GUIDELINES AND INDICATIONS FOR OUTPATIENT NON-INVASIVE DIAGNOSTIC TESTING

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NO FINANCIAL DISCLOSURES

(UNFORTUNATELY...)
OVERVIEW
NON-INVASIVE DIAGNOSTIC TESTING

GOALS:

• DIAGNOSTIC MODALITIES
  • AMBULATORY ECG MONITORING
  • ECHOCARDIOGRAMS
  • AAA SCREENING ULTRASOUND
  • ABI’S AND PAD SCREENING
  • EXERCISE AND NUCLEAR STRESS TESTS
  • CORONARY CTA

• GUIDELINES AND INDICATIONS

• TAKE HOME POINTS
<table>
<thead>
<tr>
<th>Class I</th>
<th>Class IIa</th>
<th>Class IIb</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit &gt;&gt;&gt; Risk</td>
<td>Benefit &gt;&gt; Risk</td>
<td>Benefit ≥ Risk</td>
<td>Risk ≥ Benefit</td>
</tr>
<tr>
<td>Procedure/Treatment SHOULD be performed/administered</td>
<td>Additional studies with focused objectives needed</td>
<td>Additional studies with broad objectives needed; Additional registry data would be helpful</td>
<td>Procedure/Treatment should NOT be performed/administered</td>
</tr>
<tr>
<td>should is recommended is indicated is useful/effective/beneficial</td>
<td>IT IS REASONABLE to perform procedure/administer treatment</td>
<td>Procedure/Treatment MAY BE CONSIDERED</td>
<td>SINCE IT IS NOT HELPFUL AND MAY BE HARMFUL</td>
</tr>
<tr>
<td>is reasonable can be useful/effective/beneficial</td>
<td>may/might be considered may/might be reasonable usefulness/effectiveness is unknown/unclear/uncertain or not well established</td>
<td>is not recommended is not indicated should not is not useful/effective/beneficial may be harmful</td>
<td></td>
</tr>
</tbody>
</table>
## Applying Classification of Recommendations and Level of Evidence

<table>
<thead>
<tr>
<th>Level A</th>
<th>Class I</th>
<th>Class IIa</th>
<th>Class IIb</th>
<th>Class III</th>
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<tbody>
<tr>
<td>Multiple (3-5) population risk strata evaluated</td>
<td>Recommendation that procedure or treatment is useful/effective</td>
<td>Recommendation in favor of treatment or procedure being useful/effective</td>
<td>Recommendation’s usefulness/efficacy less well established</td>
<td>Recommendation that procedure or treatment not useful/effective and may be harmful</td>
</tr>
<tr>
<td>General consistency of direction and magnitude of effect</td>
<td>Sufficient evidence from multiple randomized trials or meta-analyses</td>
<td>Some conflicting evidence from multiple randomized trials or meta-analyses</td>
<td>Greater conflicting evidence from multiple randomized trials or meta-analyses</td>
<td>Sufficient evidence from multiple randomized trials or meta-analyses</td>
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### Applying Classification of Recommendations and Level of Evidence

<table>
<thead>
<tr>
<th>Level B</th>
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<th>Class IIa</th>
<th>Class IIb</th>
<th>Class III</th>
</tr>
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<tbody>
<tr>
<td><strong>Limited (2-3) population risk strata evaluated</strong></td>
<td><strong>• Recommendation that procedure or treatment is useful/effective</strong>&lt;br&gt;• Limited evidence from single randomized trial or non-randomized studies</td>
<td><strong>• Recommendation in favor of treatment or procedure being useful/effective</strong>&lt;br&gt;• Some conflicting evidence from single randomized trial or non-randomized studies</td>
<td><strong>• Recommendation's usefulness/efficacy less well established</strong>&lt;br&gt;• Greater conflicting evidence from single randomized trial or non-randomized studies</td>
<td><strong>• Recommendation that procedure or treatment not useful/effective and may be harmful</strong>&lt;br&gt;• Limited evidence from single randomized trial or non-randomized studies</td>
</tr>
</tbody>
</table>
## Applying Classification of Recommendations and Level of Evidence

