A Light in the Dark: Cardiac MRI and Risk Mitigation

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Dr. Mikolich has NO financial disclosures relative to industry

Use of gadolinium as a MRI contrast agent is OFF LABEL

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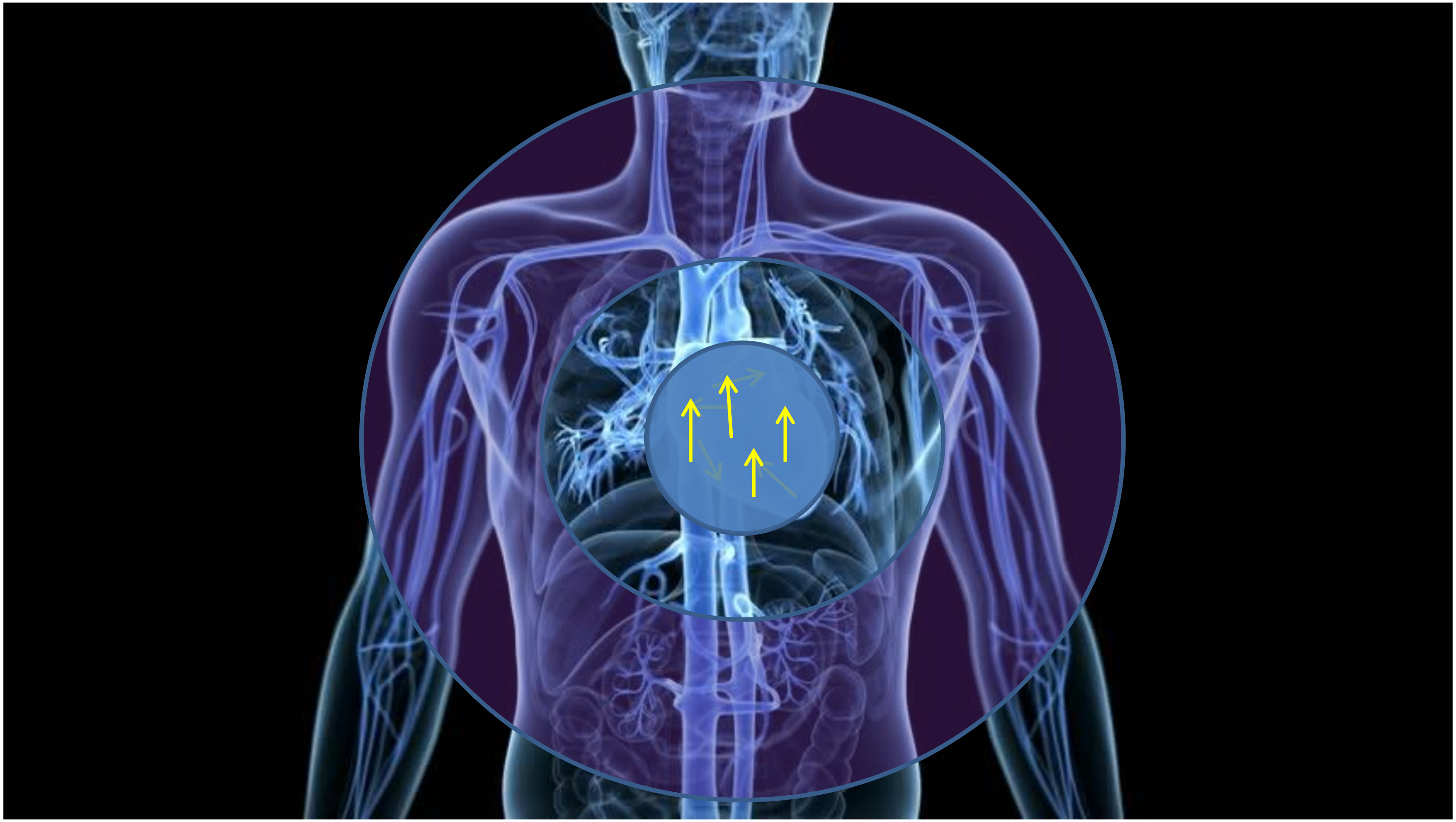
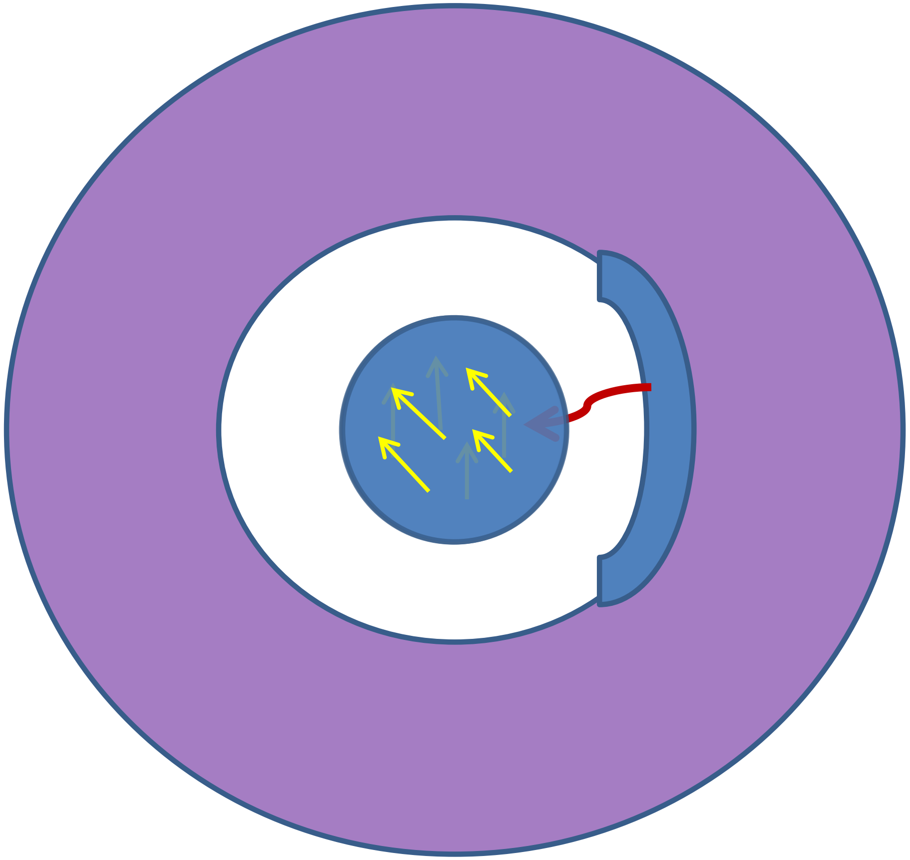
Sharon Regional Medical Center

How are Cardiac MRI Images Generated ?

