Noninvasive Cardiac Imaging in Myocardial Infarction

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Current Guidelines for Diagnosis of AMI

- Chest pain
- ST change on EKG
- Cardiac Enzymes

Do We Need Imaging for AMI Management?

- Confusing results on EKG
- Time needed for enzymes to rise
- Chest pain - typical? atypical?

- Measurement of infarct size
- Post-PCI complications
- Assessment of residual viable myocardium

Current Noninvasive Imaging Modalities for AMI Diagnosis

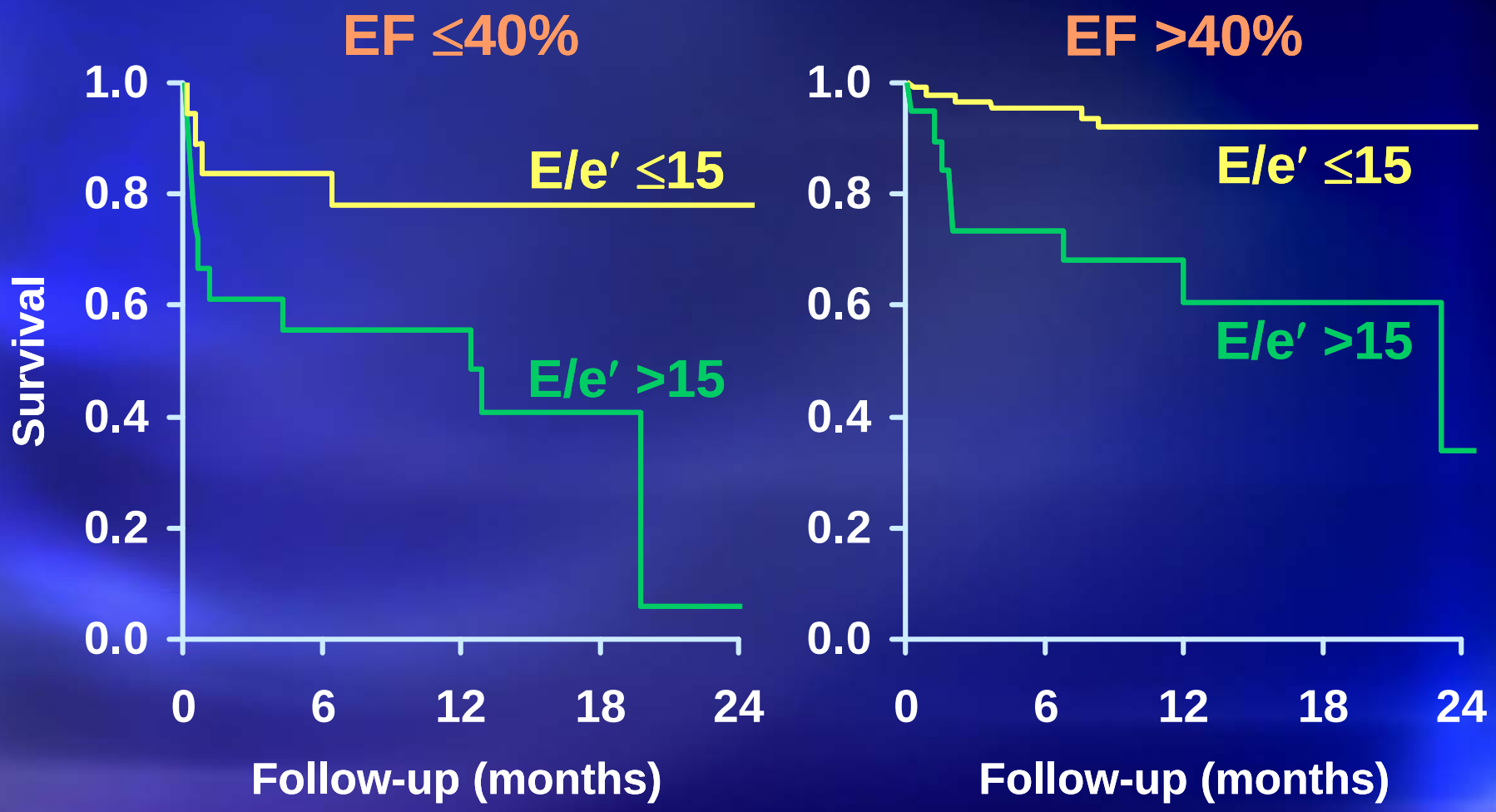
- Echocardiography
- Radionuclide perfusion scan
- Cardiac CT
- Cardiac MRI

Conventional Echocardiography

- Global LV function
- Regional wall motion for diagnosis
- Complications of MI
- Myocardial area at risk
- Myocardial viability - stress echo

Survival of Patients with Acute MI

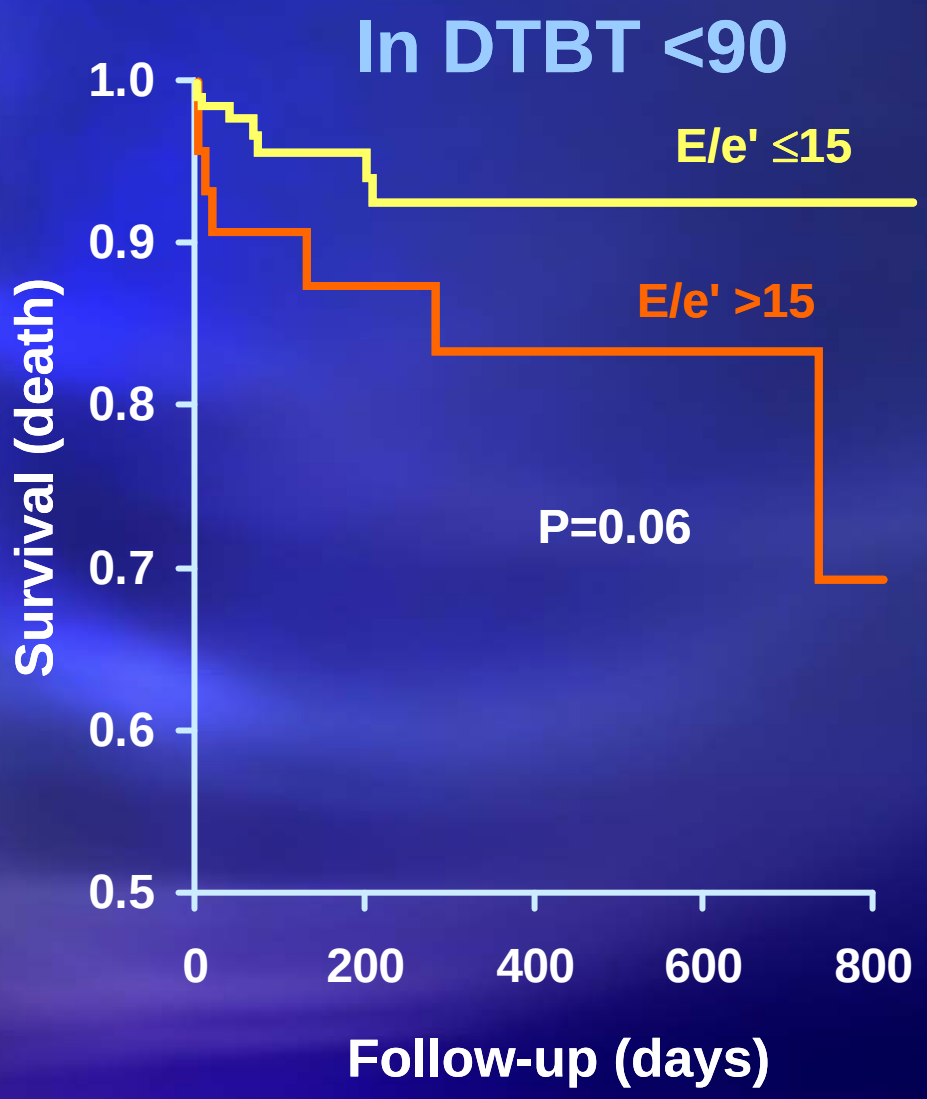
Prognosis

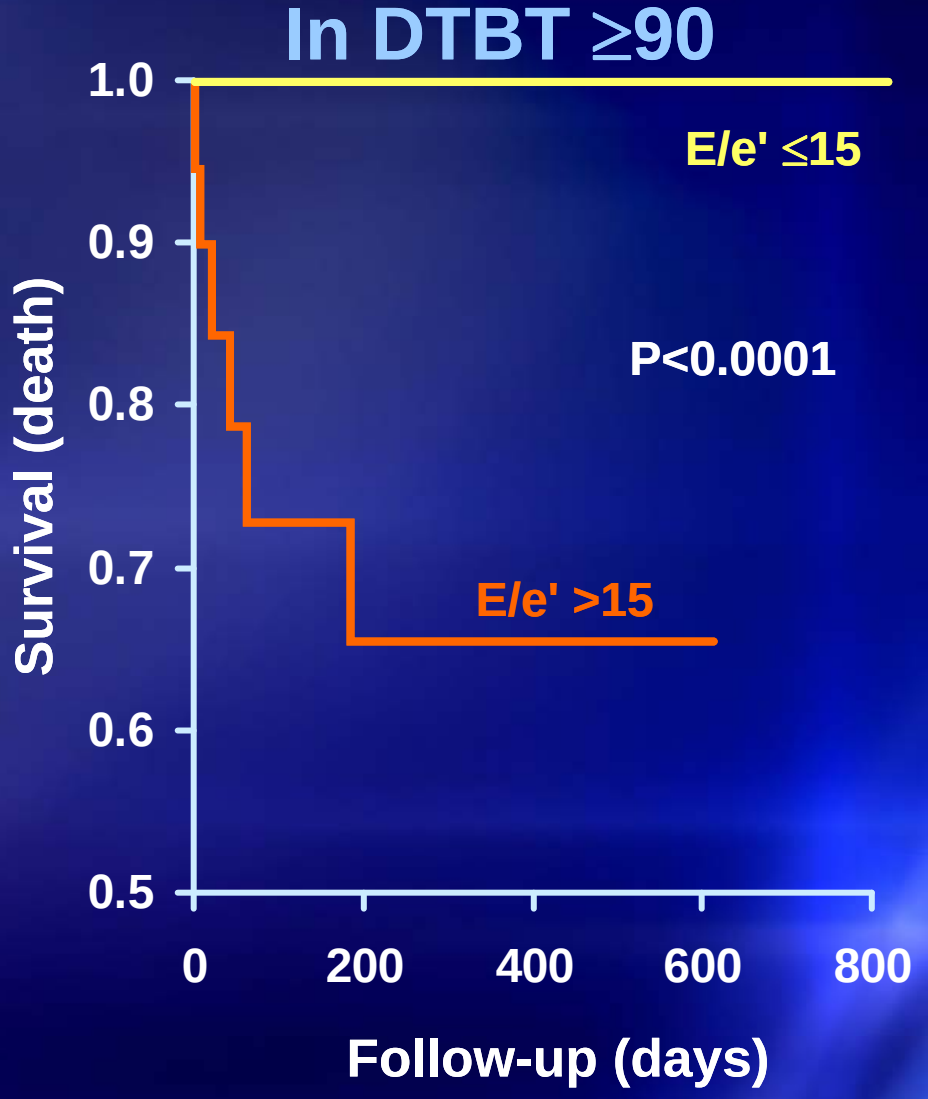


Hillis et al: JACC 43(3):360, 2004

CP1141593-3

Prognostic Value of E/E' After Acute MI





Park SJ, Ting H, Oh JK Unpublished

CP1302151-7

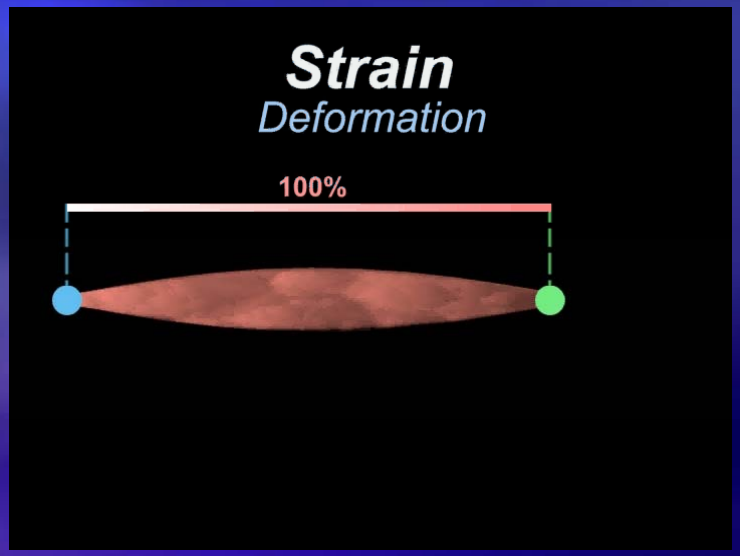
Unconventional Echocardiography

- Myocardial strain imaging
- Contrast echocardiography

Strain Imaging

- **Strain: Deformation of an object, relative to its original length**

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



If 10 cm original length is shortened to 7.5 cm, strain is (-) 25 %.

Normal strain is > 20 %.

2D Speckle Tracking Image
Normal

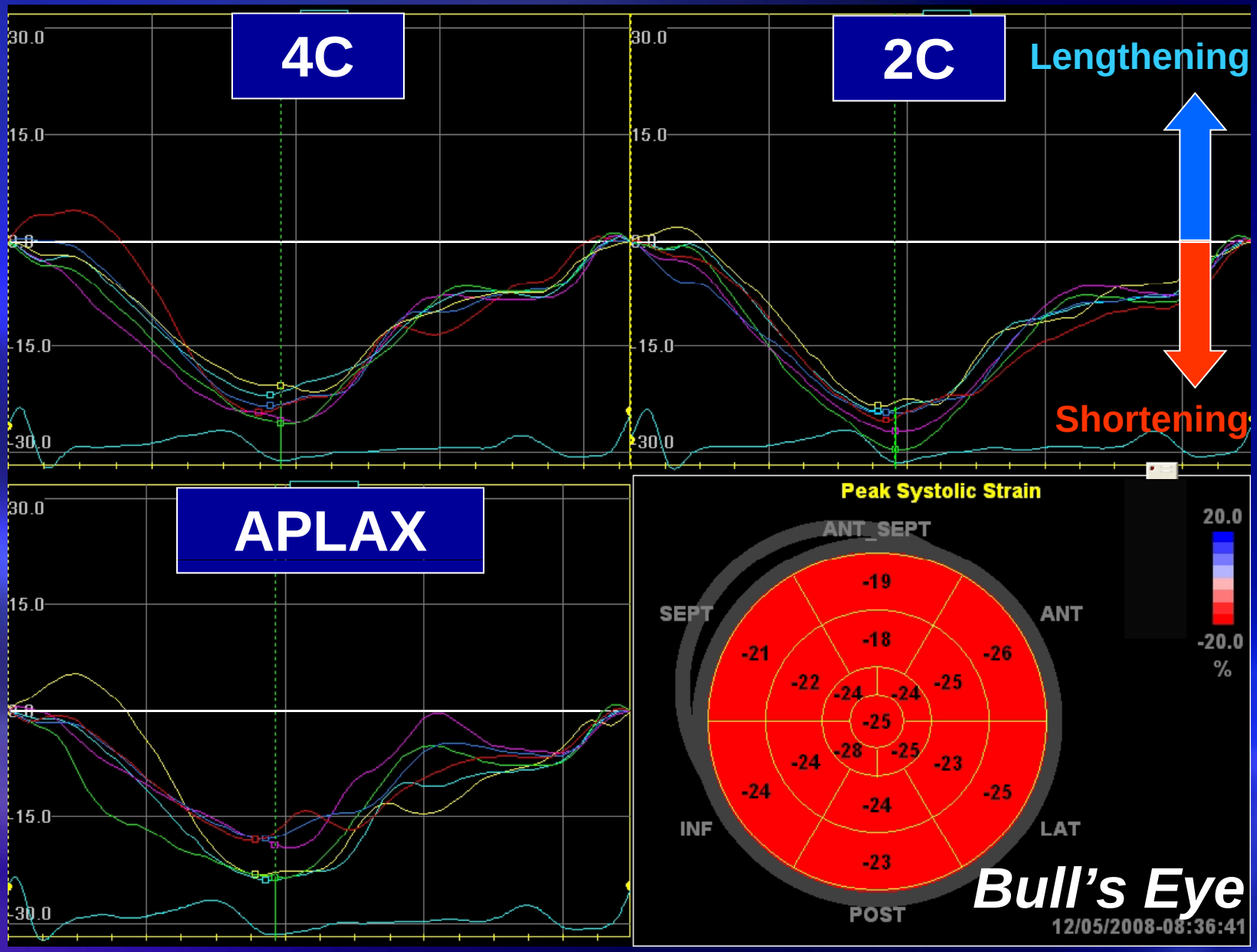
Radial strain (SAX)

