What Primary Care Providers Need to Know About Non-Invasive Cardiac Imaging: Who, When, and How?

Prem Soman, MD, PhD, FRCP
UPMC Heart and Vascular Institute
Pittsburgh, Pennsylvania

Kelley Branch, MD, MS
University of Washington Medical Center
Seattle, Washington

Thursday, November 15, 2012
Boston, Massachusetts
Session 5: What Primary Care Providers Need to Know About Non-Invasive Cardiac Imaging: Who, When, and How?

Learning Objectives

1. Recognize the differences between non-invasive cardiac imaging tests and discuss their clinical value in assessing cardiovascular risk.
2. Describe the role of pharmacologic stress agents in non-invasive cardiac imaging and the differences in their clinical and pharmacokinetic profiles.
3. Employ guideline-recommended appropriate-use criteria for non-invasive cardiac imaging tests and accurately refer patients for cardiology consultation from the primary care setting.
4. Compare and contrast non-invasive cardiac imaging tests with risk stratification by clinical variables alone in predicting cardiovascular events.

Faculty

Prem Soman, MD, PhD, FRCP
Associate Professor of Medicine (Cardiology)
University of Pittsburgh School of Medicine
Director of Nuclear Cardiology
UPMC Heart and Vascular Institute
Pittsburgh, Pennsylvania

Dr Prem Soman is an associate professor of medicine (cardiology) at the University of Pittsburgh School of Medicine, and director of Nuclear Cardiology at the Heart and Vascular Institute of the University of Pittsburgh Medical Center (UPMC). He has authored several original research papers, editorials, book chapters, and abstracts on nuclear cardiology.

Kelley Branch, MD, MS
Assistant Professor in Cardiology
University of Washington Medical Center
Seattle, Washington

Dr Kelley Branch is an assistant professor of cardiology at the University of Washington (UW), where he is the current medical director of the Coronary Care Unit and General Inpatient Cardiology as well as associate director of the Clinical Trials Service Unit. A member of the University of Washington Medical Center (UWMC) faculty since 2004, Dr Branch obtained a master’s degree in epidemiology and clinical trials from UW. His research interests lie in advanced cardiac imaging, with a focus on cardiac computed tomography (CT) and magnetic resonance imaging.

Dr Branch’s recent accolades include the American College of Cardiology (ACC)/Merck Fellowship Award, the Cardiology Teaching Excellence Award, and the UW School of Medicine Outstanding CME Teacher Award. His most recent research has been focused on the use of cardiac CT in the Emergency Room, radiation-reduction techniques for cardiac CT, and myocardial perfusion using CT. Dr Branch’s research support has also included a National Institutes of Health KL2 Mentored Training Grant. He has been invited to many national and international meetings to lecture on cardiac CT and cardiac imaging. Dr Branch is a fellow of the ACC.

Faculty Financial Disclosure Statements

The presenting faculty reports the following:
Dr Soman serves as a consultant for ICON Medical Imaging and Bracco Diagnostics Inc.
Dr Branch has no financial relationships to disclose.

Education Partner Financial Disclosure Statement

The content collaborators at Horizon CME have reported the following:
Brian Lee, PharmD; Elizabeth Wilkerson, CHES; and Cara Williams, PharmD, have no financial relationships to disclose.
**Acronym List**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMI</td>
<td>acute myocardial infarction</td>
<td>LVEDP</td>
<td>left ventricular end diastolic pressure</td>
</tr>
<tr>
<td>CA</td>
<td>coronary angiography</td>
<td>MDCT</td>
<td>multi-detector computed tomography</td>
</tr>
<tr>
<td>CABG</td>
<td>coronary artery bypass graft</td>
<td>MPI</td>
<td>myocardial perfusion imaging</td>
</tr>
<tr>
<td>CAD</td>
<td>coronary artery disease</td>
<td>MPHR</td>
<td>maximal predicted heart rate</td>
</tr>
<tr>
<td>CTA</td>
<td>computed tomography angiography</td>
<td>PCI</td>
<td>percutaneous coronary intervention</td>
</tr>
<tr>
<td>LVOT</td>
<td>left ventricular outflow tract</td>
<td>SPECT</td>
<td>single-photon emission computed tomography</td>
</tr>
</tbody>
</table>

**Suggested Reading List**


Session 5
2:30 PM – 4:00 PM

What Primary Care Providers Need to Know About Non-Invasive Cardiac Imaging: Who, When, and How?

