

Cardiac Testing

Chapter Lecture Series 2011



AMERICAN ACADEMY OF
FAMILY PHYSICIANS

STRONG MEDICINE FOR AMERICA

Disclosure

The opinions disclosed are those of the presenter and do not necessarily reflect the official policy or position of the Department of the Navy, the Department of Defense nor the US Government.

Learning Objectives

- Assess common cardiovascular conditions for which different methods of cardiac testing are indicated.
- Interpret the sensitivity, specificity and predictive values of cardiac tests for patients with different risk factors.
- Utilize patient selection criteria to identify appropriate cardiac tests and perform risk stratification or coordinate sub-specialist consultation when necessary.

Learning Objectives

- Compare and contrast the risks and benefits of including cardiac tests in the scope of practice.
- Coordinate patient care for those who require referral to sub-specialists for enhanced evaluation, testing and treatment.

Background

- 81 million Americans have cardiovascular disease (CVD)
- CVD is the leading cause of death
- Role of FP
 - Educate about CVD
 - Primary and secondary prevention
 - Identifying patients in need of intervention to treat or prevent cardiac events

Methods for Determining Estimates

- Data obtained electronically from organization members of the AAFP's research network
- Targeted cardiovascular testing ordered by PCP
 - ECG (typically in office)
 - Exercise treadmill (ETT)
 - Functional/Advanced Testing*
 - Cardiac CT scans (only 3 identified – dropped)
- All practices had EHR and clinical decision support
- Practices located in 3 regions
 - Midwest (IL, IN, MI, OH)
 - Southeast (FL, NC)
 - Texas

* Stress echo/dobutamine echo/thallium/Cardiolite

Symptom Cohort

- Midwest:
 - More “functional/advanced testing” (e.g. stress echo/dobutamine echo/thallium/Cardiolite) than exercise treadmill testing
 - Moderate risk group* more likely to receive functional/advanced testing than exercise treadmill
- Southeast & Texas:
 - More exercise treadmill (no imaging) and ECGs
 - No evidence of test adjustment by risk group

* *EHR data used to group by cardiovascular risk across the cohort*

New Diagnosis of CVD Cohort

- Midwest – 1:1 ratio
 - Functional/advanced *equal to* exercise treadmill testing before and after diagnosis
- Southeast – 10:1 ratio
 - Exercise treadmill testing *over* functional/advanced testing before and after diagnosis
- Texas – 10:1 and 3:1
 - Exercise treadmill testing *over* functional/advanced testing before diagnosis (10:1)
 - Exercise treadmill testing *over* functional/advanced testing after diagnosis (3:1)

Known Disease Cohort

- Targeted testing at least 180 days following diagnosis of CVD
- Midwest – 2:1
 - Exercise treadmill testing 2:1 over functional/advanced testing
- Southeast and Texas – 20:1
 - Exercise treadmill testing 20:1 over functional/advanced testing

No Disease Diagnosis Cohort

- 1st test ordered for pts w/out known disease – reason for test order not clear
- Midwest – slightly more treadmills ordered than functional/advanced testing
- Southeast and Texas – significantly more treadmills ordered than functional/advanced testing

Case 1

- 44-year-old Asian male
- Complains of chest pain with rest
- No other medical problems
- Who would get an ECG?
- Who would get an exercise stress test?

Biostatistics for diagnostic tests



Sensitivity

- Inherent to the diagnostic test
- Ability to correctly identify people with a given disease or condition
 - Number of true positives

Specificity

- Inherent to the diagnostic test
- Ability to correctly identify people who DO NOT have a given disease or condition
 - Number of true negatives

Calculations – 2 x 2 table

	Disease (+)	Disease (-)
Test (+)	True positive (TP)	False positive (FP)
Test (-)	False negative (FN)	True negative (TN)

Calculations – Sens and Spec

	Disease (+)	Disease (-)
Test (+)	True positive (TP)	False positive (FP)
Test (-)	False negative (FN)	True negative (TN)

Sensitivity = $TP / (TP + FN)$ -- True Positive Rate

Specificity = $TN / (TN + FP)$ -- True Negative Rate

Predictive value of a positive (+) test

- AKA Positive Predictive Value (PPV)
- Probability that patients with positive test results actually have the disease