Transversal strain (A4)

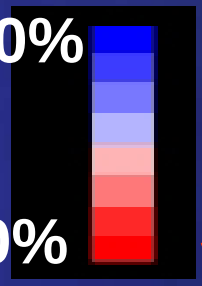
K.Ogawa, T.Hozumi et al. AJC 2006

Aplio (SSA-770A, Toshiba Japan)

Longitudinal strain: normal case Display

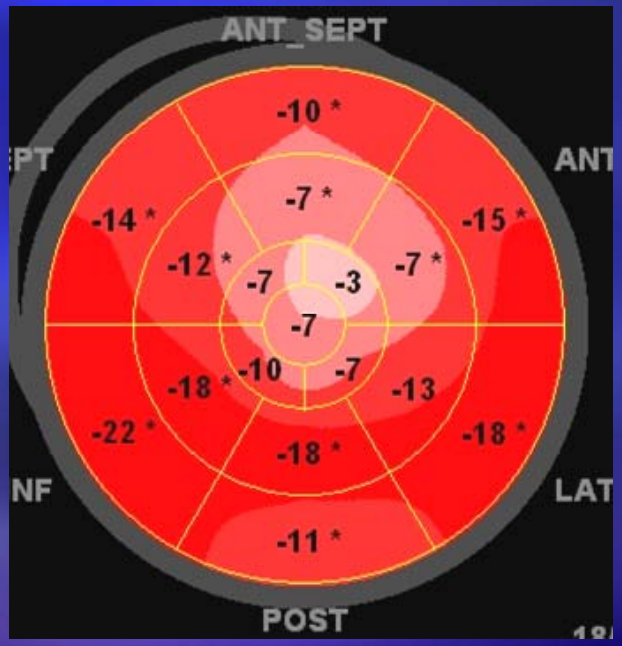


Bull's Eye Mapping of Strain

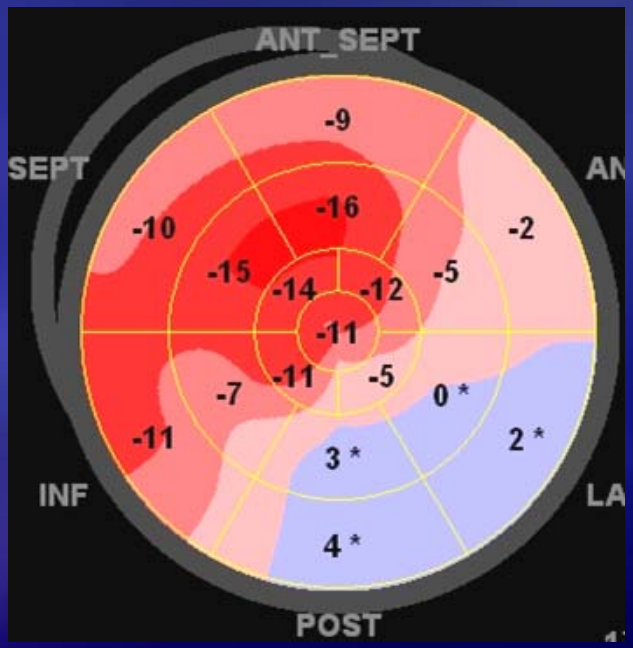


+20% Lengthening

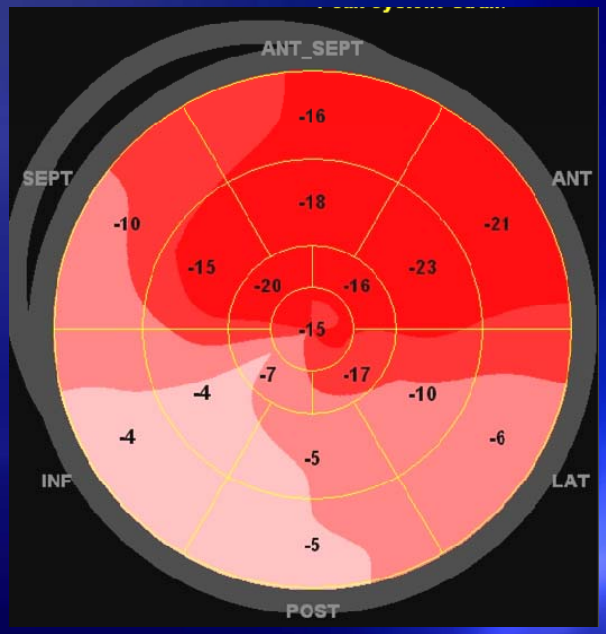
-20% Shortening



Anteroseptal MI (LAD)

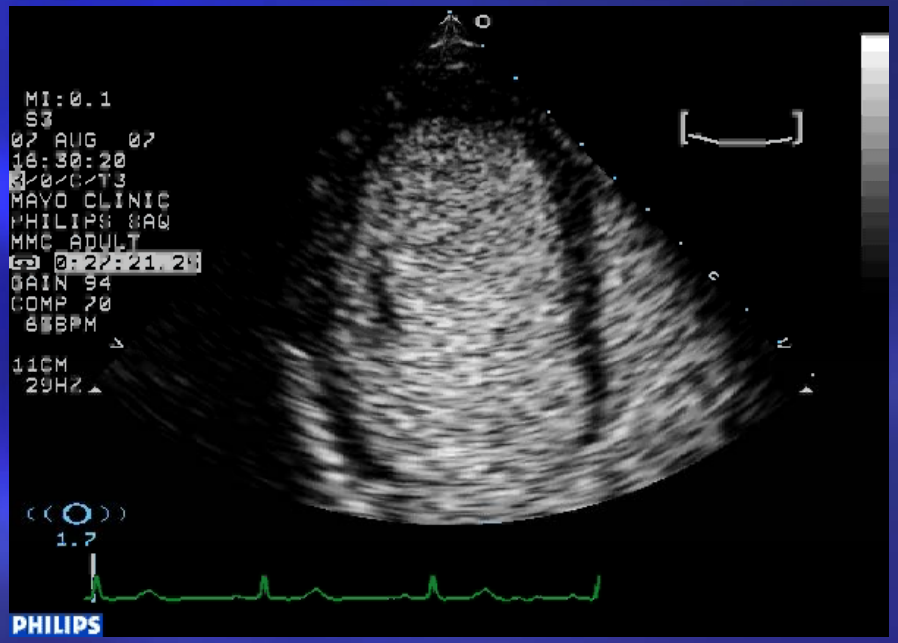


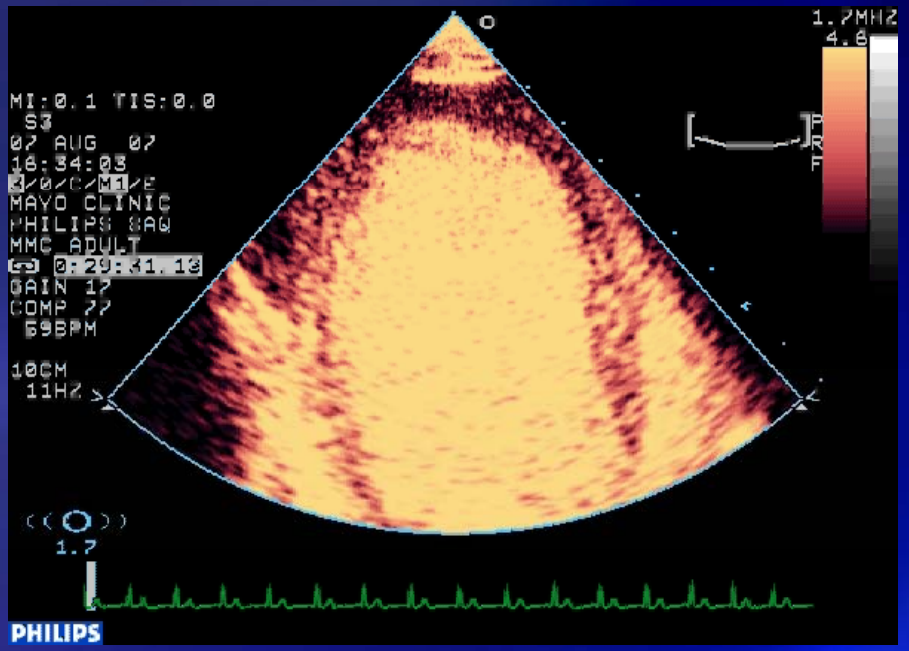
Inferolateral MI (LCX)



Inferior MI (RCA)

Contrast Echocardiography

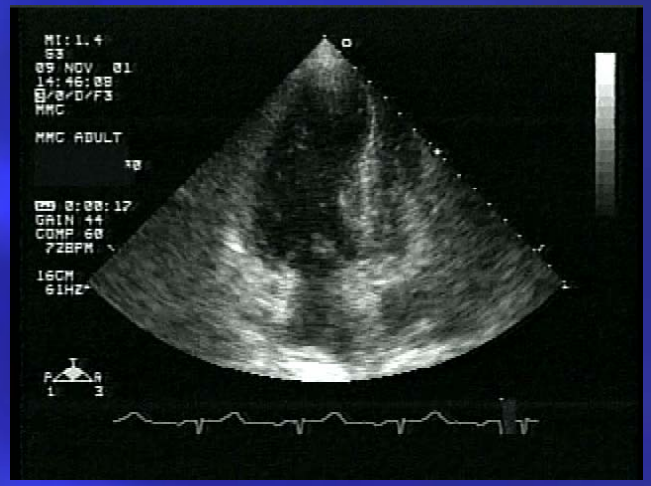


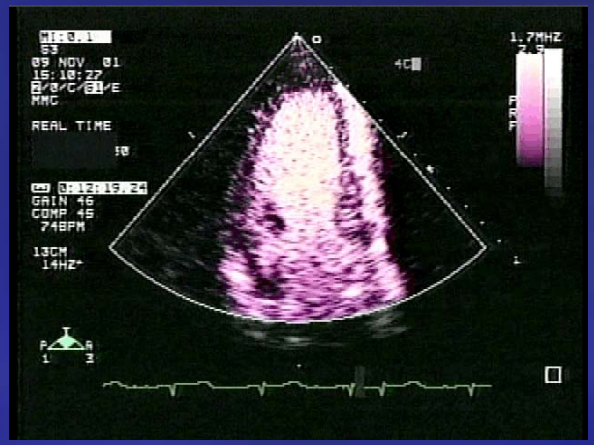


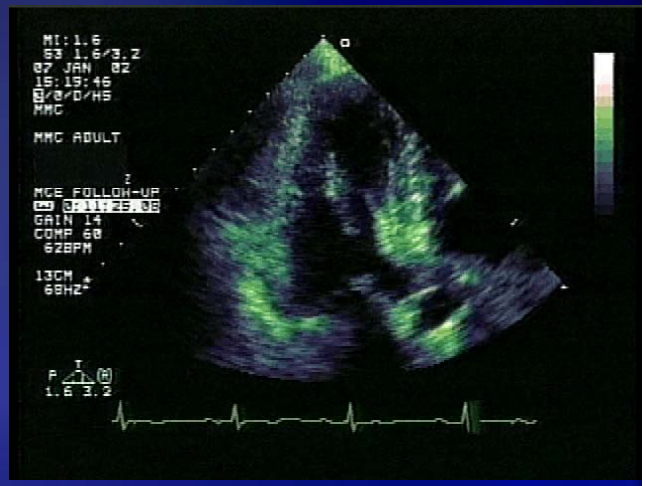
Perfusion Defect in the apical segments

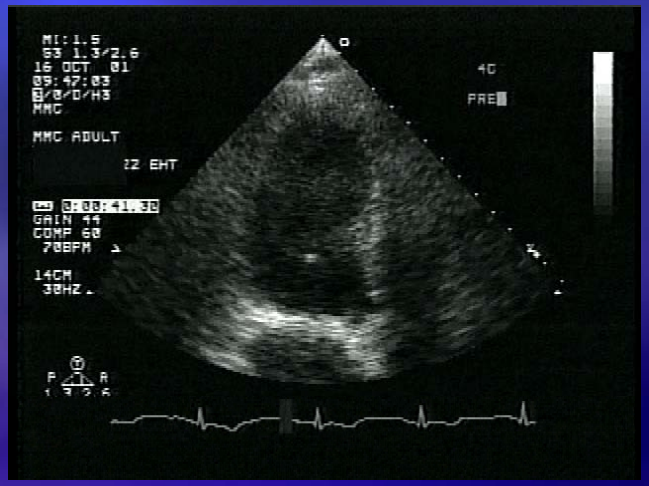
Contrast Perfusion Echo for Viability
2 patients with Anterior STEMI and PCI