Speakers:
Prem Soman, MD, PhD
Kelley Branch, MD, MS

Presenter Disclosure Information
The following relationships exist related to this presentation:
• Dr Soman serves as a consultant for ICON Medical Imaging and Bracco Diagnostics Inc.
• Dr Branch has no financial relationships to disclose.

Off-Label/Investigational Discussion
In accordance with pmiCME policy, faculty have been asked to disclose discussion of unlabeled or unapproved use(s) of drugs or devices during the course of their presentations.

Drug List

<table>
<thead>
<tr>
<th>Generic Drug Names</th>
<th>US Trade Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrochlorothiazide</td>
<td>Microzide, Hydrocot</td>
</tr>
<tr>
<td>losartan</td>
<td>Cozaar</td>
</tr>
<tr>
<td>aspirin</td>
<td>Ecotrin, Bayer, Ascriptin</td>
</tr>
<tr>
<td>dipyridamole</td>
<td>Persantine</td>
</tr>
<tr>
<td>adenosine</td>
<td>Adenoscan</td>
</tr>
<tr>
<td>regadenoson</td>
<td>Lexiscan</td>
</tr>
<tr>
<td>dobutamine</td>
<td>Dobutrex</td>
</tr>
</tbody>
</table>

What Primary Care Providers Need to Know About Non-Invasive Cardiac Imaging: Who, When, and How?

Learning Objectives

• Recognize the differences between non-invasive cardiac imaging tests and discuss their clinical value in assessing cardiovascular risk
• Describe the role of exercise and pharmacologic stress agents in non-invasive cardiac imaging and the differences in their clinical and pharmacokinetic profiles
• Employ guideline recommended appropriate use criteria for non-invasive cardiac imaging tests and accurately refer patients for cardiology consultation from the primary care setting
• Compare and contrast non-invasive cardiac imaging tests with risk stratification by clinical variables alone in predicting cardiovascular events

Demographic Question

Approximately how many patients that you’ve seen in the last 6 months have you referred for non-invasive cardiac imaging?

1. None
2. 1-5
3. 6-10
4. 11-20
5. Over 20
Pre-Activity Question 1 of 5
How confident are you in your ability to identify and refer patients for non-invasive cardiac testing?

1. Not at all confident
2. Little confidence
3. Moderately Confident
4. Confident
5. Very confident

Pre-Activity Question 2 of 5
How often do you currently refer patients for some form of stress testing?

1. Never
2. Seldom
3. About half of the time
4. Usually
5. Always

Pre-Activity Question 3 of 5
You have decided your patient needs a stress test. Which of the following is not a rationale for choosing a pharmacologic stress test?

1. Right Bundle Branch Block (RBBB)
2. Pacemaker
3. Severe DJD
4. Severe claudication
5. 2 mm ST depressions on baseline ECG

Pre-Activity Question 4 of 5
As per current national guidelines, the major role of coronary CTA is which of the following?

1. Evaluate stent patency
2. Assess left ventricular function
3. Screening for CAD in asymptomatic individuals
4. Replace stress testing as non-invasive imaging modality
5. Rule out significant coronary stenosis in patients with symptoms

Pre-Activity Question 5 of 5
A 51-year-old gentleman presents with symptoms of chest pain that have been present for the past several months. He has a several year history of HTN, dyslipidemia, and Left Bundle Branch Block (LBBB). What is the most appropriate form of stress testing for him?

