

Diagnostic Evaluation for Suspected Coronary Artery Disease

Jerome L. Fleg, M.D., FACC, FAHA

Medical Officer

National Heart, Lung, and Blood Institute

No relevant financial disclosures

Definition of Coronary Artery Disease (CAD)

- Coronary Angiography – At least 50% diameter reduction of one or more of the three coronary arteries, their major branches, or the left main coronary artery.

Clinical Manifestations of CAD

- **Angina Pectoris** – Substernal chest discomfort due to reversible myocardial ischemia induced by increased myocardial demand, reduced coronary blood flow, or their combination.
- **Acute Myocardial Infarction** – Myocardial necrosis induced by complete occlusion of a coronary artery, usually due to rupture of an atherosclerotic plaque.
 - ~1 million cases annually in the U.S.
- **Sudden Cardiac Death** – Death from a cardiac cause (e.g. CAD) within 1 hour of onset of symptoms, usually due to ventricular fibrillation caused by acute myocardial ischemia or infarction
 - ~200,000 – 400,000 cases annually in the U.S.

Medical History: Major CAD Risk Factors

- Older age
- Male sex
- Genetics (+ family Hx)
- Hypertension
- Elevated LDL cholesterol
- Low HDL cholesterol
- Smoking
- Diabetes
- Obesity
- Physical inactivity

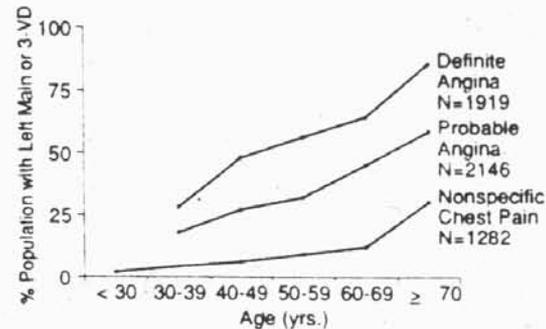
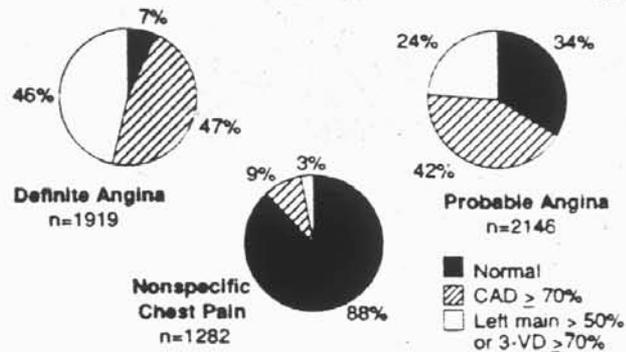
Medical History Diagnosis of Angina Pectoris

1. **Location** – substernal, but may radiate to neck, jaw, or shoulder (arm).
2. **Character** – “Discomfort” more common than “pain”. “Tightness heaviness, squeezing” also common descriptors.
Anginal equivalents: dyspnea, nausea, weakness, (pre)syncope.
3. **Precipitants**
 - Exercise
 - Emotional Stress
 - Cold Temperature
 - Meals
 - Smoking
4. **Duration/ relieving factors**
 - Typically 3-5min; if > 30 min, suspect MI
 - Relief by rest or sublingual nitroglycerin

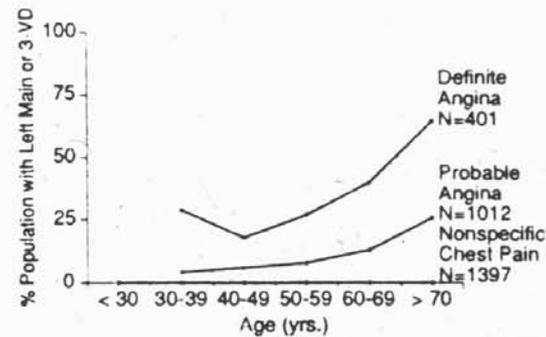
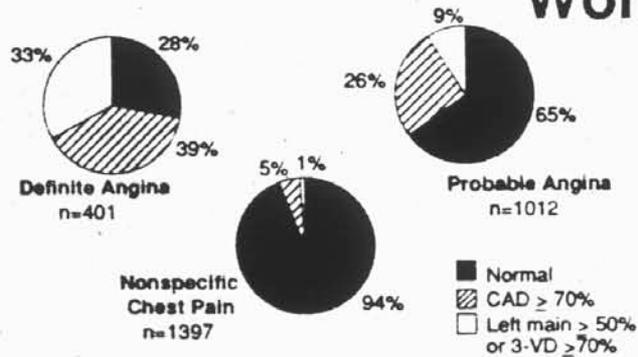
Coronary Artery Surgery Study

