Predictive Implications of Stress Testing *(Chapt. 14)*

- **Sensitivity**
- **Specificity**
- **Predictive Value**
- **Patient Risk**

1979, Weiner and coworkers

Stress testing has very little diagnostic value. A positive stress test increased the post-risk of CAD by only 6-20%, and a negative stress test decreased risk by only 2-28%.

1995, Ellstad, pg 353

"The predictive power of the normal as well as the abnormal maximal stress test can provide us with a very useful tool in the clinical management of CAD patients."

Factors to improve the accuracy of stress testing

- **Bayes Theorem application**
- **Patient selection**
  - **exclude WPW, BBB, etc.**
- **Aggressive termination criteria**
- **Additional measurements (HR, BP, exercise time)**

Predictive value and Relative Risk

- **Predictive Value of a Stress Test**
  - **A measure of how accurately an exercise test identifies an individual with CAD or w/o CAD**
    - **depends on the sensitivity and specificity of the test**
- **Relative Risk**
  - **A measure of the ability of the stress test to predict future cardiac events**
    - **depends on the predictive value of the test and the population risk**

Sensitivity = ability to detect disease when it is present.

Specificity = ability to correctly exclude disease when it is absent.

Most common criteria used are:

CAD is determined from angiography (>70% occlusion of at least one vessel

Positive test is determined from ST segment changes of >1 mm and other abnormal test results.

Methods to "Validate" Stress Test Results

- **How do you determine whether the test was positive?**
  - **ST depression, 0.5, 1.0, 1.5, <2.0 mm**
  - **ST depression with angina**
  - **exercise endurance, HR response**
- **How do you determine whether there is CAD?**
  - **Angiogram, 50-75% artery occlusion**
  - **Ventricular function tests, imaging**

Possible Test Results

- **True positive (TP) = a positive result in someone with CAD**
- **True negative (TN) = a negative result in someone without CAD**
- **False positive (FP) = a positive result in someone without CAD**
- **False negative (FN) = a negative result in someone with CAD**

Contingency Table

Test Result	Disease	
	Present	Absent
Positive	True-pos	False-pos
Negative	False-neg	True-neg

The likelihood of an asymptomatic 30-39 yr-old woman of having CAD despite a "positive" treadmill stress test is only 0 to 10% (> 2.5 mm ST depression) (Robergs 97, table 15)

What type of potential error is this?

False Positive

How do you measure sensitivity?

- **Sensitivity = (TP / All patients with abnormal angiograms) x 100**

  A measure of the proportion of patients with a positive test to the total number of patients with CAD

  Sensitivity = TP / (TP + FN) x 100
- **Sensitivity for clinical exercise testing is approximately 68% for correctly identifying someone with CAD (uses ST depression > 1mm)**

Sensitivity Example

- **100 elderly men with CAD perform a stress test**
  - **10 have a positive result (true positive)**
  - **90 have a negative result (false negative) *but have CAD***
- **What is the sensitivity of this test?**
  - **Sens. = TP/all patients with CAD**
    = TP/(TP + FN) x 100
    = 10/(10 + 90) x 100
    = 10%

Sensitivity Example 2

- **100 women take a stress test (4 have CAD, 96 do not)**
  - **10 positive stress tests**
    - **2 TP, 8 FP**
  - **90 negative stress tests**
    - **2 FN, 88 TN**
- **Sensitivity = TP/(TP + FN) x 100**
  = 2/(2 + 2) x 100
  = 50%

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Exercise testing sensitivity

- **"This poor sensitivity (aver 68%) has led some investigators to suggest routine exercise testing is nearly useless for the management of patients with CAD"** **(Thompson 01, pg 21)**
- **Sensitivity ranges from 23-90%, depending on the population studied (Bayes theorem)**

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Test factors that influence sensitivity (ACSM)

Enhance	Decrease
• maximal test	• submaximal test
• multi-lead EKG	• insufficient EKG
• additional data	• cardiac drugs (beta blockers, nitrates, calcium channel blockers)
	• pre-existing EKG changes (LVH, LBBB, WPW)

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If a treadmill protocol has a 68% sensitivity, what does this tell you?

