Myocardial Viability: Cardiac MRI or PET

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Disclosure

- None

Definition of viable myocardium

- Viable = Alive, Salvageable or able to regain function.
- Viable cardiomyocytes? Myocardial segment/s?
- Viable myocardium: Myocardial segments with reduced function that often appear dysfunctional on imaging studies. These segments are capable of functional recovery, either spontaneously or after the offending insult – usually ischemia – is removed by revascularization.

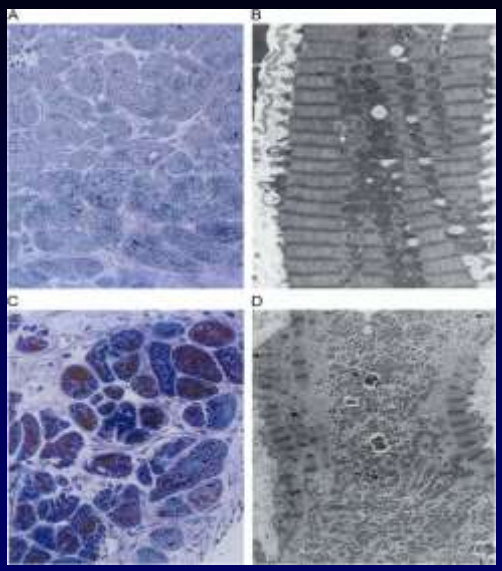
Basic concepts

- Viable myocardium is dysfunctional but alive
- Myocardial scars are dysfunctional and non-viable
- Stunned myocardium is dysfunctional and capable of spontaneous recovery
- Hibernating myocardium is dysfunctional and ischemic and revascularization may lead to functional recovery.

Problems with these definitions

- This is an oversimplification.
- Not all myocardial scars are full thickness and the degree of transmurality would determine the degree of functional recovery with revascularization.
- Techniques that are very sensitive in detecting viable myocardium may not translate into functional recovery after revascularization.
- Functional recovery is the 'gold standard' of myocardial viability assessment

Histopathologic Characteristics



1-Loss of contractile proteins (sarcomeres).

2-Glycogen-rich perinuclear zones adjacent to areas of numerous small mitochondria

3-Substantial loss of sarcoplasmic reticulum.

4-Nuclear changes with heterochromatin distributed evenly over the nucleoplasm

5-Downregulation of beta adrenergic adenylyl cyclase

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Seminars in nuclear medicine 2014

Assessment of Viability

- Dobutamine Stress Echo/MRI (Contractile Reserve).
- Myocardial Contrast Echo (Microcirculatory integrity)
- SPECT imaging using Tc labelled compounds (Intact Mitochondria).
- SPECT imaging using Thallium 201 (Cell membrane integrity).
- PET-FDG (Myocardial glucose utilization).
- Cardiac MRI (Scar detection and Contractile reserve).

Why PET

- The most well-studied method: Compares perfusion and metabolism of the heart.
- Very high energy output allows for clear imaging, less interobserver and intra-obsever variation.
- Can be combined with CT to better identification of soft tissue artifact.
- Absolute blood flow can be measure.
- Predictive of outcomes

Limitations

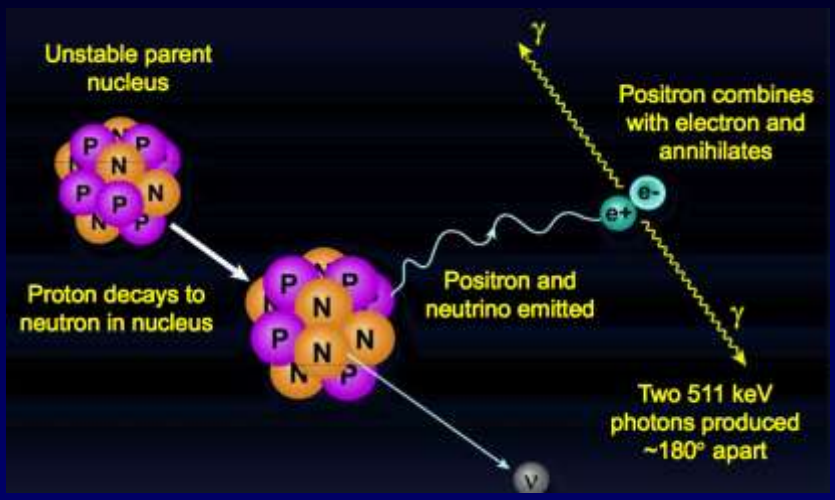
- Lower specificity to dob.echo & MRI
- Cannot differentiate b/w endocardial and epicardial viability
- High cost
- Limited availability

