DIAGNOSTIC TESTING IN PATIENTS WITH STABLE CHEST PAIN

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-Director of Froedtert Cardiology Clinics

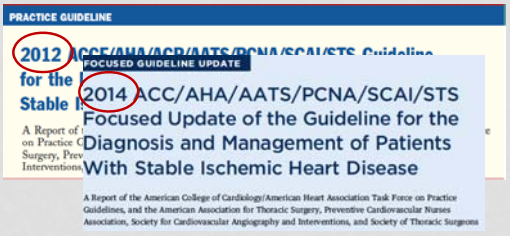
DISCLOSURES

- No financial or pharmaceutical affiliations related to topic

OBJECTIVES

- Prognosis & diagnosis
- Available modalities
- Choosing modalities

GUIDELINE-BASED CARE



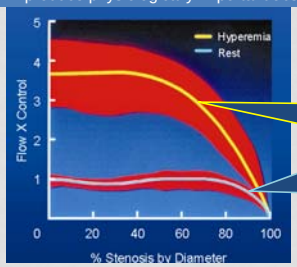
PURPOSE OF A CARDIAC STRESS TEST

- Diagnostic
  - Does the patient have occlusive coronary artery disease
- Prognostic
  - What is the likelihood of the patient suffering a myocardial infarction or dying in the near future

MJ1

CORONARY BLOOD FLOW RELATED TO DEGREE OF STENOSIS

How much stenosis in large coronary artery is needed to produce physiologically important obstruction?



Resting coronary blood flow remains relatively constant until stenosis > 90%

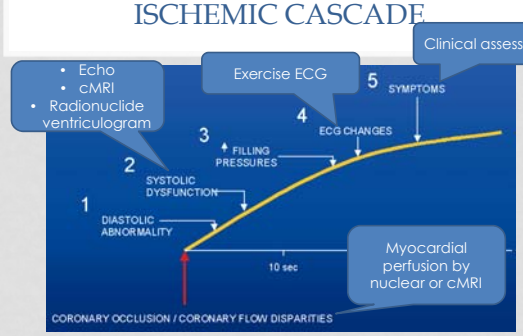
Resting coronary blood flow remains relatively constant until stenosis > 90%

Gould and Lipscomb. Am J Cardiol 1974; 33:87-94.

Slide 6

MJ1 Meskin, Joshua, 1/14/2019

ISCHEMIC CASCADE



Swigart et al. In: Silent Myocardial Ischemia. Rutshauser W, Roskam H (Eds). Berlin, Springer-Verlag, 1984, p 29.

Nesto and Kowalchuk. Am J of Cardiol, 1987; 59: 23C-30C.

NONINVASIVE ASSESSMENT

CHOOSING AN APPROACH

INITIAL STEP: RISK STRATIFICATION

- Chest pain description
  - Stable versus unstable
- Left ventricular systolic function
  - Normal LVEF versus undifferentiated cardiomyopathy
- Coronary anatomy
  - Known CAD or coronary artery calcifications
- Arrhythmia
  - Presence of ventricular arrhythmias
- Resting ECG
  - Normal versus ST-T abnormalities or Q waves
- CAD risk factors

PRETEST LIKELIHOOD OF CAD
(COMBINED DIAMOND/FORRESTER AND CASS DATA)

	Nonanginal Chest Pain		Atypical Angina		Typical Angina	
Age, y	Men	Women	Men	Women	Men	Women
30–39	4	2	34	12	76	26
40–49	13	3	51	22	87	55
50–59	20	7	65	31	93	73
60–69	27	14	72	51	94	86

Typical angina (definite)	1) Substernal chest discomfort with a characteristic quality and duration that is 2) provoked by exertion or emotional stress and 3) relieved by rest or nitroglycerin
Atypical angina (probable)	Meets 2 of the above characteristics
Noncardiac chest pain	Meets 1 or none of the typical anginal characteristics