Predictive value of a negative (-) test

- AKA Negative Predictive Value (NPV)
- Probability that patients with negative test results actually DO NOT have the disease

Calculations – PPV and NPV

	Disease (+)	Disease (-)
Test (+)	True positive (TP)	False positive (FP)
Test (-)	False negative (FN)	True negative (TN)

$$PPV = TP / (TP + FP)$$

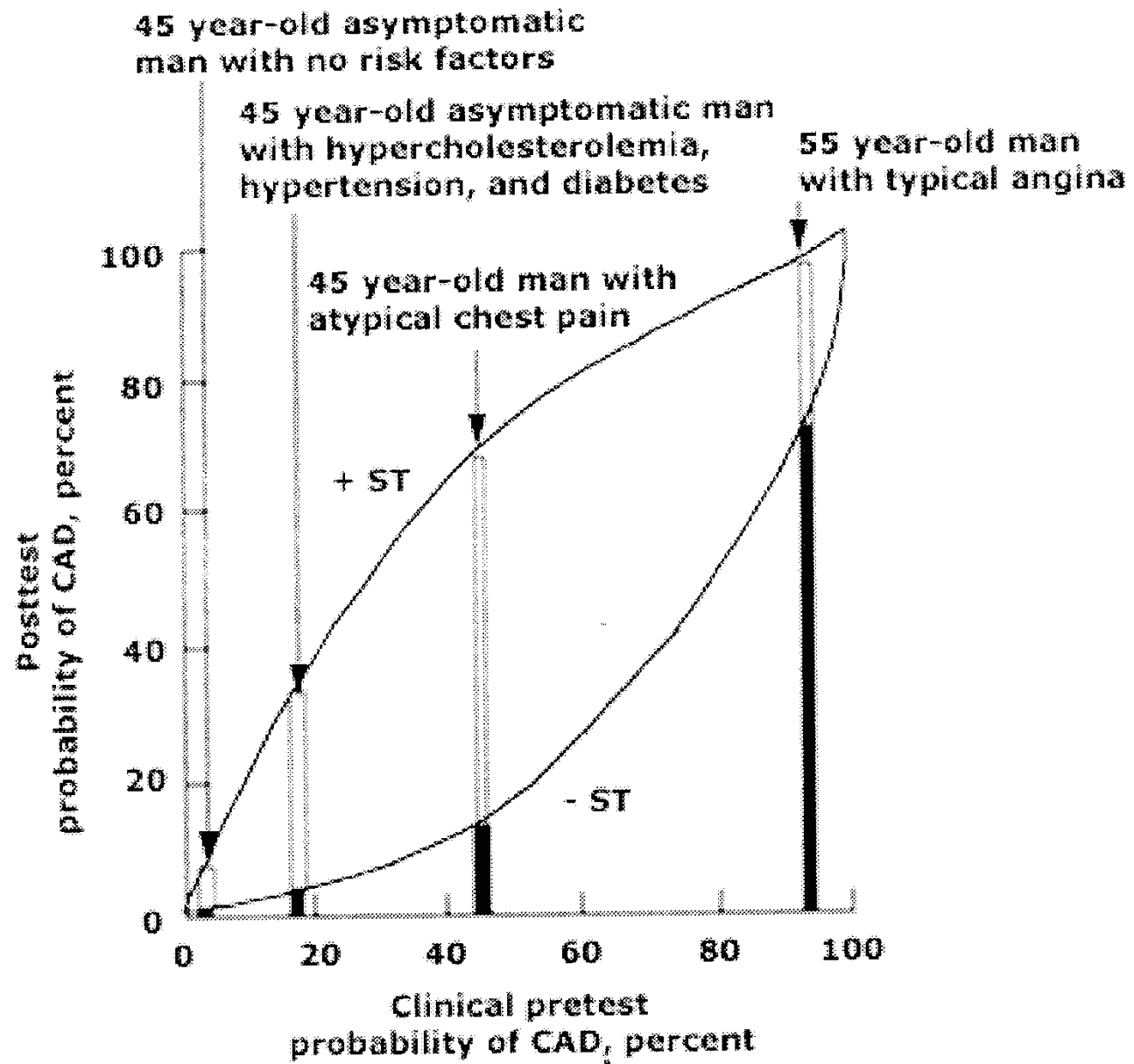
$$NPV = TN / (TN + FN)$$

Likelihood Ratios

- Likelihood ratio of a positive test (LR+)
 - Increase in odds of having the disease after a positive test result
 - = Sensitivity / (1 – Specificity)
- Likelihood ratio of a negative test (LR-)
 - Decrease in odds of having the disease after a negative test result
 - = (1 – Sensitivity) / Specificity

