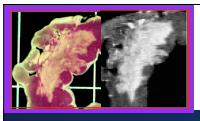
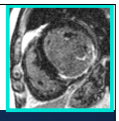
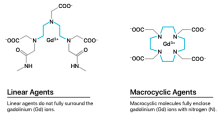




Evaluating Myocardial Viability By CMR

Dipan J. Shah, MD, FACC
Professor of Medicine, Weill Cornell Medical College
Director, Cardiovascular MRI Laboratory
Chief, Division of Cardiovascular Imaging
Houston Methodist DeBakey Heart & Vascular Center

Why has CMR taken a prominent role in viability assessment ?

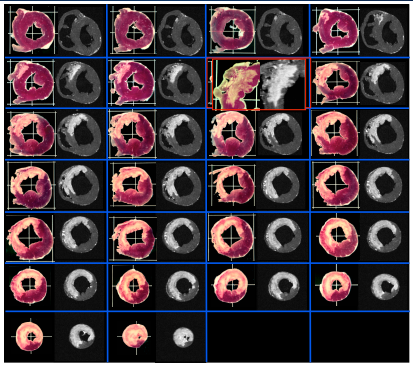


LGE-CMR Has Extensive Validation:

✓Histopathologic Validation (Animals)

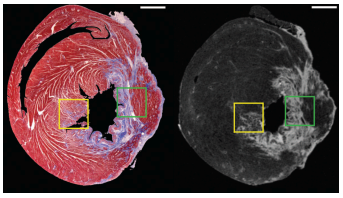
✓Clinical Validation (Humans)

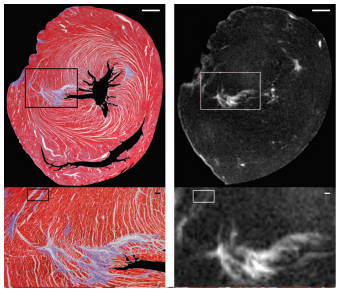
CMR Provides Exact Match to Histopathology



Kim et al . Circulation 1999.

CMR Identifies Cardiac Fibrosis in Chronic MI at the Cellular Level

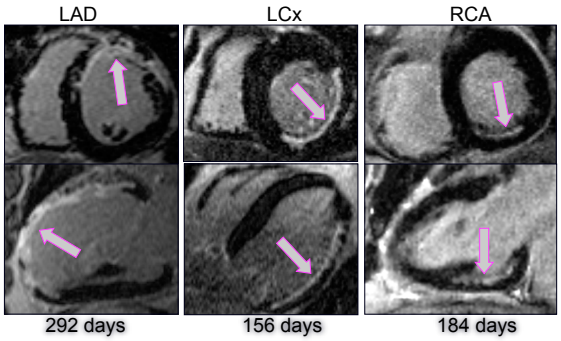




- Ex vivo rat heart Model
- Image Resolution: 50 microns, isotropic
- LGE identified clefts of viable cardiomyocytes 2-4 cells thick

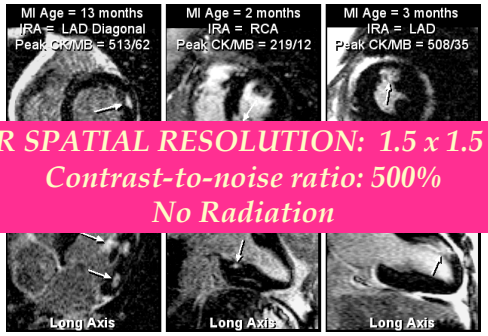
Schelbertet al. Circ Cardiovasc Imaging 2010.

INFARCT VESSEL AND LGE



Kim et al, NEJM, 2000.

SMALL MYOCARDIAL INFARCTION



CMR SPATIAL RESOLUTION: 1.5 x 1.5 mm
Contrast-to-noise ratio: 500%
No Radiation

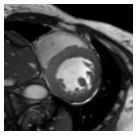
Wu et al. Lancet 2001.

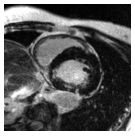
CMR Viability Study

TIME

- Insert Peripheral IV
- Place Patient In Scanner
- Cine Images
- Inject Gadolinium Contrast
- Wait 5-10 Minutes
- Delayed Enhancement Images

Cine
Morphology / Function





Late Gadolinium Enhancement
Infarction / Viability

REVASCULARIZATION PROTOCOL

Wall Motion Improvement Predicted by Delayed-Enhancement MRI?