1. Exercise stress test
2. Exercise stress MPI
3. Vasodilator stress MPI
4. Dobutamine stress echo
5. Dobutamine stress MPI

Prevalence and Impact of CHD

• An estimated 16.3 million Americans have CHD – Accounts for 1 in every 6 deaths
• This year 1.45 million Americans will have a new or recurrent coronary attack of which 195,000 are silent
• Coronary attacks are responsible for about 1.2 million hospitalizations annually – $44 billion in expenses
### CV Risk Assessment in Asymptomatic Adults

2010 ACCF/AHA Guideline Recommendations

- Framingham Risk Score should be obtained for risk assessment in all adults without history of CHD
- Resting ECG may be considered for adults with HTN or T2D
- Echo to detect LVH may be considered in adults with HTN
- CACS or EST may be considered in intermediate risk adults
- Stress echo and stress MPI are **not** indicated in low-risk or intermediate-risk asymptomatic adults
- Stress MPI may be considered for adults with T2D or strong family history of CHD or when previous testing suggests high risk of CHD, such as CACS >400

### Symptomatic Patients:

**Assessment before Stress Testing**

- History
  - Most important
- CV Risk Assessment
- Resting ECG
  - Look for ST changes, LVH, heart block, Q-waves
- When to refer to cardiology
  - Typical angina, high CV risk

### Indications for Stress Testing in Symptomatic Adults

- Diagnosis of CAD
  - Estimating the probability of obstructive CAD
- Risk Stratification in known or suspected CAD (Estimating the risk of death or non-fatal MI)
  - Low risk < 1% per year
  - Intermediate risk 1-3% per year
  - High risk > 3% per year

### Non invasive Cardiac Testing Modalities for Diagnosis and Prognosis

- Exercise stress without imaging
  - Treadmill, Bicycle
- Stress Nuclear myocardial perfusion imaging (MPI) with SPECT or PET
  - Exercise Stress, Pharmacologic Stress
- Stress Echo
  - Exercise Stress, Pharm Stress
- CT Coronary Angiography
- Newer, evolving modalities
  - Stress MRI
  - Stress CT with perfusion

### Exercise Physiology

- Exercise preferred stressor – truly physiologic
- The physiologic response to exercise stress increases myocardial oxygen demand in response to increased HR and systolic BP
- The increased oxygen demand produces coronary vasodilatation
Anatomy of EST

- ECG
- Symptoms
- Exercise capacity
- Hemodynamic response

Safety of EST

- The risk of death is 1: 10,000
- The risk of cardiac arrest is 2: 10,000
- EST post-MI is safe
  - Submax test can be performed 3-7 days post uncomplicated MI
  - Symptom-limited test 3-6 wks post-MI

Indications for EST

Class I

Adult patients (including those with complete RBBB or less than 1 mm of resting ST ↓) with an intermediate pretest probability of CAD, based on gender, age, and symptoms.

Contraindications for EST

- Acute MI (<2 days)
- Unstable angina with recent chest pain at rest
- Untreated life-threatening arrhythmias
- Decompensated heart failure
- Advanced AV block
- Acute myocarditis or pericarditis
- Active endocarditis
- Severe aortic stenosis
- Severe hypertrophic cardiomyopathy
- Uncontrolled hypertension (SBP>200, DBP>110)
- Acute systemic illness (pulmonary embolism, AD)

Sensitivity and Specificity of EST for CAD

*Compared to observed CAD with cardiac catheterization

Sensitivity* | Specificity/Normalcy*
---|---
66 | 77

Prognostic Value of EST

CASS Study - Medical Treatment Limb

- 4000 patients with EST
- Only Stage I with >1.0 mm ST ↓
  - 12% of patients
  - 5% mortality/yr
- Stage III or higher with <1.0 mm ST ↓
  - 34% of patients
  - <1% mortality/yr
- Pts with excellent exercise tolerance (> 10 METs) have good prognosis regardless of coronary anatomy
EST Indicators of Adverse Prognosis

- <6 METs of exercise
- Failure to increase SBP to 120 mm Hg
- Decrease in BP of 10 mm Hg during exercise
- Downsloping ST segment ≥ 2 mm at <6 METs involving 5 leads, persisting 5 min into recovery
- ST segment elevation
- Angina at low exercise workloads
- Sustained (>30 sec) or symptomatic VT