<table>
<thead>
<tr>
<th>Level C</th>
<th>Class I</th>
<th>Class IIa</th>
<th>Class IIb</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very limited (1-2) population risk strata evaluated</td>
<td>• Recommendation that procedure or treatment is useful/effective</td>
<td>• Recommendation in favor of treatment or procedure being useful/effective</td>
<td>• Recommendation’s usefulness/efficacy less well established</td>
<td>• Recommendation that procedure or treatment not useful/effective and may be harmful</td>
</tr>
<tr>
<td></td>
<td>• Only expert opinion, case studies, or standard-of-care</td>
<td>• Only diverging expert opinion, case studies, or standard-of-care</td>
<td></td>
<td>• Only diverging expert opinion, case studies, or standard-of-care</td>
</tr>
</tbody>
</table>
CVD RISK ASSESSMENT

• FAMILY HISTORY- FIRST DEGREE RELATIVE
  • MALE <55
  • FEMALE <65

• STANDARD FASTING LIPID PROFILE (TOTAL CHOLESTEROL, HIGH-DENSITY LIPOPROTEIN (HDL) CHOLESTEROL, LDL CHOLESTEROL, AND TRIGLYCERIDES)

• HEMOGLOBIN A1C (HBA1C) MAY BE REASONABLE FOR CARDIOVASCULAR RISK ASSESSMENT IN ASYMPTOMATIC ADULTS WITHOUT A DIAGNOSIS OF DIABETES
CVD RISK ASSESSMENT

- IN ASYMPTOMATIC ADULTS WITH HYPERTENSION OR DIABETES, URINALYSIS TO DETECT MICROALBUMINURIA IS REASONABLE FOR CARDIOVASCULAR RISK ASSESSMENT
- ECG
- CAROTID US- FOR THOSE AT INTERMEDIATE RISK AND ASYMPTOMATIC
- ECHOCARDIOGRAPHY TO DETECT LVH MAY BE CONSIDERED FOR CARDIOVASCULAR RISK ASSESSMENT IN ASYMPTOMATIC ADULTS WITH HYPERTENSION
CVD RISK ASSESSMENT

- Measurement of ABI is reasonable for cardiovascular risk assessment in asymptomatic adults at intermediate risk.

- An exercise ECG may be considered for cardiovascular risk assessment in intermediate-risk asymptomatic adults (including sedentary adults considering starting a vigorous exercise program).
INDICATIONS FOR A-ECG TO ASSESS SYMPTOMS POSSIBLY RELATED TO RHYTHM DISTURBANCES

• CLASS I
  • UNEXPLAINED SYNCOPE
  • NEAR SYNCOPE
  • EPISODIC DIZZINESS WITH NO OBVIOUS CAUSE
  • RECURRENT UNEXPLAINED PALPITATIONS

• CLASS IIB
  • EPISODIC SOB, CP, FATIGUE NOT OTHERWISE EXPLAINED
  • NEUROLOGIC EVENTS AND SUSPECT AFIB/FLUT
  • SYNCOPE, NEAR-SYNCOPE, EPISODIC DIZZINESS, PALPITATIONS AND NO OTHER OBVIOUS CAUSE

INDICATIONS FOR A-ECG TO ASSESS PATIENTS WITHOUT SIGNIFICANT SYMPTOMS FROM ARRHYTHMIA

• CLASS IIB
  • POST MI PATIENTS WITH LV DYSFUNCTION
  • CHF PATIENTS
  • HYPERTROPHIC CARDIOMYOPATHY PATIENTS

INDICATIONS FOR A-ECG TO ASSESS ANTI-ARRHYTHMIC THERAPY

- ASSESS AAD RESPONSE IN INDIVIDUALS WITH FREQUENT ARRHYTHMIAS AND REPRODUCIBLE ARRHYTHMIAS (CLASS I)