% Population with CAD

Men



Women



Physical Examination for Suspected CAD

- **Identify CAD risk factors**
 - Hypertension
 - Corneal arcus/xanthelasma
 - Retinal arteriolar changes
 - Carotid bruit
 - Reduced/absent peripheral pulses
- **During acute chest pain episode**
 - Rales, S₃ gallop, mitral regurgitation

Resting Electrocardiogram (ECG)

- Pathologic Q waves indicate prior MI
- ST segment depression nonspecific unless occurring transiently during chest pain episodes
- Other non-specific findings suggesting structural heart disease
 - LV hypertrophy, L. bundle branch block, L. atrial enlargement, atrial fibrillation

Diagnostic Testing

- Stress Tests – induce myocardial ischemia
 - Exercise:
 - Treadmill, cycle, arm ergometry
 - Pharmacologic:
 - Dobutamine to ↑ myocardial demand
 - Dipyridamole or adenosine to dilate coronary arteries
 - Physiologic:
 - Atrial pacing, mental stress

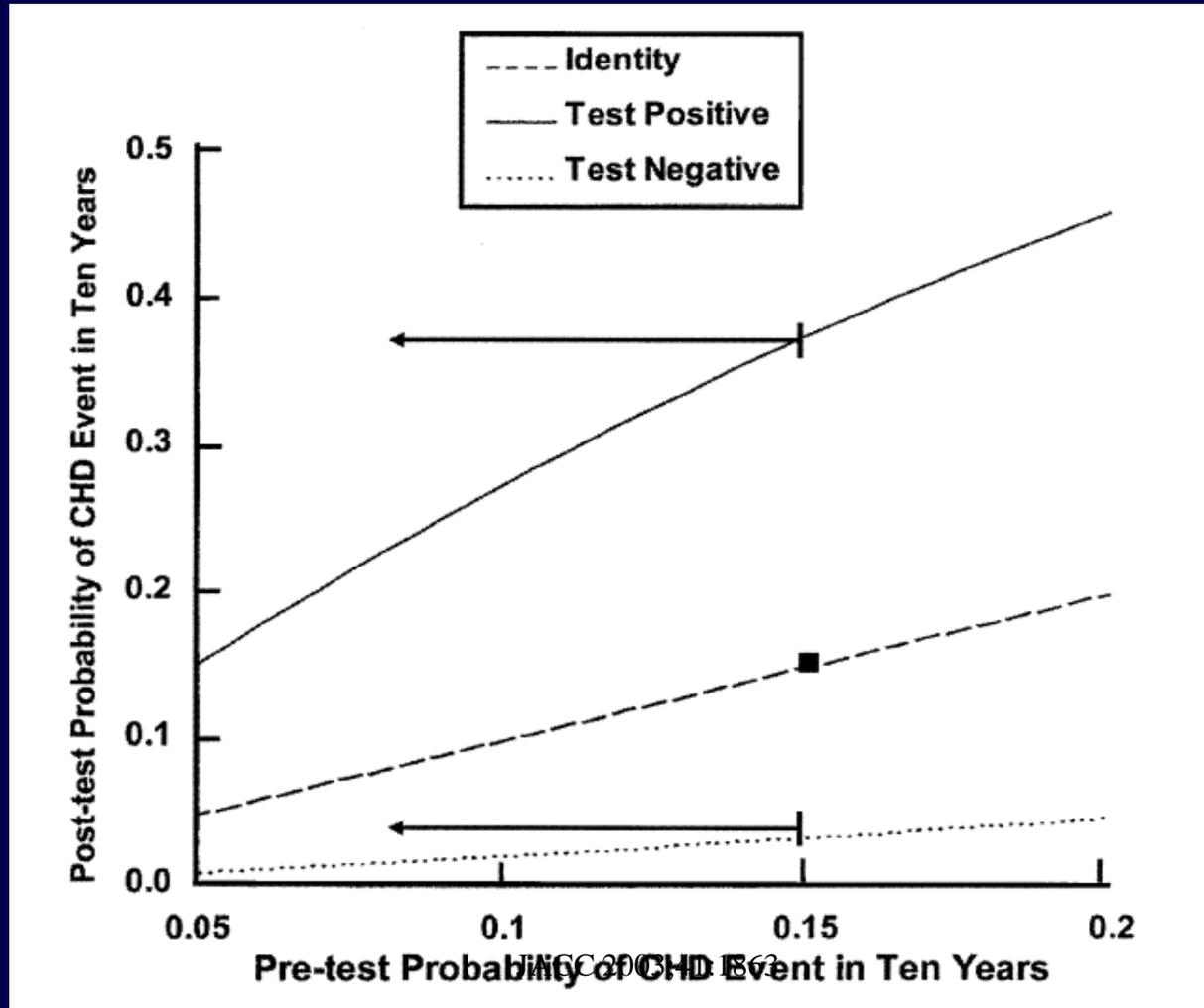
Diagnostic Tools

- Physiologic:
 - ECG
 - Radionuclide (thallium, sestamibi)
 - Echocardiography
 - MRI, PET
- Anatomic:
 - Coronary calcium scan
