

Diagnostic Evaluation for Suspected Coronary Artery Disease

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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

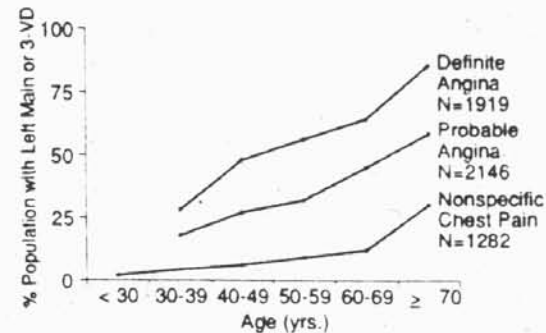
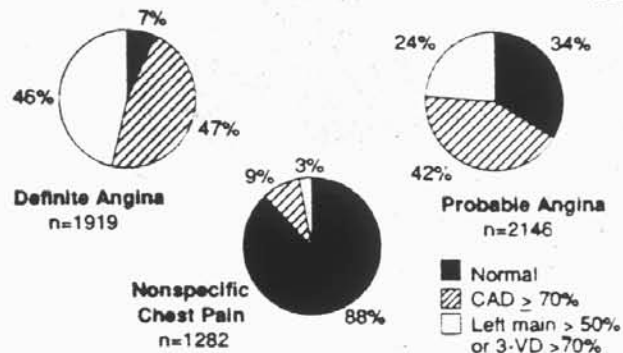
Medical History Diagnosis of Angina Pectoris

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

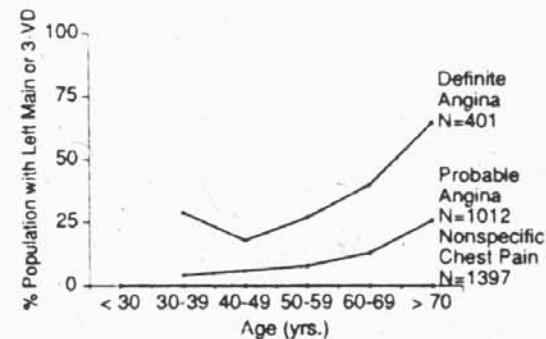
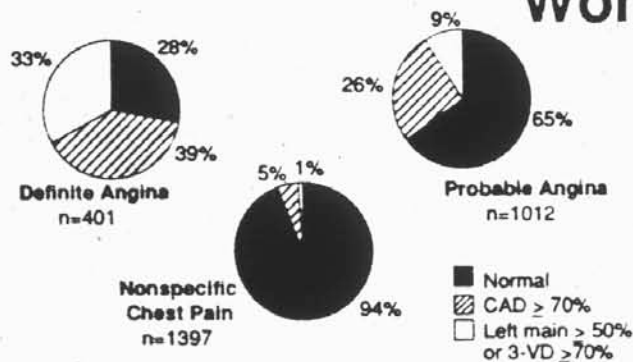
Coronary Artery Surgery Study

