Imaging in advanced heart failure

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4 major imaging techniques:

- Echocardiography
- Magnetic resonance imaging
- Multi-slice CT
- Nuclear imaging (PET and SPECT)
- Can provide all anatomical and functional information, but use should be clinically driven

Diagnosis is important

But, the imaging results need to have impact on:

patient management and choice of therapy

Patient example

Male, 62 yrs

- 1987: Infero-postero-lateral infarct
- 1988: Repeat inferior infarct
- 1994: Antero-septal infarct
- 1996: CABG: LIMA-graft LAD,
  venous graft MO-LCX and RDP/RCA
- 2000: Non-sustained ventricular tachycardia

Co-morbidities

- Diabetes II
- COPD
- chronic renal failure (creatinine 300 micromol/l)

Patient example

Male, 62 yrs

- Reduced exercise capacity
- NYHA III
- Dizziness / Hypotension

- Weight 53 kg, length 1.64 m
- RR 90/65 mmHg
- Holosystolic murmur 3/6 apex

Severe heart failure patient

To determine therapy, the information below is needed

Is it CAD? ischemia/viability?

LV function and LV size?

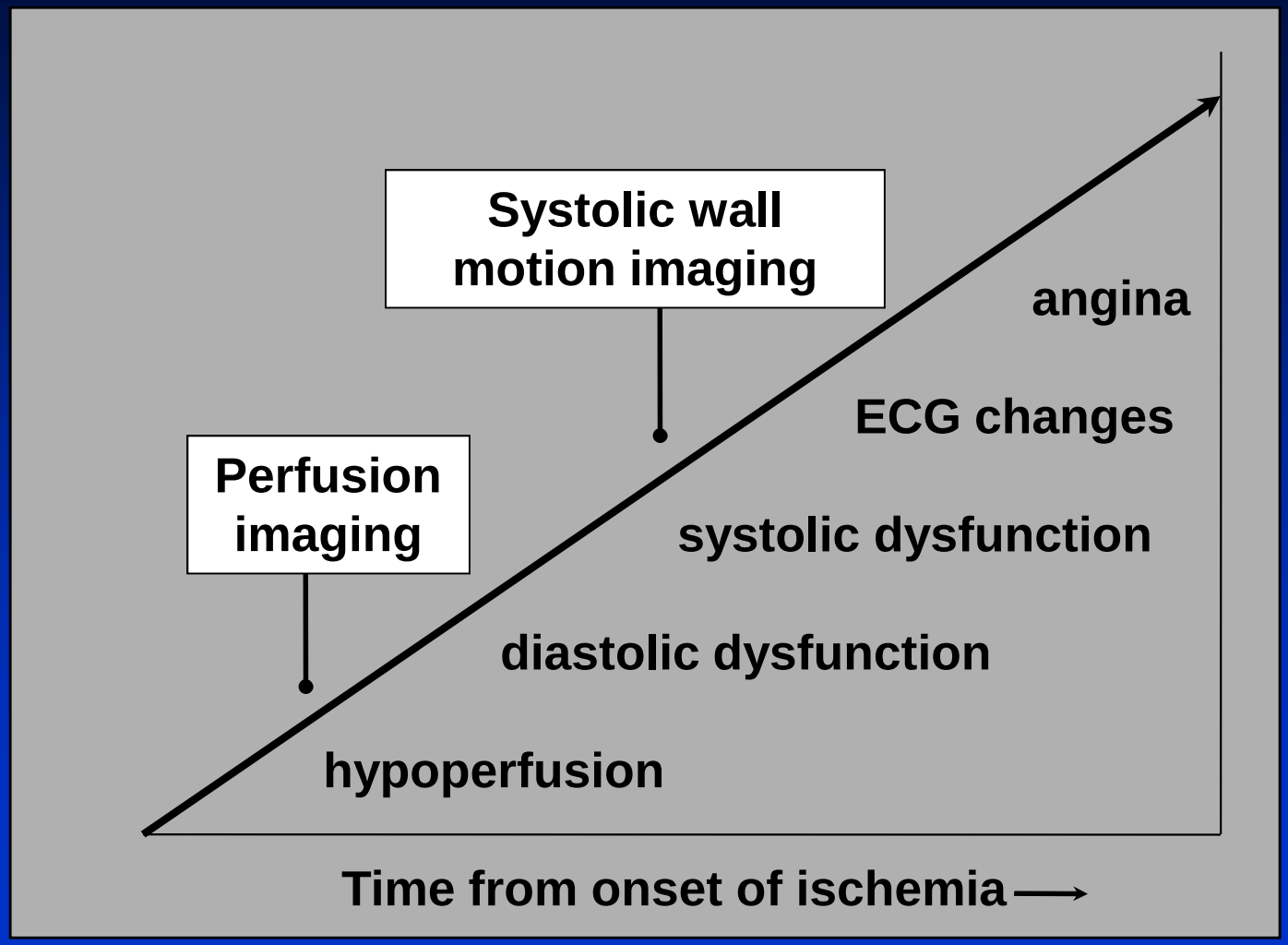
Severe MR?

ICD (CRT) needed?

CT angiography - raw data

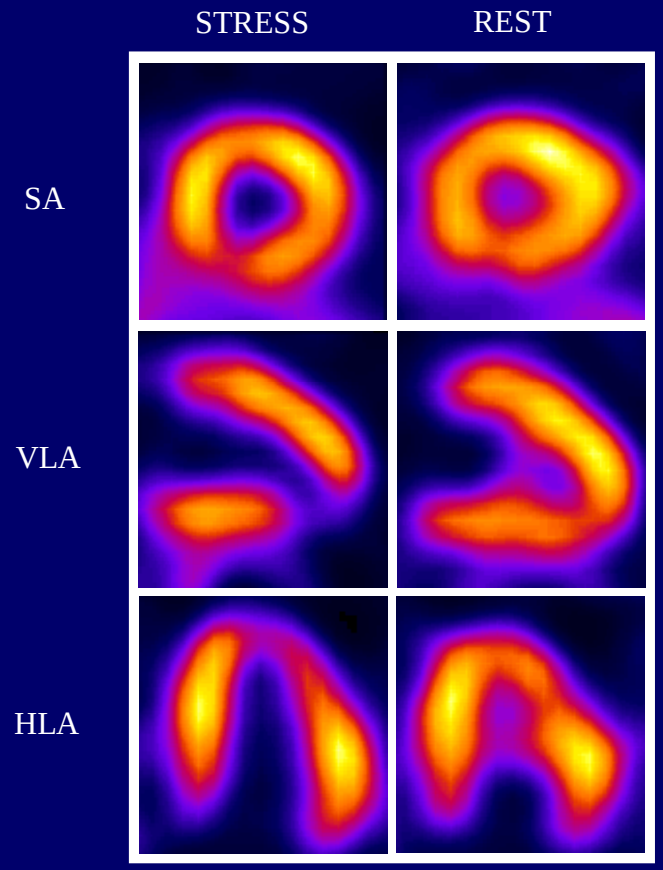
But mostly, coronary angiography

Is there ischemia?
The ischemic cascade

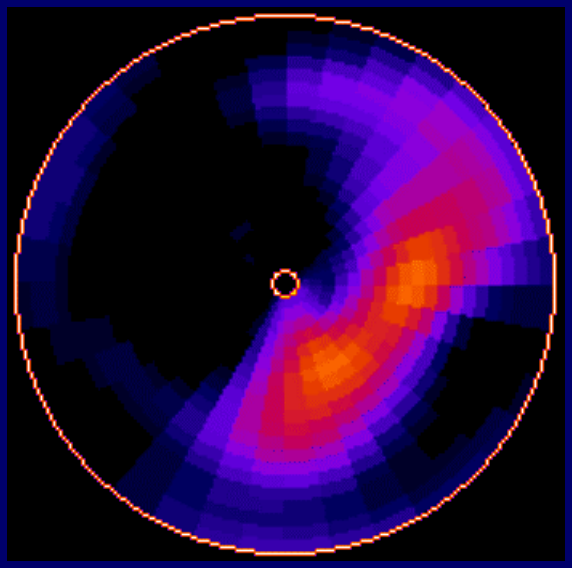


Schinkel et al. EHJ 2003

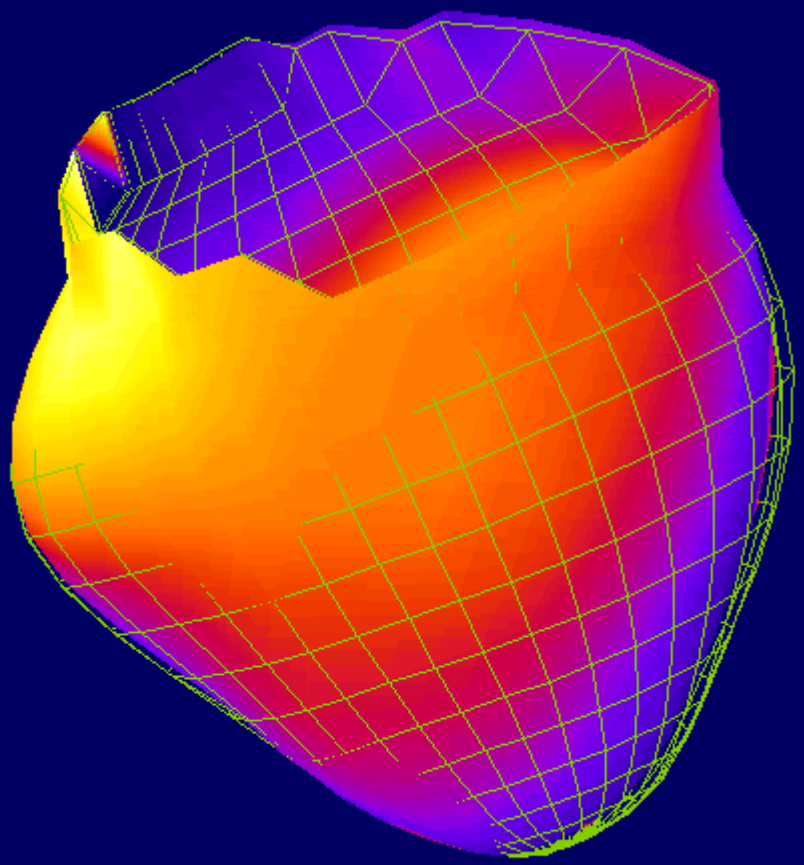
Nuclear perfusion imaging, SPECT



POLAR MAP TO QUANTIFY
EXTENT AND SEVERITY OF ISCHEMIA



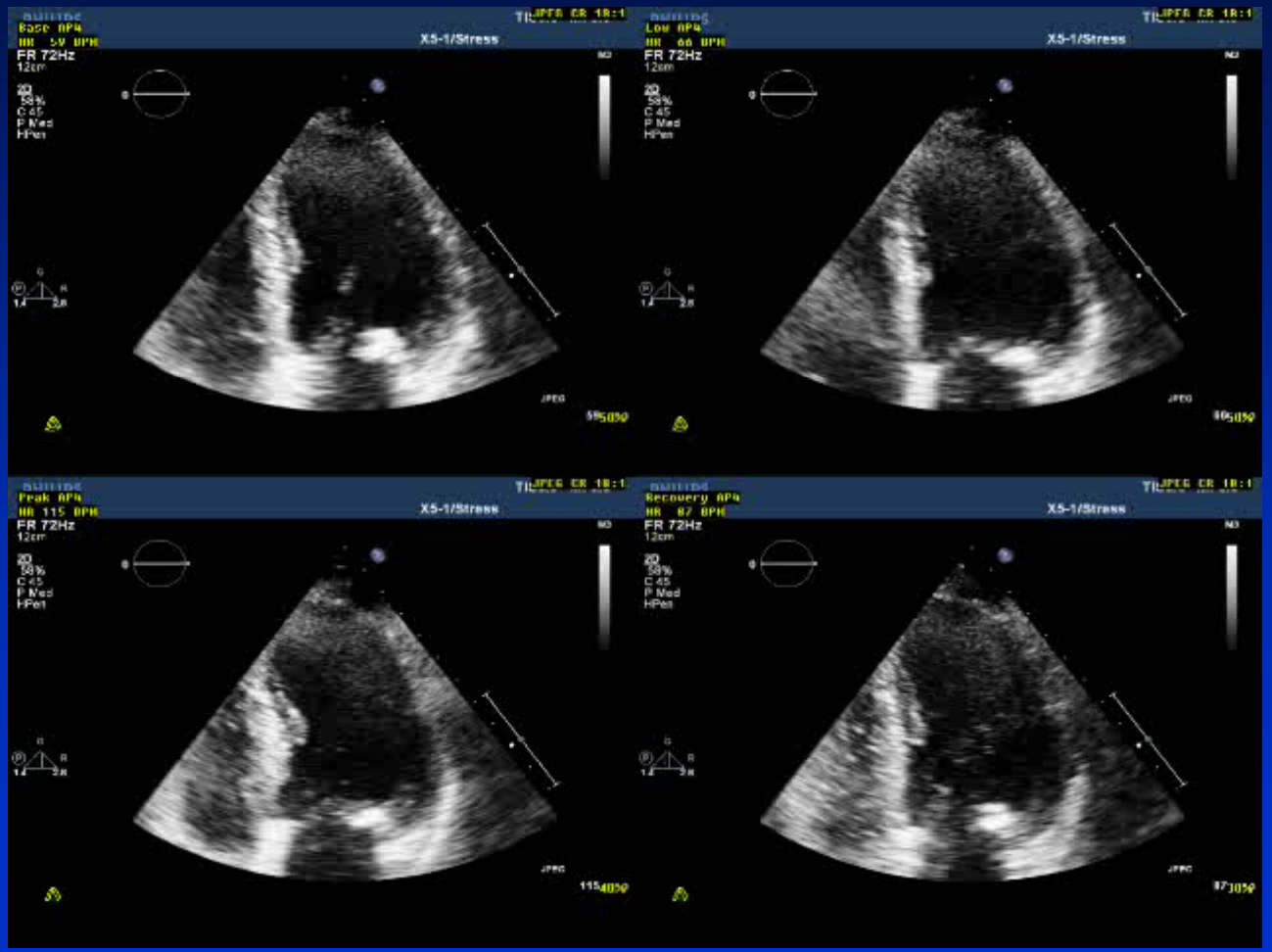
Nuclear perfusion imaging with ECG gating