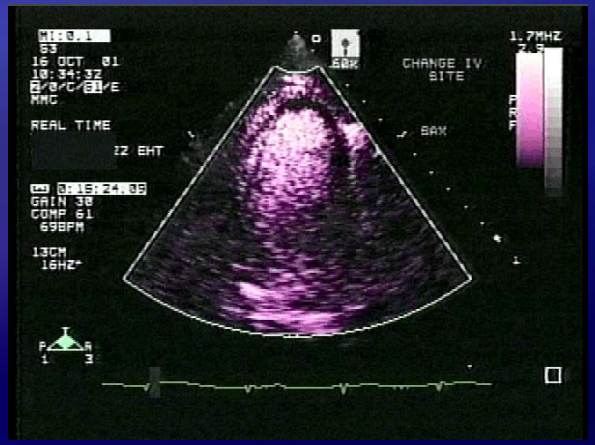
Baseline ***Follow up***

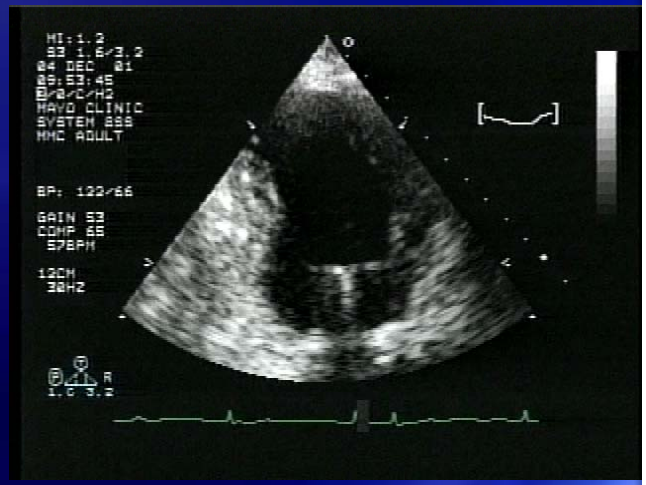




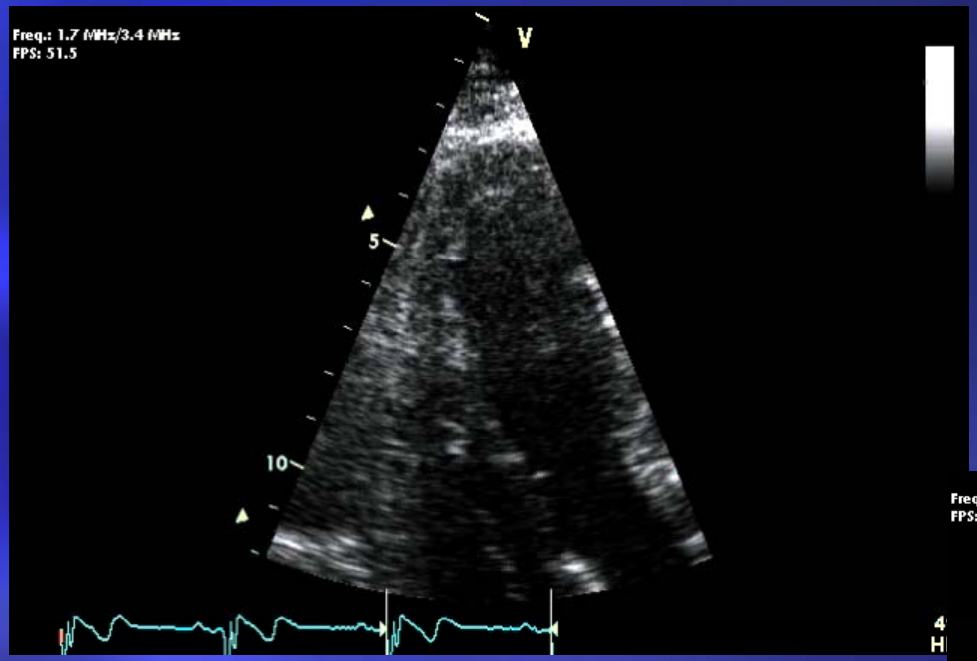


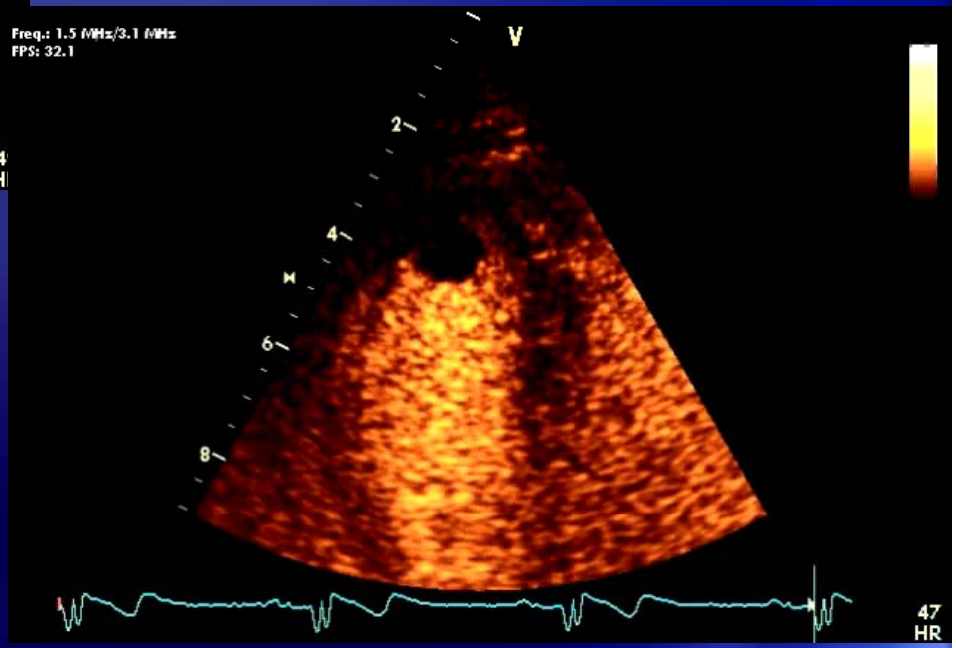






Is there apical thrombus?





CT for Myocardial Imaging

- Coronary CT angiography
- Arterial phase myocardial imaging
- Myocardial motion interpretation
- Viability imaging with delayed enhancement

Role of CCT in AMI

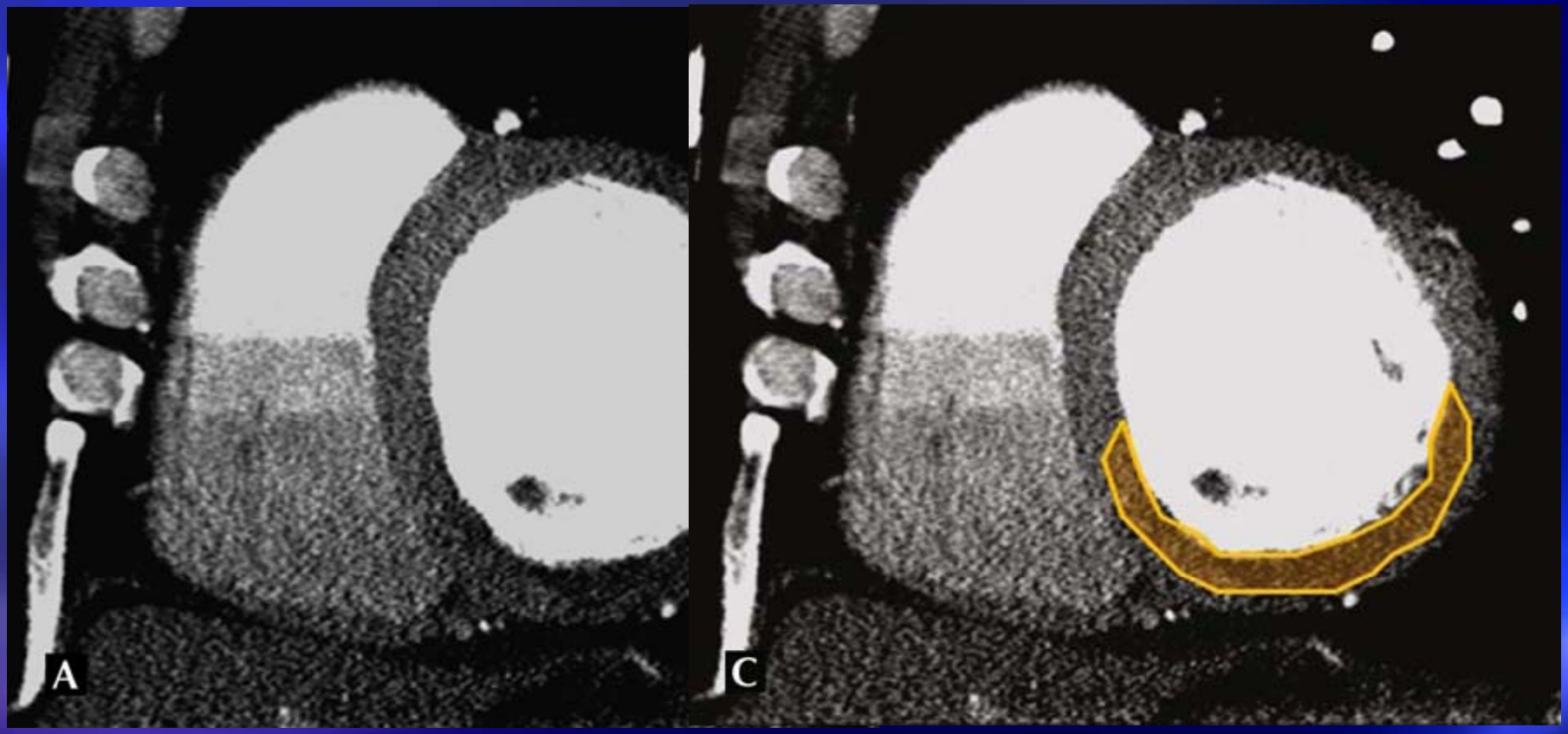
- Evaluation of acute chest pain
- Myocardial viability

Table 1. MDCT rest perfusion for diagnosis of MI

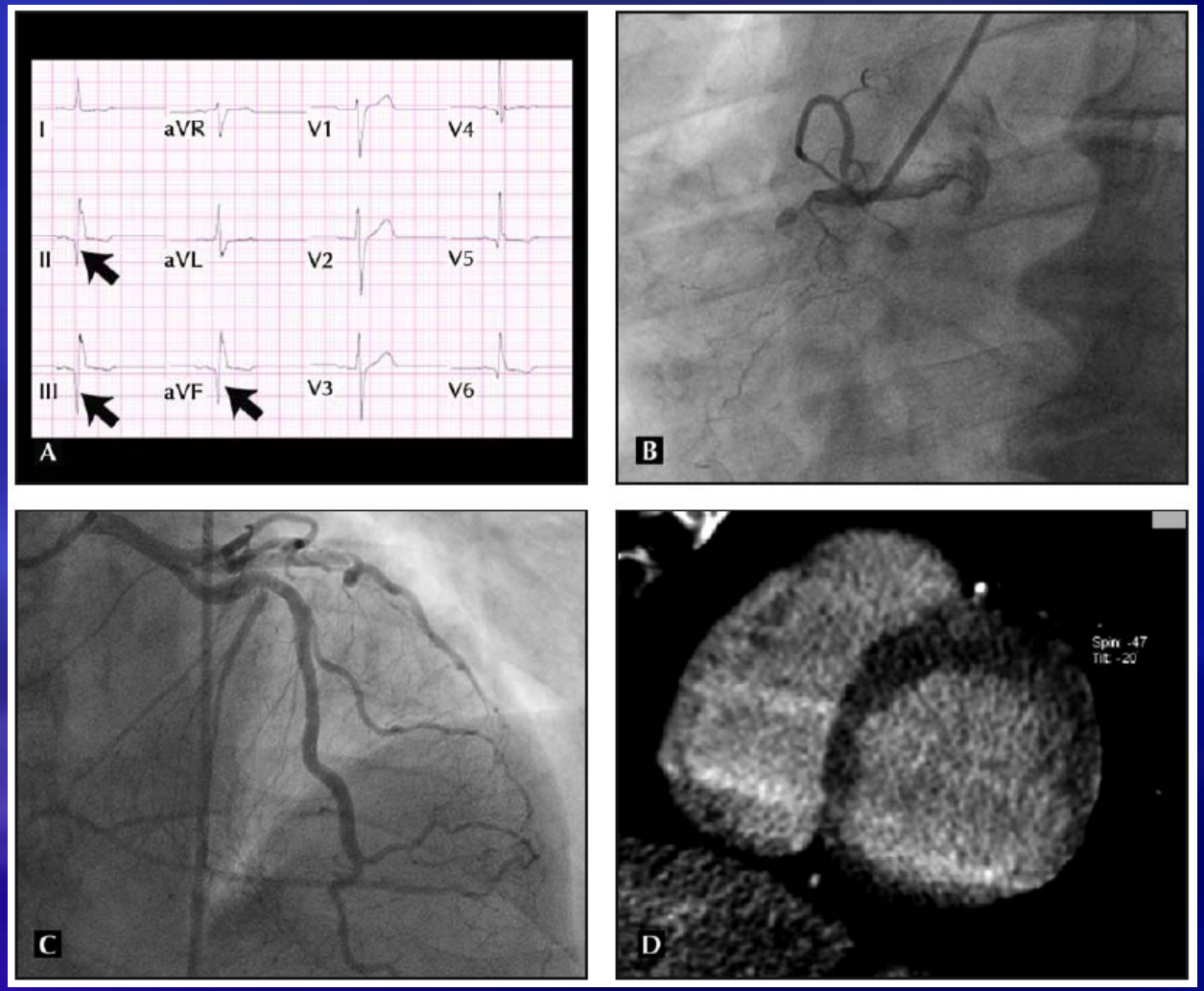
Study	Population	Imaging test(s) performed	Results	Conclusion
Nikolaou et al. [15], 2005	Chronic MI ($n = 11$); known or suspected CAD ($n = 19$)	CE-MDCT (rest); DE-CMR	10/11 MIs identified by CT (SN = 91%, SP = 79%)	CE-CT can detect chronic MI
Nieman et al. [13], 2006	Recent MI (< 7 days, $n = 16$); long-standing MI (> 12 months, $n = 13$); no MI ($n = 13$)	CE-MDCT (rest); comparison of attenuation (HU) of injured and normal remote myocardium	Lower CT attenuation with long-standing MI (-13 ± 37 HU) vs acute MI (26 ± 26 HU) vs normals (73 ± 14 HU, $P < 0.001$); long-standing MI associated with wall thinning and ventricular dilation	Recent and long-standing MIs may be differentiated based on myocardial CT attenuation and ventricular dimensions
Mahnken et al. [12], 2005	Reperfused STEMI ($n = 28$)	16-MDCT early and DE (15 min); DE-MRI	Infarct size by MR 31.2% ± 22.5% vs DE-MSCT 33.3% ± 23.8% vs early CE-MDCT 24.5% ± 18.3%	Late-enhancement MDCT appears as reliable as delayed-enhanced MRI in assessing infarct size and myocardial viability in acute MI
Gerber et al. [9], 2006	Acute MI ($n = 16$); chronic LV dysfunction ($n = 21$)	CE-MDCT (rest); delayed MDCT (10 min); FP-MRI; DE-MRI	CT-MR concordance of early PD 92% ($k = 0.54$, $P < 0.001$) and DE 82% ($k = 0.61$, $P < 0.001$)	CE-MDCT characterizes acute and chronic MI with contrast patterns similar to CE-MR
Lessick et al. [11], 2007	Post-AMI ($n = 26$), of which PCI before CT ($n = 11$)	16-MDCT: ED and DE (6 min); TTE: 3 months post-MI to assess wall motion	For patent arteries ($n = 21$): DE-CT had SN = 73% and SP = 85% for predicting follow-up segment dysfunction, compared with SN = 57% and SP = 90% for early PD	The presence and size of ED and DE after AMI is related to follow-up myocardial functional recovery
Habis et al. [10], 2007	First acute MI ($n = 36$)	64-MDCT (without contrast) 24 ± 11 min post-PCI (viable = no subendocardial or transmural hyperenhancement); rest TTE/ low-dose DSE after 2–4 weeks	Detection myocardial viability per segment: SN 98%, SP 94%, PPV 99%, NPV 79%, per-patient SN 92%, SP 100%, PPV 100%, and NPV 85%	64-slice CT after coronary angiography for an acute MI may allow for early evaluation of viable myocardium
Rubinshtein et al. [16], 2008	Suspected or stable CAD ($n = 122$)	CE-DSCT; quantitative SPECT	Detection of MI by CT; SN 75%, SP 98%, PPV 68%, and NPV 99%	Using SPECT as reference, DSCT showed moderate sensitivity and PPV but high specificity and NPV for detection of MI
Nieman et al. [14•], 2008	Early reperfused MI (≤ 5 days, $n = 21$)	64-MDCT early and DE (7 min, $n = 15$); DE MRI	Early PD on all CT and MR images (11% ± 6 vs 7% ± 4 of LV mass, $R^2 = 0.72$); DE-CT in 11/15 with good correlation ($R^2 = 0.85$) with DE-MRI	Following reperfused MI, early hypoenhancement and delayed enhancement correlated well between MDCT and MRI
Cury et al. [8••], 2008	Recent acute MI ($n = 34$); no MI ($n = 68$)	64-MDCT (PD, RWMA, EF); TTE; SPECT	Detection of acute MI by CT (SN 94%, SP 97%); MI size by CT correlated well with cardiac enzymes ($r = 0.82$) but moderately with SPECT ($r = 0.48$)	AMI can be identified by MDCT on the basis of RWMA and PD

AMI—acute MI; CAD—coronary artery disease; CE—contrast enhanced; CMR—cardiac MRI; DE—delayed enhancement; DSCT—dual-source CT; DSE—dobutamine stress echocardiography; ED—early perfusion defects; EF—ejection fraction; FP—first pass; HU—Hounsfield unit; LV—left ventricular; MDCT—multidetector CT; MI—myocardial infarction; MSCT—multislice CT; NPV—negative predictive value; PC—percutaneous coronary intervention; PD—perfusion defects; PPV—positive predictive value; RWMA—regional wall motion abnormalities; SN—sensitivity; SP—specificity; SPECT—single photon emission CT; STEMI—ST-segment elevation MI; TTE—transthoracic echocardiography.