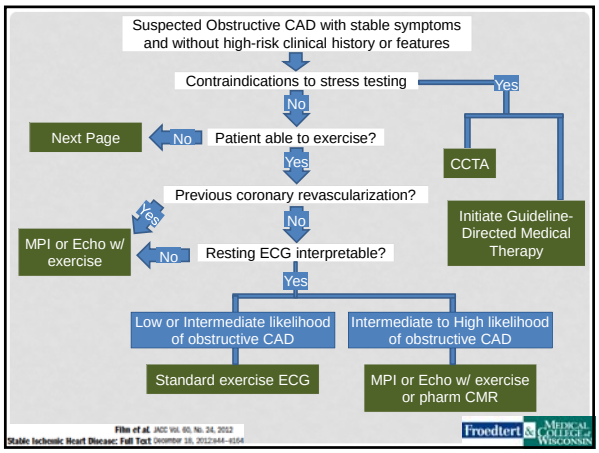
Fihn et al. JACC Vol. 60, No. 24, 2012
Stable Ischemic Heart Disease: Full Text December 18, 2012:2441–2464

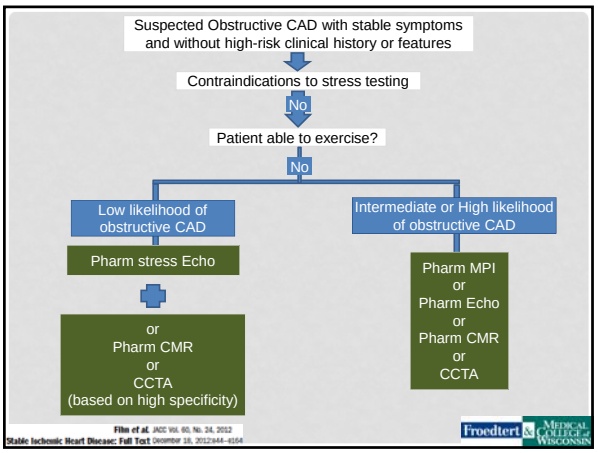
DIAGNOSTIC MODALITIES

- Clinical
  - Response to optimal medical therapy
- Increase myocardial oxygen demand to provoke ischemia
  - Treadmill ECG
  - Exercise echocardiographic stress
    - Treadmill
    - Bicycle
  - Pharmacologic echocardiographic stress
    - Dobutamine/atropine

DIAGNOSTIC MODALITIES

- Create perfusion disparities by increasing flow through coronary arteries
  - Regadenoson (Lexiscan) / dipyridamole (Persantine) / adenosine
    - Nuclear imaging (SPECT [Single photon emission computer tomography])
    - Cardiac MRI
    - PET scan
- Anatomic assessment
  - CT coronary arteries
    - Additional functional information with FFR





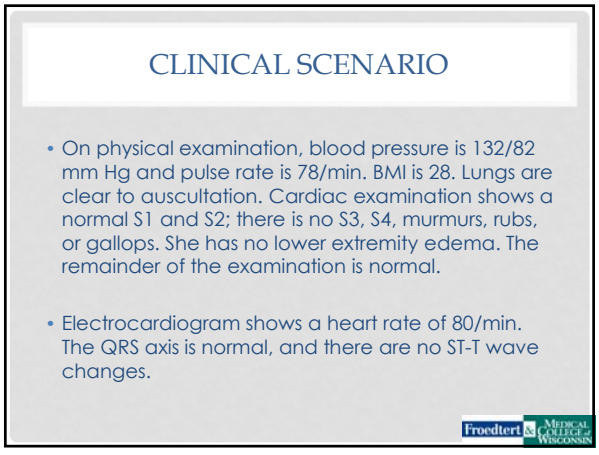
CLINICAL SCENARIO

CLINICAL SCENARIO

- A 49-year-old woman is evaluated for intermittent sharp, nonradiating, substernal chest pain for the past 2 weeks. The pain occurs more frequently in the morning and is not associated with meals or exertion but may be initiated with emotional stress. The pain often lasts for 10 minutes and subsides spontaneously.
- She has hyperlipidemia treated with pravastatin.
- Her mother had a myocardial infarction and heart failure starting at the age of 52 years.