Bayes Theorem

- Pretest probability determines posttest probability.
- The posttest odds = pretest odds x LR
- Graphical representation and sample calculation follow



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 J Am Coll Cardiol 1989;13:1653


Case #2

- 52-year-old male for wellness
- Wants to know his CAD risk
- Global estimation of CAD Risk
 - Framingham risk score
 - NCEP risk score

Framingham Risk Scores

- Men 35-80 and women 45-80
- Risk factors
 - Diabetes
 - Current cigarette smoking
 - Hypertension
 - Elevated LDL or total cholesterol
 - Low HDL
 - Family history

NCEP Calculator

 NATIONAL CHOLESTEROL EDUCATION PROGRAM
Third Report of the Expert Panel on
Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III)

Risk score results:

Age:	52
Gender:	male
Total Cholesterol:	220 mg/dL
HDL Cholesterol:	45 mg/dL
Smoker:	No
Systolic Blood Pressure:	129 mm/Hg
On medication for HBP:	No
Risk Score*	7%

* The risk score shown was derived on the basis of an equation. Other NCEP materials, such as ATP III print products, use a point-based system to calculate a risk score that approximates the equation-based one.

To interpret the risk score and for specific information about CHD risk assessment as part of detection, evaluation, and treatment of high blood cholesterol, see [ATP III Executive Summary](#) and [ATP III At-a-Glance](#).

<http://www.nhlbi.nih.gov/guidelines/cholesterol/atglance.pdf>

- Low risk < 10% for 10 years

NCEP Calculator - Women



NATIONAL CHOLESTEROL EDUCATION PROGRAM

Third Report of the Expert Panel on
Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III)

Risk score results:

Age: 52
Gender: female
Total Cholesterol: 220 mg/dL
HDL Cholesterol: 45 mg/dL
Smoker: No
Systolic Blood Pressure: 129 mm/Hg
On medication for HBP: No

Risk Score* 1%

* The risk score shown was derived on the basis of an equation. Other NCEP materials, such as ATP III print products, use a point-based system to calculate a risk score that approximates the equation-based one.

To interpret the risk score and for specific information about CHD risk assessment as part of detection, evaluation, and treatment of high blood cholesterol, see [ATP III Executive Summary](#) and [ATP III At-a-Glance](#).

<http://www.nhlbi.nih.gov/guidelines/cholesterol/atglance.pdf>

- Low risk < 10 %

Global Risk Scores

- Recommendations by risk score
- Low risk < 10%
 - LDL goal is 160 mg/dL
- Moderate risk 10-20%
 - LDL goal is 130 mg/dL
- High risk > 20%
 - LDL goal is 100 mg/dL

Other Risk Factors

- Smoking cessation
- Physical activity
- Weight assessment and dietary counseling
- Blood pressure control
- Aspirin use for high-risk patients

Novel Cardiac Markers

- Not recommended
 - Leukocyte count
 - Fasting blood sugar
 - Periodontal disease
 - Carotid intima-media thickness
 - Coronary artery calcium score
 - Homocysteine
 - Lipoprotein A

Novel Cardiac Markers

- High sensitivity C-reactive protein
 - Elevated CRP linked to CAD events
 - Adding CRP levels to intermediate risk persons improves risk stratification
 - Lack of evidence that lowering CRP decreases CAD events.
- Ankle brachial index
 - Lack of evidence that patients reclassified by ABI benefit from treatment

Coronary Artery Calcium (CAC)

- CAC part of atherosclerosis
- Correlation between CAC and luminal narrowing
- Measured by electron beam (EBCT) and multi-detector (MDCT)
- Consider for intermediate-risk patients
- No evidence intensification of therapy based on CAC makes a difference

Future Screening Tests

- Pulse wave velocity
 - Pressure wave traveling along an artery over time
- Genetic testing
 - Not ready for prime time
 - May provide additional prognostic info
- EST, MPI, CMR

