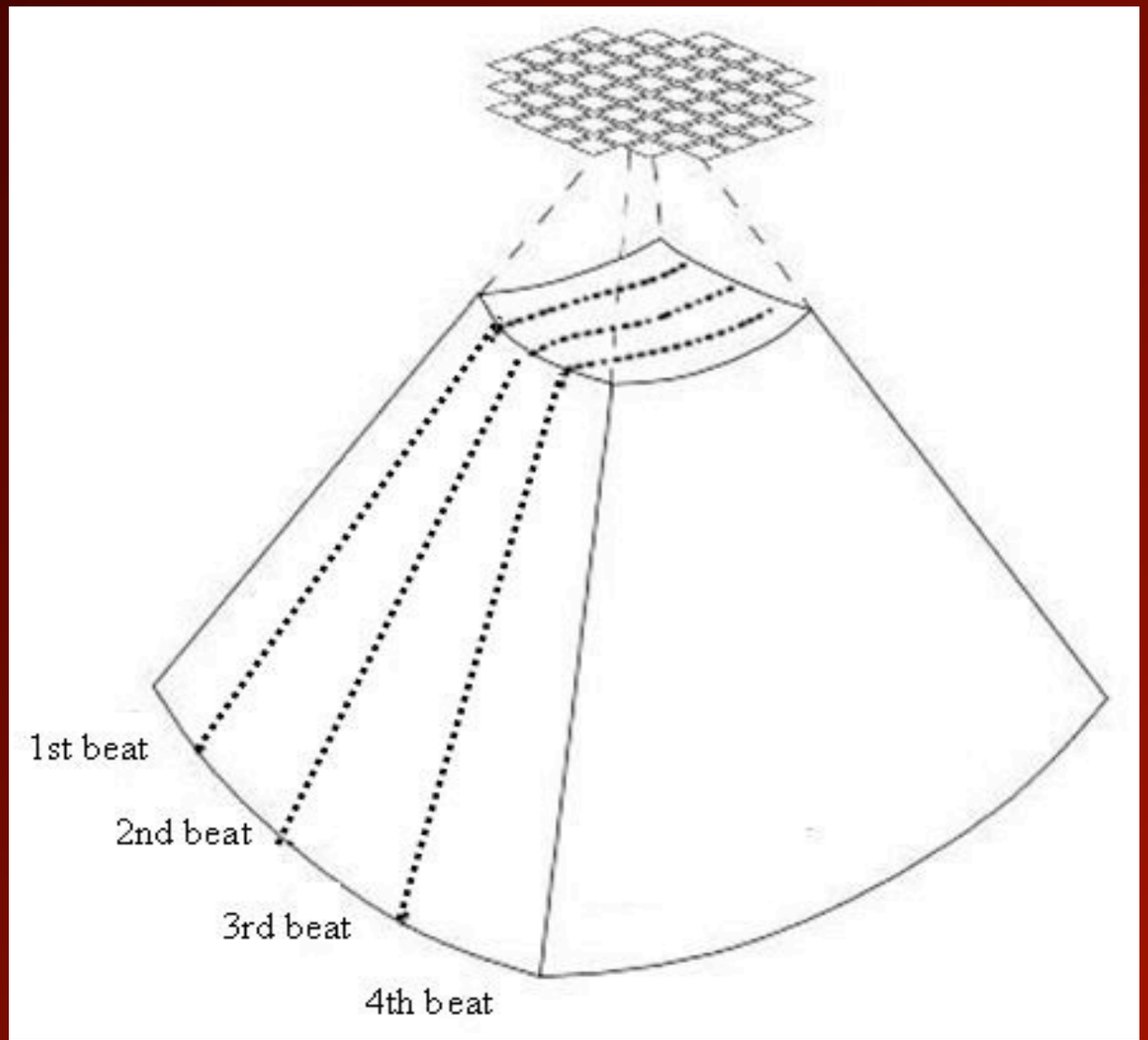




3D data acquisition

Off-line analysis

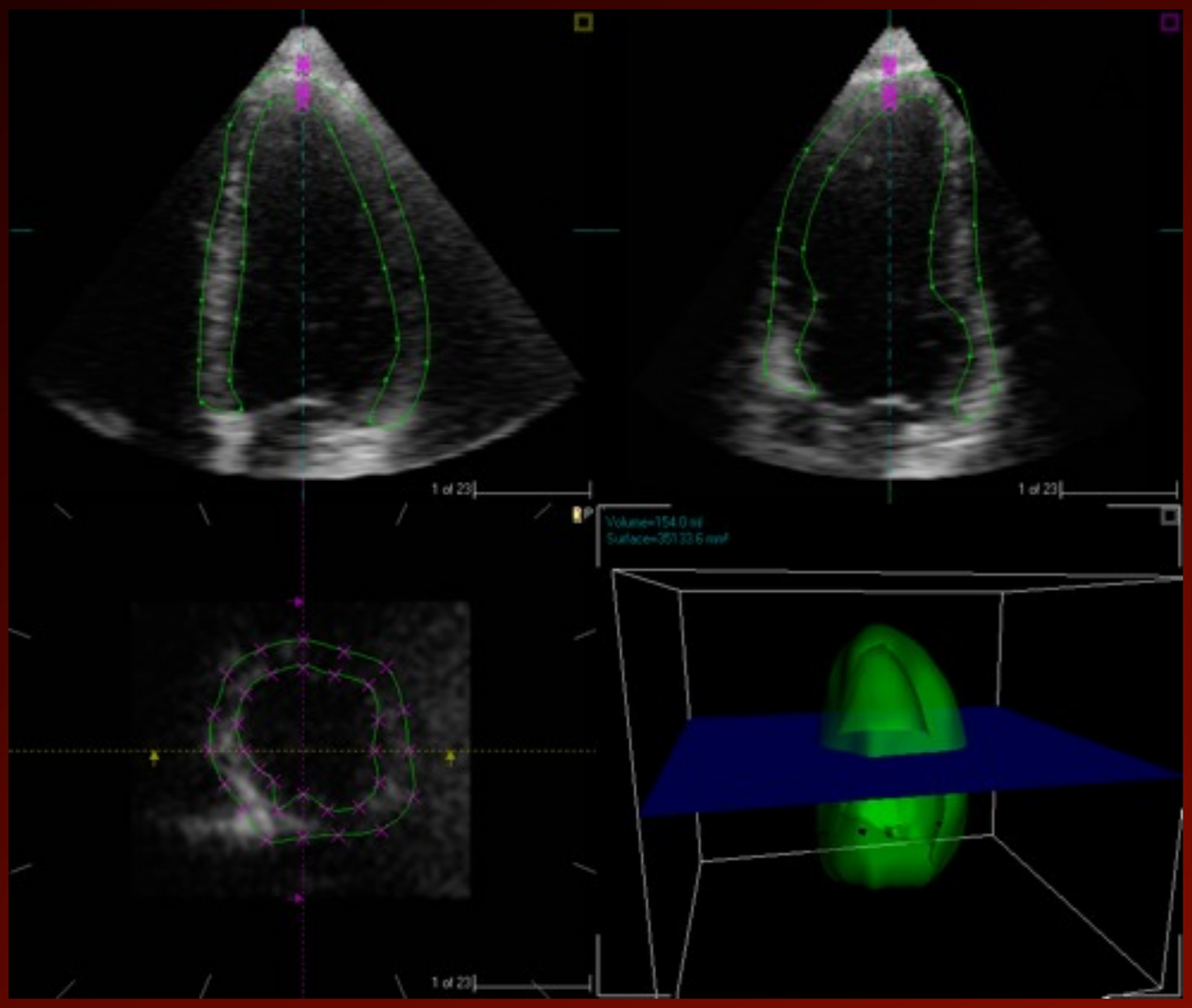
Real-time 3D-echocardiography



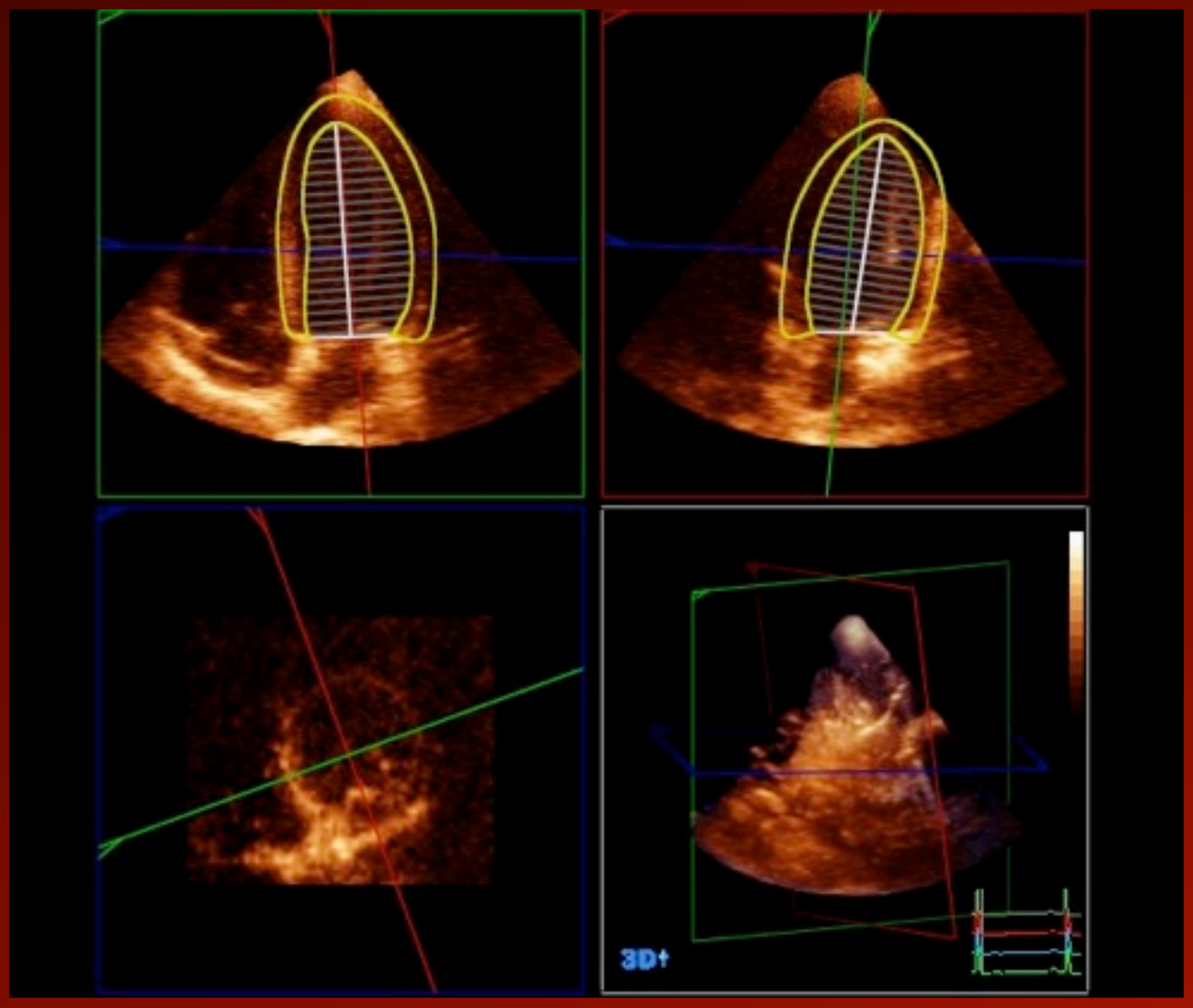
Franke et al. MedicaMundi 2003