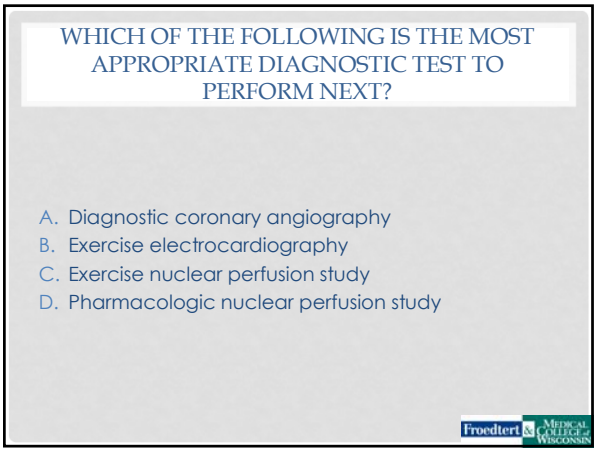
CLINICAL SCENARIO

- On physical examination, blood pressure is 132/82 mm Hg and pulse rate is 78/min. BMI is 28. Lungs are clear to auscultation. Cardiac examination shows a normal S1 and S2; there is no S3, S4, murmurs, rubs, or gallops. She has no lower extremity edema. The remainder of the examination is normal.
- Electrocardiogram shows a heart rate of 80/min. The QRS axis is normal, and there are no ST-T wave changes.



WHICH OF THE FOLLOWING IS THE MOST APPROPRIATE DIAGNOSTIC TEST TO PERFORM NEXT?

A. Diagnostic coronary angiography
B. Exercise electrocardiography
C. Exercise nuclear perfusion study
D. Pharmacologic nuclear perfusion study



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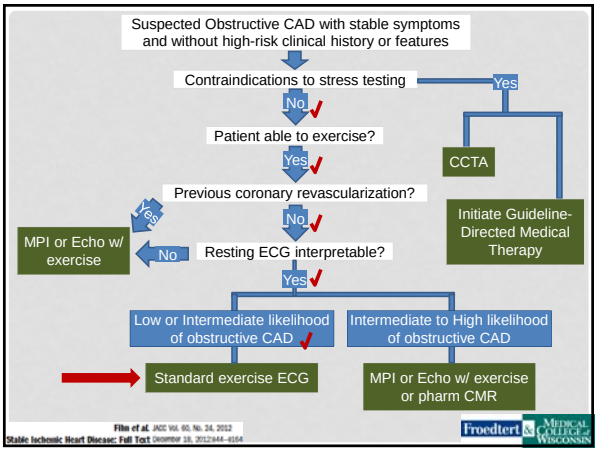
Fihn et al. JACC Vol. 60, No. 24, 2012
Stable Ischemic Heart Disease: Full Text December 18, 2012:1944–4164



NONINVASIVE ASSESSMENT
CHOOSING AN IMAGING MODALITY

CORONARY CT ANGIOGRAPHY

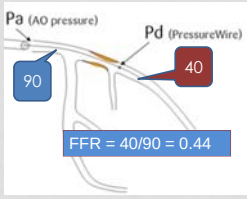
- Accurately excludes presence of CAD
  - Very high negative predictive value
- Defines anatomy of CAD
  - Single vessel versus multivessel
  - Proximal disease versus distal disease
- Prognostic implications including coronary calcium score
- Determination of physiologic significance possible with FFR

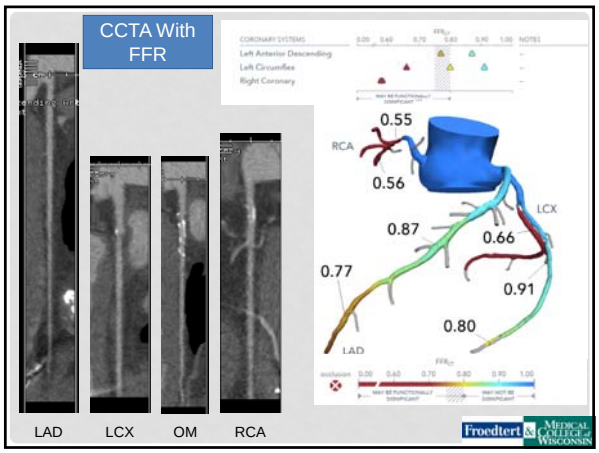
FRACTIONAL FLOW RESERVE (FFR)