Case #3

- 55-year-old male
 - Crushing substernal chest pain at 30 minutes of exercise, relieved with 2 minutes of rest
- Smoker
- Hypertension
- Sedentary
- Father with MI age 52

Chronic Stable Angina

- Clinical characteristics are key
- Rest ECG adds little to diagnosis
- Key variables
 - Typical symptoms
 - Age
 - Sex
 - Diabetes
- Exercise ECG adds about 5-6%

Case #4

- 62-year-old Hispanic female
- Acute onset of chest pain 6 hours ago
- HTN, HLP, DM, obesity, smoker
- Sedentary
- ECG with nonspecific ST-T changes
- Diagnosis?

Pre-test Probability of CAD - Men

<u>Age</u>	<u>Angina</u>	<u>Atypical</u>	<u>NonAnginal</u>
• 30-39	Interm	Interm	Low
• 40-49	High	Interm	Interm
• 50-59	High	Interm	Interm
• 60-69	High	Interm	Interm

Pre-test Probability of CAD - Women

<u>Age</u>	<u>Angina</u>	<u>Atypical</u>	<u>NonAnginal</u>
• 30-39	Interm	V Low	V Low
• 40-49	Interm	Low	V Low
• 50-59	Interm	Low	Low
• 60-69	High	Interm	Interm

Electrocardiograms for MI

- ECG changes seen within 90 minutes
- Serial evolution of ECG
 - Sensitivity = 68 percent
 - Specificity = 97 percent
- Biomarkers
 - CK-MB – Sensitivity = 79%
 - Troponin I – Sensitivity = 90-100%
- Other options

Clinical Decision Rule

- Men age >55, women age >65 1
- Known CAD or CVD 1
- Pain not with palpation 1
- Pain worse with exercise 1
- Patient assumes is cardiogenic 1
- 0-1 PPV=0.6%
- 2-3 PPV=12.1%
- 4-5 PPV=62.7%

Clinical Decision Rule

- Low risk – evaluate noncardiac
- High risk – ECG, ASA, O2 to ER
- Moderate risk
 - If ECG shows ischemia
 - ECG, ASA, O2 to ER
 - If ECG is normal or nonspecific
 - Troponin testing 6 hours after onset OR
 - Consider prompt stress testing by cardiology

TIMI Risk Score

- Simple and validated
- Seven risk factors
 - Age ≥ 65 1
 - ≥ 3 CAD risk factors 1
 - Prior coronary stenosis $>50\%$ 1
 - ST changes >0.5 mm 1
 - ASA use in last week 1
 - ≥ 2 episodes CP within 24 hours 1
 - + cardiac markers 1