Stress echo to assess flow-limiting stenosis: wall motion

rest

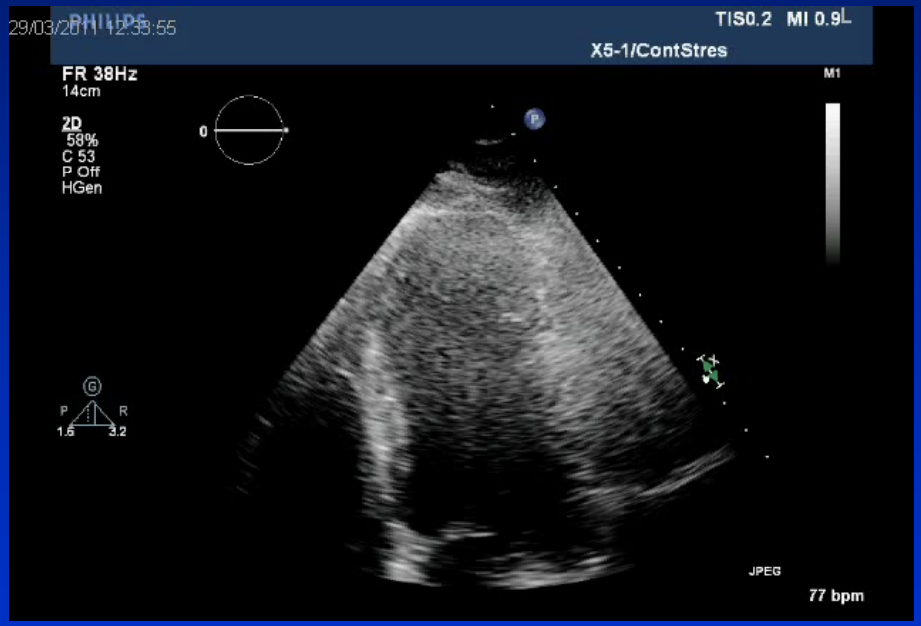
10 mcg

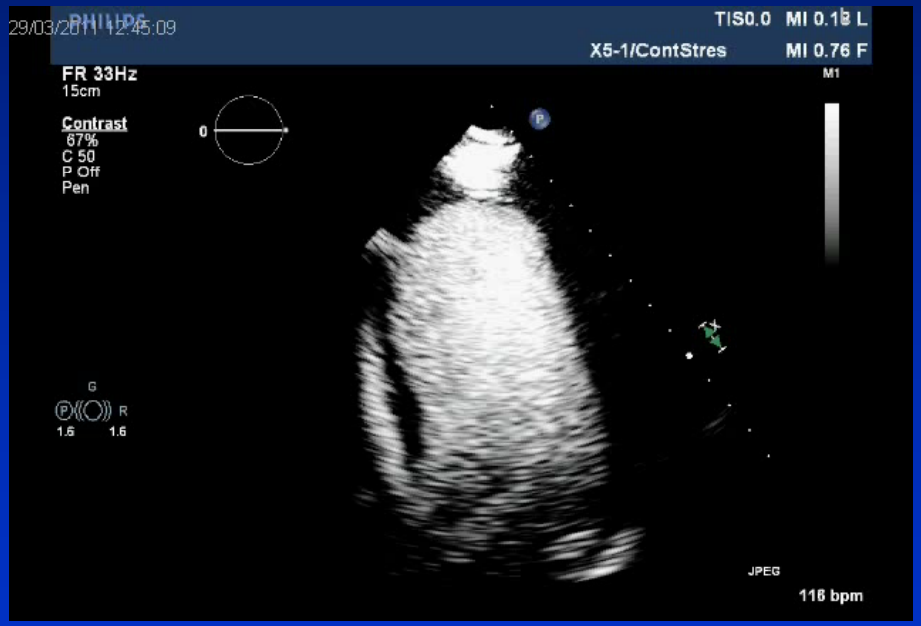


40

rest

Addition on intravenous contrast to improve border opacification

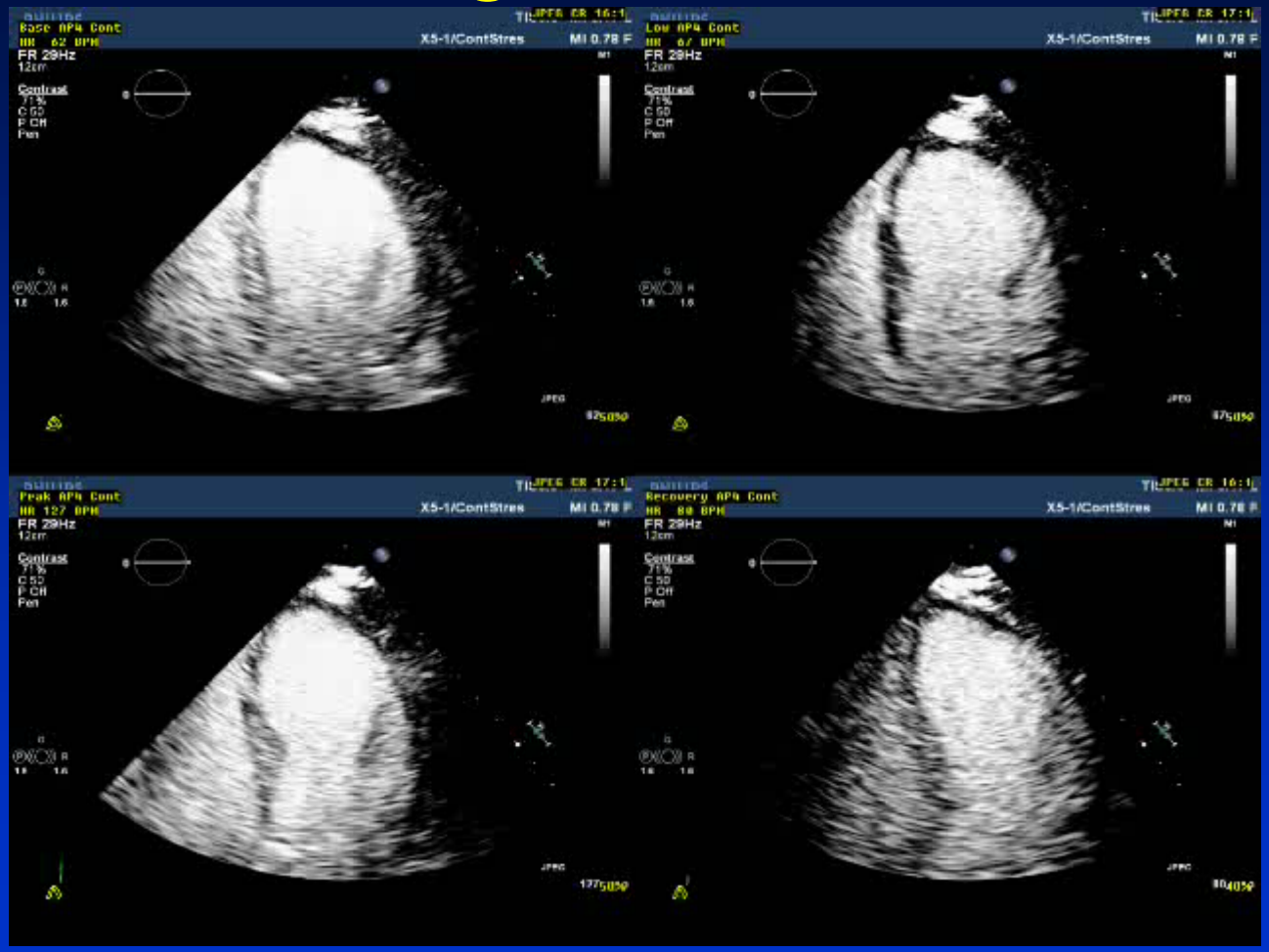




Stress echo to assess flow-limiting stenosis: wall motion

rest

10 mcg



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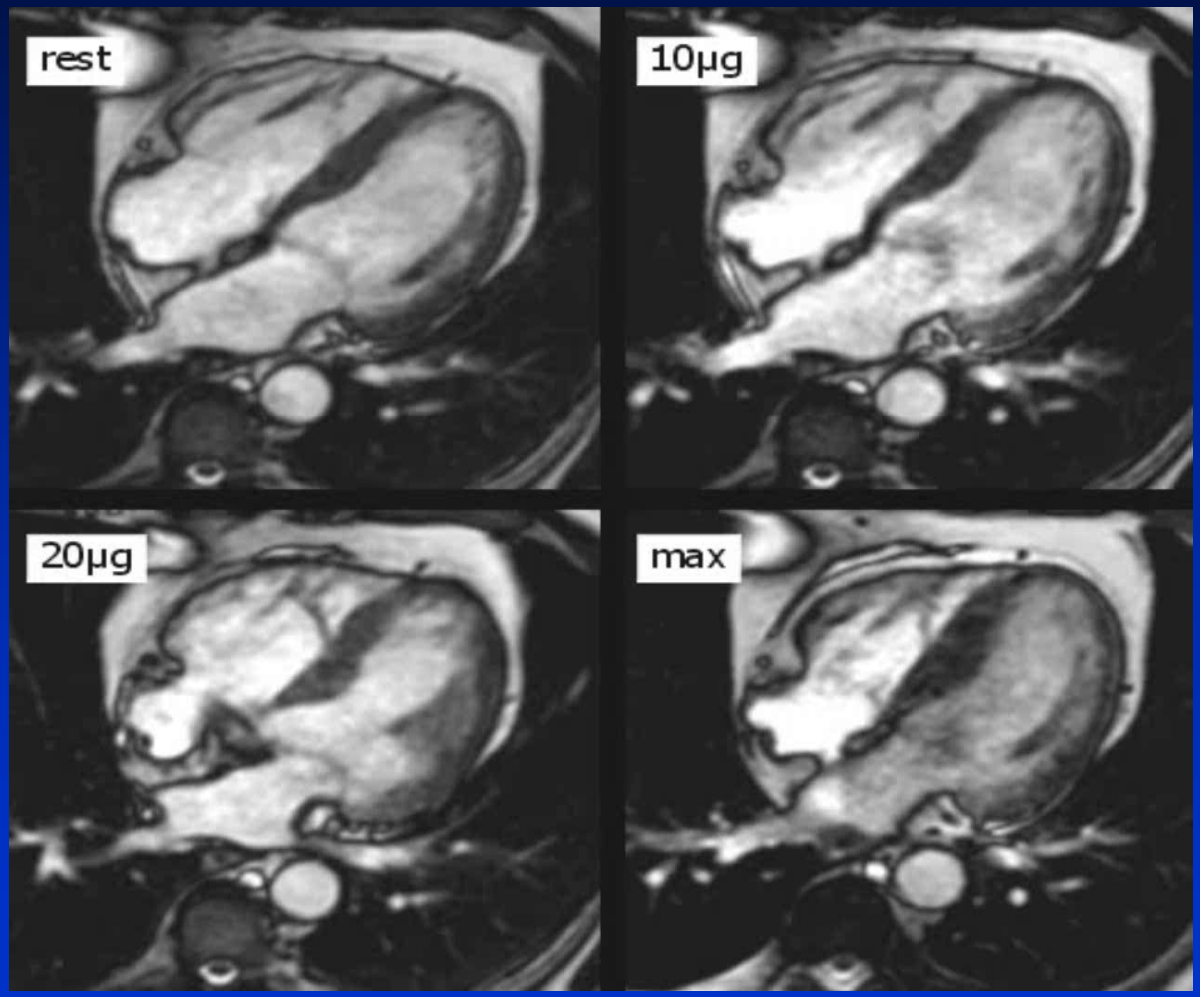
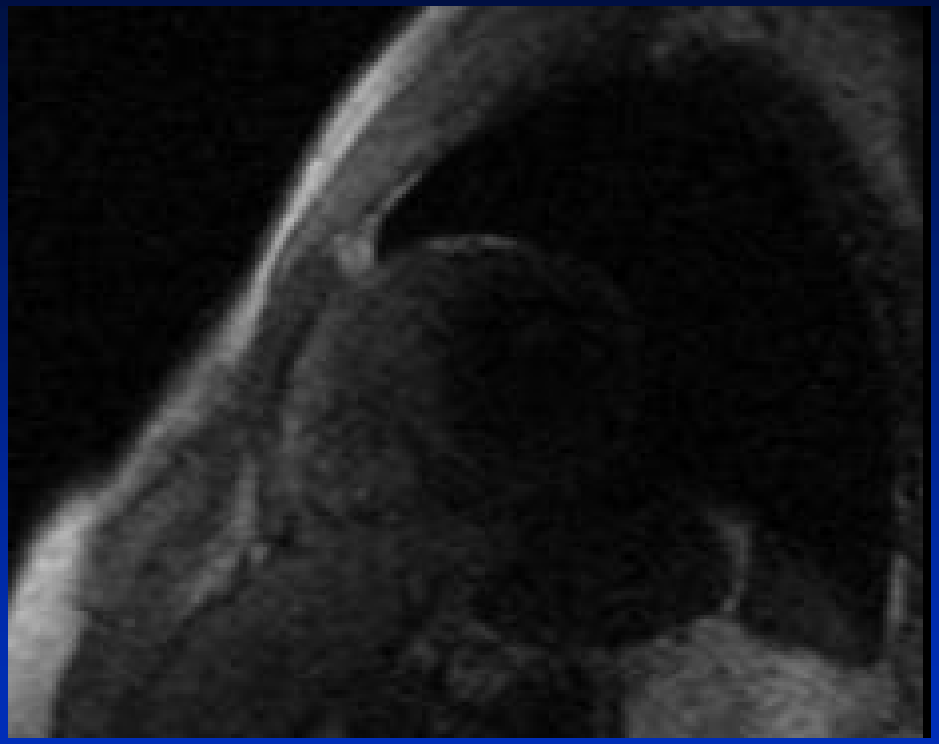
rest

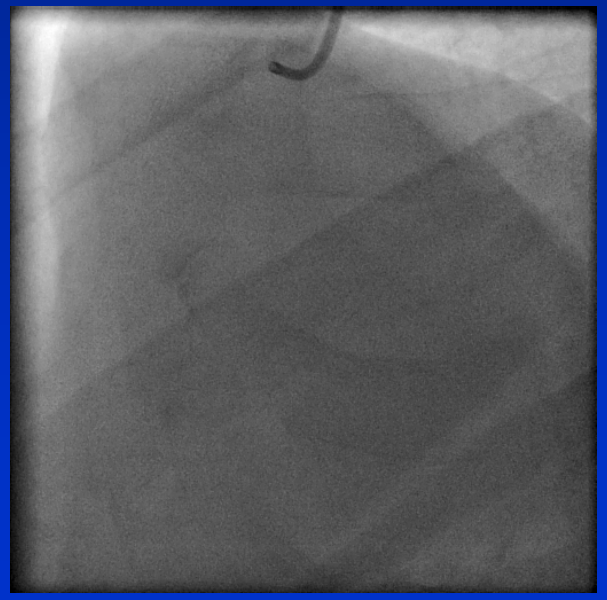
Stress MRI to assess flow-limiting stenosis: wall motion