 - CT angiography
 - Invasive coronary angiography – the “gold standard”

Diagnostic Test Performance

- Sensitivity: % of persons with CAD detected:
 $TP/TP+FN$
- Specificity: % of persons without CAD detected:
 $TN/TN+FP$
- Positive Predictive Value: % persons with (+) test who have CAD: $TP/TP+FP$
- Negative Predictive Value: % of persons with (-) test who do not have CAD: $TN/TN+FN$

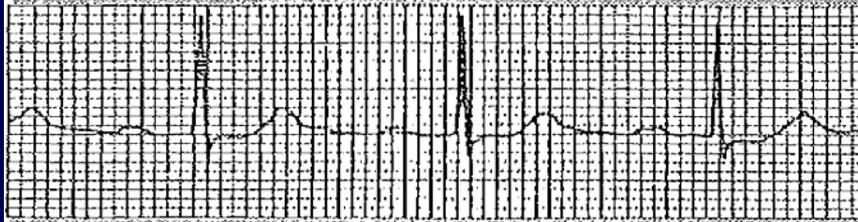
Incremental Value of Exercise Testing in Risk Stratification



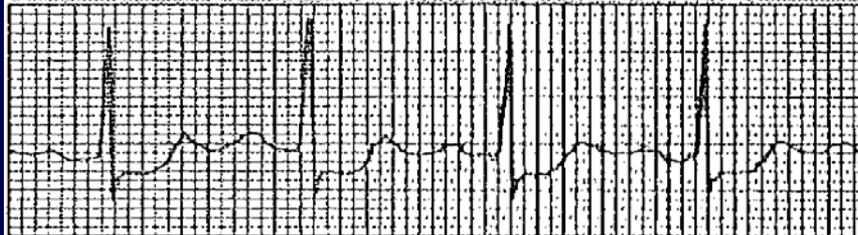
Treadmill (Cycle) Exercise Test

- Graded treadmill (cycle) exercise to exhaustion
- Positive test: Flat/down sloping ST depression $\geq 1\text{mm}$
 - Sensitivity : $\approx 65\%$
 - Specificity: $\approx 70\%$ (lower if abnormal rest ECG)
- Advantages
 - Low cost, widely available, no radiation
- Disadvantages
 - Only moderate sensitivity/specificity
 - Cannot localize or quantify ischemic region

Rest (Lead V₄)



Exercise 2:50



Exercise 4:30



Recovery 1:30



Positive treadmill exercise ECG with partial resolution by 1:30 into recovery.