- TO DETECT PROARRHYTHMIC RESPONSES TO AAD IN HIGH RISK PATIENTS (CLASS IIA)

- ASSESS RATE CONTROL IN ATRIAL FIBRILLATION (CLASS IIB)

- TO DOCUMENT RECURRENT SYMPTOMATIC OR ASYMPTOMATIC ARRHYTHMIAS DURING THERAPY (CLASS IIB)

AMBULATORY ECG

• CONTINUOUS RECORDERS
  • 2 OR 3 LEADS
  • YIELD IS LOW IN UNSELECTED POPULATIONS (15%)
  • BETTER YIELD IF LONGER DURATION (48-72) OR MORE SELECTIVE USE (SYNCOPE RATHER THAN DIZZINESS, ETC)

• EVENT MONITORING
  • IDEAL FOR INTERMITTENT OR RARE SYMPTOMS
  • NOT USEFUL IF THE PATIENT BECOMES INCAPACITATED
  • RETROSPECTIVE AND PROSPECTIVE STORAGE

AMBULATORY ECG

• MOBILE TELEMETRY

• MORE CONVENIENT FOR PATIENTS FOR LONGER DURATIONS

• CAN MONITOR FOR UP TO A MONTH

• ECG AND PATIENT TRIGGERS

• USED WHEN SHORTER TERM MONITORING UNLIKELY TO CAPTURE/DOCUMENT ARRHYTHMIA

AMBULATORY ECG

• IMPLANTABLE LOOP RECORDER

• IMPLANTED SUBCUTANEOUSLY ALONG LEFT STERNAL BORDER

• HELPFUL IN CASES OF UNEXPLAINED SYNCOPE, CRYPTOGENIC STROKE

• CAN BE LEFT IN FOR OVER A YEAR WITH FEW COMPLICATIONS

ECHO: GOALS OF EVALUATION

- LEFT VENTRICULAR SYSTOLIC FUNCTION
  - ACS? - WALL MOTION ABNORMALITIES
  - LV EF ASSESSMENT
- LV DIASTOLIC FUNCTION ASSESSMENT
- VALVULAR DISEASE
- PERICARDIAL DISEASE
- RIGHT VENTRICULAR DYSFUNCTION
- CARDIOMYOPATHIES
APPROPRIATE USE DEFINITION AND RATING

“AN APPROPRIATE IMAGING STUDY IS ONE IN WHICH THE EXPECTED INCREMENTAL INFORMATION, COMBINED WITH CLINICAL JUDGMENT, EXCEEDS THE EXPECTED NEGATIVE CONSEQUENCE* BY A SUFFICIENTLY WIDE MARGIN FOR A SPECIFIC INDICATION THAT THE PROCEDURE IS GENERALLY CONSIDERED ACCEPTABLE CARE AND A REASONABLE APPROACH FOR THE INDICATION.”

SCORE 7 TO 9: A

APPROPRIATE TEST FOR SPECIFIC INDICATION (TEST IS GENERALLY ACCEPTABLE AND IS A REASONABLE APPROACH FOR THE INDICATION).

SCORE 4 TO 6: U

UNCERTAIN FOR SPECIFIC INDICATION (TEST MAY BE GENERALLY ACCEPTABLE AND MAY BE A REASONABLE APPROACH FOR THE INDICATION). UNCERTAINTY ALSO IMPLIES THAT MORE RESEARCH AND/OR PATIENT INFORMATION IS NEEDED TO CLASSIFY THE INDICATION DEFINITIVELY.