Measurement of LV mass

TomTec



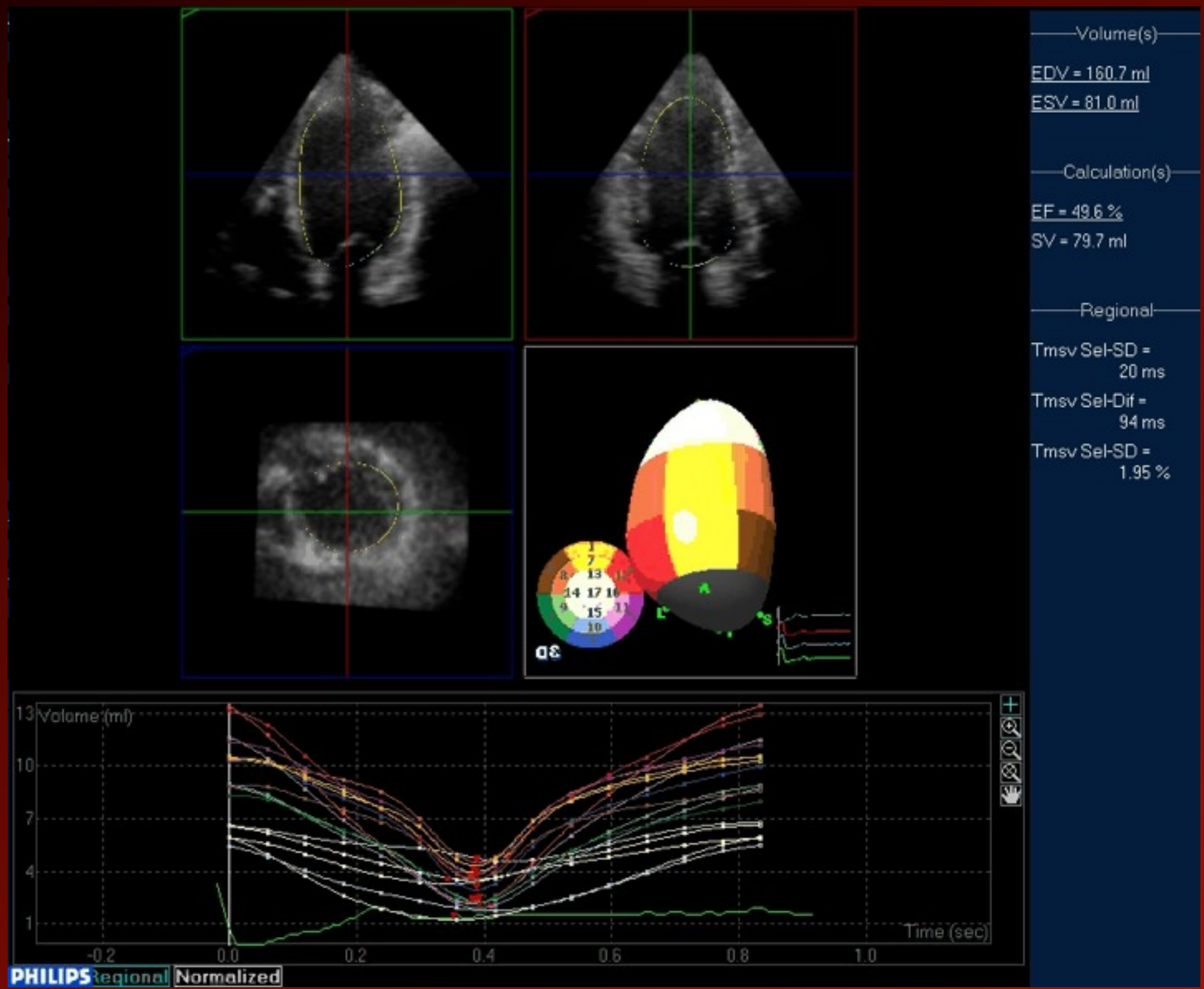
QLAB



RT3DE vs. CMR

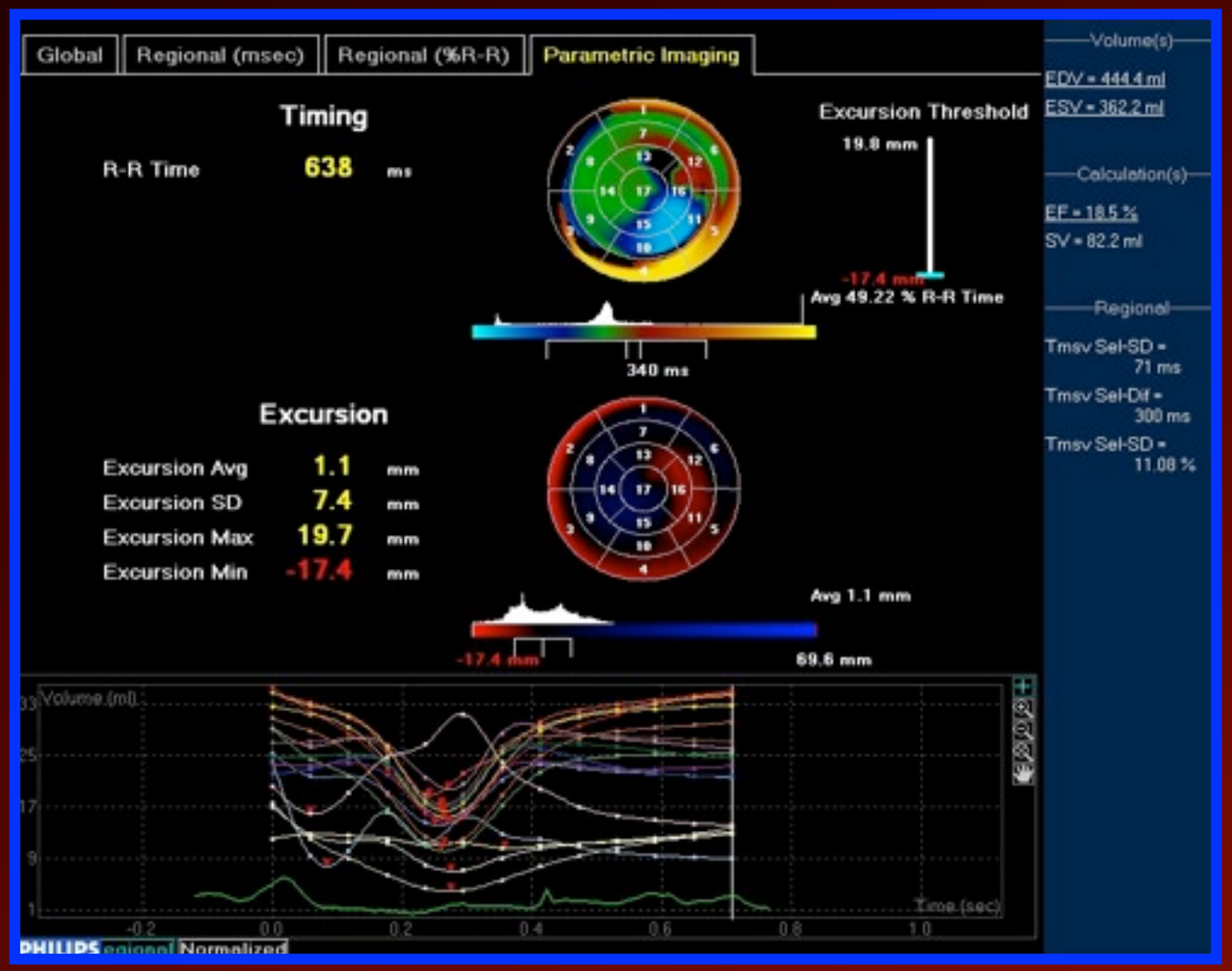
Yap, Nemes et al. Eur J Echocardiogr 2007
van den Bosch et al. Am J Cardiol 2006

