Cardiac Pre-Operative Evaluation

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Cardiology Fellow, PGY 6
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The Consultant’s Job...

I keep paying you for consulting, but you never make any recommendations.

I'm what you call a "feel good."

My job is to make you feel secure in the knowledge that someone brilliant is shaping your strategies.

This is weird; I hate you, but at the same time I feel good.

You're welcome.
Objectives of Conference

• Understand “Cardiac Clearance” for noncardiac surgery
• Apply Guidelines for pre-operative evaluation
• Who needs a stress test?
• Who needs a cath?
• Who can go to surgery?
Pre-Op Cardiac Evaluation
Potentially many facets

- Coronary atherosclerosis
  - Myocardial ischemia
- Heart failure
  - Systolic
  - Diastolic
- Arrhythmia
  - Chronic
  - Pacemaker/ICD
  - Peri-operative
- Valvular disease
- Anticoagulation & Antiplatelet issues
- Congenital heart disease
Focus on coronary atherosclerosis

• Most common question with pre-op evaluation
• Easily tested on ABIM board exam
  – High yield topic – 1% of questions on ABIM 2003 will be covered in the next hour
A 72-year-old man is referred for evaluation prior to abdominal aortic aneurysm surgery. He smokes and is on an ACE inhibitor for hypertension and is on lovastatin. He has no history of heart disease, and is asymptomatic. Resting heart rate is 86 bpm and BP is 165/90. ECG shows nonspecific T wave changes.

Which of the following is the most appropriate course of action?

A. Operating room with peri-operative Beta blocker
B. Stress test
C. Cardiac Catheterization
Question 2

A 50-year-old woman is referred for evaluation prior to laparoscopic cholecystectomy. Resting BP is 150/85 in the right arm and 162/90 in the left arm. Other than mild obesity, the remainder of the physical examination is unremarkable. She has no prior history of hypertension or other significant illness. EKG shows a Right Bundle Branch Block. Her family history is positive for hypertension and stroke. She works as a salesclerk and exercises on a treadmill for half an hour three times per week.

Which of the following is the most appropriate course of action?

A. Treadmill stress echocardiogram.
B. Adenosine nuclear perfusion study.
C. MRA of renal arteries.
D. Abdominal CT with CT angiography of renal arteries.
E. Prophylactic beta-blocker therapy.
A 55-year-old with known ischemic cardiomyopathy, EF 20%, presents with acute appendicitis. Medications include an ACE inhibitor, a beta-blocker, and a diuretic. His cardiac status has been stable, with no paroxysmal nocturnal dyspnea, orthopnea, or chest pain. Coronary angiography two years ago showed proximal occlusion of the LAD coronary artery. ECG shows an old anterior wall MI, unchanged compared to prior tracings. He works as a used car salesman and walks two miles around his neighborhood with his wife at least twice per week. Exam shows no rales, edema, jugular venous distention, or gallop.

Which of the following is the most appropriate course of action?

A. Preoperative coronary angiography and PCI if indicated.
B. Treadmill exercise test with either nuclear perfusion imaging or echocardiography.
C. Resting echocardiogram with EF and wall motion analysis.
D. Pulmonary artery catheter placement for intraoperative monitoring.
E. Postoperative ECG and troponin.
Why assess patients pre-operatively?

• Identify patients at risk for cardiac complications peri-operatively
  – Myocardial infarction
  – Arrhythmia
  – CHF
• Intervene to reduce the cardiac risk
• Pre-op evaluation in US is estimated to cost $3.7 billion/year
Some facts and figures

- 27 million patients undergo surgery annually in US
- 1 million of those will have peri-operative cardiac complication
  - $20 billion/year in extra hospital/long term care costs
- Overall risk of post-op MI is <1%
  - However, it is about 6% if there is hx of MI
  - Risk peaks within about 3 days post op, most MI’s are detected within 24 hours
Surgical Stress on the Heart

Decreased Myocardial Oxygen Delivery
- anemia/hypoxemia
- hypotension
- coronary vasospasm/thrombosis