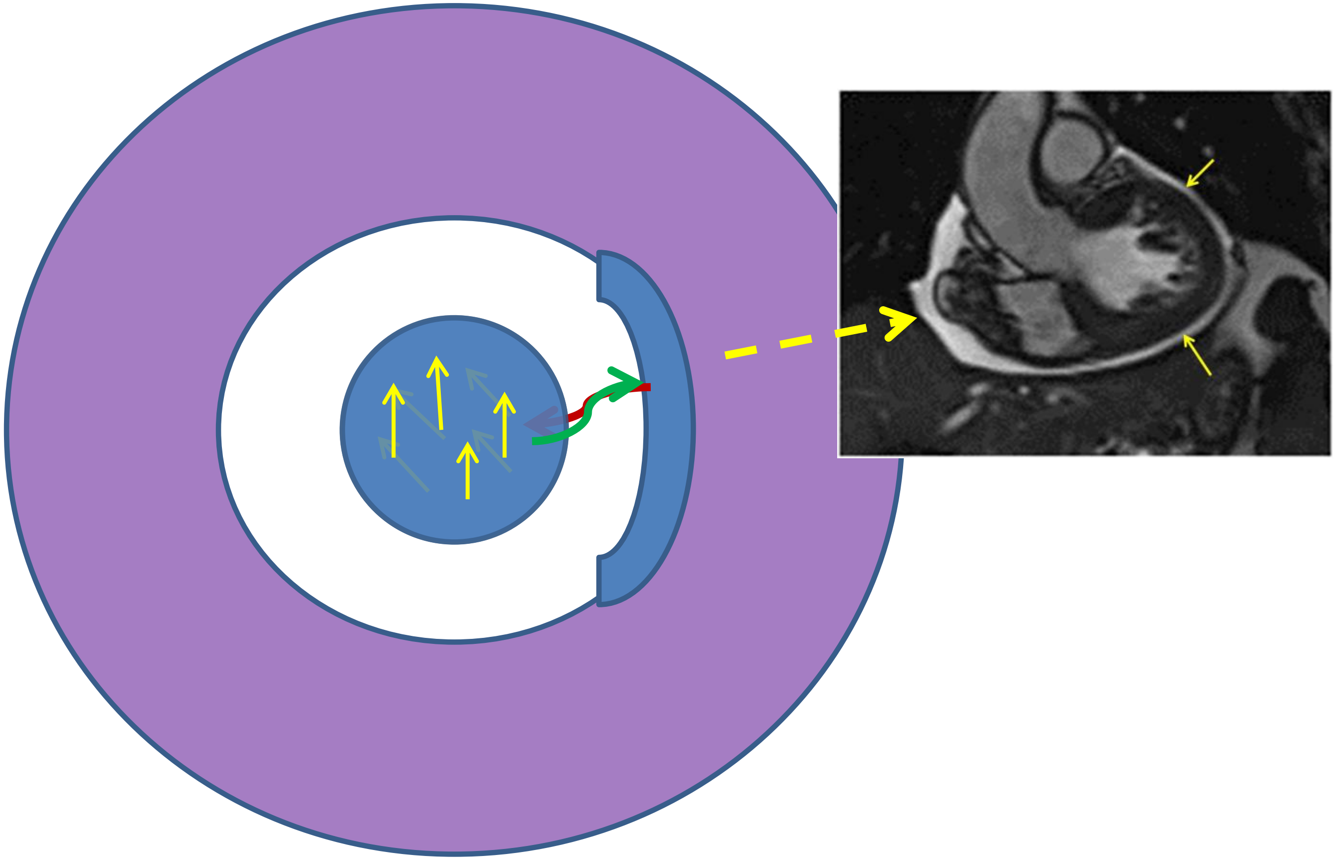
Effect of a Magnetic Field



Generation of a Cardiac MRI image

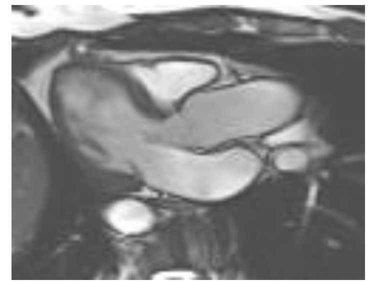


Generation of a Cardiac MRI Image

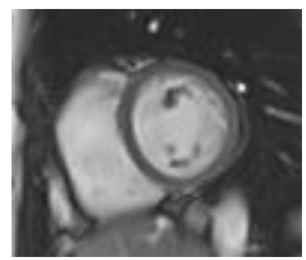


3 Most Common Cardiac Imaging Planes

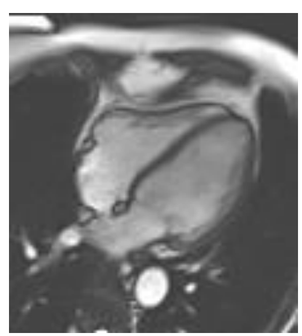
2 chamber long axis



2 chamber short axis



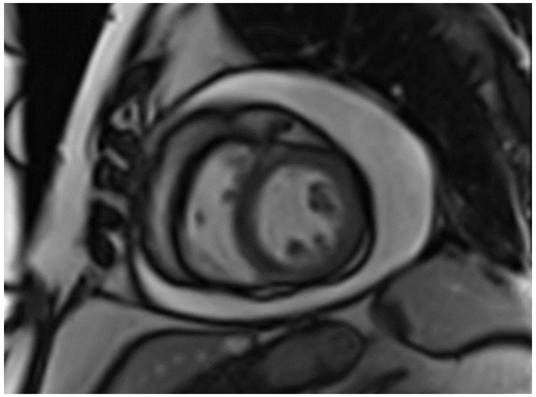
4 chamber

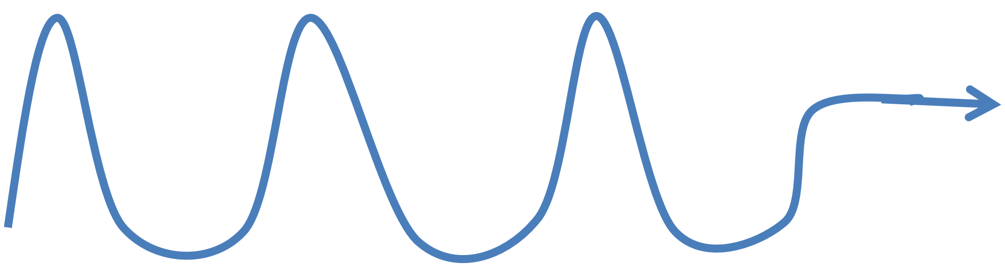


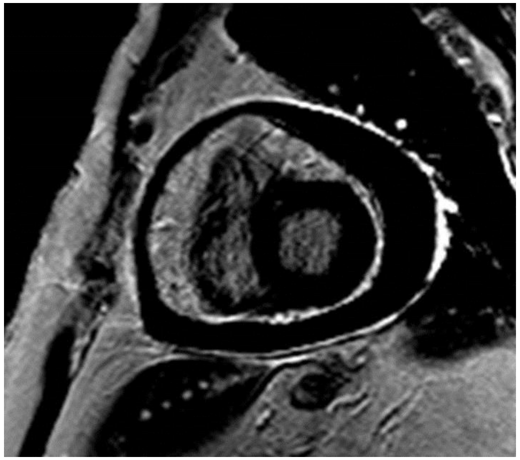
What is a Pulse Sequence ?

Why Use Multiple Pulse Sequences ?

Pulse Sequences

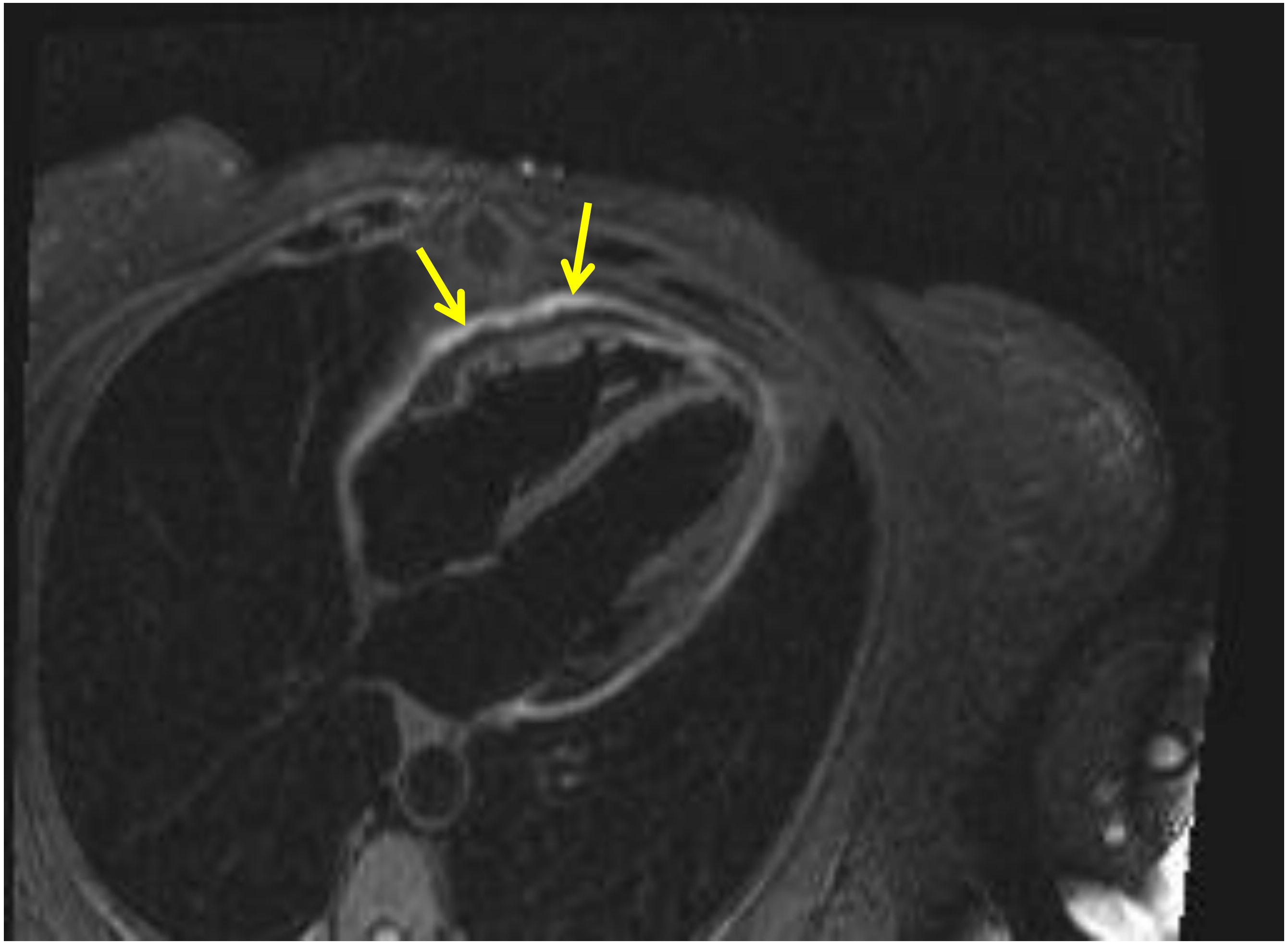






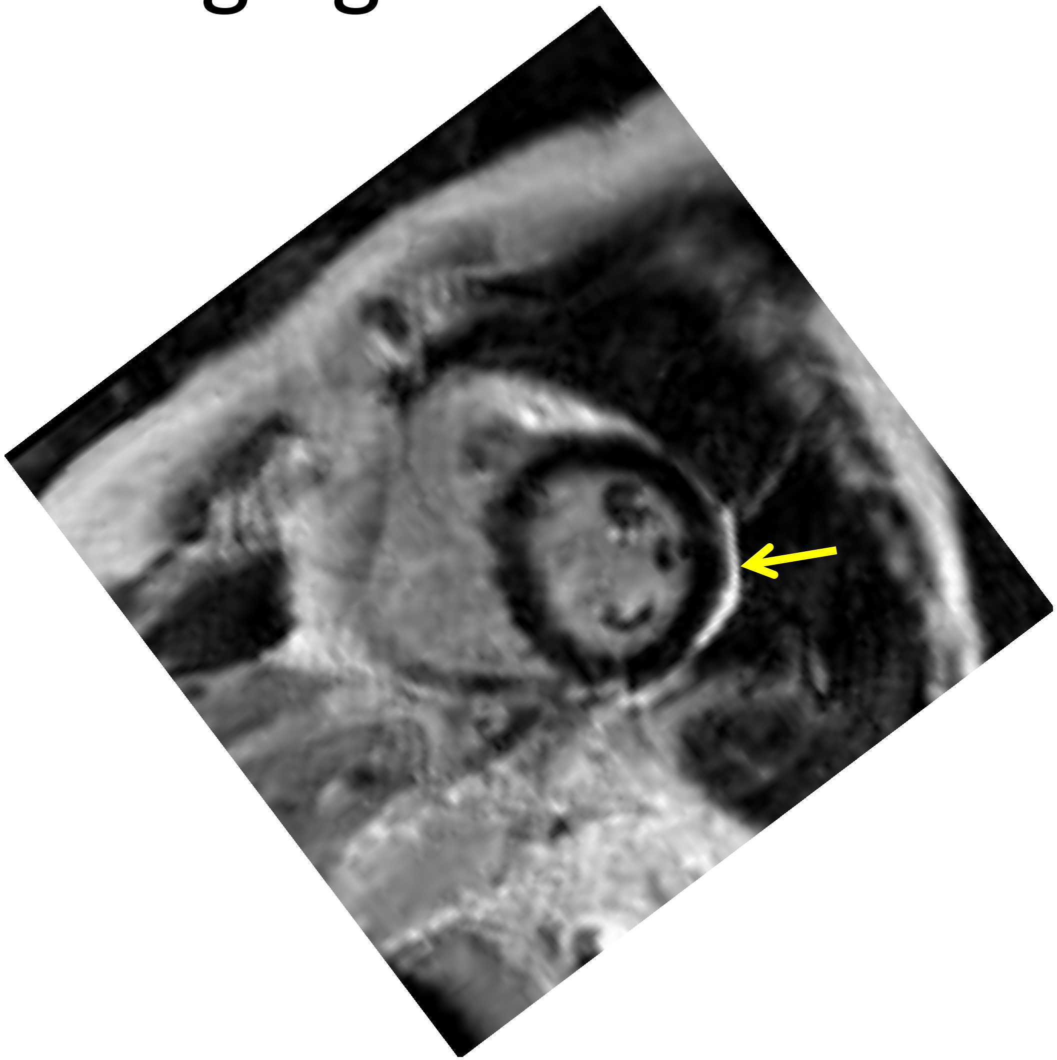
What Are the Common Uses of CMR?

