Heart Rate Recovery in association with exercise stress testing

Daniel E. Forman, M.D.
Director, Exercise Laboratory
Brigham and Women's Hospital
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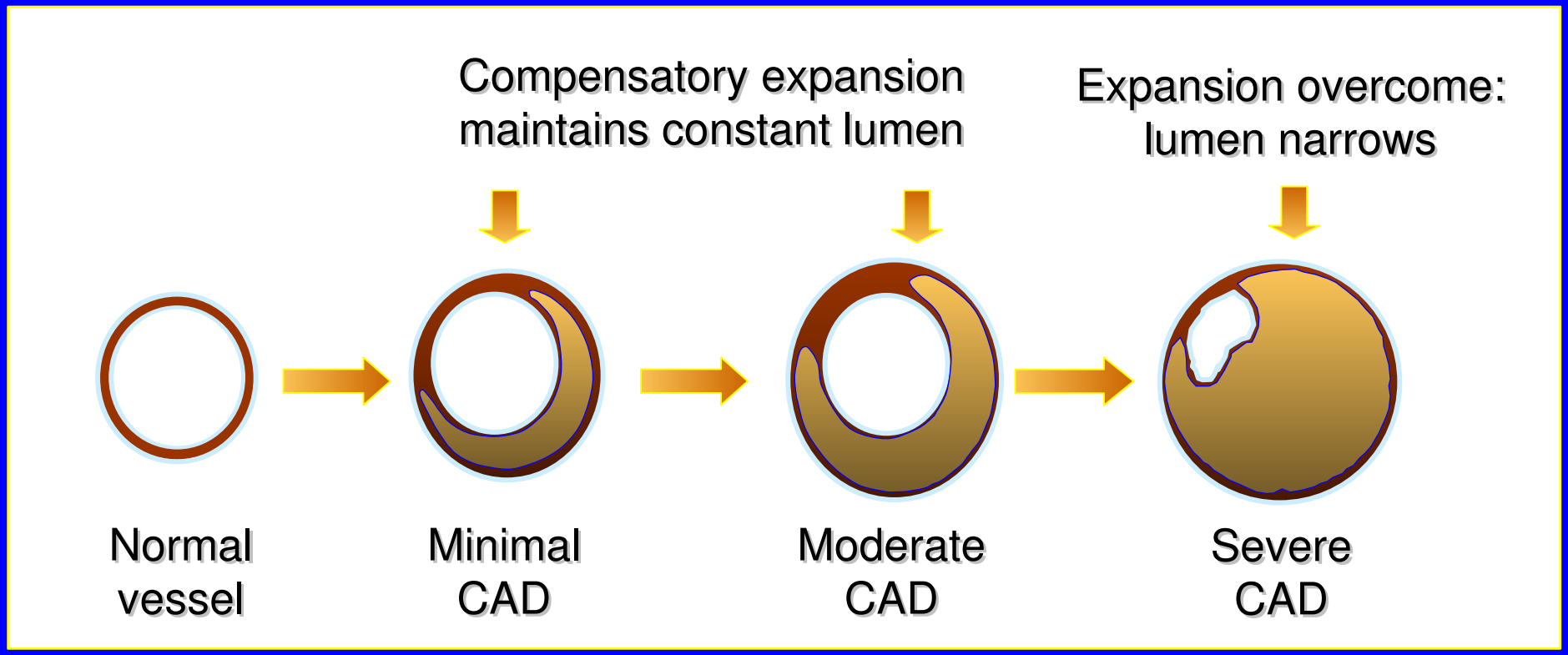
Stress Testing

- Historical Rationale for Exercise Testing
  - Test sensitive and specific to diagnose CAD
    - Symptoms and ECG changes
- Has this rationale for testing changed?
  - Diagnosis is often not the question
  - Shifting emphasis on prognosis
  - *What constitutes meaningful endpoints?*
    - What is the *best test*??