Increased Myocardial Oxygen Demand
- tachycardia
- hypertension
- increased contractility
- increased afterload

Plaque Rupture
- hemodynamic instability

Myocardial Ischemia

Postoperative Myocardial Infarction
The Old Ways of Pre-op Eval

- 1947 – Dripps; assigned physical class to patients prior to anesthesia
  - 1. A healthy patient.
  - 3. A patient with a severe systemic disease that limits activity, but is not incapacitating.
  - 4. A patient with an incapacitating systemic disease that is a constant threat to life.
  - 5. A moribund patient who is not expected to survive 24 hours with or without an operation.

- Note: In the event of an emergency operation, precede the number with an E.
## 1977 Goldman

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
<td></td>
</tr>
<tr>
<td>Age &gt; 70</td>
<td>5</td>
</tr>
<tr>
<td>MI in past 6 months</td>
<td>10</td>
</tr>
<tr>
<td><strong>Physical Exam</strong></td>
<td></td>
</tr>
<tr>
<td>3rd Heart sound or JVD</td>
<td>11</td>
</tr>
<tr>
<td>Important Aortic stenosis</td>
<td>3</td>
</tr>
<tr>
<td><strong>EKG</strong></td>
<td></td>
</tr>
<tr>
<td>Rhythm other than sinus or PAC’s</td>
<td>7</td>
</tr>
<tr>
<td>&gt;5 PVC’s per minute at any time</td>
<td>7</td>
</tr>
<tr>
<td><strong>General status</strong></td>
<td></td>
</tr>
<tr>
<td>Hypoxia, renal failure, LFT abnormality</td>
<td>3</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
<td></td>
</tr>
<tr>
<td>Intraperitoneal, aortic, or intrathoracic</td>
<td>3</td>
</tr>
<tr>
<td>Emergency</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>53</td>
</tr>
</tbody>
</table>
1986 Detsky

- Modified Goldman
- Even more complicated than Goldman
ACC 2002

• Most recent guideline for cardiac pre-operative evaluation
• Stepwise evaluation of patient
History & Physical

• History
  – What surgery?
  – Cardiac history and risk factors

• Physical
  – Neck – JVD, carotid bruits
  – Heart - 3rd or 4th heart sound, rhythm
  – Lungs – crackles
  – Extremities – edema, pulses
ACC 2002

**STEP 1**
- Need for noncardiac surgery
  - Emergency surgery
  - Operating room
  - Postoperative risk stratification and risk factor management

**STEP 2**
- Coronary revascularization within 5 yr?
  - Yes
    - Recurrent symptoms or signs?
      - Yes
        - Recurrent symptoms or signs?
        - Operating room
      - No
        - Favorable result and no change in symptoms
          - Operating room
          - Major clinical predictors

**STEP 3**
- Recent coronary evaluation
  - Yes
    - Recent coronary angiogram or stress test?
      - Yes
        - Favorable result and no change in symptoms
          - Operating room
        - Unfavorable result or change in symptoms
          - Clinical predictors
          - Intermediate clinical predictors
          - Minor or no clinical predictors
  - No
    - Medical management and risk factor modification

**STEP 4**
- Major clinical predictors
  - Consider delay or cancel noncardiac surgery
  - Medical management and risk factor modification

- Intermediate clinical predictors
  - Consider coronary angiography
  - Subsequent care dictated by findings and treatment results

- Minor or no clinical predictors
  - Go to step 6

**Major Clinical Predictors**
- Unstable coronary syndromes
- Decompensated CHF
- Significant arrhythmias
- Severe valvular disease

ACC 2002
Step 1

• Is this emergency surgery?
  – If yes, go to the OR
Step 2

• Has the patient had coronary revascularization in the last 5 years?
  – If so, does the patient have any recurrent symptoms?
  – If there are no recurrent symptoms, the patient may go to the OR
Step 3