MET – metabolic equivalent (unit of measurement); VT – ventricular tachycardia

Limitations of EST

- Some cannot exercise due to de-conditioning or orthopedic abnormalities
- Abnormal baseline ECG
- Limited diagnostic characteristics

Key Point

Exercise stress test:
- Best physiologic testing
- Good prognostic data

Myocardial Perfusion Imaging (MPI)

MPI
Nuclear Stress Testing

- IV injection of a radioactive compound (tracer) that is taken up by cardiac muscle in proportion to coronary blood flow.
- Produces a 3-D map of myocardial perfusion

Myocardial Perfusion Scan 2012
Normal Study

Inferior Ischemia

**MPI**

- **Stress Modalities**
  - Exercise
  - Pharmacologic:
    - Vasodilators (dipyridamole, Adenosine, Regadenoson)
    - Dobutamine
  - **Tracers**
    - Tc-99m-based tracers (Tc-99m sestamibi and Tc-99m tetrofosmin)
    - Thallium-201

**Indications for MPI**

- **Diagnosis of CAD**
  - Patients who cannot exercise or have confounding changes on the baseline ECG (LBBB, LVH, digitalis, pre-excitation, > 1mm ST depression at baseline)
- **Risk stratification in known or suspected CAD**
- **Assessment of myocardial viability**
- **Detecting post PCI or CABG ischemia**
- **Assessing the functional significance of coronary stenosis**

**When to refer for Pharmacological Stress?**

- Inability to achieve 85% maximal predicted heart rate with treadmill exercise
- Inability to exercise: Orthopedic, peripheral vascular, neurologic, neuromuscular conditions
- Baseline abnormal ECG: LBBB, pre-excitation (WPW), ventricular pacing, > 1mm ST depression
- Early post-MI
Pharmacologic Stress Agents for Nuclear MPI

<table>
<thead>
<tr>
<th>Agent</th>
<th>Half-life</th>
<th>Infusion Time</th>
<th>Contraindications</th>
<th>Adverse Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dipyridamole</td>
<td>33-62 min</td>
<td>10-15 min</td>
<td>Severe lung disease or asthma, 4th or 5th degree AV block, sinus node disease, asthma (dipyridamole, adenosine only)</td>
<td>Chest pain, headache, tachycardia, flushing, hypotension, bronchospasm, dyspnea, heart block</td>
</tr>
<tr>
<td>Adenosine</td>
<td>&gt;10 sec</td>
<td>4-6 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regadenoson</td>
<td>2-4 min</td>
<td>10 sec</td>
<td></td>
<td>No bronchospasm</td>
</tr>
</tbody>
</table>

Vasodilators

Catecholamines

Dobutamine | 2 min | 20-30 min | Arrhythmias, recent MI (≤ 30 days), severe HTN, severe HOCM, acute aortic aneurysm or dissection | Ischemia, arrhythmia, hypertension, headache, chest pain, palpitations, SOB |

Strength of Nuclear MPI

Practically every one can get an interpretable MPI!

Patient Preparation

• NPO 6 hours prior to injection of radiotracer

WHY???

• No caffeine 24 hrs prior to vasodilator study

• Hold beta blockers or anti-anginal if attempting to diagnosis ischemia

Effect of Antianginals on MPI

Sensitivity (%)

<table>
<thead>
<tr>
<th></th>
<th>LAD</th>
<th>LCx</th>
<th>RCA</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td>Antianginals</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
</tr>
</tbody>
</table>

* P = 0.003

N=18

High Risk Indicators on MPI

• Large perfusion defects
• Multiple perfusion defects
• Reversible ischemia
• LV dysfunction
• Poor functional capacity

CO – coronary output, LVEDP – left ventricular end diastolic pressure

Sensitivity and Specificity of Nuclear MPI for CAD

![Graph showing sensitivity and specificity of nuclear MPI for CAD]