Limitations of Stress Test for CAD:

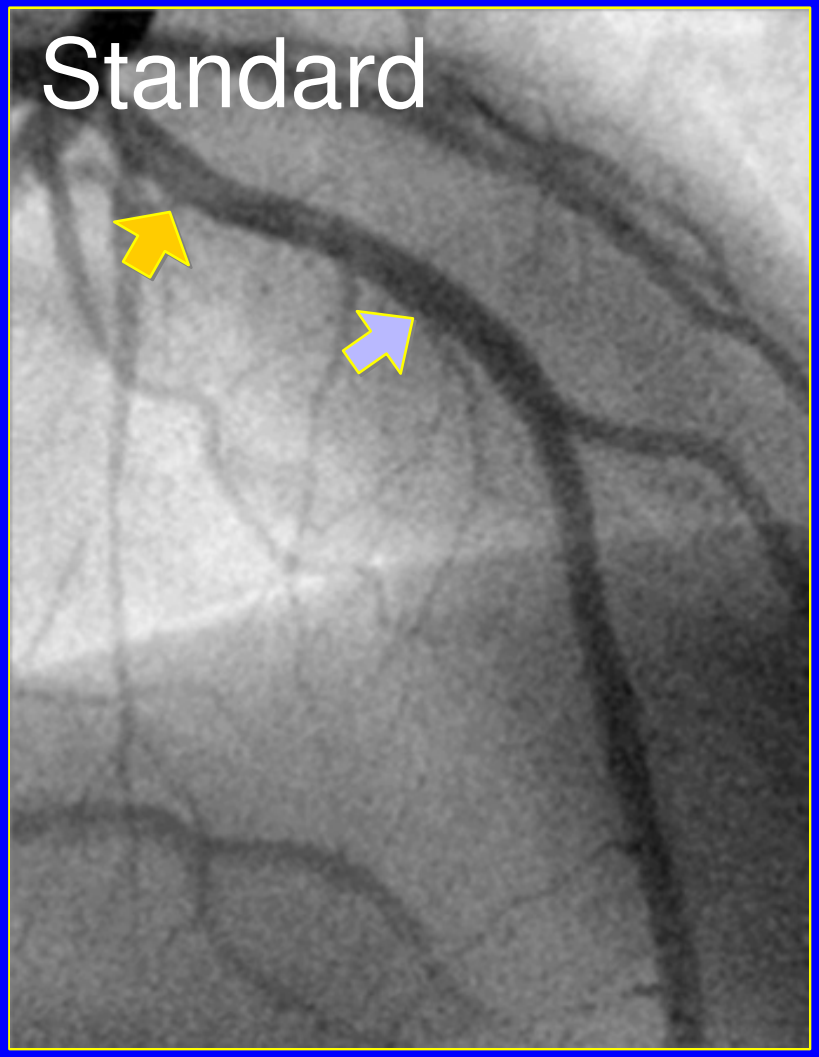
Progression ... lumen may be patent

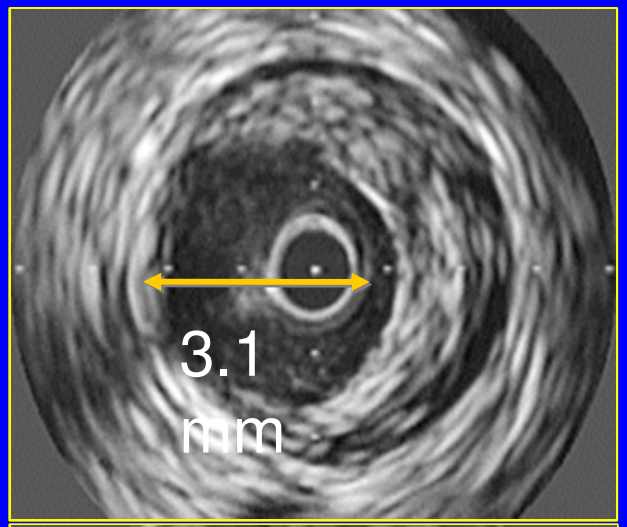


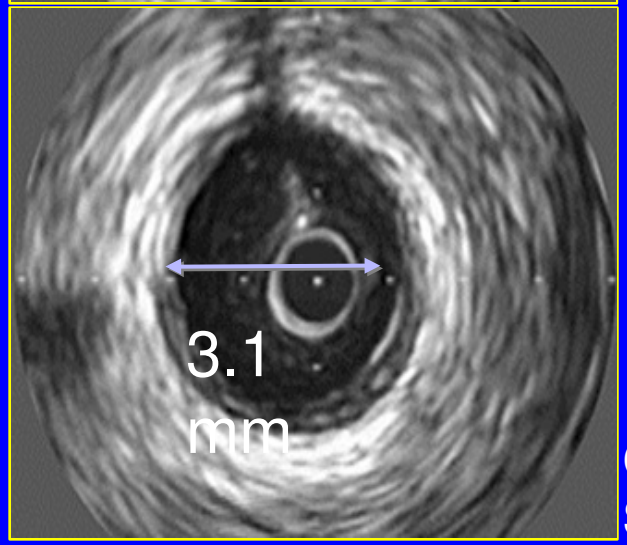
Adapted from Glagov et al. *N Engl J Med*. 1987;316:1371-1375.