- Structure and function assessment
- Assessment of inflammatory heart disease
- Stress perfusion imaging
- Assessment of myocardial viability, ie detection of infarct scar

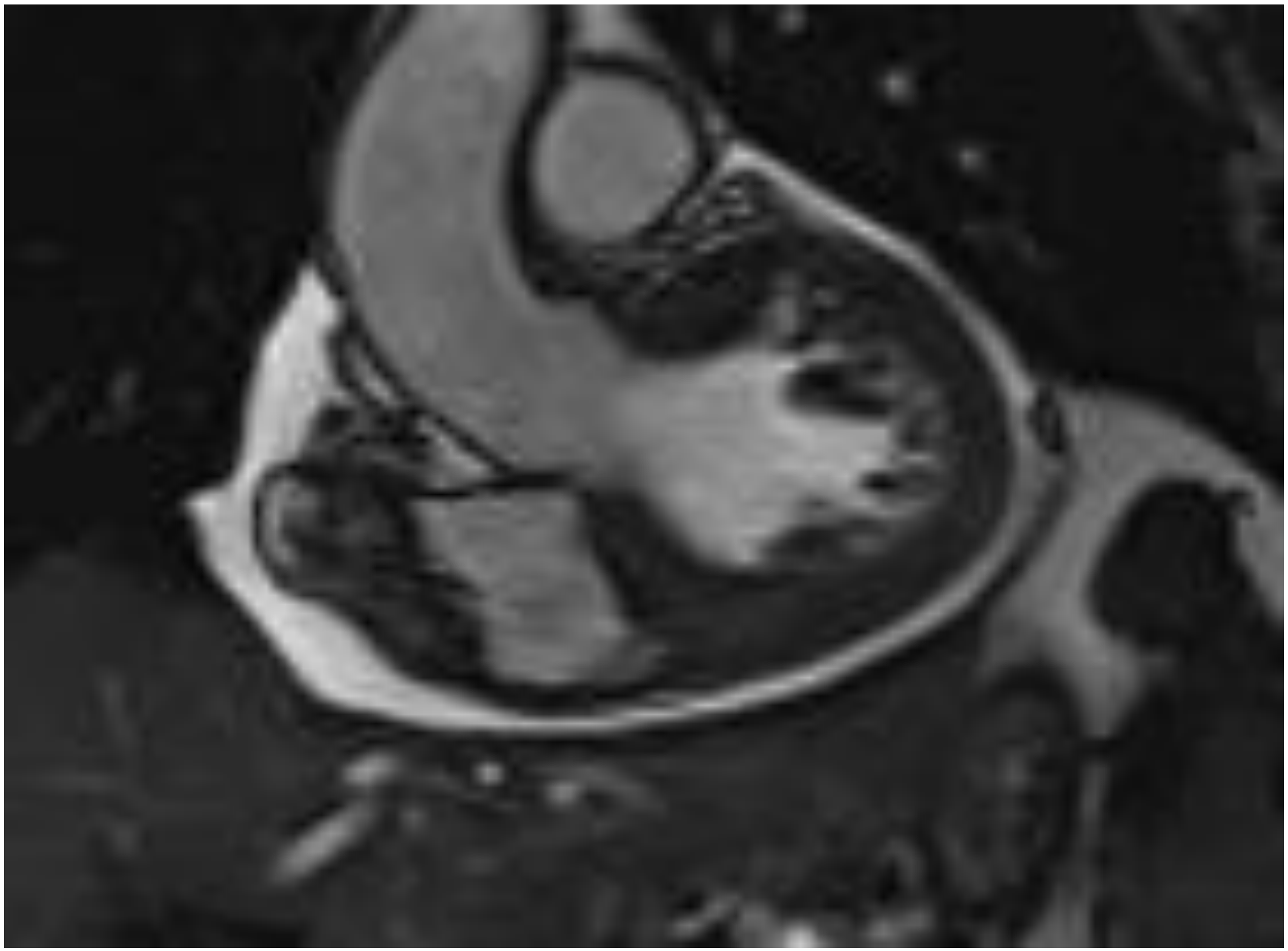


Diffuse Pattern

Pericardial Delayed Enhancement Imaging with Gadolinium



CMR detects pericardial effusions too small for 2-D echo



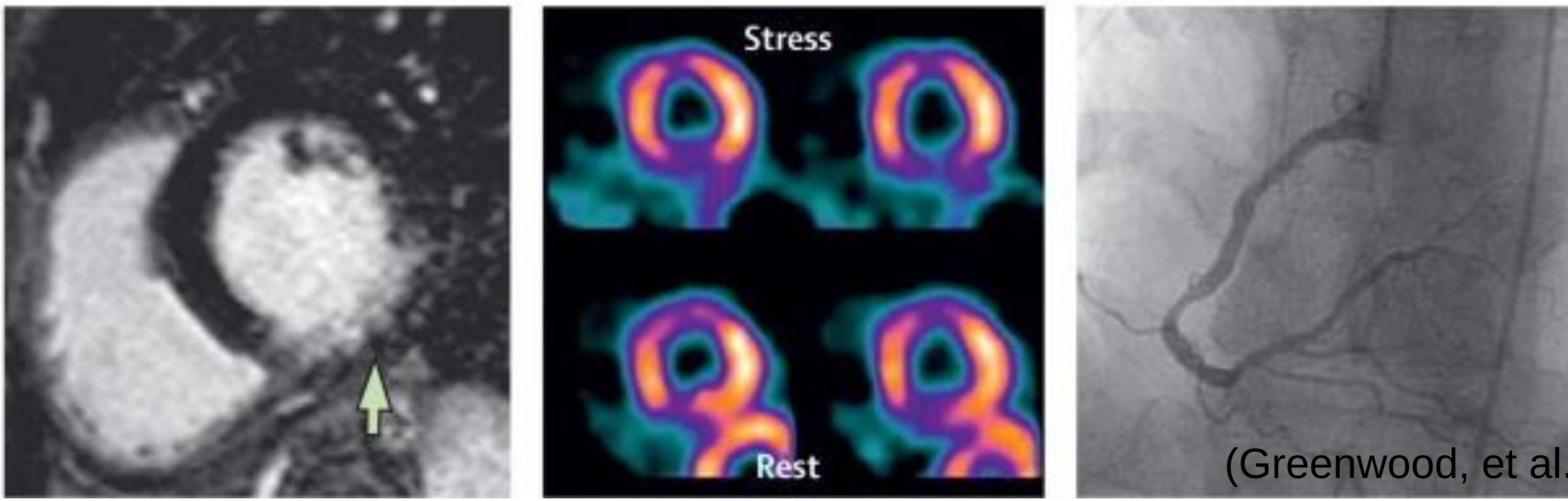
CE-MARC trial

- **CE-MARC comparatively looked at SPECT stress and CMR stress imaging.**
  - **Invasive coronary arteriography was used as a gold standard.**
  - **Claimed CMR was a superior imaging modality**

- **CE-MARC, prospectively enrolled patients scheduled for invasive coronary arteriography.**

CE-MARC trial

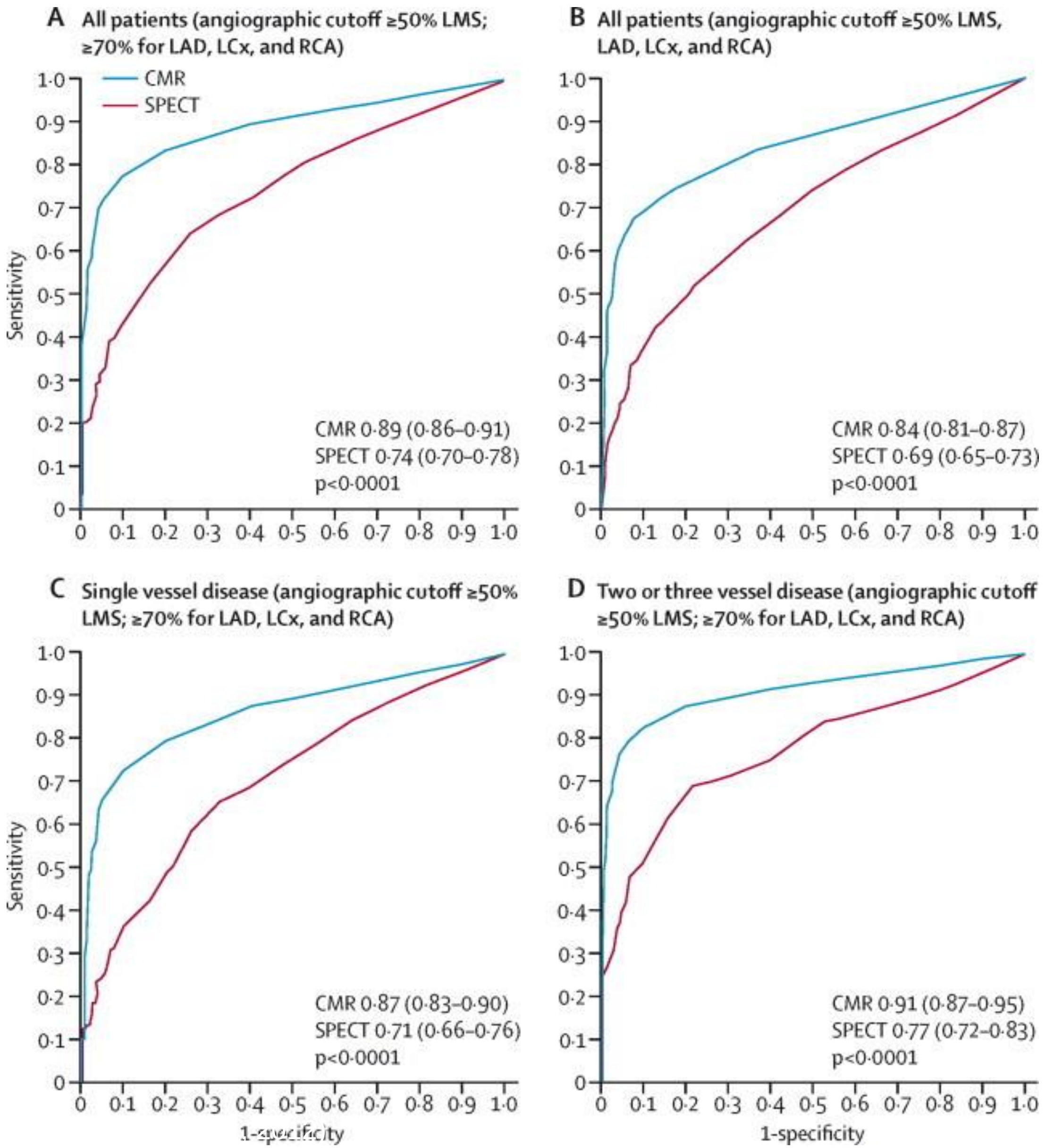
These are some images that the CE-MARC trial used as comparison between all the imaging techniques.