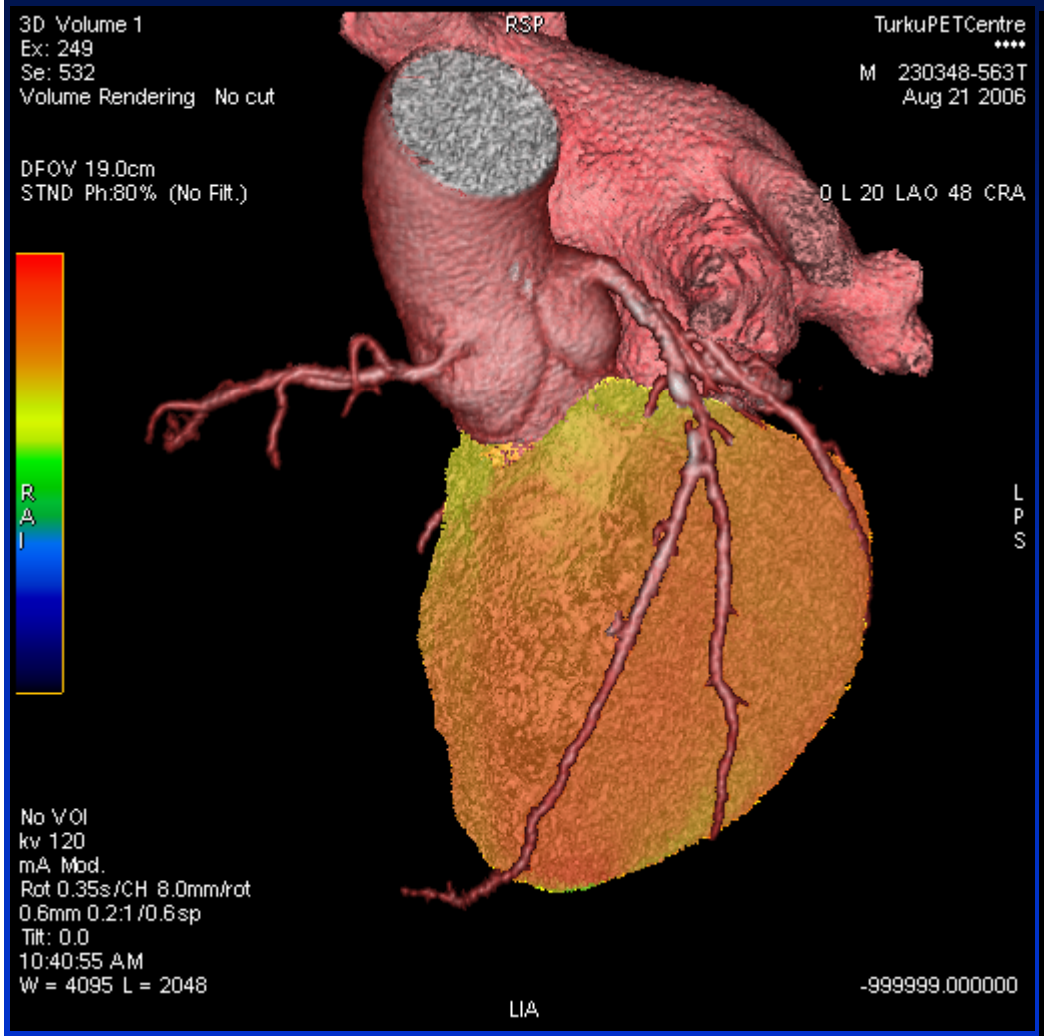
Courtesy I Paetsch

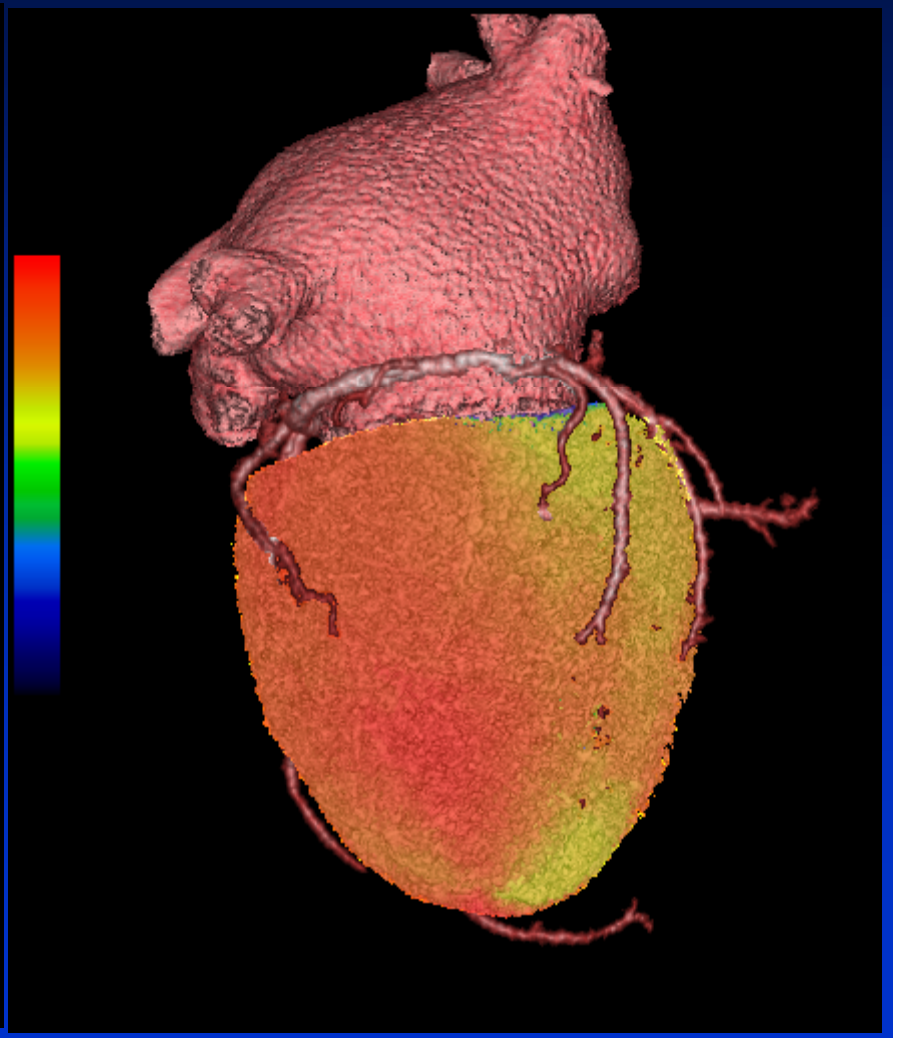
MRI – perfusion imaging





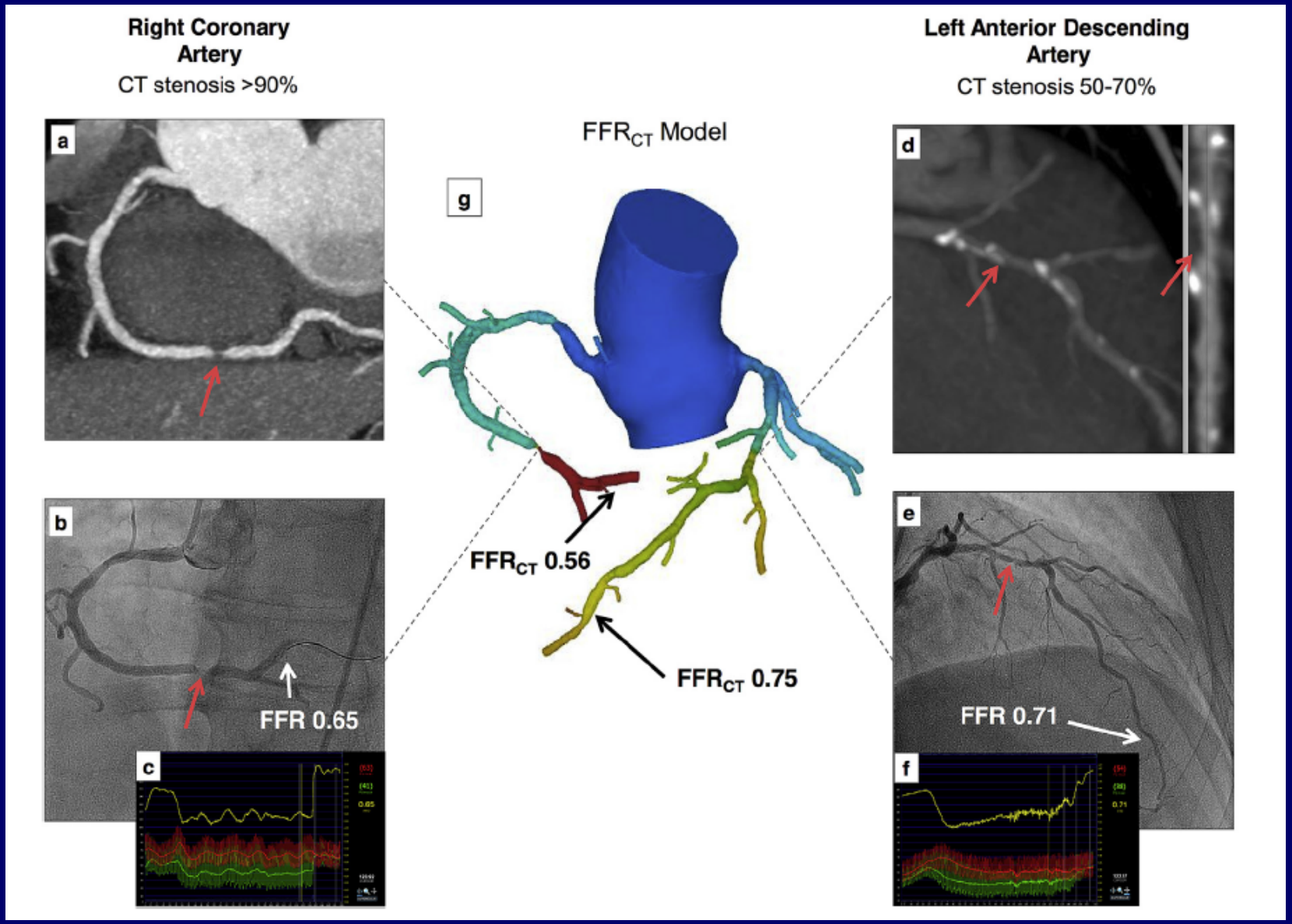
Hybrid imaging coronary anatomy and perfusion





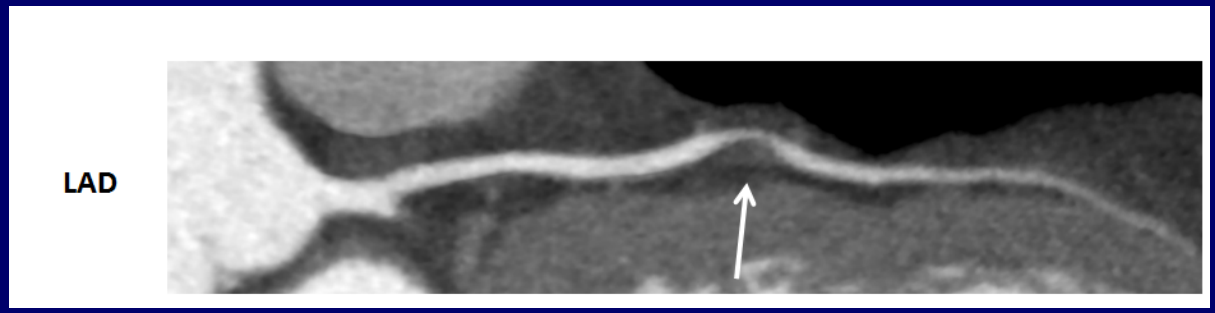
Courtesy J Knuuti

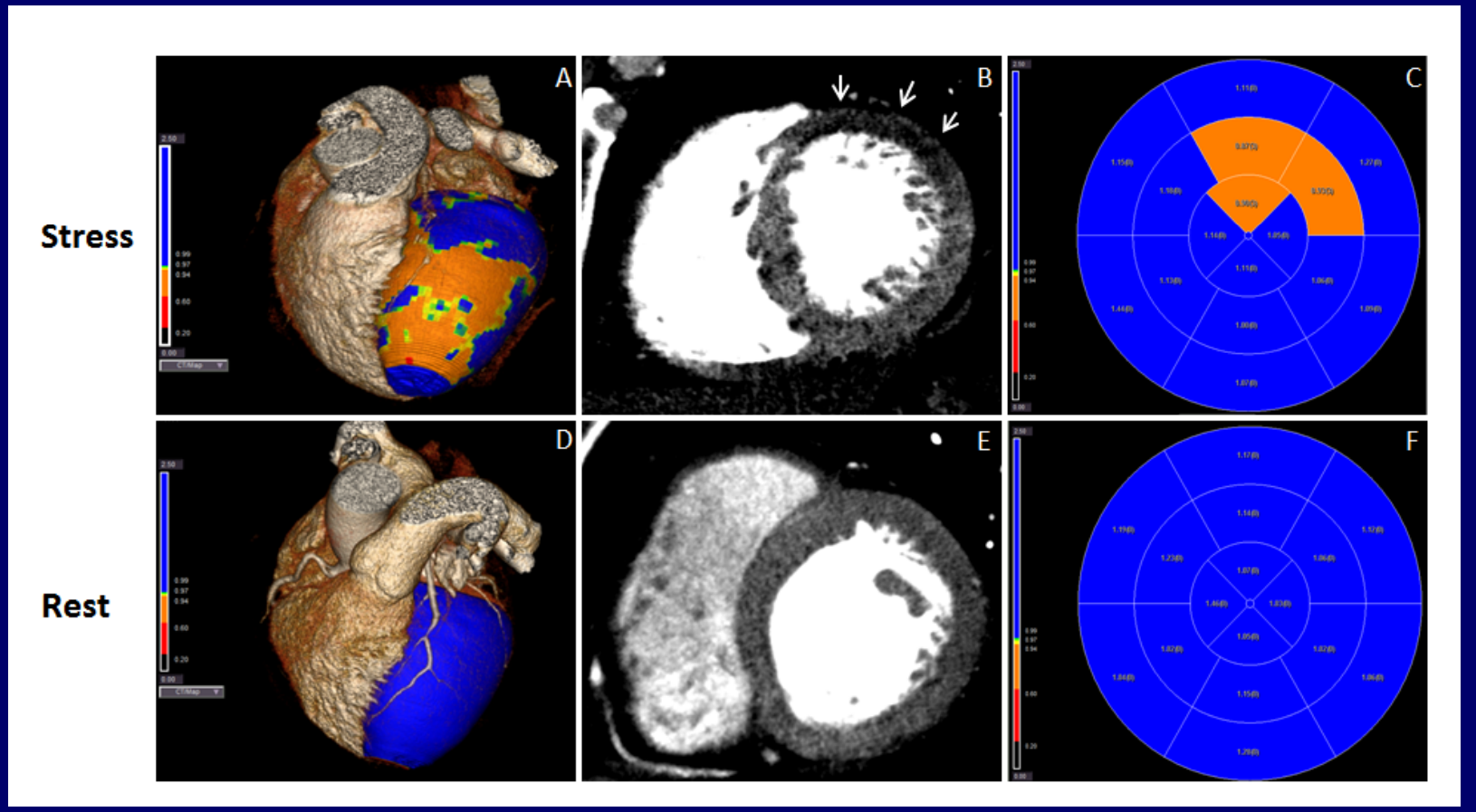
Hemodynamic significance of stenosis - FFR CT



Norgaard et al. JACC 2014

CT perfusion



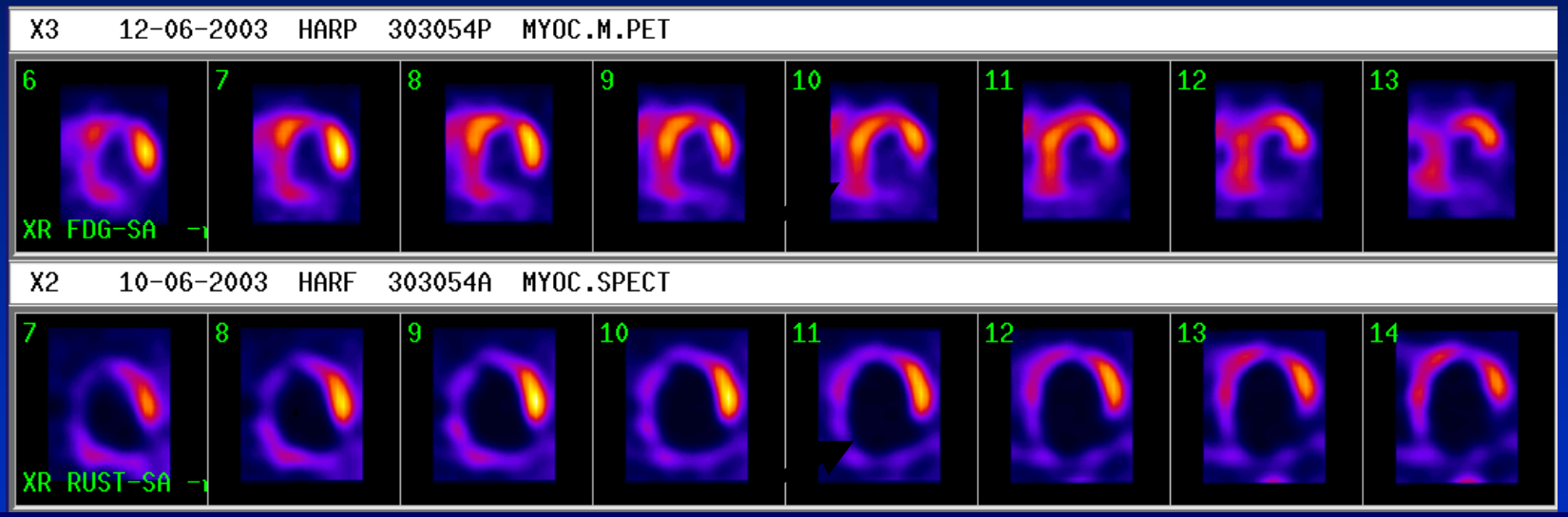


Roosendael et al. JNC 2015

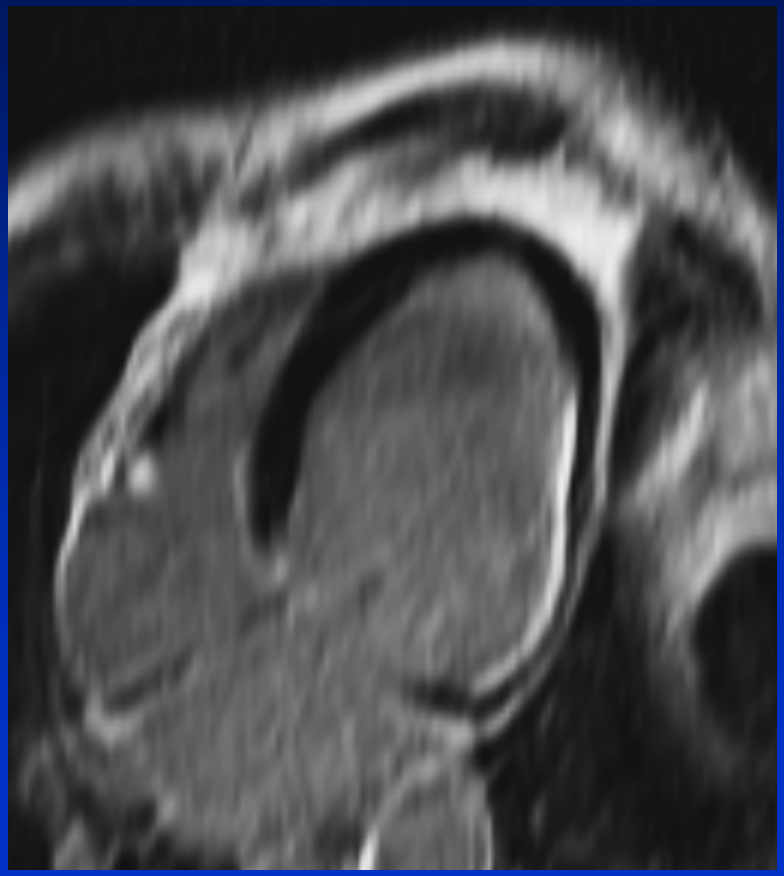
Is there viability?