SCORE 1 TO 3: I

INAPPROPRIATE TEST FOR THAT INDICATION (TEST IS NOT GENERALLY ACCEPTABLE AND IS NOT A REASONABLE APPROACH FOR THE INDICATION).
ECHO INDICATIONS: SYMPTOMS AND SIGNS

- SHORTNESS OF BREATH
- DYSPNEA ON EXERTION
- SYNCOPE
- NEAR-SYNCOPE
- HEART CLICK OR MURMUR
- HEMODYNAMIC INSTABILITY
- HYPOTENSION
- INGESTION OF CARDIOTOXIC AGENT

ASE Appropriate Use Criteria: http://www.asecho.org/i4a/pages/index.cfm?pageid=3912
ECHO INDICATIONS: DISEASE EVALUATION

- HYPERTENSION
- SUSPECTED HYPERTENSIVE CARDIOVASCULAR DISEASE (LVH ON ECG)
- CARDIOMEGALY ON CXR
- ENDOCARDITIS
- CONGESTIVE HEART FAILURE
- RECENT MI OR ACUTE CORONARY SYNDROME
- PULMONARY HYPERTENSION
- GREAT VESSEL DISEASE
  - MARFAN, EHLERS-DANLOS, LOEY-DIETZ

ASE Appropriate Use Criteria: http://www.asecho.org/i4a/pages/index.cfm?pageid=3912
ECHO INDICATIONS: FAMILY SCREENING

• PARENT, SIBLING OR CHILD
• INHERITED CARDIOMYOPATHY
  • BICUSPID AORTIC VALVE
  • COARCTATION OF AORTA
  • MARFAN’S, EHLERS-DANLOS
  • HYPERTROPHIC CARDIOMYOPATHY
  • NON-COMPACTION SYNDROME
  • DILATED CARDIOMYOPATHY
  • ARRHYTHMOGENIC RV DYSPLASIA
  • HEREDITARY HEMOCHROMATOSIS

ASE Appropriate Use Criteria: http://www.asecho.org/i4a/pages/index.cfm?pageid=3912
“IN MY HANDS”

“Marfan’s, if left undiagnosed, can lead to early and sudden death through enlargement and rupture — or dissection — of the aorta. Marfan patients frequently undergo open heart surgery to repair aorta damage. But both Hyman, who died during a volleyball game at the age of 22, and Larson, 34, were undiagnosed, as are thousands who live unknowingly with the disease.

“All it takes to know for sure is an echocardiogram.

‘They look at someone very young and healthy and don’t treat them for aortic dissection,’ says Reinking.

“Had he known he had a tissue disorder, Jonathan Larson may still be alive. It’s very important for people to know that and it’s not invasive to find out.”

ECHO INDICATIONS:

INAPPROPRIATE INDICATIONS

- ASYMPTOMATIC ISOLATED SINUS BRADYCARDIA
- SUSPECTED PULMONARY EMBOLISM IN ORDER TO MAKE A DIAGNOSIS
- TRANSIENT FEVER WITHOUT EVIDENCE OF BACTEREMIA OR A NEW MURMUR
- ROUTINE SURVEILLANCE OF A SMALL PERICARDIAL EFFUSION WITHOUT CHANGE IN CLINICAL STATUS

ASE Appropriate Use Criteria: http://www.asecho.org/i4a/pages/index.cfm?pageid=3912
AMBULATORY BP MONITOR

- VERIFICATION OF OFFICE OR HOME MEASUREMENTS
- WHITE COAT HYPERTENSION – OBTAINING ACCURATE BP MEASUREMENTS
- HYPOTENSION – OVER-MEDICATION
- BORDERLINE HTN – THERAPEUTIC DECISIONS
- DIURNAL VARIATION – NORMAL NOCTURNAL DIP
AAA SCREENING

• ONE-TIME SCREENING FOR ABDOMINAL AORTIC ANEURYSM (AAA) BY ULTRASONOGRAPHY IN MEN AGED 65 TO 75 WHO HAVE EVER SMOKED

• NO RECOMMENDATION MADE FOR SCREENING FOR AAA IN MEN AGED 65-75 WHO NEVER SMOKED

• ROUTINE SCREENING NOT RECOMMENDED FOR AAA IN WOMEN

http://www.uspreventiveservicestaskforce.org/uspstf/uspsaneu.htm
Image 5: Transverse view of AAA with intraluminal clot.

