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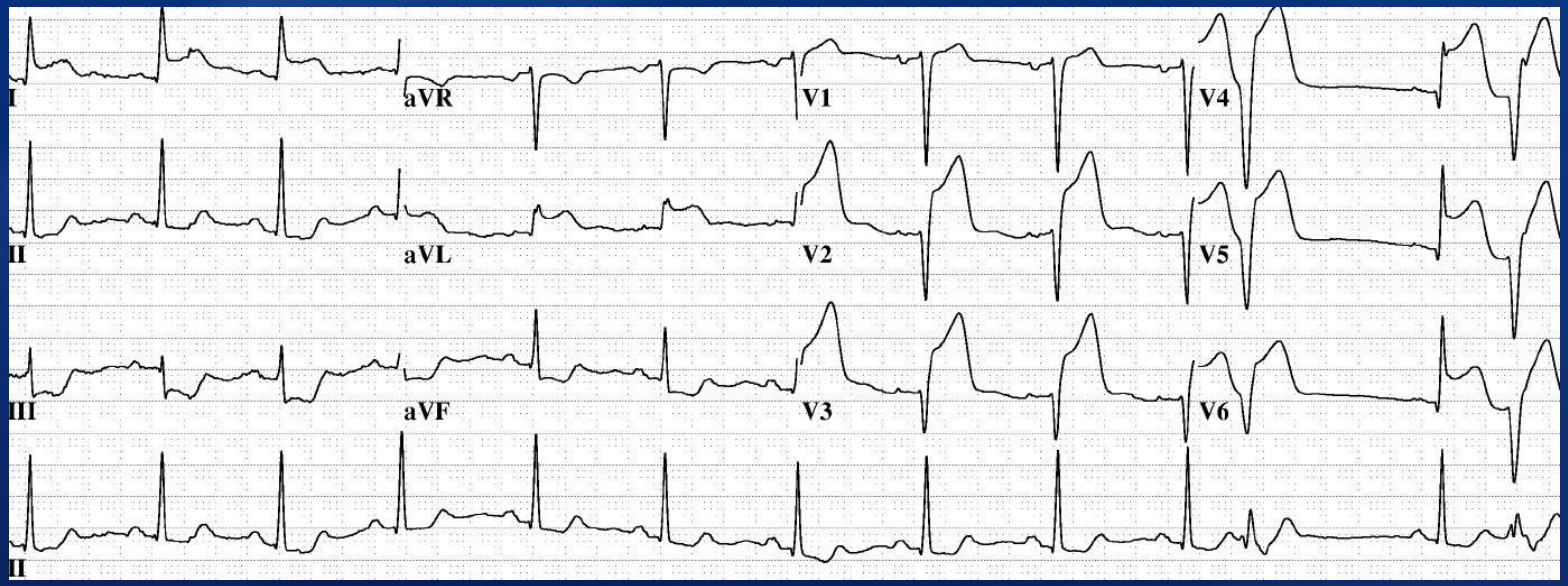
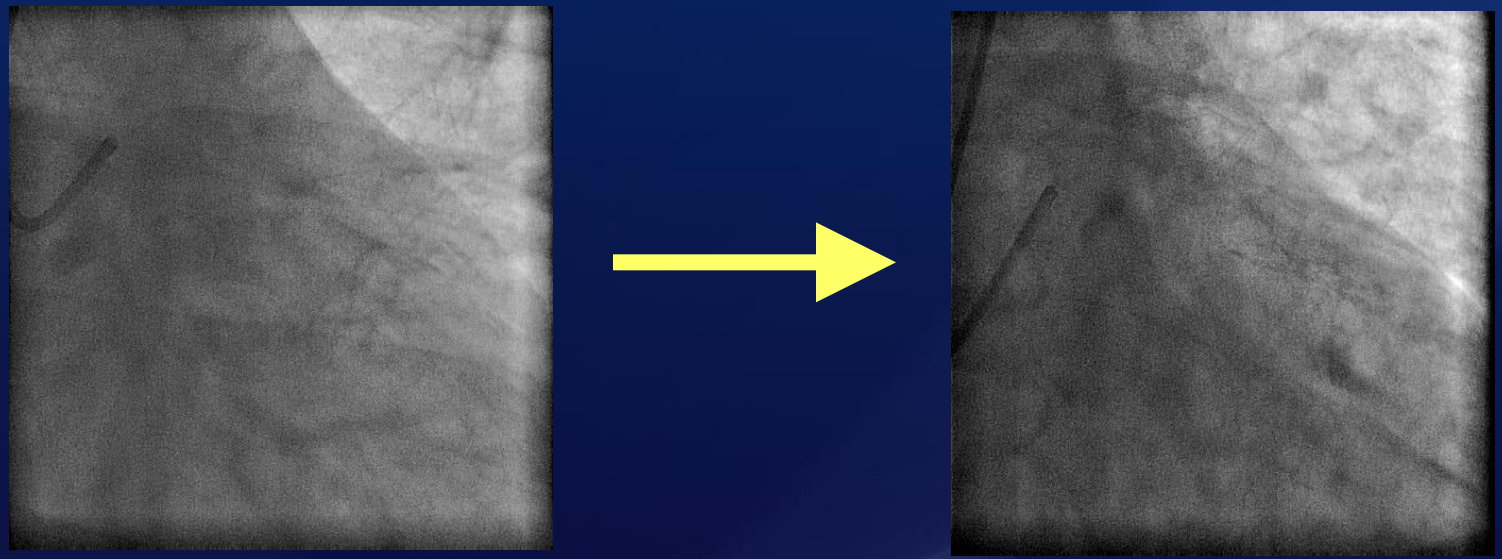
Noninvasive Imaging after STEMI

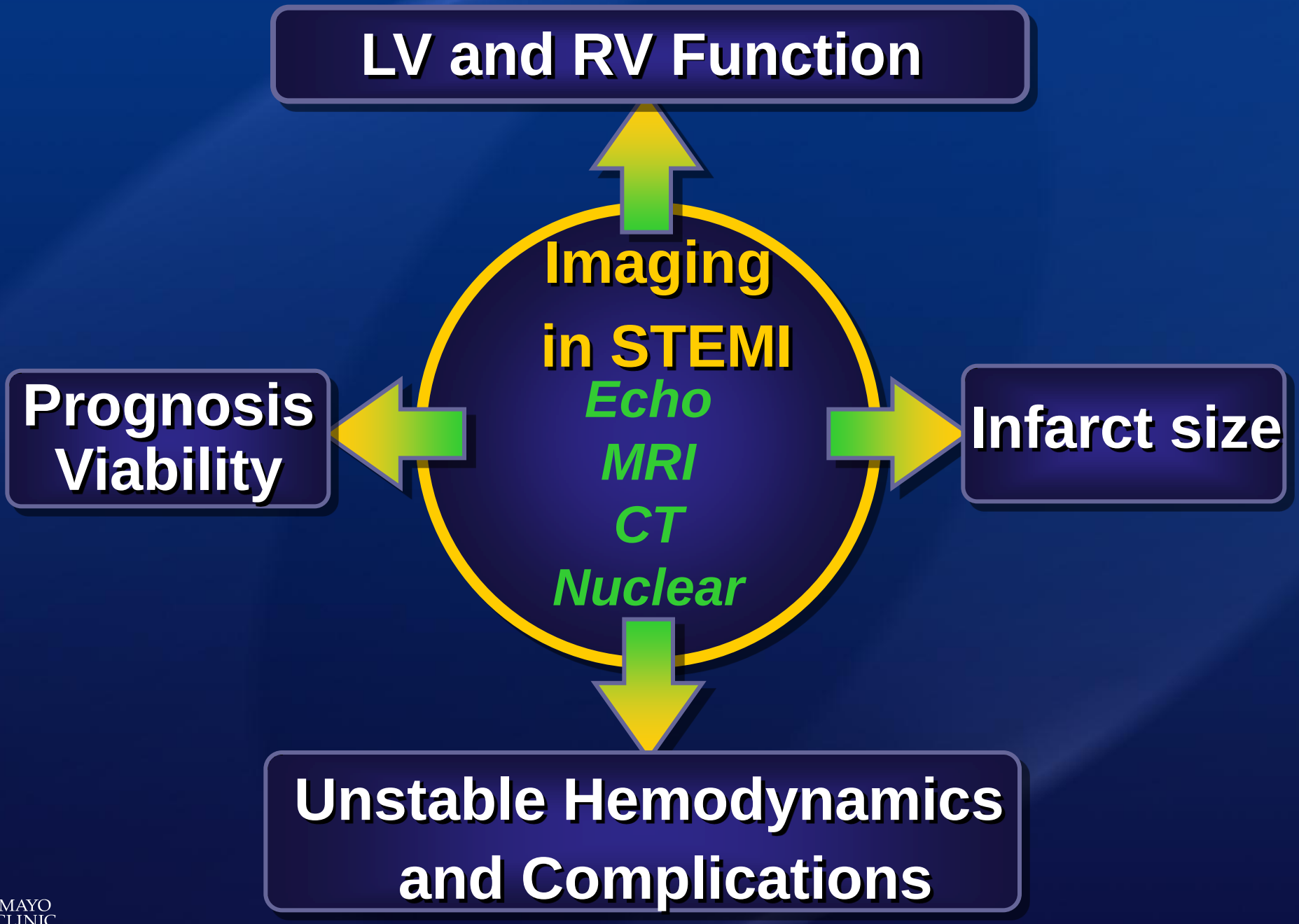
Jae K. Oh, MD
Co-Director, CV Imaging

Torino, Italy
October 20, 2011

56 year old man with STEMI







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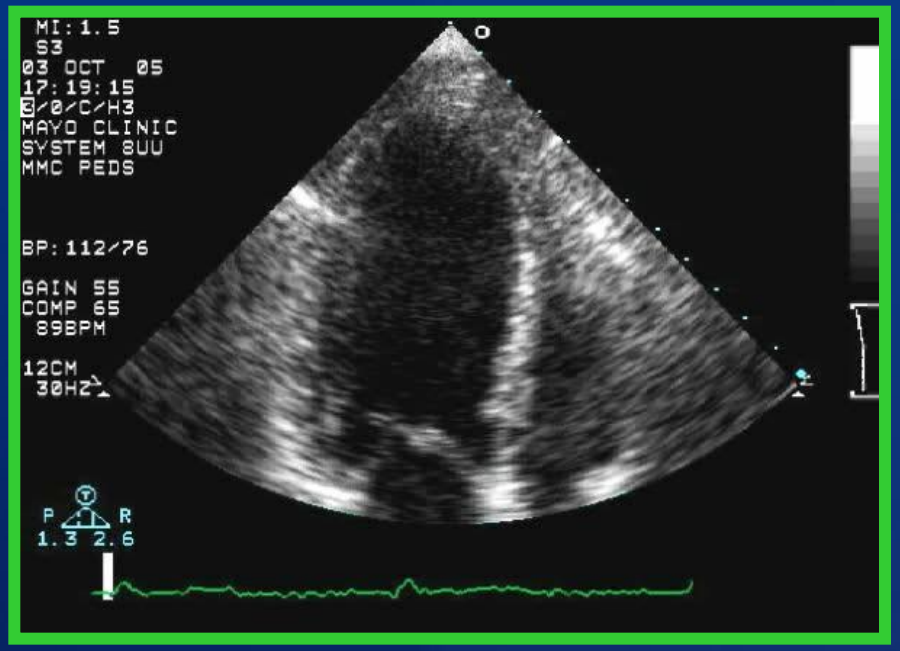
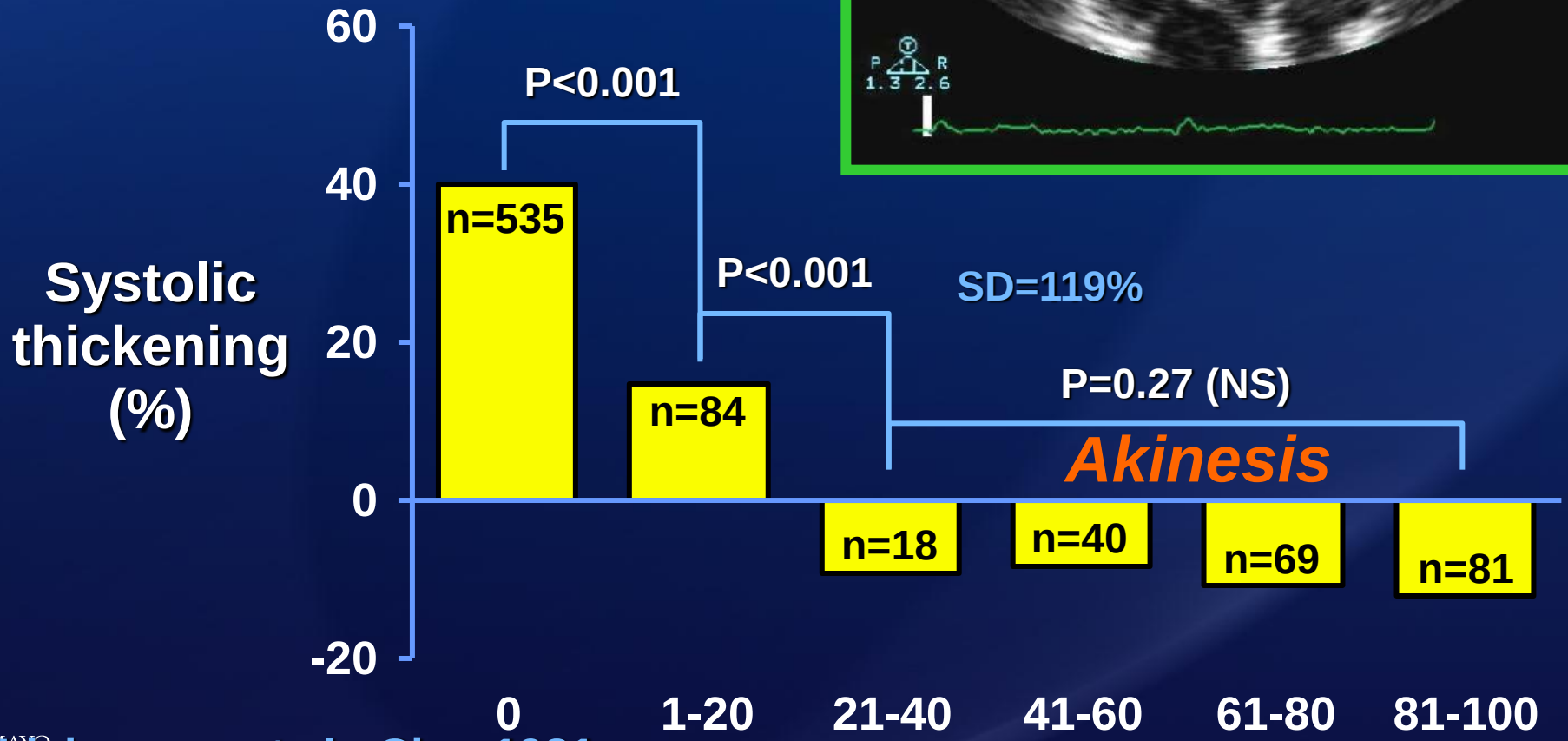
Akinetic Wall

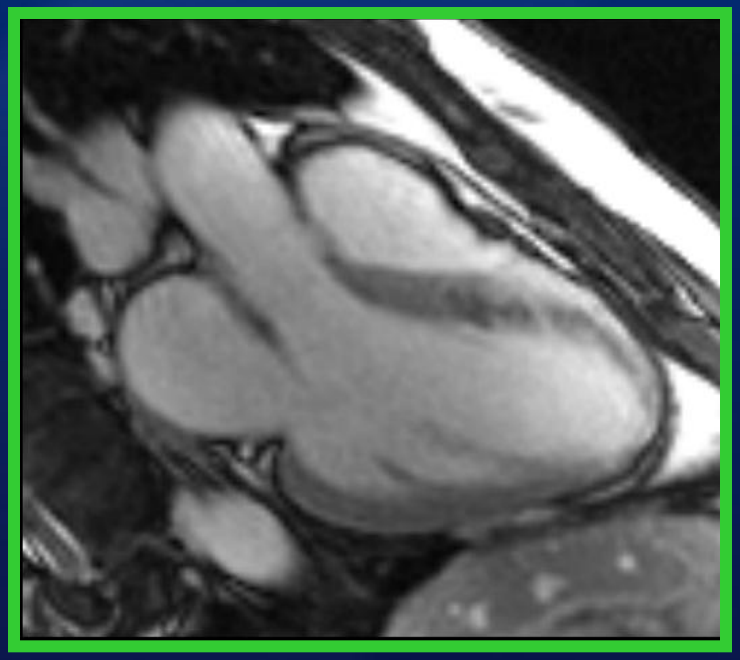
Dead or Alive?

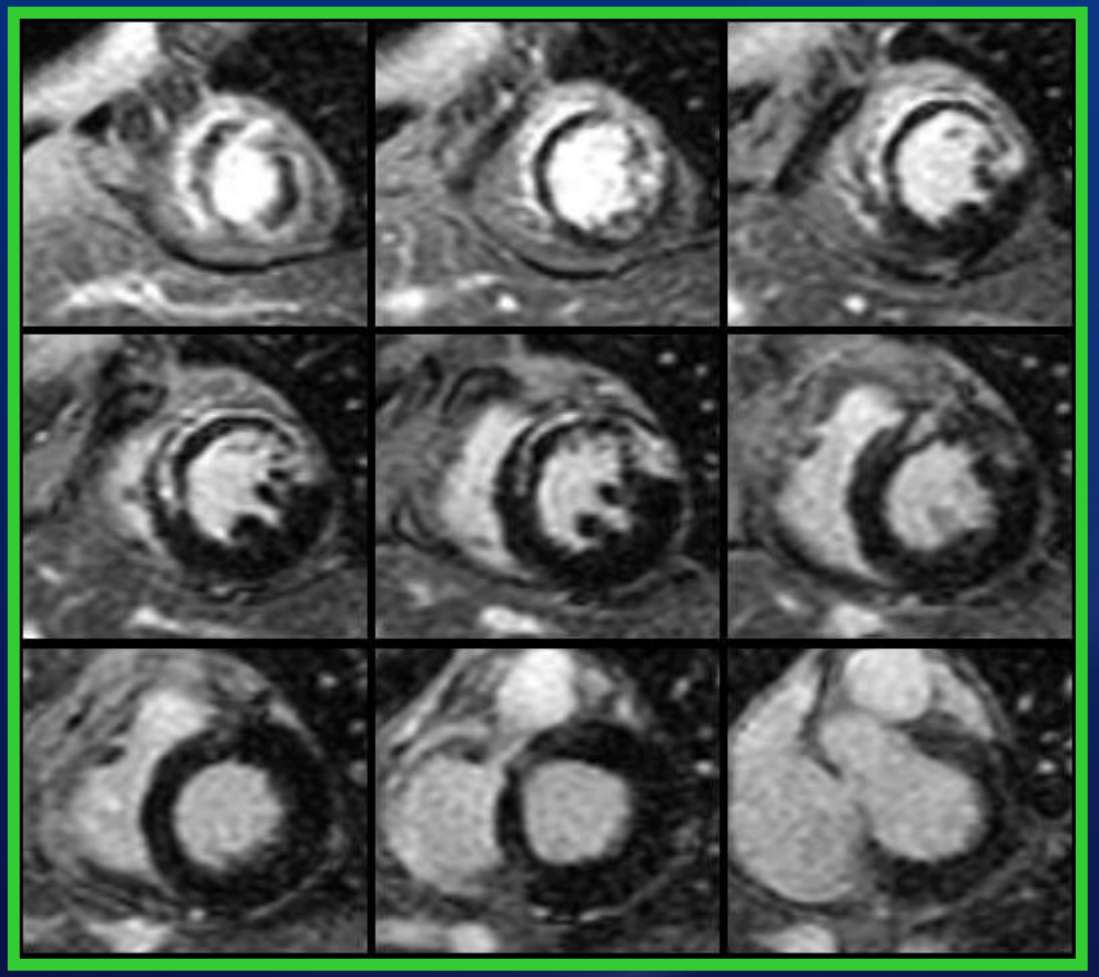




Lieberman et al: Circ, 1981

MRI with Delayed Enhancement





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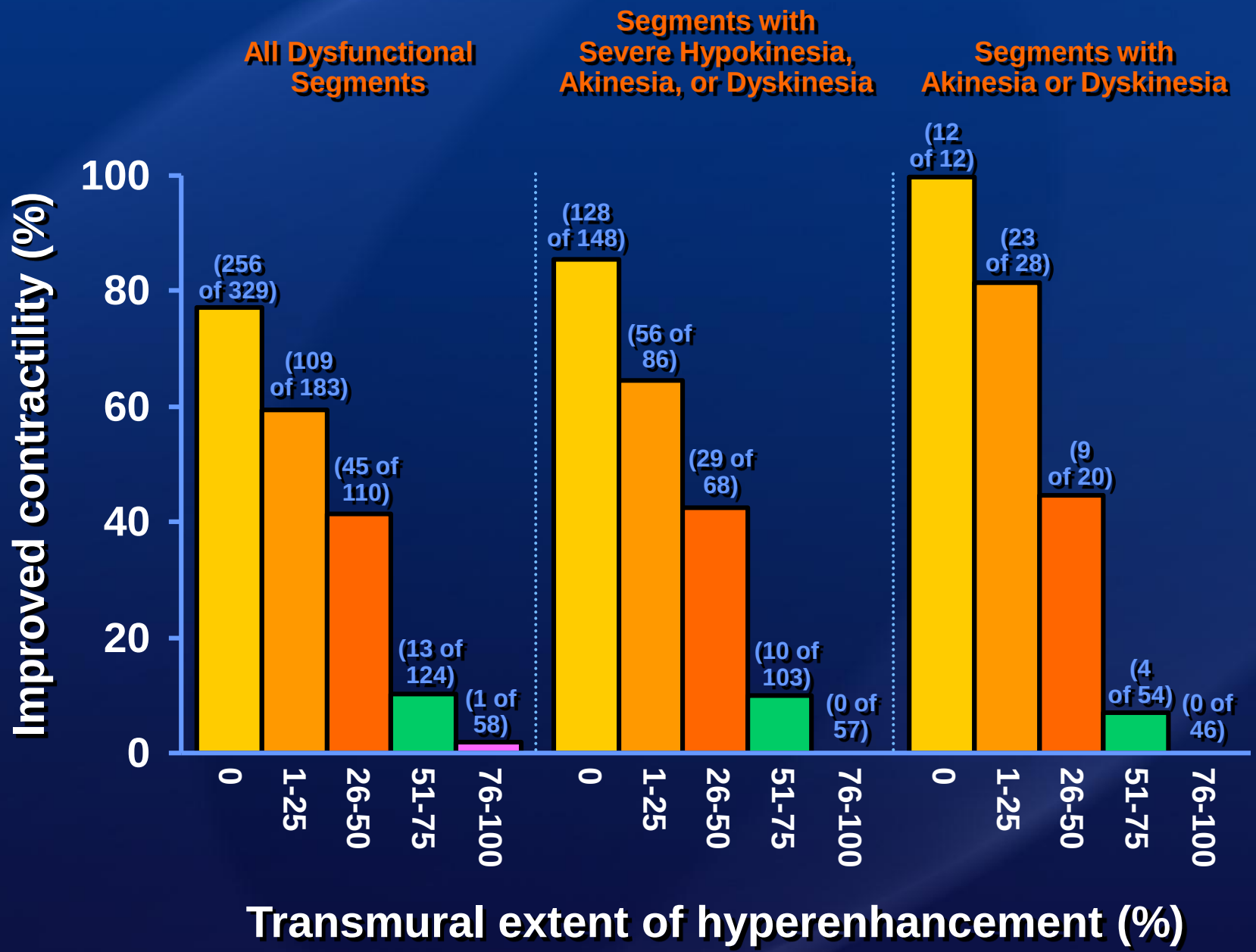

R. Kim et al NEJM 2000

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Mayo Imaging Project for STEMI patients Echocardiography vs Cardiac MRI

- Consecutive STEMI patients (N=100)
- All received reperfusion therapy (PCI)
- Echo and cardiac MRI within 48 hours of PCI
- Echo for wall motion, volume, EF, diastolic Fxn
- Cardiac MRI for volume , EF, DE %