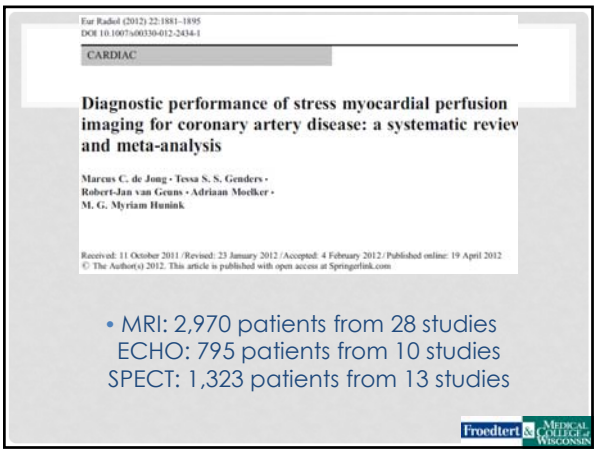
- Ratio of maximal blood flow achievable in stenotic coronary artery relative to maximal flow in the same vessel if it were normal

FFR = P_d/P_a

[abnormal if <0.8]




CCTA With FFR
0.55
RCA
0.56
LCX
0.87
0.66
0.77
0.91
0.80
LAD
LAD
LCX
OM
RCA


Eur Radiol (2012) 22:1881–1895
DOI 10.1007/s00330-012-2434-1
CARDIAC
Diagnostic performance of stress myocardial perfusion imaging for coronary artery disease: a systematic review and meta-analysis
Marcus C. de Jong · Tessa S. S. Genders · Robert-Jan van Geuns · Adriaan Moelker · M. G. Myriam Hunink
Received: 11 October 2011 / Revised: 23 January 2012 / Accepted: 4 February 2012 / Published online: 19 April 2012
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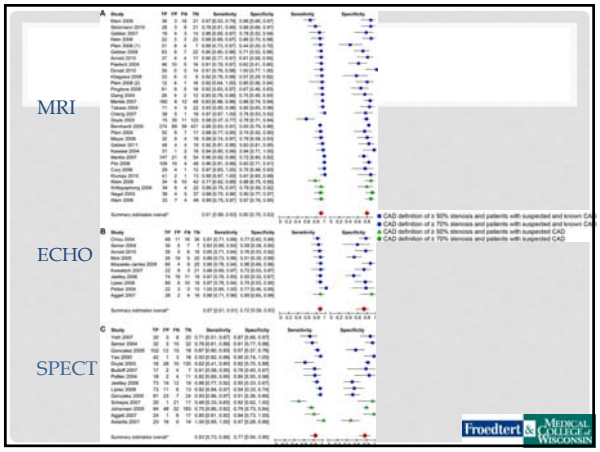
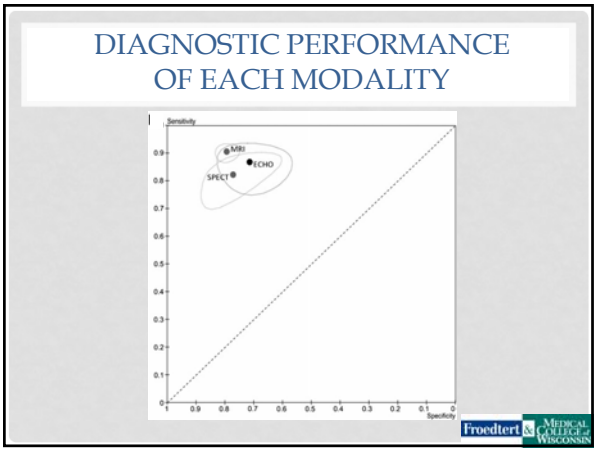
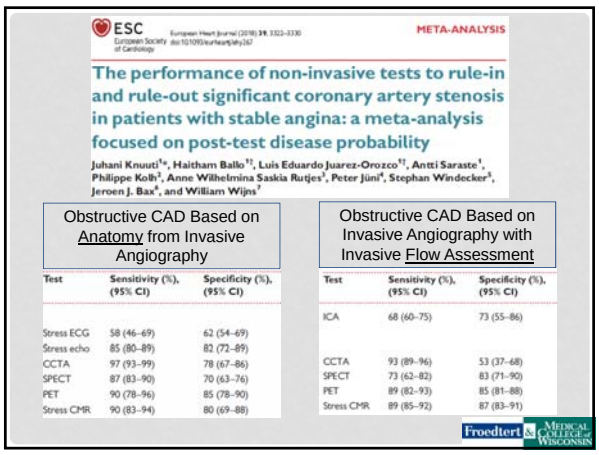
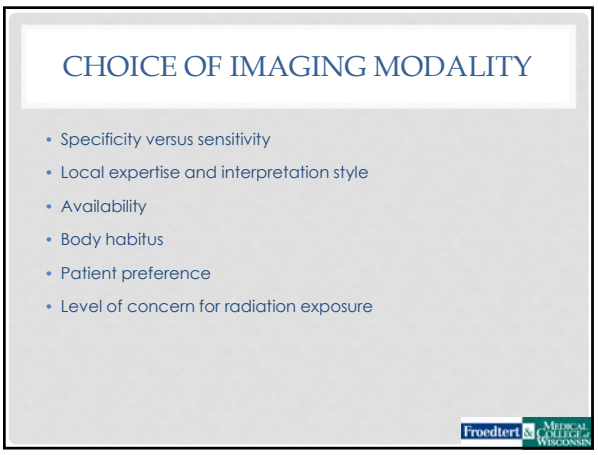
• MRI: 2,970 patients from 28 studies
ECHO: 795 patients from 10 studies
SPECT: 1,323 patients from 13 studies