Limitation of Stress Test for CAD:

Cardiac Cath is a flawed Gold





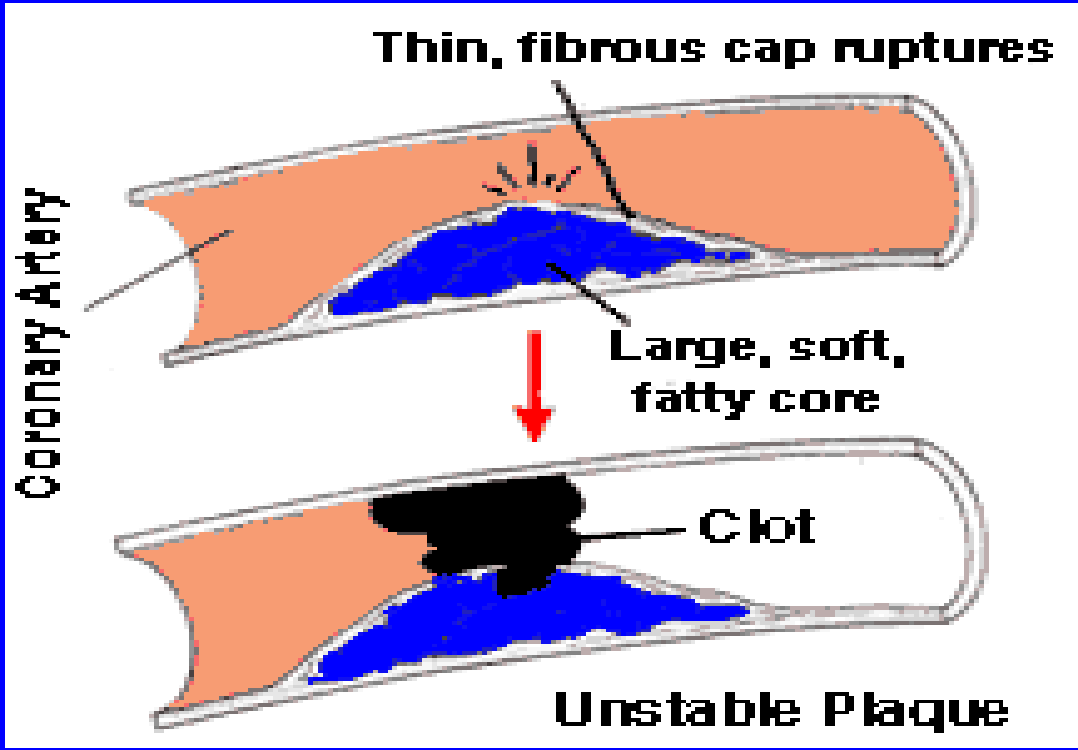


We've based our diagnostic standards on 2D imaging

Courtesy of Steven Nissen

Limitations of Stress Test for CAD:

No assessment of plaque stability



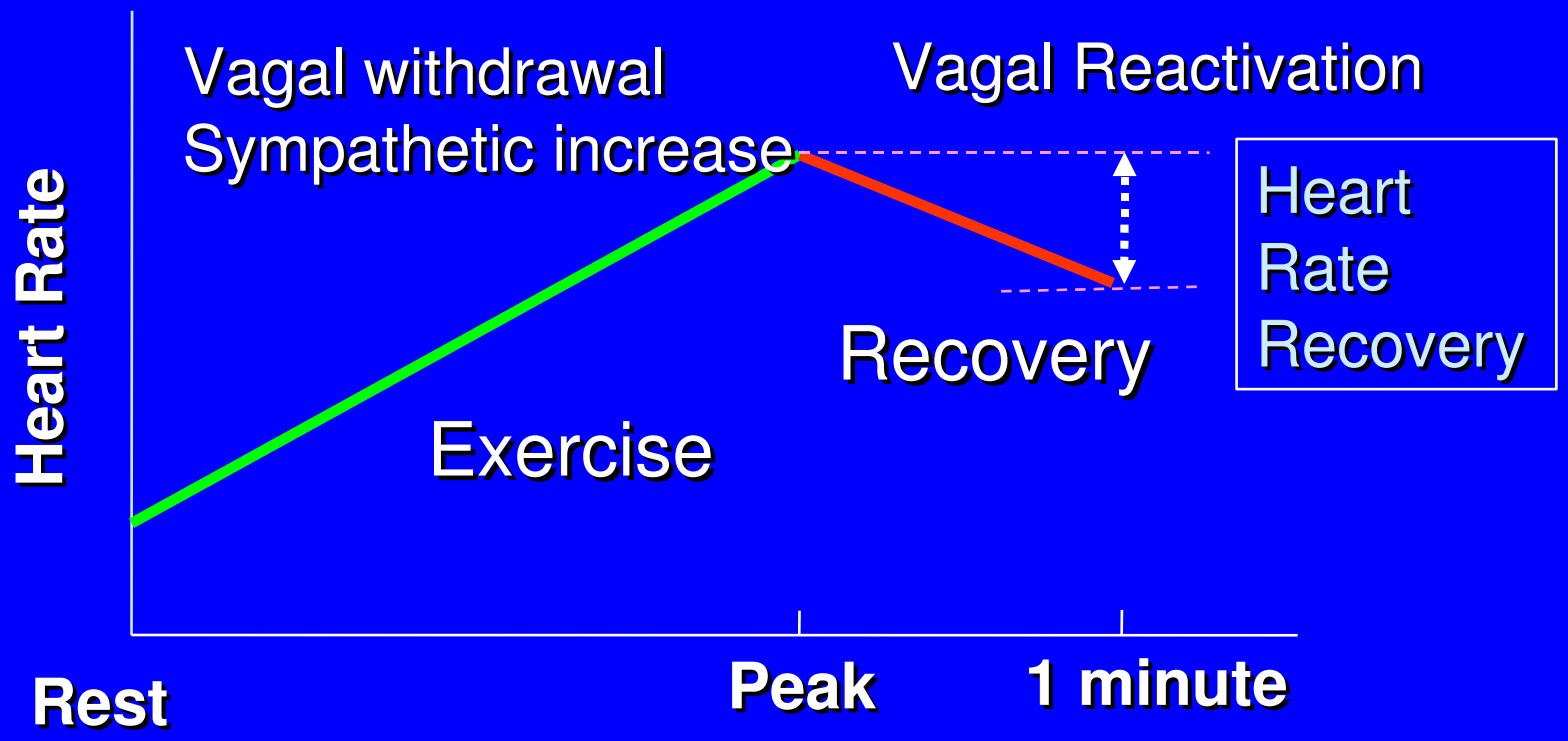
Bottom Line

- It is often hard to detect ischemia
- And even when ischemia is detected, it is difficult to discern the implications
- Prognosis is more important than diagnosis

Prognostic Endpoints

- Functional capacity
- Prognostic Scores
- HR indices: heart rate recovery

Exercise Heart Rate Responses



Heart Rate Recovery

- Biological rationale
- Seminal research
- Confounding, interactions
- External validation
- Clinical applications