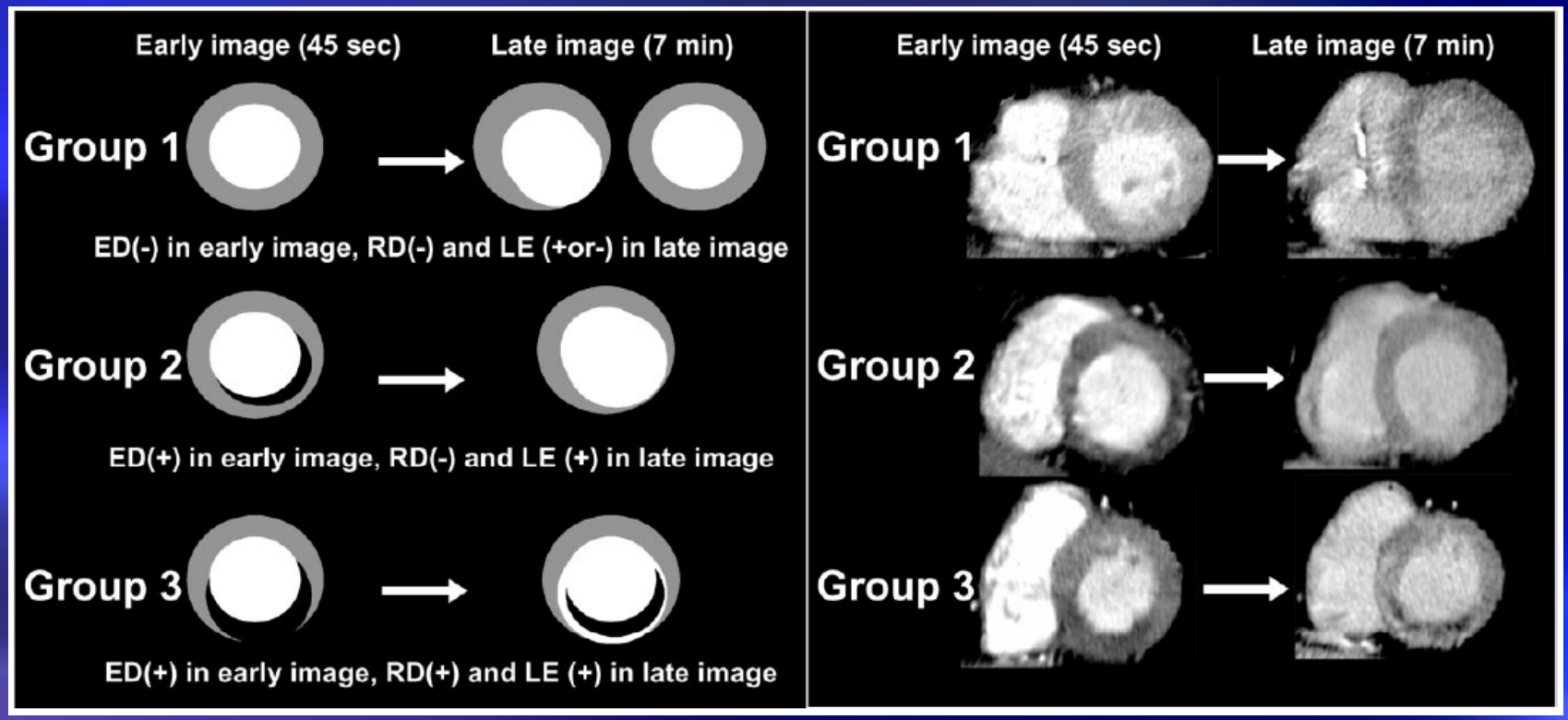
Quantification of Infarct Size



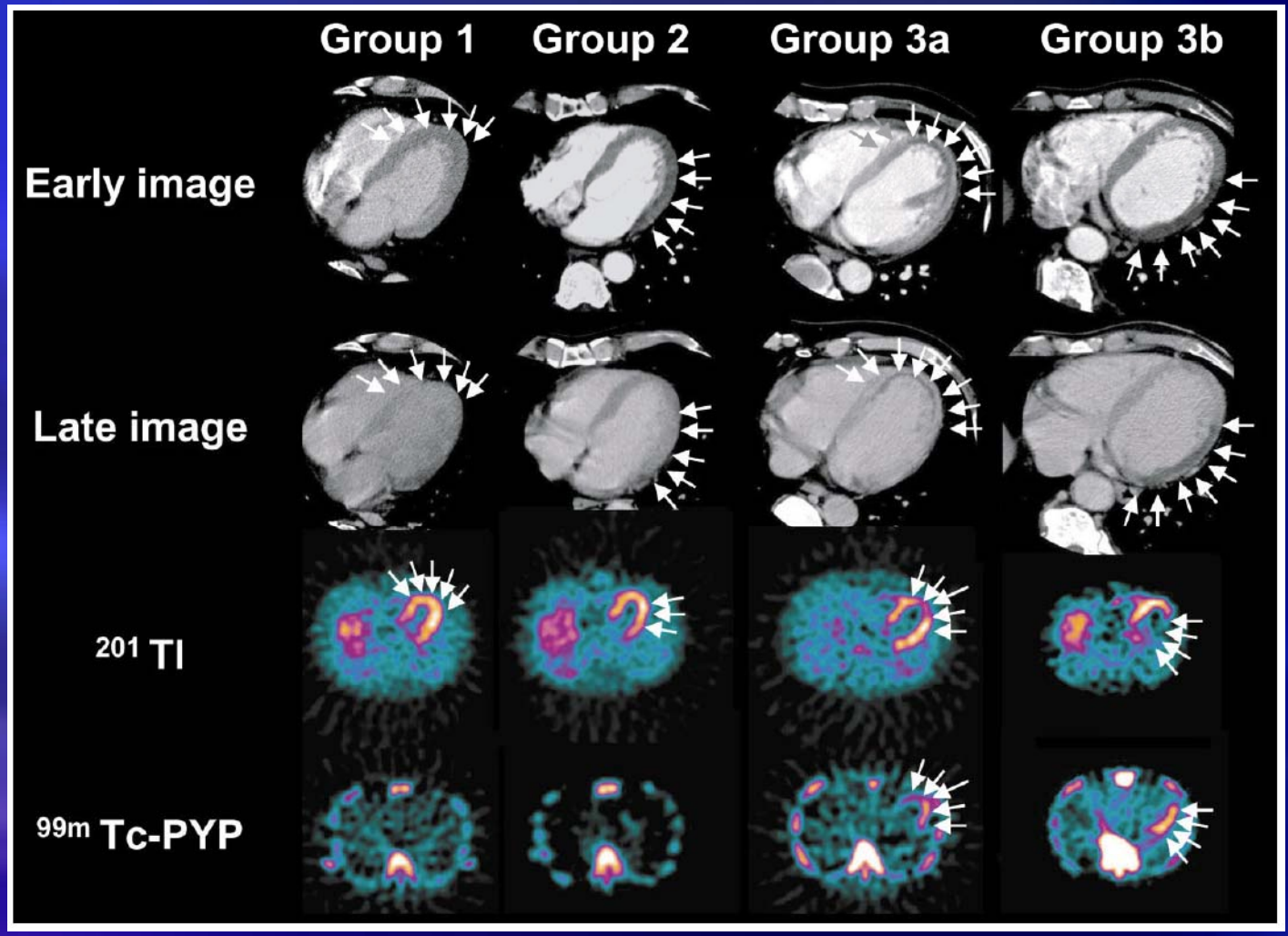
Myocardial Viability



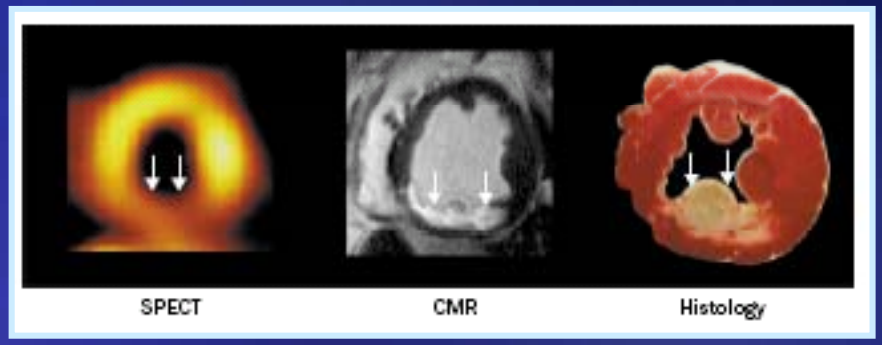
Dual-Phase CT

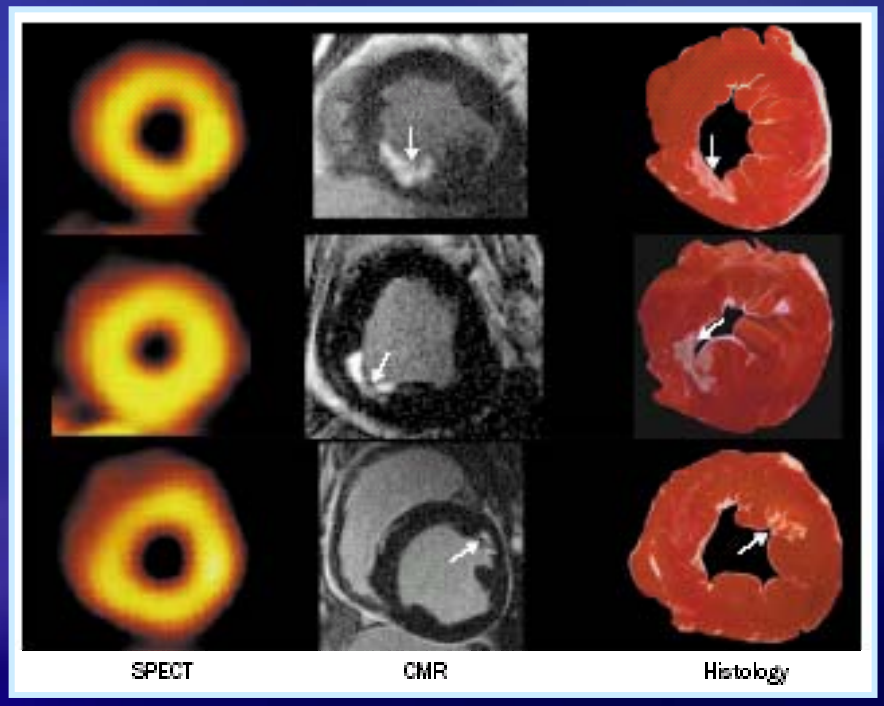


Dual-Phase CT



CMR: Delayed Enhancement





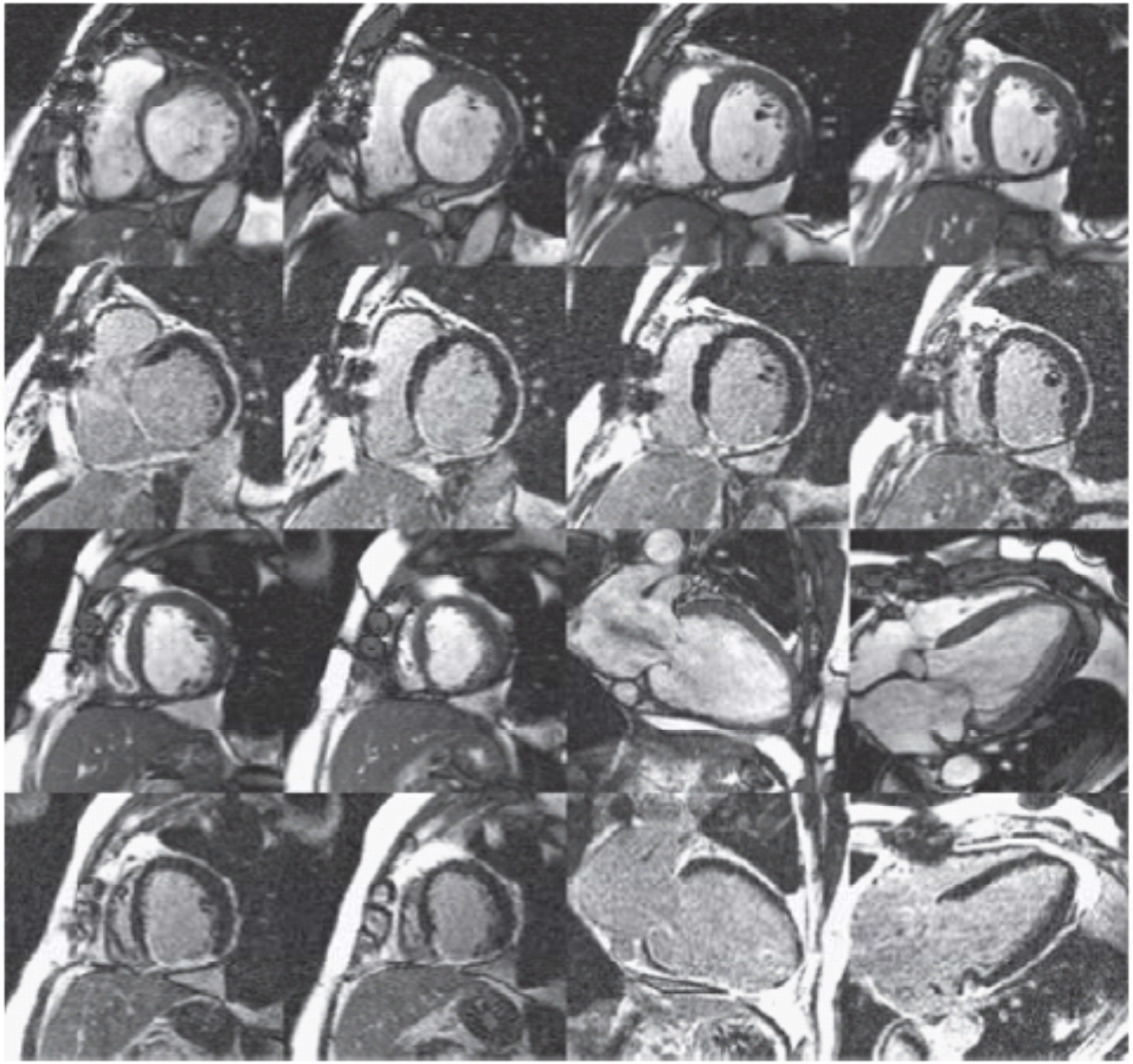
TYPICAL VIABILITY SCAN

Cine

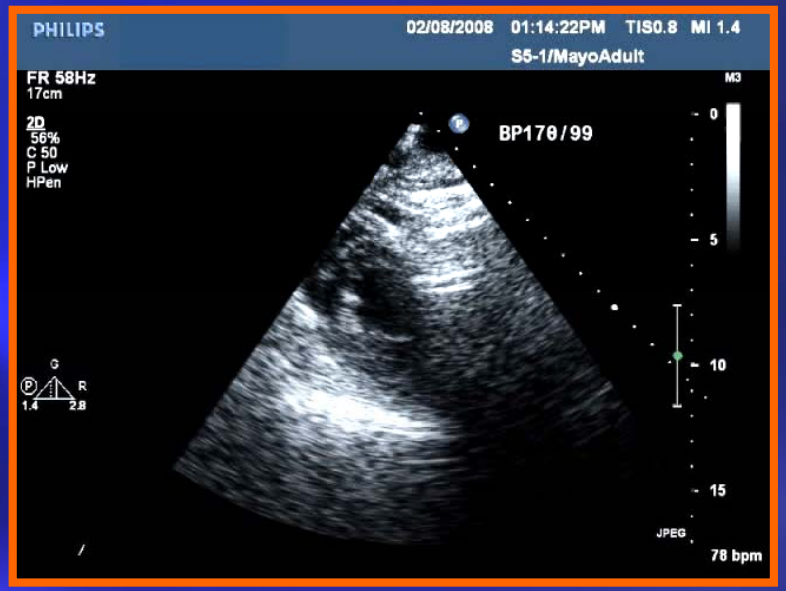
DE-MRI

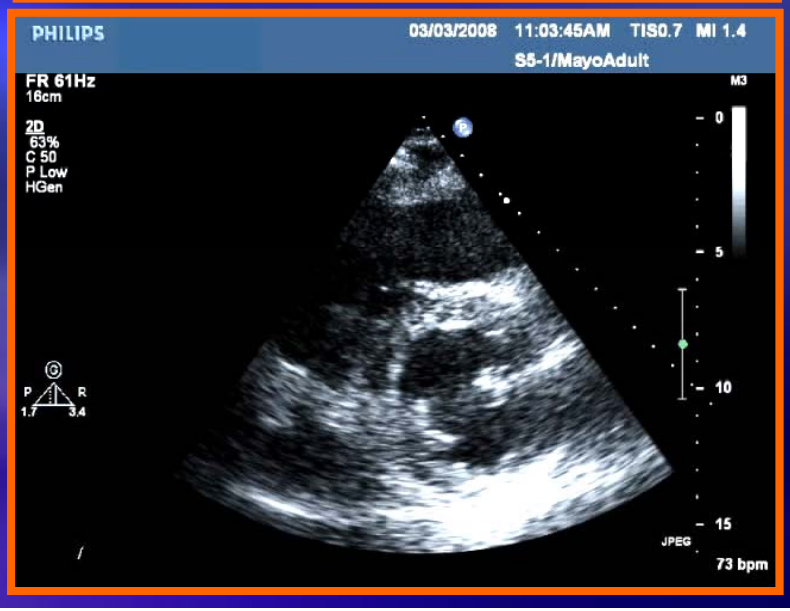
Cine

DE-MRI

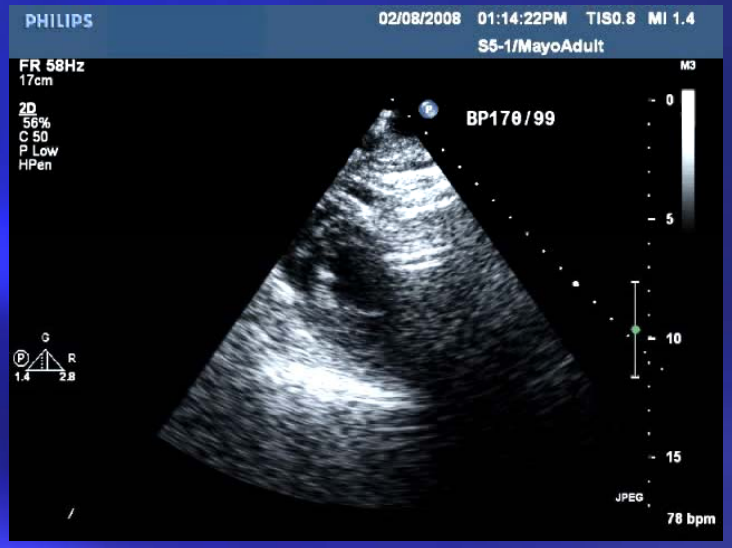


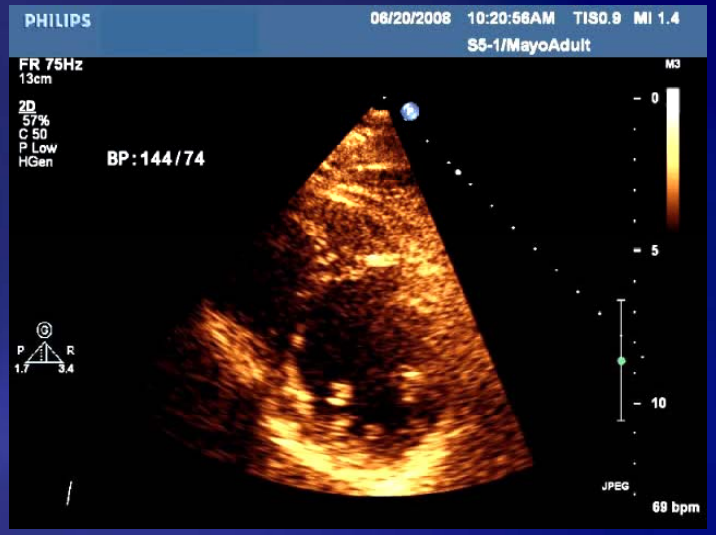
Two Patients with Inferior STEMI
Soon after PCI