Image 6: Longitudinal view of AAA with intraluminal clot.
SCREENING FOR LOWER EXTREMITY Atherosclerotic Disease

• HISTORY/PHYSICAL EXAM FINDINGS SUGGESTIVE OF PAD (CLASS I)

**Table 5** History and/or Physical Examination Findings Suggestive of PAD

<table>
<thead>
<tr>
<th>History</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claudication</td>
</tr>
<tr>
<td>Other non-joint-related exertional lower extremity symptoms (not typical of claudication)</td>
</tr>
<tr>
<td>Impaired walking function</td>
</tr>
<tr>
<td>Ischemic rest pain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal lower extremity pulse examination</td>
</tr>
<tr>
<td>Vascular bruit</td>
</tr>
<tr>
<td>Nonhealing lower extremity wound</td>
</tr>
<tr>
<td>Lower extremity gangrene</td>
</tr>
<tr>
<td>Other suggestive lower extremity physical findings (e.g., elevation pallor/dependent rubor)</td>
</tr>
</tbody>
</table>

**Table 4** Patients at Increased Risk of PAD

- Age ≥65 y
- Age 50–64 y, with risk factors for atherosclerosis (e.g., diabetes mellitus, history of smoking, hyperlipidemia, hypertension) or family history of PAD (63)
- Age <50 y, with diabetes mellitus and 1 additional risk factor for atherosclerosis
- Individuals with known atherosclerotic disease in another vascular bed (e.g., coronary, carotid, subclavian, renal, mesenteric artery stenosis, or AAA)

JAm Coll Cardiol. 2017;69(11):e71-126. doi:10.1016/j.jacc.2016.11.007
**Calculation of Ankle/Brachial Index**

**Right ABI**
- Higher of the right ankle systolic pressure (dorsalis pedis or posterior tibial)
- Higher brachial systolic pressure (Left or right arm)

**Left ABI**
- Higher of the left ankle systolic pressure (dorsalis pedis or posterior tibial)
- Higher brachial systolic pressure (Left or right arm)

**Table 3: ABI Value-Based PAD Severity Grade**

<table>
<thead>
<tr>
<th>ABI Value</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1.30</td>
<td>Poorly compressible</td>
</tr>
<tr>
<td>0.91-1.30</td>
<td>Normal</td>
</tr>
<tr>
<td>0.70-0.90</td>
<td>Mild</td>
</tr>
<tr>
<td>0.40-0.69</td>
<td>Moderate</td>
</tr>
<tr>
<td>&lt;0.40</td>
<td>Severe</td>
</tr>
</tbody>
</table>

*ABI, ankle-brachial index; PAD, peripheral artery disease
*Based on the American Diabetes Association guidelines
CARDIAC CT

- CORONARY CTA, CORONARY ARTERY CALCIUM SCORING

- CAC MAY BE CONSIDERED, IF RISK IS INDETERMINANT AND TREATMENT DECISION IS UNCERTAIN AFTER RISK ASSESSMENT, TO INFORM TREATMENT DECISIONS (CLASS IIb)

- RADIATION EXPOSURE

- CORONARY CTA
  - TRUE LOCATION AND LUMINAL NARROWING NOT ALWAYS POSSIBLE TO DETERMINE
  - PROVIDES NO INFORMATION ON FUNCTIONAL EFFECT OF LESIONS