(Greenwood, et al., 20

Figure 1: Three examples of CMR, SPECT, and angiographic findings

CE-MARC trial

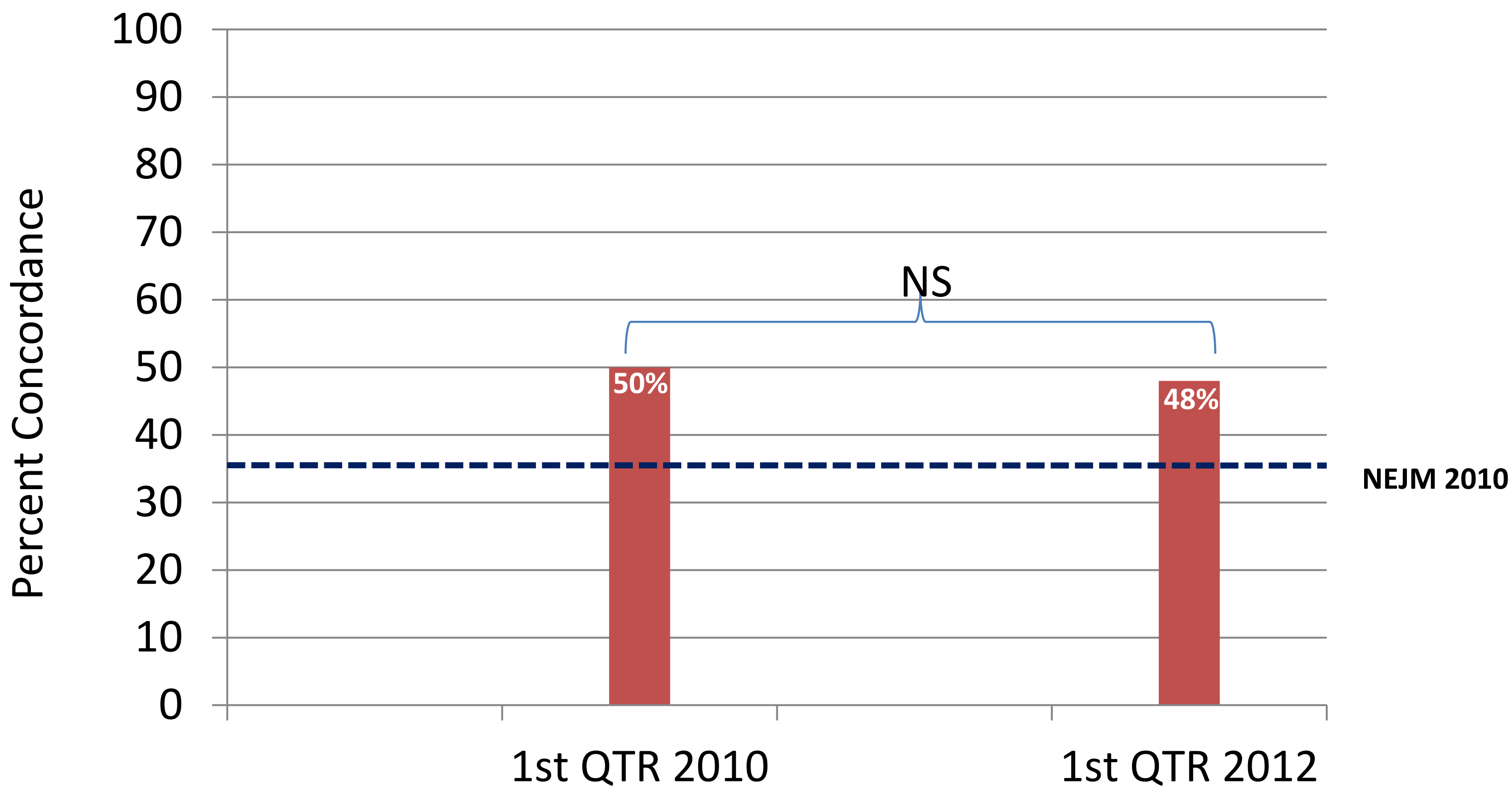


- **1-specificity represents the number of people that had a coronary heart disease**
- **Sensitivity represents the methods (CMR or SPECT) to correctly detect the problem**

Figure 2: Receiver operating characteristic curves of summed stress scores by population and coronary heart disease definition

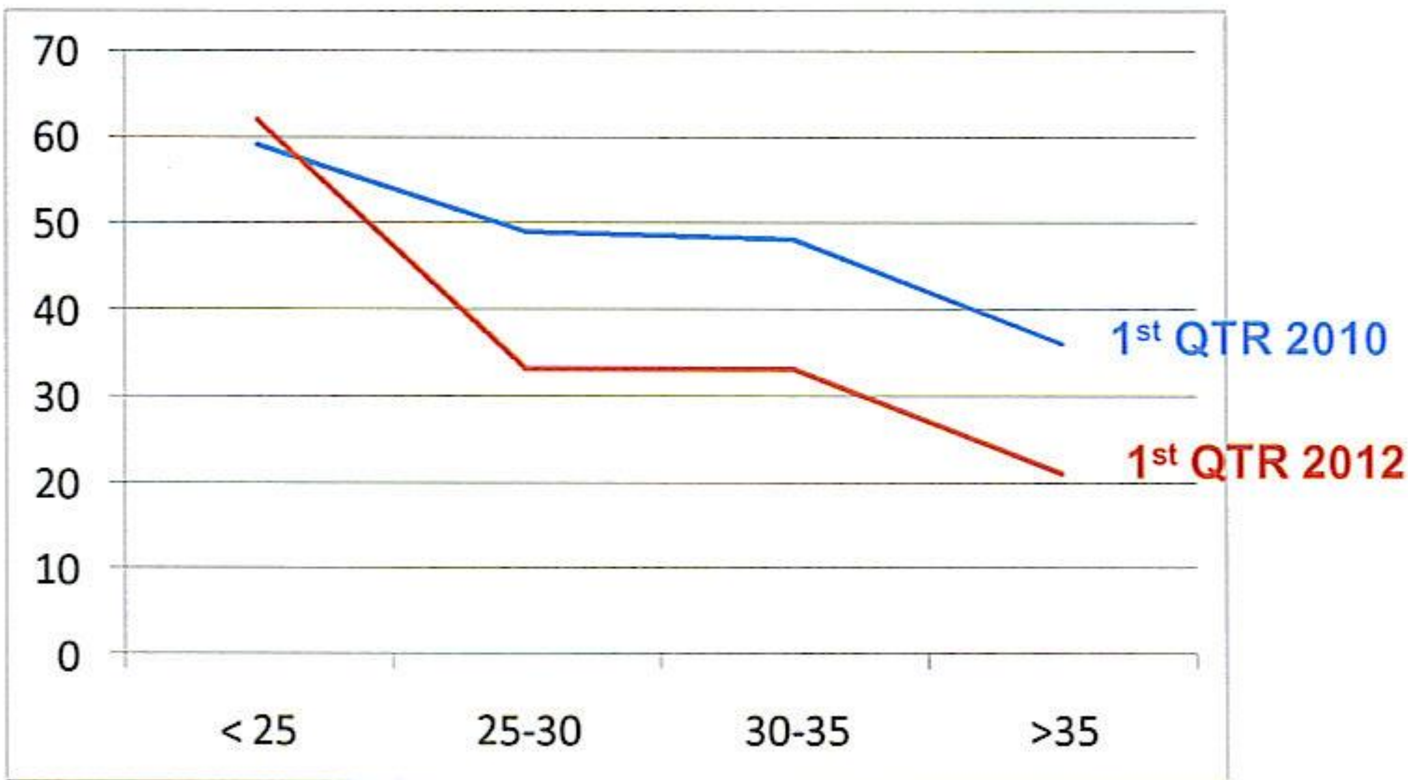
How does the superior performance of CMR stress perfusion imaging translate into practical application in the everyday care of patients with cardiac symptoms ?

Concordance MPI and Cath



EFFECT OF THIRD PARTY PAYOR PRE-AUTHORIZATION POLICY ON CONCORDANCE OF NUCLEAR STRESS PERFUSION IMAGING AND CORONARY ARTERIOGRAPHY
Brendan Malik; J. Ronald Mikolich; Amitha Dhingra; John Lisko;
J Am Coll Cardiol. 2013;61(10_S):. doi:10.1016/S0735-1097(13)61548-X

Concordance of MPI and Cath

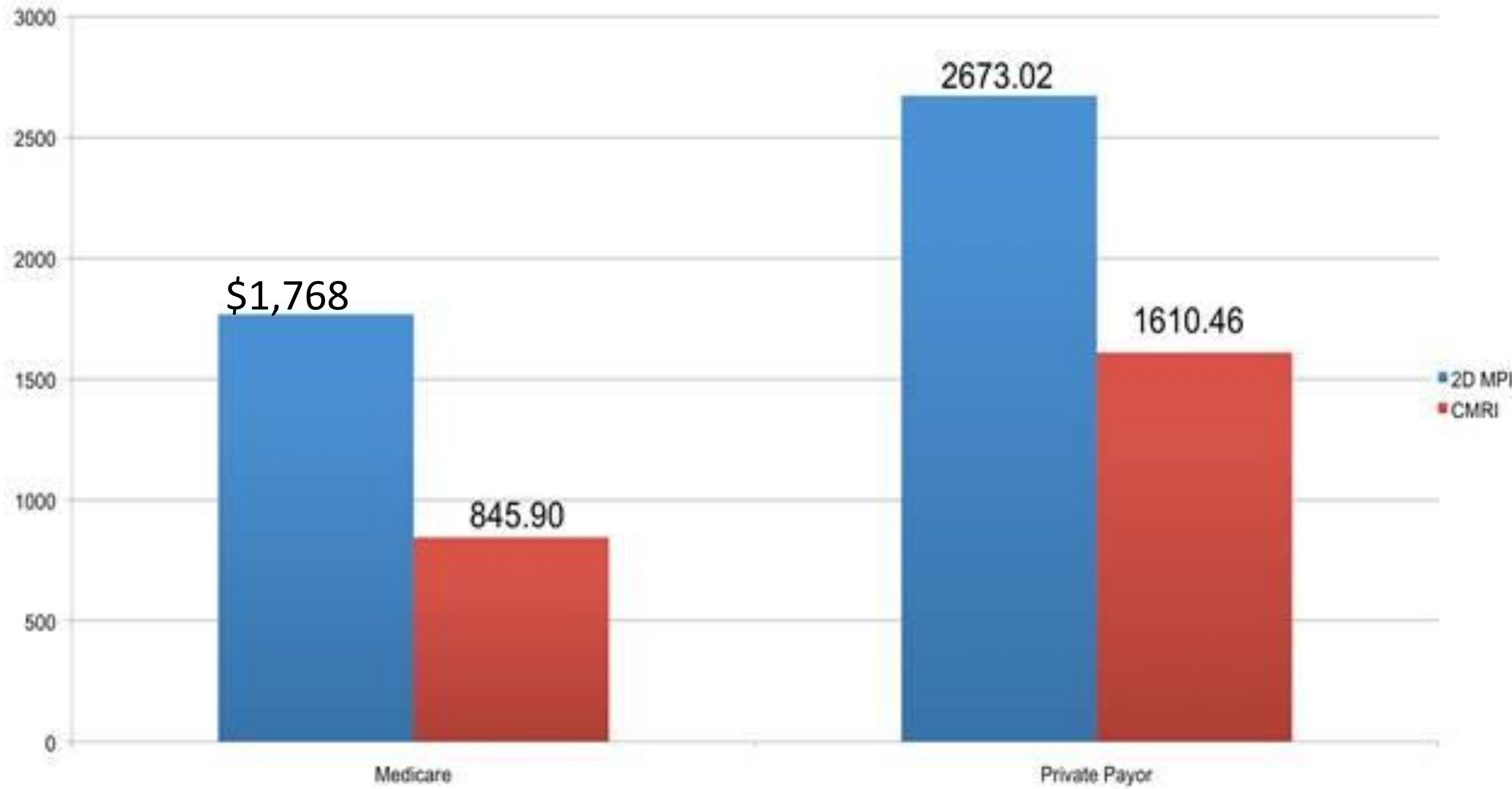


BMI kg/m2

[redacted] Medicare and Private Insurance Reimbursement for Cardiac Diagnostic Testing

Cardiac Diagnostic Test	Medicare $	Private Insurance $
EKG	17.42	30.00
Holter	87.49	195.00
EP	10,022.23	20,044.46
Non-Imaging Stress Test	75.12	200.00
Nuclear Stress Test	770.55	747.07
Echocardiograph	355.78	625.31
Stress-Echocardiograph	355.78	504.25
TEE	286.48	447.00
CT	430.51	641.50
Catheterization	1,900.00	2,400.00
MRI (75563 & 75565)*	661.49	1,346.64
MRI (75557 & 75565)*	306.53	942.41
MRI (75561 & 75565)*	455.55	760.00
* Indicates Code Number for MRI imaging test		

1 year Cost of Imaging for Obese Patients (BMI > 35)