CARDIAC MRI #1

Cine MRI for wall motion

DE-MRI for Viability

1 month

PTCA or CABG Revascularization

3 months

CARDIAC MRI #2

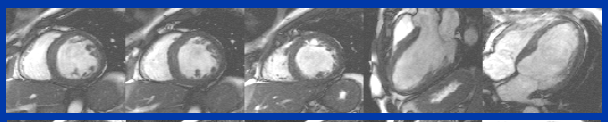
Cine MRI for wall motion

Kim et al. NEJM 2000.

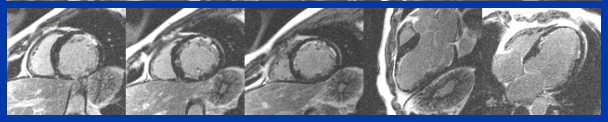
Example Case

Basal *Mid* *Apical* *3 Chamber* *4 Chamber*

A



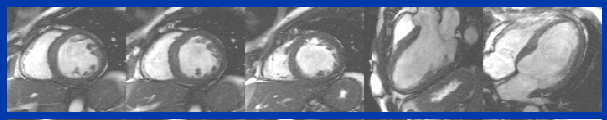
B



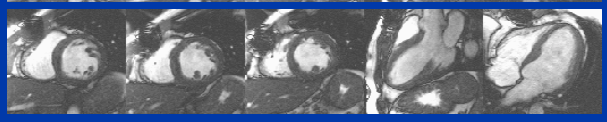
A - Cine images (LVEF 30%)
B - Late Gadolinium Enhancement (viability) images

Basal *Mid* *Apical* *3 Chamber* *4 Chamber*

A

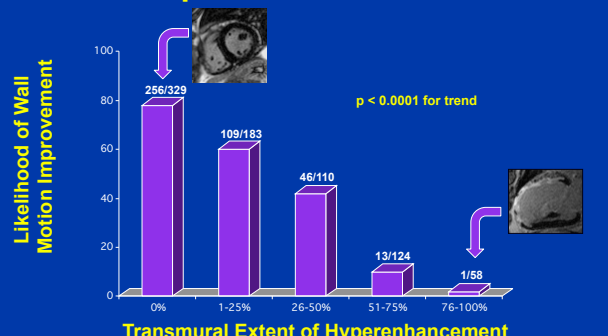


B



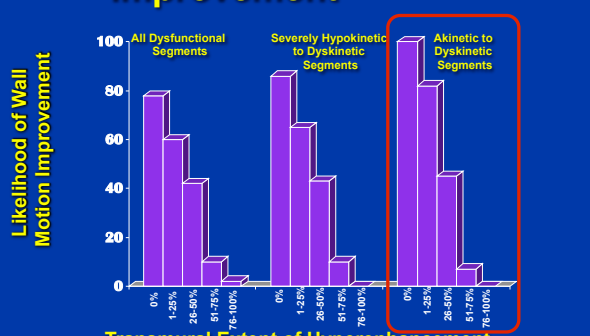
A - Cine images before revascularization (LVEF 30%)
B - Cine images after revascularization (LVEF 45%)

Prediction of Wall Motion Improvement



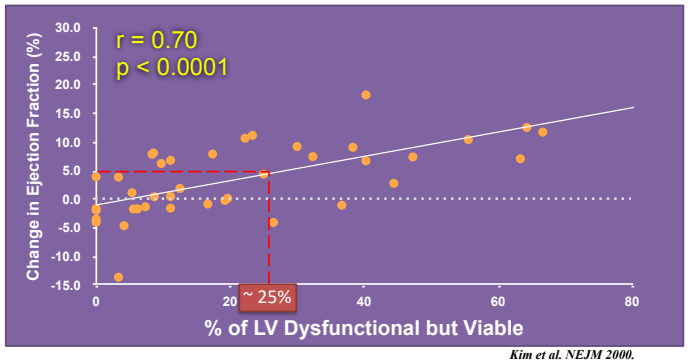
Kim et al. NEJM 2000.