JAm Coll Cardiol. 2015;66(15):1669-1671. doi:10.1016/j.jacc.2015.08.041

2010 Appropriate Use Criteria for Cardiac Computed Tomography
<table>
<thead>
<tr>
<th>CCS (Agaston)</th>
<th>Risk</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Non-Identified</td>
<td>Negative test. Findings are consistent with a low risk of having a cardiovascular event in the next 5 years.</td>
</tr>
<tr>
<td>1-10</td>
<td>Minimal</td>
<td>Minimal atherosclerosis is present. Findings are consistent with a low risk of having a cardiovascular event in the next 5 years.</td>
</tr>
<tr>
<td>11-100</td>
<td>Mild</td>
<td>Mild coronary atherosclerosis is present. There is likely mild or minimal coronary stenosis. A mild risk of having CAD exists.</td>
</tr>
<tr>
<td>101-400</td>
<td>Moderate</td>
<td>Moderate calcium is detected in the coronary arteries and confirms the presence of atherosclerotic plaque. A moderate risk of having a cardiovascular event exists.</td>
</tr>
<tr>
<td>&gt;400</td>
<td>High</td>
<td>A high calcium score may be consistent with significant risk of having a cardiovascular event within the next 5 years.</td>
</tr>
</tbody>
</table>
DETECTION OF ASYMPOTOMATIC CAD

• APPROPRIATE
  • NEW AFIB + HIGH CHD RISK BY FRAMINGHAM
  • VENTRICULAR TACH + MOD-HIGH CHD RISK
  • HF OR LV SYSTOLIC DYSFUNCTION (WITHOUT CP)

• INAPPROPRIATE
  • LOW CHD RISK BY FRAMINGHAM + NO CP
  • LOW PRETEST POSSIBILTY OF CAD, ECG INTERPRETABLE, AND ABLE TO EXERCISE
  • HIGH PRETEST POSSIBILITY: ST ELEVATIONS

http://content.onlinejacc.org/article.aspx?articleid=1136997
DETECTION OF CAD: SYMPTOMATIC

• APPROPRIATE
  • INTERMEDIATE OR HIGH PRE-TEST PROBABILITY
    \[(\text{ECG INTERPRETABLE OR NOT}; \text{ ABLE TO EXERCISE OR NOT})\]

• INAPPROPRIATE
  • HIGH PRE-TEST PROBABILITY, ST ELEVATIONS
  • LOW PRE-TEST PROBABILITY, ECG IS INTERPRETABLE, AND ABLE TO EXERCISE

• UNCERTAIN
  • LOW PRETEST PROBABILITY, ECG UNINTERPRETABLE OR UNABLE TO EXERCISE

http://content.onlinejacc.org/article.aspx?articleid=1136997
Pre-Test Probability

Age, Gender, and Type of Chest Pain:

Typical angina (definite):
1) Substernal chest pain
2) provoked by exertion or emotional stress
3) relieved by rest and/or nitroglycerin

Atypical / Probable:
Chest pain or discomfort that lacks one of the characteristics of definite or typical angina

Non-anginal chest pain:
Chest pain or discomfort that meets one or none of the typical angina characteristics

http://content.onlinejacc.org/article.aspx?articleid=1136997
Table A. Pretest Probability of CAD by Age, Gender, and Symptoms*

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Nonanginal Chest Pain</th>
<th>Asymptomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;39</td>
<td>Men</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>40–49</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Intermediate</td>
<td>Very low</td>
</tr>
<tr>
<td>50–59</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Intermediate</td>
<td>Very low</td>
</tr>
<tr>
<td>&gt;60</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

*Modified from the ACC/AHA Exercise Testing guidelines to reflect all age ranges.¹⁴

EXERCISE STRESS TESTING

• SCREENING FOR LATENT DISEASE
• CHEST PAIN OR OTHER SIGNS SUGGESTIVE, BUT NOT DIAGNOSTIC FOR CAD
• EVALUATING THE EFFECTS OF MEDICAL AND SURGICAL THERAPY
• FUNCTIONAL CAPACITY
• FORMING AN EXERCISE PRESCRIPTION
• STIMULUS TO A CHANGE IN LIFESTYLE
AVOID EXERCISE