• Has the patient had a coronary evaluation (Cardiac catheterization or stress test) in the past 2 years?
  – If results were favorable and symptoms have not changed, pt may go to OR
Step 4

• Are there any Major Clinical Predictors?
  – Unstable coronary syndrome
  – Decompensated CHF
  – Significant arrhythmia
  – Significant valvular disease

• If any of these are present then Cardiac Catheterization is a recommended strategy pre-operatively
Step 5

• Are there any Intermediate Clinical Predictors?
  – Mild angina pectoris
  – Prior MI
  – Compensated or prior CHF
  – Diabetes
  – Renal insufficiency

• If any of these are present then must stratify functional status and risk of operation
Intermediate clinical predictors

**STEP 6**
- Clinical predictors
  - Functional capacity (Poor (<4 METs) vs. Moderate or excellent (>4 METs)
  - Surgical risk

**STEP 8**
- Noninvasive testing
  - Low risk: Noninvasive testing
  - High risk: Invasive testing
    - Consider coronar angiography
    - Subsequent care* dictated by findings and treatment results
- Intermediate clinical predictors
  - High surgical risk procedure
  - Intermediate surgical risk procedure
  - Low surgical risk procedure
- Operating room
- Postoperative risk stratification and risk factor reduction

**Intermediate Clinical Predictors**
- Mild angina pectoris
- Prior MI
- Compensated or prior CHF
- Diabetes mellitus
- Renal insufficiency
Step 6

• What is the functional status
  – $\geq 4$ Mets or $< 4$ Mets
  – If $< 4$ Mets then stress test
What’s a MET?

<table>
<thead>
<tr>
<th>Table 2. Estimated Energy Requirements for Various Activities*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 MET</strong></td>
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<tr>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td><strong>4 METs</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>4 METs</strong></td>
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<tr>
<td></td>
</tr>
<tr>
<td><strong>Climb a flight of stairs or walk up a hill?</strong></td>
</tr>
<tr>
<td><strong>Walk on level ground at 4 mph or 6.4 km per h?</strong></td>
</tr>
<tr>
<td><strong>Run a short distance?</strong></td>
</tr>
<tr>
<td><strong>Do heavy work around the house like scrubbing floors or lifting or moving heavy furniture?</strong></td>
</tr>
<tr>
<td><strong>Participate in moderate recreational activities like golf, bowling, dancing, doubles tennis, or throwing a baseball or football?</strong></td>
</tr>
<tr>
<td><strong>Participate in strenuous sports like swimming, singles tennis, football, basketball, or skiing?</strong></td>
</tr>
</tbody>
</table>

MET indicates metabolic equivalent.

*Adapted from the Duke Activity Status Index (20) and AHA Exercise Standards (96).
Step 6 (Continued)

- What is the functional status
  - $\geq 4$ Mets or $< 4$ Mets
  - If $< 4$ Mets then stress test

- What is the surgical risk?
  - Low or intermediate risk, go to OR
  - High risk, go to stress test
### Table 3. Cardiac Risk* Stratification for Noncardiac Surgical Procedures

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (Reported cardiac risk often greater than 5%)</td>
<td>Emergent major operations, particularly in the elderly</td>
</tr>
<tr>
<td></td>
<td>Aortic and other major vascular surgery</td>
</tr>
<tr>
<td></td>
<td>Peripheral vascular surgery</td>
</tr>
<tr>
<td></td>
<td>Anticipated prolonged surgical procedures associated with large fluid shifts and/or blood loss</td>
</tr>
<tr>
<td>Intermediate (Reported cardiac risk generally less than 5%)</td>
<td>Carotid endarterectomy</td>
</tr>
<tr>
<td></td>
<td>Head and neck surgery</td>
</tr>
<tr>
<td></td>
<td>Intraperitoneal and intrathoracic surgery</td>
</tr>
<tr>
<td></td>
<td>Orthopedic surgery</td>
</tr>
<tr>
<td></td>
<td>Prostate surgery</td>
</tr>
<tr>
<td>Low† (Reported cardiac risk generally less than 1%)</td>
<td>Endoscopic procedures</td>
</tr>
<tr>
<td></td>
<td>Superficial procedure</td>
</tr>
<tr>
<td></td>
<td>Cataract surgery</td>
</tr>
<tr>
<td></td>
<td>Breast surgery</td>
</tr>
</tbody>
</table>