Stress Echocardiography

- Can be used with exercise or pharmacologic stress
- Positive test: new regional wall motion abnormality
 - Sensitivity: \approx 70-80%
 - Specificity: \approx 80-90%
- Advantages
 - Widely available, no ionizing radiation, good diagnostic performance, detects structural abnormalities
- Disadvantages
 - Subjective reading – depends on reader expertise
 - Suboptimal imaging in obese, elderly, COPD patients

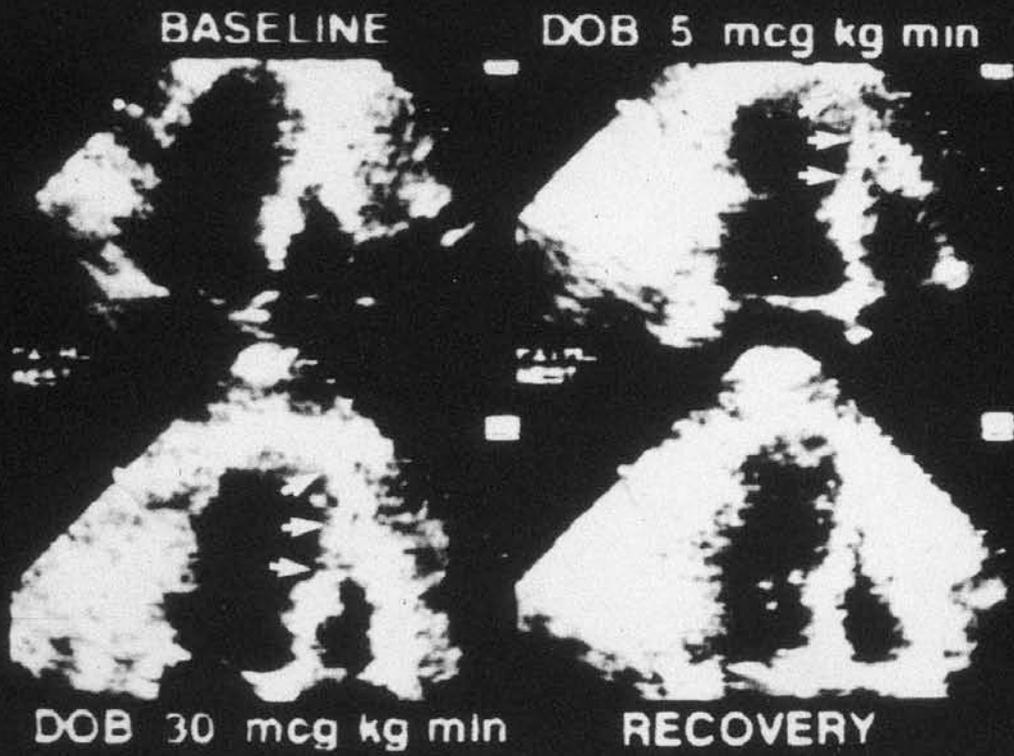


Figure 3. End-systolic echocardiographic frames at baseline and during, low- and high-dose dobutamine infusion, as well as 10 minutes following dobutamine infusion, in a patient with a mid-left anterior descending coronary artery stenosis. Note the development of significant hypokinesia in the mid- to distal septum and apex (arrows), with improvement during recovery. DOB=dobutamine.

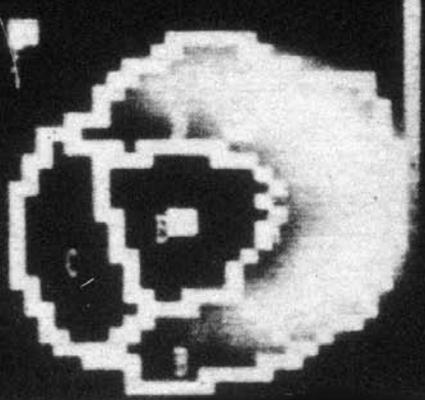
Radionuclide Stress Test

- Thallium-201 and/or technetium-99m isotopes
 - Can be used and exercise or pharmacologic stress
- Positive Test: reversible LV perfusion defect
 - Sensitivity: $\approx 80-85\%$
 - Specificity: $\approx 70-75\%$
- Advantages
 - Widely available, computer-assisted reading
- Disadvantages
 - Ionizing radiation, reduced performance with severe obesity, large breasts, L. bundle branch block