RT3DE

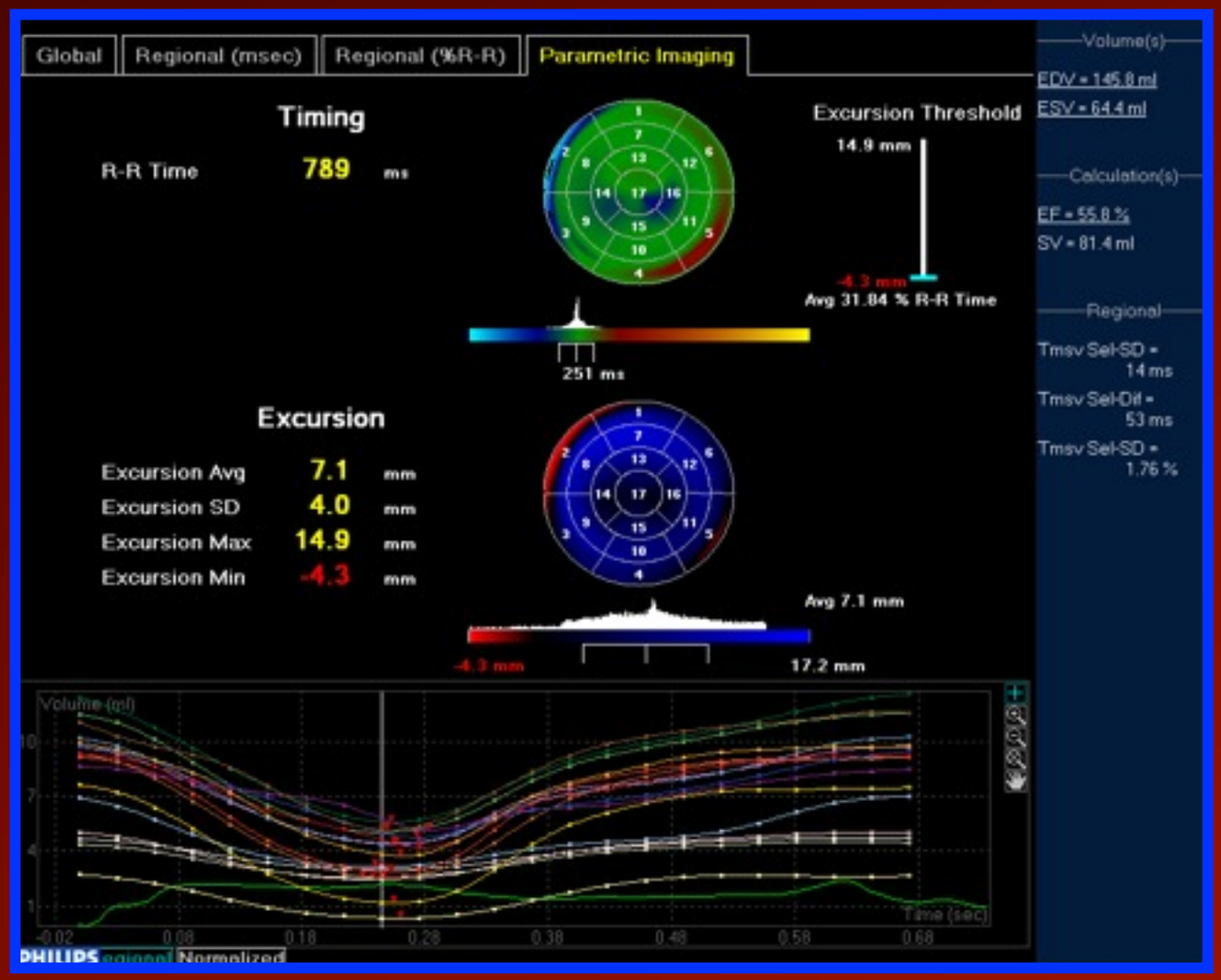

Volume(s)
EDV = 160.7 ml
ESV = 81.0 ml
Calculation(s)
EF = 49.6 %
SV = 79.7 ml
Regional
Tmsv Sel-SD = 20 ms
Tmsv Sel-Dif = 94 ms
Tmsv Sel-SD = 1.95 %
Volume (ml)
13
10
7
4
1
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Time (sec)
PHILIPS Regional Normalized

Parametric Imaging

Before CRT



After CRT



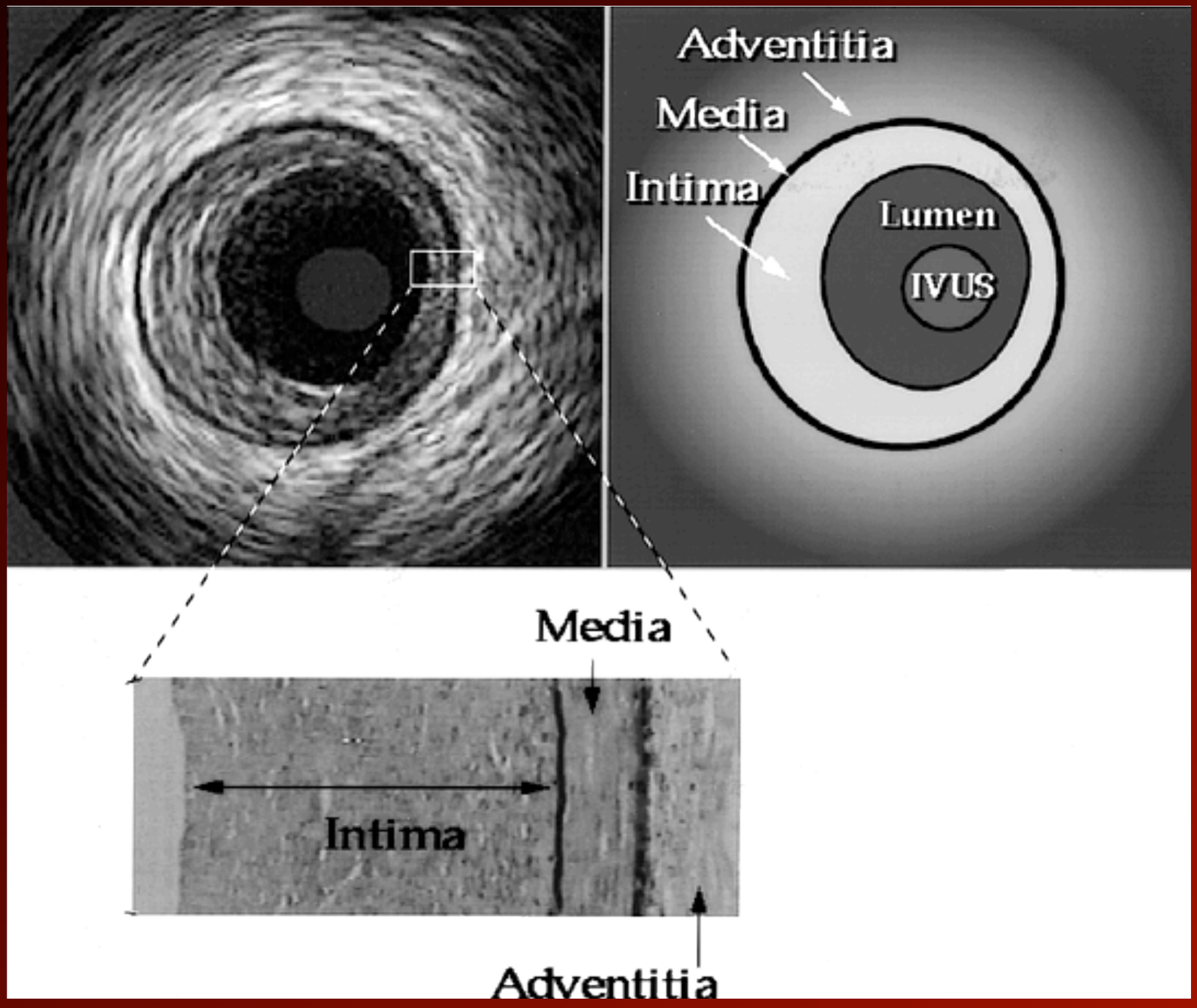
RT3DE

- 3-dimensional speckle tracking
- Ventricular contraction dynamics
- Torsion and twist
- Dysynchronia analysis