Data on PET

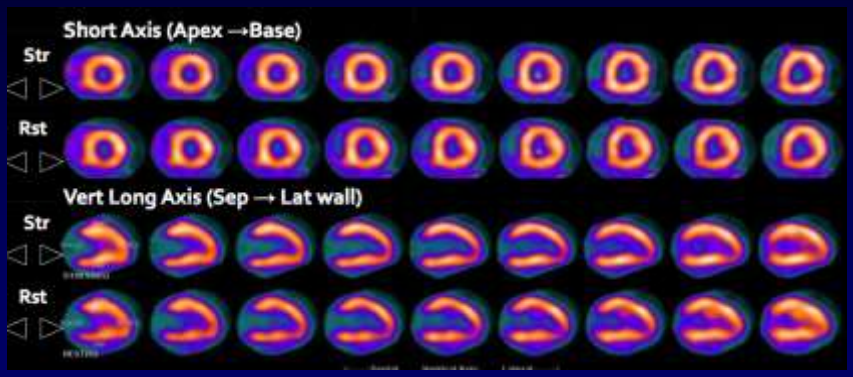
For predicting segmental functional recovery, the pooled data showed

- Sensitivity of 93%
- Specificity of 58%

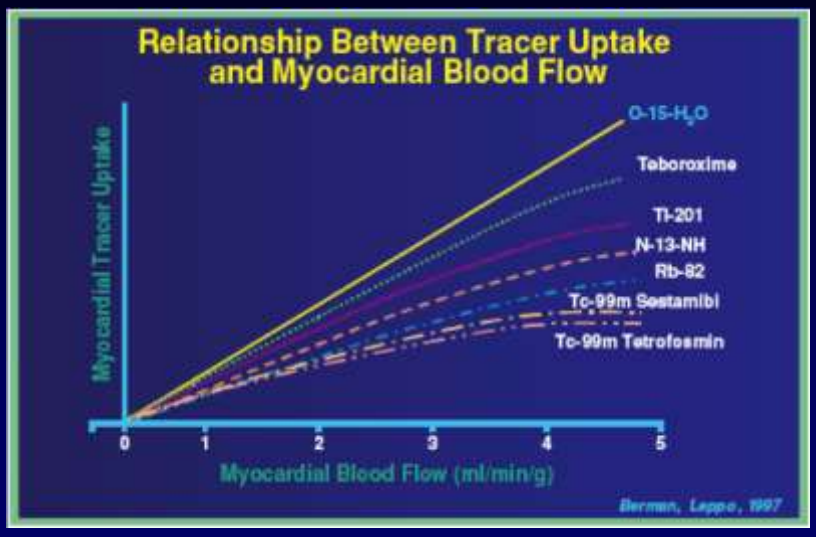
Positron Emission and Annihilation



Example of PET Imaging



PET Tracers versus SPECT



PET Tracers

- **Perfusion Agents**
  - Rubidium-82
  - N-13 Ammonia
  - O-15 Water
- **Metabolic Agents**
  - F-18 Fluorodeoxyglucose

PET Perfusion Agents

AGENT	1/2-LIFE	DOSE	MEAN POSITRON RANGE	PRODUCTION
O-15 Water	2.0 min	60–100 mCi	1.1 mm	Cyclotron
N-13 Ammonia	9.8 min	7–20 mCi	0.7 mm	Cyclotron
Rb-82	75 sec	20–60 mCi	2.4 mm	Generator

Metabolic imaging

- The myocardium typically uses 2/3 fatty acid oxidation and 1/3 glucose to meet its energy needs.
- During ischemia, energy production is shifted from fatty acid oxidation to glucose which may contribute up to 70%of the total energy production.
- Uptake of glucose increases in the post-prandial state. So usually the patient is asked to fast for 6 hours followed by administration of a glucose load (25-100g) to stimulate natural insulin production.