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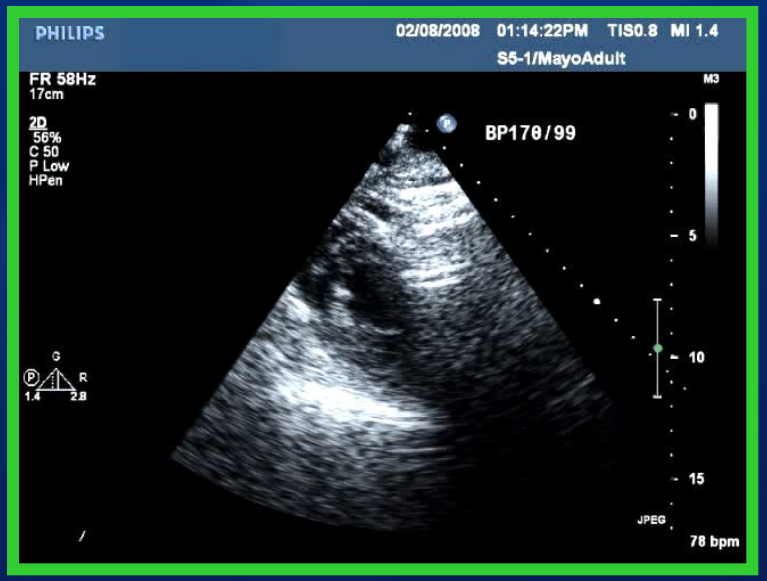
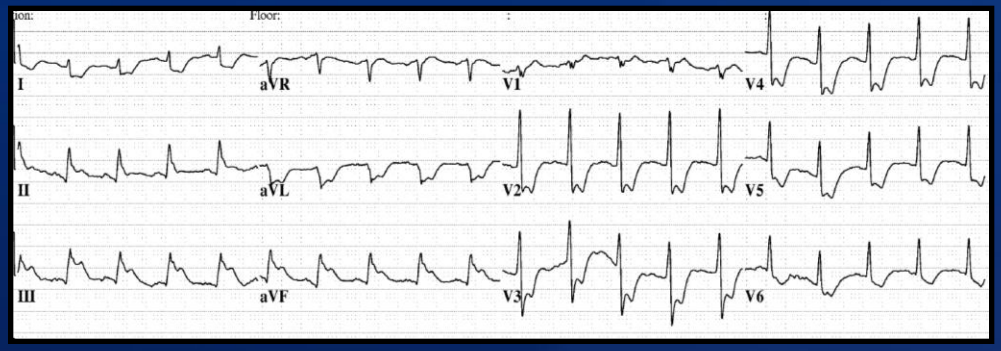
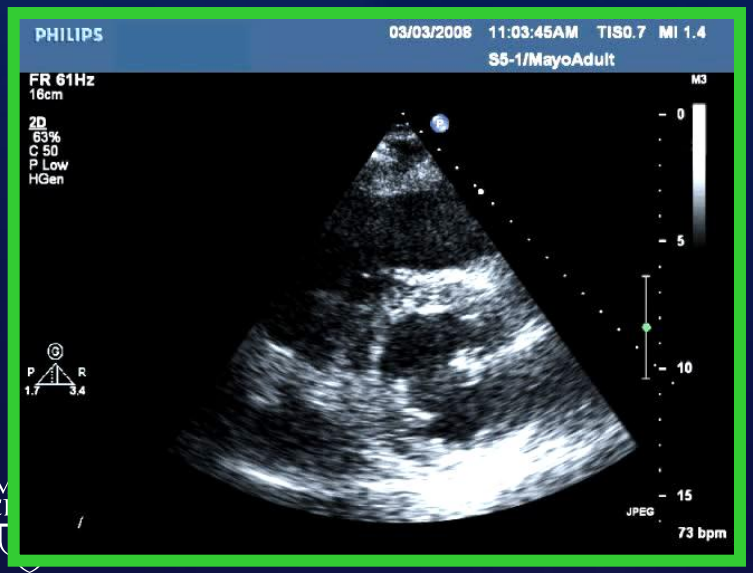
Two Patients with Inferior STEMI
Soon after PCI

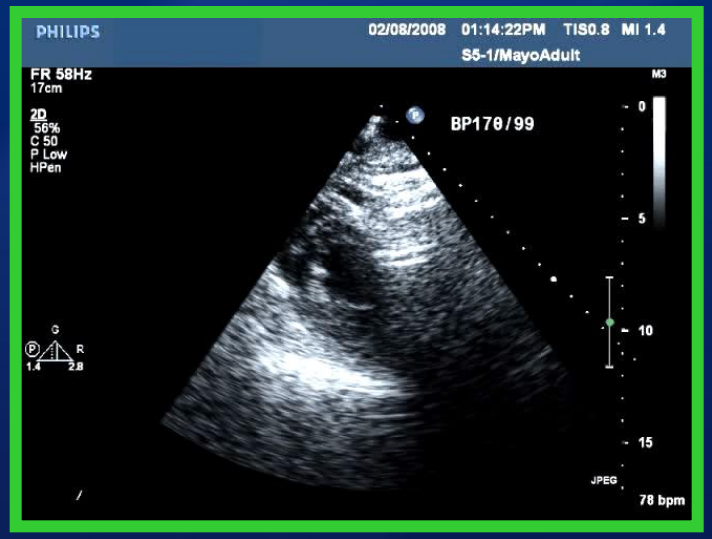


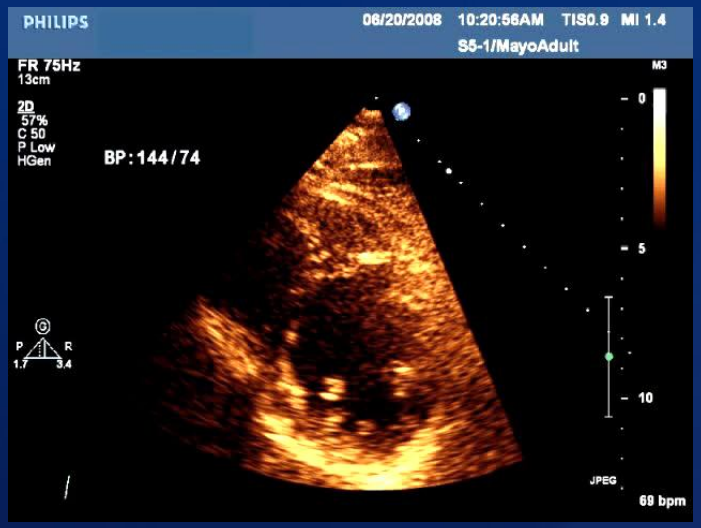




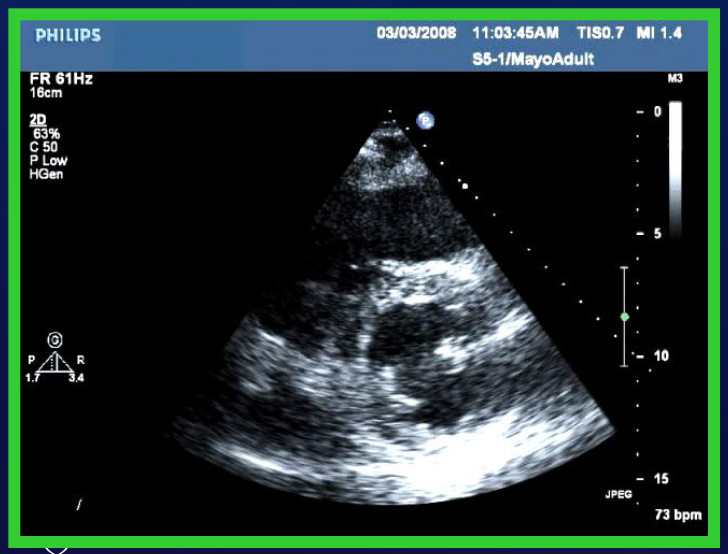
Two Patients with Inferior STEMI

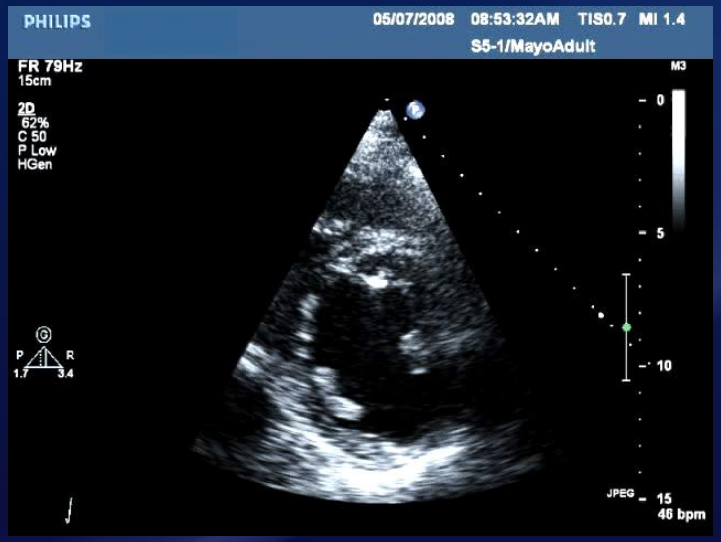
After PCI and 6 weeks Follow-up





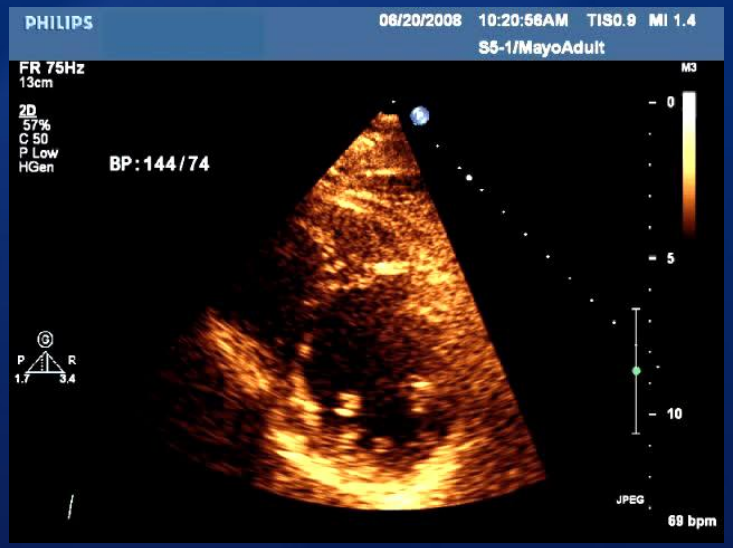
Improved

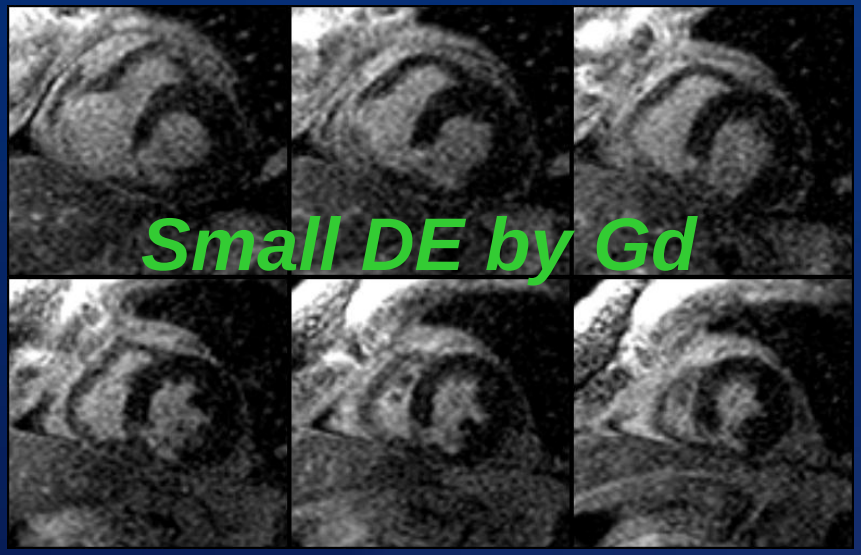


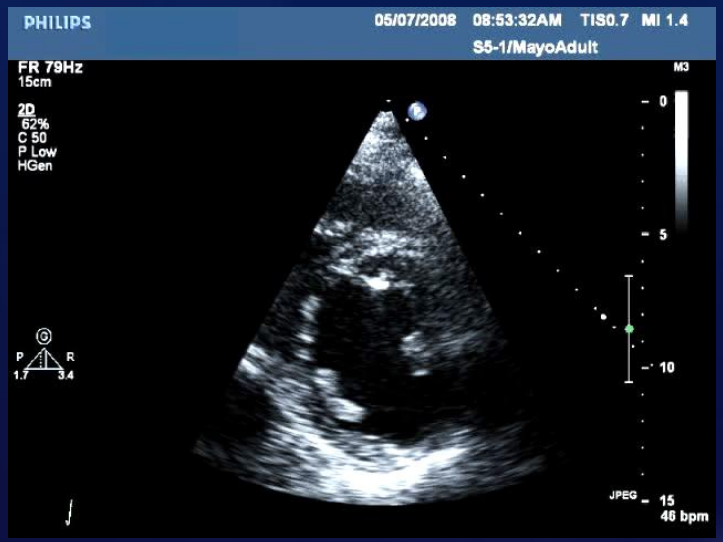


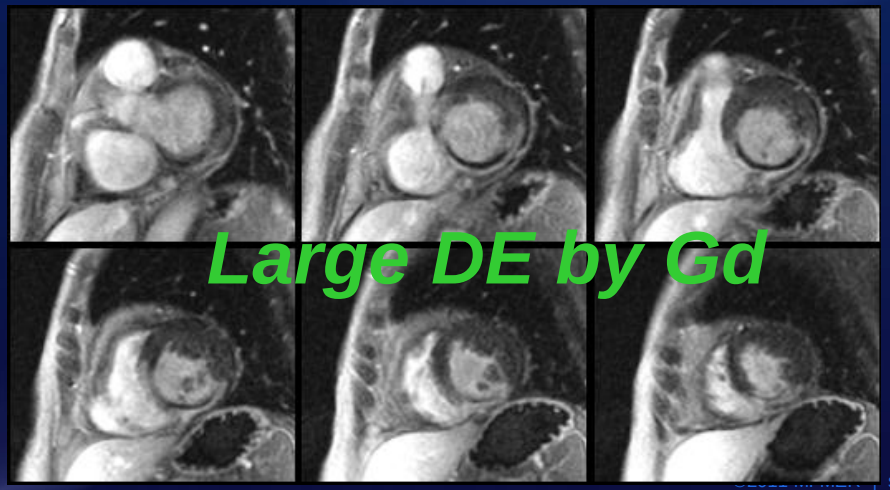
Remodeled

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









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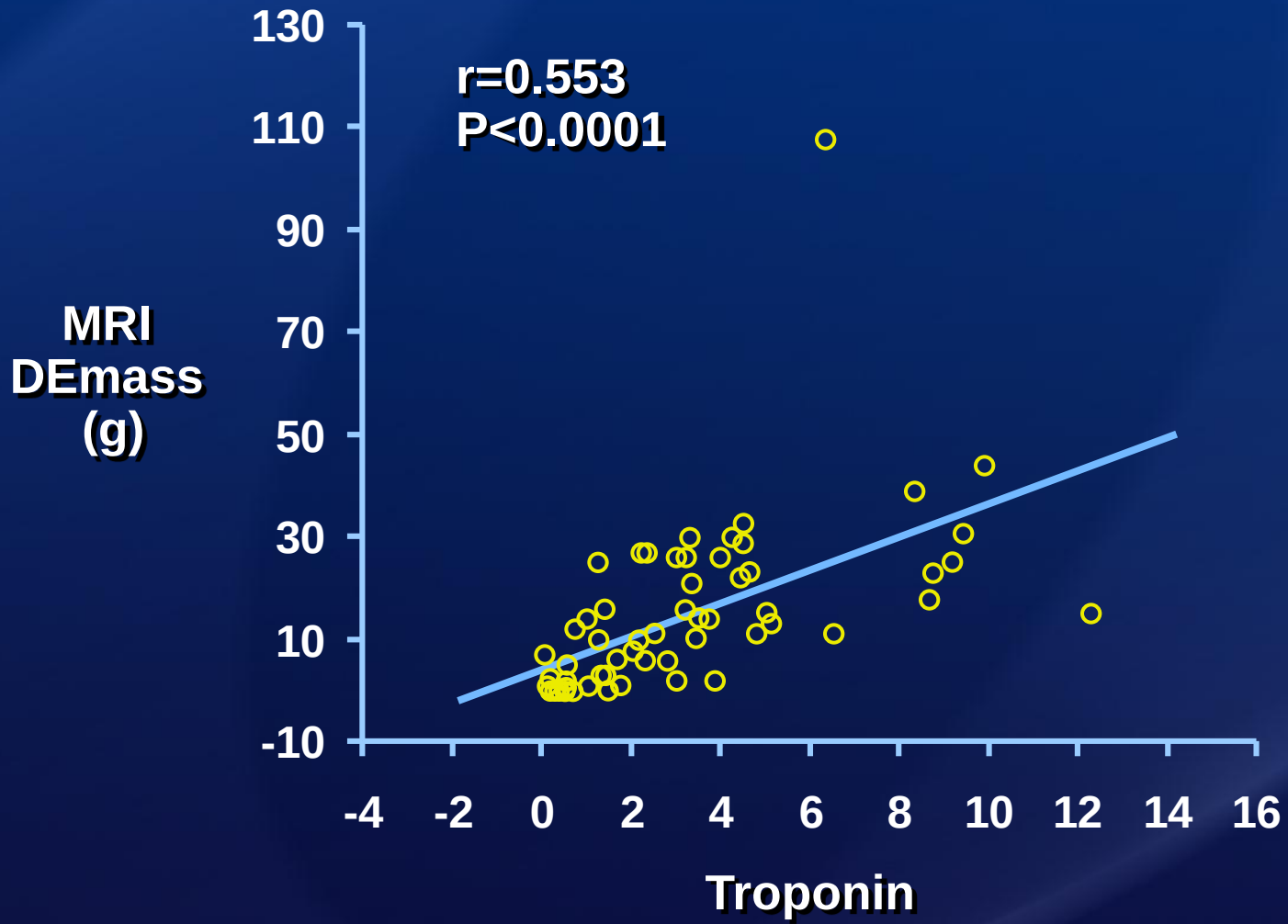
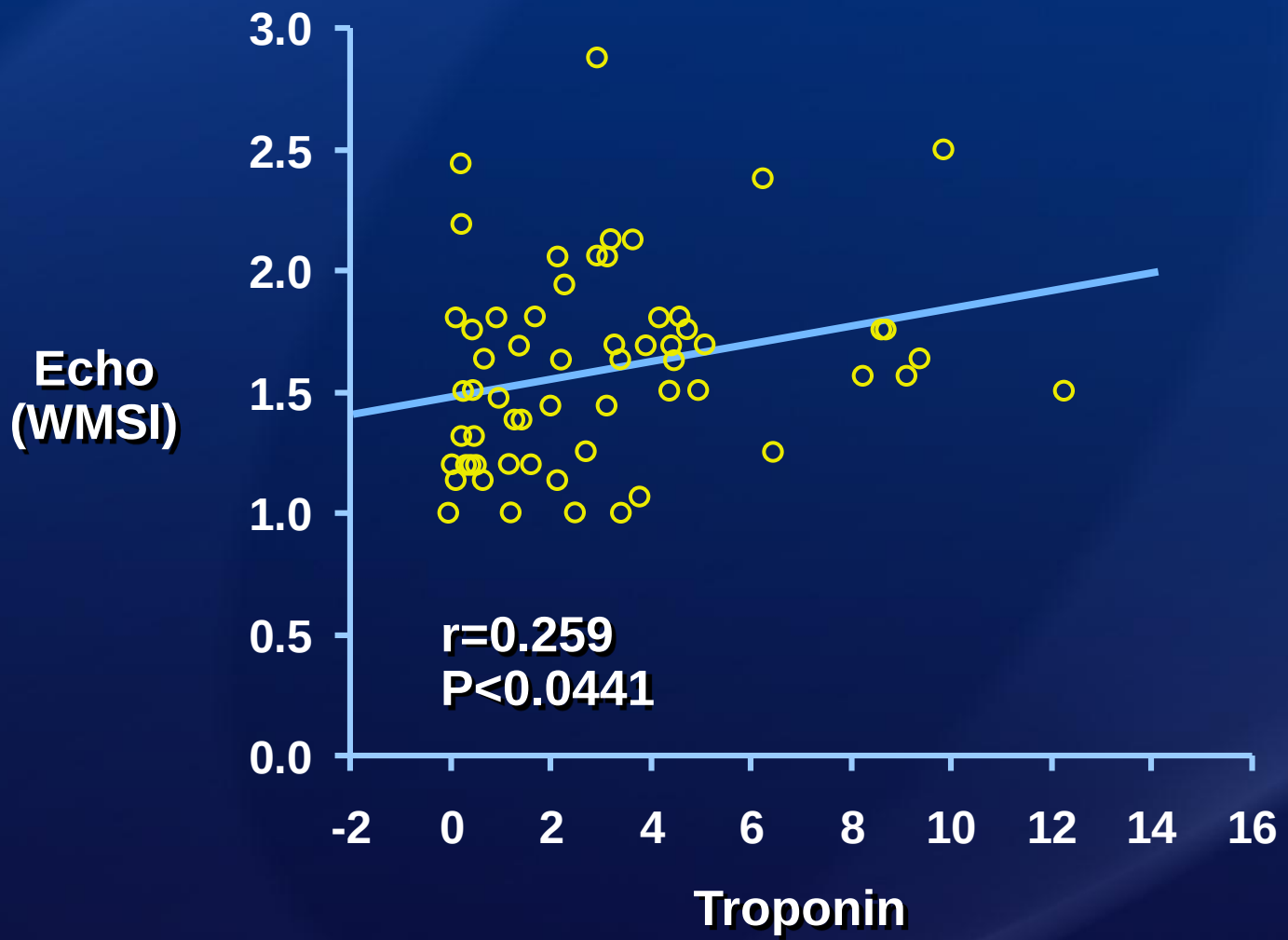
STEMI Imaging Project at MCR

MRI Infarct Mass vs Troponin



Couri, Bell, Oh et al in preparation

STEMI Imaging Project
Echo WMSI vs Troponin



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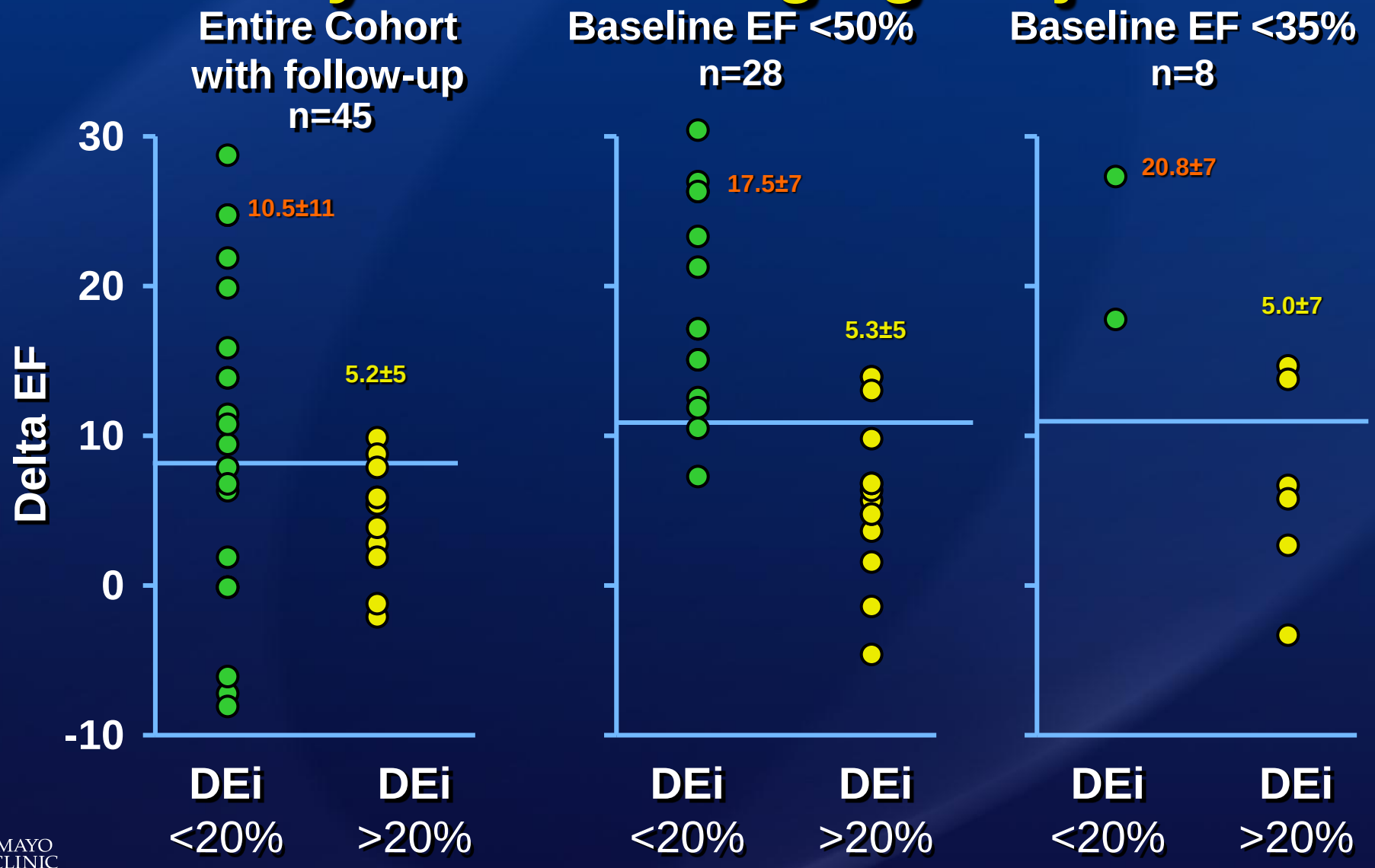
Change in LV EF (6-12 weeks)
Mayo STEMI Imaging Project