% 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

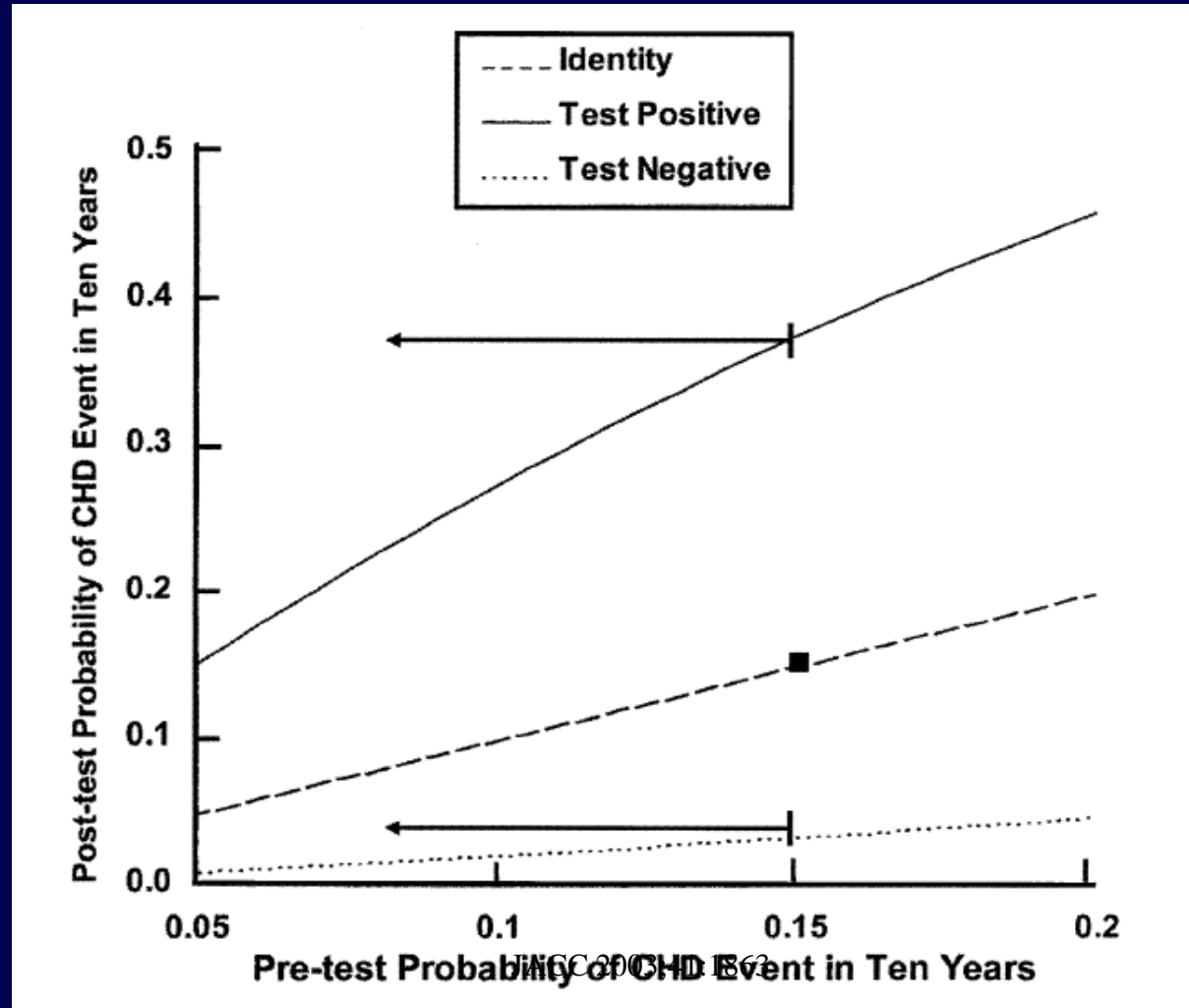
CT angiography

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)