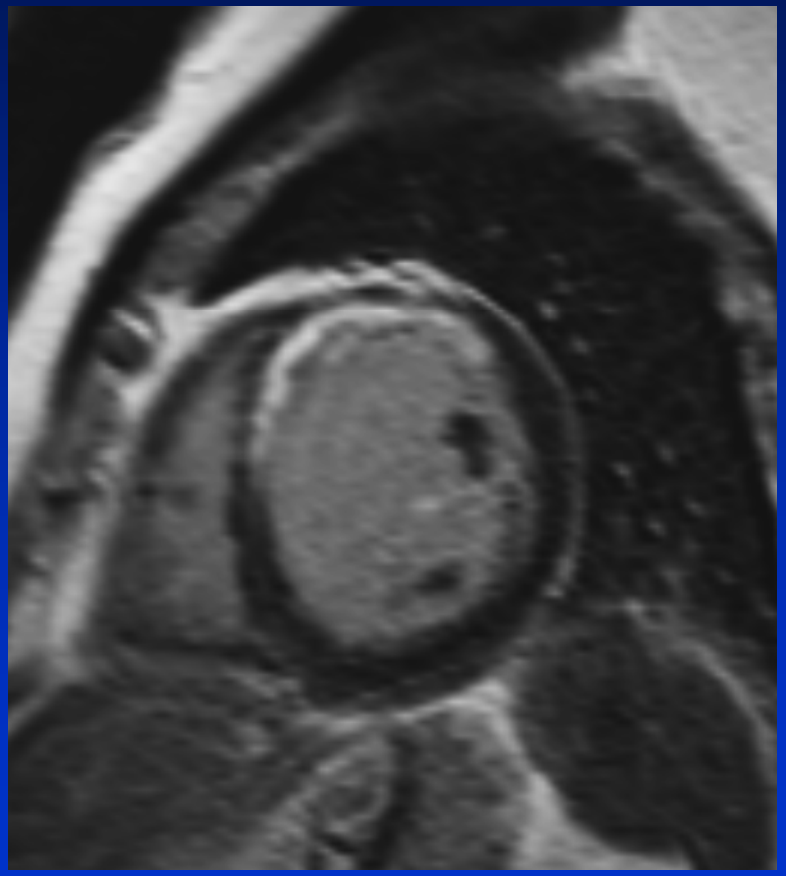
FDG

Perf

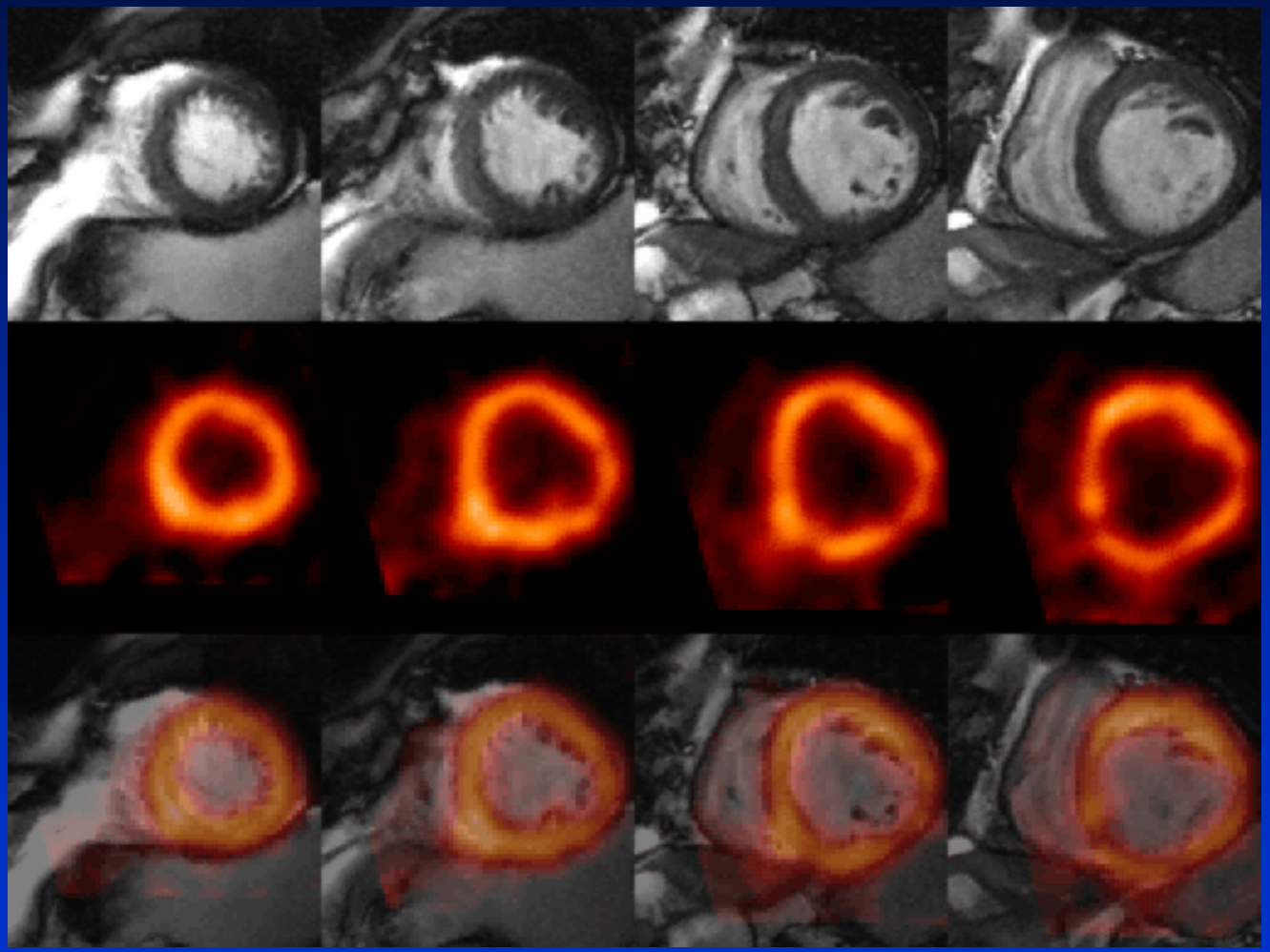


Infarct imaging with delayed enhancement MRI





Viability assessment - Future?



M. Schwaiger et al.

Severe heart failure patient

To determine therapy, the information below is needed

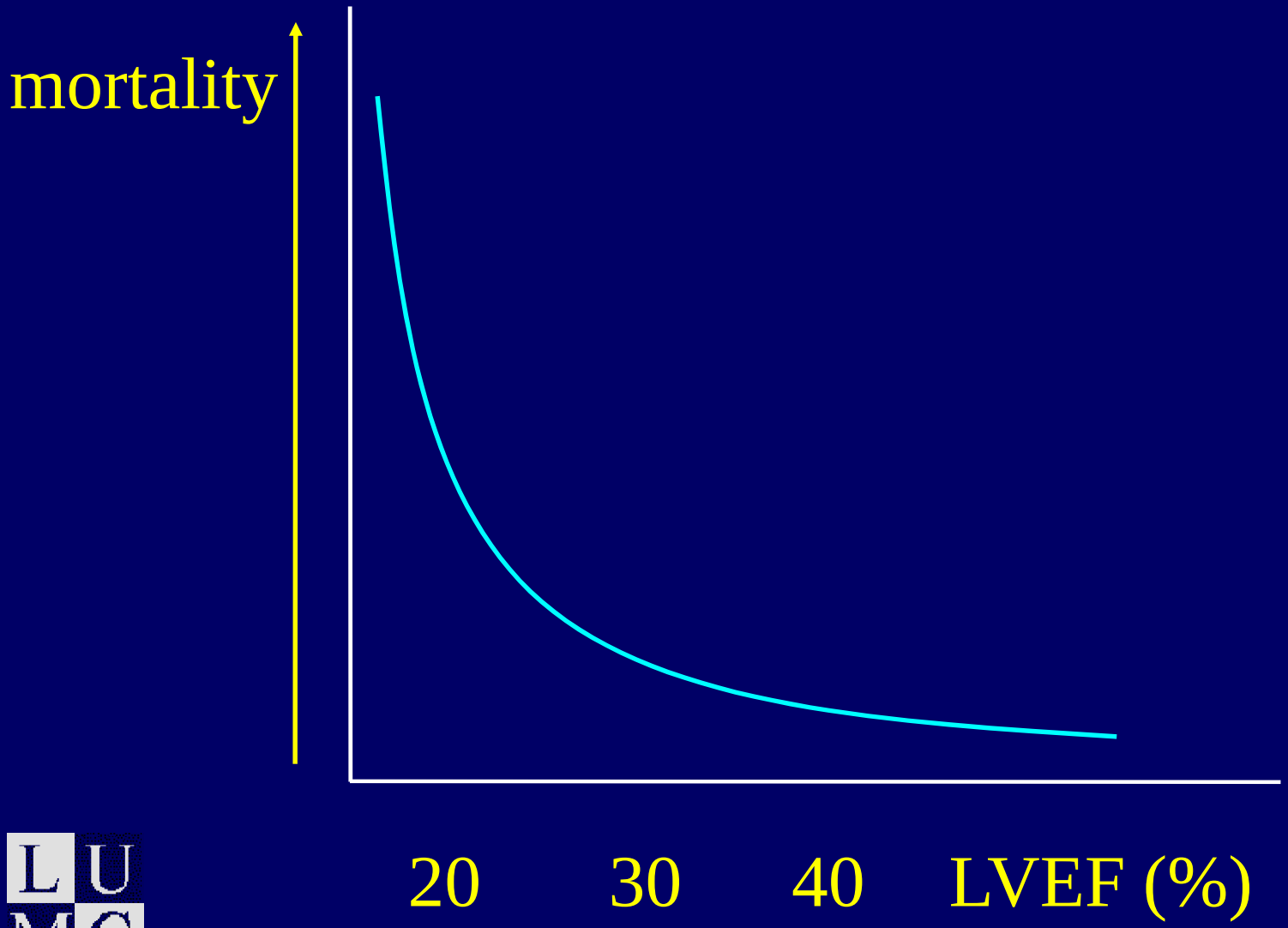
Is it CAD? ischemia/viability?

LV function and LV size?

Severe MR?

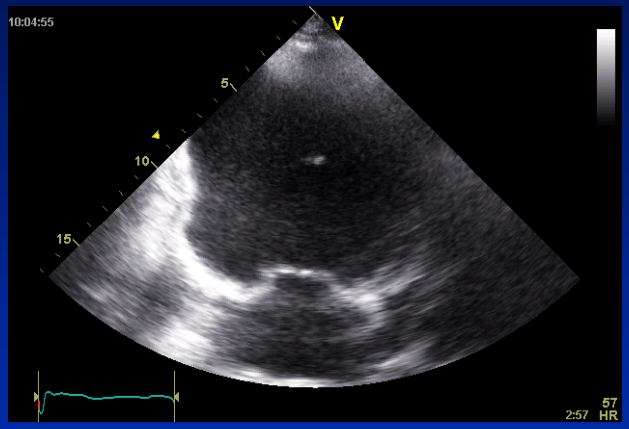
ICD (CRT) needed?

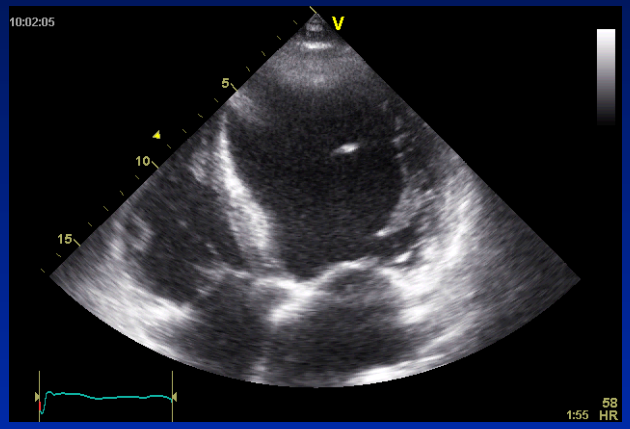
LV function and size?

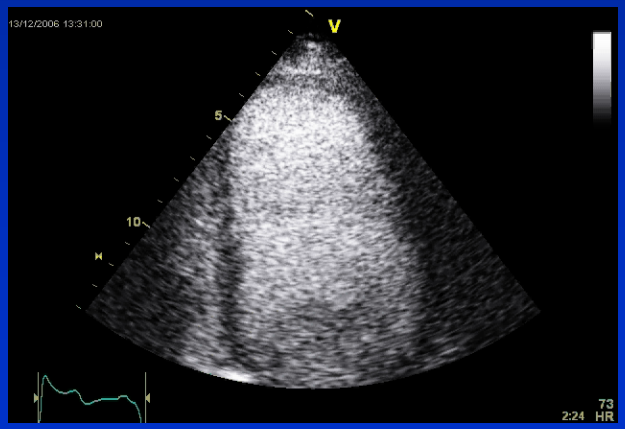


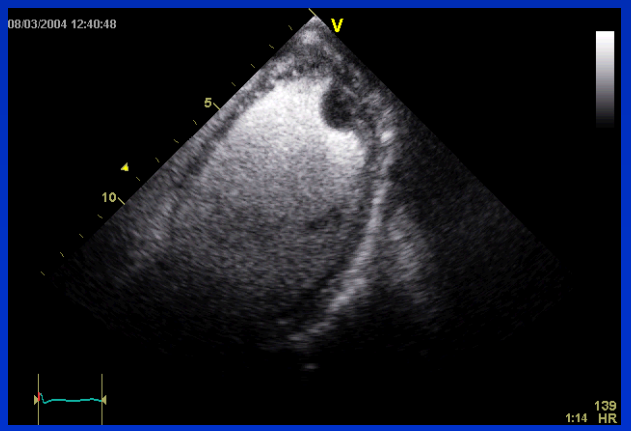
Adapted from White et al. NEJM 1986

LV function and size?