Risk Stratification with Nuclear MPI

- Particular strength of Nuclear MPI
- Supported by large volume of data

Prognostic Value of Normal MPI

Risk of Major Cardiac Events when MPI is normal

<table>
<thead>
<tr>
<th>No. of Studies</th>
<th>No. of Patients</th>
<th>Mean Follow-up (Mo)</th>
<th>Events Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>27,000</td>
<td>26.8</td>
<td>0.6%</td>
</tr>
</tbody>
</table>


Prognostic Value of Abnormal MPI

- Review of 14 studies
- 12 fold risk of nonfatal MI or death with abnormal study

Prognostic Value of Abnormal MPI

MPS Provides Incremental Benefit for Further Risk Stratification

Use of MPI to Plan Therapy

10,627 Patients
498 All-Cause Mortality

Medical therapy
Revascularization

Stress MPI Limitations

- Long-protocol (patient unfriendly!)
- May underestimate extent of disease in multivessel CAD
- Involves a small radiation dose to the patient

Stress Echocardiography
Kelley Branch, MD, MS

Stress Echo

- Based on principle that ischemic myocardium becomes hypokinetic
- Baseline echo to identify regional wall motion
- Immediate echo to look for changes in wall motion
- Exercise or pharmacologic (dobutamine) stress
- Low “stress” = viability
- High “stress” = ischemia

Normal Stress Echo

Abnormal Stress Echo

Sensitivity and Specificity of Non-Invasive Tests for CAD

*Compared to observed CAD with cardiac catheterization

ECG – electrocardiogram; SPECT – single-photon emission computed tomography; CAD – coronary artery disease


Stress Echo Limitations

- Technical quality of images
  - COPD
  - Obesity
- Timing of acquisition of images
- Learning curve
- Operator dependent
- Reproducibility

COPD – chronic obstructive pulmonary disease

Event-Free Survival Curves for Total Cardiac Events

Similar prognostic data for nuclear MPI and stress echo

Comparison of 4 models Tested in Predicting All Cardiac Events

Prognostic Value of Stress Echo vs Stress MPI

- Exercise echo and MPI improve diagnostic and prognostic power of clinical variables including stress ECG
- Comparable prognostic information
- Choice of echo or MPI depends on several factors, including availability, feasibility, expertise, and cost considerations

Key Points

- Use exercise with stress MPI or echocardiography, when possible
- Prepare patient – no caffeine, anti-anginals
- Similar diagnostic and prognostic data with MPI and echo, but incremental to clinical data alone
- Choice between MPI and echo?
  - Use what your Center does best

Cardiac CT

MPH – myocardial perfusion imaging
Challenges of Coronary Imaging

• Small vessels with complex anatomy in rapid motion
• Small vessels require high spatial resolution
• Coronary motion requires excellent temporal resolution

Why Are We Using CT for Coronary Imaging 30 Years Later?

Better Machines
- Better detectors
- Improved spatial resolution
- Increased number detectors
- Improved volume coverage
- Faster gantry rotation time
- Improved temporal resolution

Coronary CTA
Axial Dataset

Normal Coronary Arteries

3D Volume Rendering
Coronary Arteries

Coronary Atherosclerotic Plaque
Coronary Stenosis

Limitations of Coronary CTA

- Calcification
  - "blooming"
- Rapid heart rate
  - "motion"
- Stents
- Distal / small vessels

CTA – computed tomography angiography

CCTA and Invasive Angiography: Meta-Analysis

- 28 studies, N=2024 patients

CCTA can "rule out" CAD with high sensitivity and negative predictive value

AHA Scientific Statement
Assessment of Coronary Artery Disease by Cardiac Computed Tomography

Key Statement: CT Coronary angiography is reasonable for the assessment of obstructive disease in symptomatic patients (Class IIa, Level of Evidence: B)

CCTA – coronary computed tomography angiography; PPV – positive predictive value; NPV – negative predictive value; 95% CI – confidence interval.