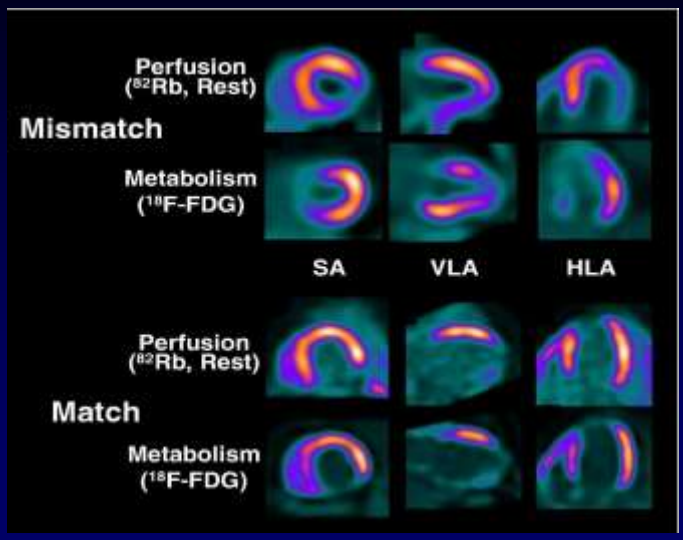
Metabolic imaging

- ^{18}F-FDG is a glucose analog
- Initial uptake is comparable to glucose uptake
- After phosphorylation, it remained trapped in the myocyte and cannot be further metabolized and therefore becomes a strong signal for imaging

PET Viability Interpretation

- Areas that are well perfused with metabolic activity are viable
- Flow metabolism mismatch-reduced perfusion with intact metabolism: hibernating viable myocardium
- Flow metabolism match-impaired FDG uptake with reduced perfusion-scar

PET Viability Interpretation

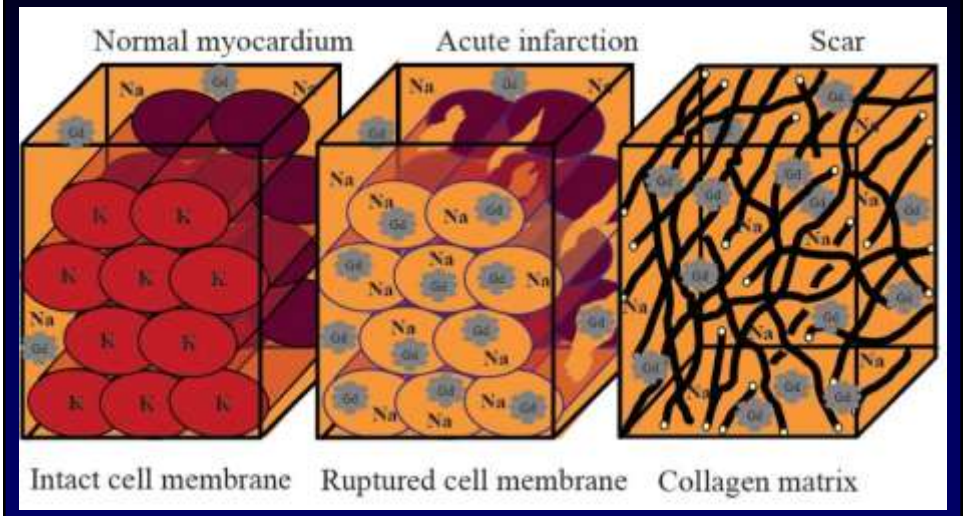


Frank M. Bengel et al. JACC 2009;54:1-15

Cardiac MRI for Viability

- Preserved wall thickness >5.5mm correlated with PET viability
- Dobutamine cine MRI
  - Improved thickening>2mm by low dose dobutamine CMR
  - Higher accuracy than dobutamine echo
  - Monitoring difficult
- Delayed enhancement MRI(DEMRI)