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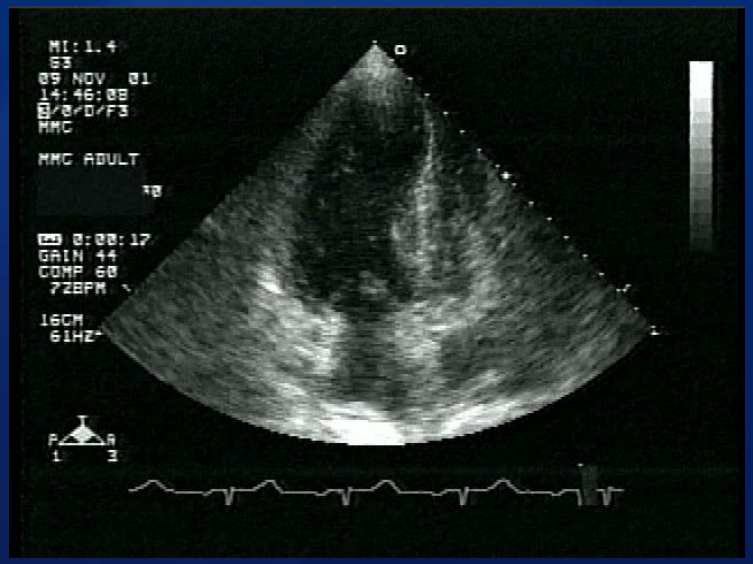
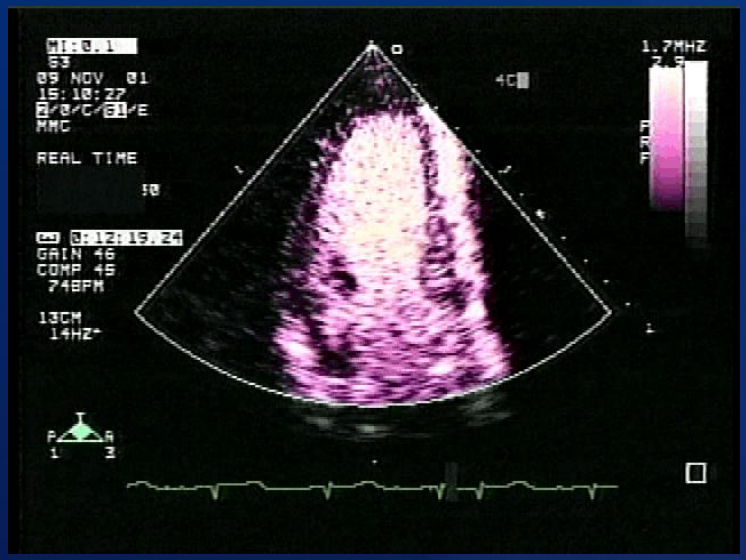
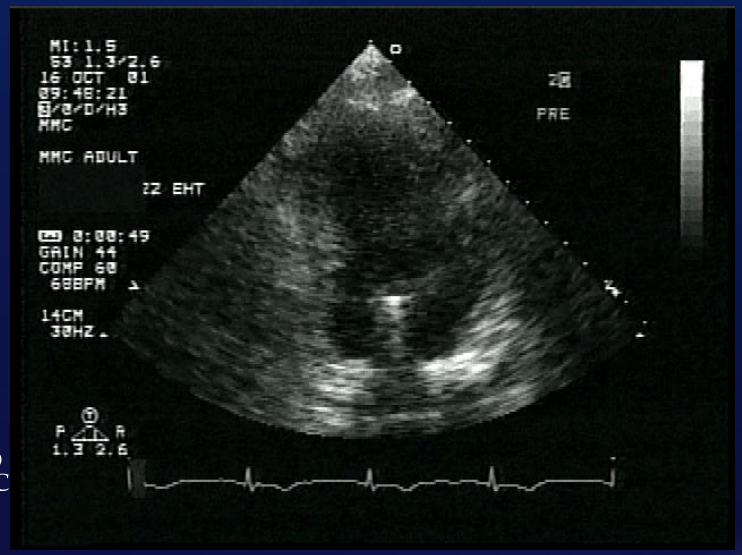
Contrast Perfusion Echo for Viability

2 patients with Anterior STEMI and PCI
Both have TIMI 3 Flow





Normal Perfusion



Perfusion Defect

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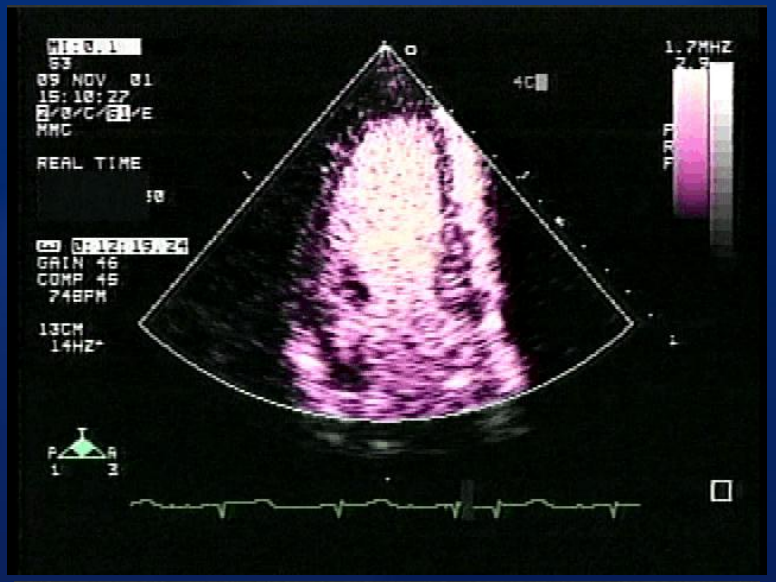
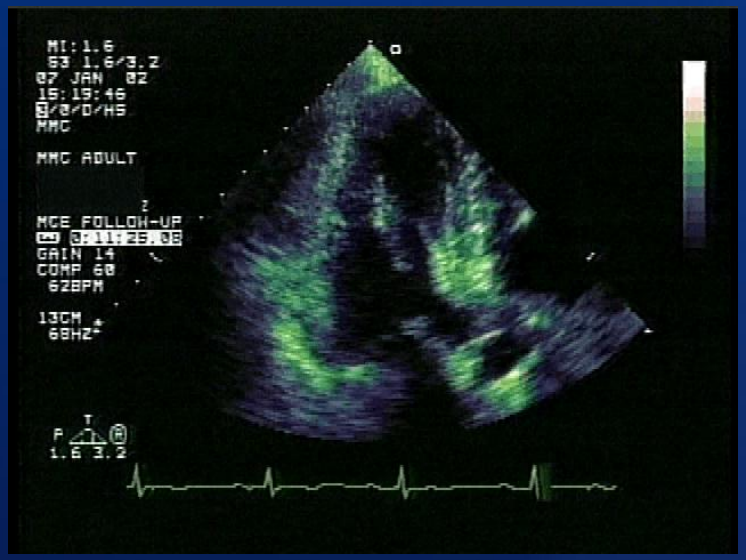
6 weeks later

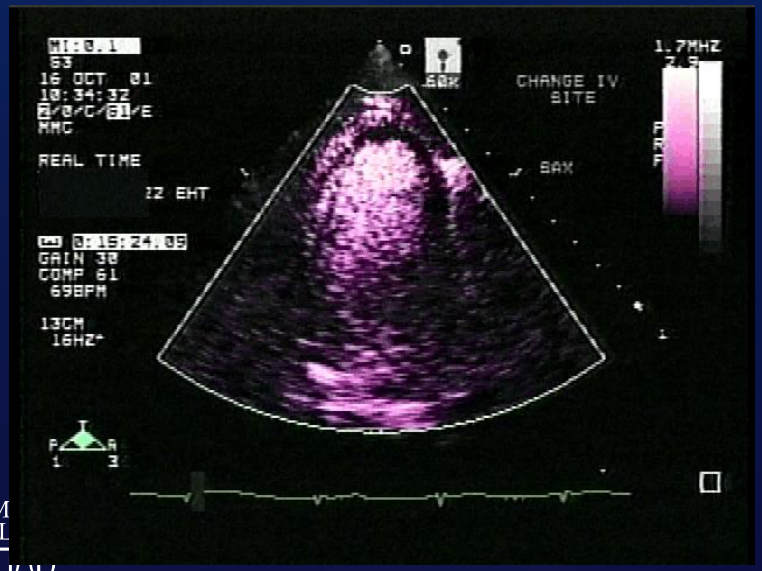
2 patients with Anterior STEMI and PCI

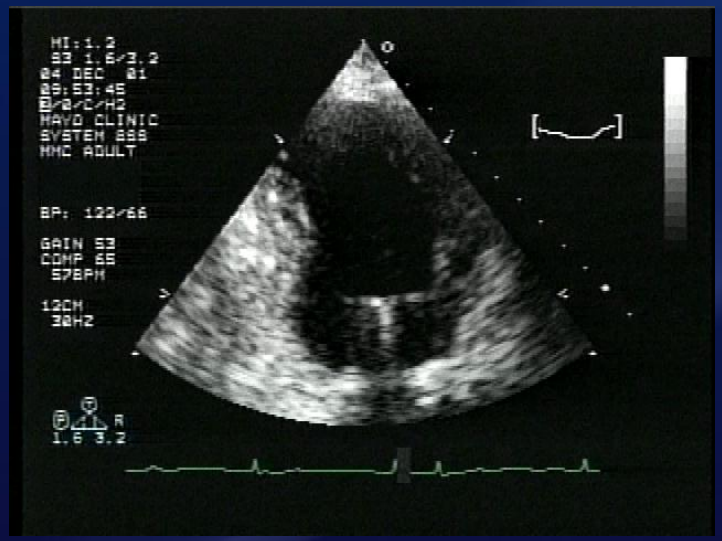




Normal Perfusion

Recovered



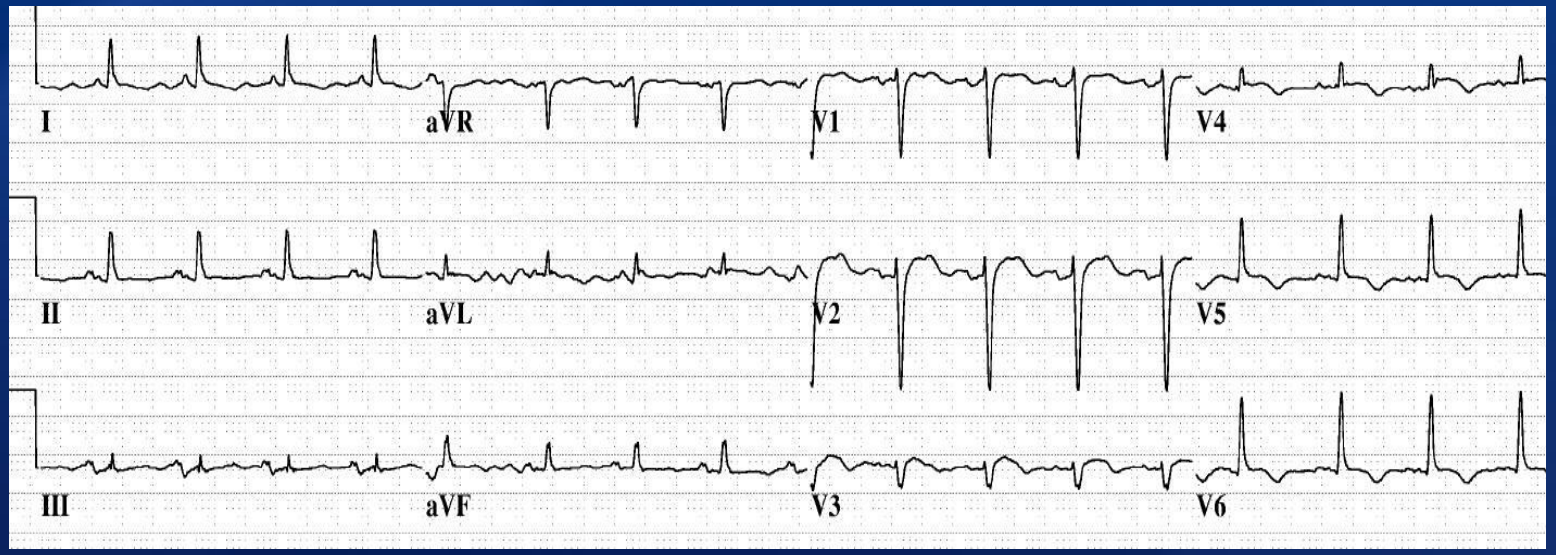


Perfusion Defect

Remodeled

83 year old woman

Pulmonary Edema and shock after Shoulder Surgery



Troponin T 1.49 ng/ml
Creatinine 2.6 mg %

What will be your next step in management?

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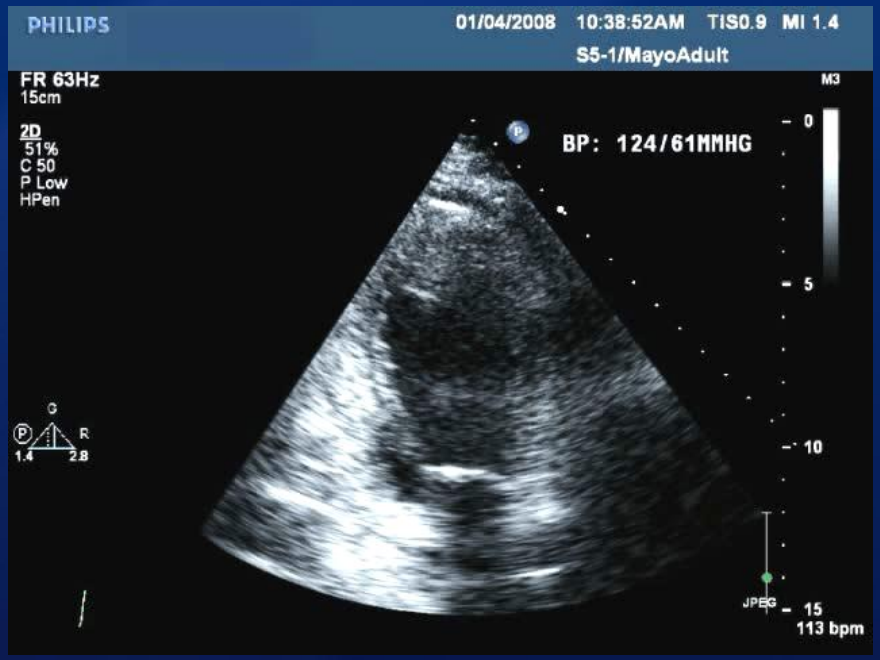
83 year old woman
Pulmonary Edema after Shoulder Surgery



Is it apical ballooning?

Would you proceed with coronary angiogram?

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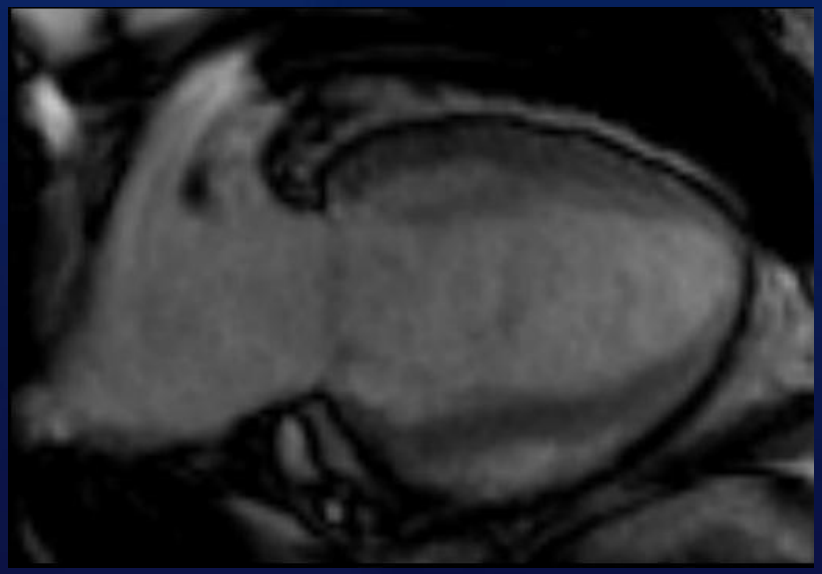
Cardiac MRI Follow up

Baseline



Delayed Enhancement

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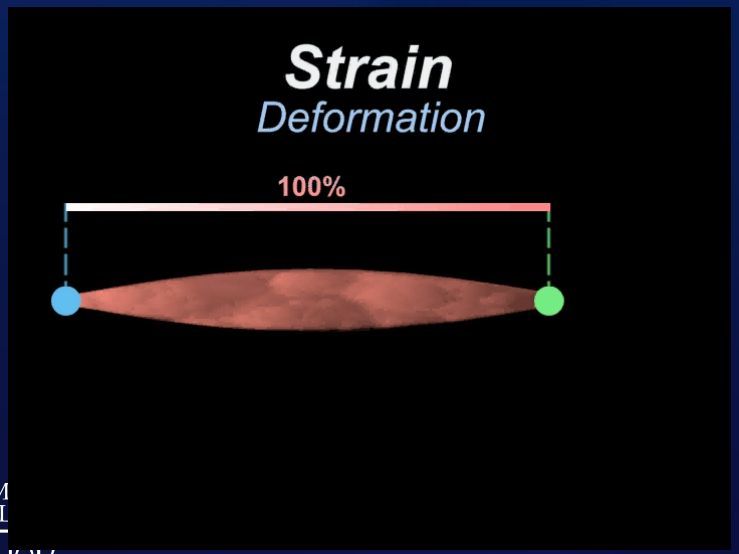
Strain Imaging

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

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



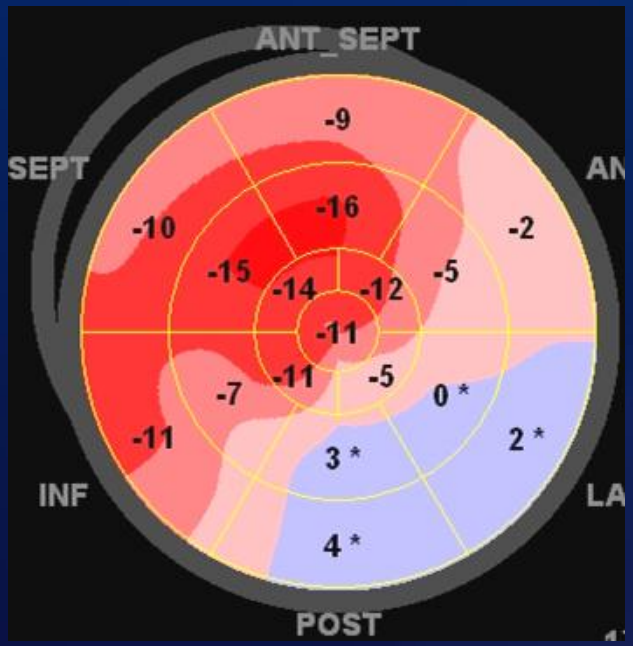
If 10 cm original length is shortened to 7.5 cm, strain is (-) 25 %.

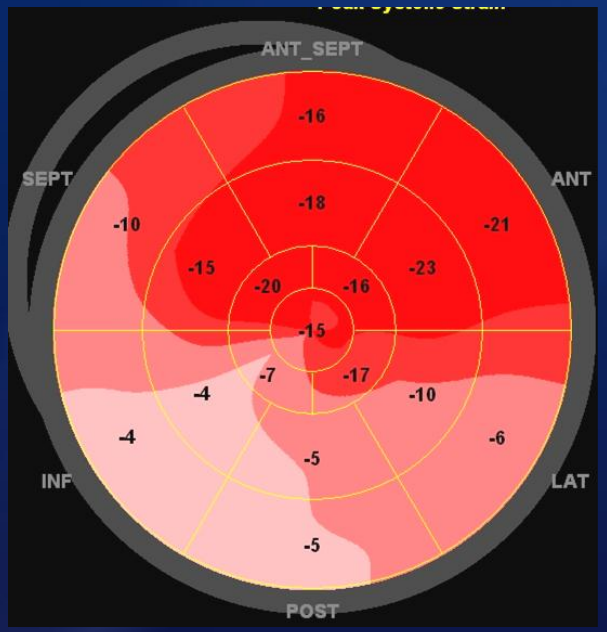
Normal strain is > 20 % shortening (-).