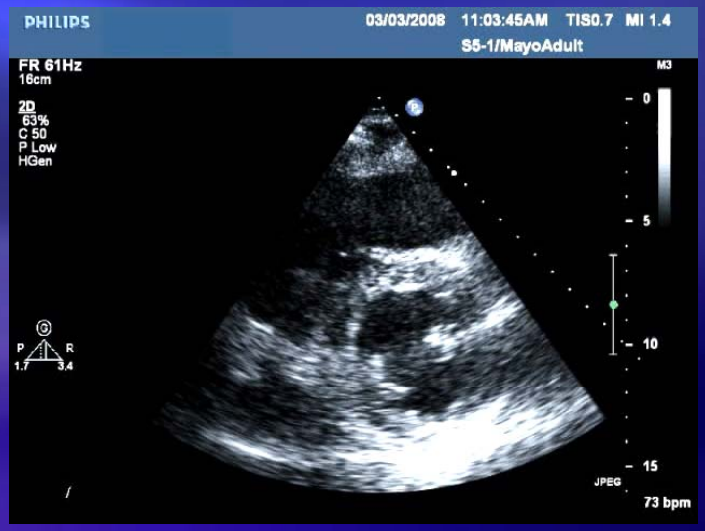


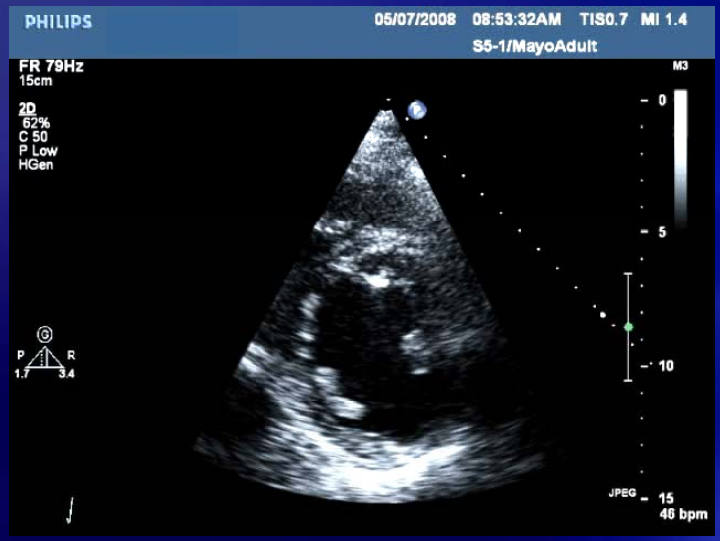


Two Patients with Inferior STEMI After PCI and Follow-up

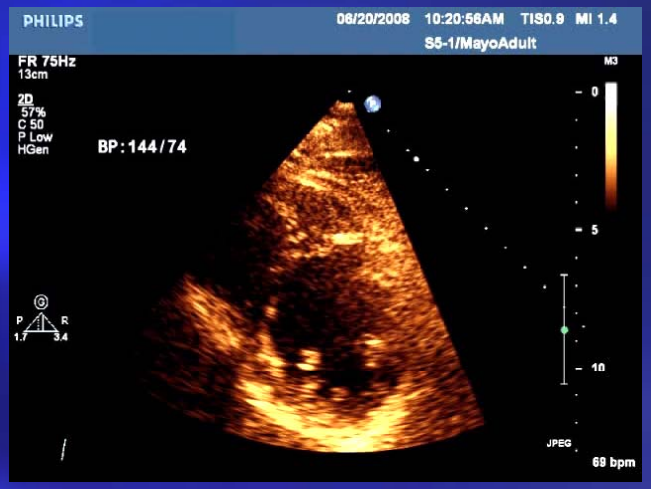


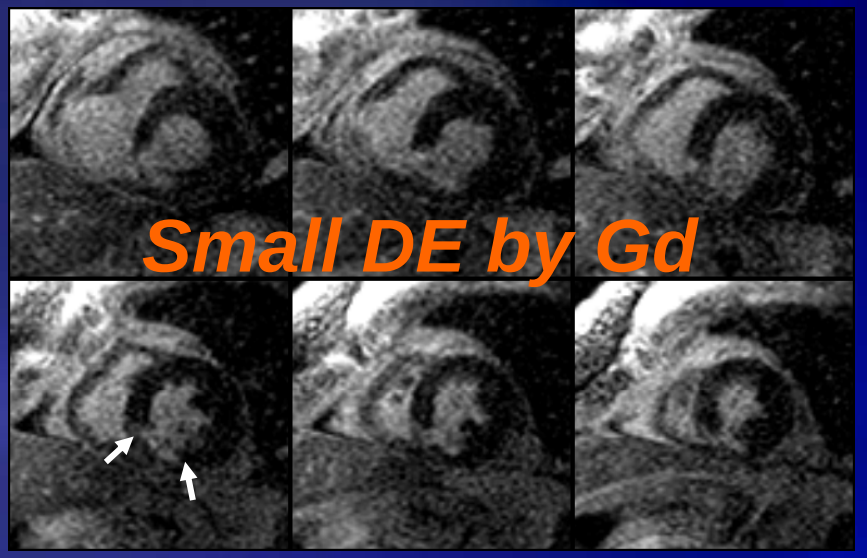


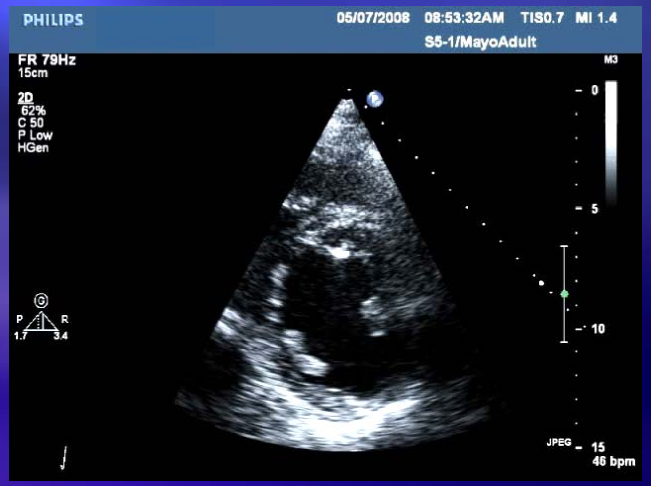


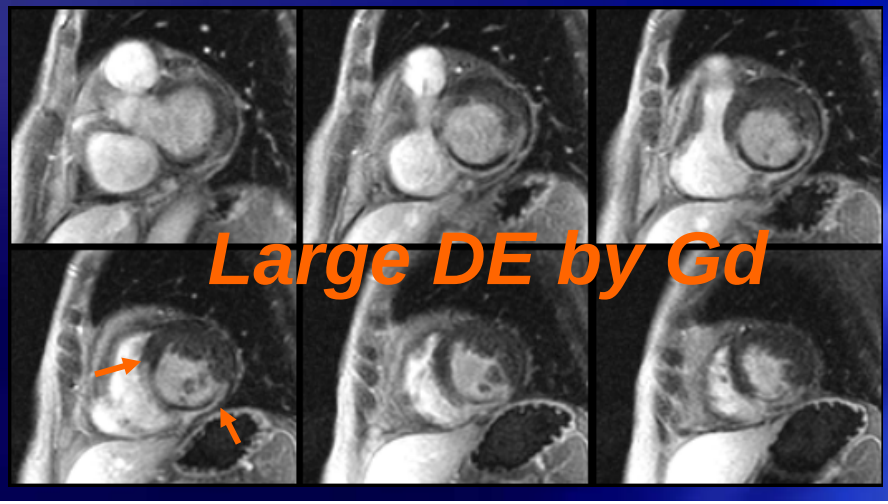


Two Patients with Inferior STEMI
Follow-up Echo and Baseline MRI



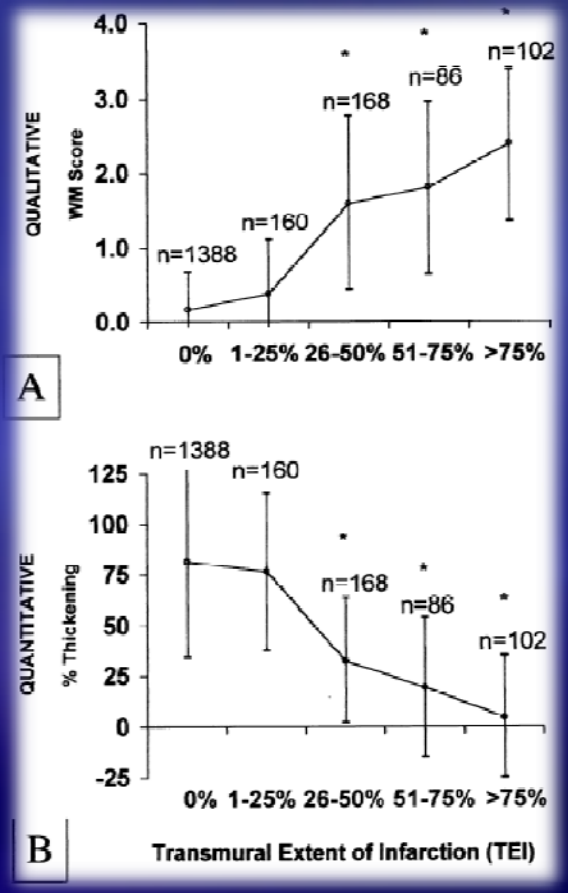




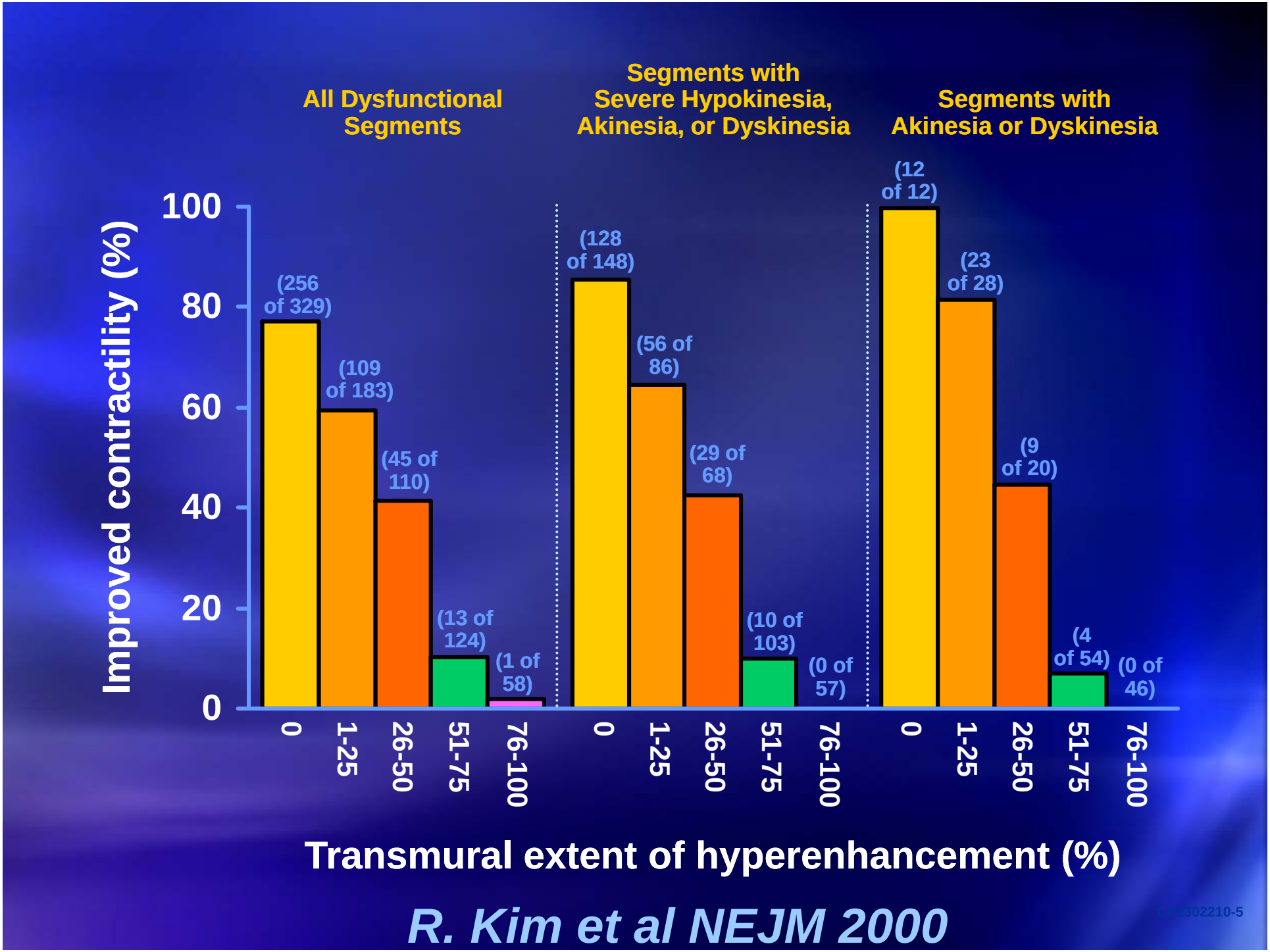


Myocardial Function and DHE

- Transmural extent of infarction and contractility