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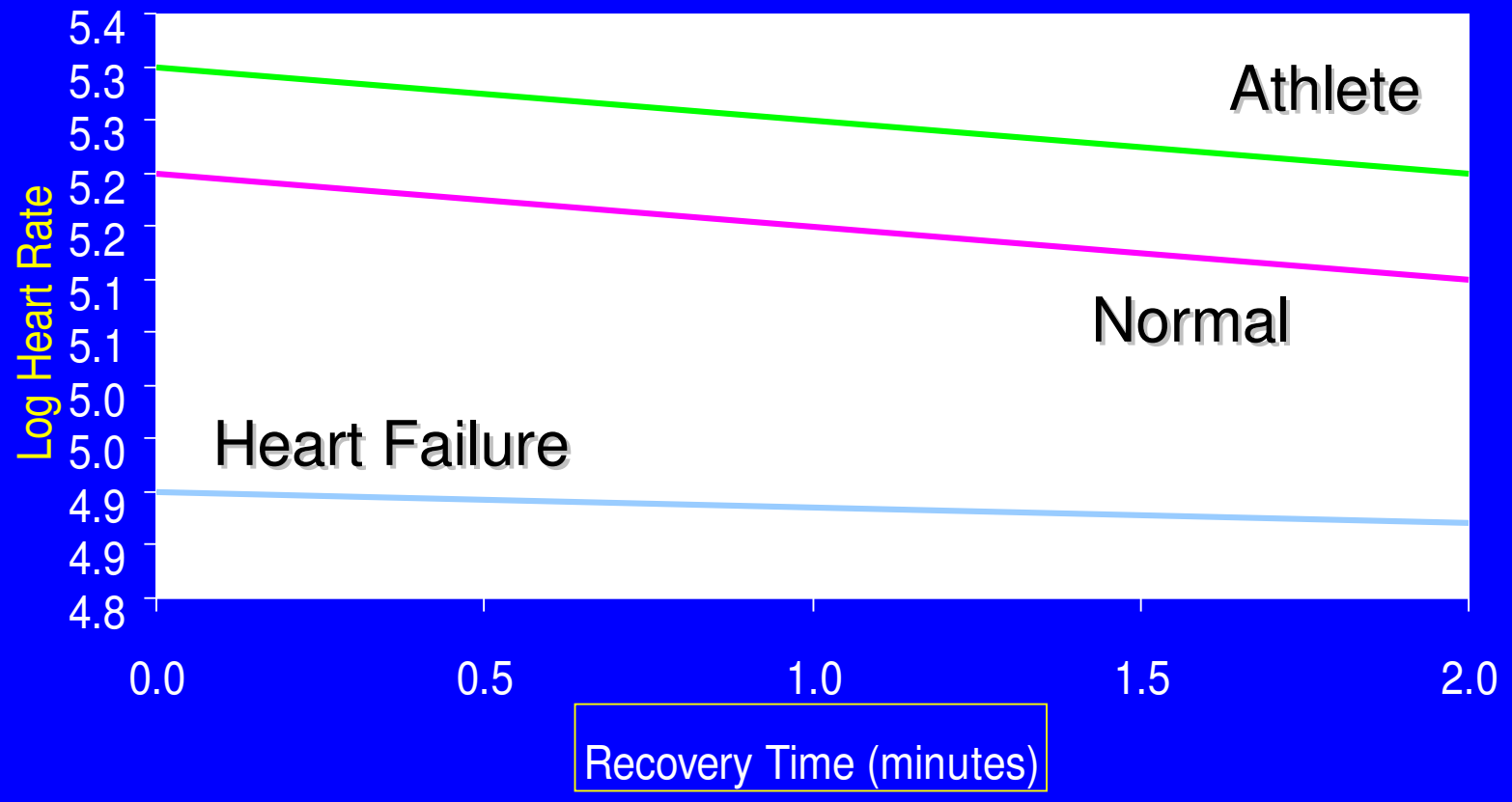
HR Recovery: After Atropine