• LEFT BUNDLE BRANCH BLOCK
• DECREASED FUNCTIONAL CAPACITY
• VENTRICULAR PACING
• CHRONIC DEBILITATION
• FUNCTIONAL IMPAIRMENT
• PATIENTS TAKING BETA BLOCKERS OR OTHER NEGATIVE CHRONOTROPIC AGENTS

http://content.onlinejacc.org/article.aspx?articleid=1136997
### Bruce Protocol (Sub Maximal Table)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Minutes</th>
<th>% grade</th>
<th>km/h</th>
<th>MPH</th>
<th>METS</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>10</td>
<td>2.7</td>
<td>1.7</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>12</td>
<td>4.0</td>
<td>2.5</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>14</td>
<td>5.4</td>
<td>3.4</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>16</td>
<td>6.7</td>
<td>4.2</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>18</td>
<td>8.0</td>
<td>5.0</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>20</td>
<td>8.8</td>
<td>5.5</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>21</td>
<td>22</td>
<td>9.6</td>
<td>6.0</td>
<td>20</td>
</tr>
</tbody>
</table>
ST SEGMENT DEPRESSION DURING EXERCISE

No ST Depression | J-point only Depression | Upsloping ST Depression | Horizontal ST Depression | Downsloping ST Depression

60-80 ms after J-point | <1.0 mm (0.1 mV) | ≥1.0 mm | ≥1.0 mm | ≥1.0 mm

Negative standard ECG responses | Equivocal standard ECG response | Positive standard ECG responses
ST DEPRESSIONS

ST DEPRESSION DISTRIBUTION DOES NOT CORRELATE TO CORONARY TERRITORY AT RISK.

ST DEPRESSIONS ARE PARTICULARLY SPECIFIC ON ADENOSINE/DIPYRIDAMOLE/REGADENOSON STRESS BUT LESS SPECIFIC ON DOBUTAMINE PROTOCOLS.

ST DEPRESSIONS ARE OFTEN FALSELY POSITIVE FOR ISCHEMIA WITH HYPERTENSION, DIGOXIN, HYPOKALEMIA, AND WOMEN.
ST ELEVATIONS

ST ELEVATIONS REFLECT TRANSMURAL ISCHEMIA AND ARE SIGNIFICANT IN EXERCISE, ADENOSINE STRESS AND DO CORRELATE TO CORONARY TERRITORY AT RISK.

THE EXCEPTION IS DOBUTAMINE, WHICH OFTEN HAS ISCHEMIC CHANGES NOT STRICTLY CORRELATED TO ISCHEMIA.
T-WAVE INVERSIONS

T-WAVE INVERSIONS ARE NOT SPECIFIC AND YOU DO NOT NEED TO WAIT UNTIL THEY RETURN TO NORMAL BEFORE PHASING OUT OF THE STUDY.
KEY PARAMETERS OF TEST RESULTS: ST SEGMENTS AND BEYOND

- EXERCISE DURATION
- ONSET/RESOLUTION OF SYMPTOMS
- ONSET/RESOLUTION OF ST-T CHANGES
- MAGNITUDE OF ST CHANGES
- IMPAIRED HR RESPONSE (“CHRONOTROPIC INCOMPETENCE”)
- HIGH-GRADE ARRHYTHMIAS; E.G., PROLONGED VT; PAROXYSMAL ATRIAL FIBRILLATION/FLUTTER; HIGH GRADE AV BLOCK
FINDINGS ASSOCIATED WITH POOR PROGNOSIS

- LOW WORKLOAD
  - < 6.5 METS
  - < 6 MINUTES OF BRUCE PROTOCOL
- LOW PEAK HEART RATE
  - HR < 120 BPM (NOT ON BETA BLOCKER)
- DECREASE OR BLUNTED SYSTOLIC BP RESPONSE
  - REMAINS UNDER 130 MMHG
- ST SEGMENT DEPRESSION > 2 MM
  - MULTIPLE LEADS
  - PROLONGED RECOVERY > 6 MINUTES
- ST SEGMENT ELEVATION NON-Q WAVE LEADS
- INCREASE IN COMPLEX VENTRICULAR ECTOPY
- EXERCISE-INDUCED ANGINA
Duke Treadmill Score