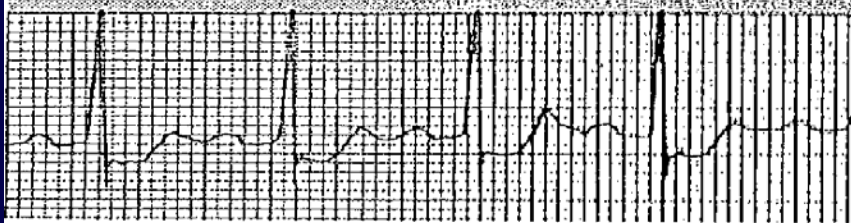
Exercise 2:50



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

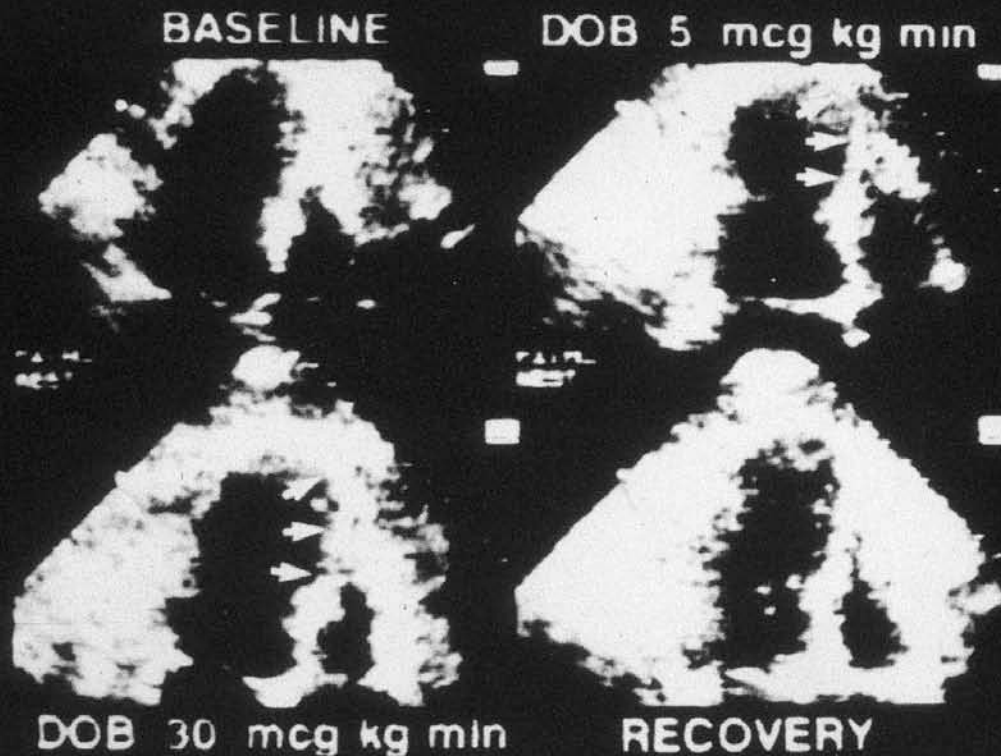


Figure 3. End-systolic echocardiographic frames at baseline and during, low- and high-dose dobutamine infusion, as well as 10 minutes following dobutamine infusion, in a patient with a mid-left anterior descending coronary artery stenosis. Note the development of significant hypokinesia in the mid- to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

Radionuclide Stress Test

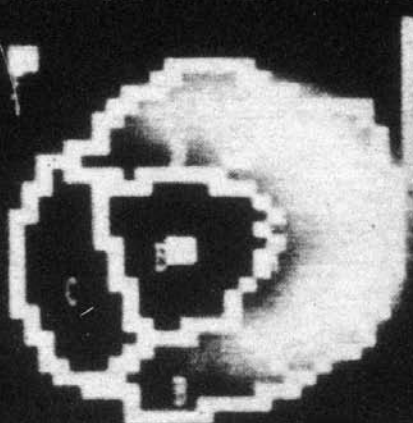
- Thallium-201 and/or technetium-99m isotopes
 - Can be used and exercise or pharmacologic stress
- Positive Test: reversible LV perfusion defect
 - Sensitivity: $\approx 80-85\%$
 - Specificity: $\approx 70-75\%$
- Advantages
 - Widely available, computer-assisted reading
- Disadvantages
 - Ionizing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



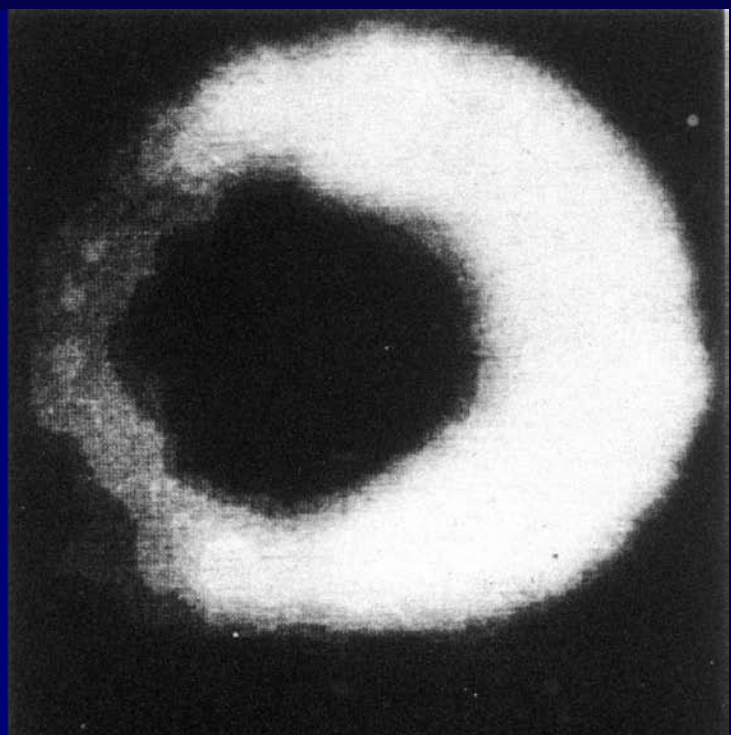
18.E.

T-HRED-BEL.