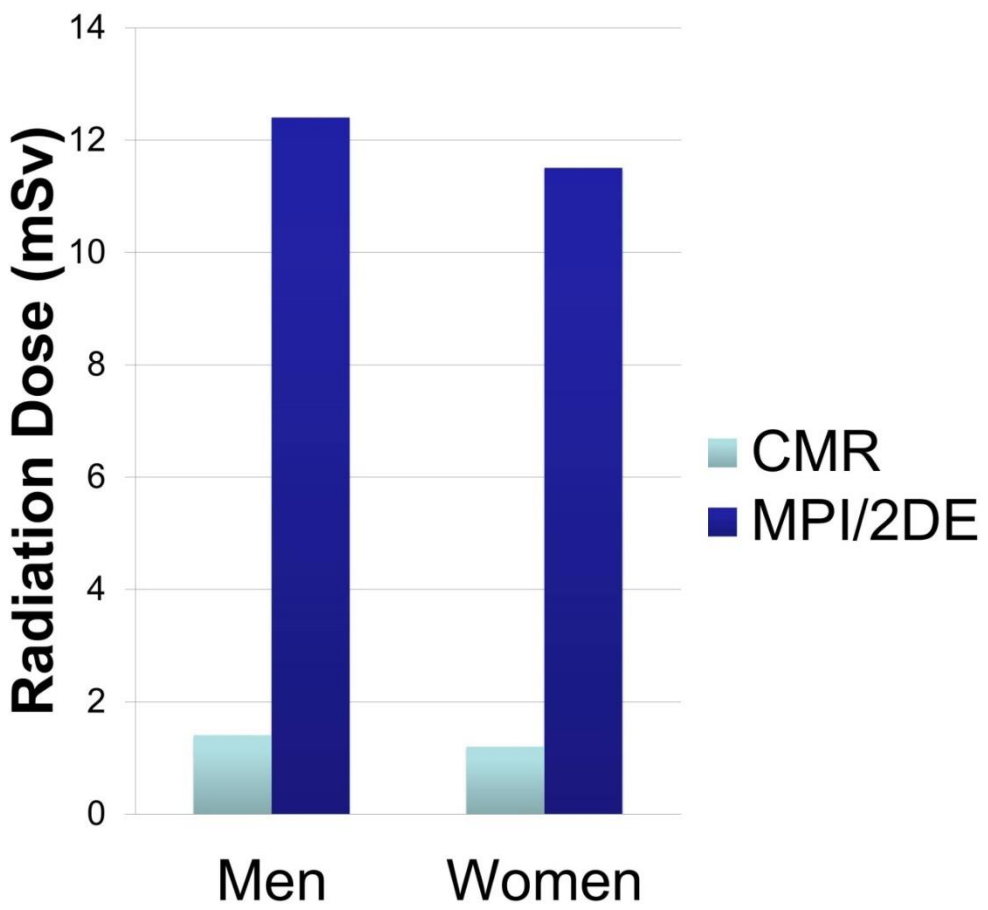


Radiation Dose Considerations

Cardiac Diagnostic Test	Radiation Exposure (mSv)
EKG	0
Holter Monitor	0
EP	3.2
Non-Imaging Stress Test	0
Nuclear Stress Test	12.5
Echocardiography 2-D	0
Stress-Echocardiography	0
TEE	0
Coronary CT angio	10.5
Coronary Arteriography	12.0
CMR	0

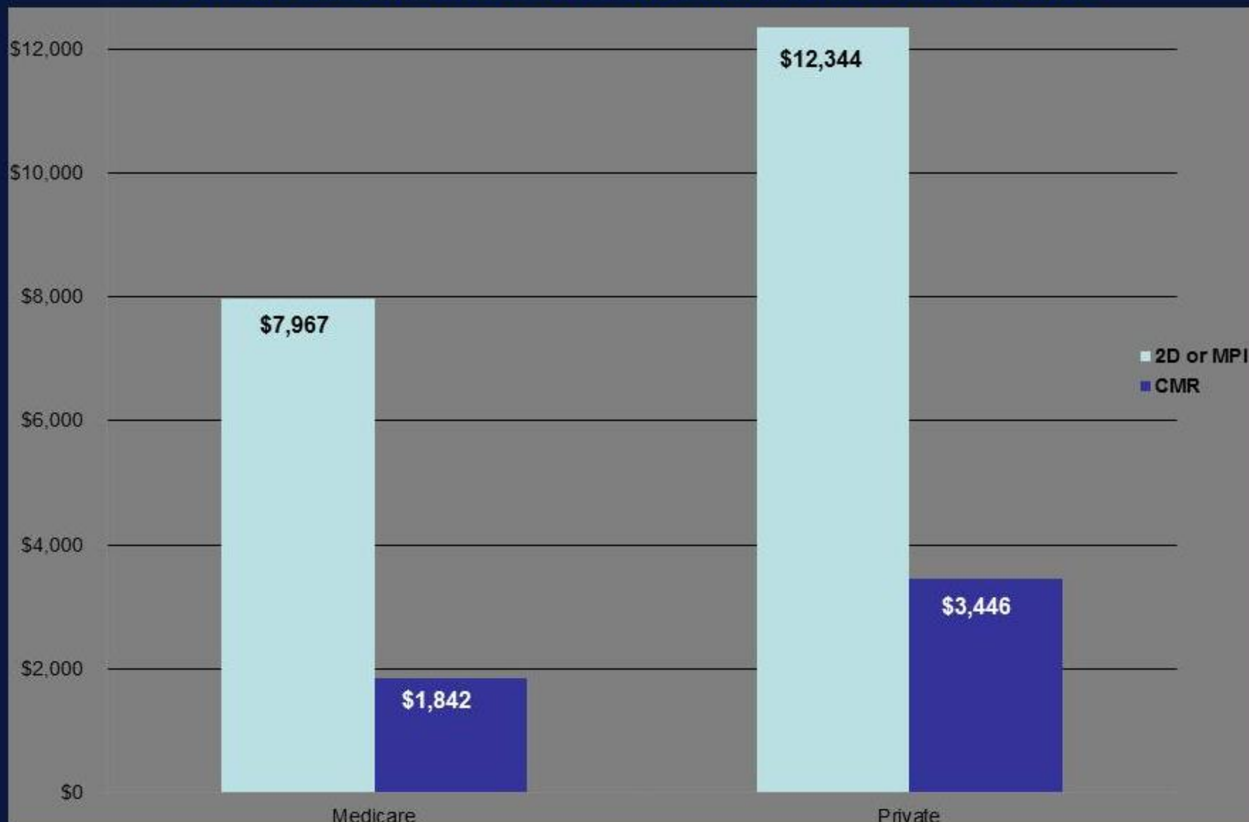
Initial Cardiac Diagnostic Testing: A Radiation Perspective

Julianne Matthews MPH, Nicholas Boniface MPH, Brandon Mikolich MD, and J. Ronald Mikolich MD
Northeast Ohio Medical University and Sharon Regional Health System



What about the use of CMR in non-obese patients ?

Average 1 Year Cost per Patient: CMR vs 2D or MPI For Medicare and Private Insurance Patients



What About AICDs ?

- Current guidelines, based on late 80's and early 90's 2-D echo data recommend AICD implantation for patients with LVEF < 35%
- Have you ever wondered why so many of those patients NEVER have an ICD discharge?
- Maybe it has something to do with the prognostic tool we're using.

Identification of Myocardial Scar

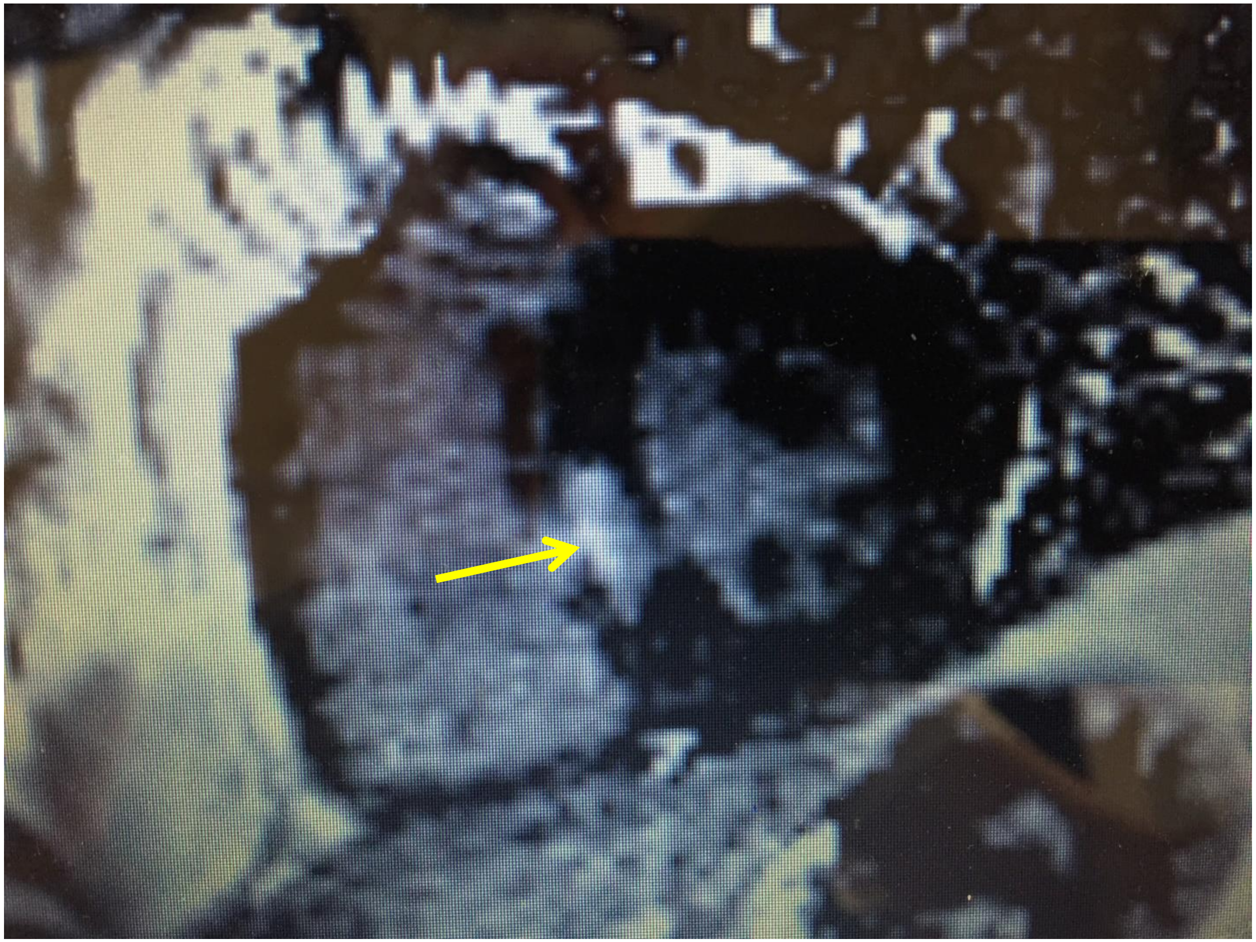
Normal myocardium appears "black"