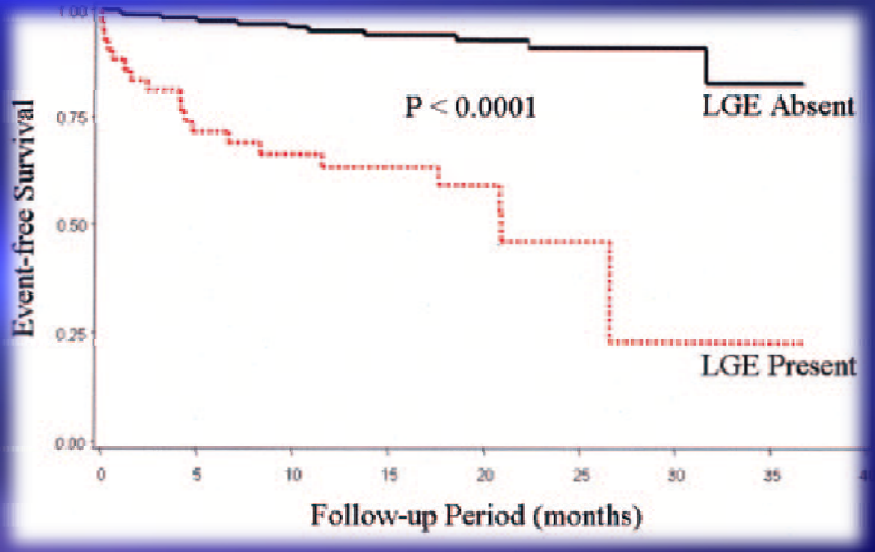
Marholdt, JACC 2003



R. Kim et al NEJM 2000

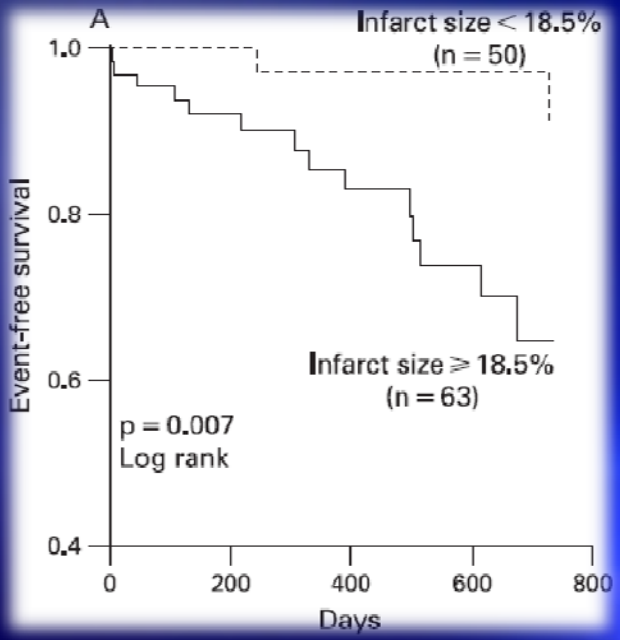
Prognosis Associated with DHE

Chest pain without known OMI



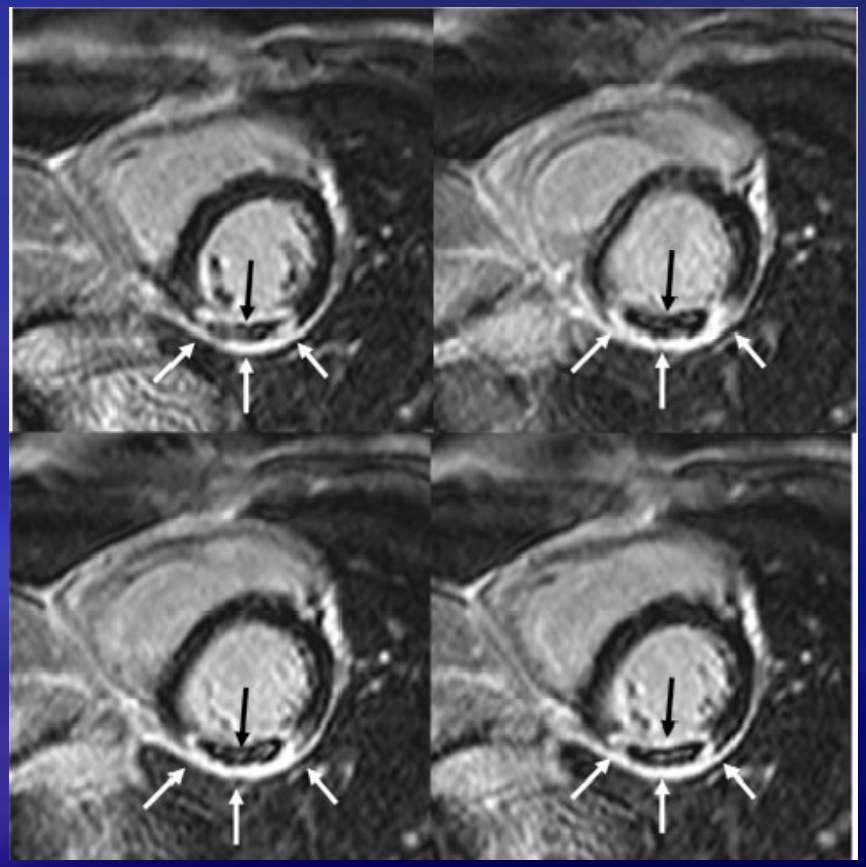
Kwong, Circ 2006

Post-STEMI



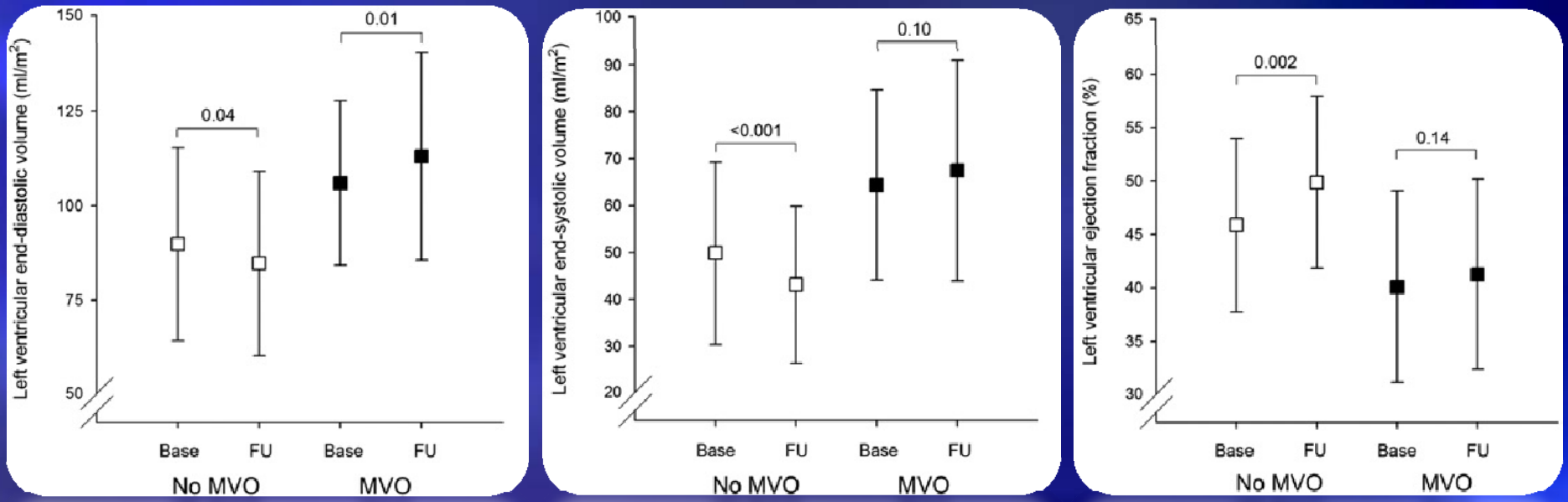
Wu, Heart 2008

Additional Information: Microvascular Obstruction



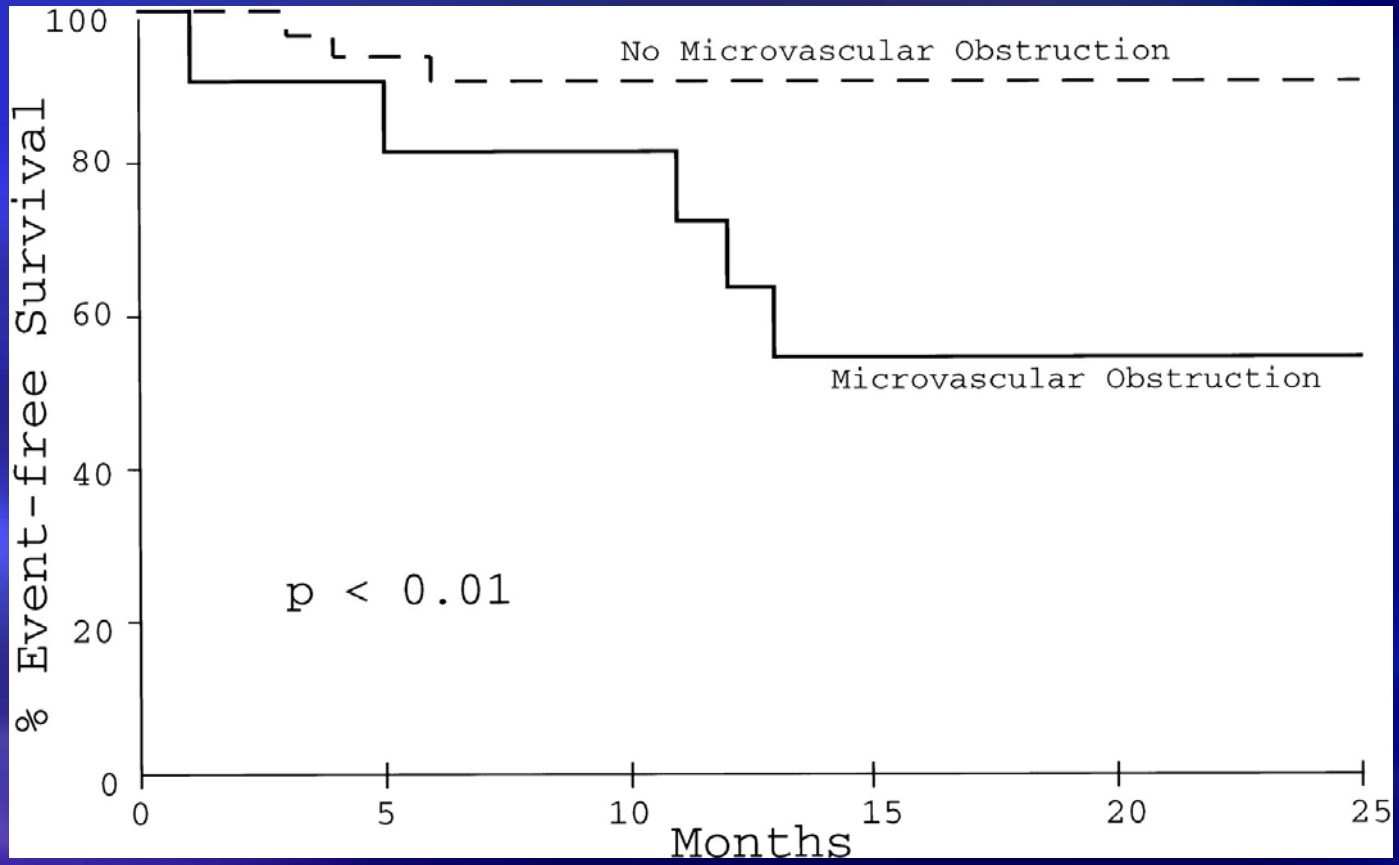
Sakuma, JMRI 2007

Functional Recovery after AMI and MO



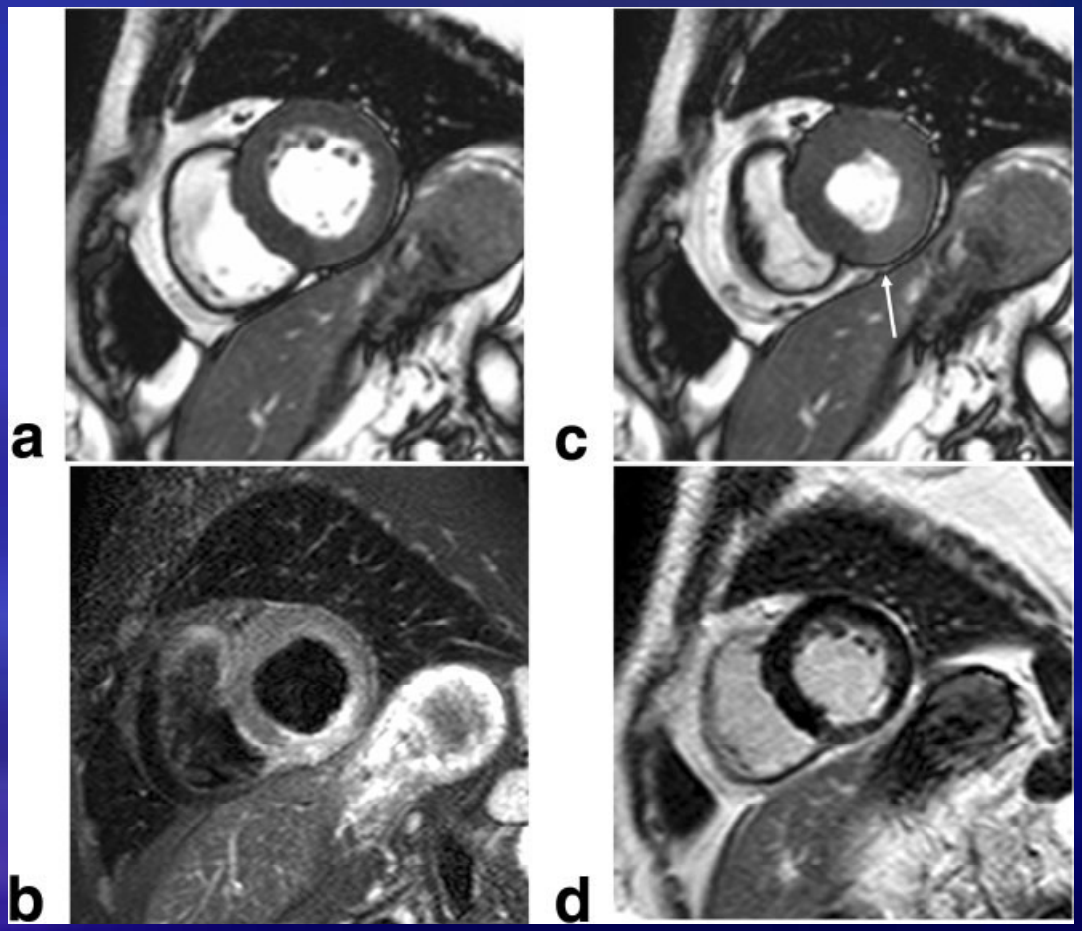
Nijveldt, JACC 2008