918 CELL CT:MAX=832 MIN=58 AV=333



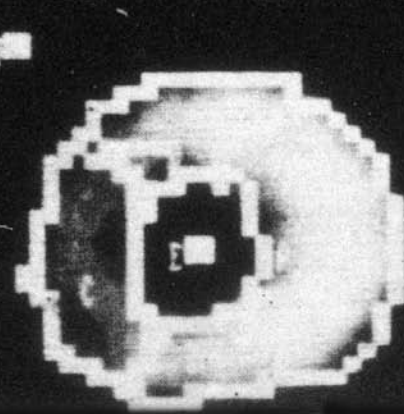
COUNTS
A: 117375
B: 10538
C: 14472
D: 15988
E: 888
F: 62



18.E.

T-HRED-FUNE

918 CELL CT:MAX=867 MIN=35 AV=336



COUNTS
A: 117375
B: 10538
C: 14472
D: 15988
E: 888
F: 62

Stress Cardiac Magnetic Resonance Imaging

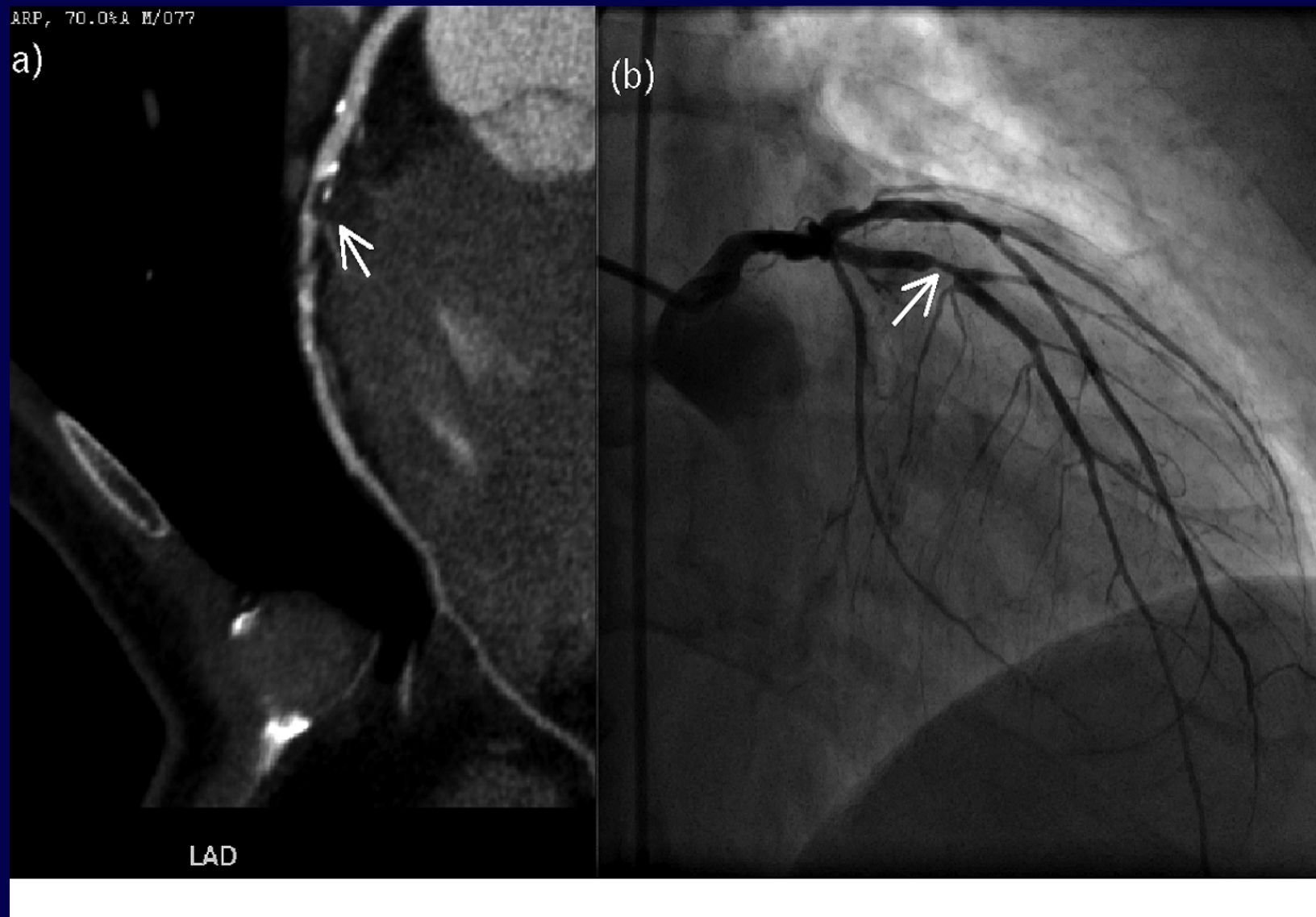
- Used with dobutamine or adenosine
- Positive test: reversible perfusion defect
- Diagnostic accuracy increased by delayed enhancement imaging
 - Sensitivity: $\approx 85\text{-}90\%$
 - Specificity: $\approx 80\text{-}85\%$
- Advantages
 - No ionizing radiation, good diagnostic performance
- Disadvantages
 - 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.