Coronary CTA in the ED
Enhance Triage

43-year-old female, chest pain, ECG - sinus bradycardia – 1st troponin (-)

64 Slice Cardiac CT in the ED

Sensitivity and Specificity of Non-Invasive Tests for CAD

*Compared to observed CAD with cardiac catheterization

CCTA can “rule out” CAD with high sensitivity and negative predictive value

Key Statement:
CT Coronary angiography is reasonable for the assessment of obstructive disease in symptomatic patients (Class IIa, Level of Evidence: B)

Sensitivity and Specificity of Non-Invasive Tests for CAD

Ex. ECG
Ex. SPECT TI
Ex. SPECT Tc
Ex. Echo
CCTA

Sensitivity
Specificity/Normalcy

68 77
91 99
84 93
87 90
96 100

CCTA in the ED Enhance Triage

43-year-old female, chest pain, ECG - sinus bradycardia – 1st troponin (-)
CCTA Prognosis: Meta-Analysis

Annual Event Rates Stratified by Degree of CAD*

- No CAD
- Non-Obstructive CAD
- Obstructive CAD

<table>
<thead>
<tr>
<th>Event Rate per 100 Patients per Year</th>
<th>No CAD</th>
<th>Non-Obstructive CAD</th>
<th>Obstructive CAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACE</td>
<td>9.17</td>
<td>1.81</td>
<td>24.82</td>
</tr>
<tr>
<td>Death</td>
<td>0.10</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revasc</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MACE = major adverse cardiac events

All groups were significantly different by analysis of variance (p < 0.05)


Confirm
A Large International Multicenter Registry

All-Cause 3-year Survival in 23,854 Patients without Known CAD

<table>
<thead>
<tr>
<th>Survival Probability</th>
<th>Normal</th>
<th>Non-Obstructive</th>
<th>1-Vessel CAD</th>
<th>2-Vessel CAD</th>
<th>3-Vessel CAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 0</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Year 1</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Year 2</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Year 3</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>


Incremental Prognostic Value of CCTA

<table>
<thead>
<tr>
<th>Global Chi-Square</th>
<th>Clinical</th>
<th>Clinical + MPI</th>
<th>Clinical + MSCT</th>
<th>Global Chi-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>P = 0.85</td>
<td>4.4</td>
<td>15.8</td>
<td>20.5</td>
<td>30.4</td>
</tr>
</tbody>
</table>

CCTA – coronary CT angiography; MPI – myocardial perfusion imaging; MSCT – multislice CT


Key Points

- Coronary CTA has high sensitivity and negative predictive value to rule out CAD
  - Use in Emergency Department or Urgent Care for CAD evaluation
- Need slow regular heart rate
- Calcium can interfere with imaging, but has prognostic value
- Coronary CT has incremental prognostic value compared to clinical data

Patient Cases

Case 1

- 76-year-old man
- Presents for BP check
- Currently feels well, admits to a few episodes of chest pain in the last 2 months
Case 1, Cont’d

- Past Medical History
  - Essential hypertension; former smoker – quit 15 years ago
- Medications
  - ASA 81 mg po qd; HCTZ 12.5 mg po qd; Losartan 100 mg po qd
- Physical Exam
  - BP 126/78  HR 71  SpO2 96% RA BMI 24.9
  - Awake, alert, pleasant
  - Chest – clear without rales; Heart – normal heart sounds without murmurs; Abd – soft, not obese; Extremities – mild pedal edema bilaterally

Case 1: Question 1 of 2

How would you address this patient’s reported episodes of chest pain?

1. Reassure the patient since he is no longer having chest pain
2. Refer for exercise stress test
3. Refer for stress MPI
4. Refer for coronary CTA
5. Refer for invasive coronary angiogram

Exercise Stress Test

- Exercised 5:35 min on a Bruce protocol (stage II), achieved 75% maximum predicted heart rate
  - Normal BP response
  - Rest ECG – NSR at 72 bpm
  - ECG at peak stress – Sinus tachycardia without ischemic ECG changes
  - Test terminated due to fatigue; denied angina

- Exercise stress test inconclusive

Case 1: Question 2 of 2

What would be appropriate at this time?