That 68% of individuals with CAD are detected with this test.

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What is specificity?

- **Specificity = (TN / all patients without CAD) x 100**
  - ***Specificity = ability to correctly exclude disease when it is absent***
  - ***Spec = TN/(TN + FP) x 100***
- **Specificity in clinical exercise testing is approximately 77%**

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"A test should not be classified as negative unless the patient has attained an adequate level of cardiovascular stress, generally > 85% predicted maximal HR."

ACSM pg 126

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What type of error do you risk by not performing a maximal exercise test?

False Negative

Specificity is increased by:

- **Not testing patients with pre-existing abnormal resting EKG (false positives)**
  - **Hypertrophy of the left ventricle**
  - **Certain medications (digitalis)**
  - **mitral valve prolapse**
  - **anemia**
  - **female gender**
- **Specificity = TN/(TN + FP) x 100**

Specificity Example

- **100 45 yr-old baseball players are screened for CAD (20 CAD, 80 no CAD)**
  - **40 have a positive stress test (18 TP, 22 FP)**
  - **60 have a negative stress test (2 FN, 58 TN)**
  - **What is the specificity of this test?**
- **Spec. = TN/(TN + FP) x 100**
  = 58/(58 + 22) x 100
  = 72.5%

Sensitivity and Specificity of Various Stress Tests

Stress Test	Sensitivity (%)	Specificity (%)
Exercise EKG	40-80	60-90
Exercise Echo	85	85-90
Dobutamine echo	85	85
Exercise SPECT	85-90	85

SPECT = single photon emission computed tomography (thallium or Tc)

Predictive Value of a Test

The ability of a stress test to correctly identify CAD or no-CAD

- **PV for a positive test =**
  TP/ (TP + FP) x 100
  The proportion of true positive of all positive results
- **PV for a negative test =**
  TN / (TN + FN) x 100
  The proportion true negatives of all negative results

Relative Risk

- **The predictive value tells you the accuracy of the exercise test**
- **HOWEVER--**
- **To predict relative risk for an individual, the PV must be interpreted in light of the patient's age, gender, symptoms, and amount of ST segment depression**

Patient relative risk

- **If a patient has a positive stress test his risk is dependent on--**
  - **the sensitivity of the test**
  - **the specificity of the test**
  - **the patient population**
- **RR = risk of having CAD with a positive stress test/risk of having CAD with a negative stress test**

Relative Risk, example

- **A patient has a relative risk of 5. What does this mean?**
  - **He is 5 times more likely to have CAD since he had a positive stress test than if he had a negative stress test**

Stress Test results and Survival

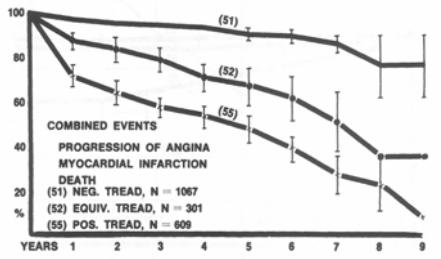

FIGURE 14–7. Survival without all coronary events in the negative responders (51), in equivocal responders (those with ST-segment depression from 0.5–1.4 mm) (52), and in classically positive responders (ST-segment depression of 1.5 or more mm) (55).

Conclusions

- **What is meant by the test sensitivity?**
  - **Ability to correctly identify patients with CAD**
- **What is meant by the test specificity?**
  - **Ability to correctly clear those without disease**
- **How does one calculate the predictive value of a test? (% identified correctly)**
  - **PV+ = TP/all positive results**
  - **PV- = TN/all negative results**

Conclusions, cont.

- **What can enhance the predictive value of exercise testing?**
  - **(max test, additional measurements, patient selection)**
- **What needs to be considered to determine the relative risk for an individual?**
  - **Predictive value of a test & patient population risk**
- **So, if all this is done, is it worthwhile performing a stress to screen for CAD disease?**
  - **Most agree yes**