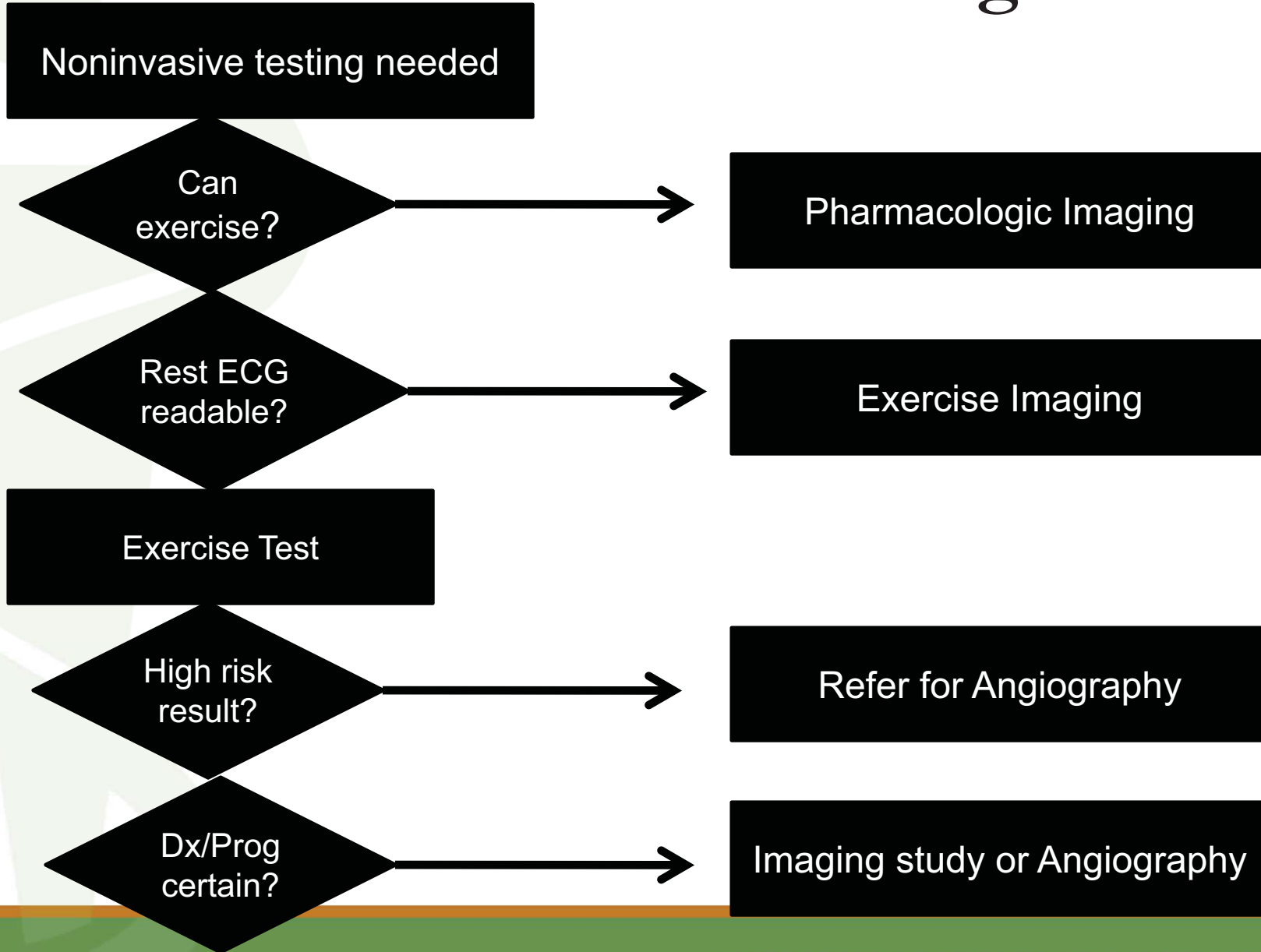
TIMI Risk Score

- Increasing TIMI risk score
 - Increase in MI, mortality, ischemia
- 0,1
 - 5%
- 4
 - 20%
- 6,7
 - 41%

Noninvasive Testing

- What is the next step?
- Noninvasive testing
 - EST
 - MPI
 - Scintigraphy
 - SPECT
 - Echo
 - Cardiac CT, MR, PET

Noninvasive Test Algorithm



Test	Subjects	Sensitivity (95% CI)	Specificity (95% CI)	LR + (95% CI)	LR – (95% CI)	DX Accuracy
ETT	96	31% (17-49%)	52% (40-64%)	0.65 (.36-1.18)	1.32 (0.95-1.84)	46%
ETT	68	33% (21-48%)	74% (53-87%)	1.28 (0.57-2.81)	0.90 (0.66-1.24)	47%
MPI	68	80% (66-89%)	78% (58-90%)	3.68 (1.67-8.10)	0.26 (0.14-0.48)	79%
DSE	901	72% (67-76%)	88% (85-91%)	5.97 (4.64-7.68)	0.32 (0.28-0.37)	80%
MDCT 64	123	99% (93-100%)	75% (62-84%)	3.91 (2.54-6.01)	0.01 (0-0.17)	88%
MDCT 40	21	73% (51-96%)	83% (53-100%)	4.39 (0.72-27)	0.32 (0.13-0.8)	76%
MDCT 16	70	89% (67-97%)	88% (77-95%)	7.61 (3.53-16.4)	0.12 (0.03-0.44)	89%

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J Fam Prac 2010;59:534-535

Exercise Stress Testing

- Recommended by ACC/AHA guidelines for management of low-risk ACS patients, including women
- Well validated
- Inexpensive
- Available
- Easy to perform

Exercise Stress Testing

- Diagnostic accuracy overall
- Meta analysis
 - Sensitivity = 68%
 - Specificity = 77%
- Three studies without workup bias
 - Sensitivity = 50%
 - Specificity = 90%
- Does EST rule out CAD well?