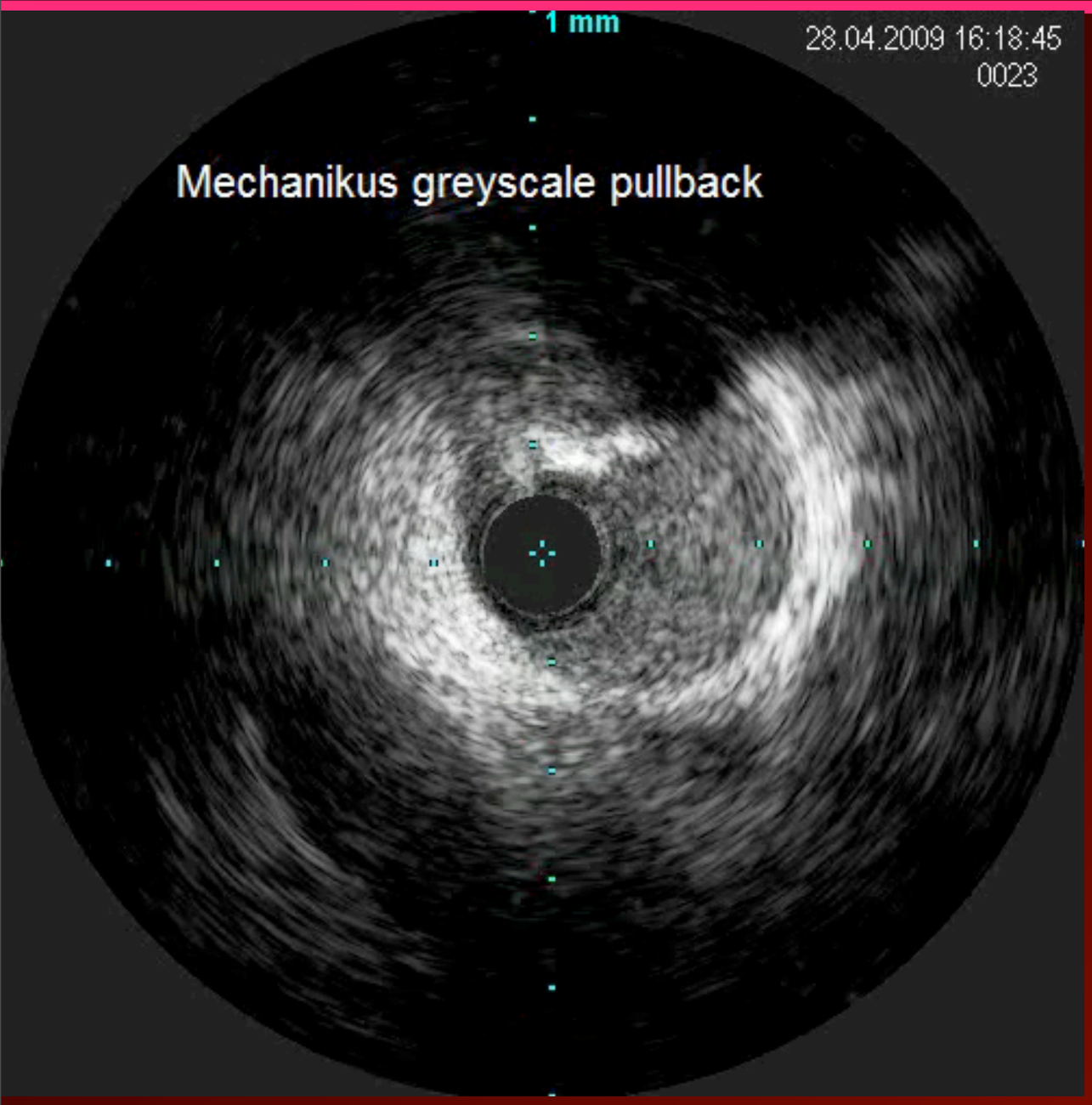
Intravascular ultrasound (IVUS)

- Invasive technique - microtransducer
- Diagnostic applications
  - detection of wall structure
  - measuring plaque volume
  - angiographically uncertain lesions
  - tissue characterization
- Postinterventional applications

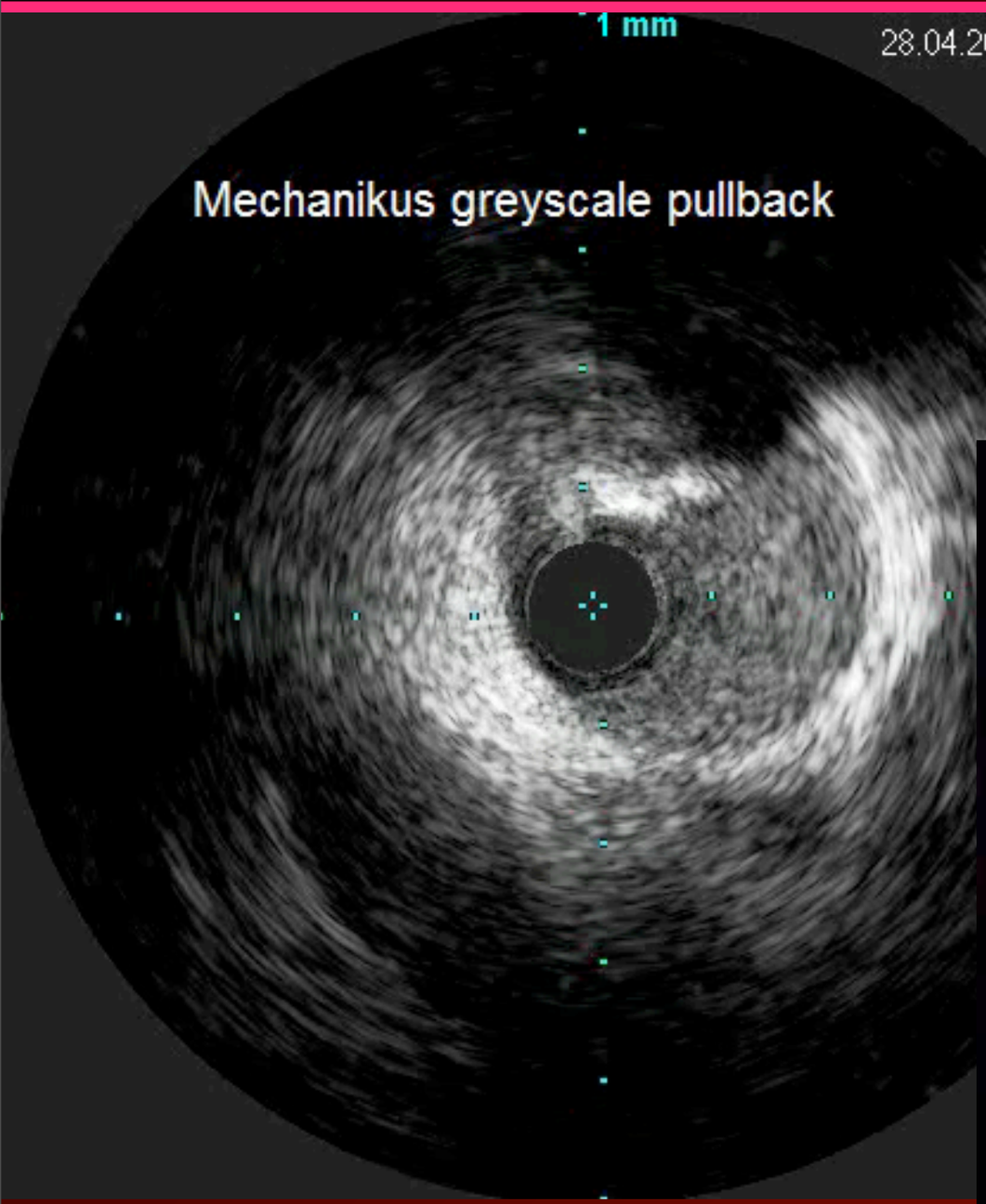
Vessel anatomy



IVUS



IVUS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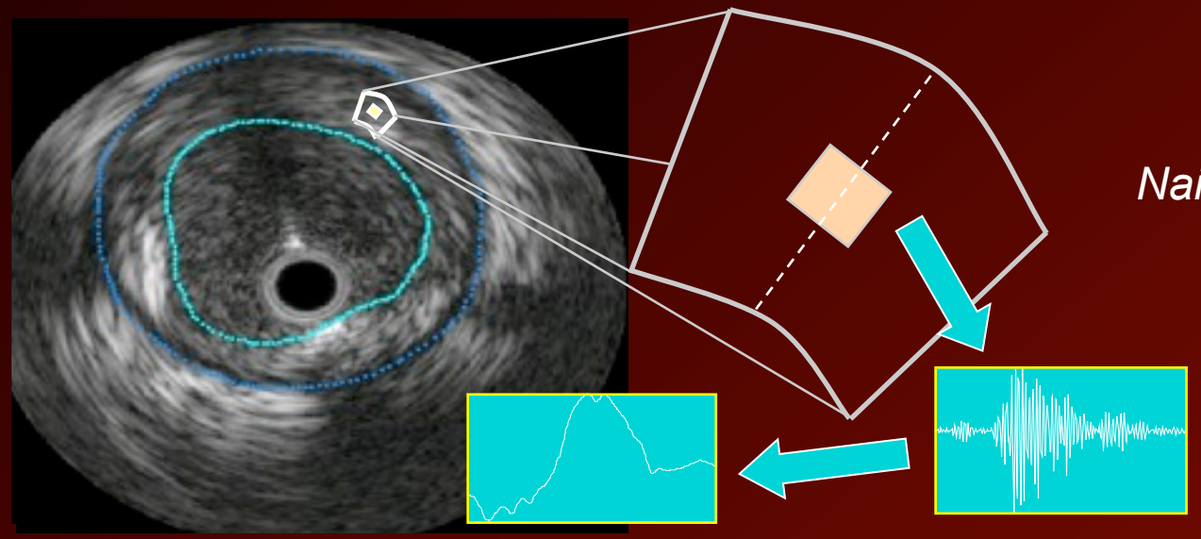
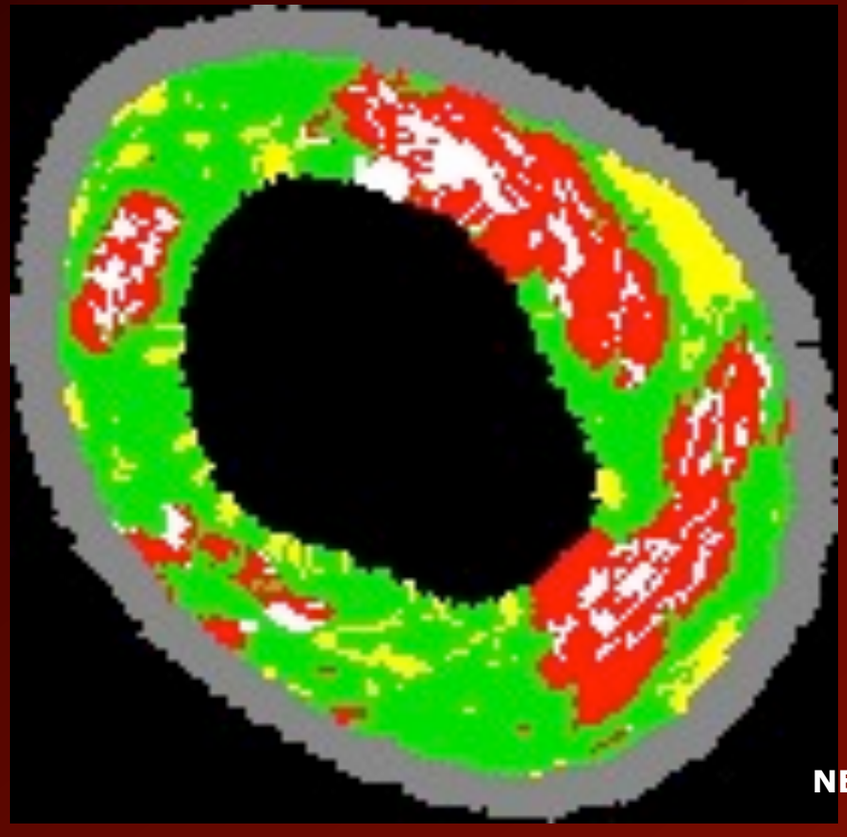
Virtual histology