Prediction of Wall Motion Improvement



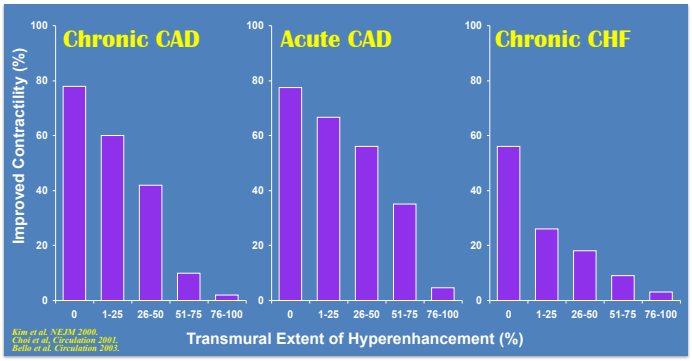
Kim et al. NEJM 2000.

Prediction of Global Improvement

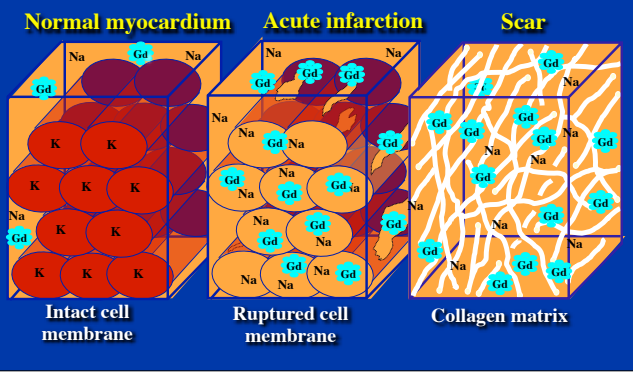


Kim et al. NEJM 2000.

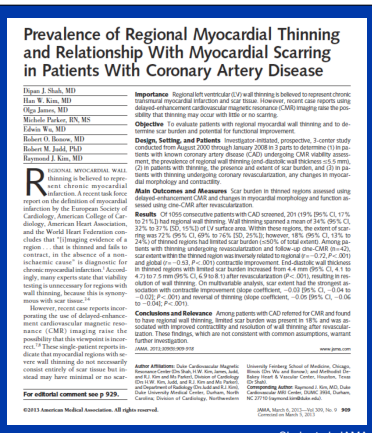
Extent of Viability and Likelihood of Functional Improvement



Mechanism of LGE

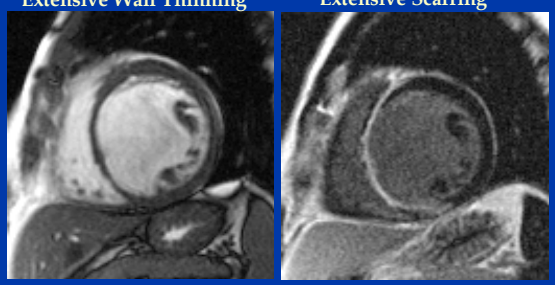


Prevalence of Regional Myocardial Thinning and Relationship With Myocardial Scarring in Patients With Coronary Artery Disease



Shah et al, JAMA, 2013.

Extensive Wall Thinning / Extensive Scarring

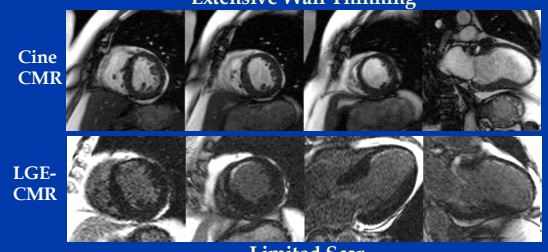


Cine CMR — DE-CMR

Shah et al, JAMA, 2013.

Example Case:

Extensive Wall Thinning



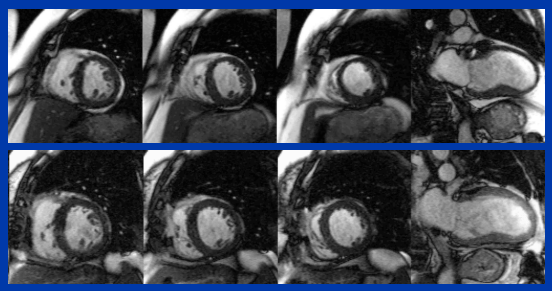
Limited Scar

Shah et al, JAMA, 2013.