*Combined incidence of cardiac death and nonfatal myocardial infarction.  †Do not generally require further preoperative cardiac testing.
Minor Clinical Predictors

- Advanced age
- Abnormal ECG
- Rhythm other than sinus
- Low functional capacity
- History of stroke
- Uncontrolled systemic hypertension

**Minor Clinical Predictors**

1. Clinical predictors
   - Functional capacity
   - Surgical risk

2. Noninvasive testing
   - High surgical risk procedure
   - Low risk

3. Invasive testing
   - Consider coronary angiography
   - Subsequent care dictated by findings and treatment results

**Flowchart:**
- Step 7: Clinical predictors
  - Poor (<4 METs)
  - Moderate or excellent (>4 METs)
- Step 8: Noninvasive testing
  - Operating room
- Postoperative risk stratification and risk factor reduction
Step 7

• Minor or no clinical predictors
  – Advanced age
  – Abnormal EKG
  – Rhythm other than sinus
  – Low functional capacity
  – History of stroke
  – Uncontrolled hypertension
Functional status (Minor predictors)

- If moderate or excellent then proceed to OR
- If <4 METS
  - Low or intermediate risk procedure can go to OR
  - High risk procedure, go to stress test
Benefits of Revascularization prior to surgery

• Retrospective studies have looked at balloon angioplasty
  – May be beneficial when PTCA is done 90 days prior to surgery

• Retrospective bare metal stent data
  – Surgery should be delayed AT LEAST 4 weeks after stent placement
  – Drug eluting stents?

• CABG prior to surgery has shown morbidity/mortality similar to patients without CAD
CARP
Coronary Artery Revascularization Prophylaxis

- VA study of 510 patients undergoing vascular surgery
  - 33% Abdominal aortic aneurysm
  - 67% Lower extremity arterial occlusive disease
- Avg age 66 years, significant but stable CAD
  - Randomized to revascularization vs. med management
    - 59% PCI; 41% CABG
- Surgery delayed 54 days (vs 18 days) for revascularization

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Revascularization</th>
<th>Medical Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postop MI</td>
<td>11.6%</td>
<td>14.3%</td>
</tr>
<tr>
<td>30-day mortality</td>
<td>3.1%</td>
<td>3.4%</td>
</tr>
<tr>
<td>2.7-year mortality</td>
<td>22%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Presented AHA 2004
Other Peri-operative measures

- Routine use of Swan-Ganz (pulmonary artery) catheters has not been shown to improve outcome.
- Peri-operative (pre- and post-) beta blockade is beneficial (mortality) for higher risk patients.
- Nitroglycerin may decrease ischemia, but has not been shown to decrease MI or mortality.
- Alpha-2 Agonists (Clonidine) *may* be beneficial in patients with CAD.
Peri-operative Beta Blockade
NEJM, July 2005

• Large retrospective review of 782,969 patients
  – 663,635 (85 percent) had no recorded contraindications to beta-blockers
  – 122,338 (18 percent) received Beta blocker during the first two hospital days
    • 14% with RCRI of 0
    • 44% with RCRI of >=4
  – RCRI 0 or 1- treatment of no benefit, possible harm
  – RCRI of 2, odds ratio of death in hospital 0.88
  – RCRI of 2, odds ratio of death in hospital 0.71
  – RCRI of >=4, odds ratio of death in hospital 0.58

REVISED CARDIAC RISK INDEX
(Circulation 1999; 100:1043-1049)