Nair A et al. Circulation 2002; 106:2200.

RF signal



VH colour code

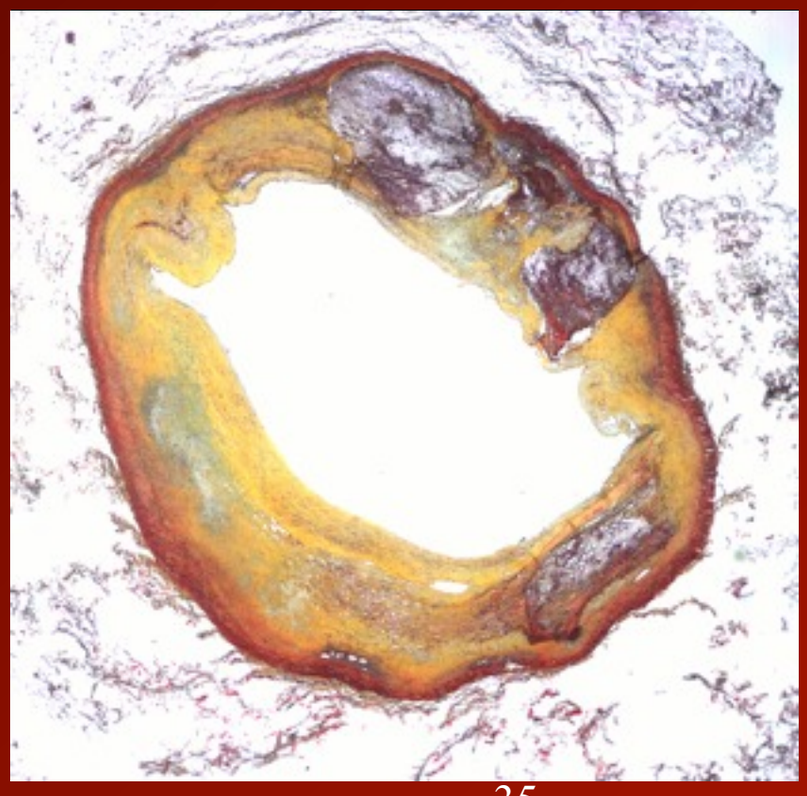
MEDIA

FIBROSUS

FIBROFATTY

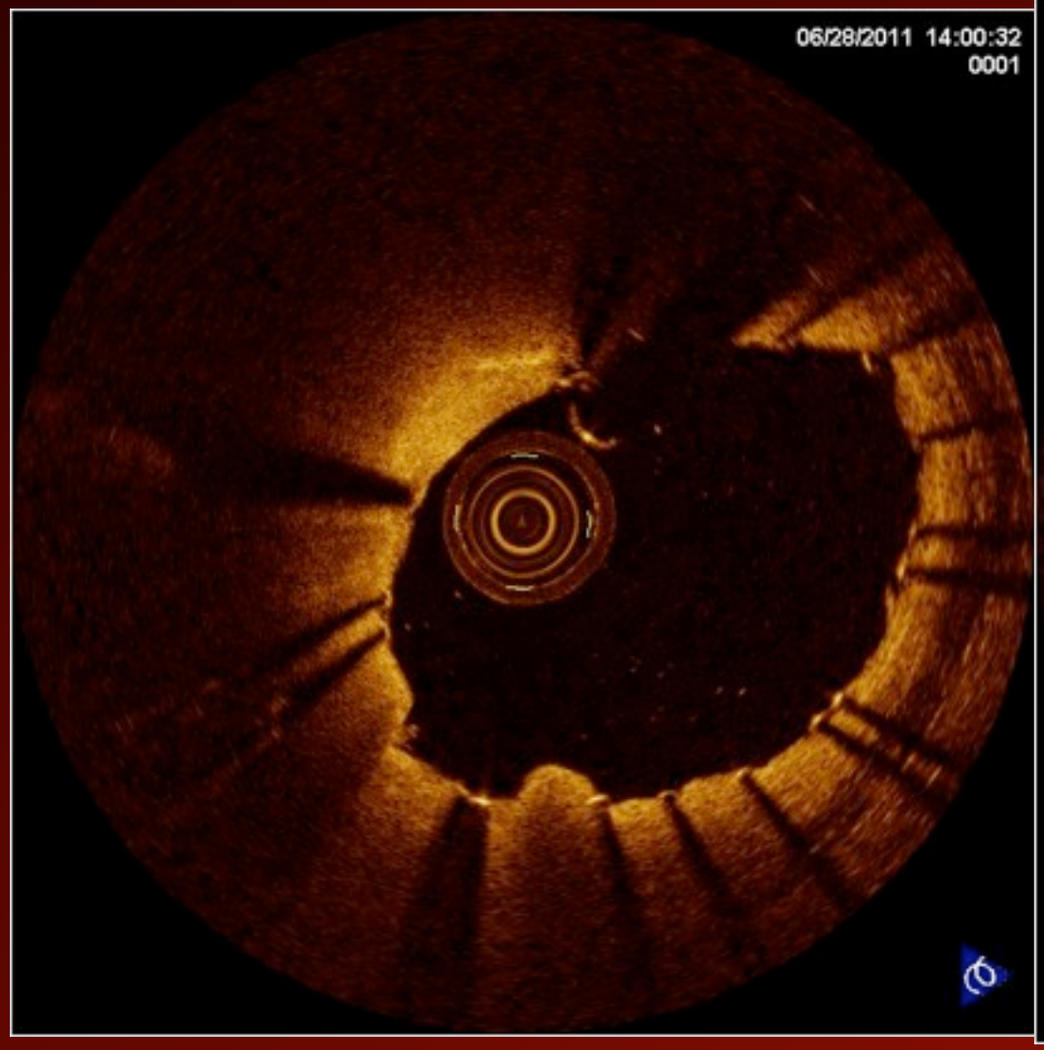
CALCIUM

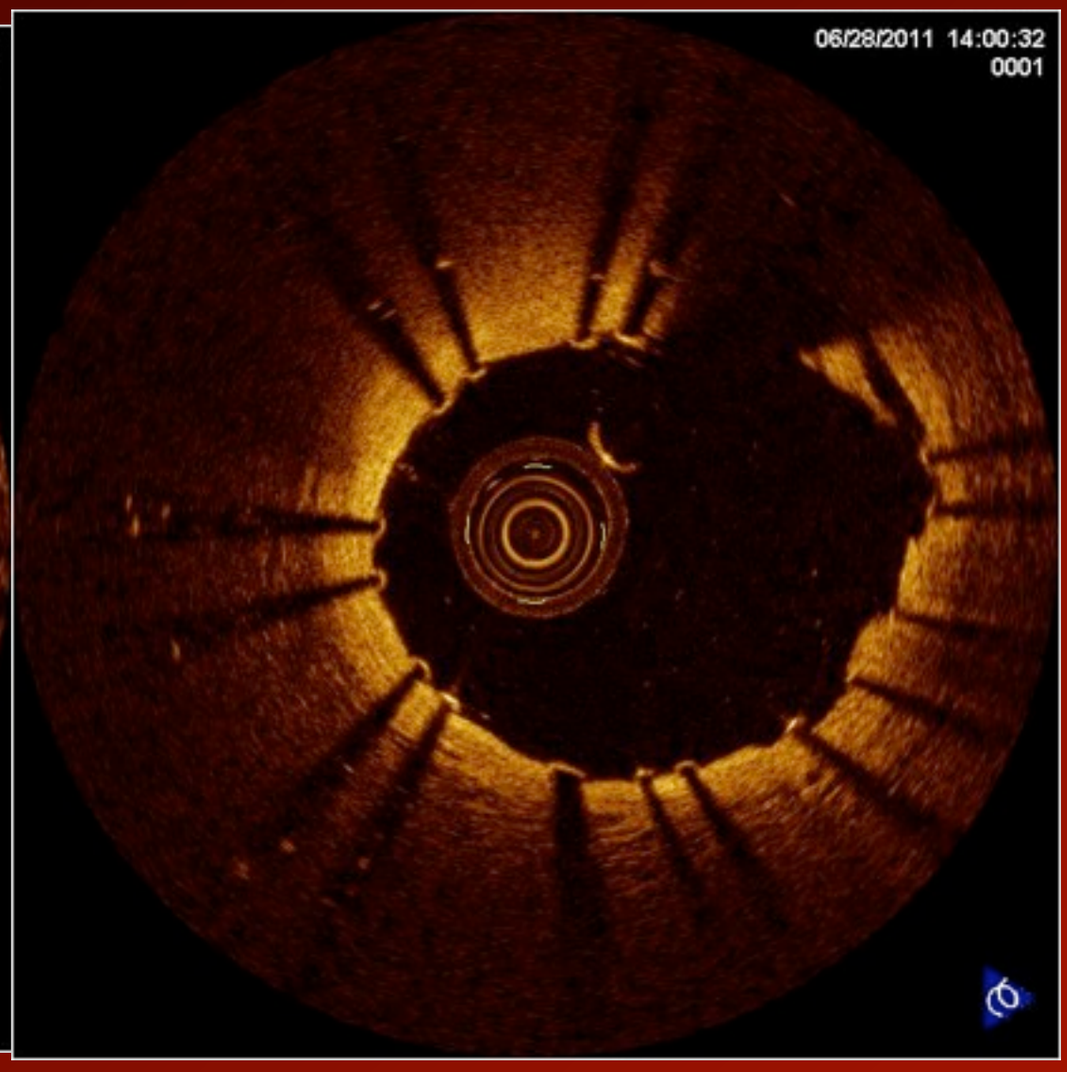
NECROTIC CORE



Optical Coherence Tomography (OCT)

- Near-infrared light
- High resolution
- Art conservation ➜ diagnostic medicine





Coronary function tests

- Coronary flow reserve (CFR)
- Fractional flow reserve (FFR)
- Index of microvascular resistance (IMR)

MDCT

- Multidetector system - al least 16, 64 (256, 320)

- Heart anatomy, myocardial function