Example Case:

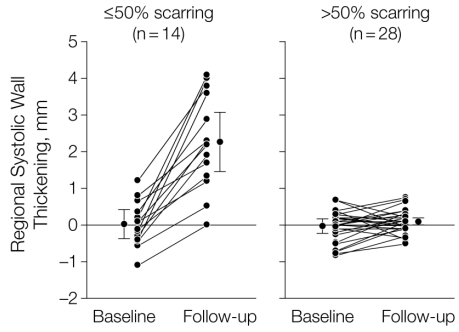
LVEF 30%

CABG



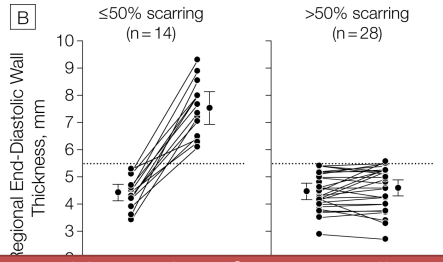
LVEF 50% Shah et al, JAMA, 2013.

Relationship of Scar and Functional Improvement



Shah et al, JAMA, 2013.

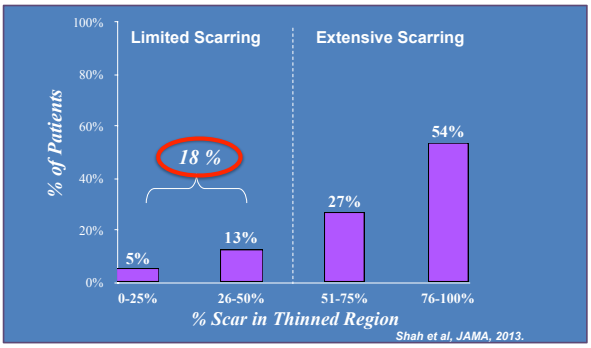
Relationship of Scar and Change in EDWT



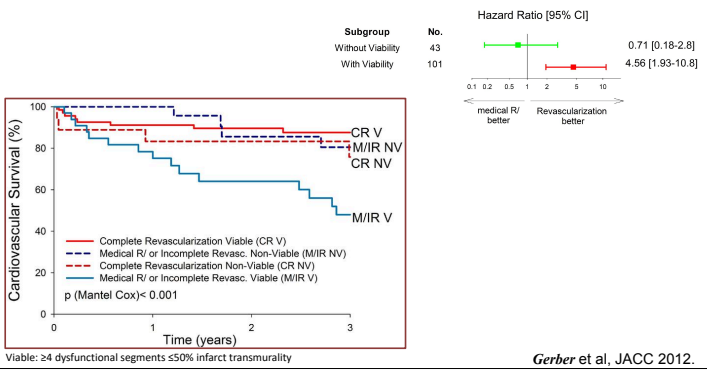
CMR is able to identify potentially reversible myocardial thinning

Shah et al, JAMA, 2013.

What is the prevalence of thinning with limited scar?



CV Survival was worse in patients with viable myocardium who remained under medical treatment or underwent incomplete revascularization

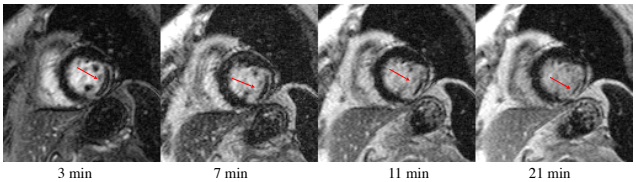


Viable: ≥4 dysfunctional segments ≤50% infarct transmurality

Gerber et al, JACC 2012.

Microvascular Obstruction

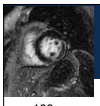
- 60 year old man
- Acute STEMI
- Primary PCI of LCX



3 min 7 min 11 min 21 min

Time after contrast administration

Microvascular Obstruction and MACE



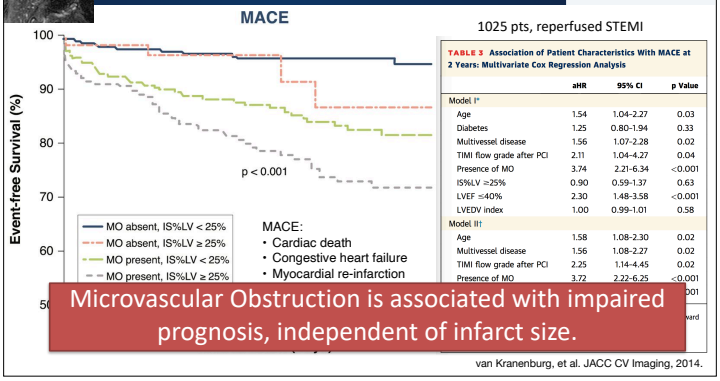
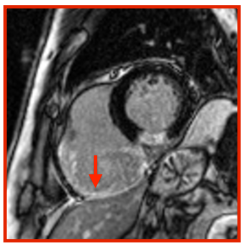