Treadmill Score =
\[ \text{Ex.time (min)} \]
\[-5 \times (ST\text{-seg dev in mm}) - 4 \times \text{ex.angina index} \]

(0-no angina, 1 angina, 2 if angina stops test)

High Risk= -11, mortality - >5% annually

Low Risk= +5, mortality - 0.5% annually
NUCLEAR STRESS TEST

• DIAGNOSIS OF CAD
  • PRESENCE
  • LOCATION
  • EXTENT

• ASSESSMENT OF DEGREE OF CORONARY ARTERY STENOSIS AND IMPACT ON PERFUSION

• MYOCARDIAL VIABILITY
  • ISCHEMIA VS. SCAR
  • PREDICT IMPROVEMENT FOLLOWING REVASCULARIZATION

• RISK ASSESSMENT / PROGNOSIS
  • POST MI
  • PRE-OP BEFORE HIGH RISK SURGERY
NUCLEAR STRESS TEST IN ASYMPTOMATIC PATIENTS

NUCLEAR STRESS TESTING IN PREVIOUSLY TESTED PATIENTS

NUCLEAR STRESS TESTING IN PRE-OPERATIVE ASSESSMENT

PHARMACOLOGICAL STRESS TESTING USE

• ADENOSINE AND REGADENOSON (LEXISCAN)
  • INABILITY TO EXERCISE
  • INABILITY TO AMOUNT A HEART RATE RESPONSE (AVN BLOCKER)
  • LBBB OR PACED RHYTHM
  • SIGNIFICANT ST DEPRESSIONS ON BASELINE EKG
  • EVALUATE ISCHEMIC BURDEN IN SYMPTOMATIC PATIENTS WITH KNOWN OBSTRUCTIVE CAD

http://content.onlinejacc.org/article.aspx?articleid=1136997
PHARMACOLOGICAL STRESS TESTING USE

• DOBUTAMINE
  • INABILITY TO EXERCISE
  • UNCONTROLLED RAD/BRONCHOSPASM
  • PATIENTS UNDER INFLUENCE OF METHYLXANTHINES AND UNABLE TO EXERCISE.
  • ASSESSMENT OF CARDIAC RESERVE

http://content.onlinejacc.org/article.aspx?articleid=1136997
CAUTION WITH PHARMACOLOGICAL AGENTS

• AVOID ADENOSINE AND REGADENOSON (LEXISCAN)
  • BRONCHOSPASM
  • HIGH GRADE AV BLOCKS
  • USE OF METHYLXANTHINES
    (CAFFEINE/AMINOPHYLLINE/THEOPHYLLINE)
  • USE OF AGGRENOX (DIPYRIDAMOLE)

http://content.onlinejacc.org/article.aspx?articleid=1136997
CAUTION WITH PHARMACOLOGICAL AGENTS

• AVOID DOBUTAMINE
  • HOCM
  • UNCONTROLLED HTN
  • ARRHYTHMIAS
  • RECENT MI

http://content.onlinejacc.org/article.aspx?articleid=1136997
TAKE-HOME PRACTICE POINTS!

• AMBULATORY ECG: DIFFERENT FORMS AND DURATIONS OF USE FOR SPECIFIC GOALS
• AMBULATORY ECG – BEYOND THE HOLTER
• AMBULATORY BP MONITORING FOR DIAGNOSIS OF OCCULT HTN
• ECHO FOR SOB, DOE, HTN, CARDIOMEGALY
• FAMILY SCREENING FOR CERTAIN DISEASE STATES
• CTA CORONARIES FOR LOW AND INTERMEDIATE RISK PATIENTS
• STRESS TESTING: PRE TEST PROBABILITY!
THANK YOU
• QUESTIONS??????