Exercise Stress Testing

- Indications
 - Diagnosis of CAD in symptomatic patient
 - Best with intermediate pretest probability
 - Prognosis/management with known CAD
 - Screen for CAD in asymptomatic patient
 - High-risk only, not routine
 - Exercise capacity for CHF/transplant
 - Arrhythmias
 - Selected patients only

Exercise Stress Testing

- **Contraindications**
 - AMI within 48 hours
 - Unstable angina
 - Uncontrolled arrhythmias
 - Severe valvular stenosis
 - Uncontrolled CHF
 - Aortic dissection
 - Acute PE
 - Disorders affecting exercise

Exercise Stress Testing

- Interpretation
 - ECG changes
 - Blood pressure response
 - Symptoms
 - Chronotropic response
 - Level of effort
 - Metabolic equivalents or METS

Exercise Stress Testing

- Issues in female patients
 - Sensitivity = 61%
 - Specificity = 70%
 - ST segment depression
 - Baseline ST-T changes
 - Hormonal effects on ST segments
 - Prognostic value less

Exercise Stress Testing

- Issues in female patients (con't)
 - Exercise capacity
 - Chronotropic response
 - Inability to achieve 85% of max predicted
 - Abnormal heart rate recovery
 - Blood pressure response
 - Fall in SBP by >10 mm Hg abnormal

Exercise Stress Testing

- Duke Treadmill Score (DTS)
 - DTS = Exercise time – (5X ST deviation) – (4X angina score index)
 - Scores
 - Low risk $\geq +5$
 - Moderate risk -10 to +4
 - High risk ≤ -11
 - Improved sensitivity in one study to 75-78% for severe disease.