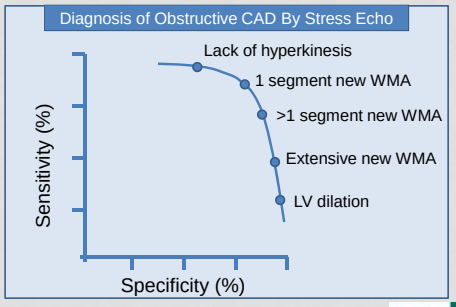

MRI
ECHO
SPECT


DIAGNOSTIC PERFORMANCE OF EACH MODALITY
Sensitivity
Specificity
MRI
ECHO
SPECT


ESC
META-ANALYSIS
The performance of non-invasive tests to rule-in and rule-out significant coronary artery stenosis in patients with stable angina: a meta-analysis focused on post-test disease probability
Juhani Knuuti, Haitham Ballo, Luis Eduardo Juarez-Orozco, Antti Saraste, Philippe Kolh, Anne Wilhelmina Saskia Rutjes, Peter Jüni, Stephan Windecker, Jeroen J. Bax, and William Wijns
Obstructive CAD Based on Anatomy from Invasive Angiography
Test | Sensitivity (%), (95% CI) | Specificity (%), (95% CI)
Stress ECG | 58 (46–69) | 62 (54–69)
Stress echo | 85 (80–89) | 82 (72–89)
CCTA | 97 (93–99) | 78 (67–86)
SPECT | 87 (83–90) | 70 (63–76)
PET | 90 (78–96) | 85 (78–90)
Stress CMR | 90 (83–94) | 80 (69–88)
Obstructive CAD Based on Invasive Angiography with Invasive Flow Assessment
Test | Sensitivity (%), (95% CI) | Specificity (%), (95% CI)
ICA | 68 (60–75) | 73 (55–86)
CCTA | 93 (89–96) | 53 (37–68)
SPECT | 73 (62–82) | 83 (71–90)
PET | 89 (82–93) | 85 (81–88)
Stress CMR | 89 (85–92) | 87 (83–91)