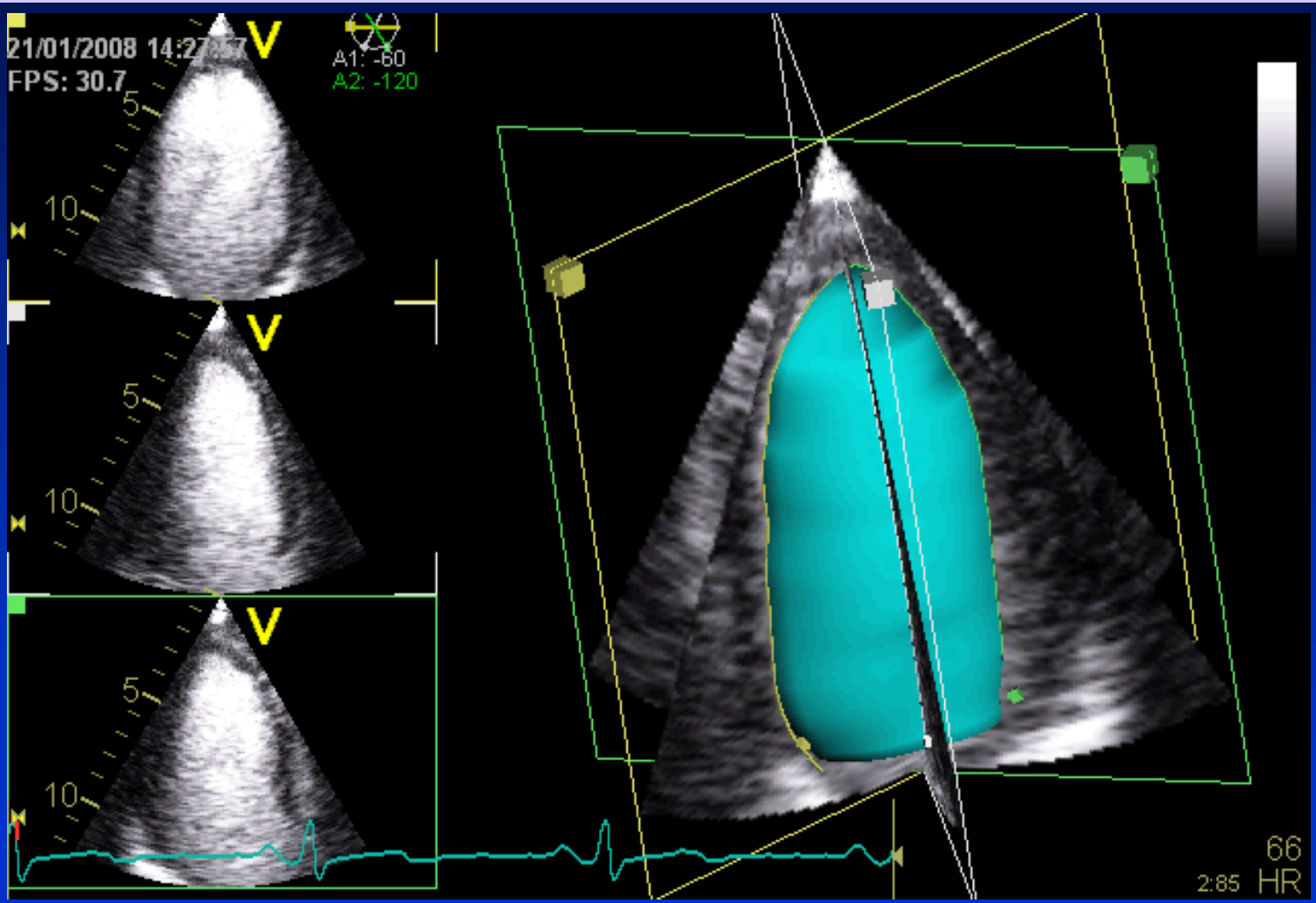




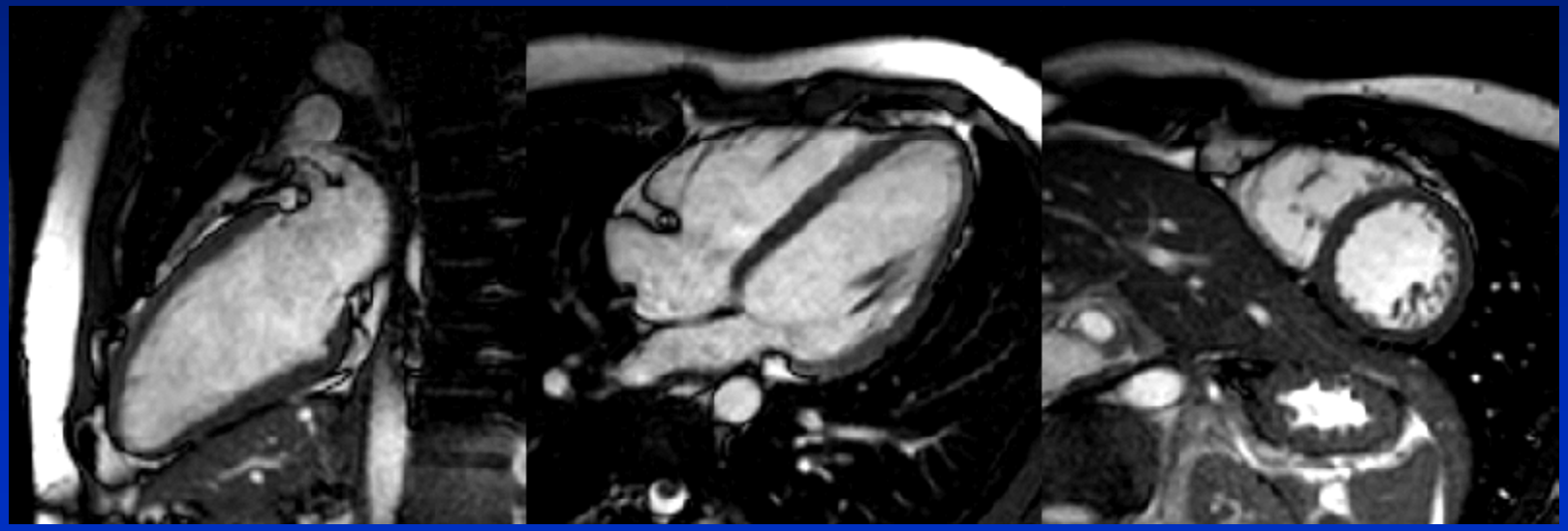




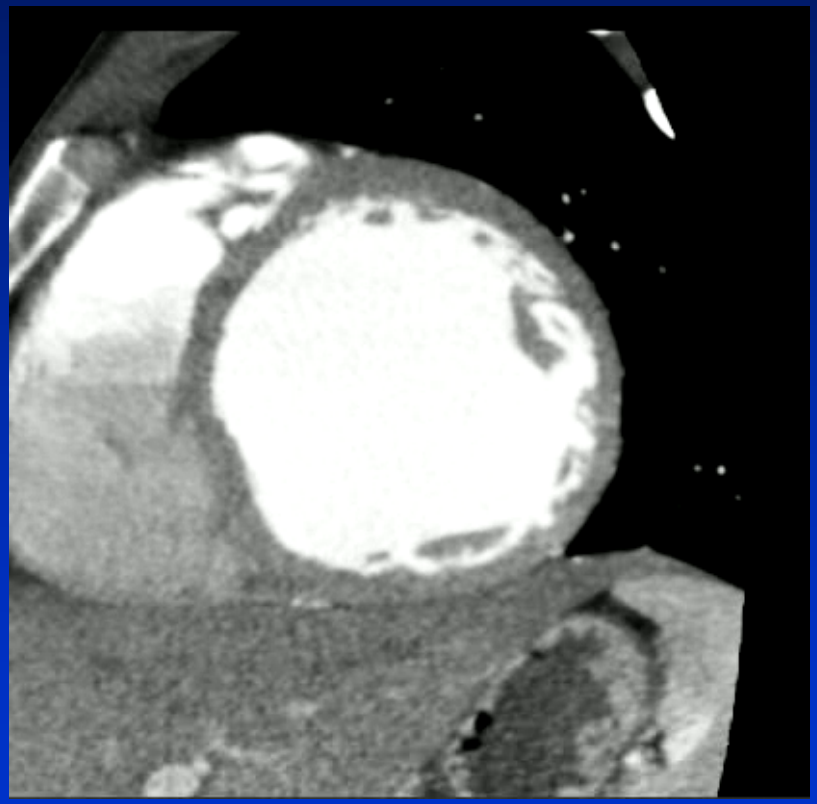
LV function and size?
Towards 3D imaging?



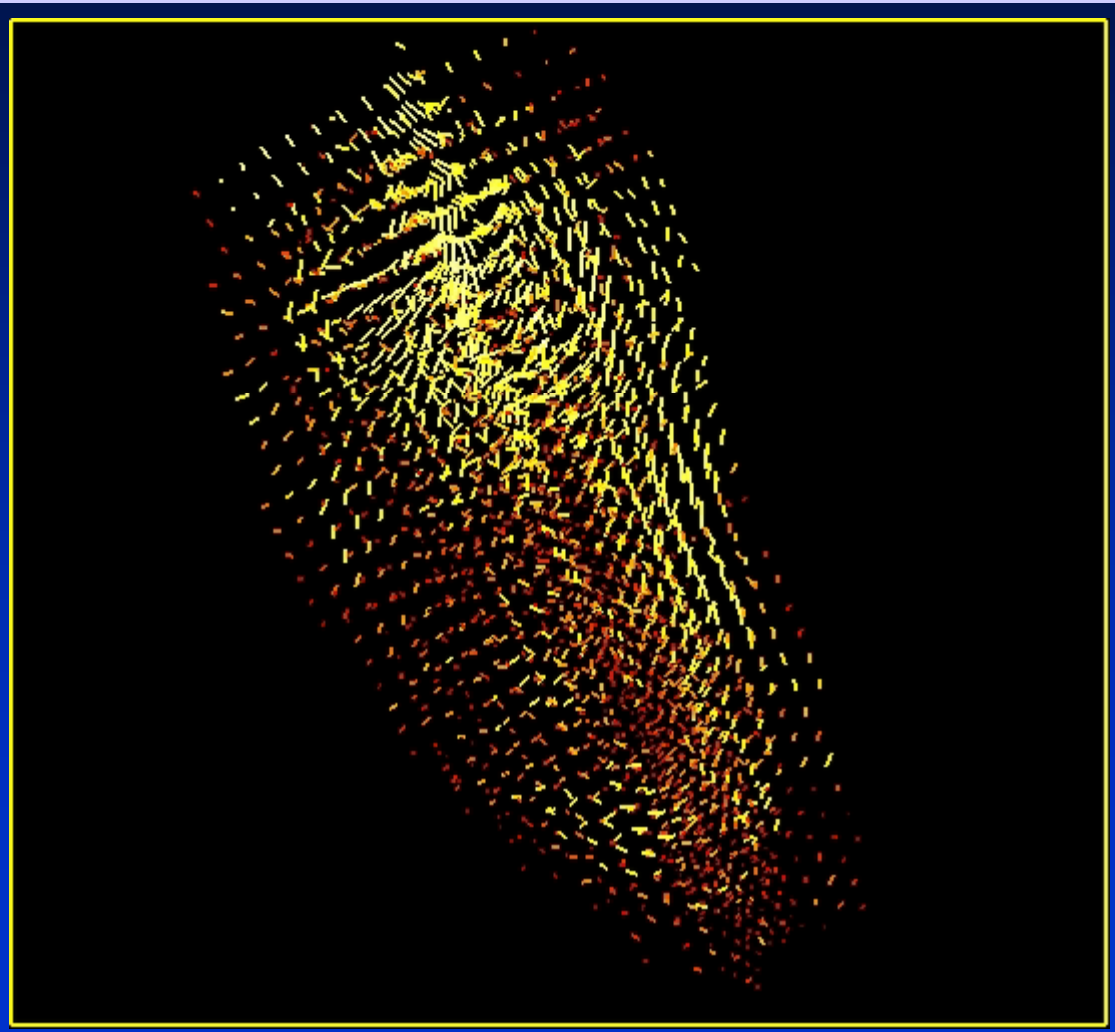
LV function and size?
Other techniques?



LV function and size?
Other techniques?

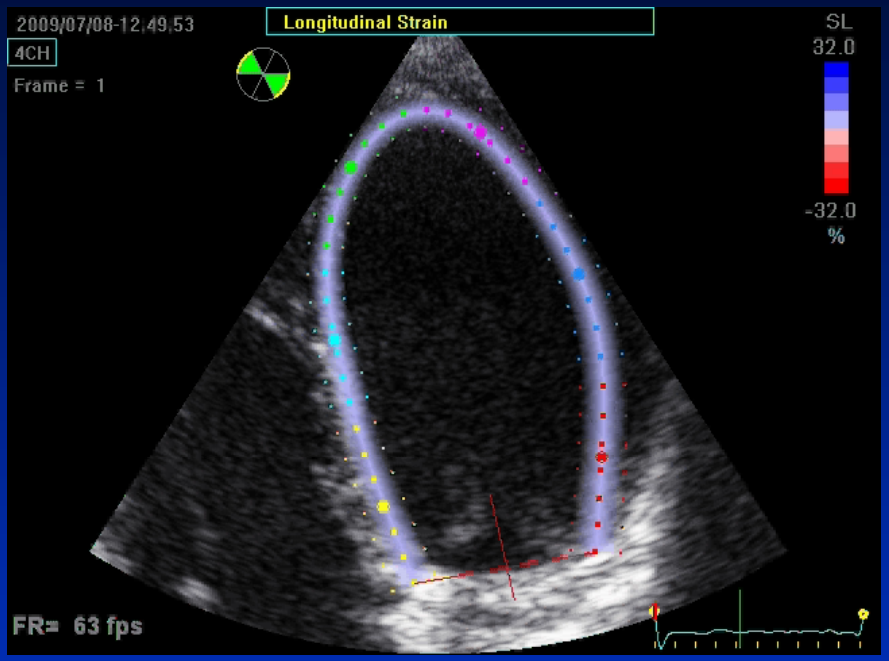


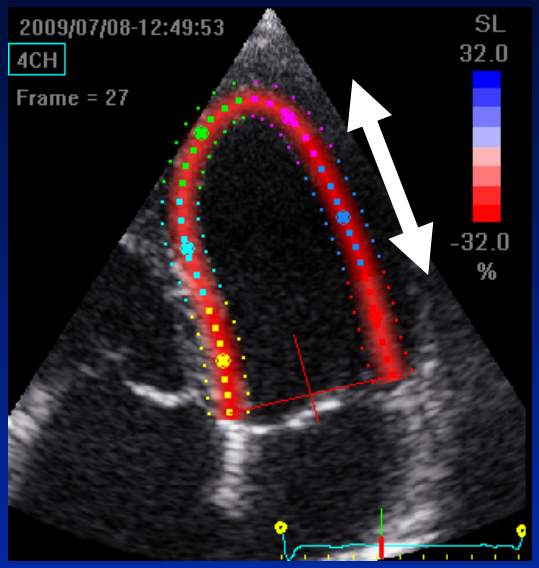
Value of LV flow patterns?