Gadolinium (Gd) is taken up in the spaces between fibrin in scar

Gd is 400 times brighter than myocardium

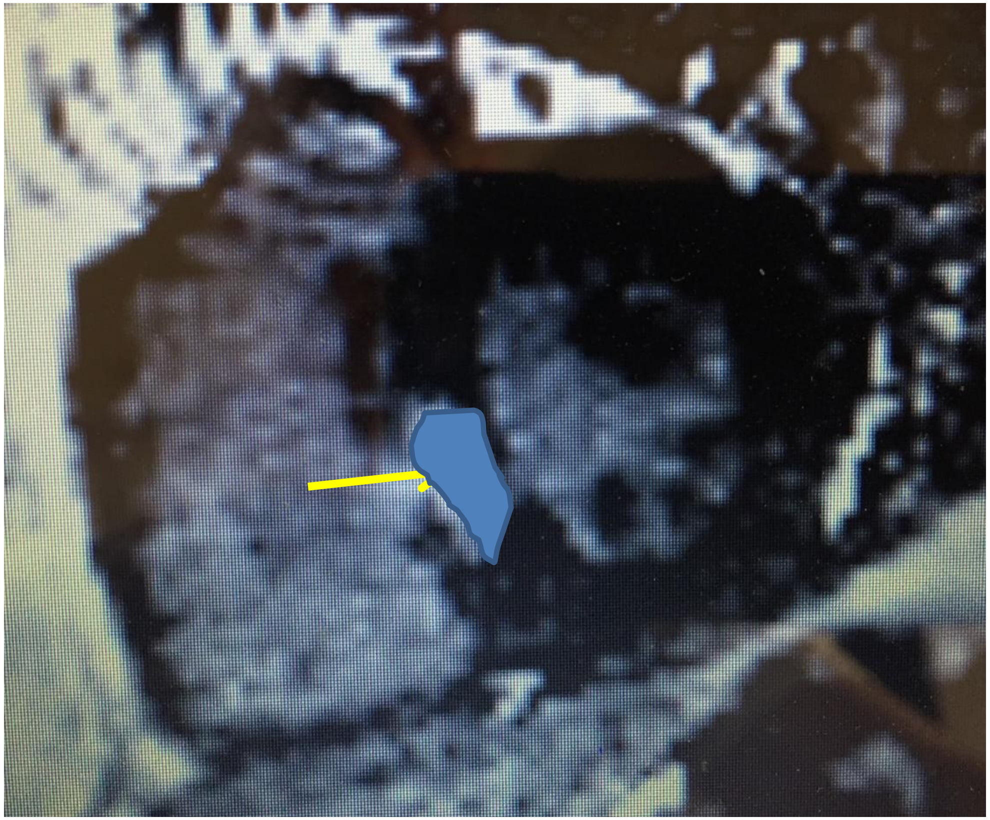
4 chamber view
Late Gadolinium Enhancement
(LGE)

Septal MI via Gadolinium Enhancement



2 Chamber short axis view

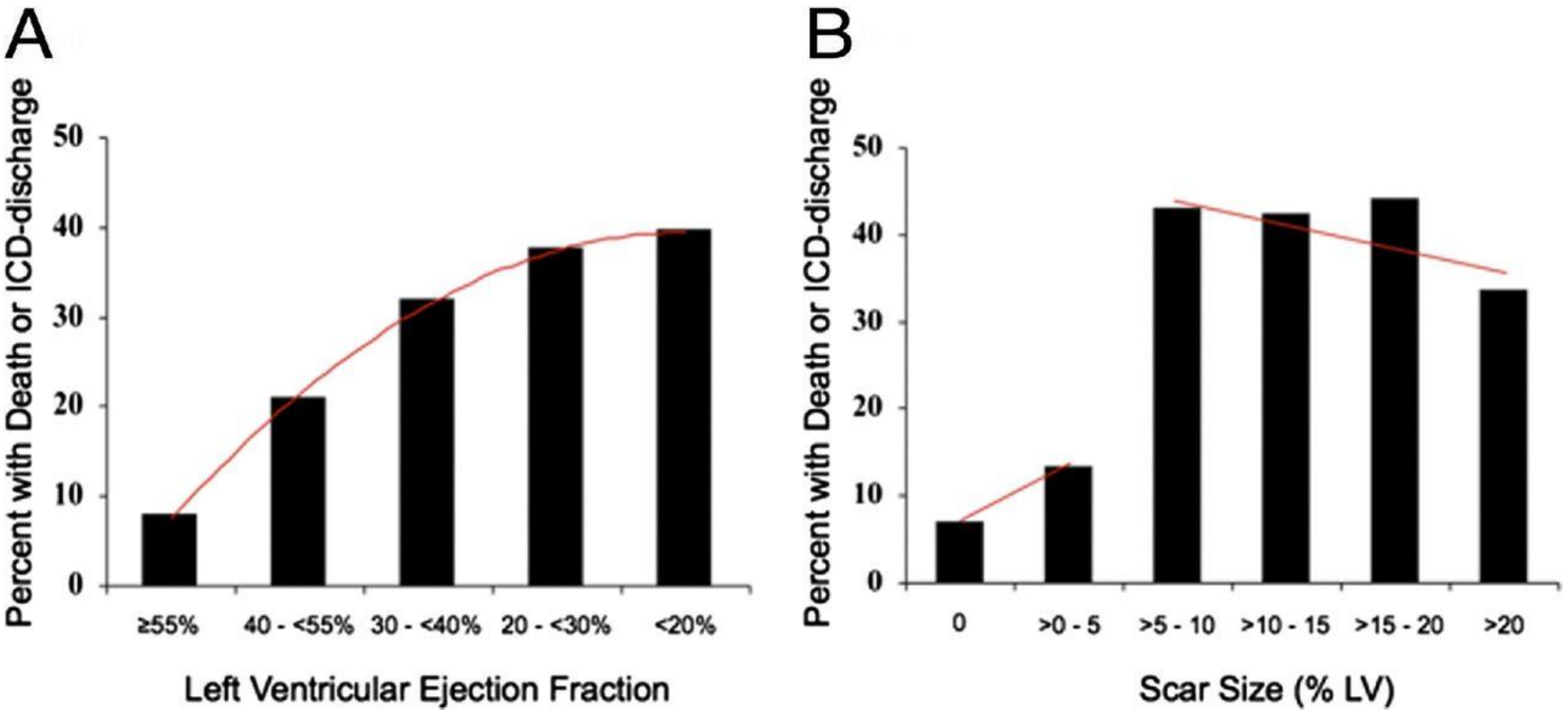
Quantification of Myocardial



AICD Outcome Data

- Kim et al at Duke studied 137 patients who underwent AICD implantation based on 2-D echo criteria, per current guidelines
- All patients had a cardiac MRI study pre-ICD including ejection fraction and % myocardial scar
- 3 year follow-up for sudden cardiac death or ICD discharge

Outcomes: EF vs % Scar



Igor Klem et al. JACC 2012;60:408-420

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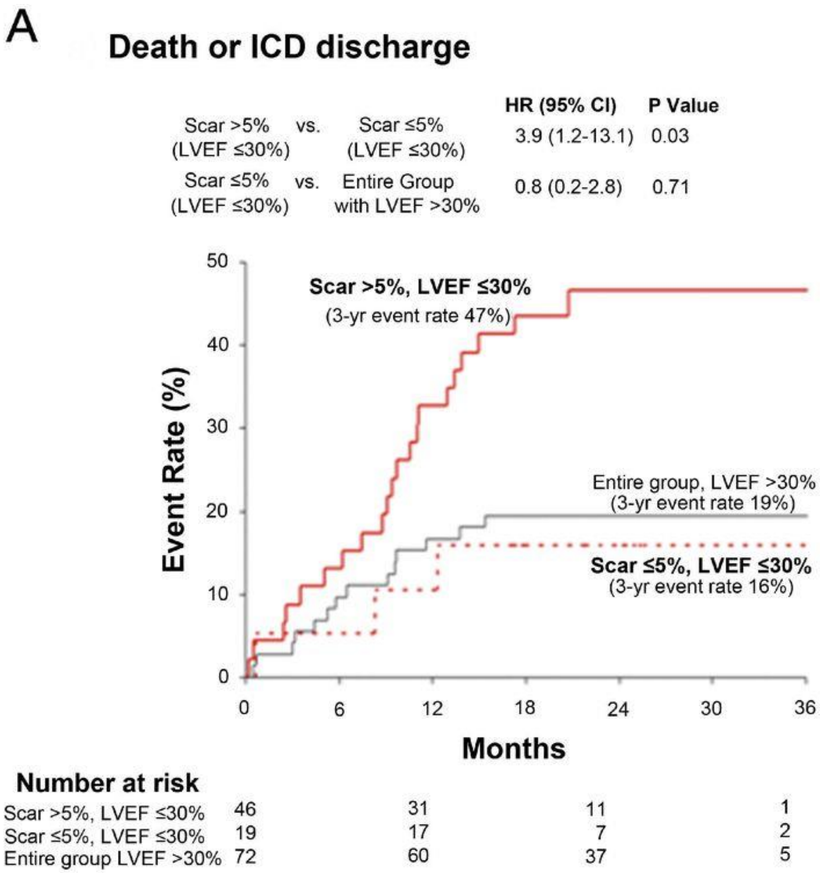


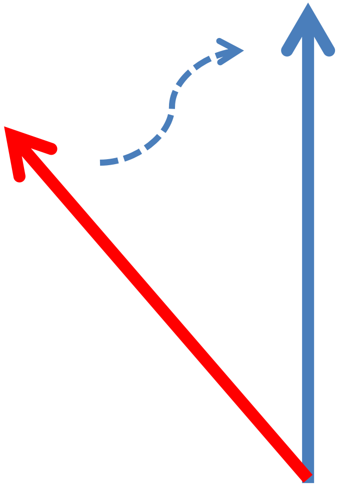
Igor Klem et al. JACC 2012;60:408-420

So, do you want your AICD implanted on the basis of your LV ejection fraction or your percentage of myocardial scar ?

The Future: Lighting the Dark

- A test which could differentiate myocardial ischemia from non-cardiac chest pain in less than 15 min
- A test which does not require contrast
- A test which does not involve radiation exposure
- A test with 97% accuracy

T1 Relaxation Time



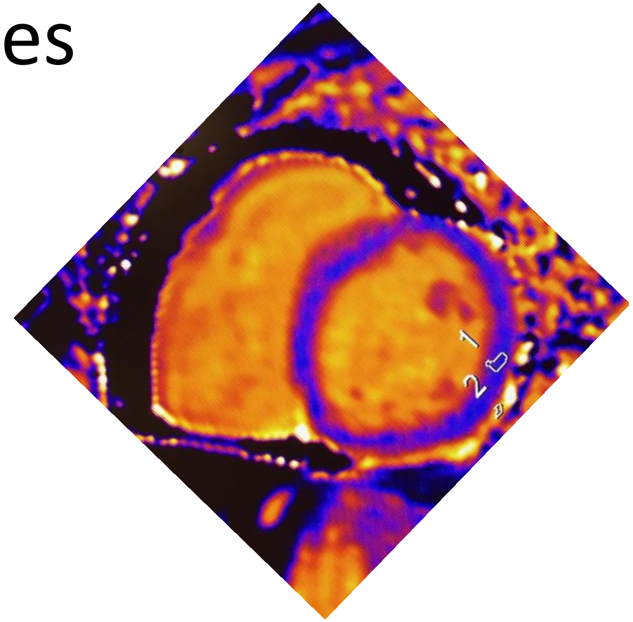
Since myocardial cells are mostly water, changes in myocardial water content will alter the T1 relaxation time.