TABLE 3 Association of Patient Characteristics With MACE at 2 Years: Multivariate Cox Regression Analysis

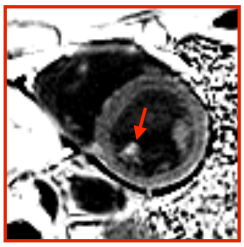
	aHR	95% CI	p Value
Model I*			
Age	1.54	1.04-2.27	0.03
Diabetes	1.25	0.80-1.94	0.33
Multivessel disease	1.56	1.07-2.28	0.02
TIMI flow grade after PCI	2.11	1.04-4.27	0.04
Presence of MO	3.74	2.21-6.34	<0.001
IS%LV ≥25%	0.90	0.59-1.37	0.63
LVEF ≤40%	2.30	1.48-3.58	<0.001
LVEDV index	1.00	0.99-1.01	0.58
Model II†			
Age	1.58	1.08-2.30	0.02
Multivessel disease	1.56	1.08-2.27	0.02
TIMI flow grade after PCI	2.25	1.14-4.45	0.02
Presence of MO	3.72	2.22-6.25	<0.001

Microvascular Obstruction is associated with impaired prognosis, independent of infarct size.

van Kranenburg, et al. JACC CV Imaging, 2014.



Inferior Infarction with RV MI

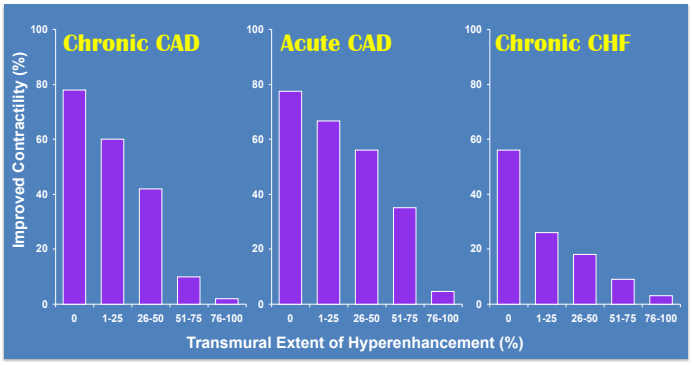


Papillary Muscle Scar

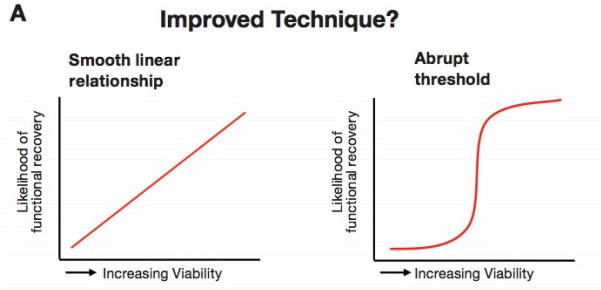
Is Functional Improvement the Best Standard of Truth ?

- Incomplete revascularization
- Recurrent events between revascularization and FU imaging
- Tethering of regions with extensive scarring adjacent to viable regions
- Myocardial dysfunction may not be due to coronary hypoperfusion
- Timing of optimal follow up imaging

Extent of Viability and Likelihood of Functional Improvement



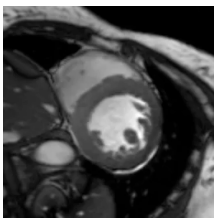
Viability Is Not a Dichotomous Physiology



Van Assche MDHVJ 2013

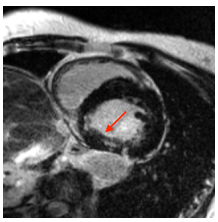
All myocardial dysfunction may not be due to coronary hypo-perfusion