Courtesy J Westenberg

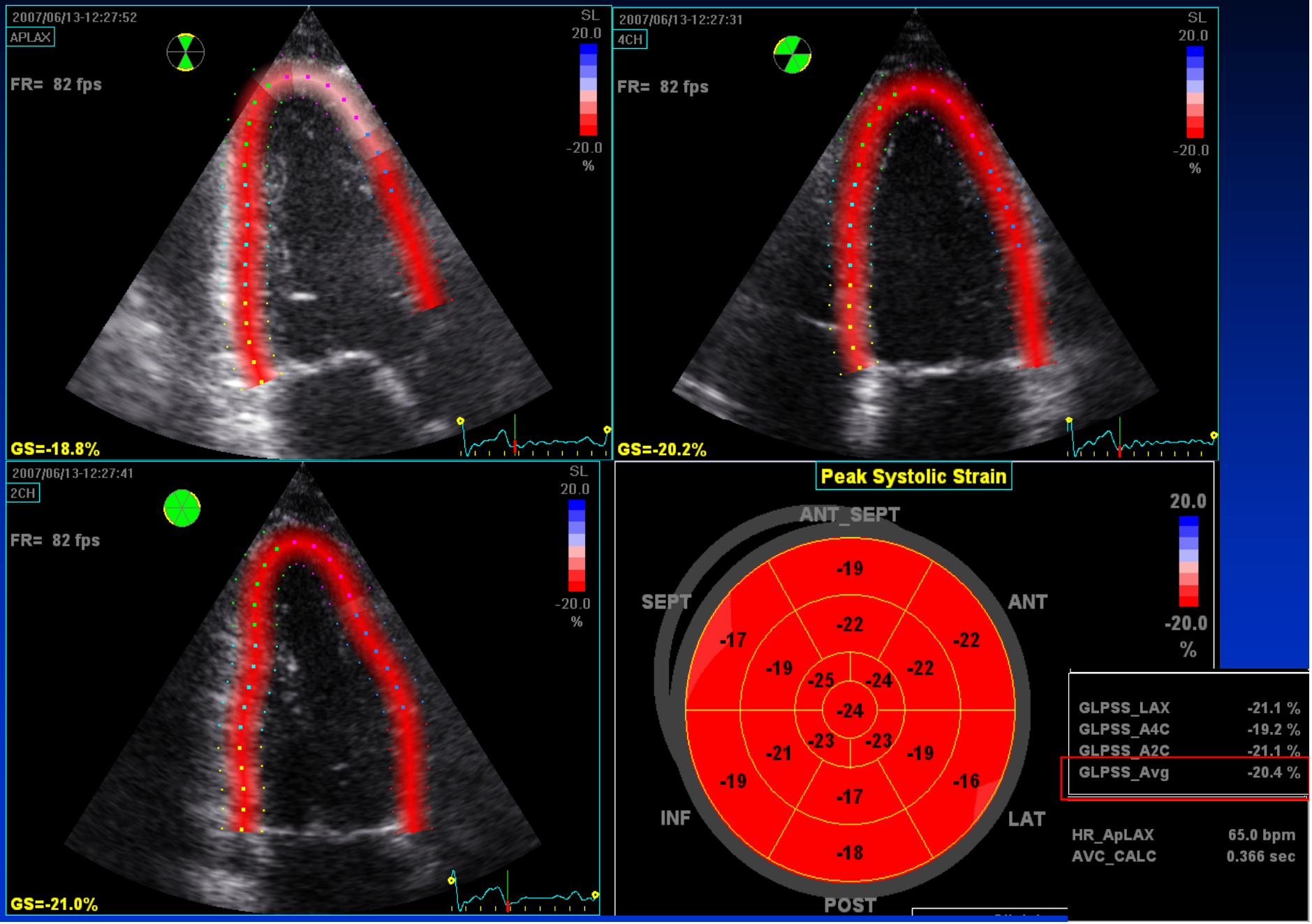
Advanced LV function assessment



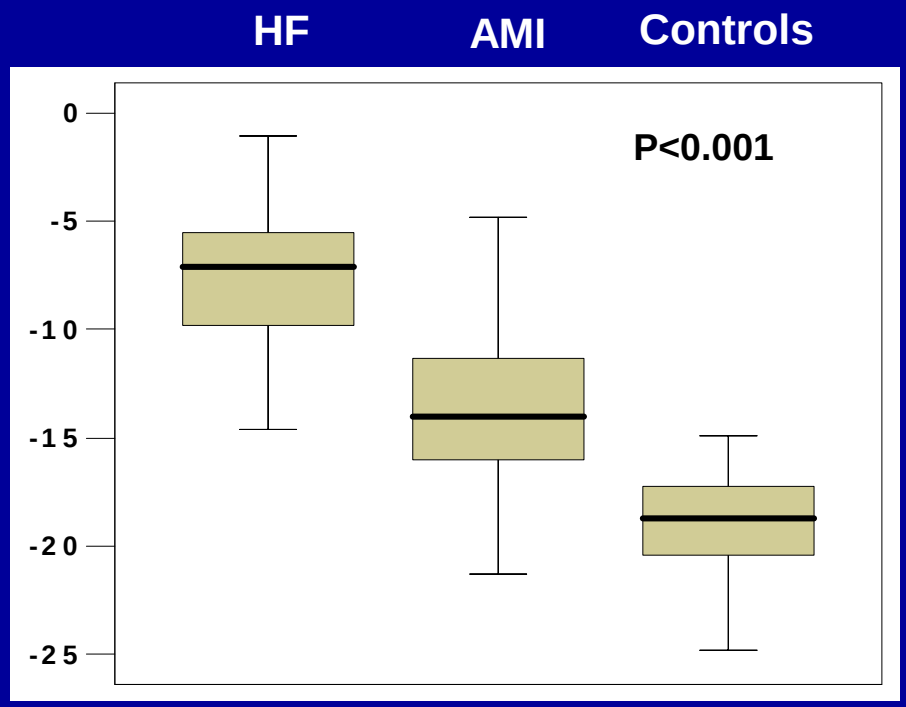


Longitudinal strain

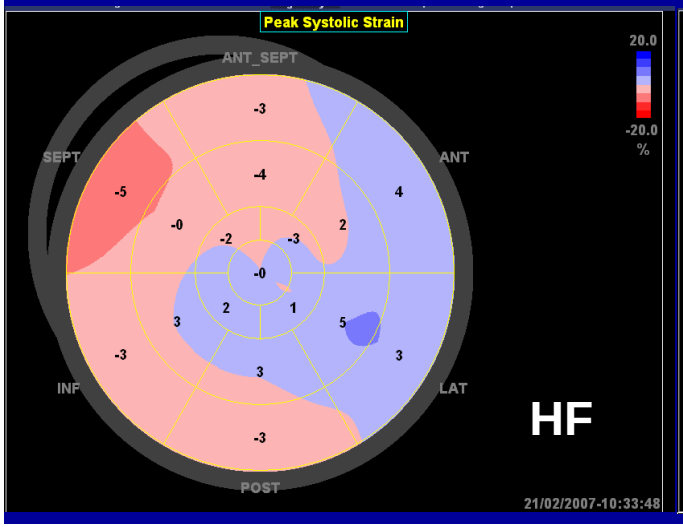
From regional to global LV strain



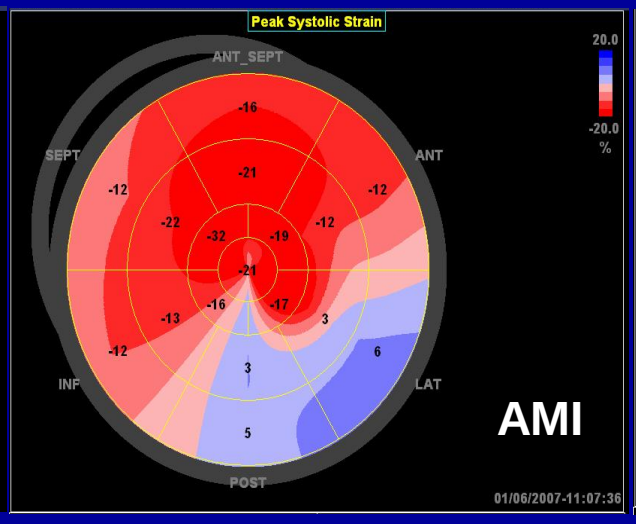
Global strain maps: HF, infarction, and normal



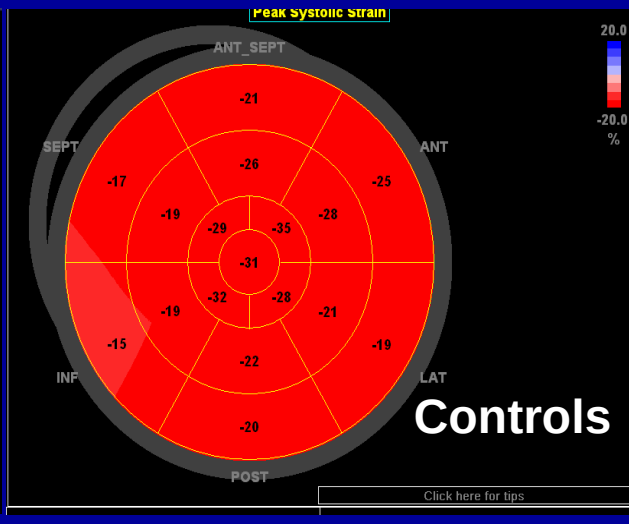
GLPSS Avg: -7.3 ± 3%



GLPSS Avg: -13.8 ± 3.3%



GLPSS Avg: -19.1 ± 3.1%



Severe heart failure patient

To determine therapy, the information below is needed

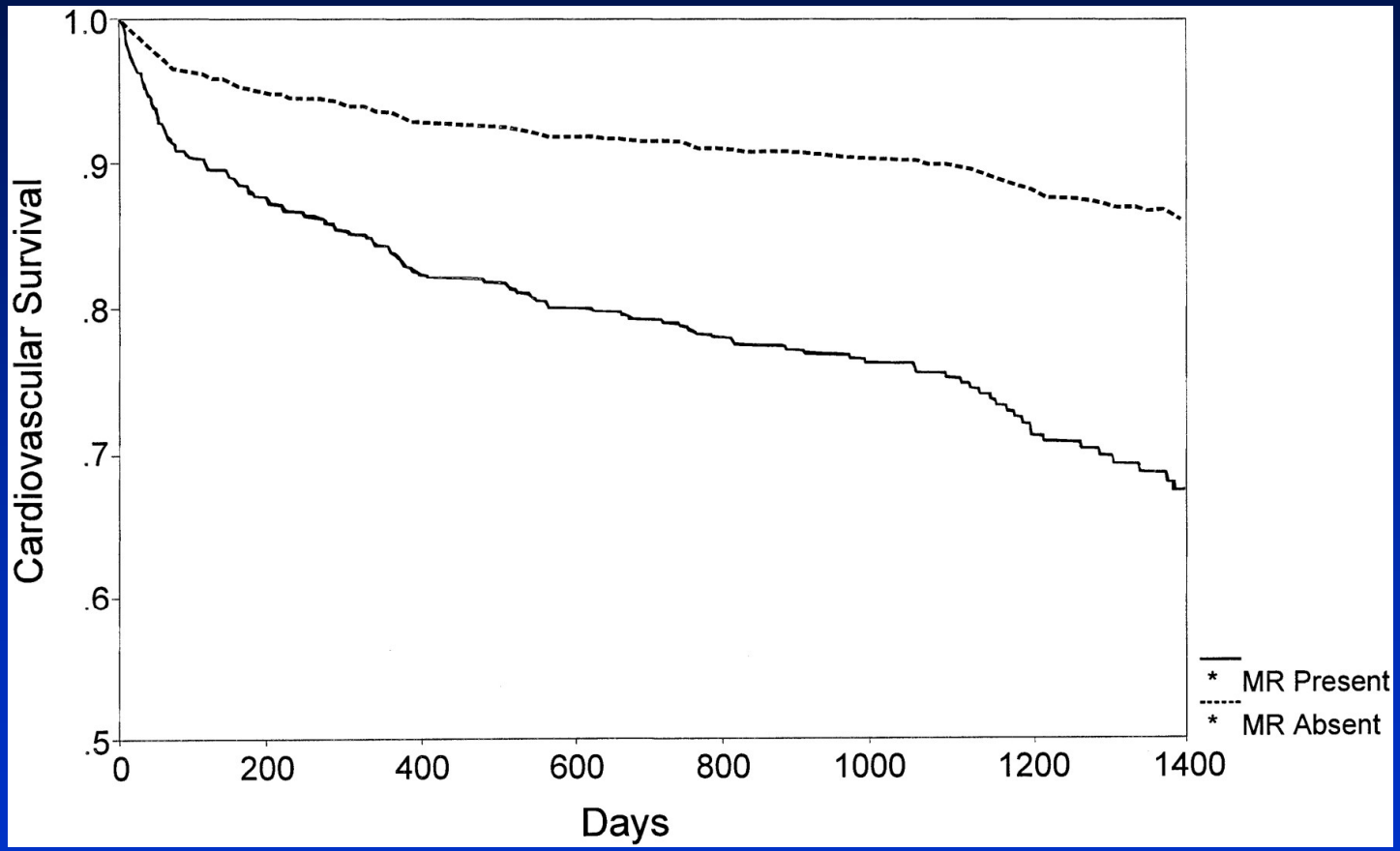
LV function and LV size?

Is it CAD? ischemia/viability?

Severe MR?

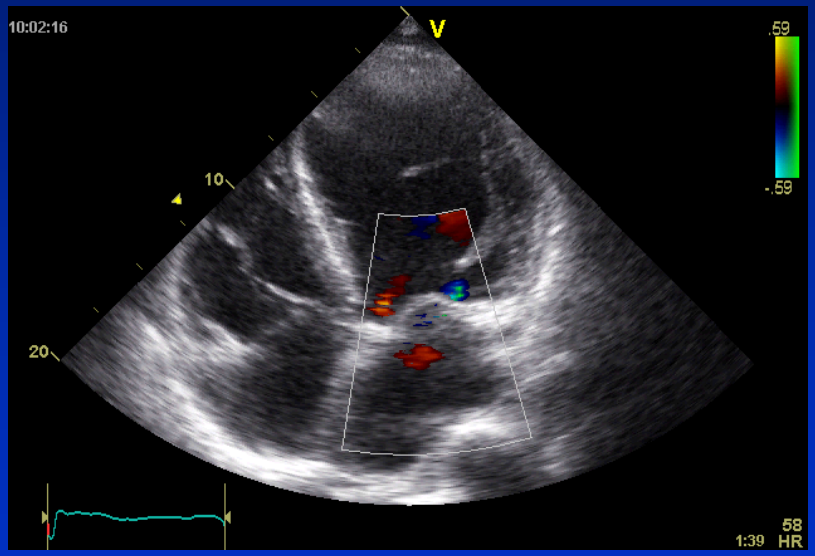
ICD (CRT) needed?

Severe MR affects prognosis

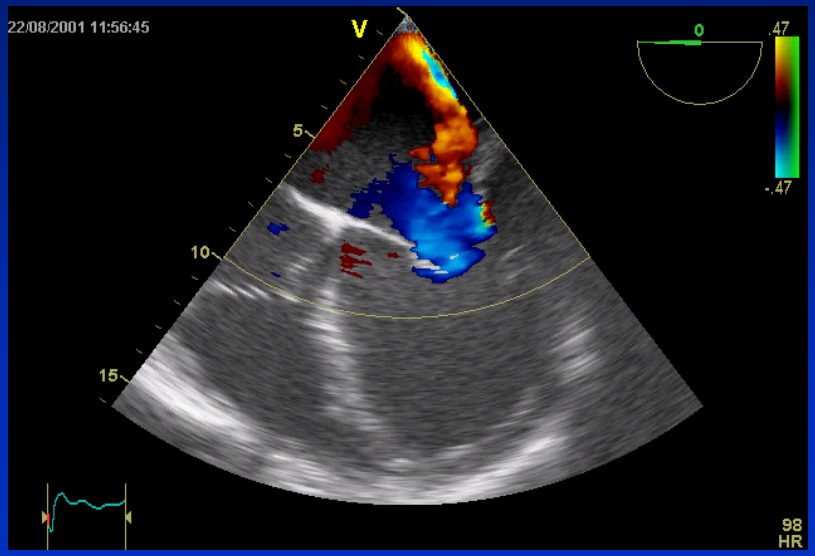


Lamas et al. Circ 1997

Severe MR?