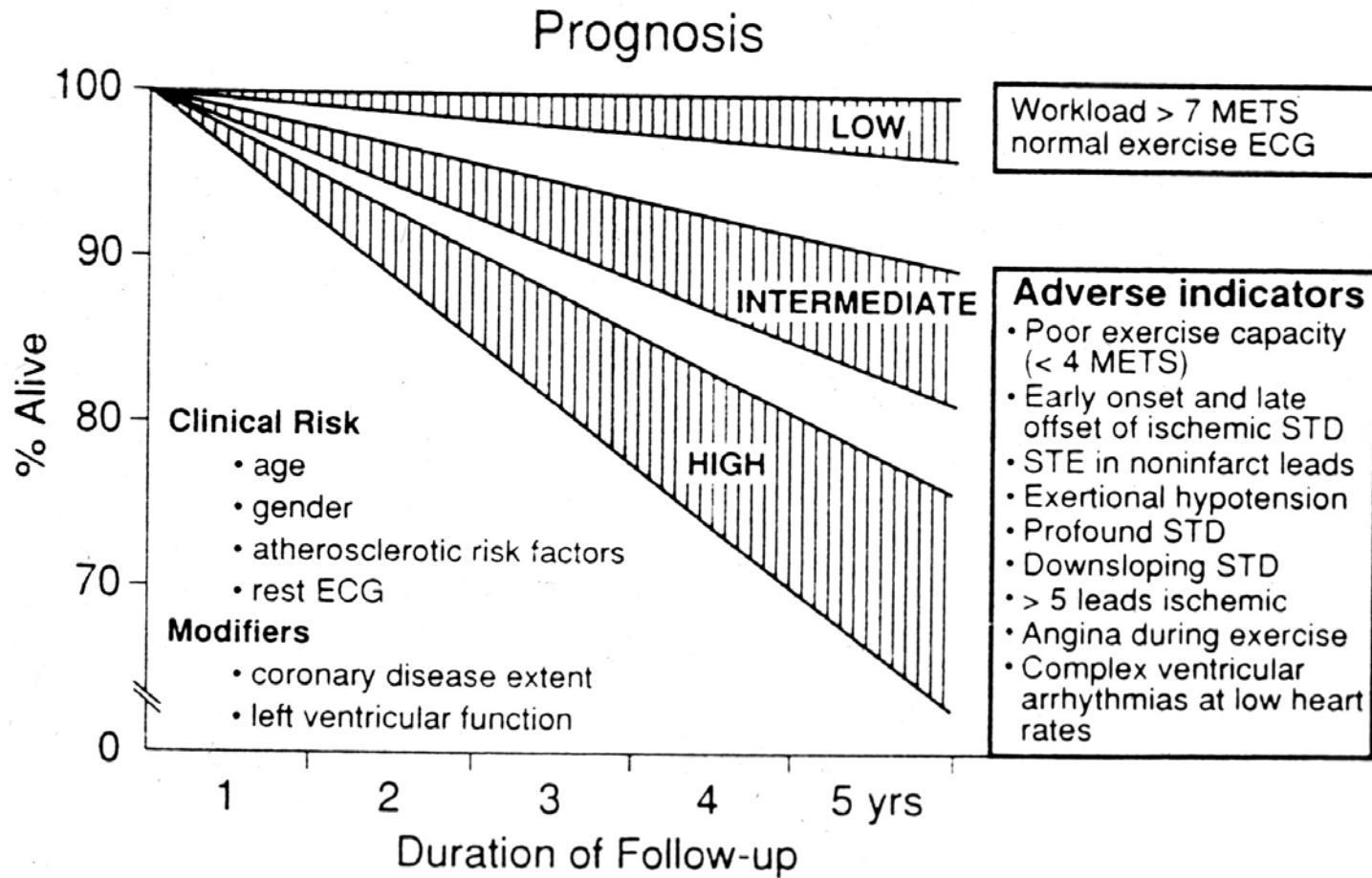
Invasive Coronary Angiography (ICA)