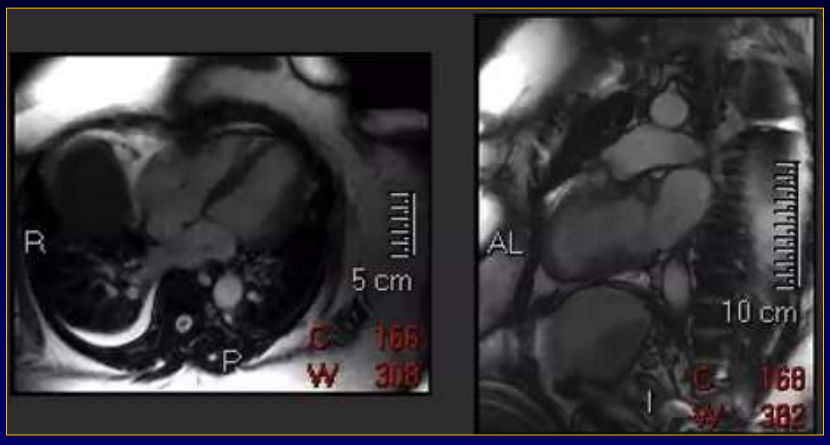
Mechanism of Late Gadolinium Enhancement in infarcted or scarred tissue



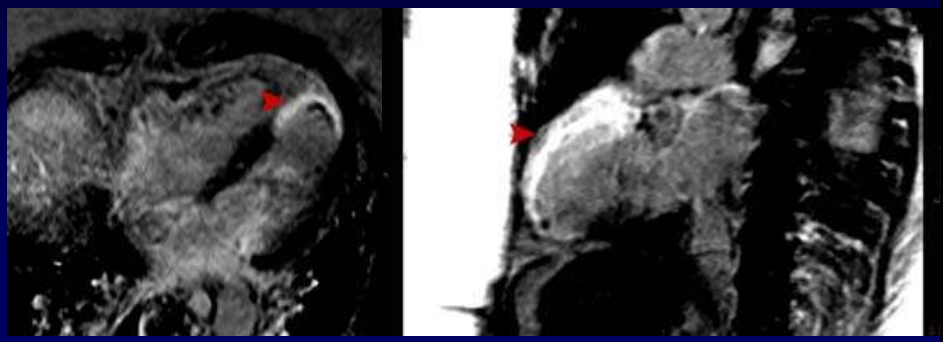
Cardiac MRI for Viability

- Scarring begins at sub-endocardial surface and extends toward the epicardium
- Transmural extent of infarct used to determine viability of each segment.
- Likelihood of functional improvement inversely related to TEI
- 78%with no delayed hyperenhancement improved, only 2% with >75% TEI improved (Kim RJ et al; NEJM 2000)