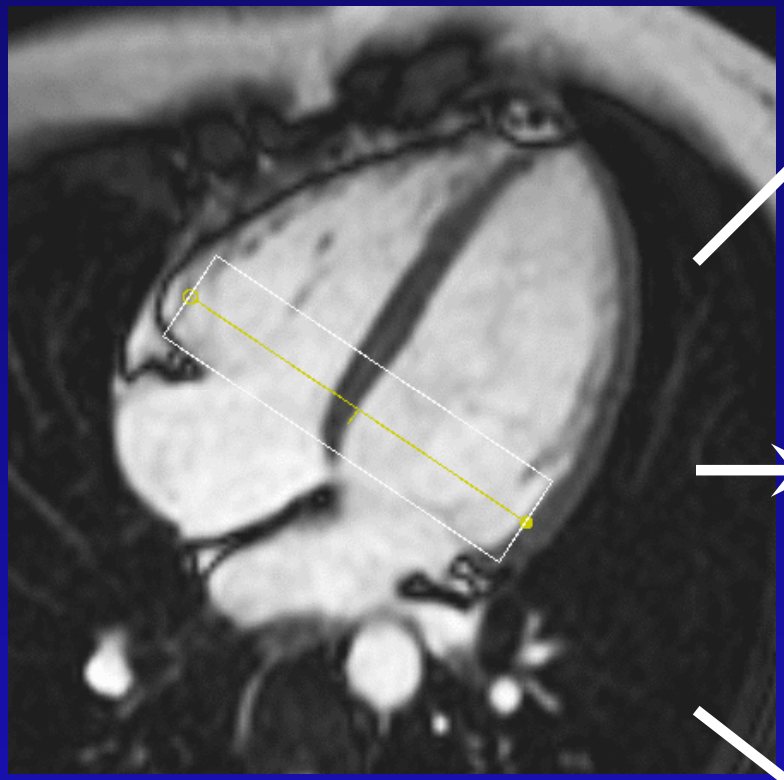


TTE

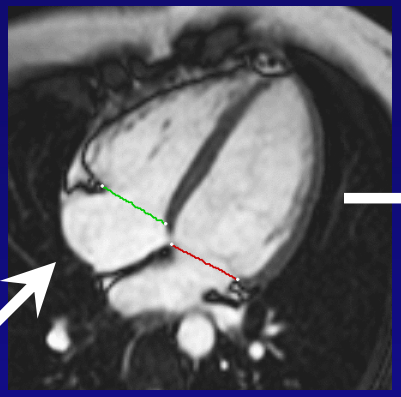


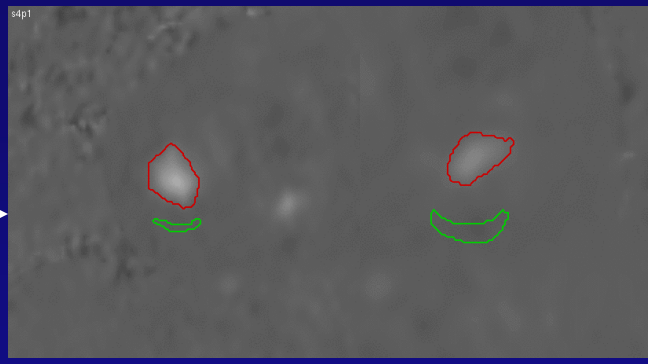
TEE

MRI: 3D Flow Quantification in All Valves

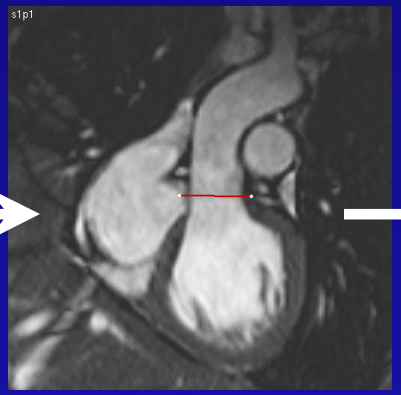


3D volume scan /w 3-dir velocity encoded MRI

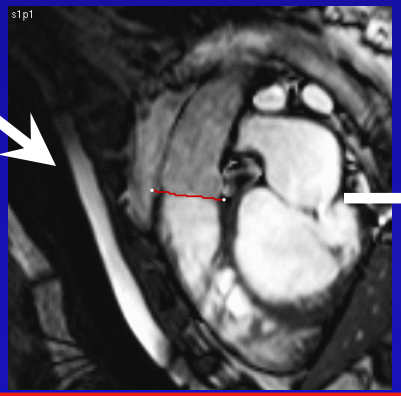




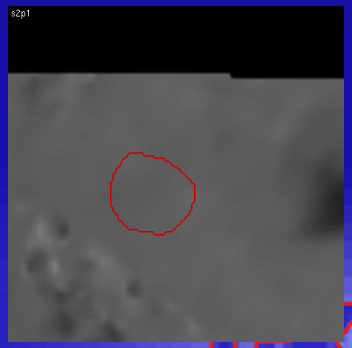
MV & TV



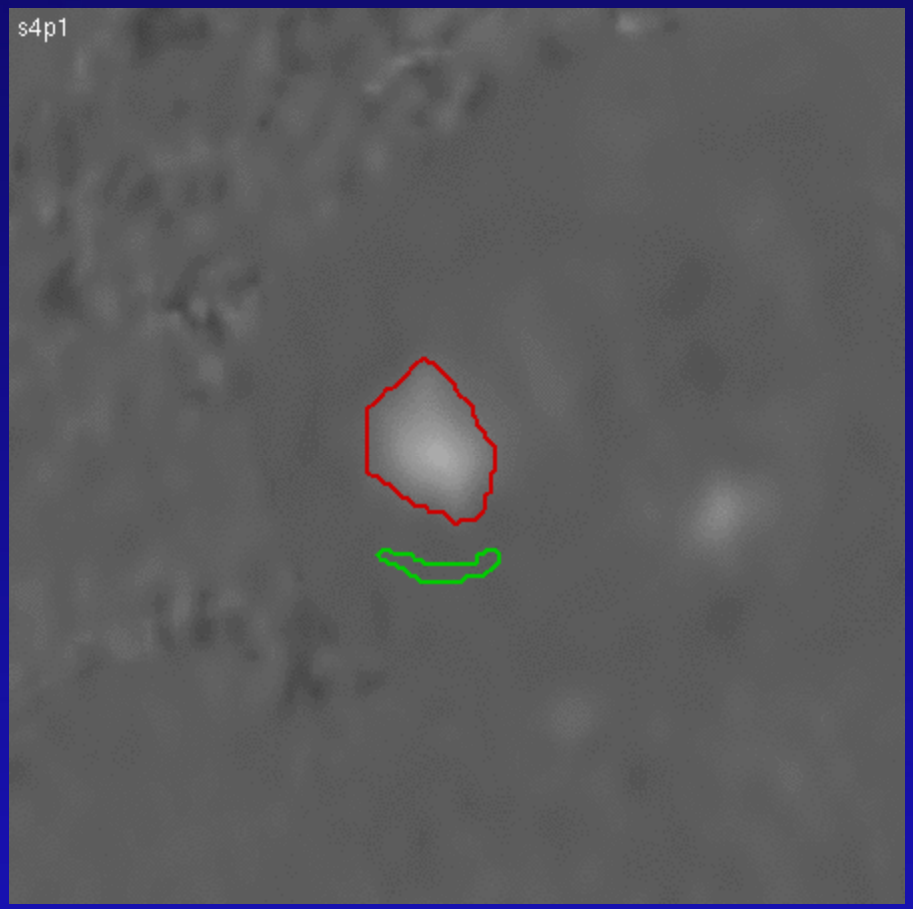
AV



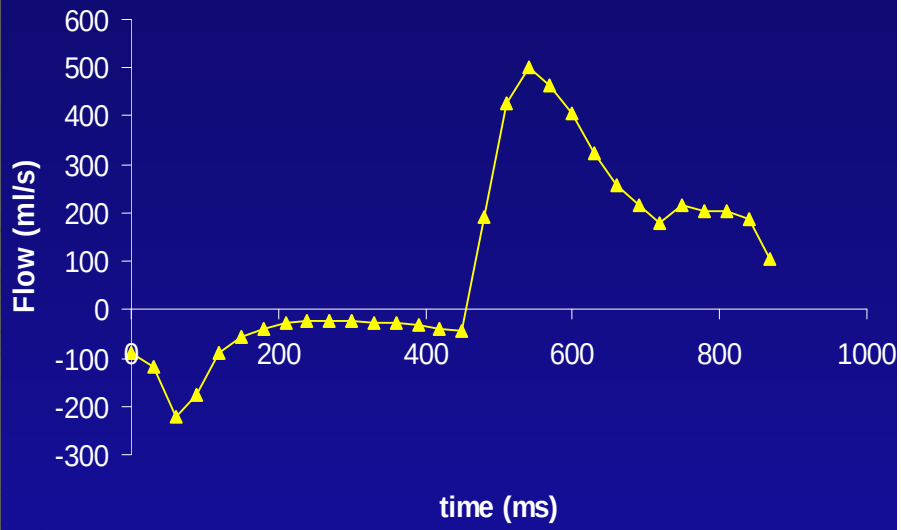
PV



MRI: 3D Flow Quantification mitral valve



MV flow



$V_{forward}$ = 116 ml

V_{back} = 32 ml

V_{eff} = 84 ml

Regurg. Fraction = 27%

Severe heart failure patient

To determine therapy, the information below is needed

LV function and LV size?

Is it CAD? ischemia/viability?

Severe MR?

ICD (CRT) needed?

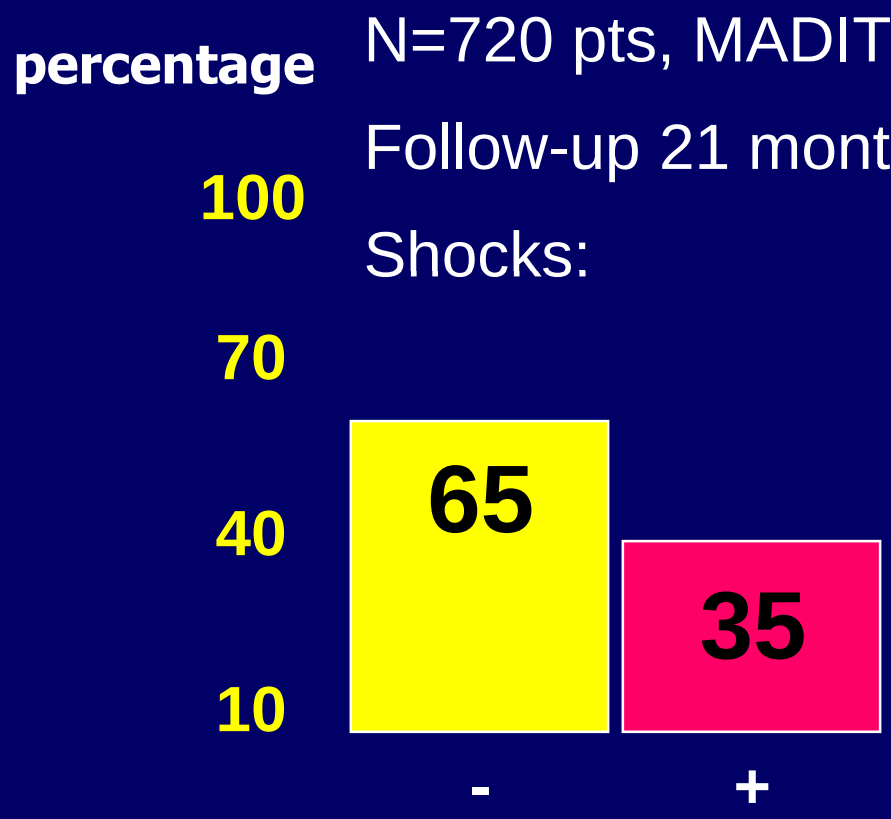
ICD needed?

- Patients with:
  previous infarction
  LVEF <30%

- Benefit from ICD:
- MADIT II: improved survival

ICD needed?

ICD shocks in primary prevention



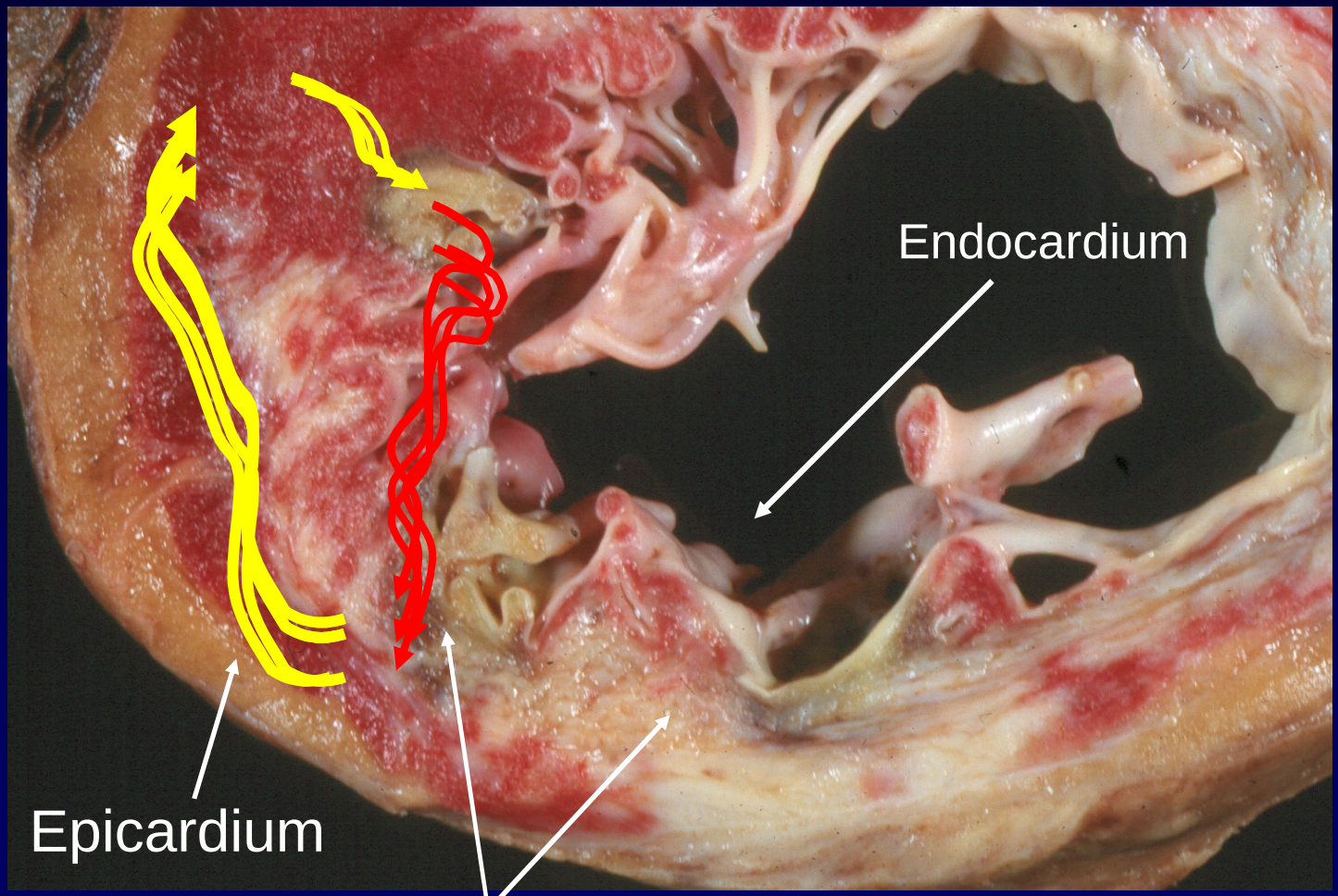
N=720 pts, MADIT II

Follow-up 21 months

Shocks:

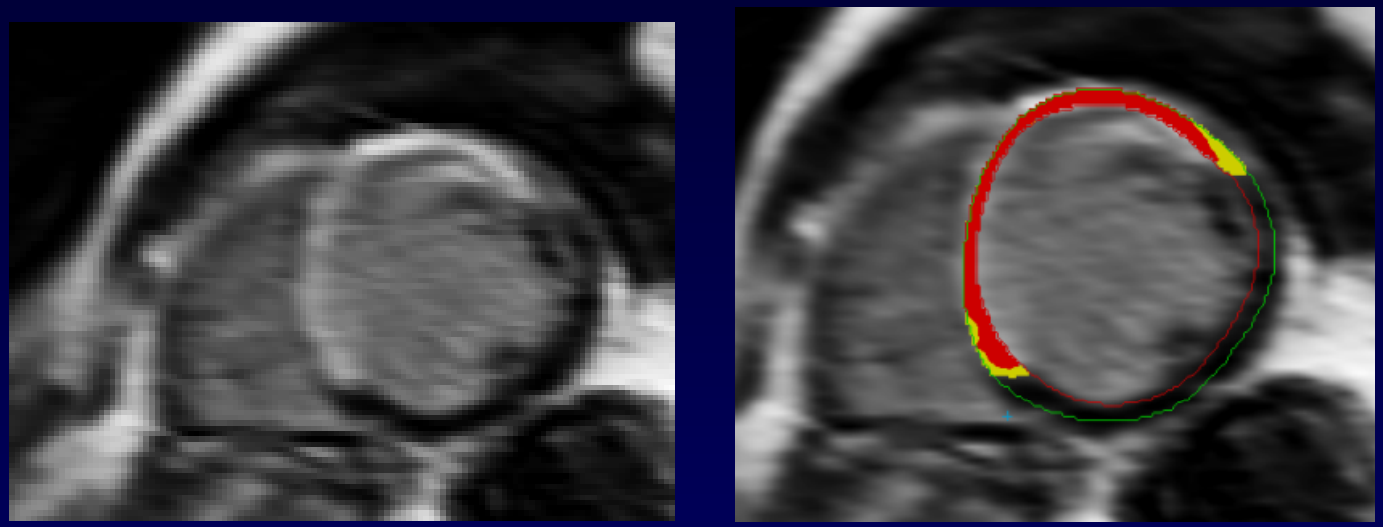
Moss et al. Circ 2004

What is the pathophysiological substrate for SCD in CAD?