- 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

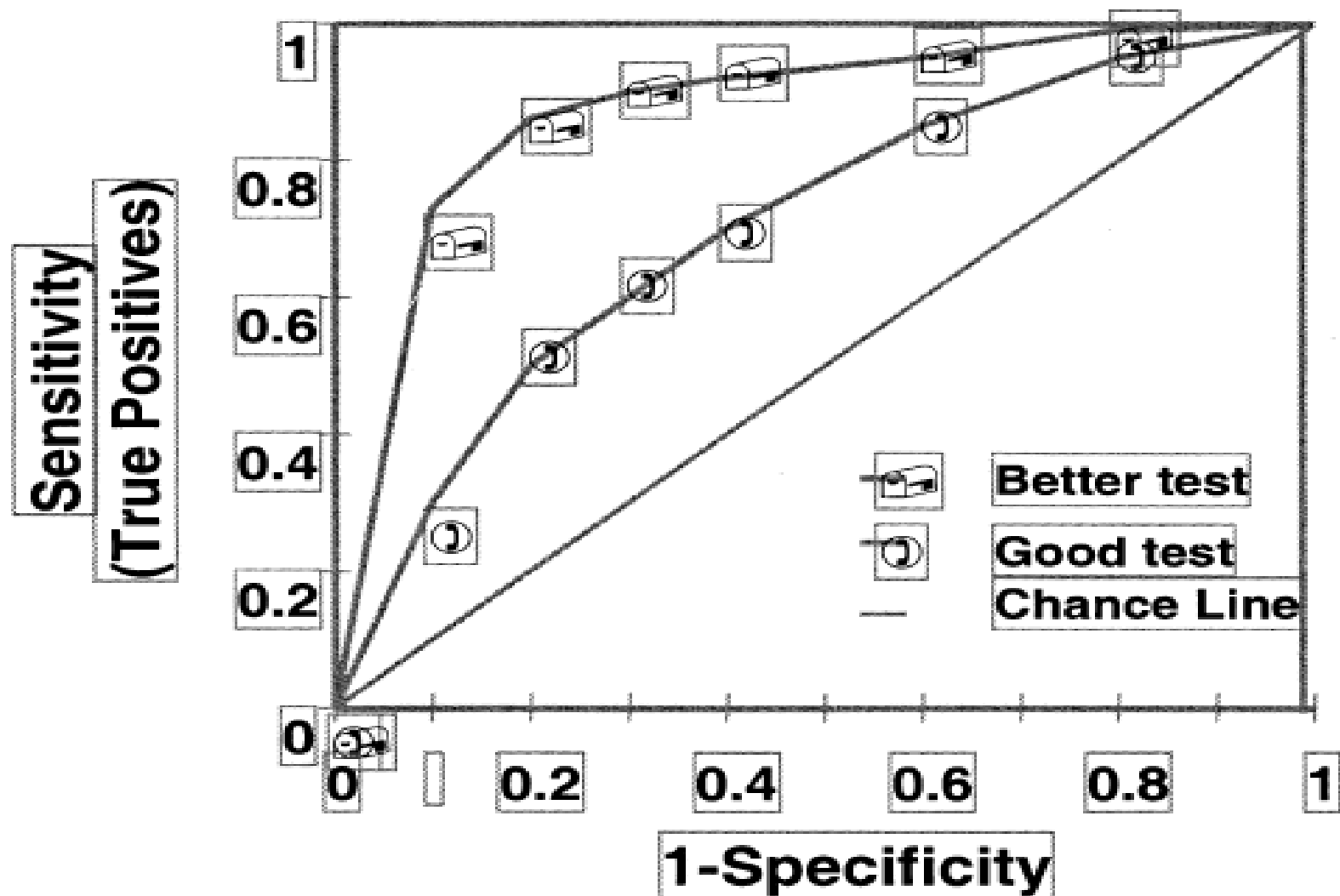


Table 1. Nonexercise stress cardiac imaging

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