- CT coronary angiography
  - coronary stenoses
  - coronary anomalies
  - bypass grafts and stents
- Exclusion of suspected coronary disease - low or intermedieate risk - high negative predictive value

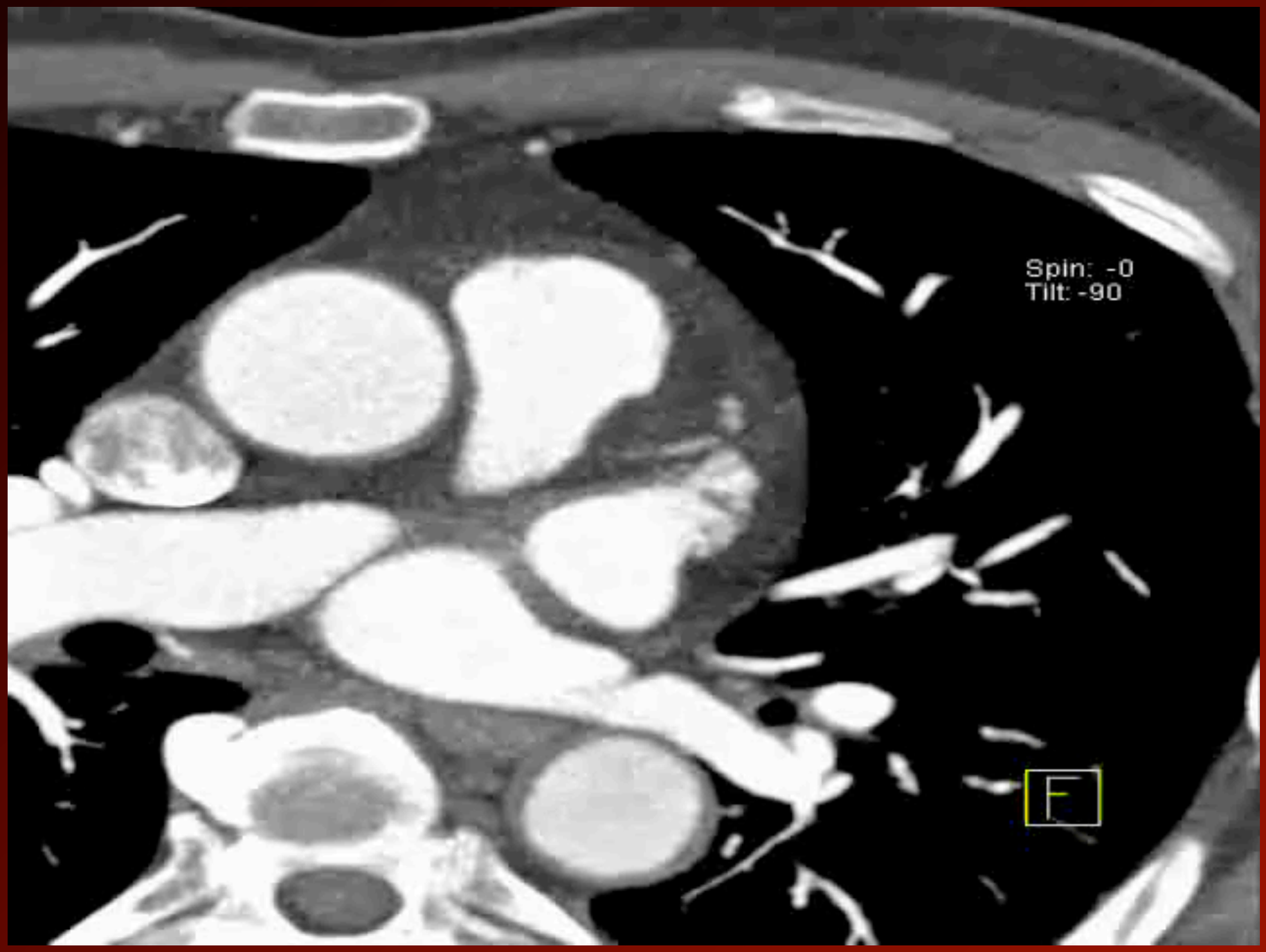
MDCT

- Plaque anatomy and structure
  - calcified, soft plaque - dual source CT
- Vulnerable plaque detection - TCFA
  - thin cap, lipid rich necrotic core - ACS

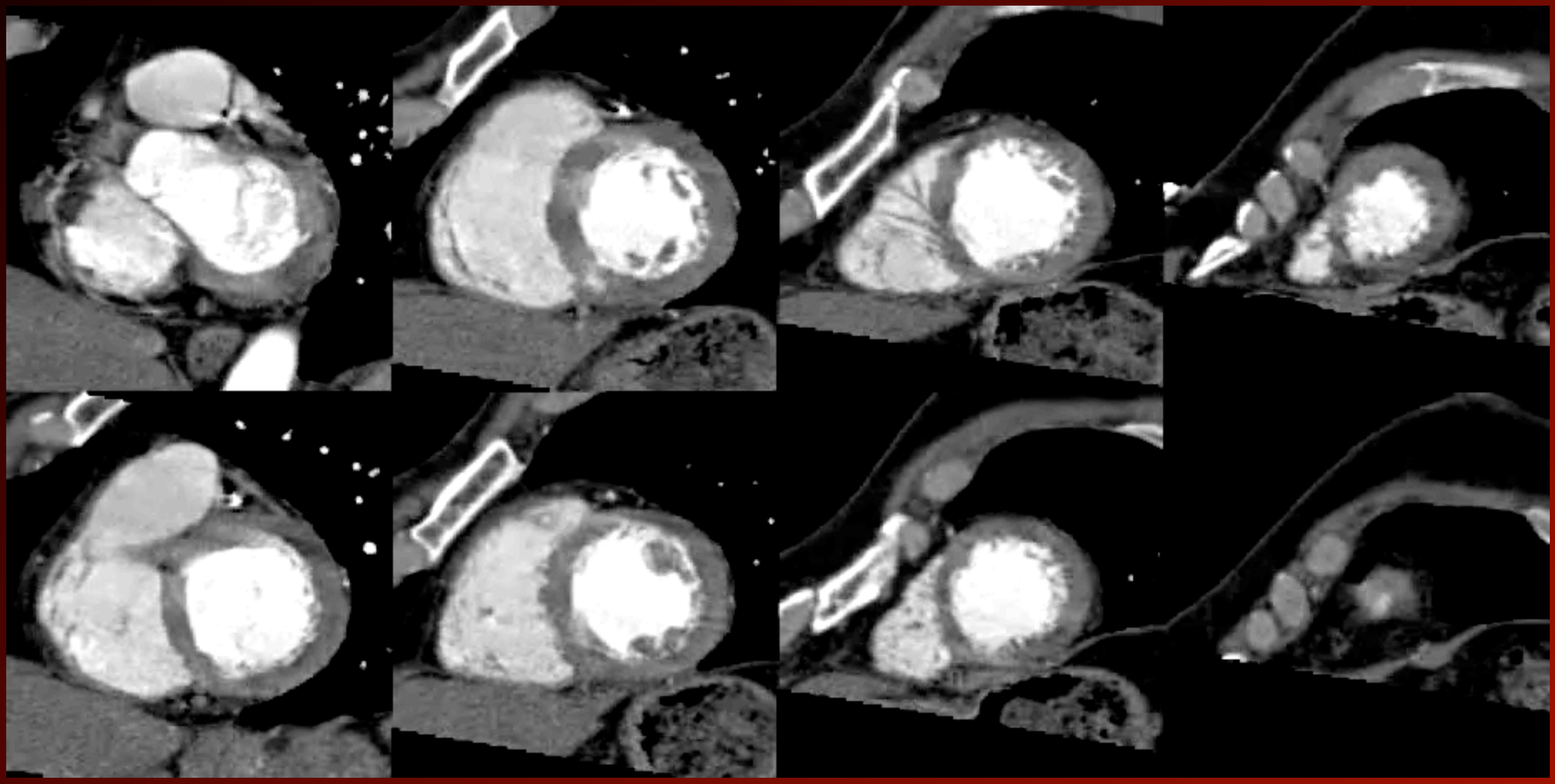
MDCT

- Emergency unit - “triple rule-out”
- chest pain
  - myocardial infarction
  - pulmonary embolism
  - aortic dissection
- 24/7 service