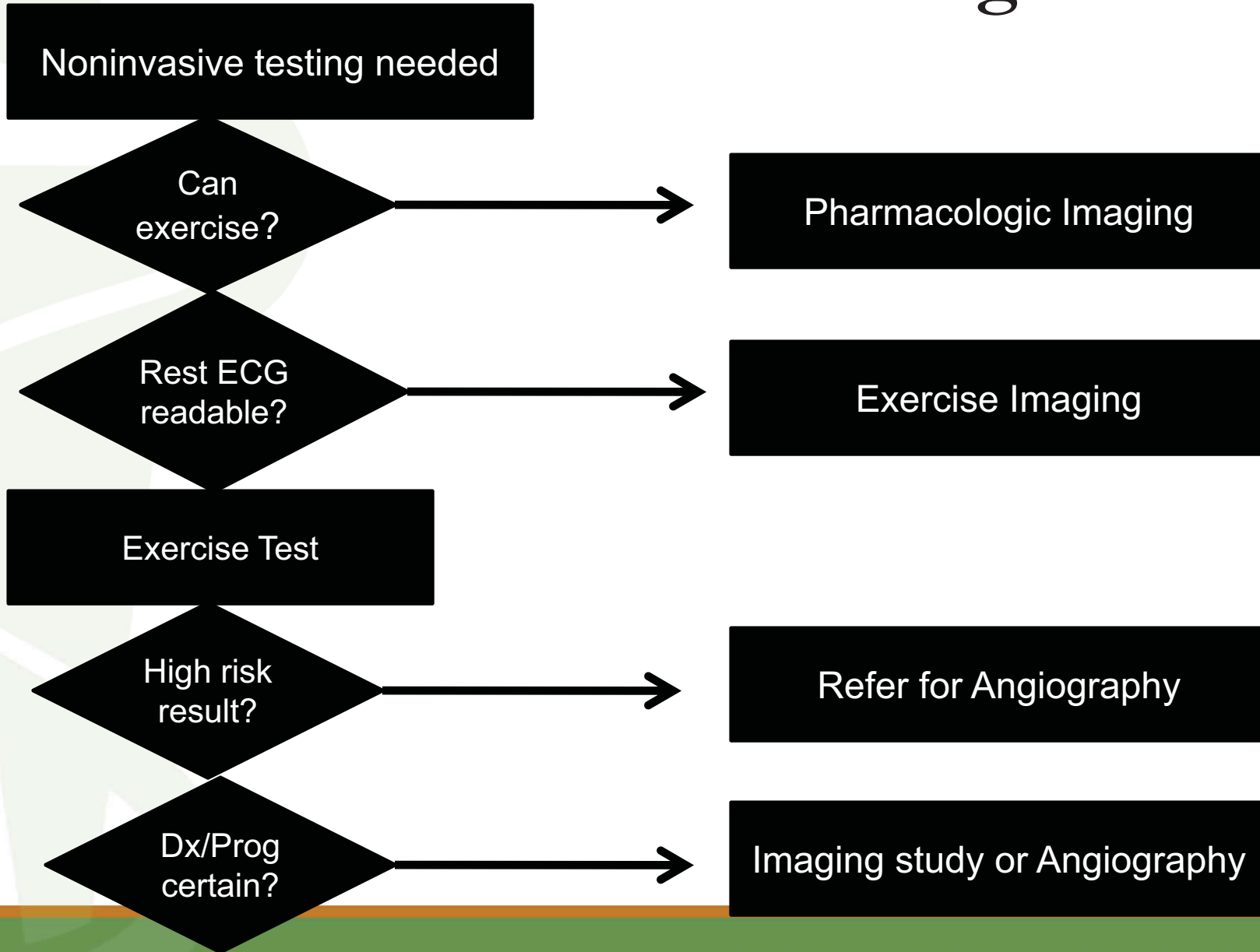
Case #4

- EST results
 - 1.5 mm ST depression in inferior leads
 - No symptoms
 - Achieved 8 METS
 - Exercised 10 minutes
 - Normal BP response
 - Normal heart rate recovery
 - No rhythm changes

Case #4

- Pre-test probability is intermediate
 - Her FRS is 11%
 - Pretest probability at 40% due to symptoms and EXT results
- Sensitivity at 61%, specificity at 70%
- LR + = 2.03
- Posttest probability = 57.6%

Noninvasive Test Algorithm



Myocardial Perfusion Imaging

- Planar Scintigraphy
 - No longer used
- Single-photon emission computed tomography (SPECT)
- Cardiac Positron Emission Tomography
- Cardiac Magnetic Resonance

Stress MPI

- Appropriate for diagnosis and risk stratification for chest pain patients
- Higher sensitivity than exercise ECG
- Thallium SPECT
 - 90% Sensitivity
 - 70% Specificity
- Sestamibi now recommended

Pharmacologic MPI

- For patients unable to exercise
- Pharmacologic agent
 - Adenosine
 - Dipyridamole
 - Dobutamine
 - Regadenoson
- Sensitivity 88%
- Specificity 77%

Stress Echocardiography

- Considered effective for CAD diagnosis
- Sensitivity is 76%
- Specificity is 88%
 - For > 50% coronary stenosis or cardiac events
 - Exercise vs. dobutamine
- Stress echo may be more cost-effective than exercise ECG

Coronary CT Angiography

- Noninvasive method of studying coronary arteries for stenosis
- Also gain information about LV function
- Most studies are single center and small with less than 100 patients
- Sensitivity = 94-95%
- Specificity = 82%

Cardiovascular MR

- Technical requirements similar to CTA
- Advantages
 - No radiation
 - No iodine contrast
 - No heart rate control needed
 - No issues with coronary calcium
- Sensitivity = 72%
- Specificity = 87%

Case #4

- Stress MPI done – SPECT
- Results negative for CAD
 - Thallium SPECT
- Do you trust these results?
- Sensitivity of 90%
- NPV = 99%

Review & Recommendations

- Primary Prevention
 - Traditional risk factor screening
 - Framingham or ATP III/NCEP
 - Low risk <10%
 - Counsel on lifestyle
 - Intermediate risk 10-20%
 - Consider CAC testing
 - High risk >20%
 - Consider EST testing

Review & Recommendations

- Acute Chest Pain Evaluation
 - Rest MPI during chest pain
- Noninvasive testing indicated
 - Exercise ECG if able with DTS
 - Most validated and inexpensive
 - Pharmacologic MPI
 - Stress Echo
 - CCTA
 - Depending on local availability/expertise