Increased T1 Relaxation Time

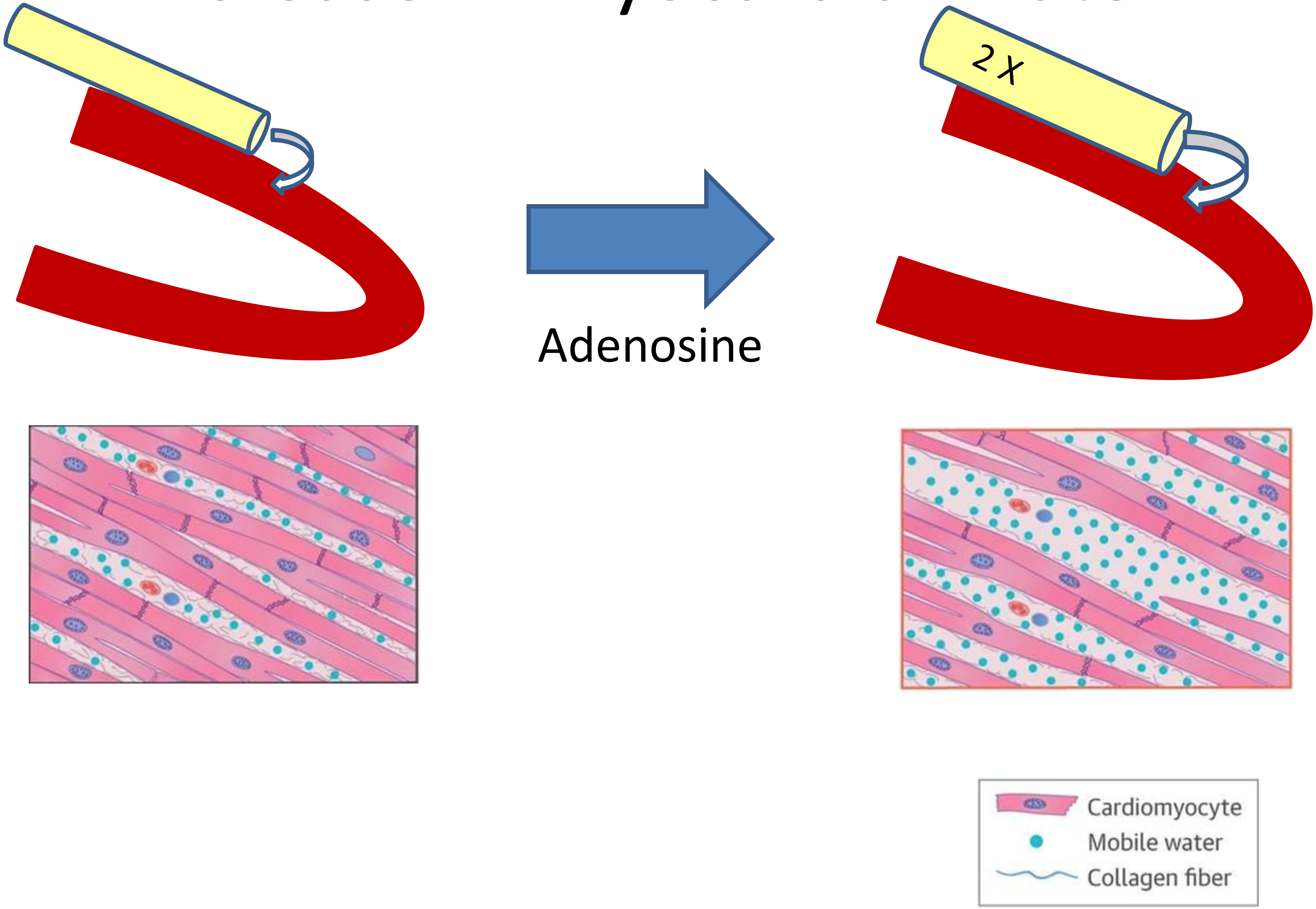
- Myocardial edema
- Acute myocardial infarction
- Acute myocarditis
- Global myocardial injury due to sepsis
- Myocardial fibrosis
- Myocardial amyloidosis

More Recent Findings of T1 Relaxation Times

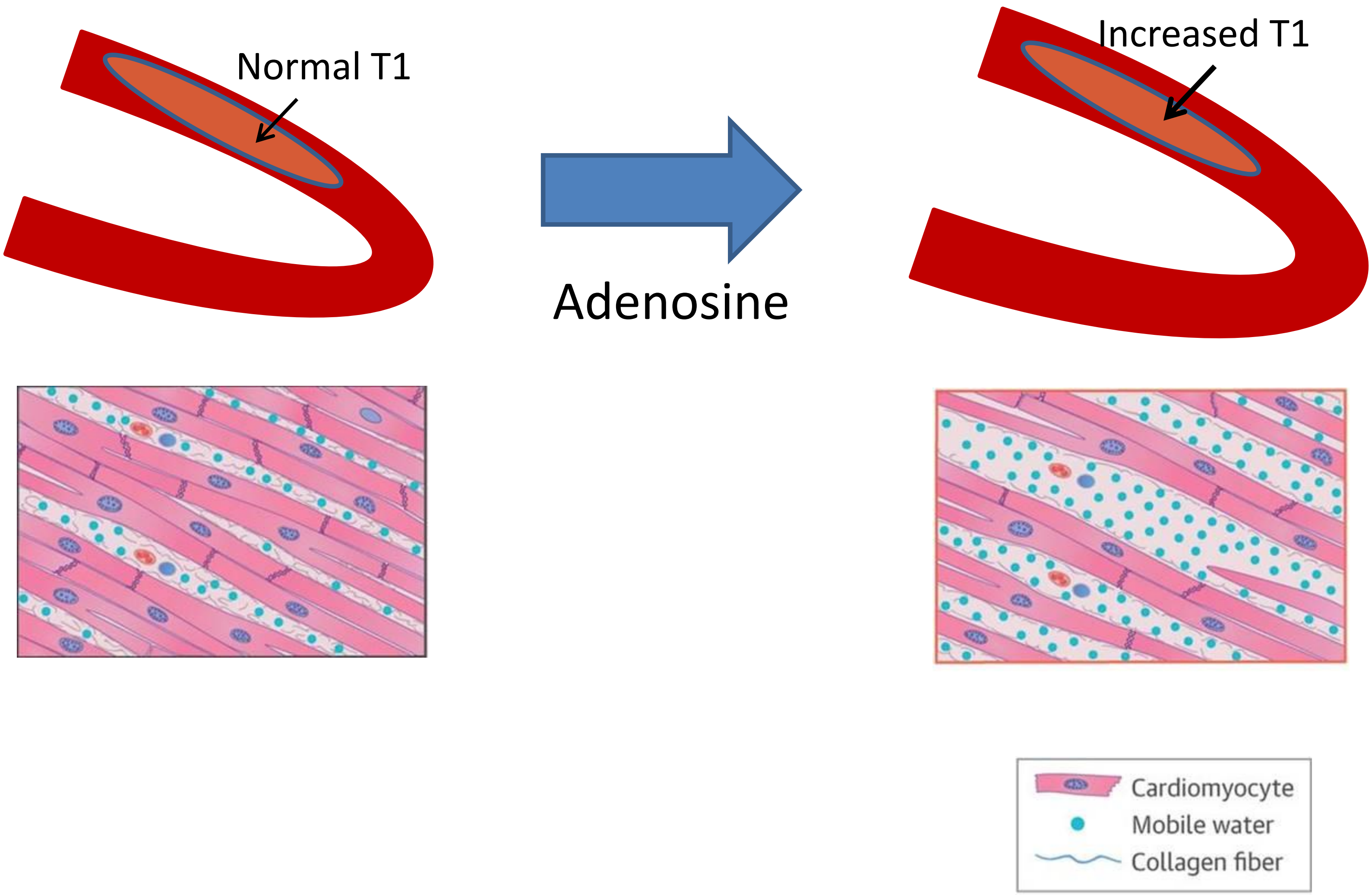
- Increase in coronary blood flow, ie exercise, vasodilation with adenosine
- T1 relaxation times can now be "mapped" and color coded on CMR images