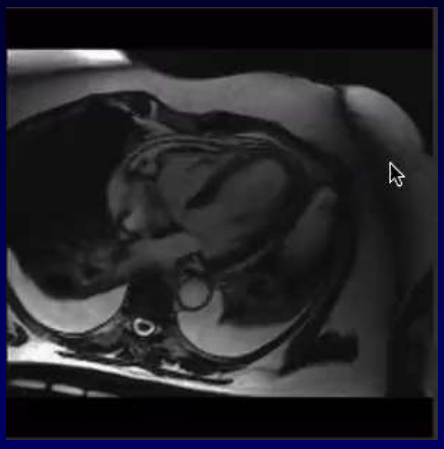
SSFP cines imaging



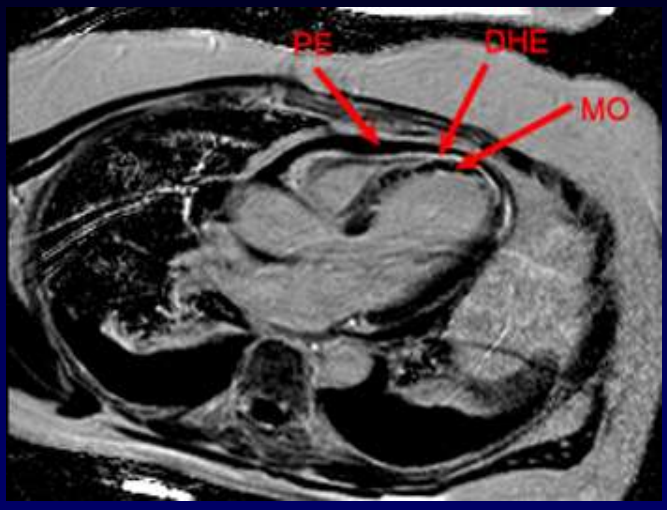
Delayed Enhanced imaging



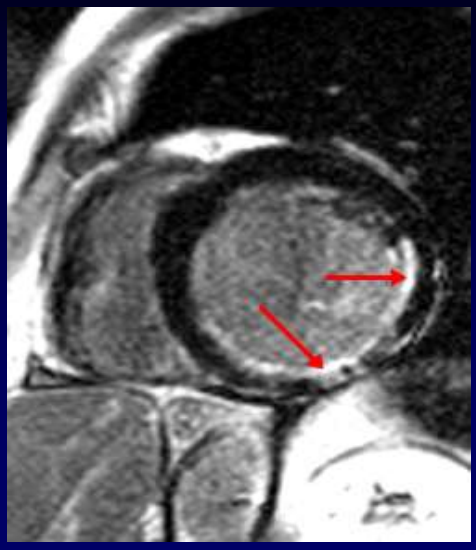
SSFP cines imaging



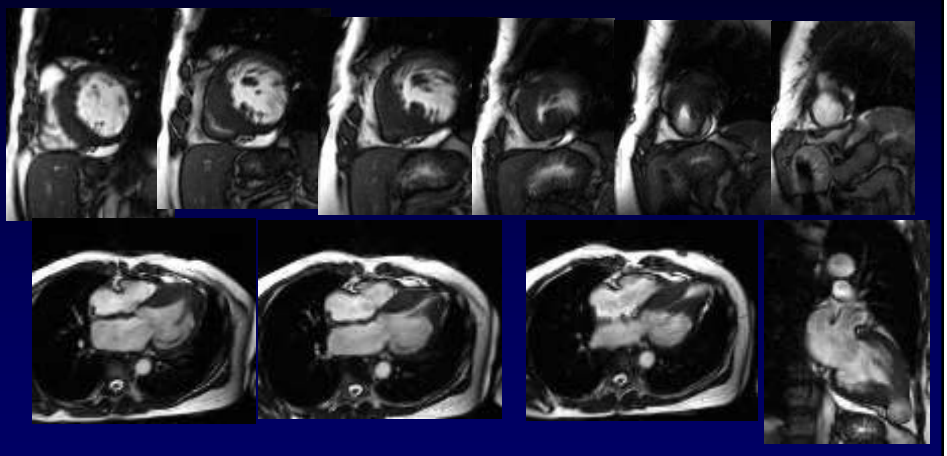
Delayed Enhanced imaging



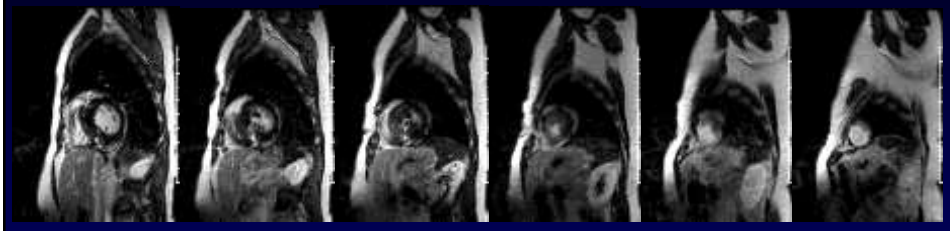
Non-transmural infarction

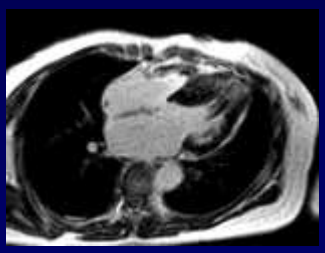


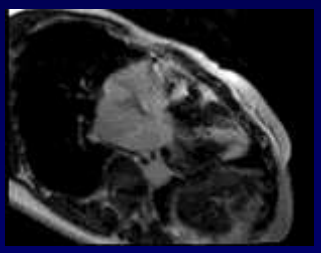
Cardiac MR



Cardiac CMR







Advantages

- Accurate assessment of extent of scar
- Superior spatial resolution
- Simultaneous assessment of perfusion, function and viability
- Good imaging windows

Disadvantages

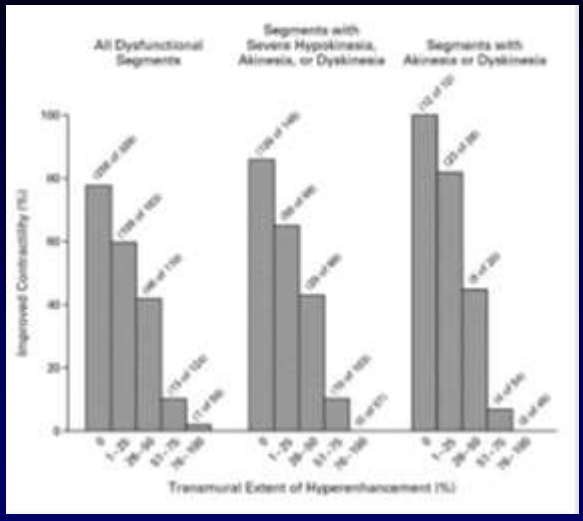
- High cost, limited availability
- Longer time
- Contraindicated with implanted ferromagnetic objects
- Gadolinium contra.in CKD with GFR<30ml/min
- Claustrophobia, Breathholding required

Data on MRI

- Using a cutoff value of 25% transmurality of scar tissue, the sensitivity and specificity were 86% and 61% to predict improvement of function
- Using 50%, the sensitivity and specificity were 97% and 44%
- Using 75%, sensitivity and specificity would be 100% and 15%, respectively

Kim RJ et al, NEJM, 2000;343:1445–53

DHE to predict the result of revascularization



Kim, Wu, Rafael, et al., NEJM 2000;343:1445-1453

DHE to Predict SCD in ICM

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Imaging in Heart Rhythm Disorders

Assessment of Myocardial Scarring Improves Risk Stratification in Patients Evaluated for Cardiac Defibrillator Implantation