Strain Imaging for Wall Motion

+20% Lengthening

-20% Shortening



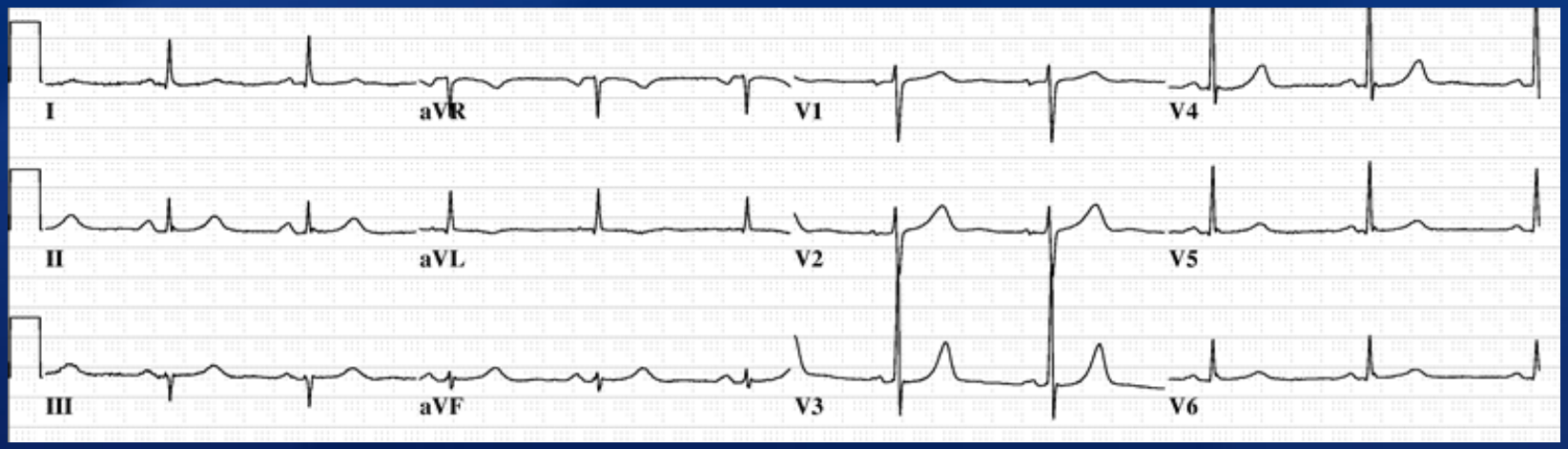


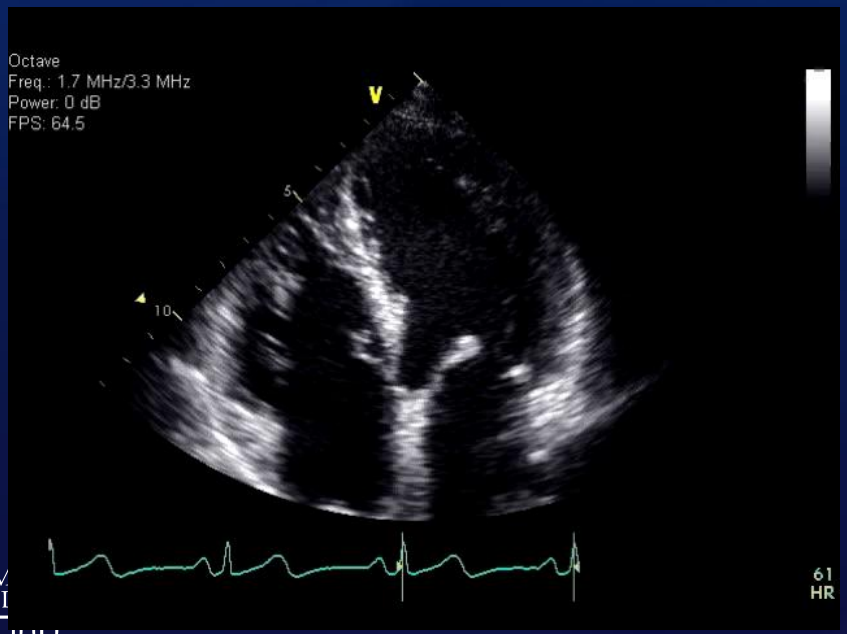
Anteroseptal MI (LAD)

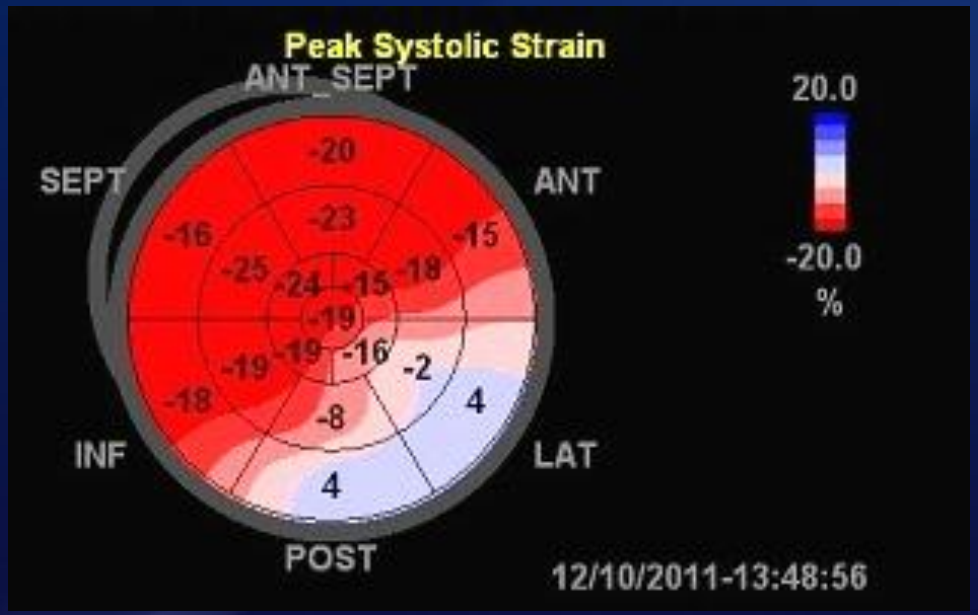
Inferolateral MI (LCX)

Inferior MI (RCA)

75 year old woman with chest pain
Oct 12, 2011







Longitudinal and Circumferential SR, LV Remodeling, and Prognosis After MI

- The VALIANT (Valsartan in Acute Myocardial Infarction Trial) Echo study enrolled 603 patients with LV dysfunction, heart failure, or both 5 days after MI.

J Am Coll Cardiol 2010;56:1812–22

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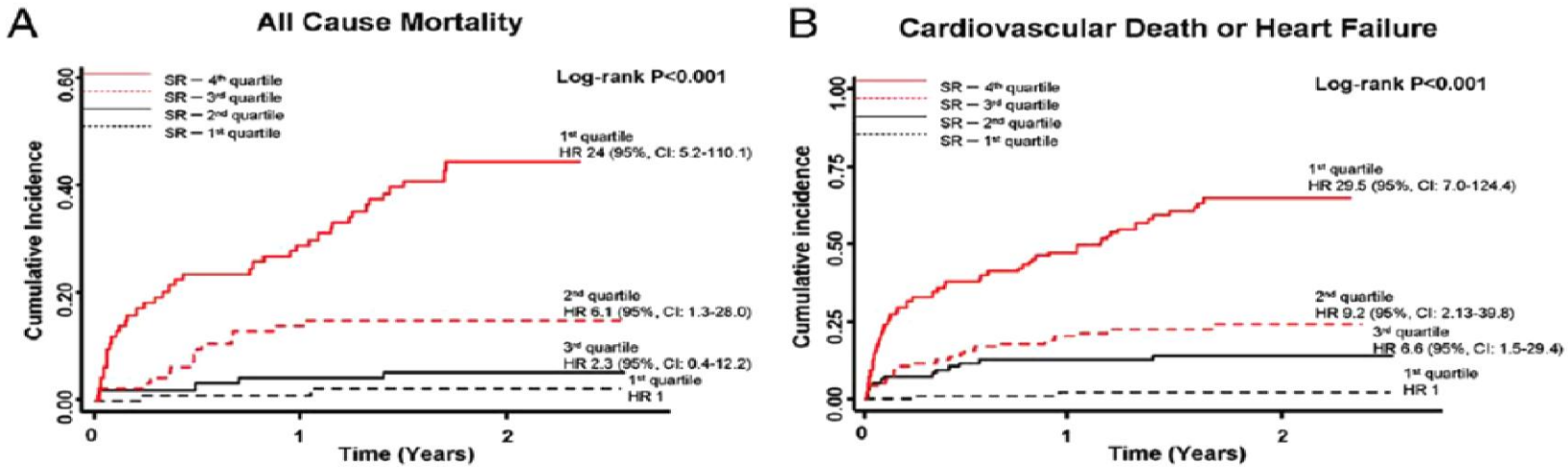
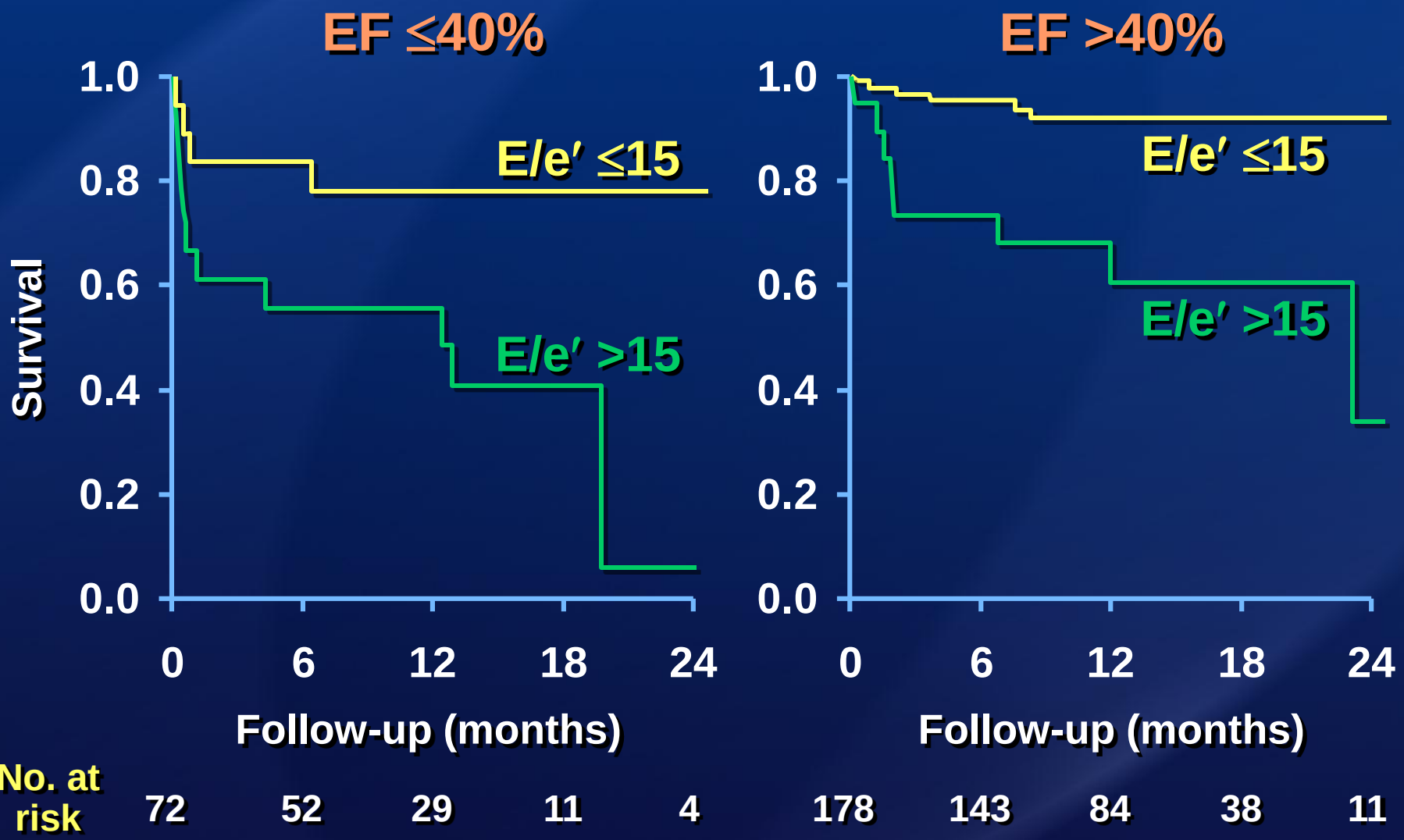
VALIANT Trial



J Am Coll Cardiol 2010;56:1812–22

Survival of Patients with Acute MI

Prognosis



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

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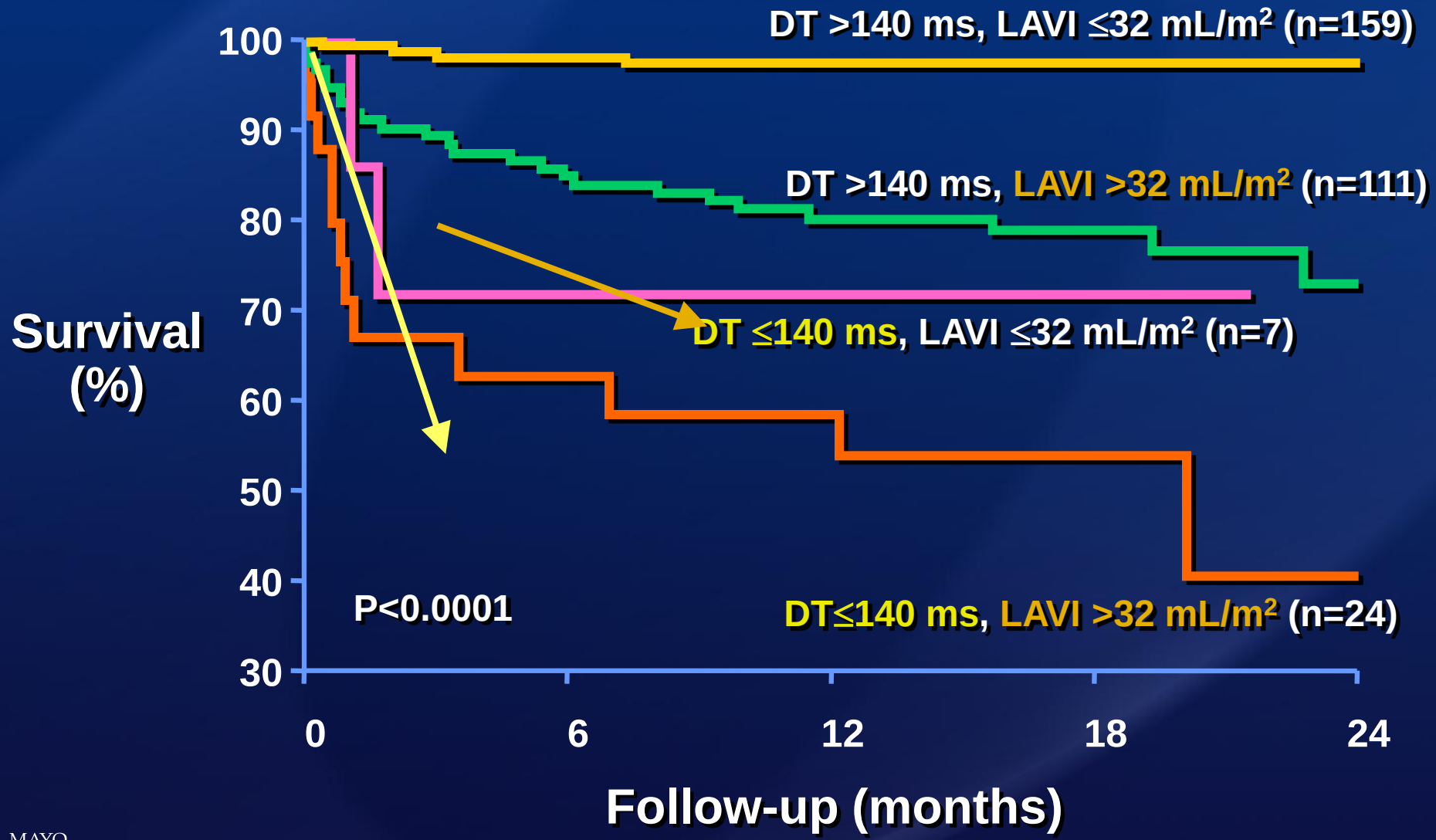
Survival after AMI

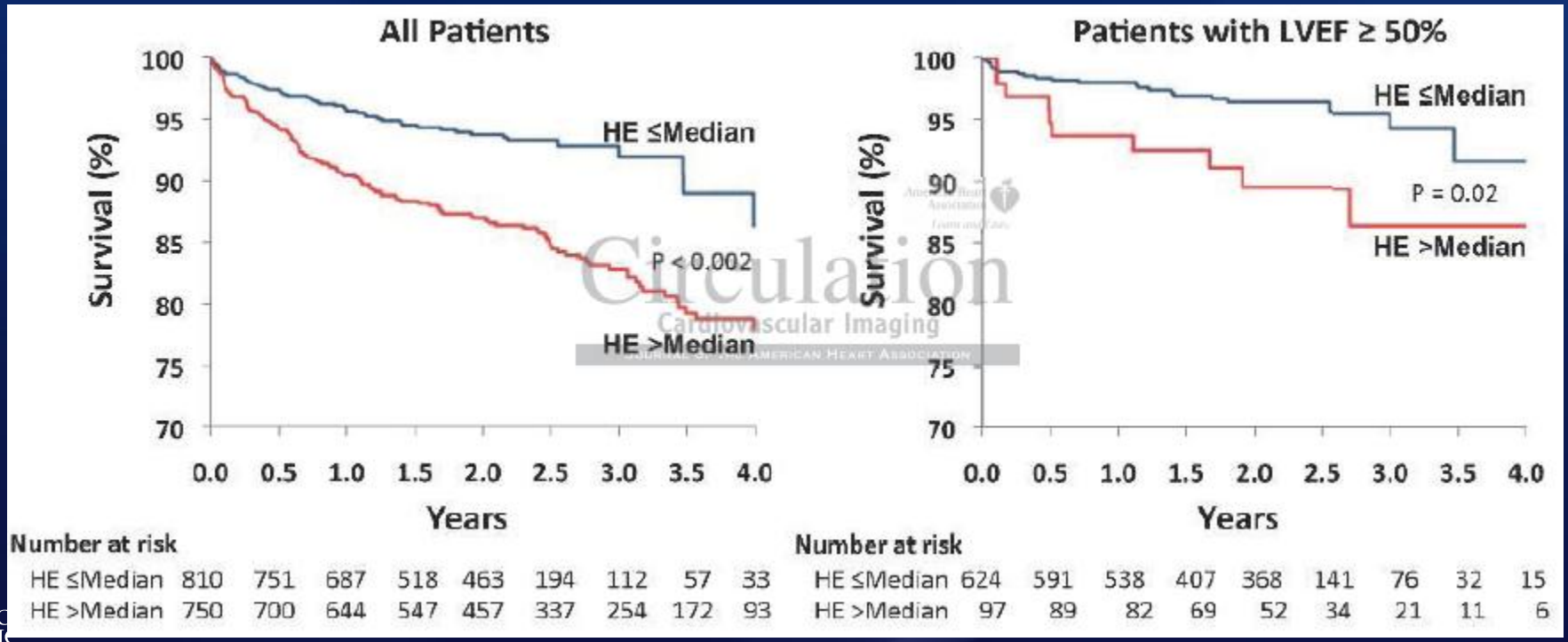
Prognostic Role of DT and LAVI



Moller, Oh, Pellikka et al Circulation 2003

Prognostic Value of Routine Cardiac MRI An International Multicenter Study

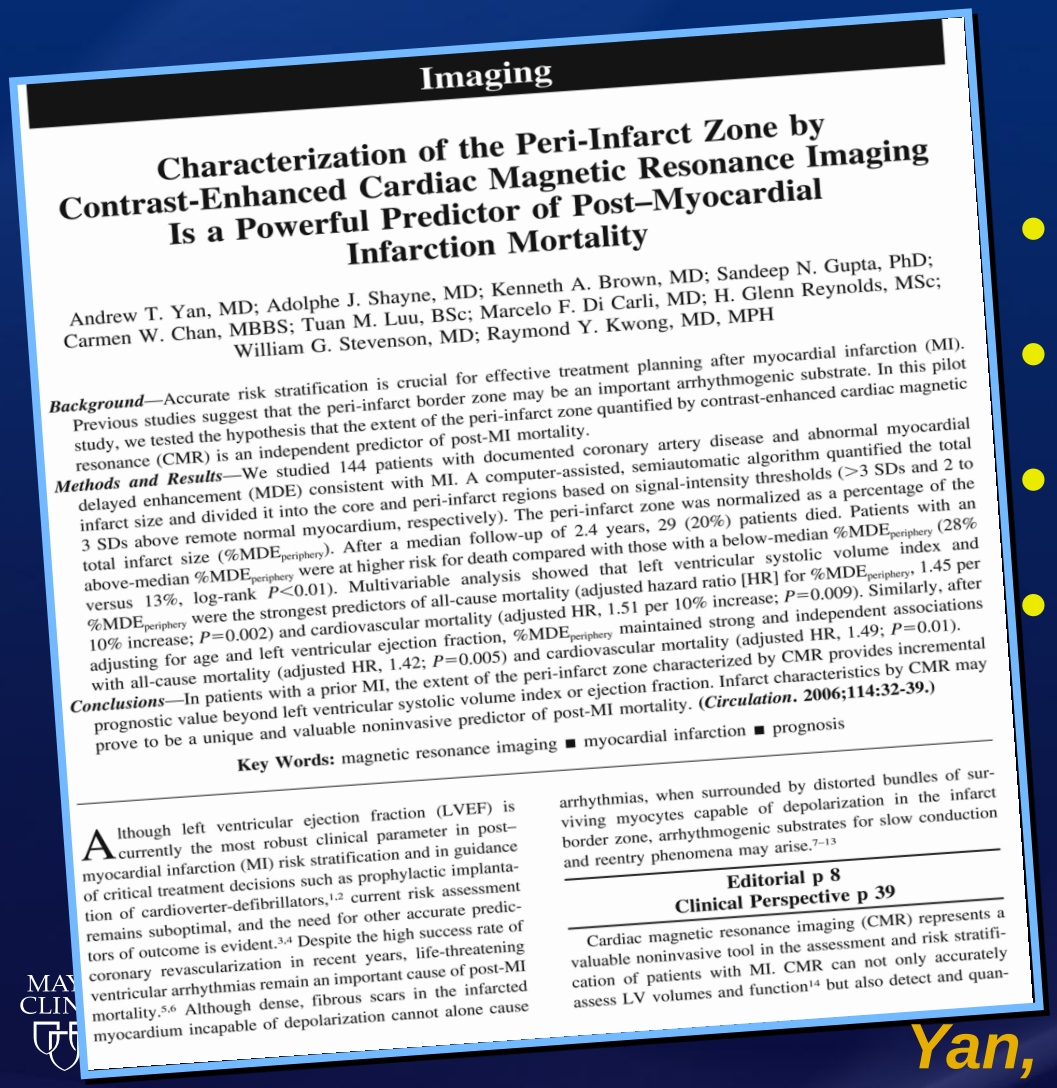
- 1049 / 1560 patients had DE (77 had recent MI)
- 2.4 year Follow-up
- Age, LVEF, and HE



Klem I, Kim R et al Circulation CV Imaging 2011 e-pub

Post MI Mortality

Peri-infarct zone by Cardiac MRI



Imaging

Characterization of the Peri-Infarct Zone by Contrast-Enhanced Cardiac Magnetic Resonance Imaging Is a Powerful Predictor of Post–Myocardial Infarction Mortality

Andrew T. Yan, MD; Adolphe J. Shayne, MD; Kenneth A. Brown, MD; Sandeep N. Gupta, PhD; Carmen W. Chan, MBBS; Tuan M. Luu, BSc; Marcelo F. Di Carli, MD; H. Glenn Reynolds, MSc; William G. Stevenson, MD; Raymond Y. Kwong, MD, MPH

Background—Accurate risk stratification is crucial for effective treatment planning after myocardial infarction (MI). Previous studies suggest that the peri-infarct border zone may be an important arrhythmogenic substrate. In this pilot study, we tested the hypothesis that the extent of the peri-infarct zone quantified by contrast-enhanced cardiac magnetic resonance (CMR) is an independent predictor of post-MI mortality.

Methods and Results—We studied 144 patients with documented coronary artery disease and abnormal myocardial delayed enhancement (MDE) consistent with MI. A computer-assisted, semiautomatic algorithm quantified the total infarct size and divided it into the core and peri-infarct regions based on signal-intensity thresholds (>3 SDs and 2 to 3 SDs above remote normal myocardium, respectively). The peri-infarct zone was normalized as a percentage of the total infarct size (%$MDE_{periphery}$). After a median follow-up of 2.4 years, 29 (20%) patients died. Patients with an above-median %$MDE_{periphery}$ were at higher risk for death compared with those with a below-median %$MDE_{periphery}$ (28% versus 13%, log-rank $P<0.01$). Multivariable analysis showed that left ventricular systolic volume index and %$MDE_{periphery}$ were the strongest predictors of all-cause mortality (adjusted hazard ratio [HR] for %$MDE_{periphery}$, 1.45 per 10% increase; $P=0.002$) and cardiovascular mortality (adjusted HR, 1.51 per 10% increase; $P=0.009$). Similarly, after adjusting for age and left ventricular ejection fraction, %$MDE_{periphery}$ maintained strong and independent associations with all-cause mortality (adjusted HR, 1.42; $P=0.005$) and cardiovascular mortality (adjusted HR, 1.49; $P=0.01$).