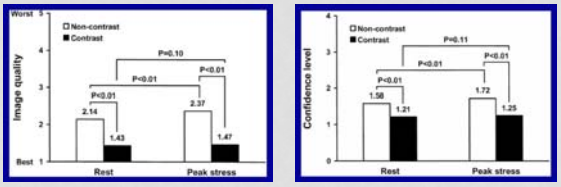

CHOICE OF IMAGING MODALITY
• Specificity versus sensitivity
• Local expertise and interpretation style
• Availability
• Body habitus
• Patient preference
• Level of concern for radiation exposure

LOCAL INTERPRETATION STYLES FOR INFLUENCE SENSITIVITY AND SPECIFICITY



LOCAL PRACTICES FOR INFLUENCE SENSITIVITY AND SPECIFICITY

Echo Contrast Usage Results in Enhanced Confidence & Image Quality



Rainbird: J Am Soc Echo 2001;14;378-85

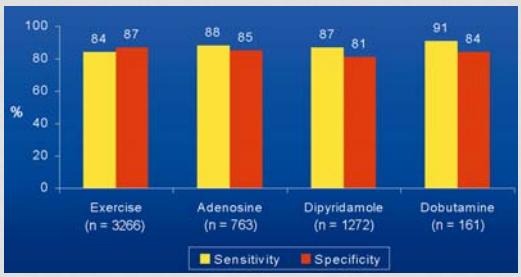
NONINVASIVE ASSESSMENT

CHOOSING A STRESS AGENT

CHOICE OF STRESS AGENT

- Exercise preferred
  - Provides additional prognostic information
  - Correlation of symptoms with findings
- Pharmacologic stress
  - Used if unable to exercise
  - Regadenoson (Lexiscan)/adenosine/ dipyridamole (Persantine)
    - Nuclear imaging
    - cMRI
  - Dobutamine
    - Echo
    - Nuclear imaging (not commonly used)

DIAGNOSTIC ACCURACY BASED ON STRESS AGENT



Leppo JA. J Nucl Cardiol. 1996;3:S22-S26.

CHOICE OF PHARMACOLOGIC AGENT

Condition	Dobutamine	Vasodilator (regadenoson, adenosine, etc.)
Bronchospasm	✓	✗
2nd or 3rd degree heart block	✓	✗
Significant elevation in blood pressure	✗	✓
Large aortic aneurysm	✗	✓
Ventricular arrhythmia	✗	✓
Atrial fibrillation/flutter	✗	✓

PROGNOSIS BASED ON TESTING

BEYOND CORRELATION WITH CORONARY ARTERY STENOSIS

- Prognostic value of stress testing to predict clinical outcomes
  - Death
  - Myocardial infarction
  - Need for revascularization

PROGNOSTIC VARIABLES DURING STRESS TEST

- Exercise duration
  - Strongest prognostic value
  - Coronary Artery Surgery Study (CASS)
    - Three-vessel CAD and preserved left ventricular function
      - 100% 4 year survival in those who exercised more than 12 minutes

ORIGINAL ARTICLE

Prognostic Value of a Treadmill Exercise Score in Outpatients with Suspected Coronary Artery Disease

N Engl J Med 1991; 325:849-853 | September 19, 1991 | The NEW ENGLAND JOURNAL of MEDICINE

- Duke treadmill score
  - Exercise time - (5 x ST deviation) - (4 x anginal index)
    - Anginal index: 0 = none; 1 = nonlimiting; 2 = stopped test
- Predicts CV mortality per year
  - Low-risk (>4): < 1%
  - Intermediate-risk (−10 to +4):1% to 3%
  - High-risk (< −10): > 5%

The Prognostic Value of Normal Exercise Myocardial Perfusion Imaging and Exercise Echocardiography

A Meta-Analysis

Louise D. Metz, MD,* Mary Beattie, MD,† Robert Hom, MD,‡ Rita F. Redberg, MD, MSc,§ Deborah Grady, MD, MPH,∥¶† Kirsten E. Fleischmann, MD, MPH§