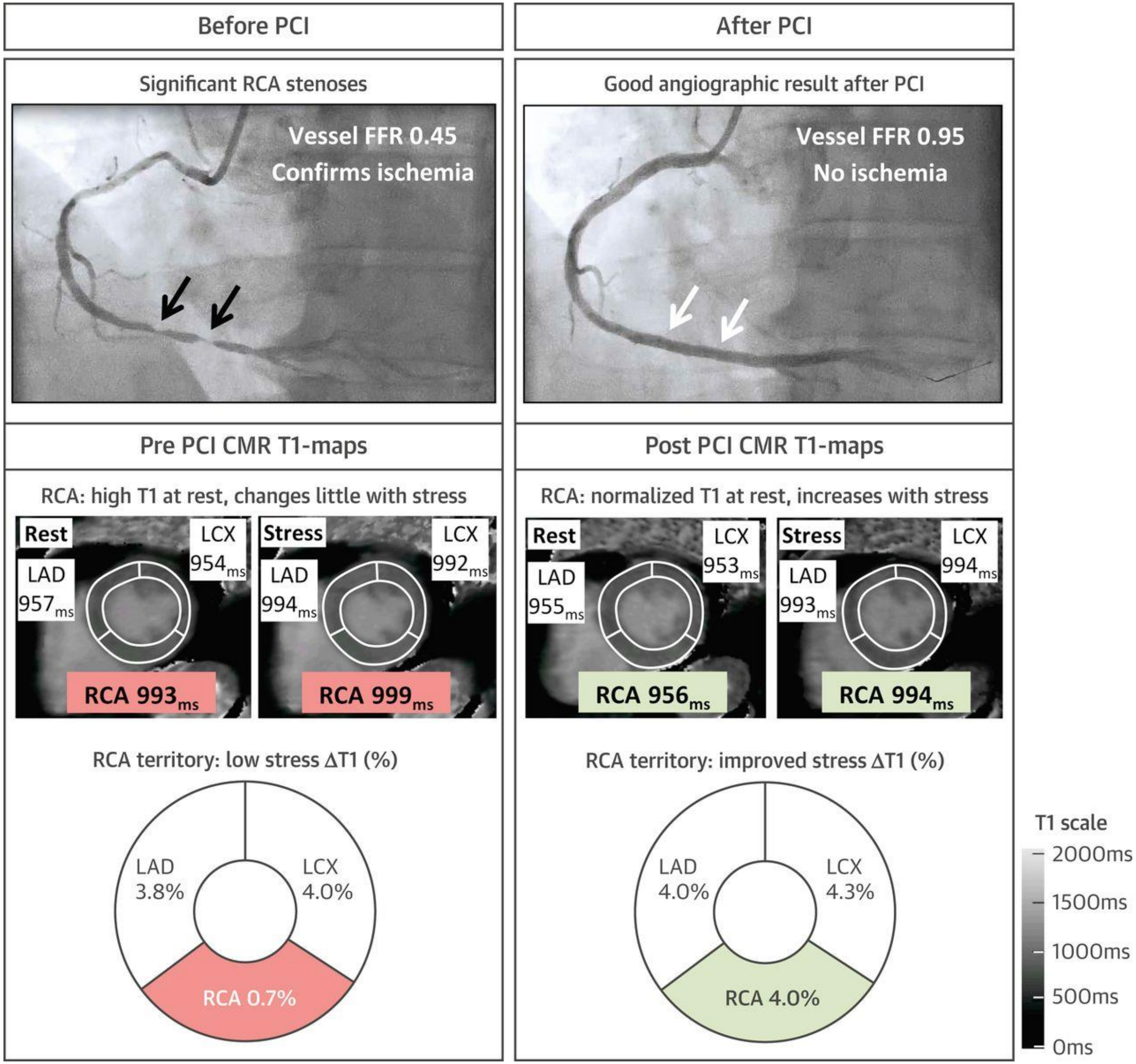


Increase in Myocardial Flow Causes an Increase in Myocardial Water



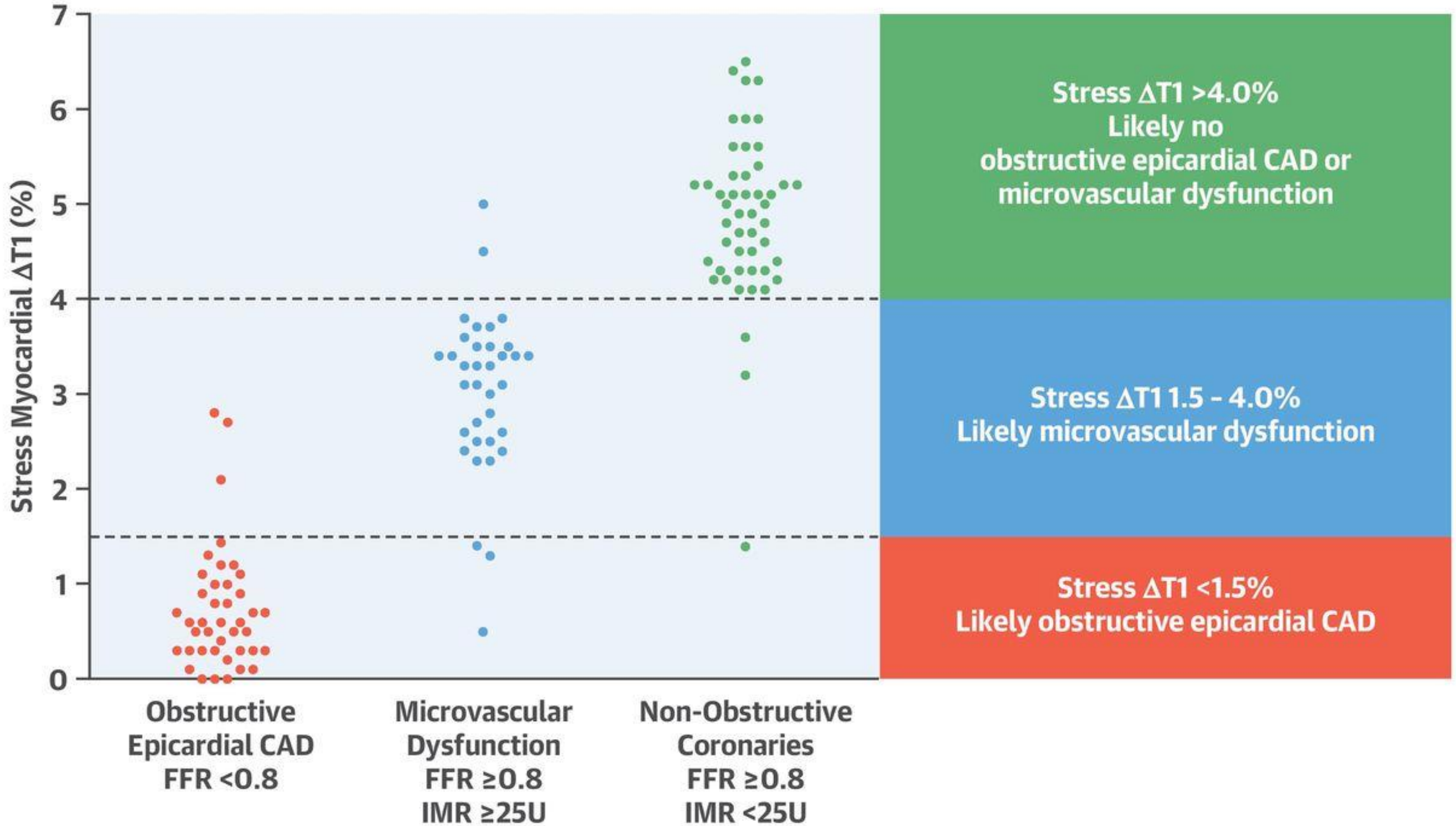
Increase in Myocardial Flow and Water Causes an Increase in T1 Relaxation Time



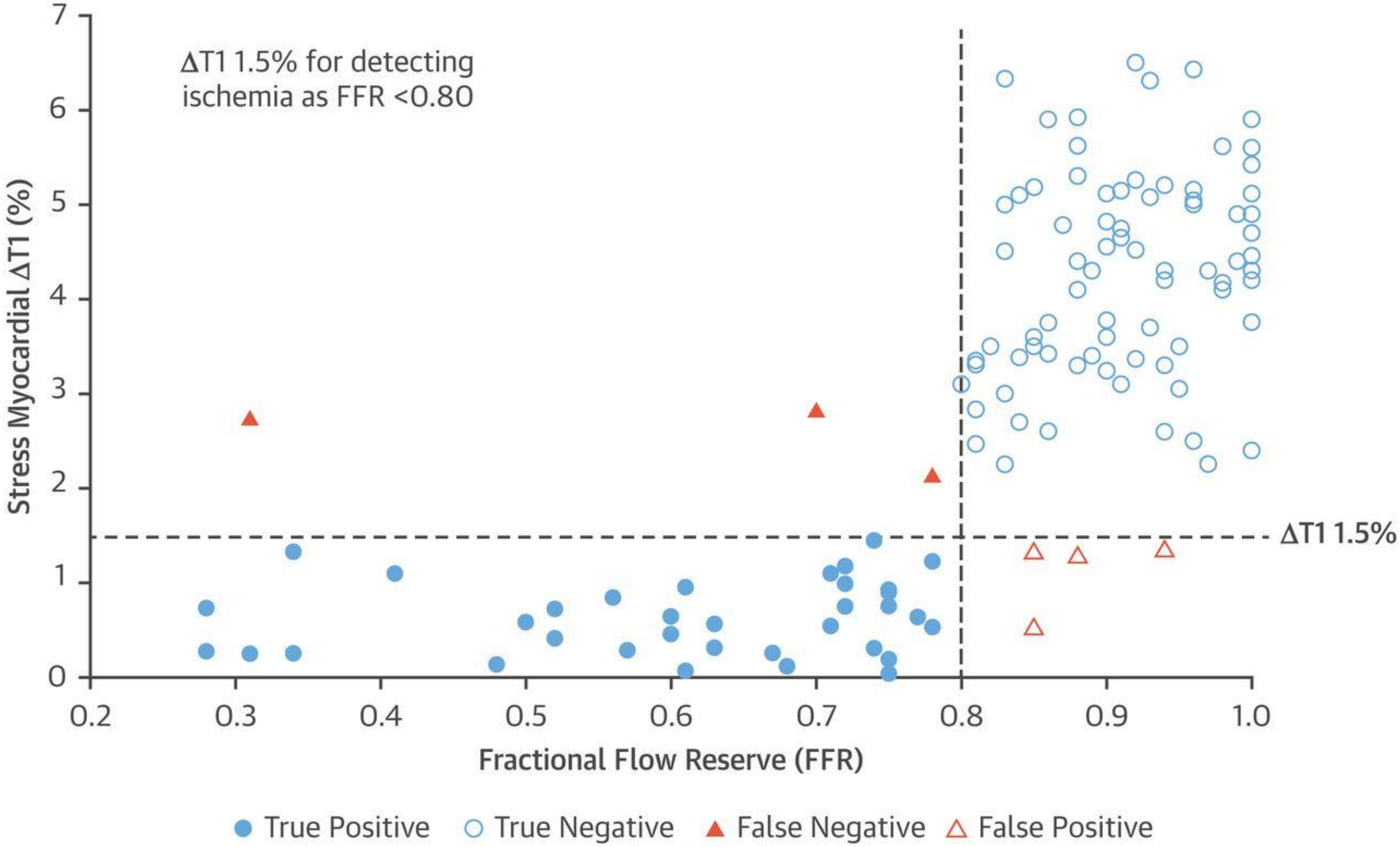


Alexander Liu et al. JACC 2018;71:957-968

CENTRAL ILLUSTRATION: CMR Stress T1 Mapping for the Assessment of Epicardial and Microvascular CAD



Liu, A. et al. J Am Coll Cardiol. 2018;71(9):957-68.



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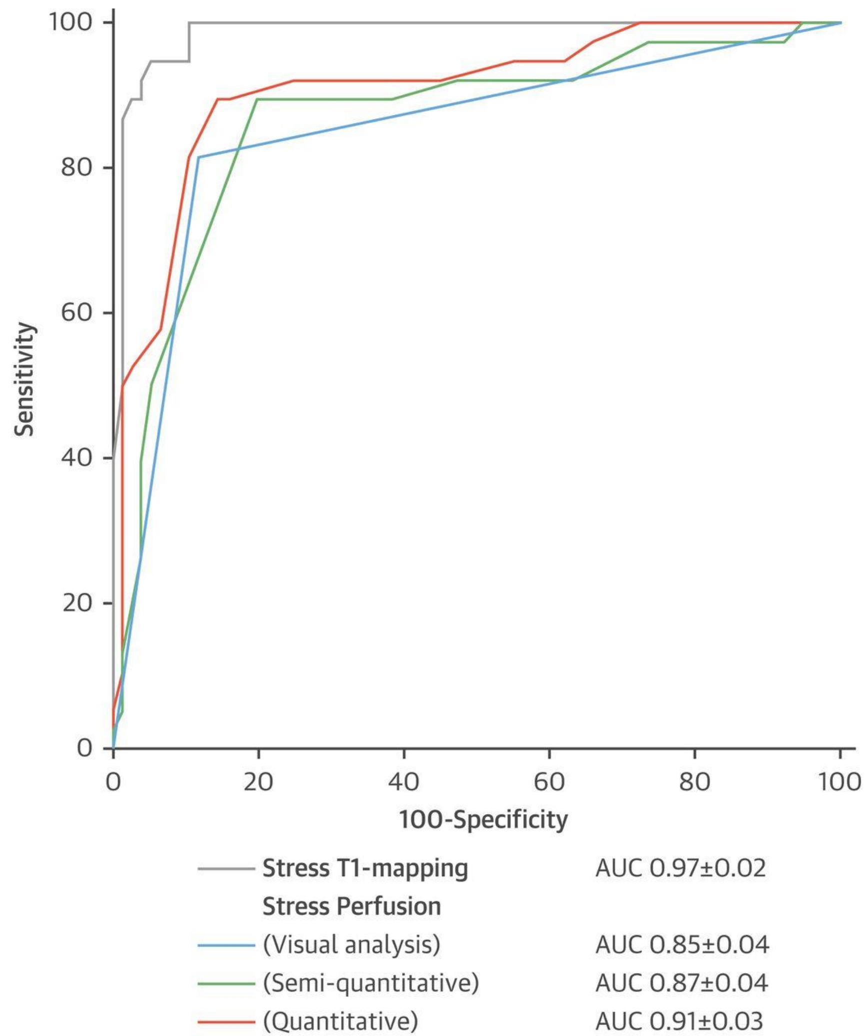

Alexander Liu et al. JACC 2018;71:957-968

How Can CMR Help You in Your Practice at Your Hospital ?

- Better detection and quantification of many common cardiac pathologies
- More accurate assessment of myocardial ischemia and scarring for therapeutic decisions
- Reduction in cost
- Reduction in patient radiation exposure
- Detection of inflammatory heart disease