- Each risk factor is assigned one point.
- **1. High-risk surgical procedures**
  - Intraperitoneal
  - Intrathoracic
  - Suprainguinal vascular
- **2. History of ischemic heart disease**
  - History of myocardial infarction
  - History of positive exercise test
  - Current complain of chest pain considered secondary to myocardial ischemia
  - Use of nitrate therapy
  - ECG with pathological Q waves
- **3. History of congestive heart failure**
  - History of congestive heart failure
  - Pulmonary edema
  - Paroxysmal nocturnal dyspnea
  - Bilateral rales or S3 gallop
  - Chest radiograph showing pulmonary vascular redistribution
- **4. History of cerebrovascular disease**
  - History of transient ischemic attack or stroke
- **5. Preoperative treatment with insulin**
- **6. Preoperative serum creatinine > 2.0 mg/dL**

<table>
<thead>
<tr>
<th>RISK OF MAJOR CARDIAC EVENT</th>
<th>Points</th>
<th>Class</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>I</td>
<td>0.4%</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>II</td>
<td>0.9%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>III</td>
<td>6.6%</td>
<td></td>
</tr>
<tr>
<td>3 or more</td>
<td>IV</td>
<td>11%</td>
<td></td>
</tr>
</tbody>
</table>

"Major cardiac event" includes myocardial infarction, pulmonary edema, ventricular fibrillation, primary cardiac arrest, and complete heart block
Unresolved issues

• No randomized trials for PCI
• ? Timing after PCI
  – PTCA
  – Bare metal stent
  – Drug eluting stent
• Optimal timing and duration of Beta blocker therapy
• Role of Alpha-2 agonists?
A 72-year-old man is referred for evaluation prior to abdominal aortic aneurysm surgery. He smokes and is on an ACE inhibitor for hypertension and is on lovastatin. He has no history of heart disease, and is asymptomatic. Resting heart rate is 86 bpm and BP is 165/90. ECG shows nonspecific T wave changes. Which of the following is the most appropriate course of action?

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C. Resting echocardiogram with EF and wall motion analysis.
D. Pulmonary artery catheter placement for intraoperative monitoring.
E. Postoperative ECG and troponin.
Pearls for the Boards

• Emergencies go straight to OR!
• Remember – Revascularization in past 5 years or favorable stress test/cath in past 2 years with stable symptoms = OR
• Direct path to Catheterization is ONLY indicated with major clinical predictors
• Low risk surgery can usually go to OR
• High risk (vascular) surgery needs a stress test (per guidelines) unless low risk patient with >4 METS of function
• Good functional status + intermediate risk surgery = OR
• Carotid endarterectomy is a moderate risk procedure
Noninvasive options

• Exercise EKG
• Nuclear Imaging
• Stress echocardiography
• PET
• Electron Beam CT
• CT (16/64 slice) & MRI
Ischemic Cascade
Exercise EKG
The basic “stress test”

• Patient exercises on treadmill or bicycle
  – Bruce protocol common for treadmill
    • Start at 1.7 mph at 10% grade
    • Increase about 0.8 mph and 2% every 3 minutes
• EKG monitoring performed throughout
• Patient must achieve 85% of maximum predicted HR for valid results
  – Max HR = 220 - Age
Patients who should not have EKG only

- These lead to uninterpretable EKG or have high rate of false positives
  - Left Bundle Branch Block
  - Wolf-Parkinson-White (Ventricular pre-excitation)
  - Left Ventricular hypertrophy with strain
  - Ventricular pacing
  - Digoxin use
Positive EKG Stress

• PQ segment used as reference baseline
• Identify J point as junction of QRS complex and ST segment
• Measure ST changes 60-80 ms after J point
• ≥1mm of ST depression that is horizontal or downsloping
• 1mm ST depression with upsloping may be equivocal
Comparison of ST segment response

- A = Slowly Upsloping ST segment depression
- B = Horizontal ST segment depression
- C = ST depression with downsloping
ABNORMAL EXERCISE ECG WITH MARKED HORIZONTAL ST-SEGMENT DEPRESSION