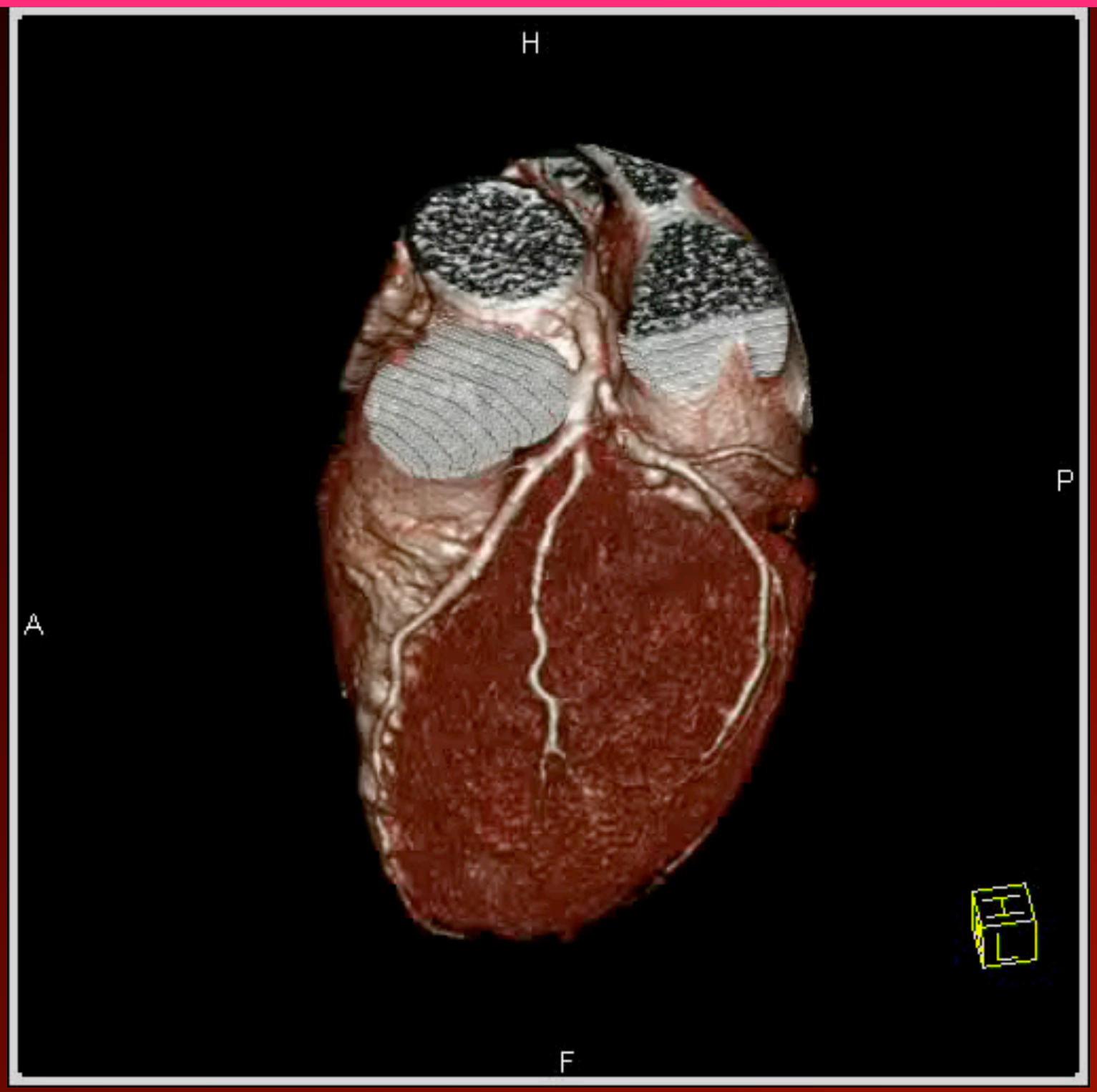
MDCT



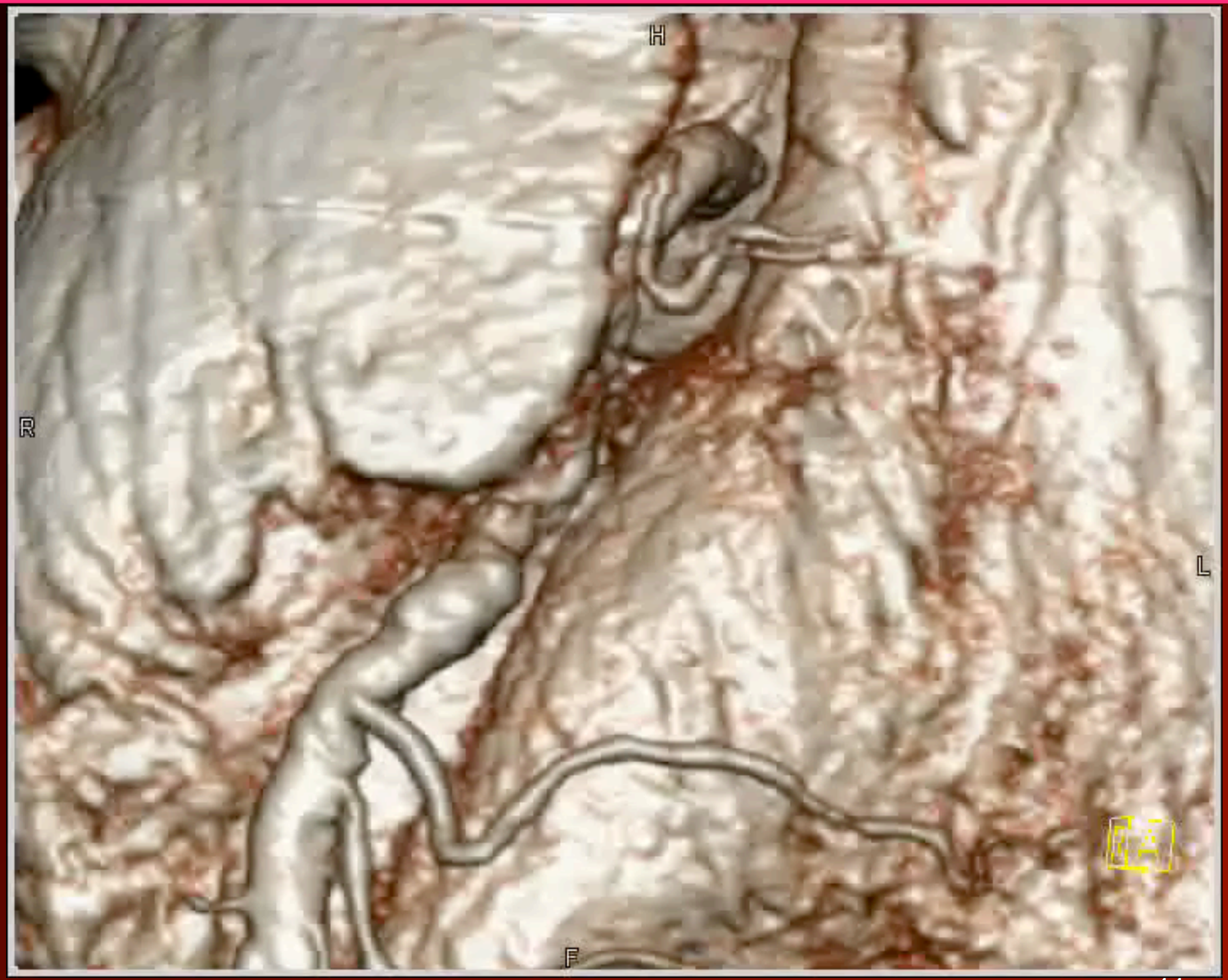
MDCT



MDCT



MDCT



Cardiac MR

- Magnetic resonance imaging
- 1.5 Tesla minimum
- Both anatomy and function
- No radiation
- Excellent image quality