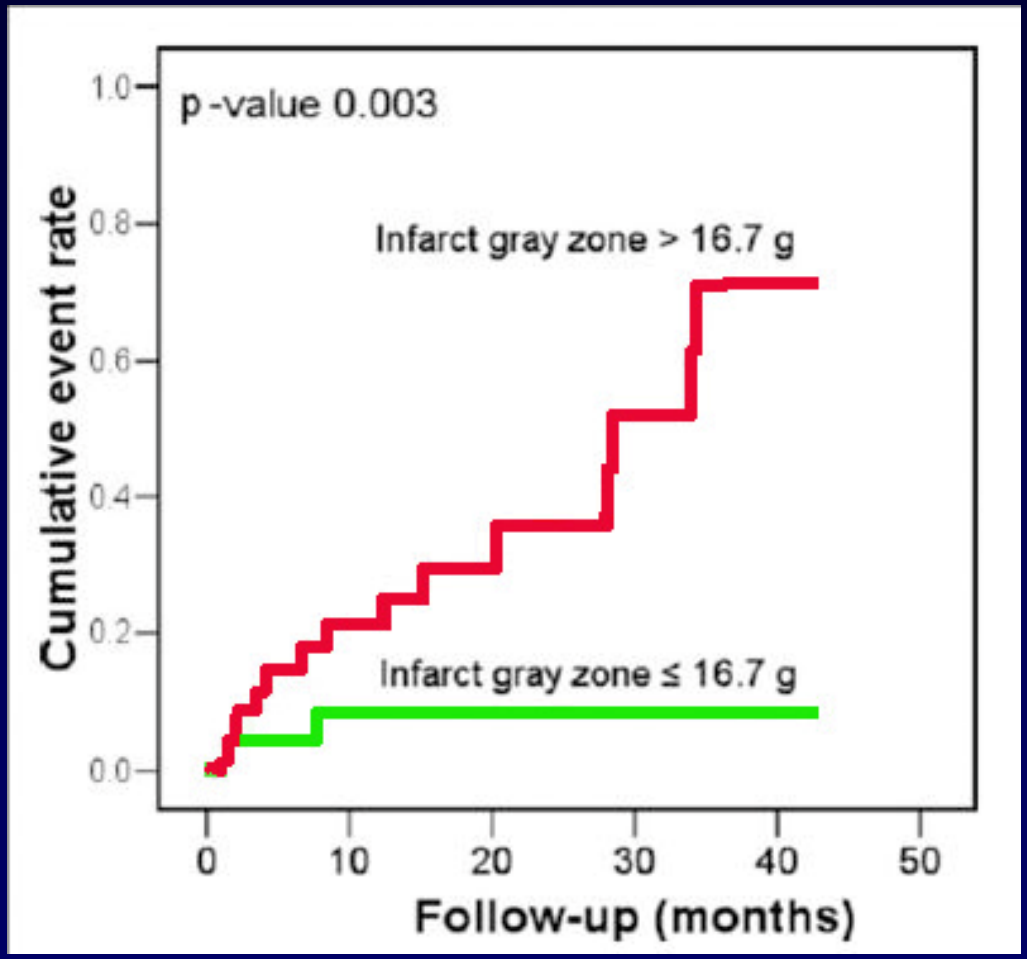
Courtesy W Stevenson

MRI to assess arrhythmogenic substrate:



- Late-gadolinium enhancement: scar area and peri-infarct zone

Value of border zone to predict VTs



HR (95%CI): 1.47 (1.04 to 2.08)
P = 0.003

Roes et al. Circ Cardiovasc Imaging 2009

Severe heart failure patient

To determine therapy, the information below is needed

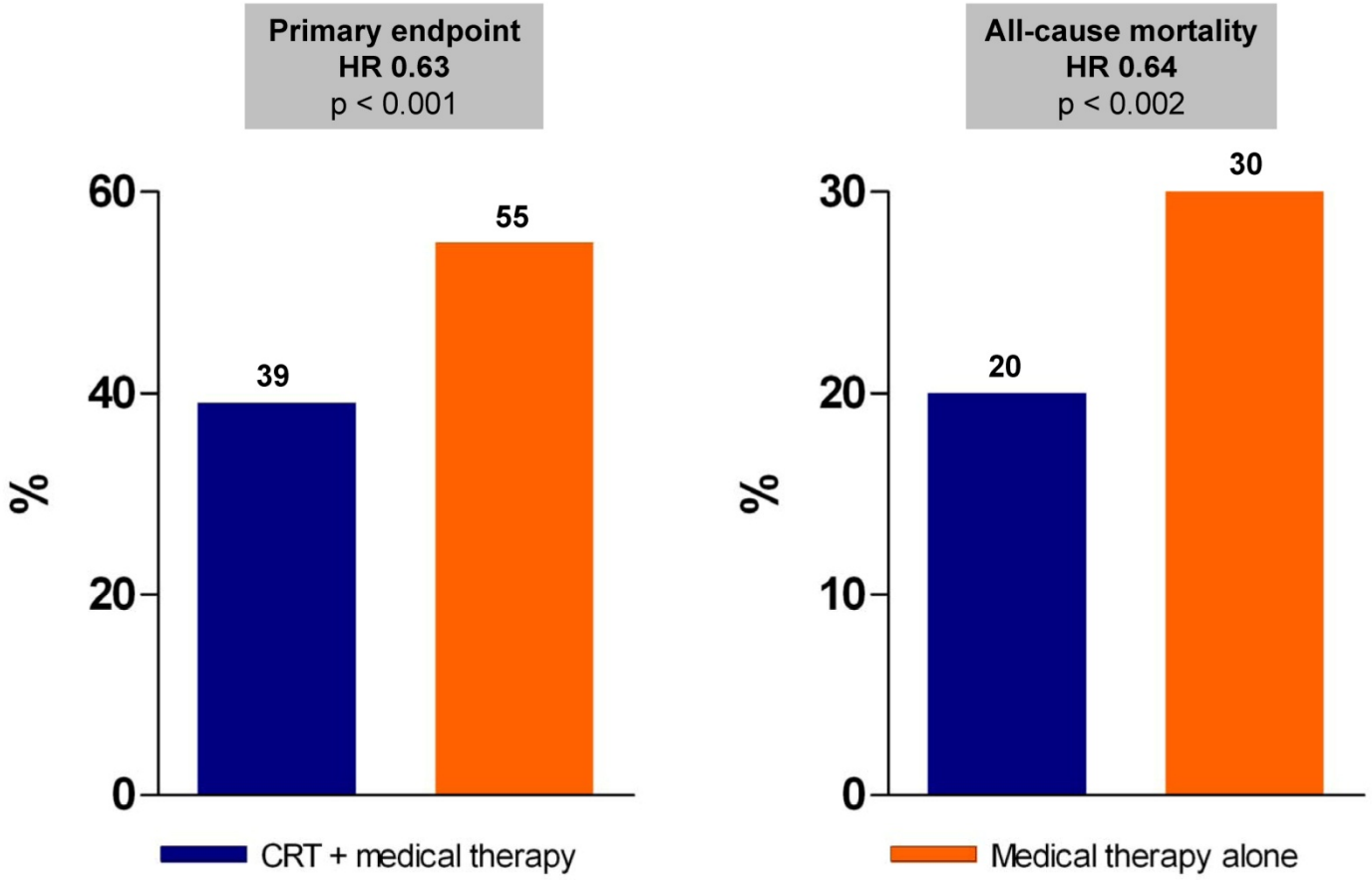
LV function and LV size?

Is it CAD? ischemia/viability?

Severe MR?

ICD (CRT) needed?

CARE-HF: Main Trial Results



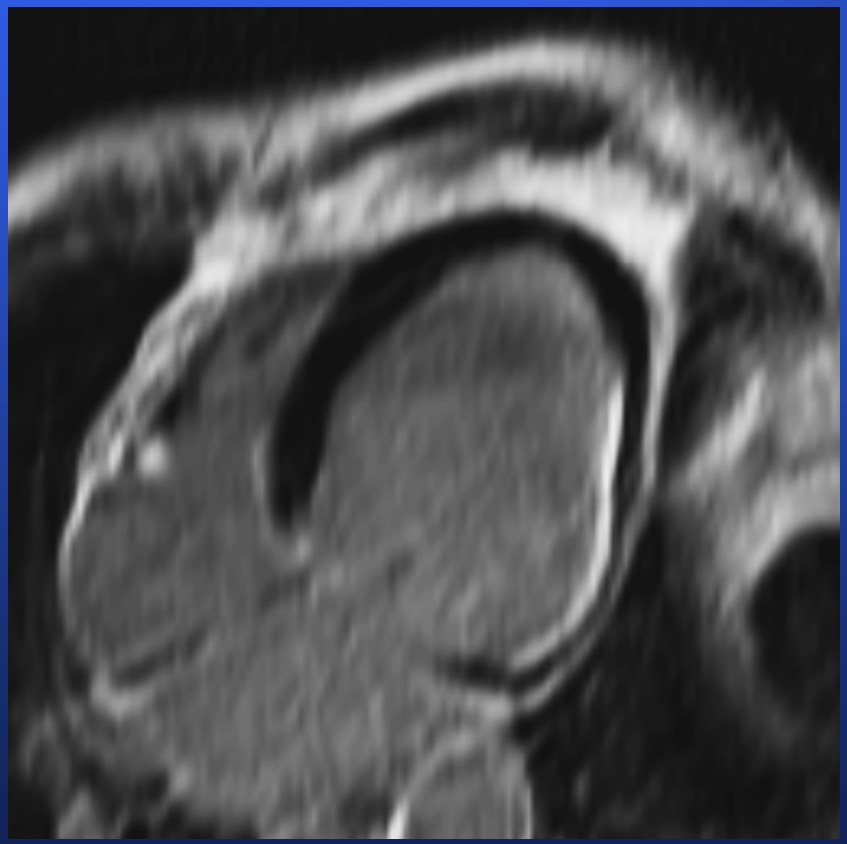
Cleland et al. NEJM 2006

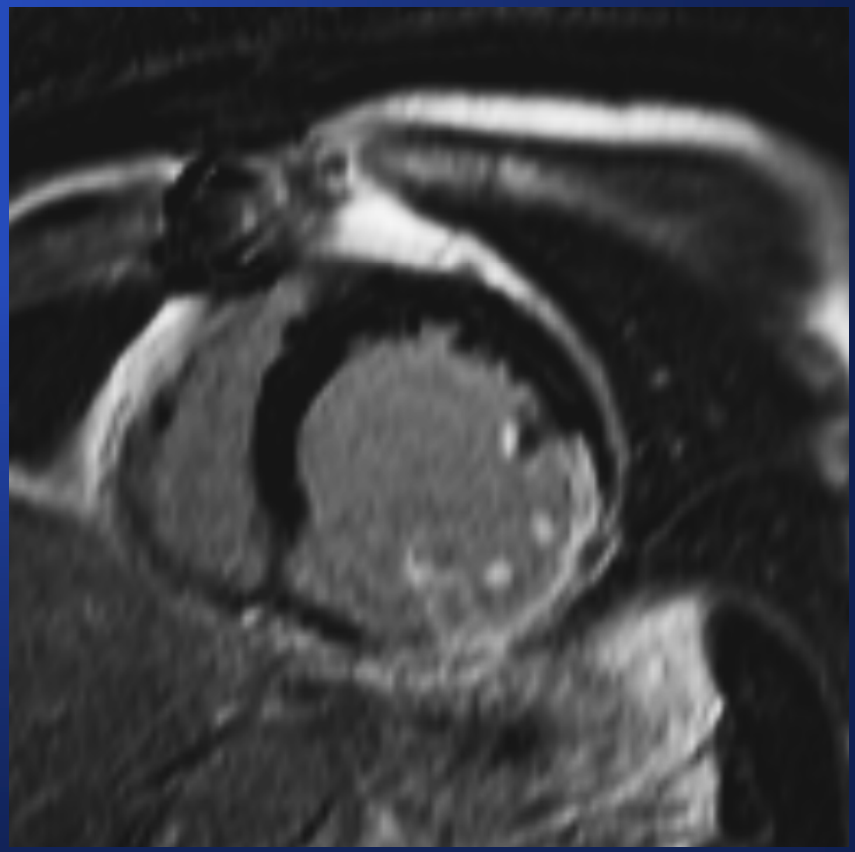
Current selection criteria for CRT

- HF NYHA II-IV
- LVEF < 35 %
- QRS > 120 ms / 150 ms
- LBBB, RBBB or IVCD

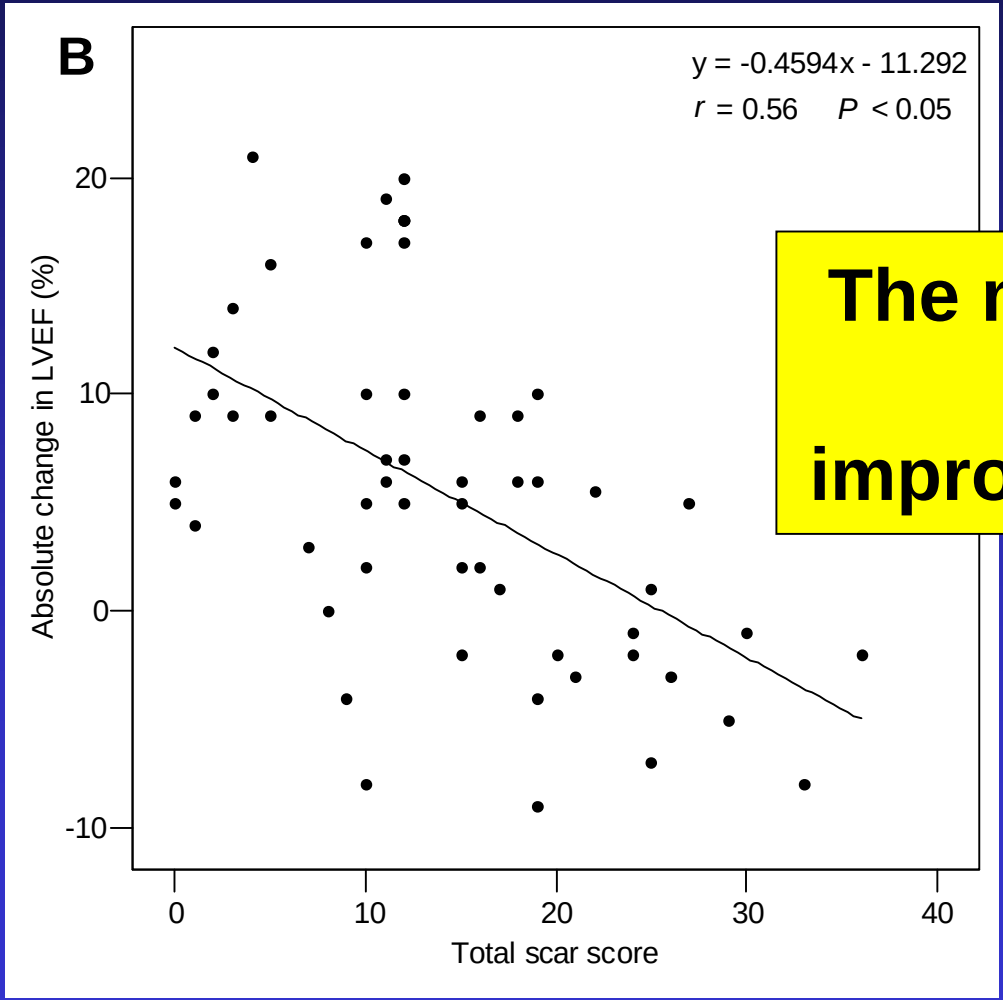
Non-response rate : 30-40% at 6 months

Scar tissue in the target region?





Total scar score vs. Response



The more scar tissue, the less improvement after CRT

Severe heart failure patient

Complex information is needed to determine and individualize therapy

Can be provided by multi-modality imaging