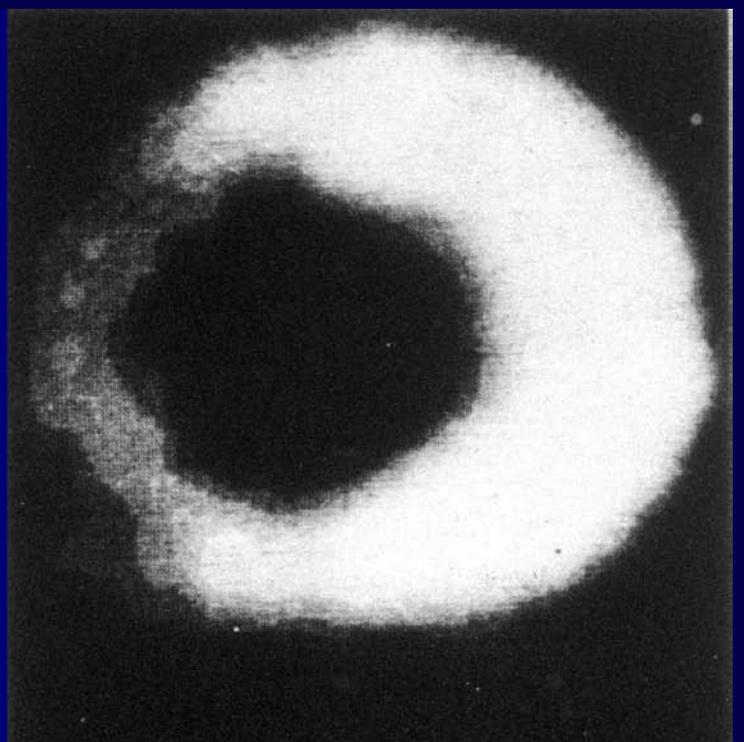


28.E. T-HRED-BEL.

919 CELL CT:MAX=832 MIN=58 HV=333

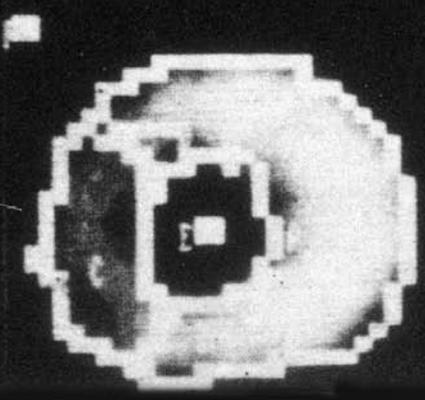


COUNT
 1177
 1107
 1440
 1598
 1400
 1300
 1200
 1100
 1000
 900
 800
 700
 600
 500
 400
 300
 200
 100
 0



28.E. T-HRED-BEL.