1. Stop there and see patient in f/u in 3 months
2. Refer for pharmacologic stress test
3. Refer for coronary CTA
4. Refer for invasive coronary angiogram

Pharmacologic Stress Test

The decision was to proceed with a pharmacologic stress test

Regadenoson MPI

- Rest ECG – NSR at 68 bpm
- ECG at peak stress – NSR at 94 bpm; TWI developed in II, III, aVF, V5-V6
- Resting BP 134/88; at peak stress 102/66
- Developed angina at peak stress
Case 2

• 57-year-old woman

• Recently seen for chest pain that she has been experiencing for several months and thought to be GERD

• Jaw pain started 2 months ago

• Pain not related to exertion

• Complains of increasing fatigue

Case 2, Cont’d

• Past Medical History
  – Hypertension

• Medications
  – HCTZ 12.5 mg po qd

• Physical Exam
  – BP 142/78 HR 71 Ht 5’3” Wt 114 lbs
  – Awake, alert, cooperative
  – Chest – clear without rales; Heart – normal heart sounds without murmurs
  – Abd – non-obese, soft; Extremities – no edema

Case 2: Question 1 of 2

What would you do regarding this patient’s complaints of chest pain?

1. Reassure patient that these symptoms are consistent with GERD, prescribe PPI and see her in 1 month
2. Refer for stress test
3. Refer for coronary CT angiogram
4. Refer for invasive coronary angiogram

She is referred for a stress echocardiogram…
Stress Echocardiogram

- Exercise capacity
  - 14:30 min
  - Resting BP 135/83 mmHg
  - BP at peak stress 210/98 mmHg
  - Peak HR 144 bpm, 88% max predicted for age
  - Exercise stopped as pt achieved target HR

- ECG
  - At rest, NSR 61 bpm, normal
  - At peak stress, negative for ischemia, rare PACs and PVCs

Case 2: Question 2 of 2

What would be an appropriate next step for this patient?

1. She exercised for 14:30 minutes without chest pain or ischemic ECG changes. No further testing is necessary as these results portend an excellent prognosis; manage her risk factors medically.

2. The stress echo is (+), refer to invasive coronary angiography to exclude occlusive CAD.

3. Given her hypertensive response, this may represent a false (+) stress test. Consider another noninvasive test.

Post-Activity Question 1 of 5

After participating in this activity, how confident are you in your ability to identify and refer patients for noninvasive cardiac testing?

1. Not at all confident
2. Little confidence
3. Moderately Confident
4. Confident
5. Very confident

Confirm
A Large International Multicenter Registry

All-Cause 3-year Survival in 23,854 Patients without Known CAD

- Normal
- Non-Obstructive
- 1-Vessel CAD
- 2-Vessel CAD
- 3-Vessel CAD
- 3-Vessel Off Main

Survival Probability

Survival Time (years)


Coronary CTA

Post-Activity Question 2 of 5

After participating in this activity, how often will you now refer patients for some form of stress testing?

1. Never
2. Seldom
3. About half of the time
4. Usually
5. Always

Post-Activity Question 3 of 5

You have decided your patient needs a stress test. Which of the following is not a rationale for choosing a pharmacologic stress test?

1. Right Bundle Branch Block (RBBB)
2. Pacemaker
3. Severe DJD
4. Severe claudication
5. 2 mm ST depressions on baseline ECG

Post-Activity Question 4 of 5

As per current national guidelines, the major role of coronary CTA is which of the following?

1. Evaluate stent patency
2. Assess left ventricular function
3. Screening for CAD in asymptomatic individuals
4. Replace stress testing as non-invasive imaging modality
5. Rule out significant coronary stenosis in patients with symptoms

Post-Activity Question 5 of 5

A 51 year old gentleman presents with symptoms of chest pain that have been present for the past several months. He has a several year history of HTN, dyslipidemia, and Left Bundle Branch Block (LBBB). What is the most appropriate form of stress testing for him?

1. Exercise stress test
2. Exercise stress MPI
3. Vasodilator stress MPI
4. Dobutamine stress echo
5. Dobutamine stress MPI

Q & A

Thank You