Conclusions—In patients with a prior MI, the extent of the peri-infarct zone characterized by CMR provides incremental prognostic value beyond left ventricular systolic volume index or ejection fraction. Infarct characteristics by CMR may prove to be a unique and valuable noninvasive predictor of post-MI mortality. **(*Circulation*. 2006;114:32-39.)**

Key Words: magnetic resonance imaging ■ myocardial infarction ■ prognosis

Although left ventricular ejection fraction (LVEF) is currently the most robust clinical parameter in post–myocardial infarction (MI) risk stratification and in guidance of critical treatment decisions such as prophylactic implantation of cardioverter-defibrillators,[1,2] current risk assessment remains suboptimal, and the need for other accurate predictors of outcome is evident.[3,4] Despite the high success rate of coronary revascularization in recent years, life-threatening ventricular arrhythmias remain an important cause of post-MI mortality.[5,6] Although dense, fibrous scars in the infarcted myocardium incapable of depolarization cannot alone cause arrhythmias, when surrounded by distorted bundles of surviving myocytes capable of depolarization in the infarct border zone, arrhythmogenic substrates for slow conduction and reentry phenomena may arise.[7–13]

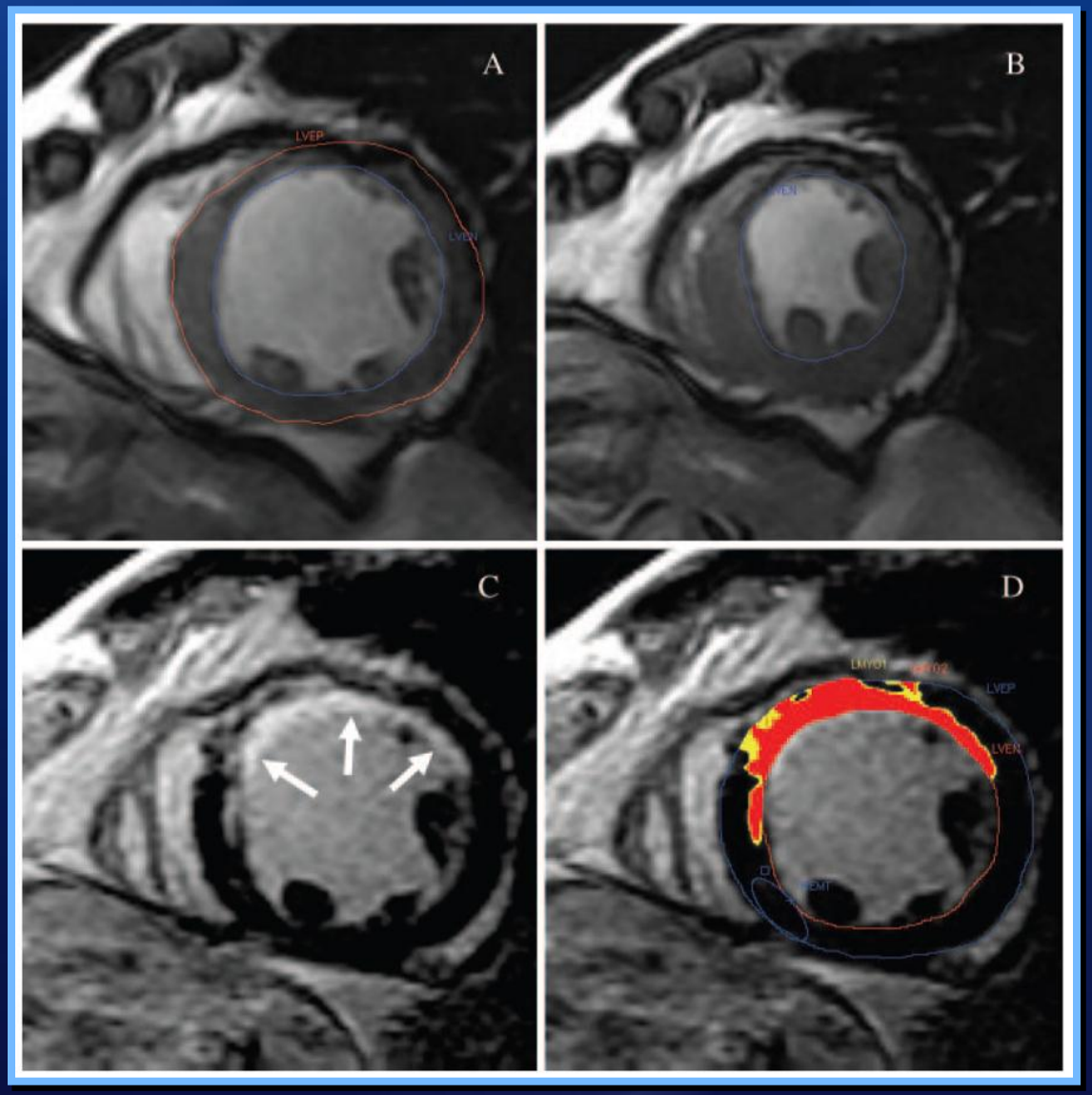
Editorial p 8
Clinical Perspective p 39

Cardiac magnetic resonance imaging (CMR) represents a valuable noninvasive tool in the assessment and risk stratification of patients with MI. CMR can not only accurately assess LV volumes and function[14] but also detect and quan-

- 144 pts with MDE
- Infarct sig int >3SD
- Peri Infarct 2-3 SD
- 29 (20%) died after 2.4 year follow up

Yan, Kwong et al Circ July 2006

Cardiac MRI after MI



Infarct Core

Peri-infarct zone

Yan et al:
Circ 114:32, 2006

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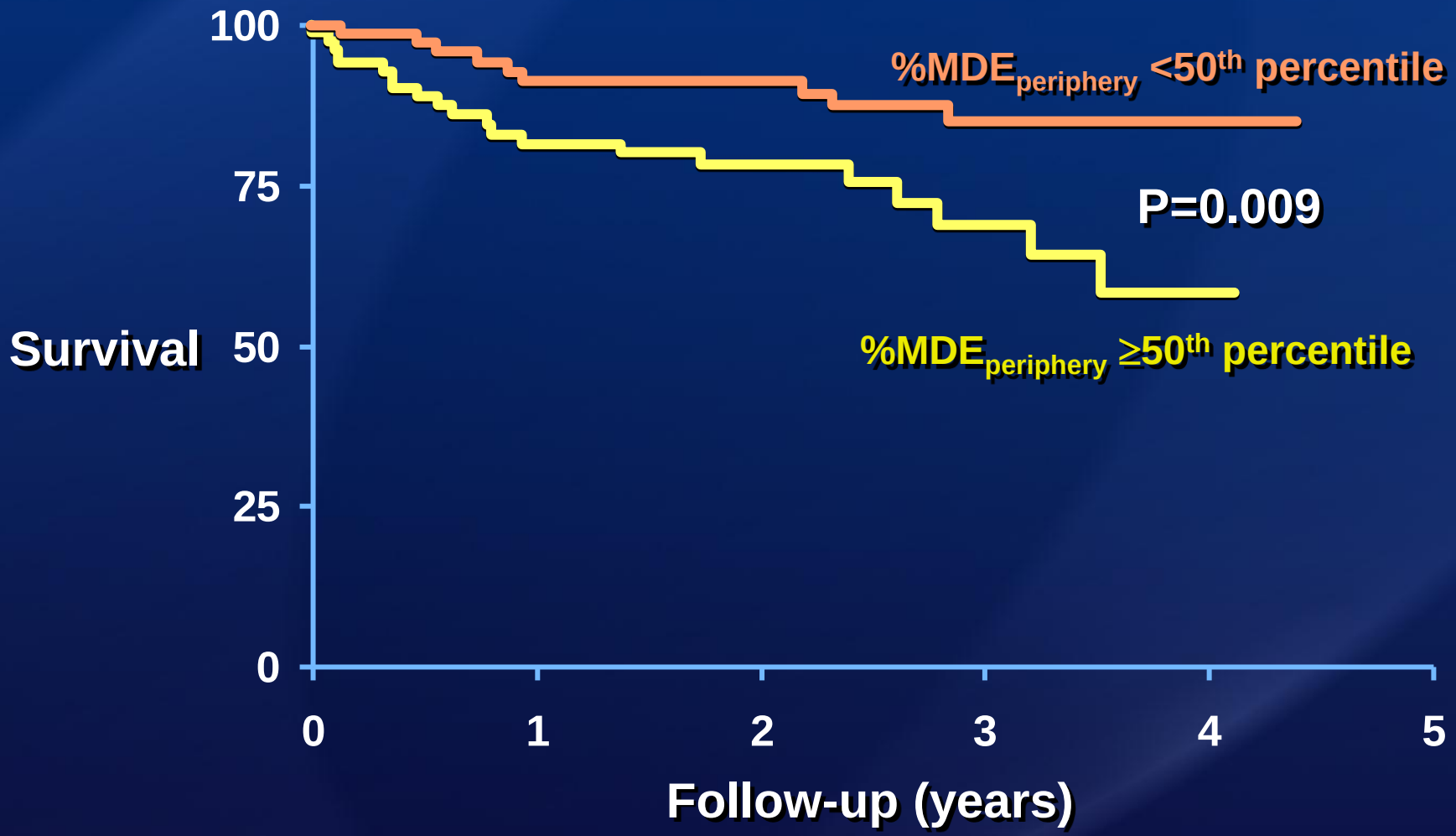
Kaplan-Meier Survival Curves for All-Cause Mortality



Yan et al: Circ 114:32, 2006

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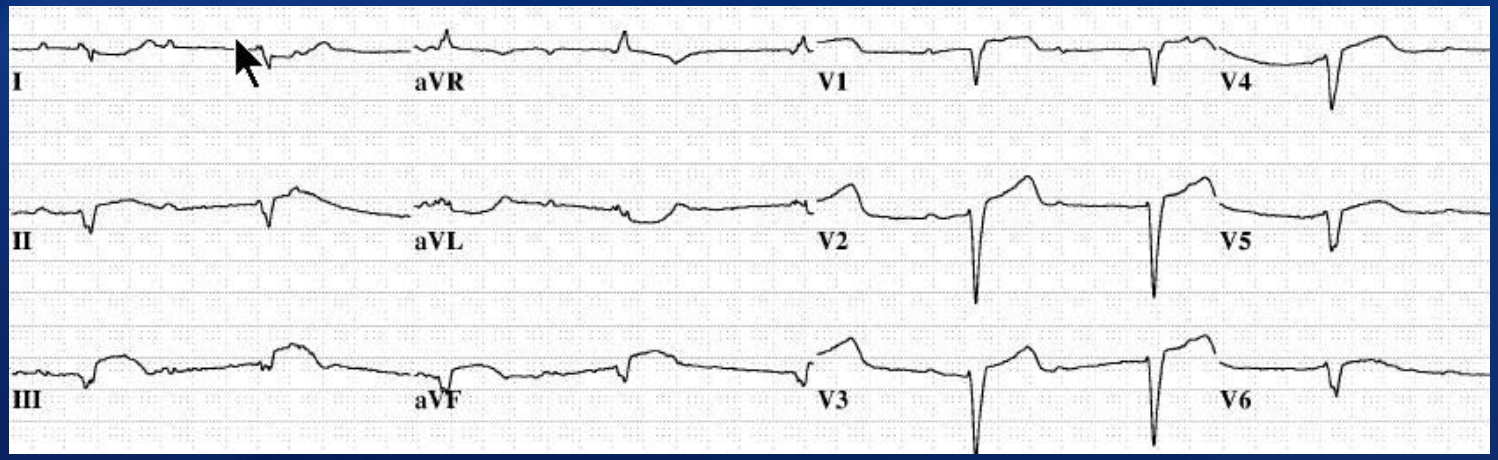
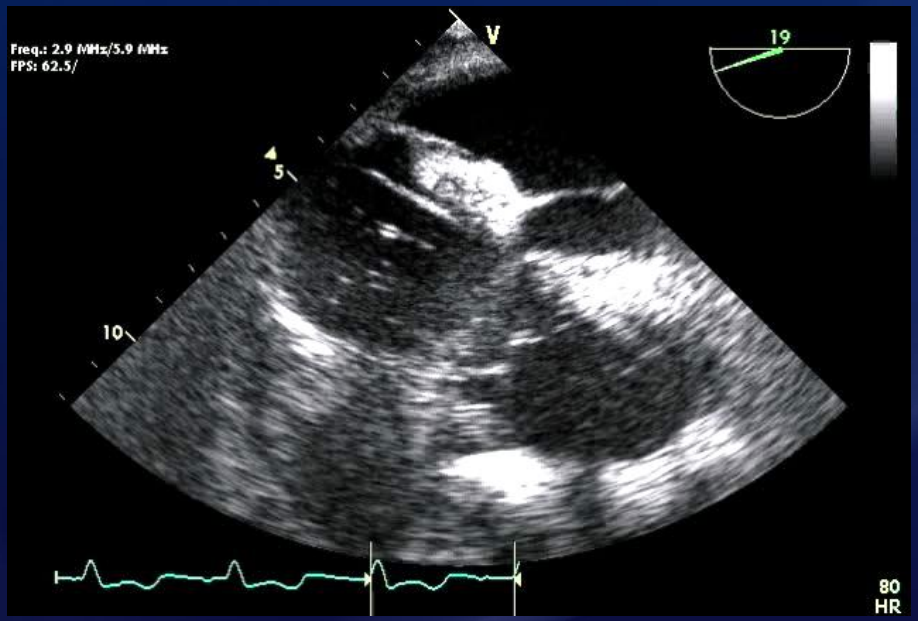
Normal Coronaries and STEMI Echocardiography





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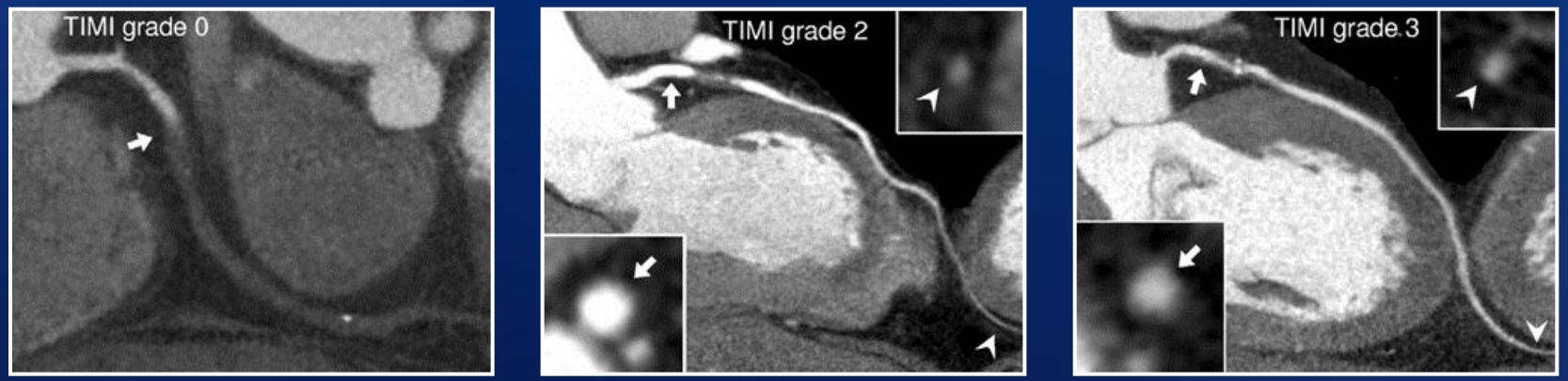
Curved Multiplanar CT Reformation and Short-Axis Cross-Sectional Views of Infarct-Related Arteries in Patients with TIMI Flow Grades 0, 2, and 3



Visualization of the IRA by 64-slice MDCT enables noninvasive differentiation of angiographic TIMI flow grade 3 from TIMI flow grade 2 coronary reperfusion during the acute phase in patients with STEMI. The sensitivity, specificity, and accuracy of a diagnosis of TIMI flow grade 3 on the basis of a CT number ratio of 0.54 were 92%, 97%, and 97%, respectively.

.

Yamashita et al: J Am Coll Cardiol Img 2011;4:141-9

MAYO CLINIC

Summary
Noninvasive Imaging after STEMI

- Echocardiography is still the most common imaging test which provides most clinically relevant information
- Main limitation of Echo is its inability to predict final infarct size unless we do myocardial contrast or strain imaging
- Cardiac MRI is the most robust imaging to provide infarct size, volume, and EF…Hence, prognosis
- Coronary CT has a limited use

MAYO CLINIC

Thanks for Listening !

JACC: CARDIOVASCULAR IMAGING
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DOI:10.1016/j.jcmg.2011.07.005

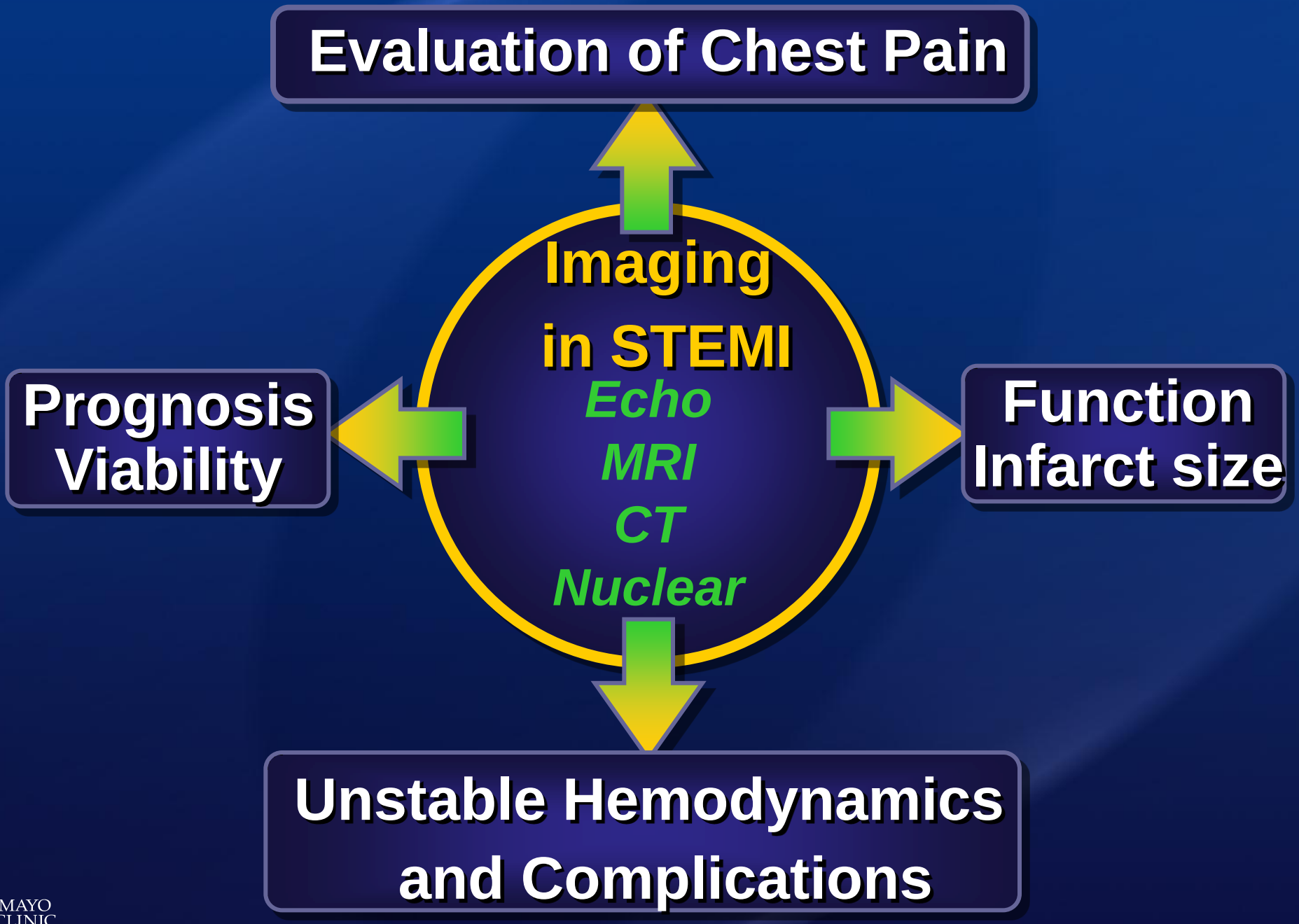
NEWS AND VIEWS

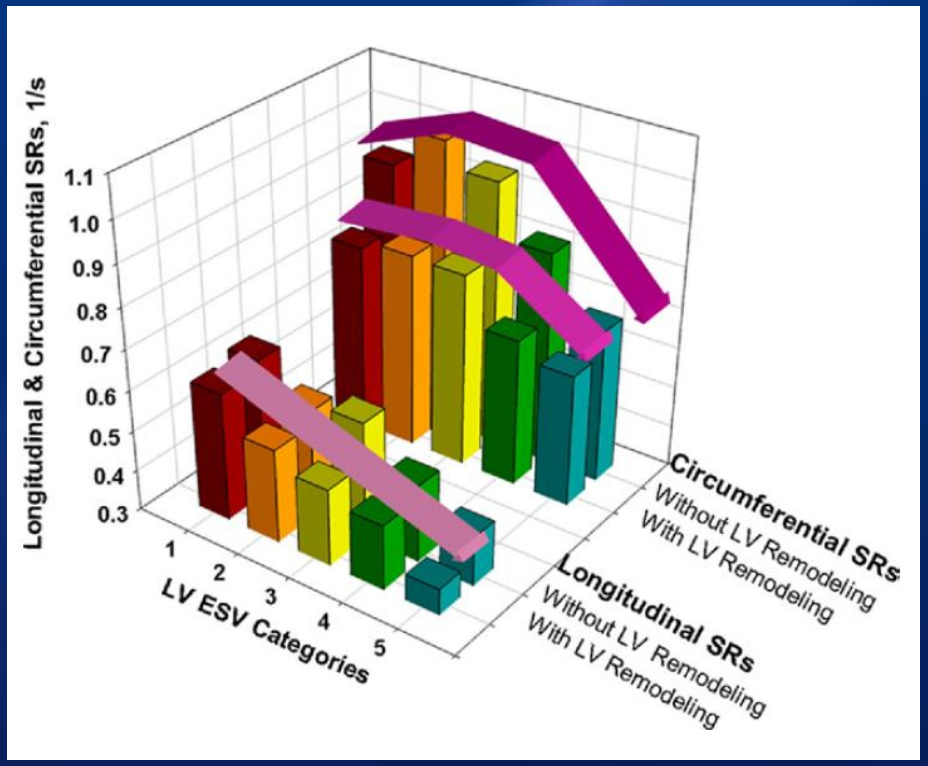
T2-Weighted Imaging to Assess Post-Infarct Myocardium at Risk

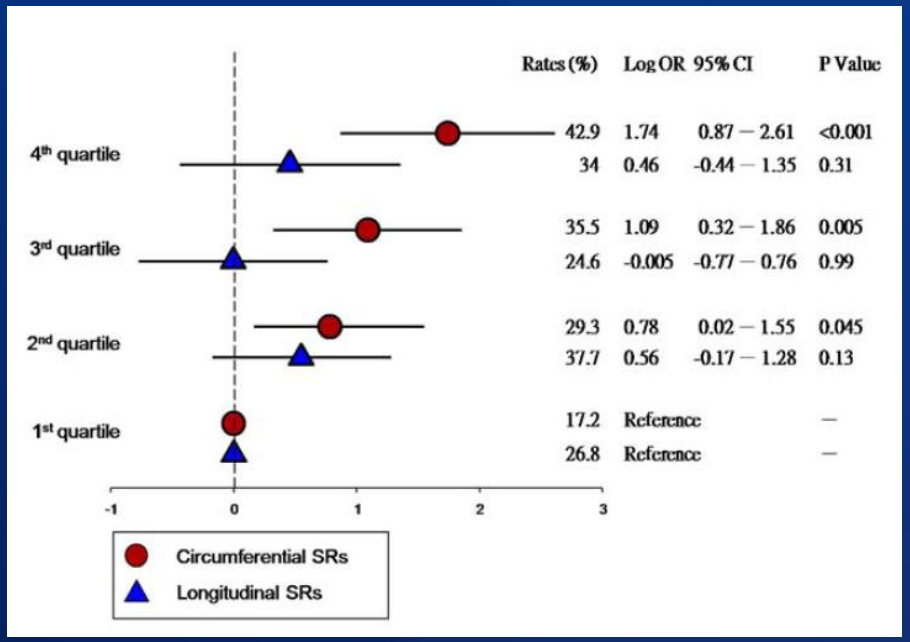
Matthias G. Friedrich, MD, Han W. Kim, MD, Raymond J. Kim, MD

Montreal, Quebec and Calgary, Alberta, Canada; and Durham, North Carolina

Section Editor: Christopher M. Kramer, MD


Evaluation of Chest Pain
Imaging in STEMI
Echo
MRI
CT
Nuclear
Prognosis Viability
Function Infarct size
Unstable Hemodynamics and Complications





Both longitudinal and circumferential SRs were independent predictors of outcomes after MI, whereas only circumferential SRs was predictive of remodeling, suggesting that preserved circumferential function might serve to restrain ventricular enlargement after MI