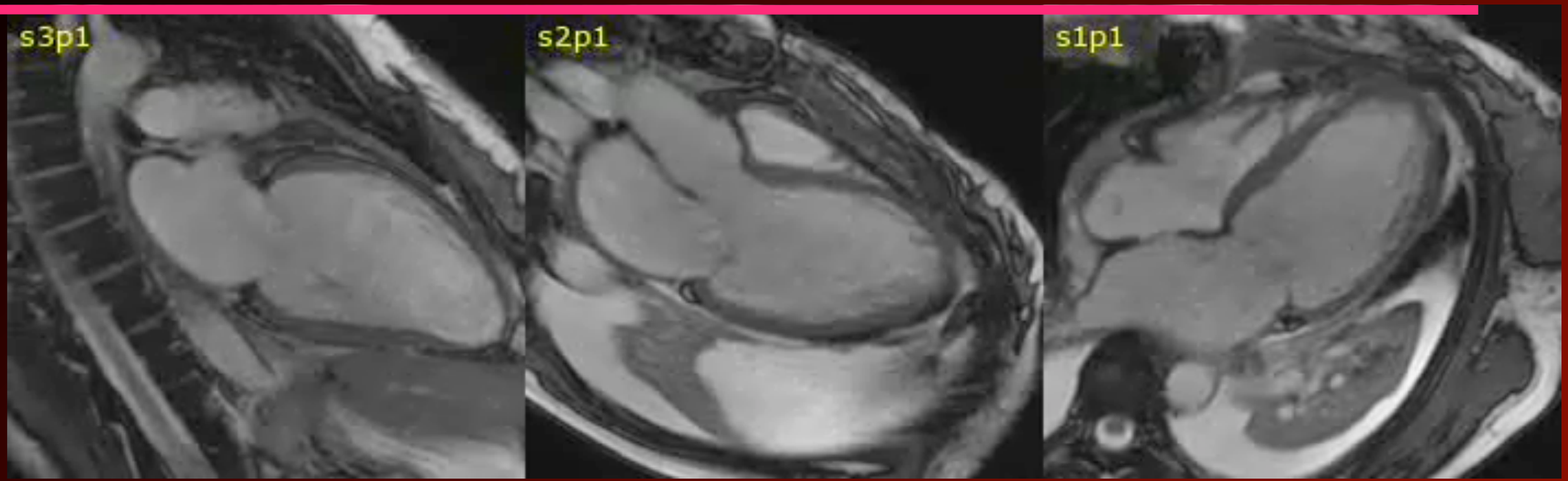
Cardiac MR

- Left and right ventricular volumes and ejection fraction
- Systolic and diastolic function
- Coronary anatomy, anomalies
- Myocardial perfusion
- Myocardial infarction and damage
  - late enhancement

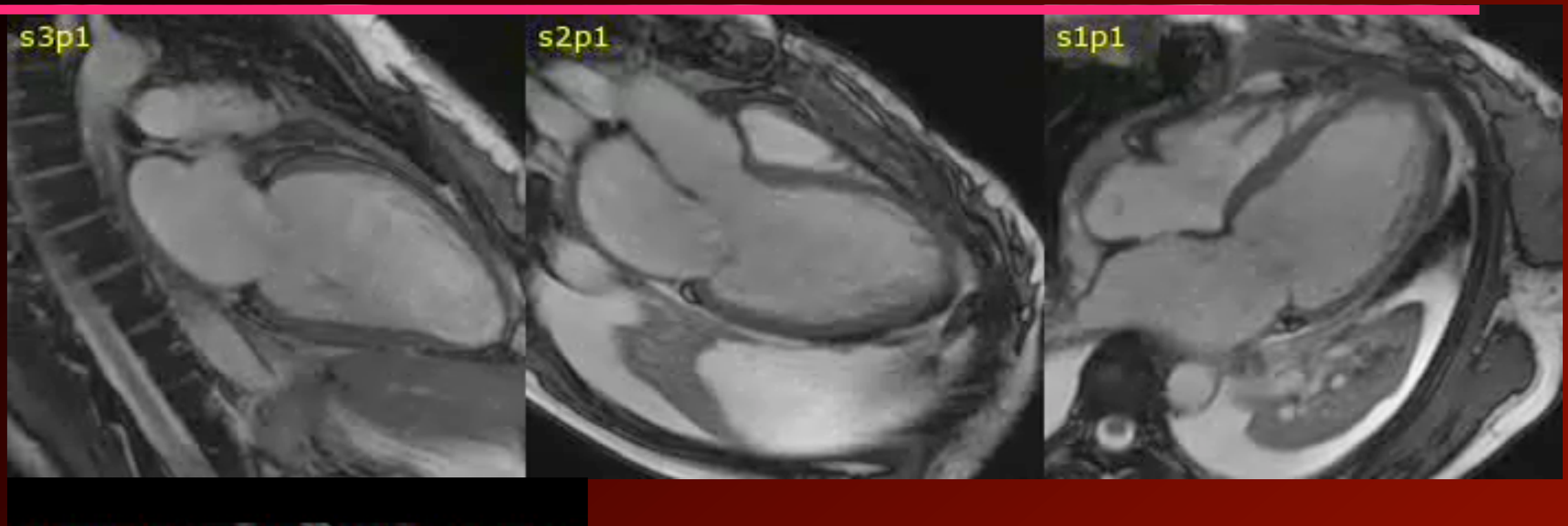
Cardiac MR

- Informative in all heart diseases
- Uniquely diagnostic in
  - ARVC
  - non-compaction CM
- MR angiography

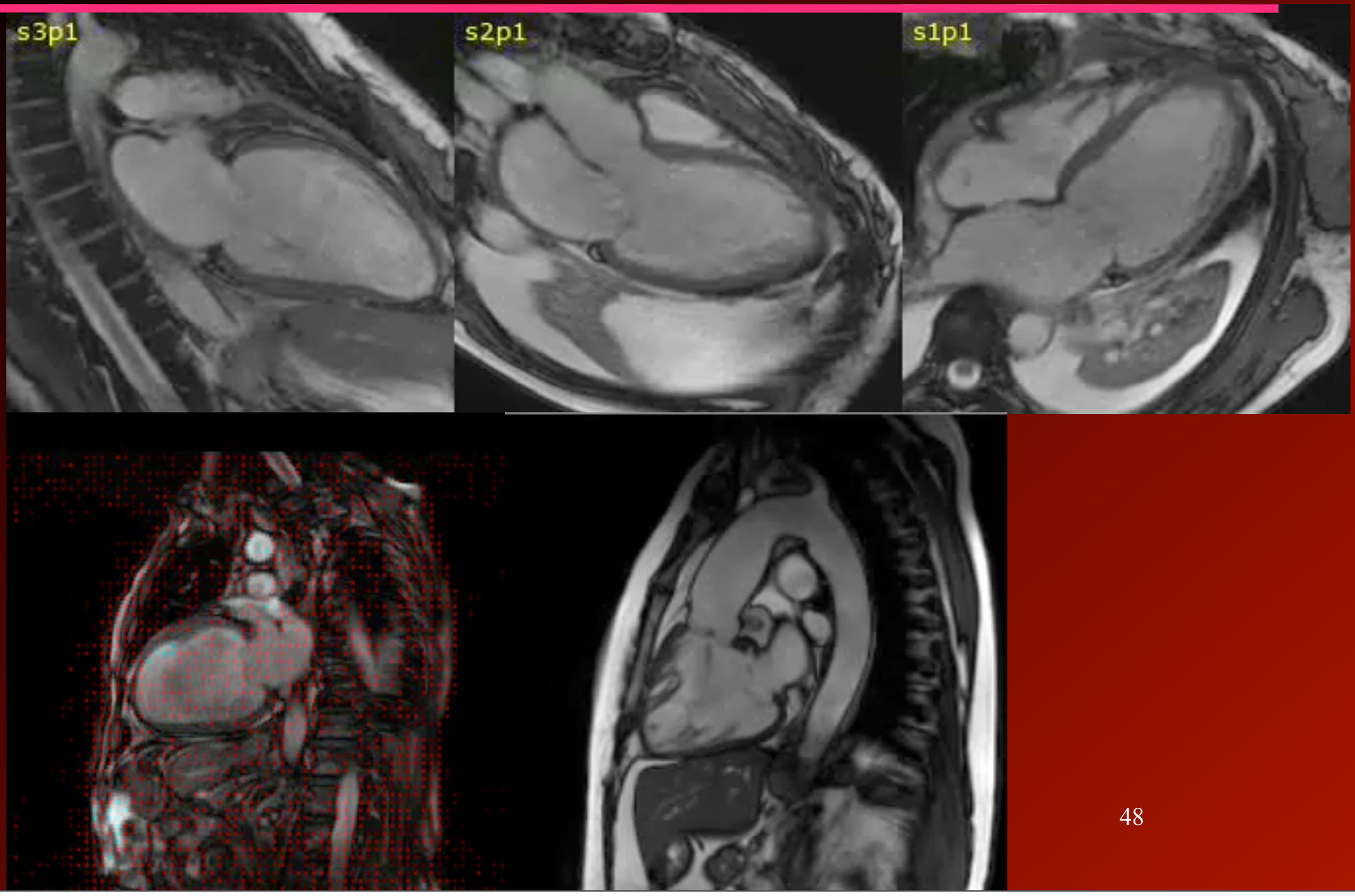
MR



MR



MR



MR

Novel development

VScan - GE

New technologies

- Newer and newer techniques emerging
- New technologies are expensive
- Unnecessary studies are costly
- Adequate indications can improve healthcare and decrease patient's burden
- Students should know indications and drawbacks of these new technologies without knowing technical details

Summary

- Besides physical examination routine investigational methods should be tought in details
- For basic methods (ECG) diagnostic capability required
- Basic knowledge of echocardiography (TTE, TEE, stress) - diagnostic value, limitations
- 3D-Echo, MDCT, MR - role in decision making
- Newer techniques - research tools, future implementation
- These new technologies might become widely available soon, therefore students must know about them!

Thank you for your attention!

11. július 22., péntek