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Exercise EKG

• 1 in 2500 risk of death or MI\(^1\)
• Sensitivity about 68%, Specificity about 77%\(^2\)
  (using 50% stenosis by cath as gold standard)
• Functional capacity assessed by METS
• BP expected to rise with exercise
• Poor heart rate recovery (HR decrease <12bpm 2 minutes after peak exercise) has negative prognosis
• Location of ST depressions does not anatomically localize coronary lesions

1 DiMarco
2 Gianrossi
Exercise testing in Females

• Increased incidence of false positives compared to males\(^1\)
  – CASS data shows sensitivity similar for women (76%) and men (78%)
  – However, specificity for women (64%) lower than for men (73%)

• Functional information is important
  – Females achieving 7.5 METS have same 20 year mortality prognosis with or without ST depression\(^2\)

1 Wiener
2 Mora
Nuclear Stress Test

• Basic concepts
  – Images the heart at rest and stress
  – Compare images to determine if coronary perfusion is reduced with stress
  – Scar areas revealed by lack of perfusion at rest
  – Gating techniques allow calculation of ejection fraction
Nuclear Stress Testing

• Choice of stress agents
  – Exercise
  – Pharmacological
    • Dobutamine
      – \( \beta \)-1 agonist which increases contractility, cardiac index, and oxygen consumption
    • Vasodilators
      – Adenosine
        » Direct vasodilator
      – Dipyridamole (Persantine)
        » Indirect vasodilator (enhances endogenous adenosine)
Nuclear Stress Testing

• Choice of Imaging Agents
  – Thallium-201
    • K+ analogue
  – Technitium-99m
    • Sestamibi (Cardiolite)
    • Tetrofosmin (Myoview)
    • Improved image resolution due to higher energy
      – Obesity
Short axis View of the Heart

[Diagram of the heart with labeled parts: RVO, RV, VS, LAD, LV]
Reversible ischemia of anterior, lateral, and inferior walls with LV dilatation
Prognosis

Annual Rate of Death or MI with Normal and Abnormal SPECT scans using Tc-99m
Nuclear Stress Testing

• Overall sensitivity 88%, specificity 85%
• Adenosine and dipyrimadole are contraindicated in bronchospastic disease
Stress Echocardiography

• Basic Principles
  – Imaging the heart at stress and rest
  – Evaluate for wall motion abnormalities at stress
  – Can identify akinetic scar areas
  – Dependent on adequate acoustic windows
Stress Echocardiography

• Pick a method of stress
  – Exercise
  – Dobutamine

• 81% Sensitivity, 92% specificity for at least 50% stenosis by angiography
## Overall performance of stress tests

<table>
<thead>
<tr>
<th>Method</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress EKG</td>
<td>68%</td>
<td>77%</td>
</tr>
<tr>
<td>Stress Echo</td>
<td>81%</td>
<td>92%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>88%</td>
<td>90%</td>
</tr>
</tbody>
</table>
Other Methods of Stress Imaging

• MRI
  – Dobutamine MRI similar to Dobutamine echo in premise
  – Better imaging, does not depend on acoustic windows

• PET
  – Similar to other nuclear imaging
  – Not widely available
Non Stress Imaging

Protocols for evaluation of coronary and bypass graft stenoses

- Multidetector CT angiography
  - 16 and 64 slice detectors in use
  - Iodinated contrast, ionizing radiation
- MRI (coronary)
  - Not widely available
  - Long acquisition times
- Both susceptible to artifacts during tachycardia
- Both techniques are in further development
- Compared to angiography (>50% stenosis)
  - MRI 75% sensitivity, 77% specificity
  - CT (16 slice) 82% sensitivity, 79% specificic

Electron Beam CT

• Not a stress test
• Noninvasive evaluation of coronary calcification
• ACC 2000 guidelines essentially do not recommend use of EBCT
• USPSTF recommends against using EBCT to screen asymptomatic patients
• Probably best employed in asymptomatic patients – but studies not conclusive on indications or long term prognosis
ACC 2002 Guideline for Exercise Testing


References