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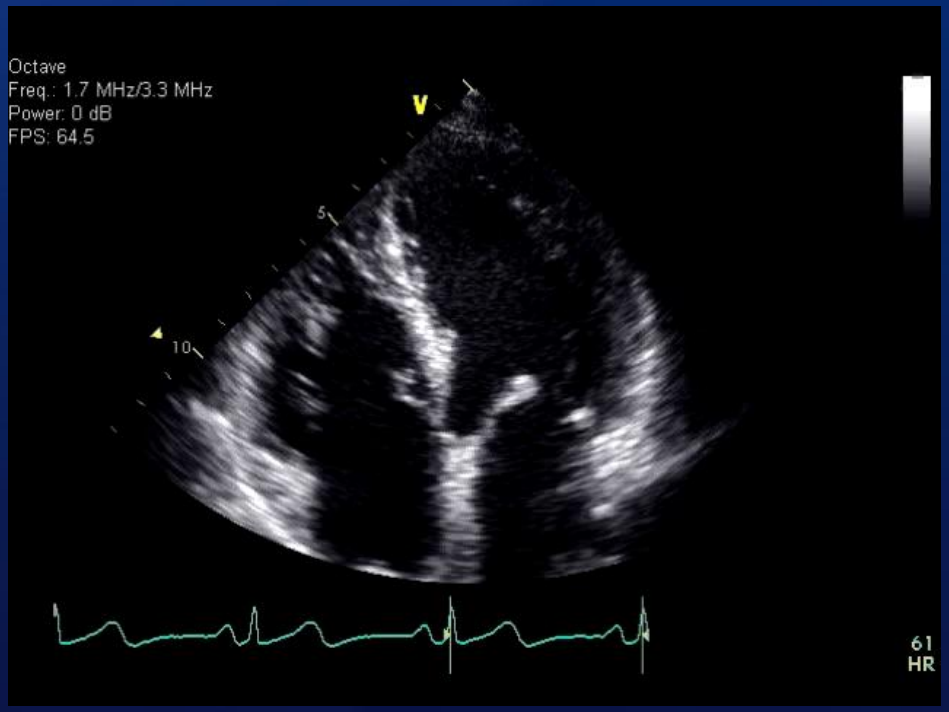
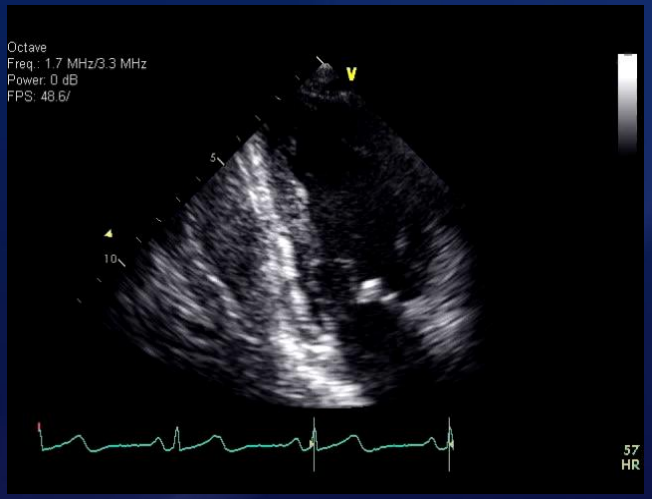
75 year old woman with chest pain
Normal ECG





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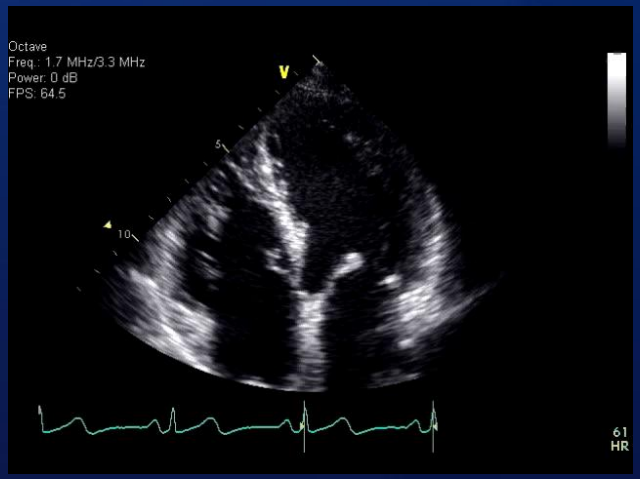
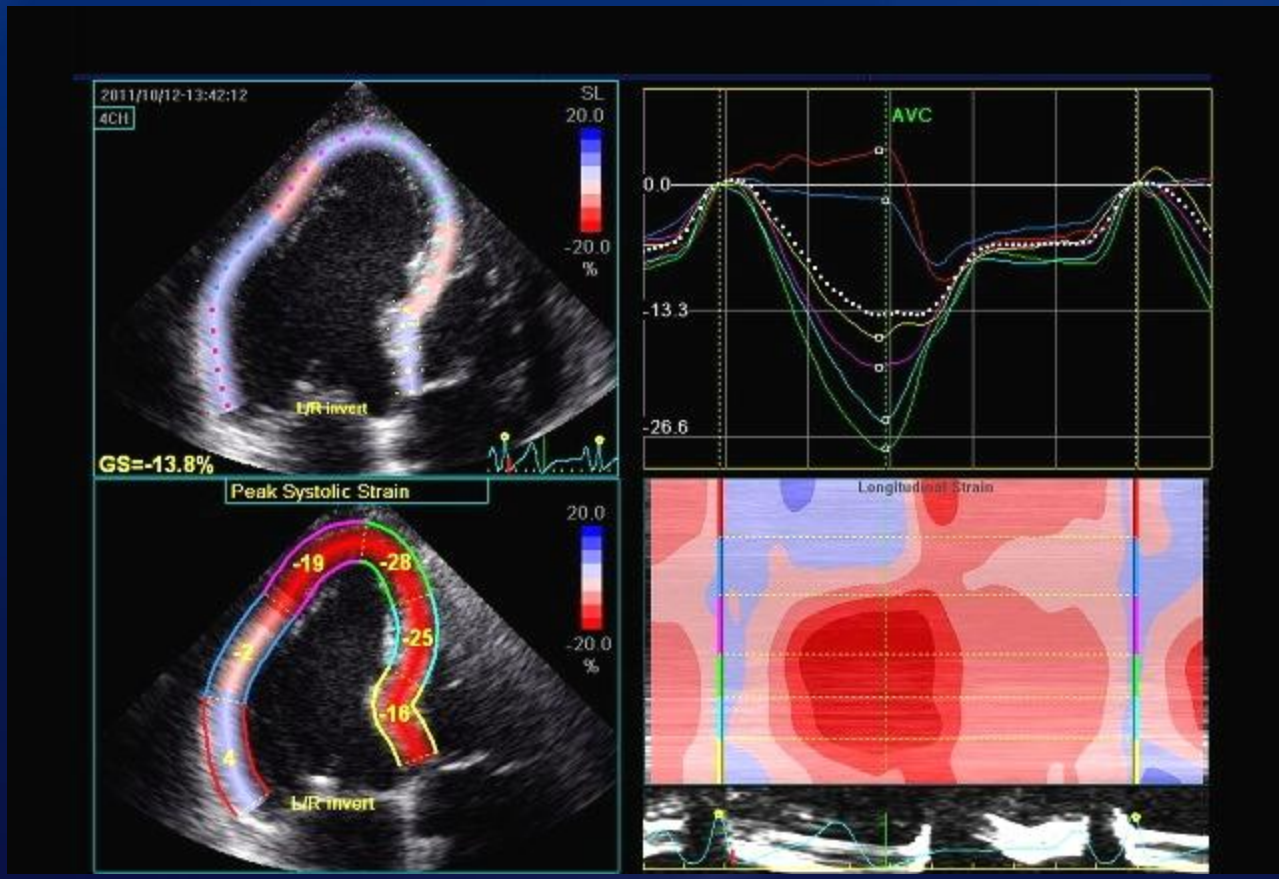
75 year old woman with chest pain
Normal ECG





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Longitudinal 2D strain at rest predicts the presence of left main and three vessel coronary artery disease in patients without regional wall motion abnormality

Jin-Oh Choi, Sung Won Cho, Young Bin Song, Soo Jin Cho, Bong Gun Song, Sang-Chol Lee, and Seung Woo Park*

Division of Cardiology, Cardiac and Vascular Centre, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, no. 50, Irwon-dong, Gangnam-gu, Seoul 135-710, Korea

Received 15 December 2008; accepted after revision 2 April 2009; online publish-ahead-of-print 28 April 2009

KEYWORDS
Ventricular function;
Myocardial ischaemia;
Coronary stenosis

Aims Non-invasive echocardiographic detection of coronary artery disease (CAD), even in left main or three-vessel CAD, usually requires a stress test since regional wall motion abnormalities (RWMA) are not always evident at rest. Strain is a more sensitive parameter of myocardial systolic function and may be abnormal in patients with severe CAD.

Methods and results We evaluated whether peak systolic longitudinal strain (PSLS) of left ventricle using 2D speckle tracking method might be useful for screening of severe CAD. One hundred and eight patients who underwent echocardiography and coronary angiography were evaluated. Patients were grouped according to the coronary angiographic findings as follows; high-risk group with left main or three-vessel CAD ($n = 38$), low-risk group with one- or two-vessel CAD ($n = 28$), and control group without CAD ($n = 30$).

PSLSs of all left ventricular segments were obtained successfully in 96 (89%) patients. None had RWMA at resting echocardiogram. PSLS was significantly reduced, especially in mid- and basal segments, in the high-risk group. Receiver operating characteristic (ROC) curve analysis demonstrated that mid- and basal PSLSs could effectively detect patients with severe CAD (area under ROC curve = 0.83, 95% CI

Peak systolic longitudinal strain was lower in patients with severe CAD without regional wall motion abnormalities (cut-off of 17.9 % strain)

Choi et al Samsung Medical Center, Korea European J. Echo 2009

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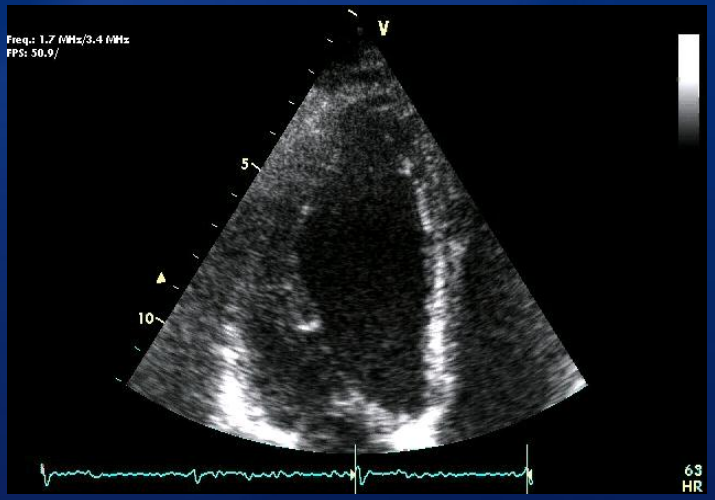
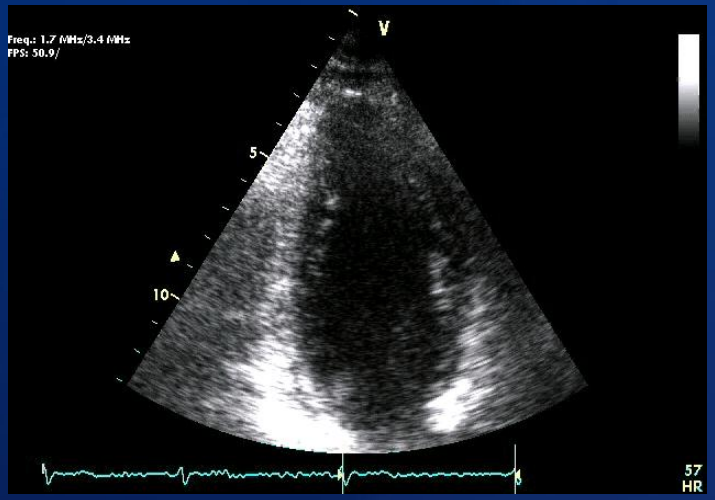
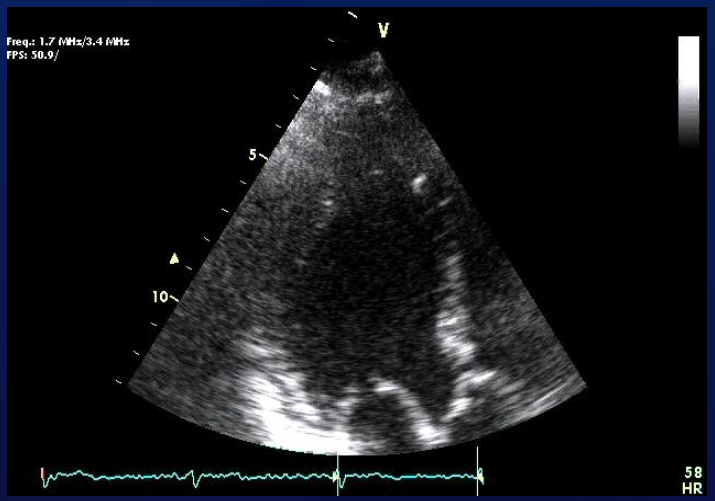
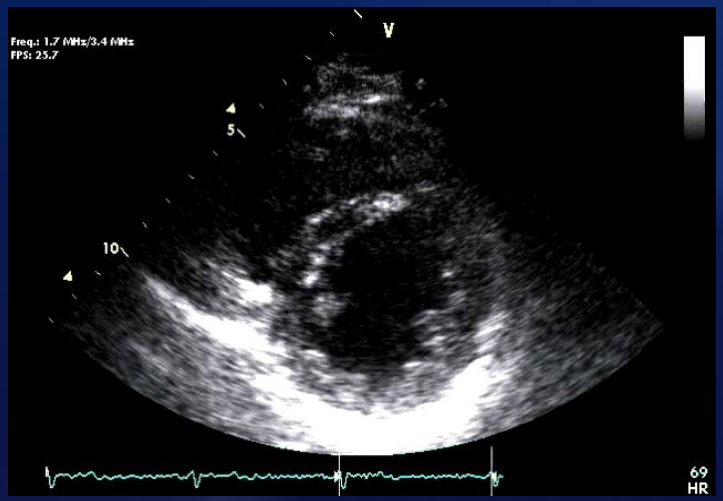
Regional Wall Motion Analysis
51 year old woman with chest pain Mayo Experience



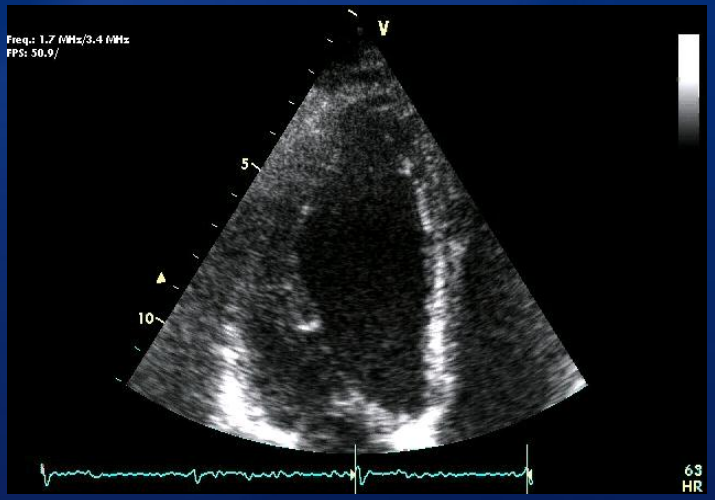


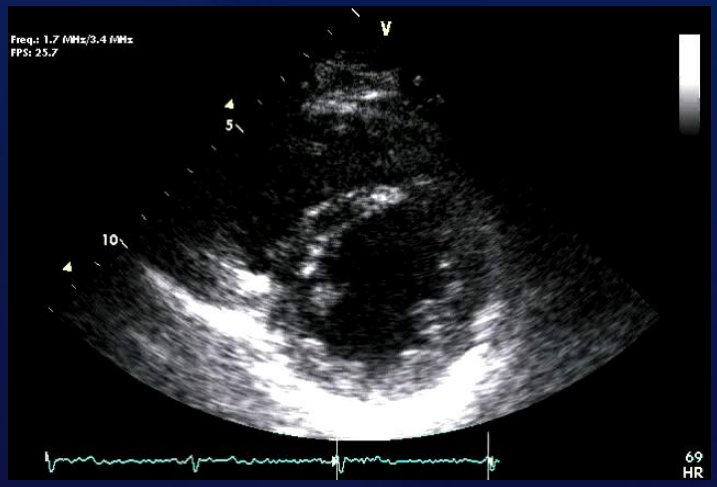


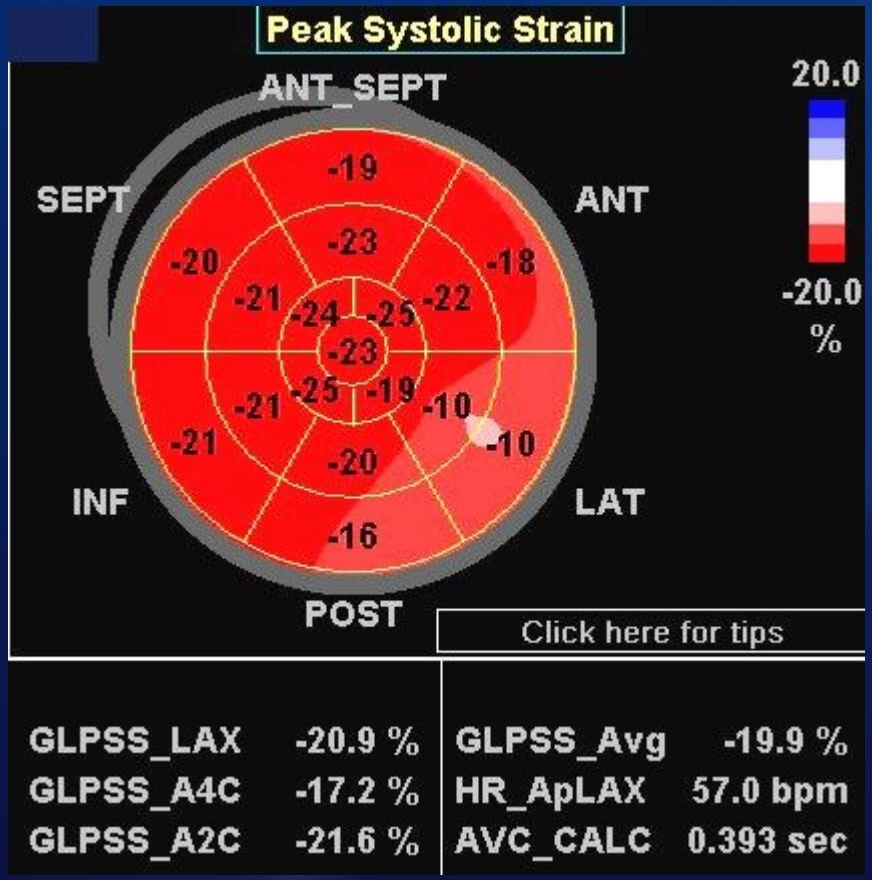


MAYO CLINIC

Regional Wall Motion Analysis
51 year old woman with chest pain Mayo Experience







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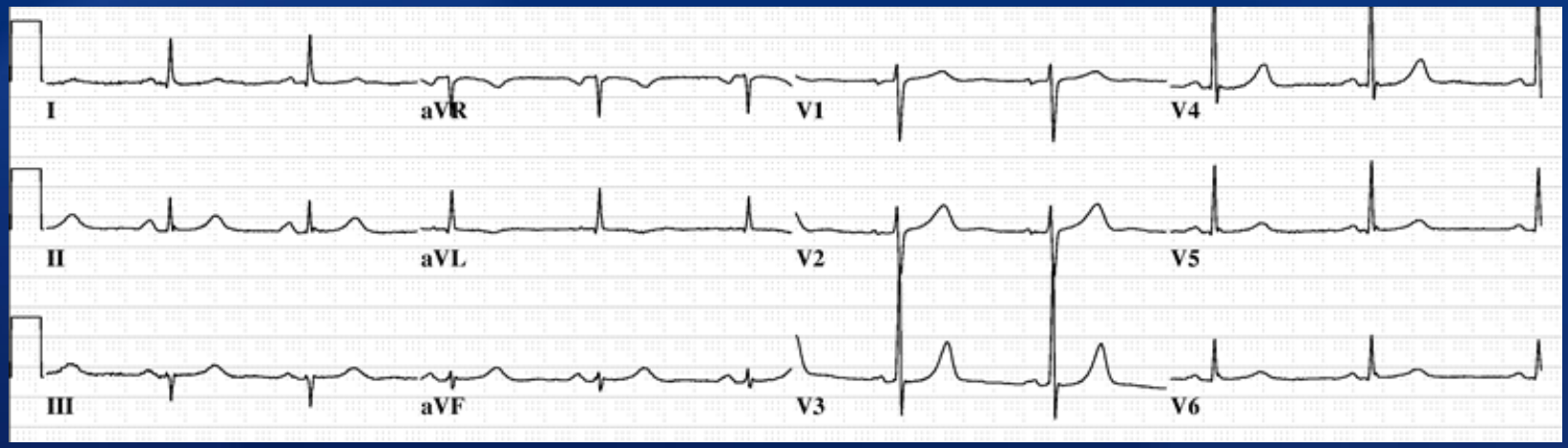
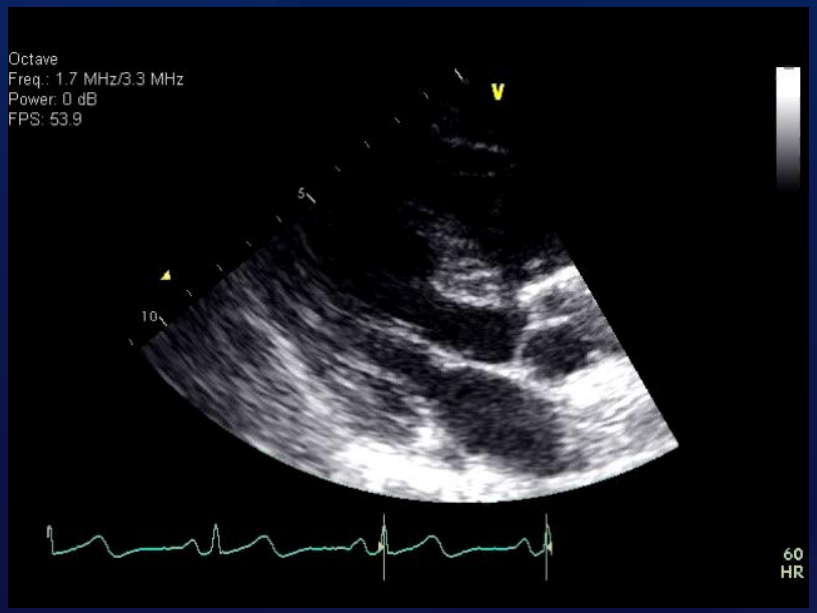
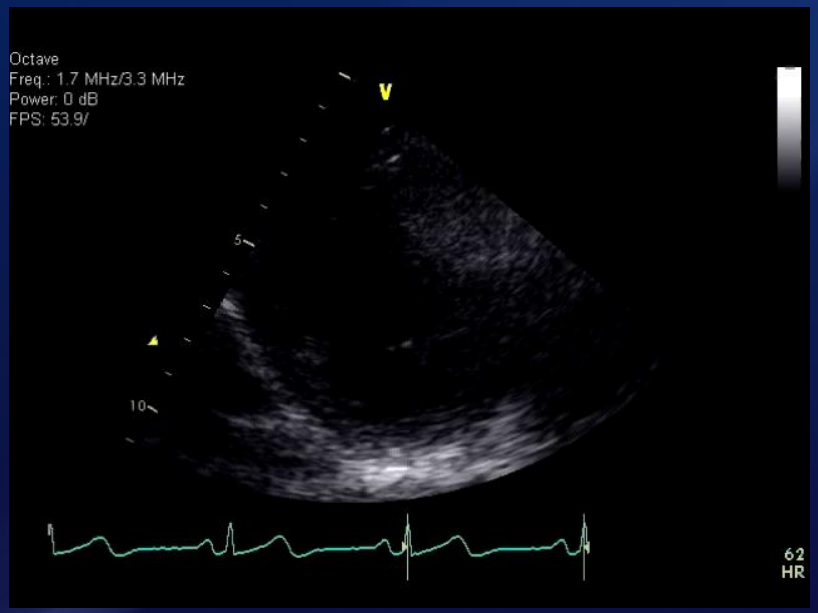
75 year old woman with CP
October 12, 2011