JACC Vol. 49, No. 2, 2007 January 16, 2007:227–37

- Total of 11,000 patients
  - *CV death, MI, unstable angina & revascularization*
- Normal stress yields annual risk of 0.4–0.9%
- NPV for MI and cardiac death
  - *MPI: 98.8% over 36 months of follow-up*
  - *Echo: 98.4% over 33 months of follow-up*
- Corresponding annualized event rates
  - *MPI: 0.45% per year*
  - *Echo: 0.54% per year*

PROMISE TRIAL

Prospective Multicenter Imaging Study for Evaluation of Chest Pain (PROMISE)
March 14. 2015

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Outcomes of Anatomical versus Functional Testing for Coronary Artery Disease

Pamela S. Douglas, M.D., Udo Hoffmann, M.D., M.P.H., Manesh R. Patel, M.D., for the PROMISE Investigators*

COMPARISON

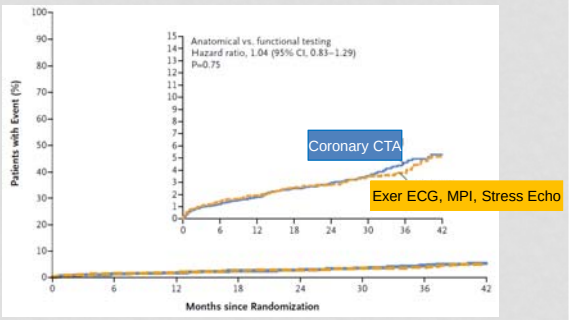
Anatomic: Coronary CTA

Functional: Exercise ECG, Nuclear stress test, Stress Echo

Composite End Point

death, MI, unstable angina, major procedural complication

Kaplan–Meier Estimates of the Composite Primary End Point as a Function of Time after Randomization



TAKE HOME POINTS

TAKE HOME POINTS

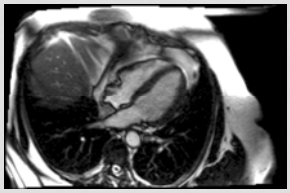
1. Exercise ECG testing is recommended as the initial test of choice in patients with a normal baseline ECG and an intermediate pretest probability of coronary artery disease based on age, sex, and symptoms
2. Results of stress testing should be used to determine both prognosis and diagnosis
3. Modality of stress testing should be based on ability to exercise, local expertise and risk of adverse reaction from stress agent

QUESTIONS

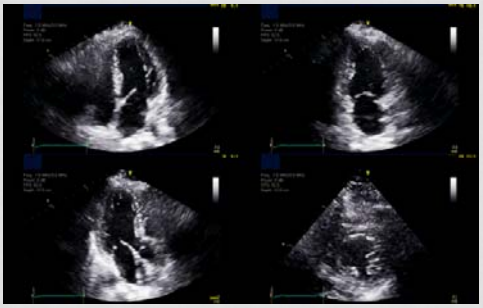
EXAMPLES OF IMAGING MODALITIES

NUCLEAR PERFUSION STUDY

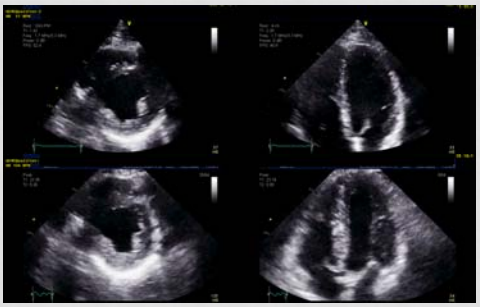
CARDIAC MRI



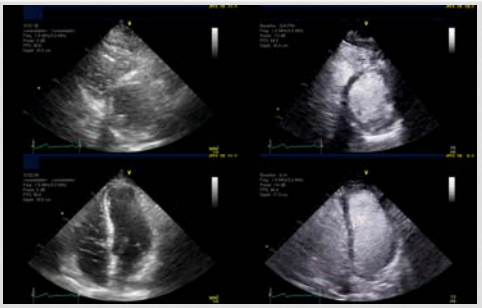
STRESS ECHO PROTOCOL



STRESS ECHO: REST VS STRESS



POOR ENDOCARDIAL DEFINITION



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