918 CELL CT:MAX=867 MIN=35 HV=333



COUNT
 1177
 1107
 1440
 1598
 1400
 1300
 1200
 1100
 1000
 900
 800
 700
 600
 500
 400
 300
 200
 100
 0

Stress Cardiac Magnetic Resonance Imaging

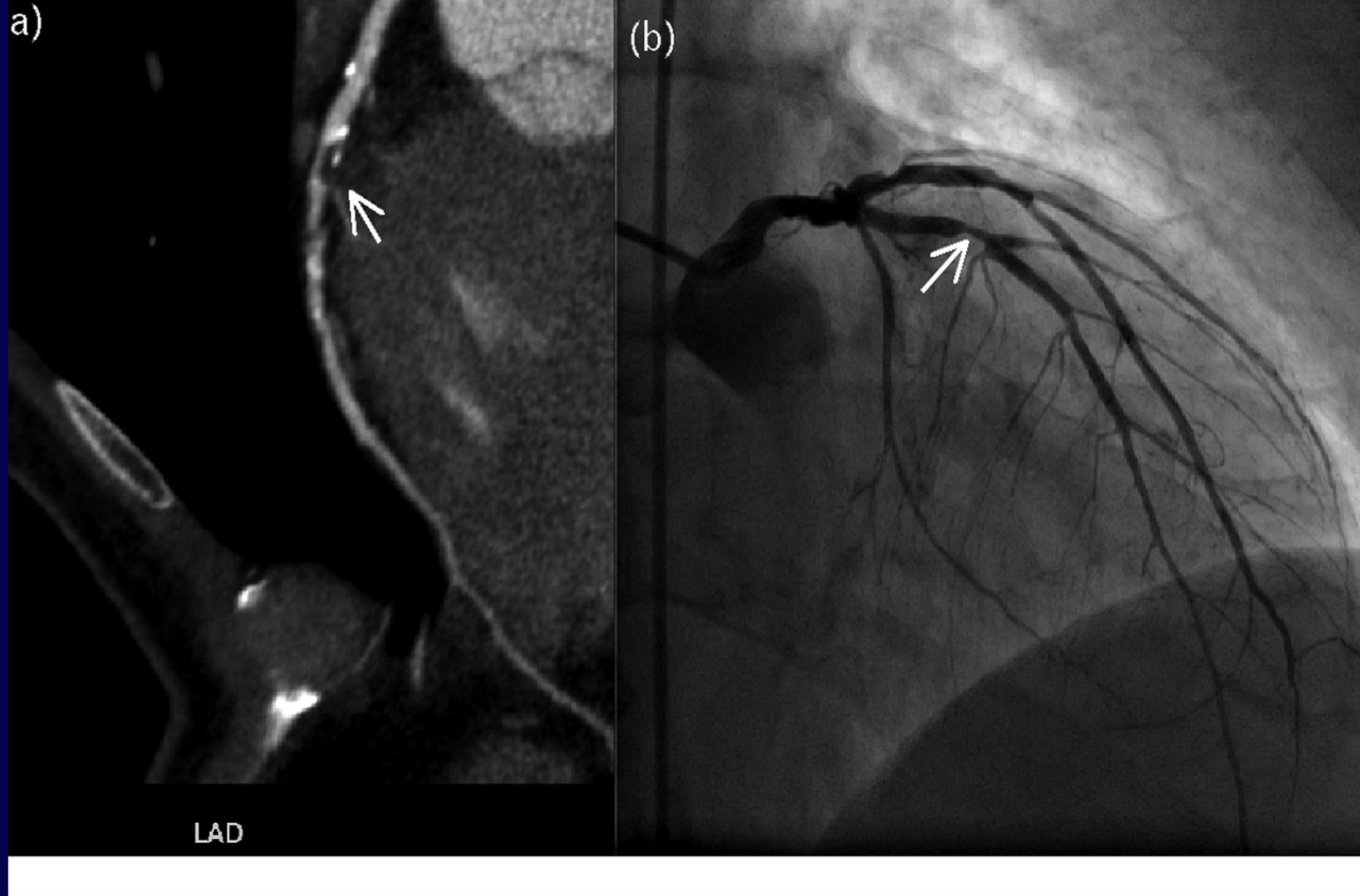
- Used with dobutamine or adenosine
- Positive test: reversible perfusion defect
- Diagnostic accuracy increased by delayed enhancement imaging
 - Sensitivity: \approx 85-90%
 - Specificity: \approx 80-85%
- Advantages
 - No ionizing radiation, good diagnostic performance
- Disadvantages
 - Costly, not widely available, cannot image patients with ICD's, pacemakers

Electron Beam Computed Tomography

- Coronary artery calcium scan
 - Screening tool
- Positive test: Calcium in coronary artery wall
 - Severity graded in Hounsfield units
- Advantages
 - Low radiation dose
 - Stress test not required
- Disadvantages
 - Does not measure % stenosis

Coronary Computed Tomographic Angiography (CCTA)

- Defines coronary artery anatomy
- Positive test: Coronary artery lumens diameter reduction > 50%
 - Sensitivity: \approx 90-95%
 - Specificity: \approx 85-90%
- Advantages
 - Very high sensitivity; excellent in ruling out CAD
 - Stress test not required
- Disadvantages
 - High radiation dose, need for beta-blockers, relatively costly, requires contrast injection



Left panel: Contrast –enhanced CCTA, showing calcified and non-calcified stenosis of mid-LAD.

Right panel: Invasive CA confirms the LAD stenosis.