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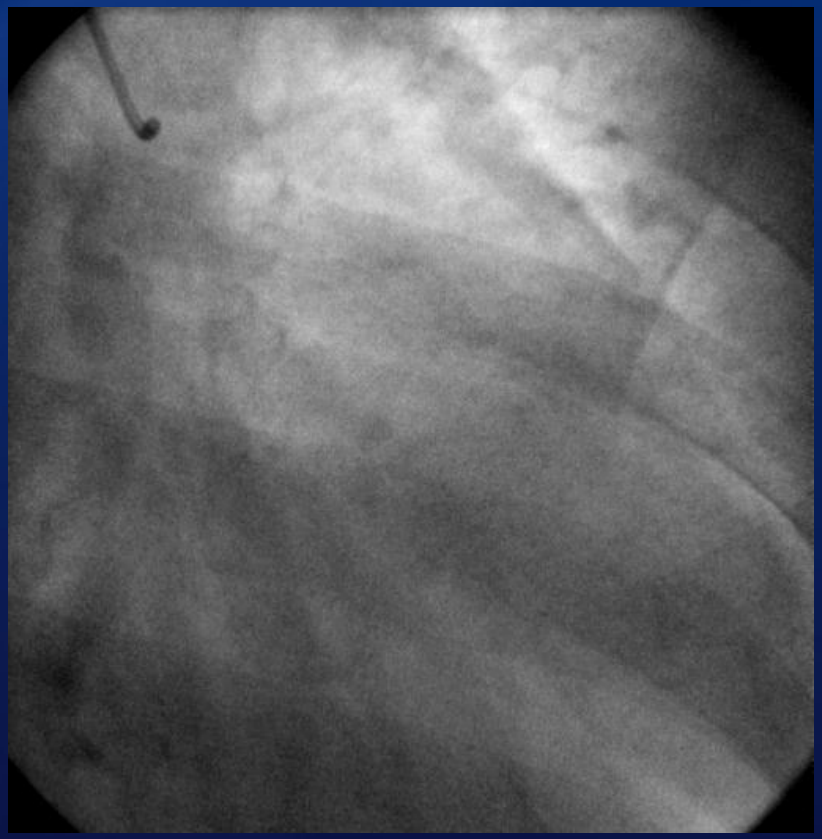
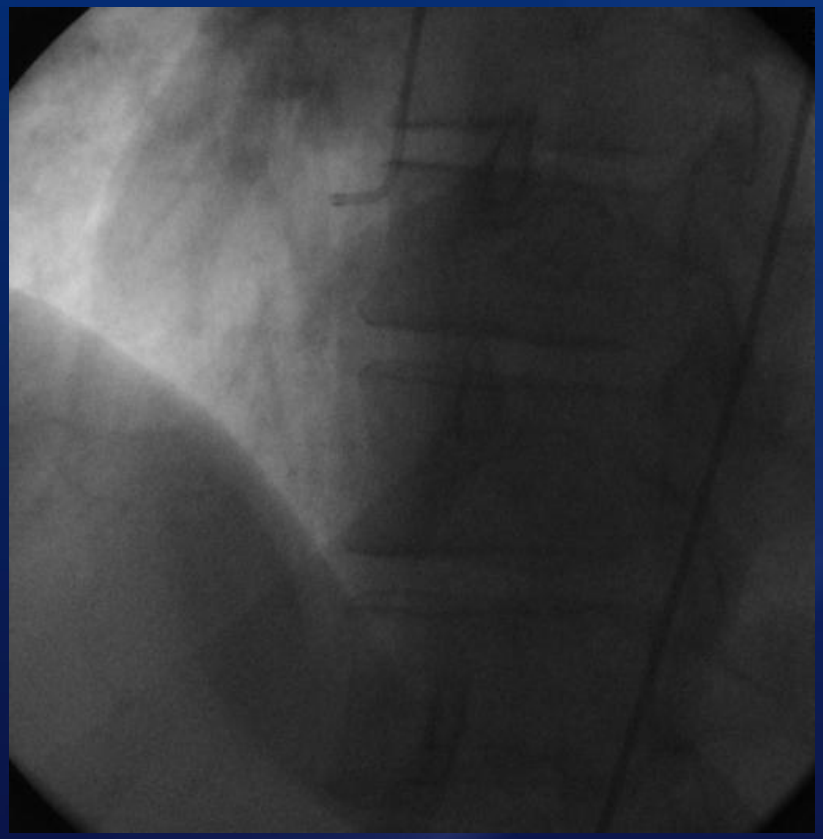
Regional Wall Motion Analysis
Strain Case Example
Coronary Angiography





LCx dissection

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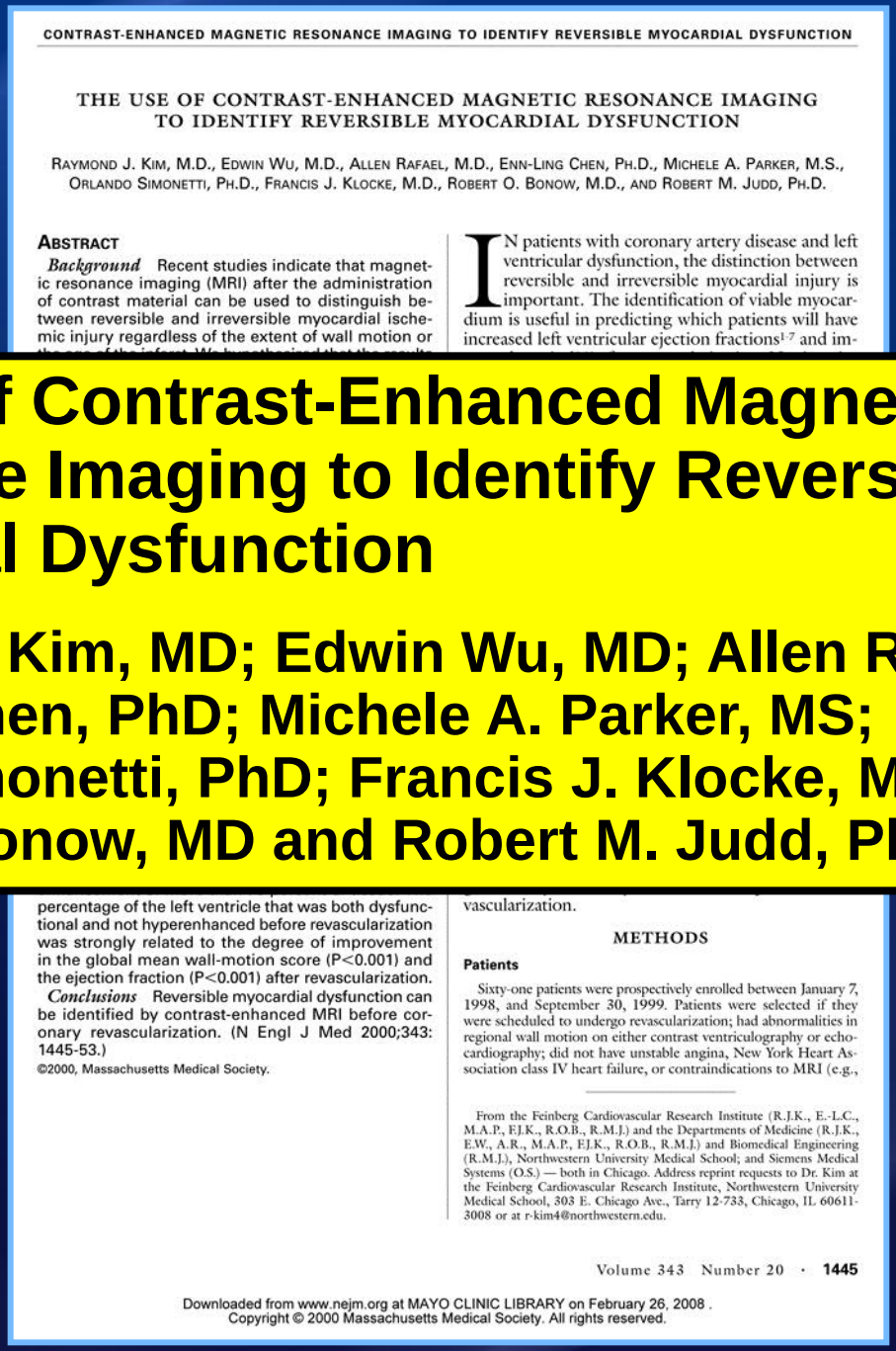


CONTRAST-ENHANCED MAGNETIC RESONANCE IMAGING TO IDENTIFY REVERSIBLE MYOCARDIAL DYSFUNCTION

THE USE OF CONTRAST-ENHANCED MAGNETIC RESONANCE IMAGING TO IDENTIFY REVERSIBLE MYOCARDIAL DYSFUNCTION

RAYMOND J. KIM, M.D., EDWIN WU, M.D., ALLEN RAFAEL, M.D., ENN-LING CHEN, PH.D., MICHELE A. PARKER, M.S., ORLANDO SIMONETTI, PH.D., FRANCIS J. KLOCKE, M.D., ROBERT O. BONOW, M.D., AND ROBERT M. JUDD, PH.D.

ABSTRACT

Background Recent studies indicate that magnetic resonance imaging (MRI) after the administration of contrast material can be used to distinguish between reversible and irreversible myocardial ischemic injury regardless of the extent of wall motion or

IN patients with coronary artery disease and left ventricular dysfunction, the distinction between reversible and irreversible myocardial injury is important. The identification of viable myocardium is useful in predicting which patients will have increased left ventricular ejection fractions[1-7] and im-

percentage of the left ventricle that was both dysfunctional and not hyperenhanced before revascularization was strongly related to the degree of improvement in the global mean wall-motion score ($P<0.001$) and the ejection fraction ($P<0.001$) after revascularization.

Conclusions Reversible myocardial dysfunction can be identified by contrast-enhanced MRI before coronary revascularization. (N Engl J Med 2000;343: 1445-53.)

vascularization.

METHODS

Patients

Sixty-one patients were prospectively enrolled between January 7, 1998, and September 30, 1999. Patients were selected if they were scheduled to undergo revascularization; had abnormalities in regional wall motion on either contrast ventriculography or echocardiography; did not have unstable angina, New York Heart Association class IV heart failure, or contraindications to MRI (e.g.,

From the Feinberg Cardiovascular Research Institute (R.J.K., E.-L.C., M.A.P., E.J.K., R.O.B., R.M.J.) and the Departments of Medicine (R.J.K., E.W., A.R., M.A.P., E.J.K., R.O.B., R.M.J.) and Biomedical Engineering (R.M.J.), Northwestern University Medical School; and Siemens Medical Systems (O.S.) — both in Chicago. Address reprint requests to Dr. Kim at the Feinberg Cardiovascular Research Institute, Northwestern University Medical School, 303 E. Chicago Ave., Tarry 12-733, Chicago, IL 60611-3008 or at r-kim4@northwestern.edu.

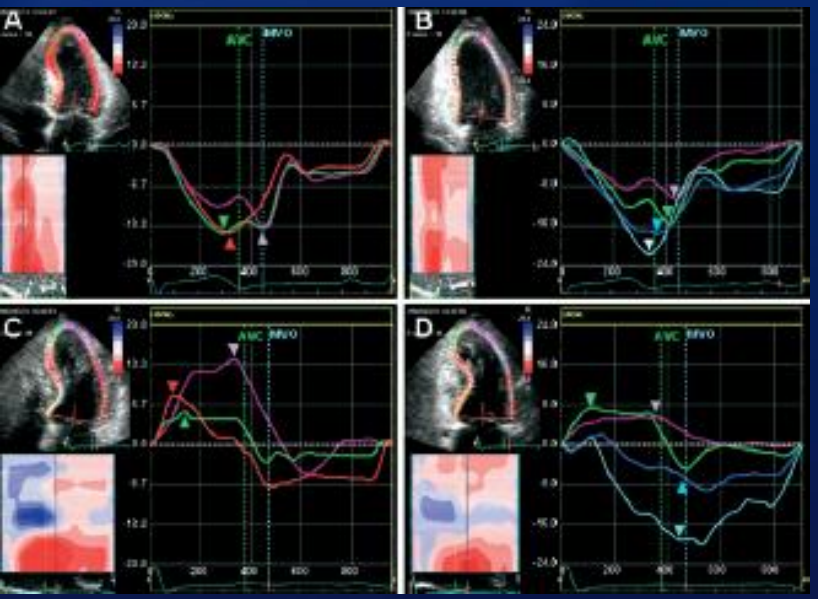
The Use of Contrast-Enhanced Magnetic Resonance Imaging to Identify Reversible Myocardial Dysfunction

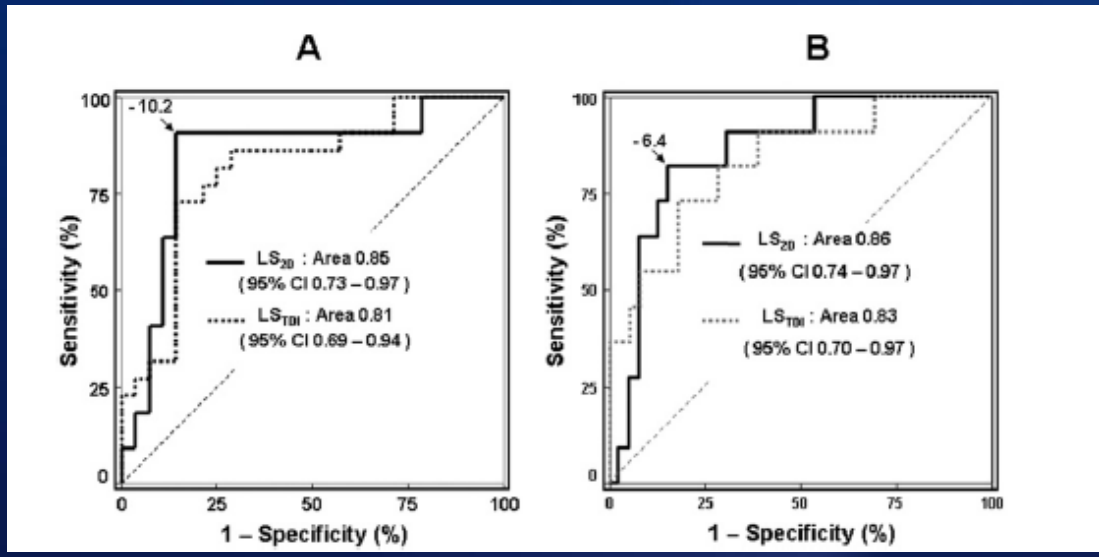
Raymond J. Kim, MD; Edwin Wu, MD; Allen Rafael, MD; Enn-Ling Chen, PhD; Michele A. Parker, MS; Orlando Simonetti, PhD; Francis J. Klocke, MD; Robert O. Bonow, MD and Robert M. Judd, PhD

NEJM 2000

LV remodeling Prediction after anterior AMI and reperfusion

Strain Imaging (TDI & Speckle)





Remodeling ***CV Events***

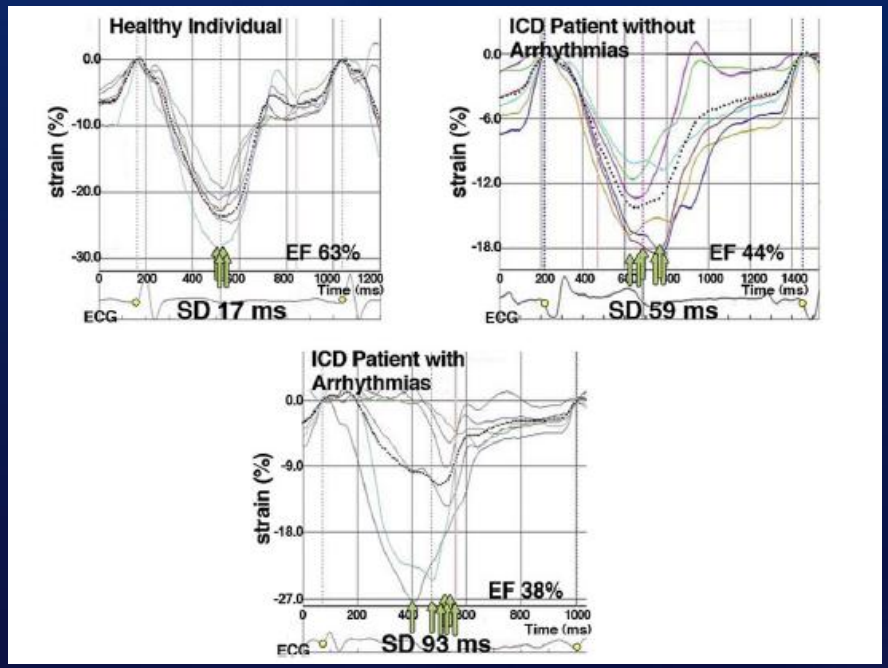
Park et al. JASE March 2008

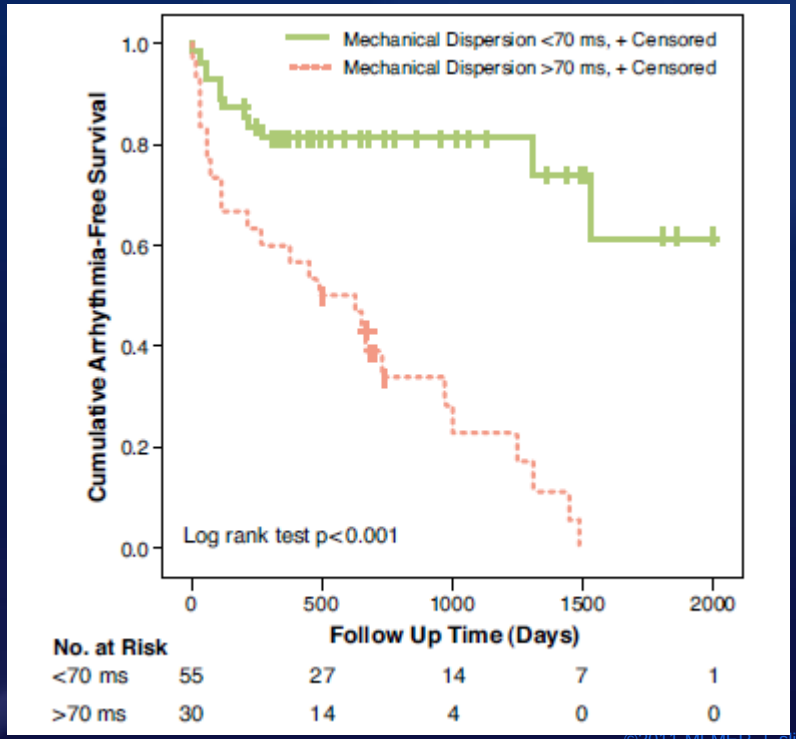
MAYO CLINIC

Mechanical Dispersion Assessed by Myocardial Strain in Patients After Myocardial Infarction for Risk Prediction of Ventricular Arrhythmia

Kristina H. Haugaa, MD,*† Marit Kristine Smedsrud, MD,*† Torkel Steen, MD, PhD,‡
Erik Kongsgaard, MD, PhD,* Jan Pål Loennechen, MD, PhD,§‖ Terje Skjaerpe, MD, PhD,‖
Jens-Uwe Voigt, MD, PhD,¶ Rik Willems, MD, PhD,¶ Gunnar Smith, MD,‡
Otto A. Smiseth, MD, PhD,* Jan P. Amlie, MD, PhD,* Thor Edvardsen, MD, PhD*
Oslo and Trondheim, Norway; and Leuven, Belgium

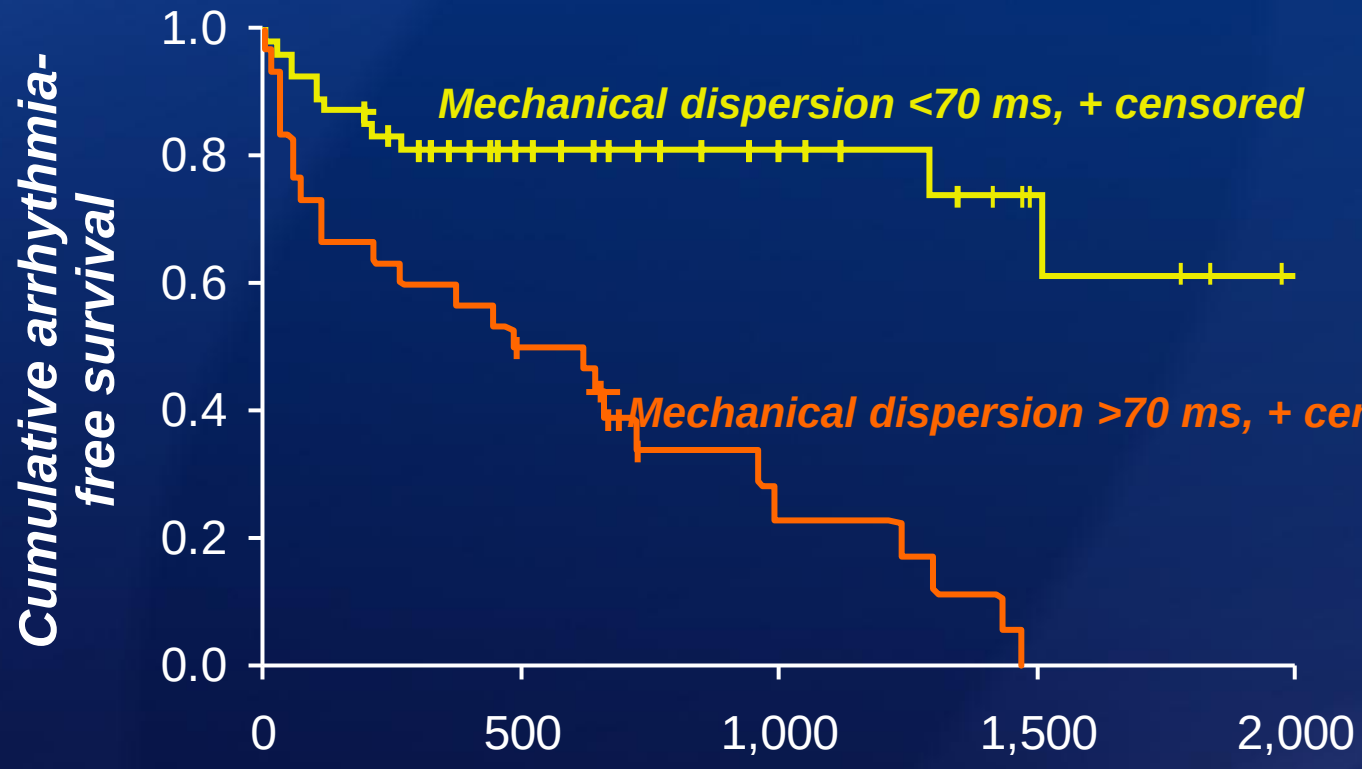
Mech Dispersion = SD of time to maximum myocardial shortening of 16 segments