MO and Prognosis



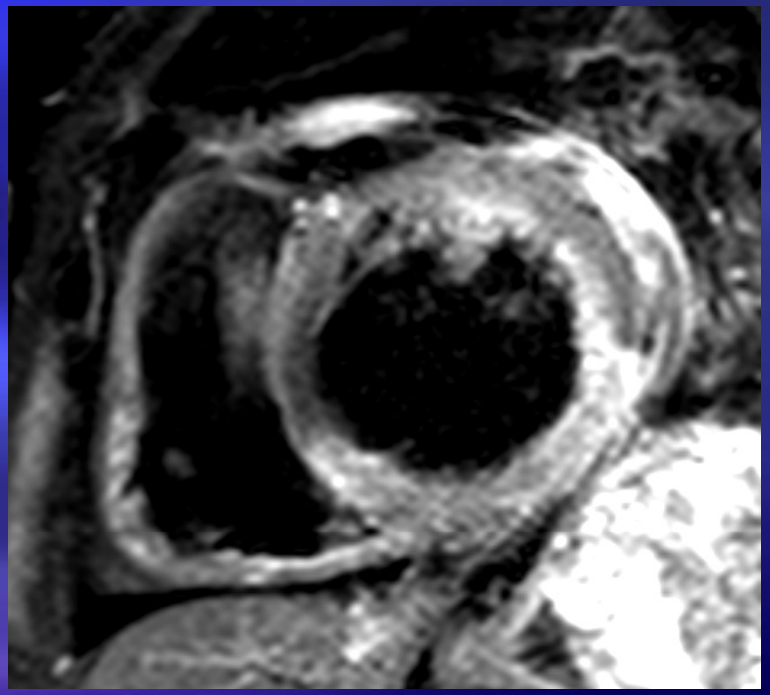
Wu, Circulation 1998

AMI with Edema

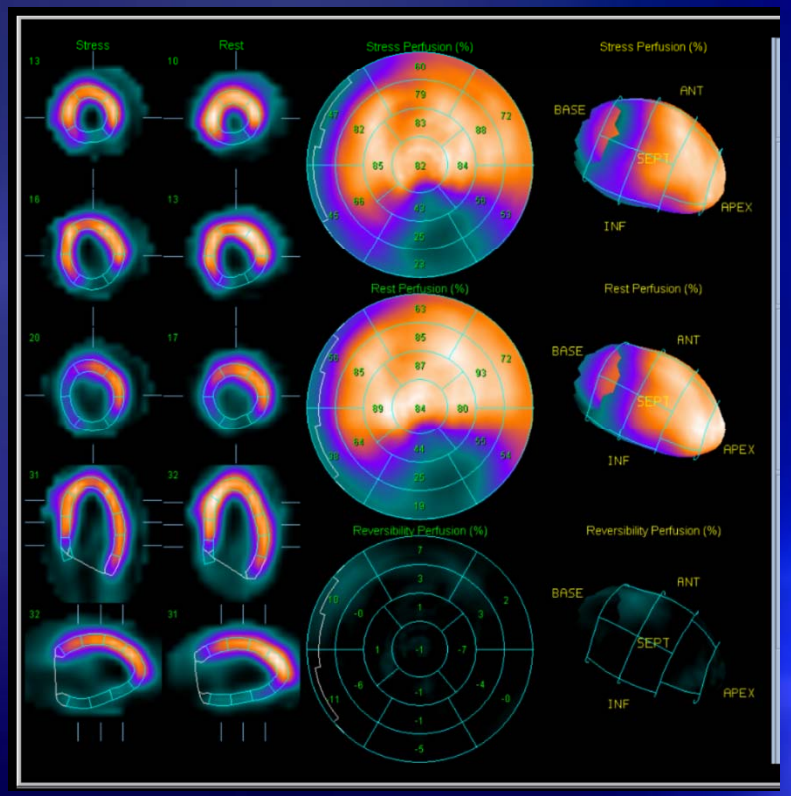


Sakuma, JMRI 2007

T2WI for Edema in MI

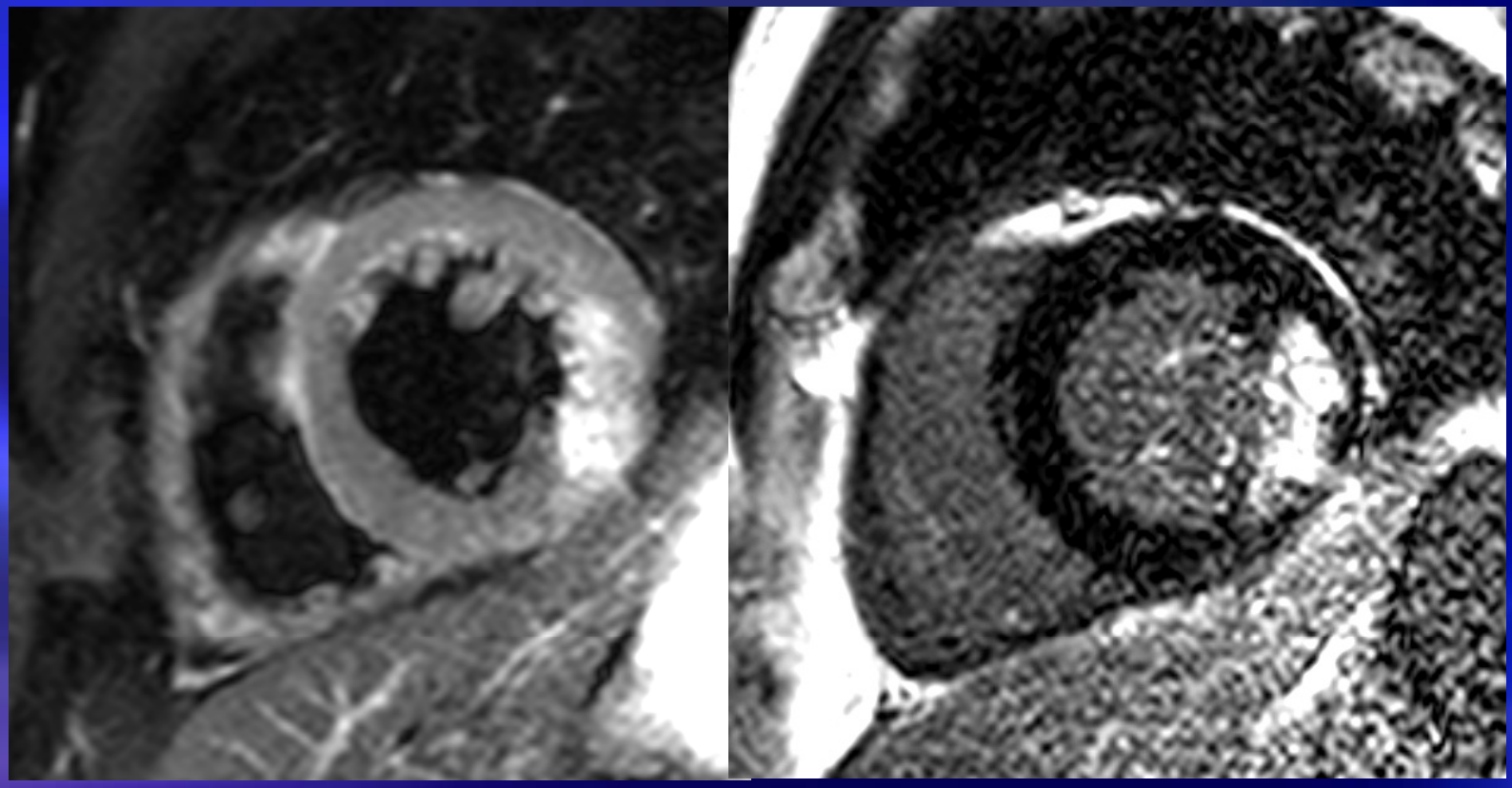


T2WI-triple IR



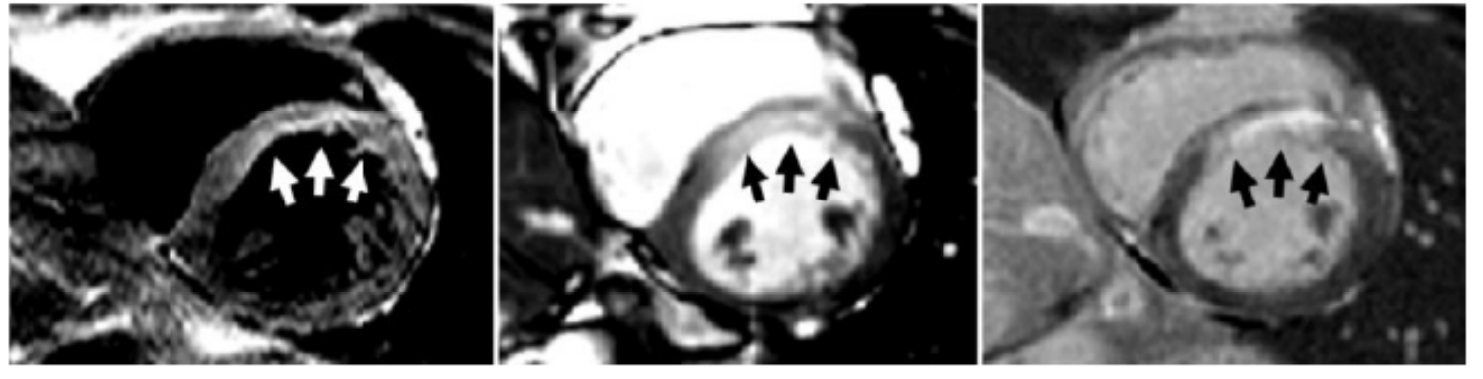
Myoview Scan

Acute MI with Swelling

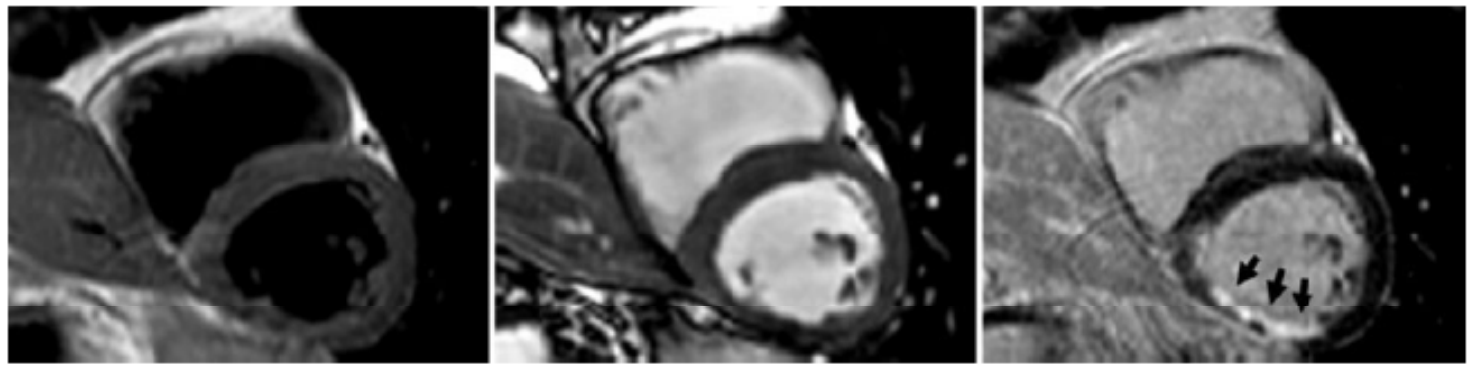


T2WI

With a Newer Sequence



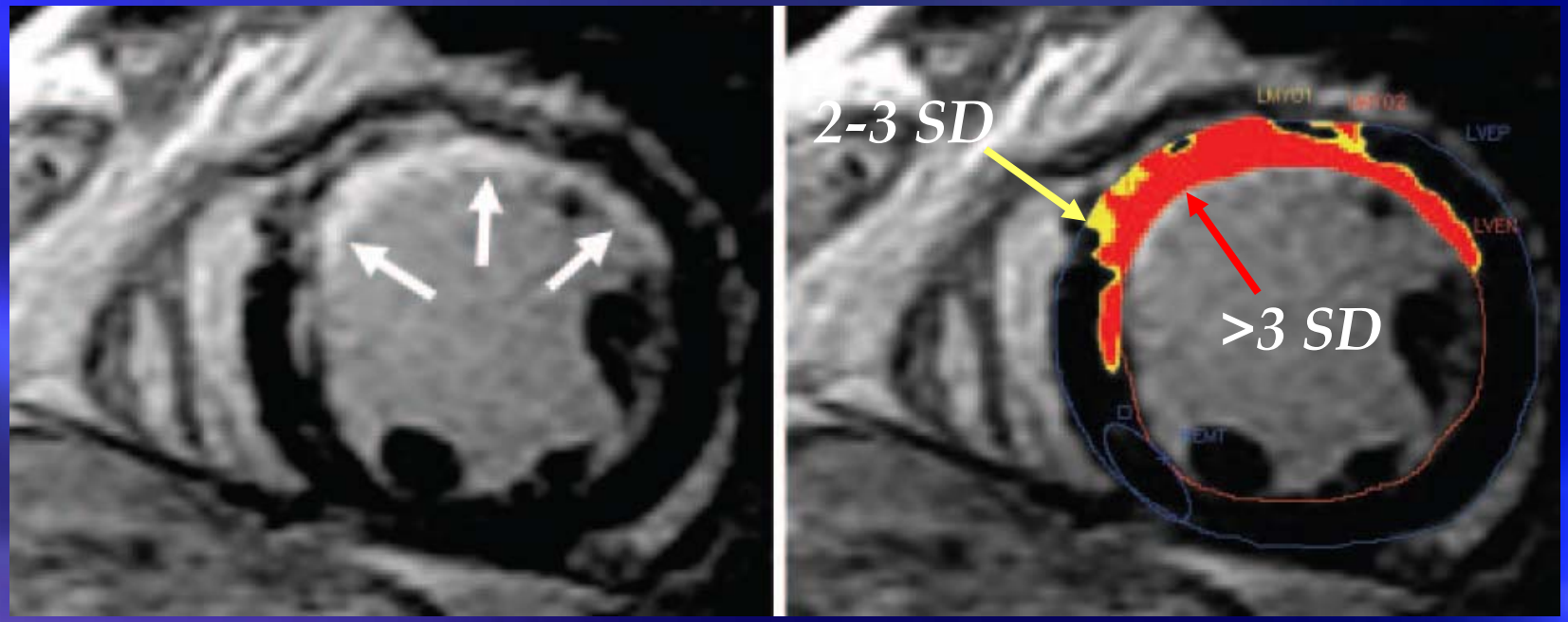
Acute MI



Chronic MI

Kellman, Magn Reson Med 2007

Peri-Infarct Zone Enhancement (The "Grey" Zone)