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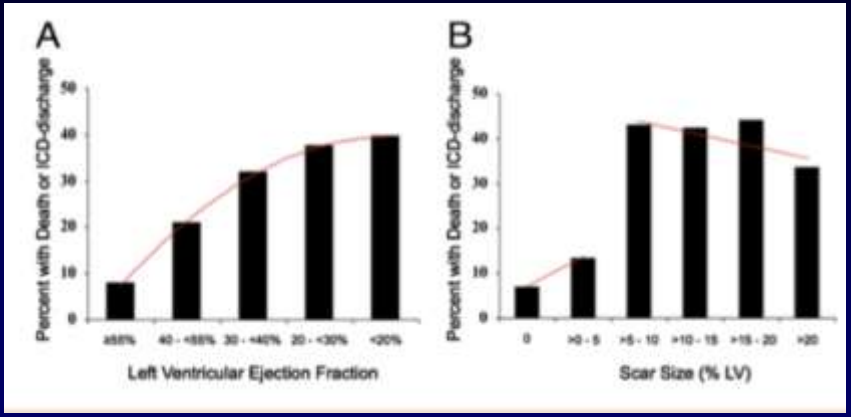
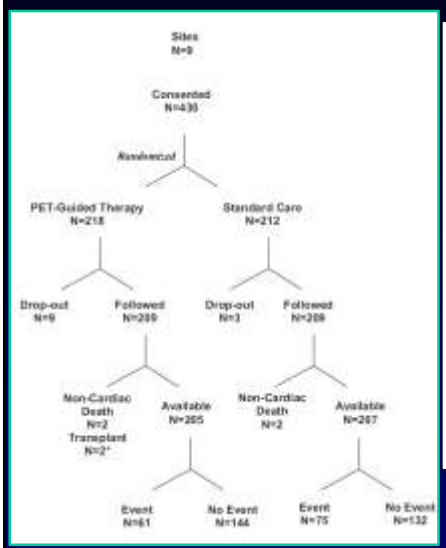
DHE to Predict SCD in ICM



J Am Coll Cardiol. 2012;60(5):408-420. doi:10.1016/j.jacc.2012.02.070

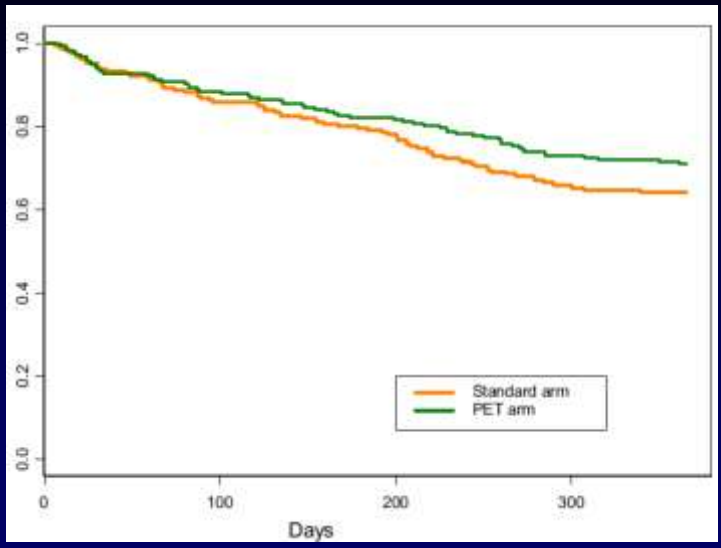
PARR2



- EF ≤ 35% considered for revascularization, transplant, or HF work- up with high suspicion of CAD.
- Randomized patients to a PET-guided therapy or "standard care" (no PET).
- Imaging physicians issued a therapy recommendation based on PET findings and treating physicians then made a decision regarding revascularization.
- Patients in the standard care arm had no PET, but could have another viability test, which was performed in 138 of 209 (66%) patients.
- Primary outcome: composite of cardiac death, myocardial infarction, or recurrent cardiac hospitalization within 1 year.

J Am Coll Cardiol 2007;50:2002-2012

PARR2



The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Myocardial Viability and Survival in Ischemic Left Ventricular Dysfunction

Robert O. Bonow, M.D., Gerald Maurer, M.D., Kerry L. Lee, Ph.D., Thomas A. Holly, M.D., Philip F. Binkley, M.D., Patrice Desvigne-Nickens, M.D., Jaroslaw Drozda, M.D., Ph.D., Pedro S. Farsky, M.D., Arthur M. Feldman, M.D., Torsten Doenst, M.D., Ph.D., Robert E. Michler, M.D., Daniel S. Berman, M.D., Jose C. Nicolau, M.D., Ph.D., Patricia A. Pellikka, M.D., Krzysztof Wrobel, M.D., Nasri Alotti, M.D., Ph.D., Federico M. Asch, M.D., Liliana E. Favaloro, M.D., Lilin She, Ph.D., Eric J. Velazquez, M.D., Robert H. Jones, M.D., and Julio A. Panza, M.D., for the STICH Trial Investigators*