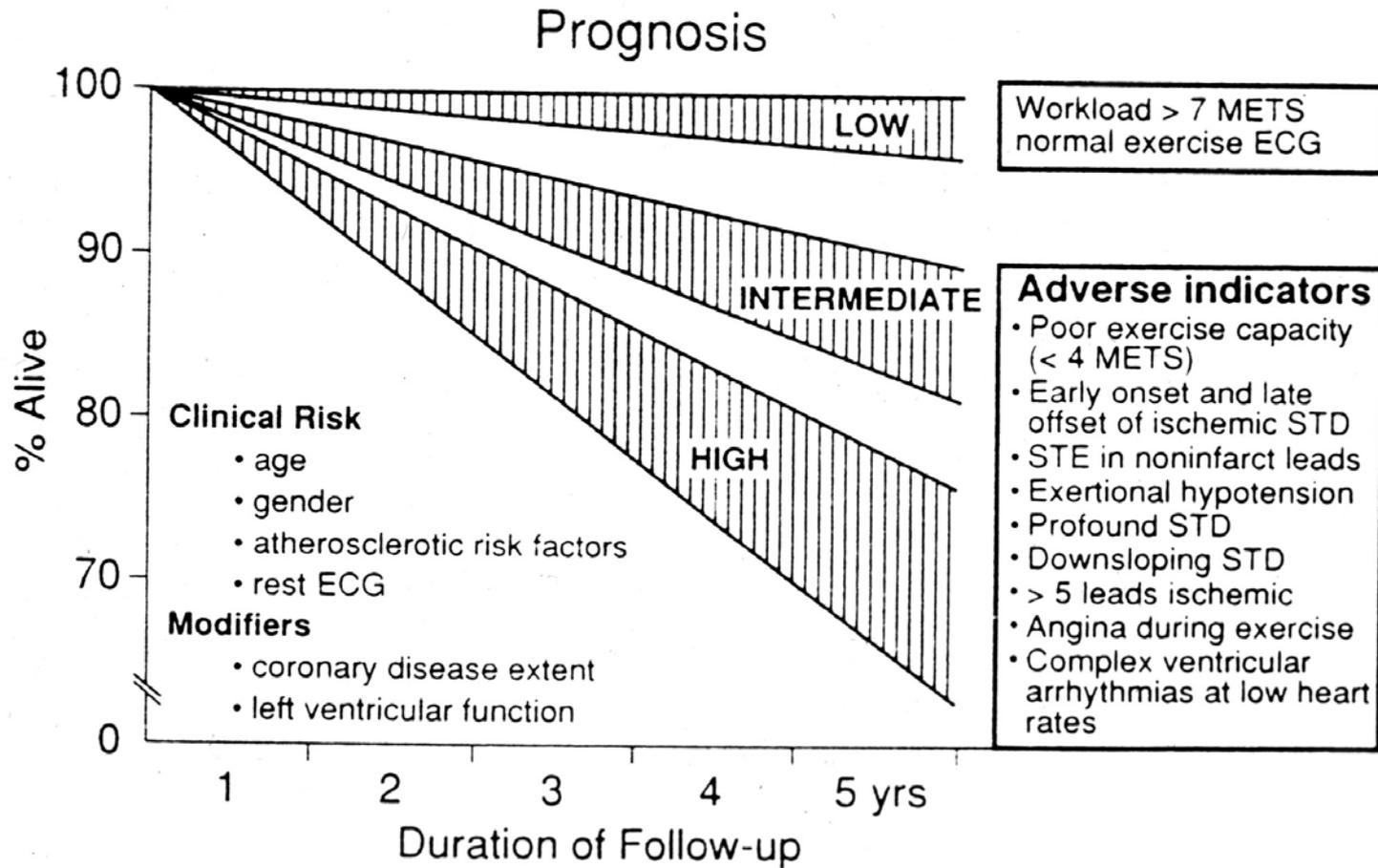
Invasive Coronary Angiography (ICA)

- The “gold standard” for anatomic CAD
- Positive test: $\geq 50\%$ reduction in coronary lumen diameter
- Advantages
 - High resolution images
 - Stress test not required
- Disadvantages
 - Invasive, costly, high radiation burden, “oculostenotic reflex”

Summary

- CAD most common form of heart disease in the U.S.
- High morbidity & mortality
- A good medical history/exam guides the work-up
- Numerous non-or minimally-invasive diagnostic tools using stress imaging
- Anatomic testing using CCTA or ICA
- ICA remains the “gold standard” for CAD diagnosis