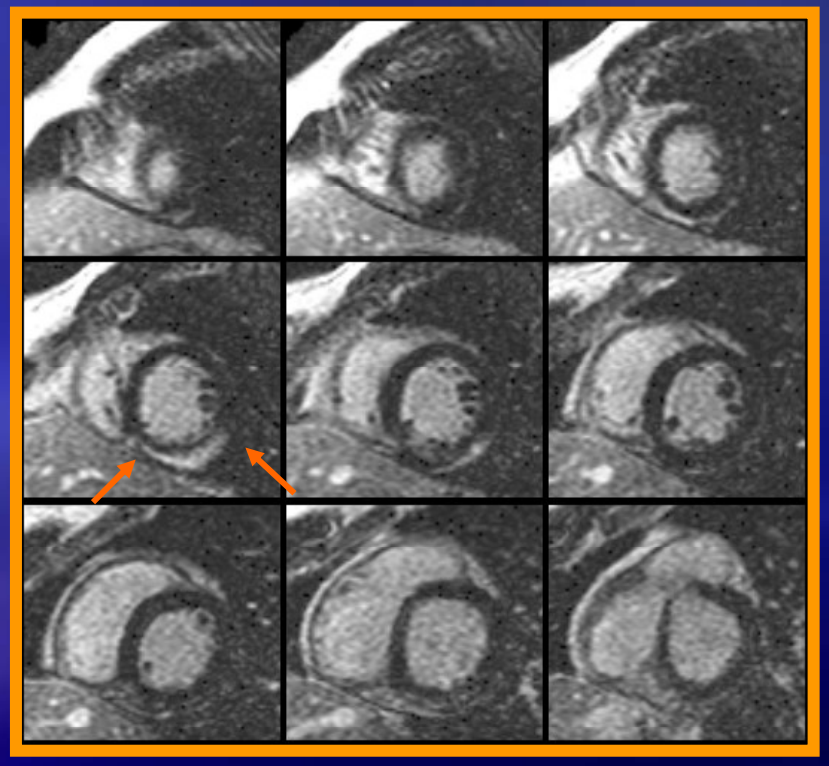


Yan AT et al. Circulation 2006;114;32-39.

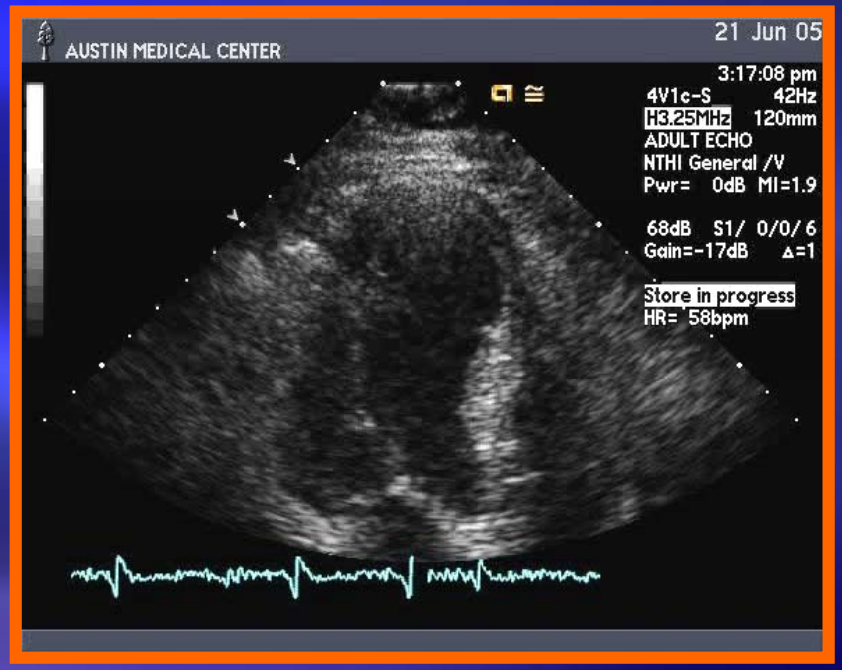
STEMI ?

Chest and left arm pain for 1 hr.

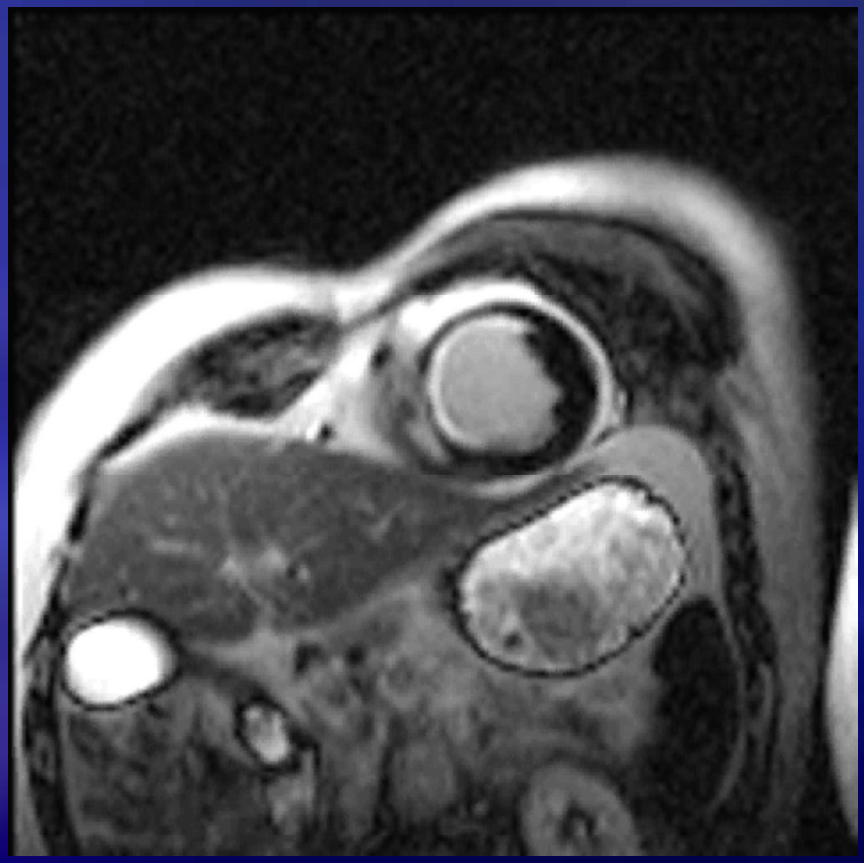
Increased Troponin



65 year old woman with chest pain

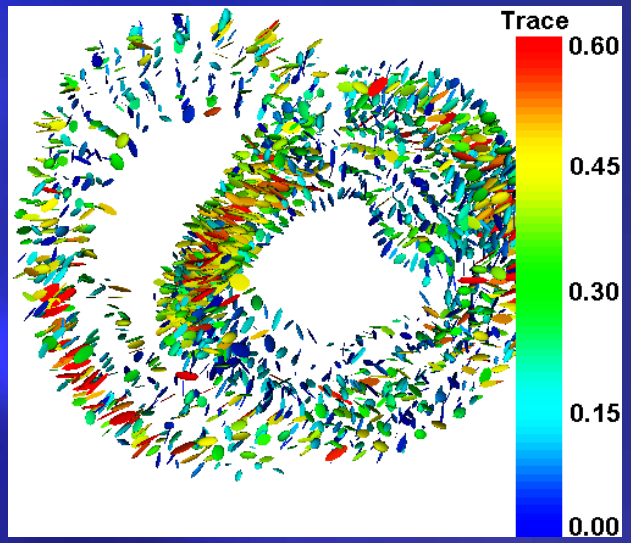


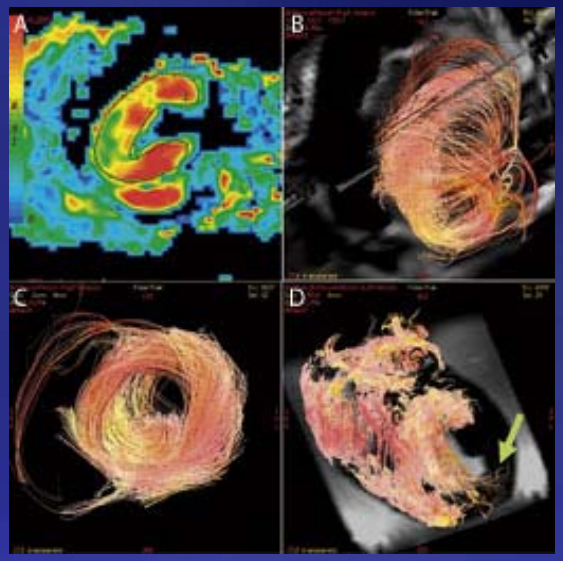
Cine Delayed Enhancement



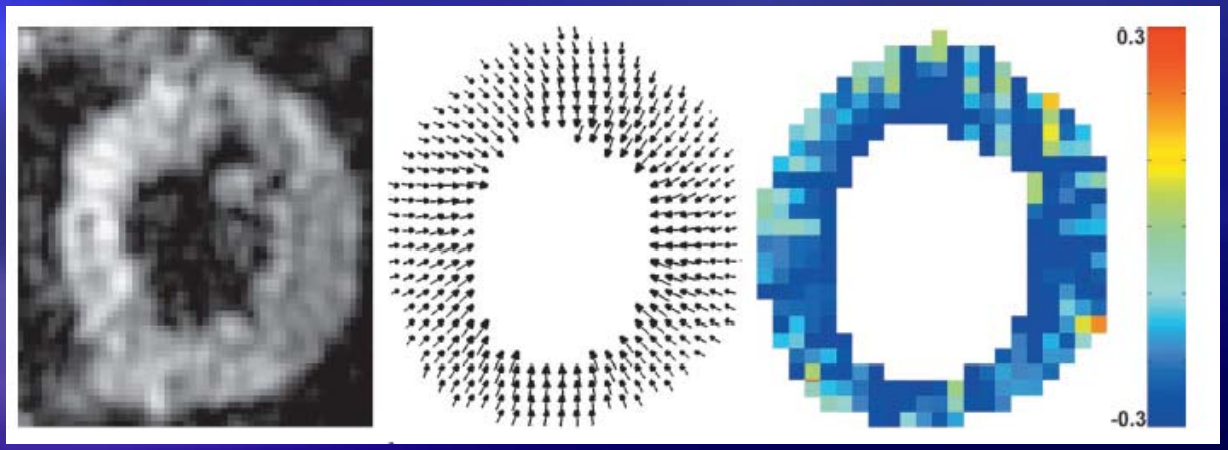
Courtesy of Siemens Med. Systems

Cardiac MRI New Technology

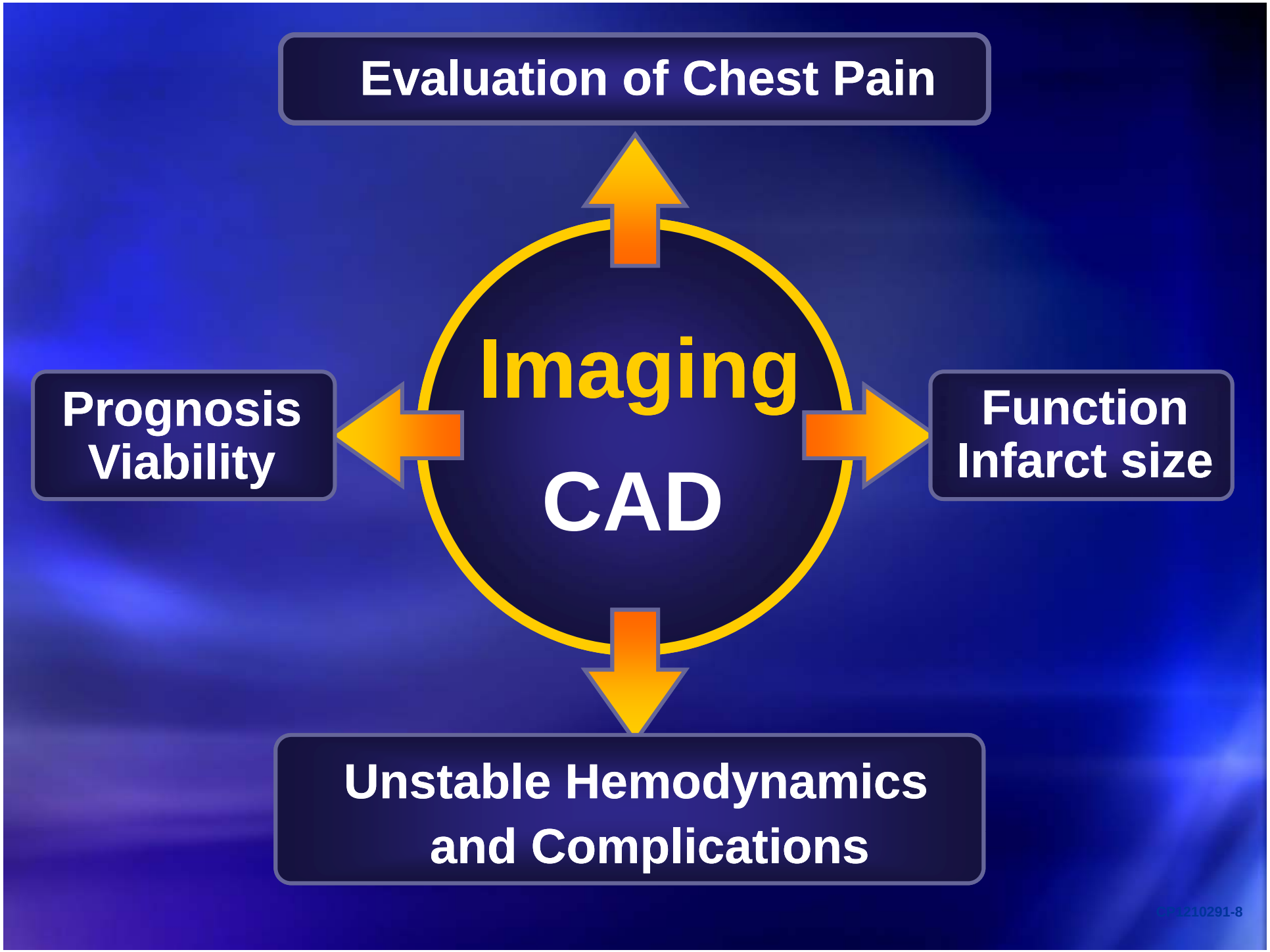




Diffusion Tensor Imaging



Myocardial Strain Imaging


Evaluation of Chest Pain
Imaging
CAD
Prognosis
Viability
Function
Infarct size
Unstable Hemodynamics
and Complications