•The first prospective randomized trial testing the hypothesis that CABG improves survival in patients with ischemic LV dysfunction [EF-26.7%±8.6] compared to outcome with aggressive medical therapy

•Myocardial viability identifies patients with CAD and LV dysfunction who have the greatest survival benefit with CABG compared to aggressive medical therapy

N Engl J Med 2011;364:1617-25

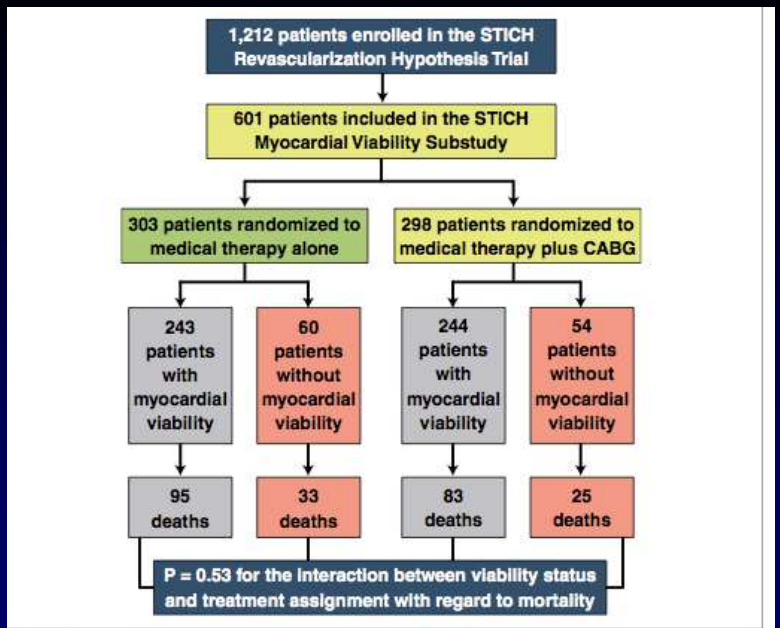
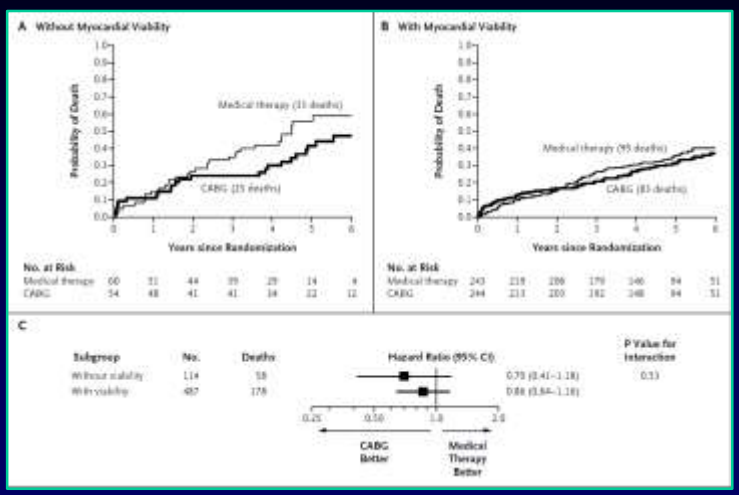


Figure 4. Flowchart of the STICH Myocardial Viability Substudy

STICH Trial- substudy



Conclusion

- Randomized trials of viability using PET and Cardiac MRI are lacking.
- Currently available evidence does not support the use of viability testing as the arbitrator in the decision making process regarding revascularization in ischemic cardiomyopathy
- In ischemic cardiomyopathy: Multiple factors play important prognostic role. Viability alone cannot provide an unequivocal answer

Thank you