Cine



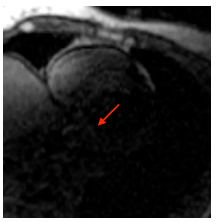
Morphology / Function

Late Gadolinium Enhancement



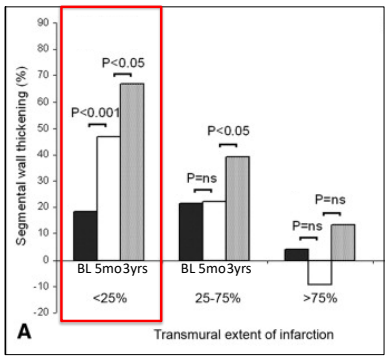
Infarction / Viability

Stress Perfusion



Perfusion / Ischemia

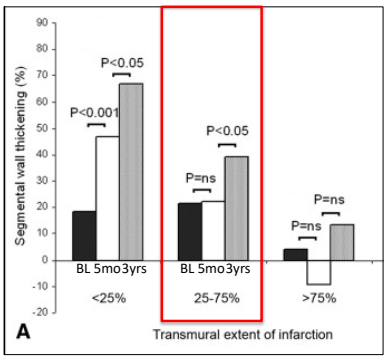
Chronic Total Occlusion:



- Segments < 25% TEI
  - Improved at 5 months
  - and further at 3 years
- Segments 25-75% TEI
  - No improvement at 3 mo
  - Improved at 3 years
- Segments > 75% TEI
  - No improvement at 5 months or 3 years

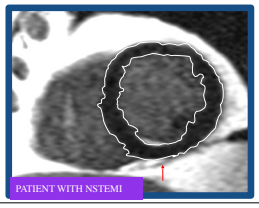
Kirschbaum et al. AJC 2008

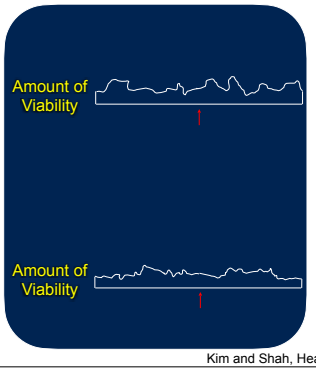
Chronic Total Occlusion



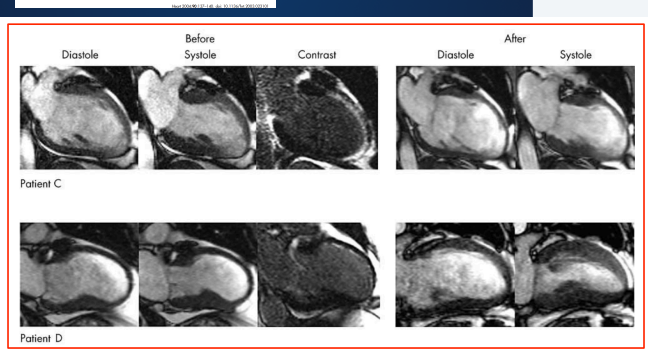
- Segments < 25% TEI
  - Improved at 5 months
  - and further at 3 years
- Segments 25-75% TEI
  - No improvement at 3 mo
  - Improved at 3 years
- Segments > 75% TEI
  - No improvement at 5 months or 3 years

Kirschbaum et al. AJC 2008



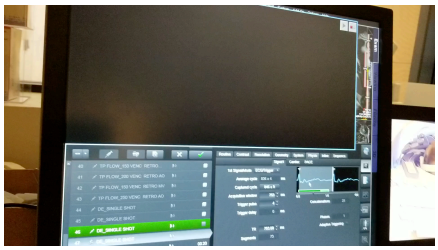


Kim and Shah, Heart 2004.

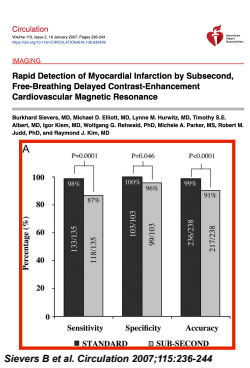


Kim and Shah, Heart 2004.

Single shot LGE Acquisition



- Performed in ~ 1 min
- No need for breath holding
- Independent of arrhythmia



Sievers B et al. Circulation 2007;115:236-244

Special Considerations for CMR:

- No special dietary preparation required
- Requires gadolinium contrast
  - ✓ Renal Insufficiency is no longer an absolute contraindication with availability of Group II gadolinium agents
- Implanted Devices
  - ✓ Pacemaker artifact is limited
  - ? ICD requires use of specialized "broadband" pulse sequence
  - ? Sub-Q ICD may be problematic

X Mechanical Support: IABP of LVAD

CONCLUSION:

- Uniquely able to directly image both viable and nonviable myocardium
- Able to assess viability without stressor agent
- Able to predict likelihood of functional improvement in chronic CAD, acute CAD, and chronic heart failure undergoing medical RX
- Able to identify reversible myocardial thinning

THANK YOU FOR YOUR ATTENTION !!