Exercise Testing



ROC Curve

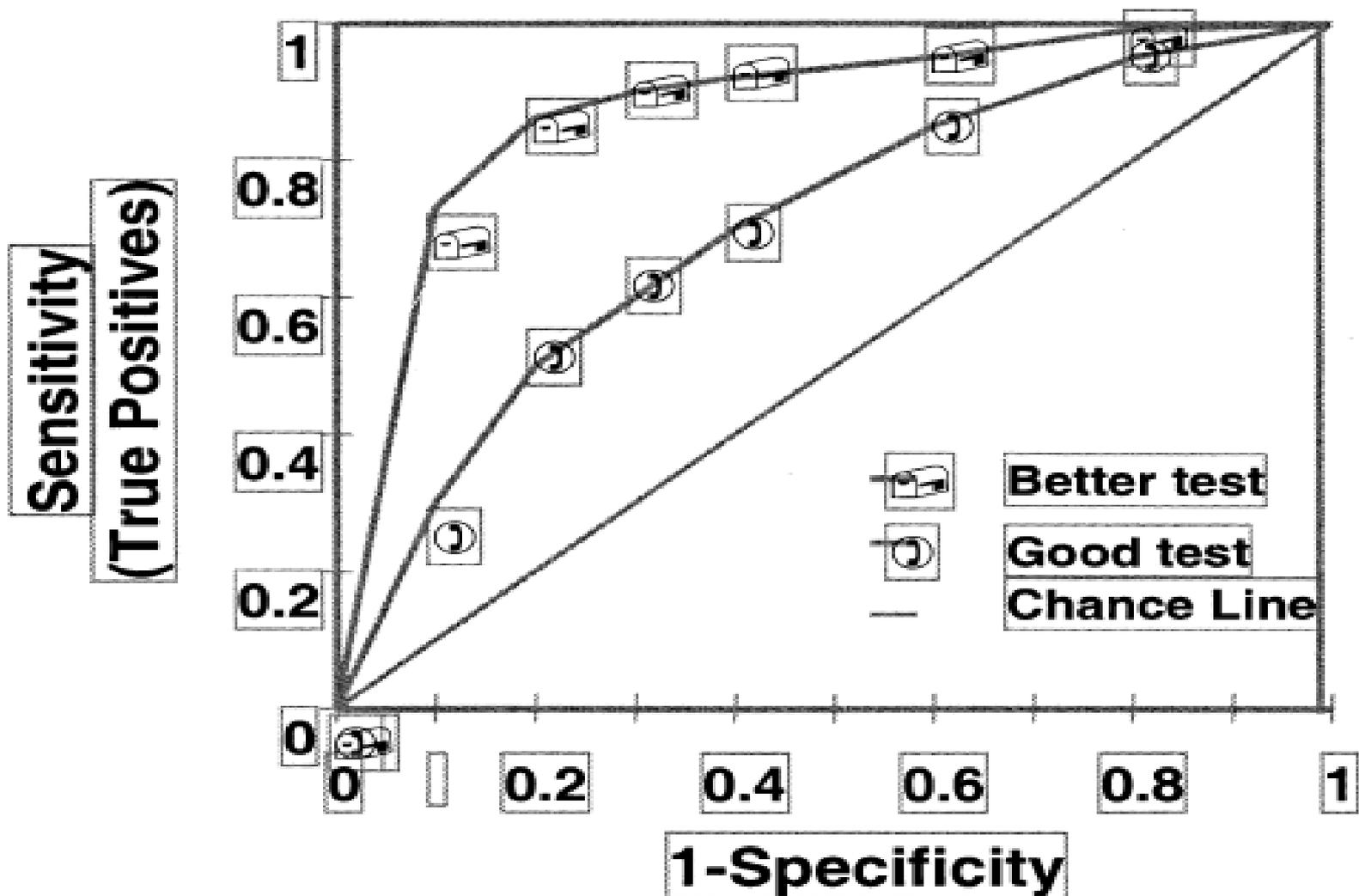


Table 1. Nonexercise stress cardiac imaging

Pharmacologic stress

- Coronary vasodilation (dipyridamole, adenosine, adenosine triphosphate, arbutamine)
- Inotropic/chronotropic augmentation (dobutamine, dopamine, isoproterenol, epinephrine)
- Coronary vasoconstriction (spasm) (ergonovine, tobacco)

Atrial pacing

- Transvenous
- Transesophageal

Mental stress

- Speech, arithmetic, Color-Stroop test

Cold pressor test