JACC CV Imaging 2010

Kaplan-Meier Arrhythmia-Free Survival in 85 Post-MI Patients with an ICD



No. at risk					
<70 ms	55	27	14	7	1
>70 ms	30	14	4	0	0

Haugaa et al: J Am Coll Cardiol Img 2010;3:247-56

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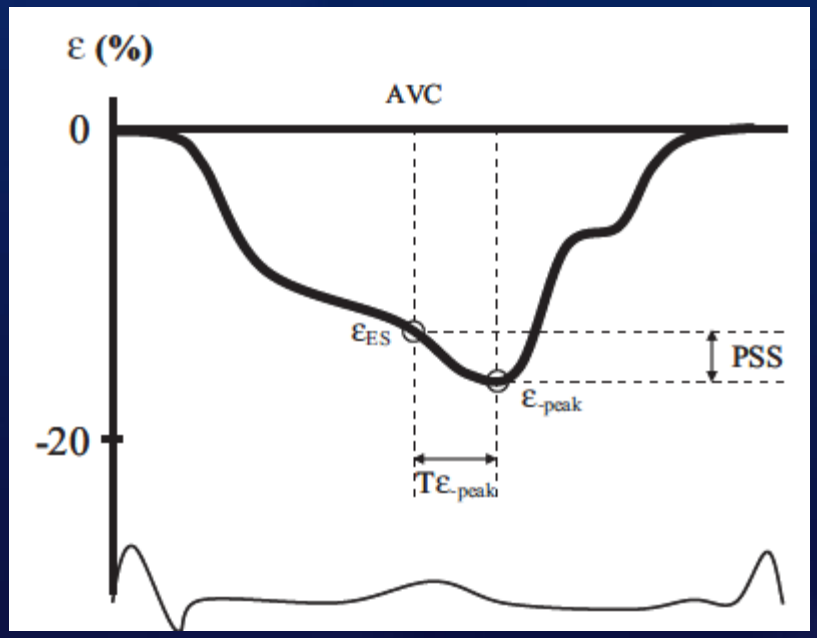
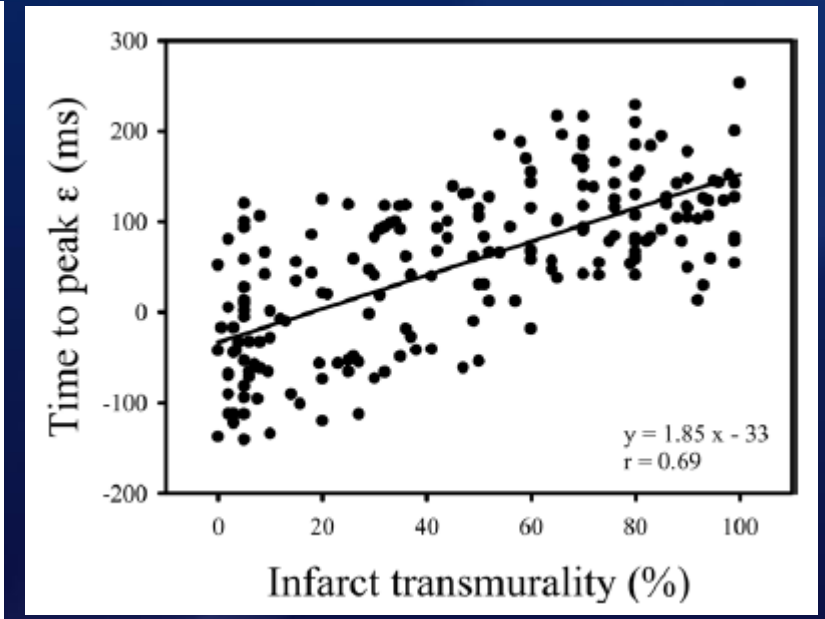
 |

Strain Imaging for Transmurality

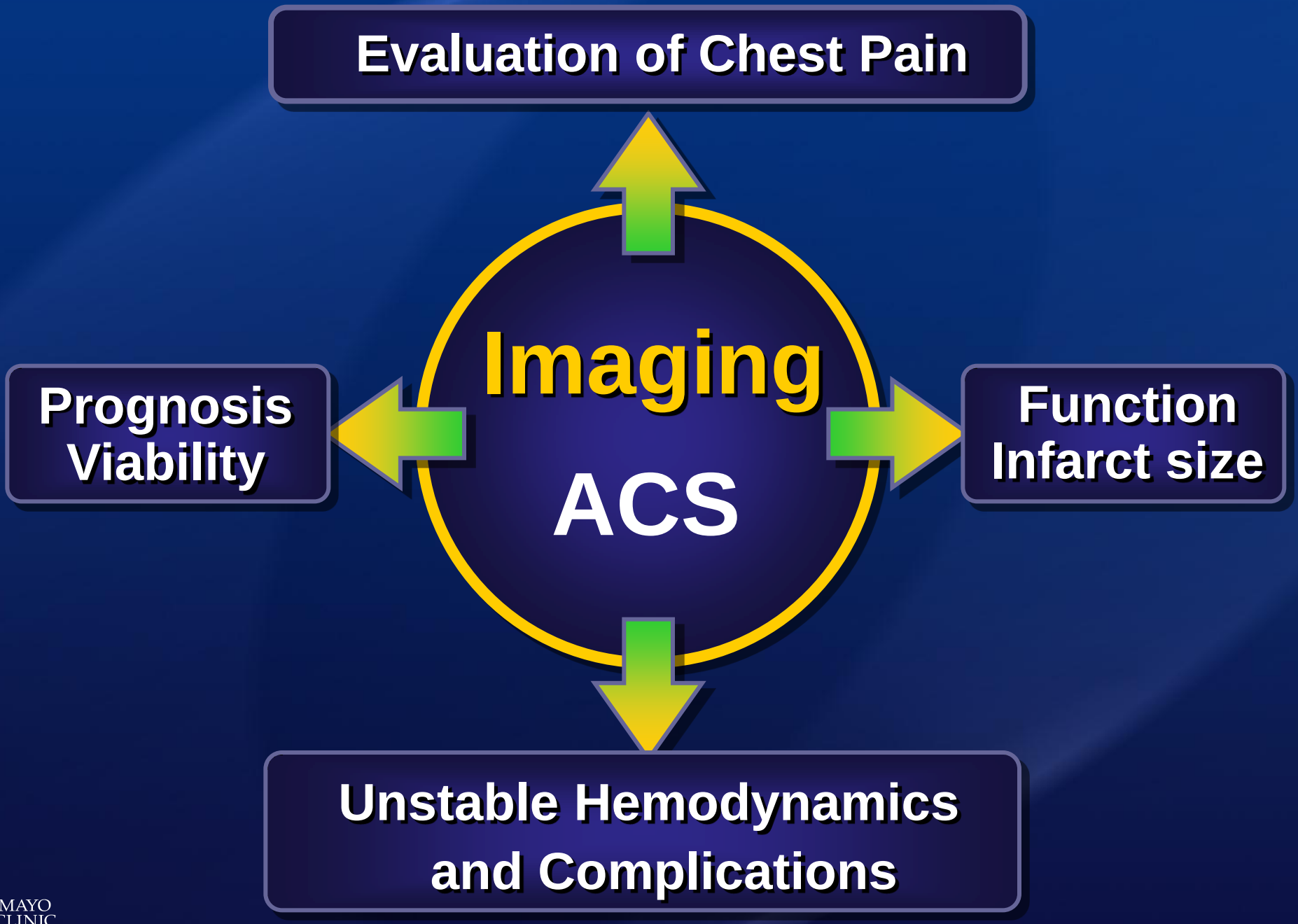
Is Postsystolic Shortening a Marker of Viability in Chronic Left Ventricular Ischemic Dysfunction? Comparison with Late Enhancement Contrast Magnetic Resonance Imaging

Pascal Lim, MD, Agnès Pasquet, MD, PhD, Bernhard Gerber, MD, PhD, Anne Marie D'Hondt, MS, David Vancraeynest, MD, Pascal Guéret, MD, and Jean Louis J. Vanoverschelde, MD, PhD, *Brussels, Belgium; and Créteil, France*





Lim et al JASE 2008



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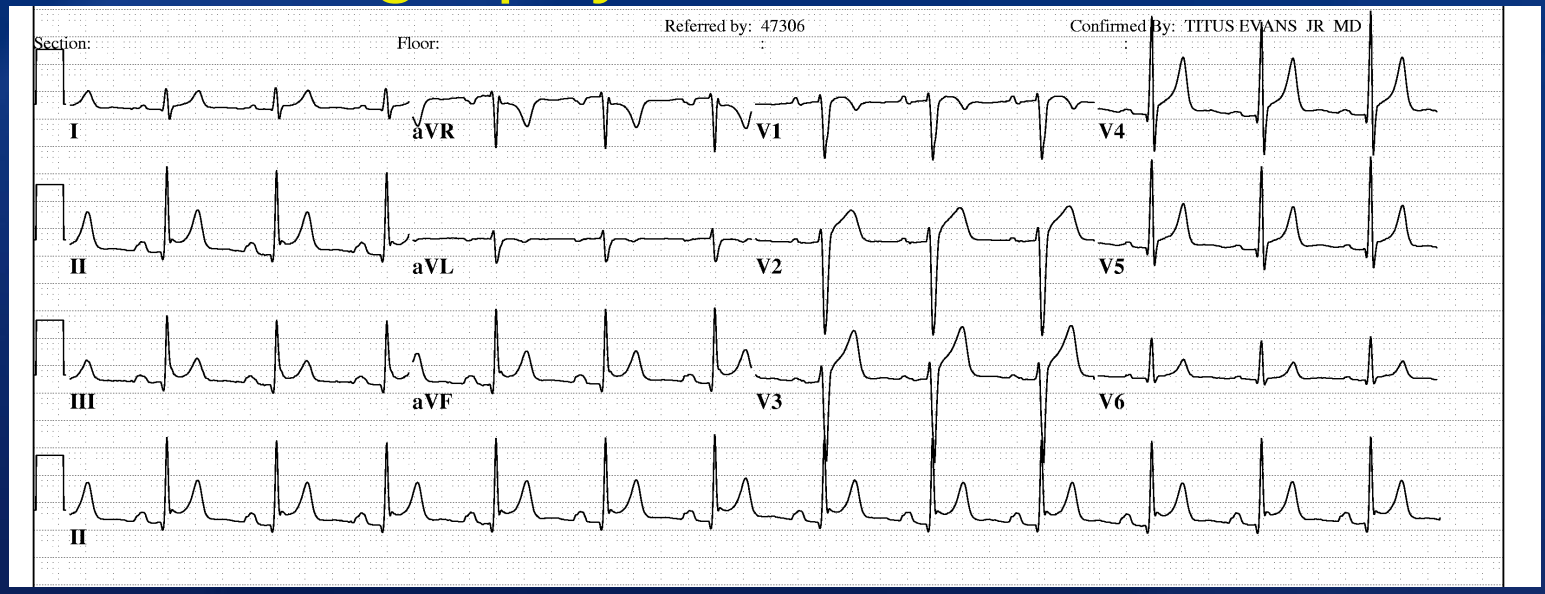
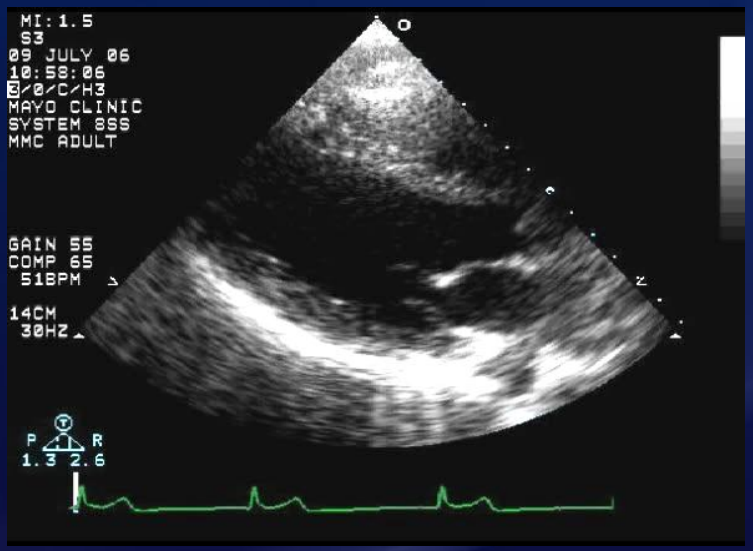
Normal Coronaries and STEMI Echocardiography





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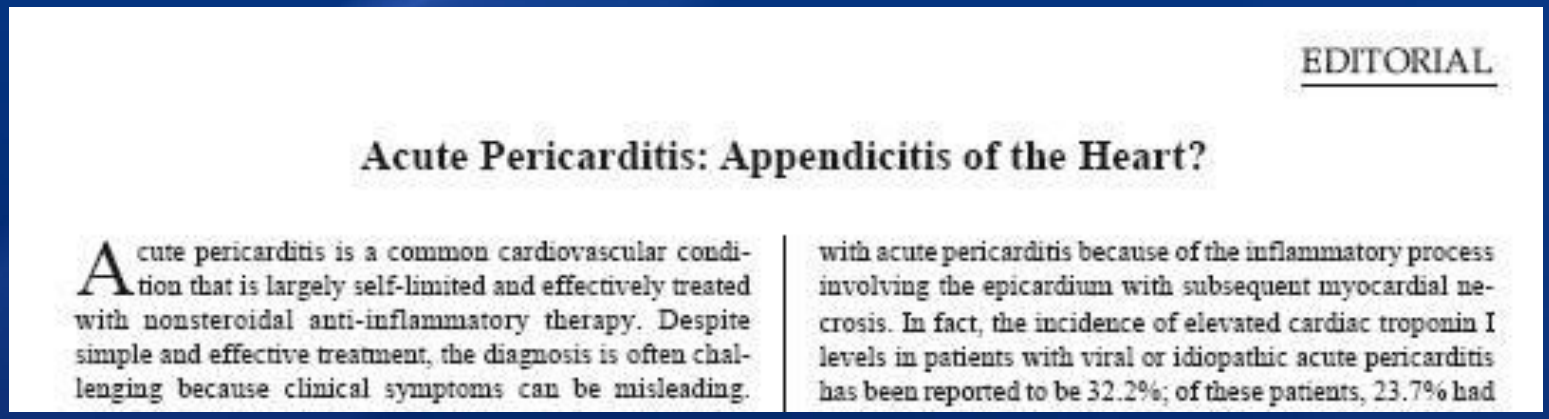

EDITORIAL

Acute Pericarditis: Appendicitis of the Heart?

Acute pericarditis is a common cardiovascular condition that is largely self-limited and effectively treated with nonsteroidal anti-inflammatory therapy. Despite simple and effective treatment, the diagnosis is often challenging because clinical symptoms can be misleading.

with acute pericarditis because of the inflammatory process involving the epicardium with subsequent myocardial necrosis. In fact, the incidence of elevated cardiac troponin I levels in patients with viral or idiopathic acute pericarditis has been reported to be 32.2%; of these patients, 23.7% had

"Differentiating pericarditis from STEMI can be challenging. This situation is similar to removing a normal appendix so that a real case of acute appendicitis will not be overlooked. Occasionally, it is necessary to perform cardiac catheterization in a patient with acute pericarditis to rule out AMI"

KR Bainey and DL Bhatt Mayo Clinic Proc Jan 2009
Editorial for Salisbury's article

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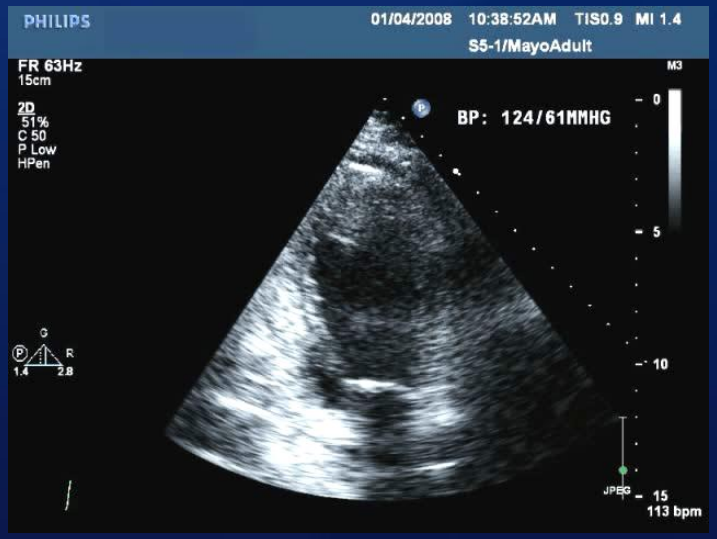
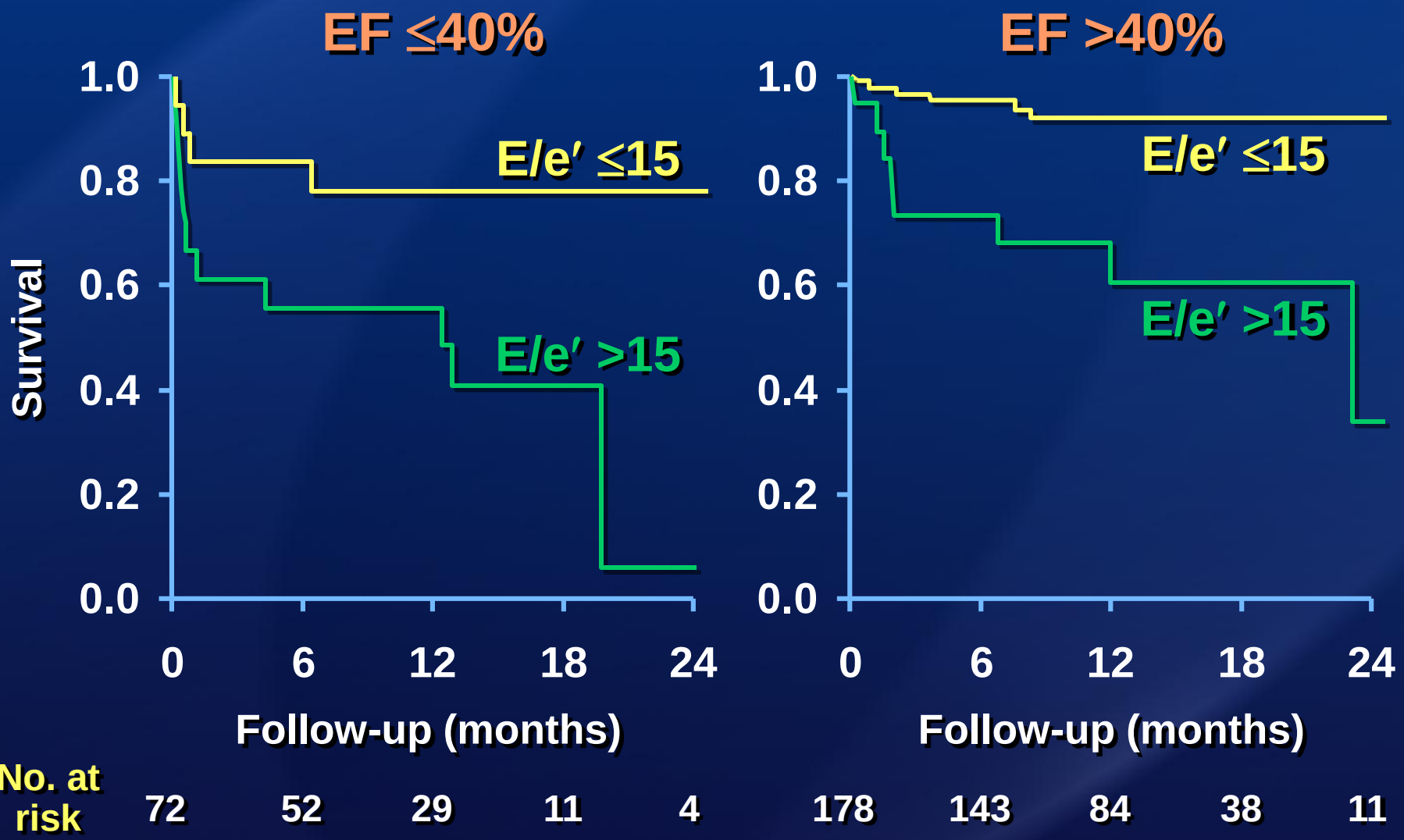
Myocardial Contrast Perfusion Study



Survival of Patients with Acute MI

Prognosis



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

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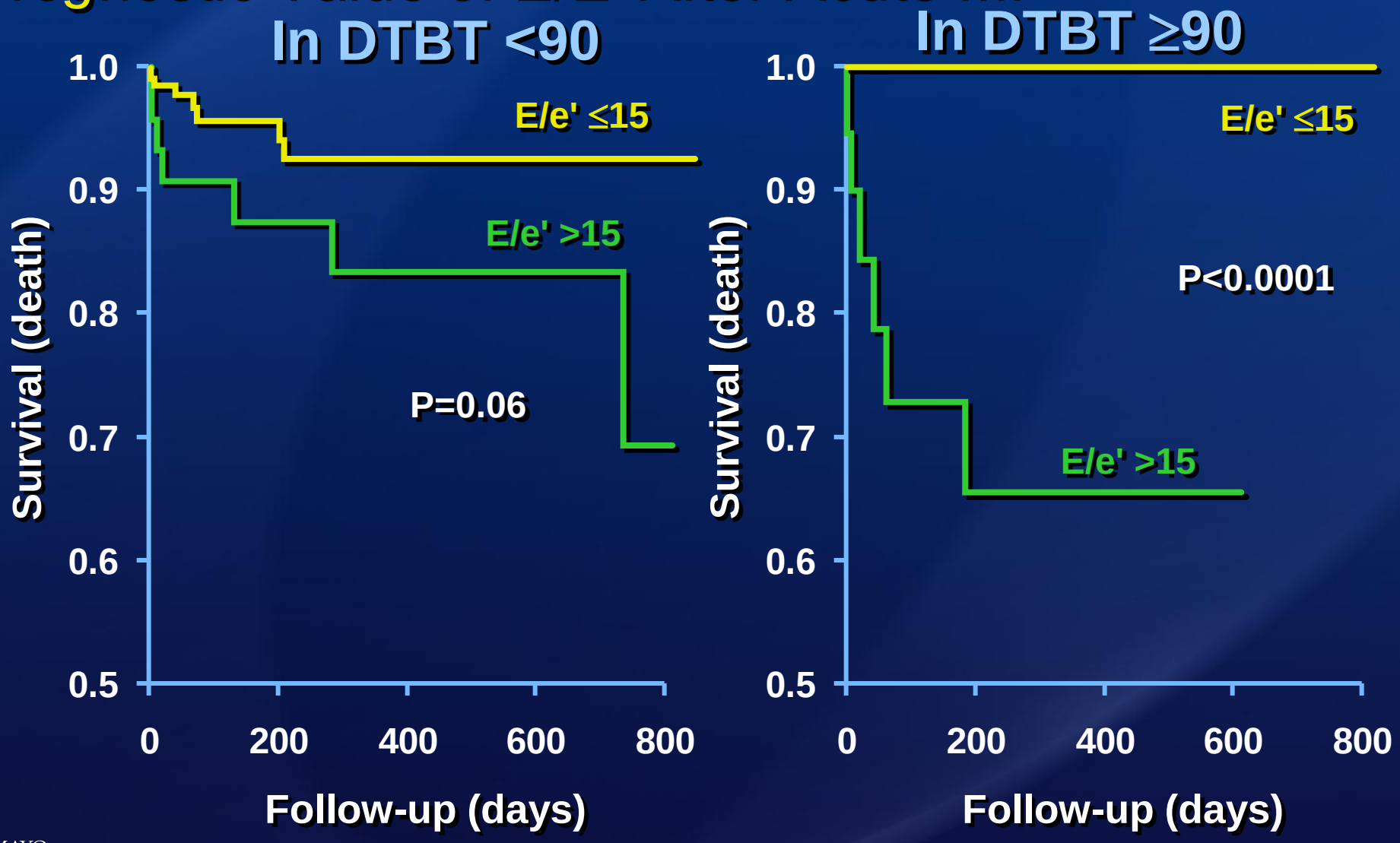
Prognostic Value of E/E' After Acute MI



Park SJ, Ting H, Oh JK Unpublished

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CV Imaging

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Congratulations and Thank You !

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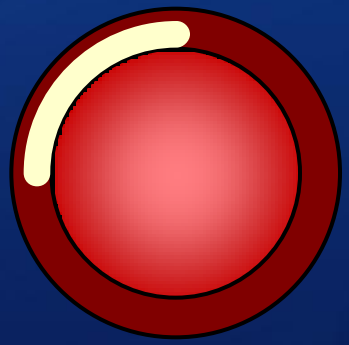
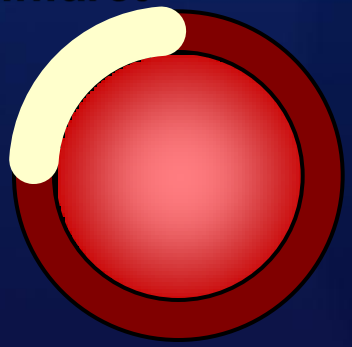
Cardiac MRI Hyperenhancement Patterns

Ischemic

Subendocardial infarct

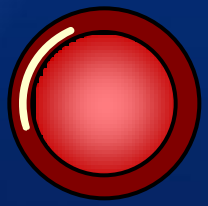


Transmural infarct

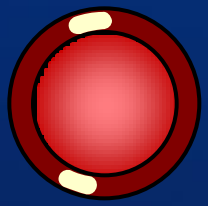


Nonischemic

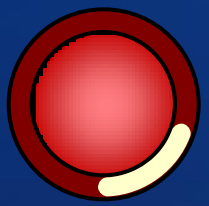
Mid-wall HE



- Idiopathic dilated cardiomyopathy
- Myocarditis



- Hypertrophic cardiomyopathy
- RV pressure overload (eg, congenital heart disease, pulmonary HTN)



- Sarcoidosis
- Myocarditis
- Anderson-Fabry disease
- Chagas' disease

Epicardial HE

Sarcoidosis, myocarditis, Anderson-Fabry disease, Chagas' disease

Shah DJ et al: Nat Clin Pract CV Med 2(11):597, 2005