Imai JACC 24;1529;1994

Autonomic Function and Mortality

↑ Sympathetic Tone

Chronotropic Incompetence

↓ Vagal Tone

HR Recovery

Increased Risk of Death

Heart Rate Recovery

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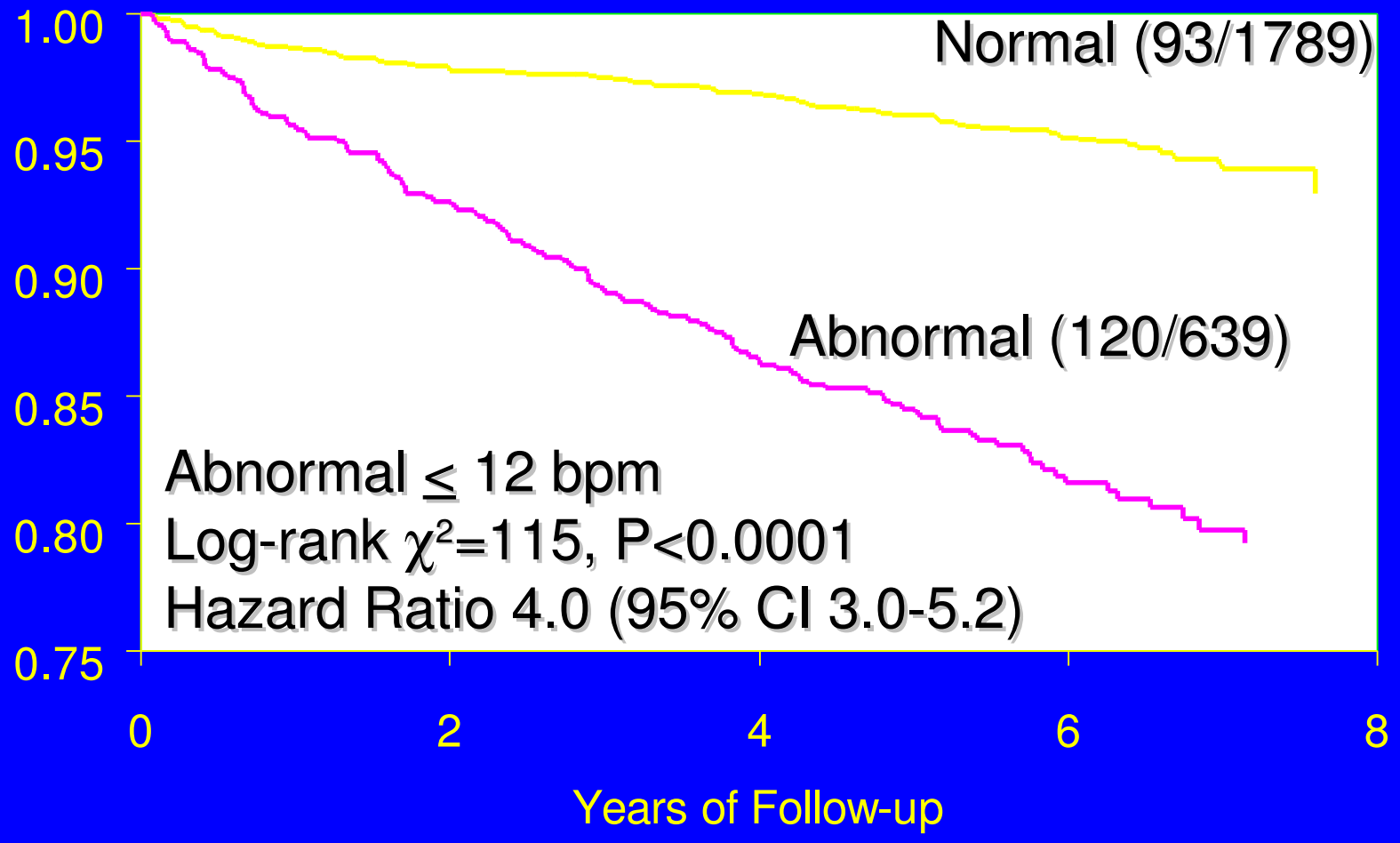
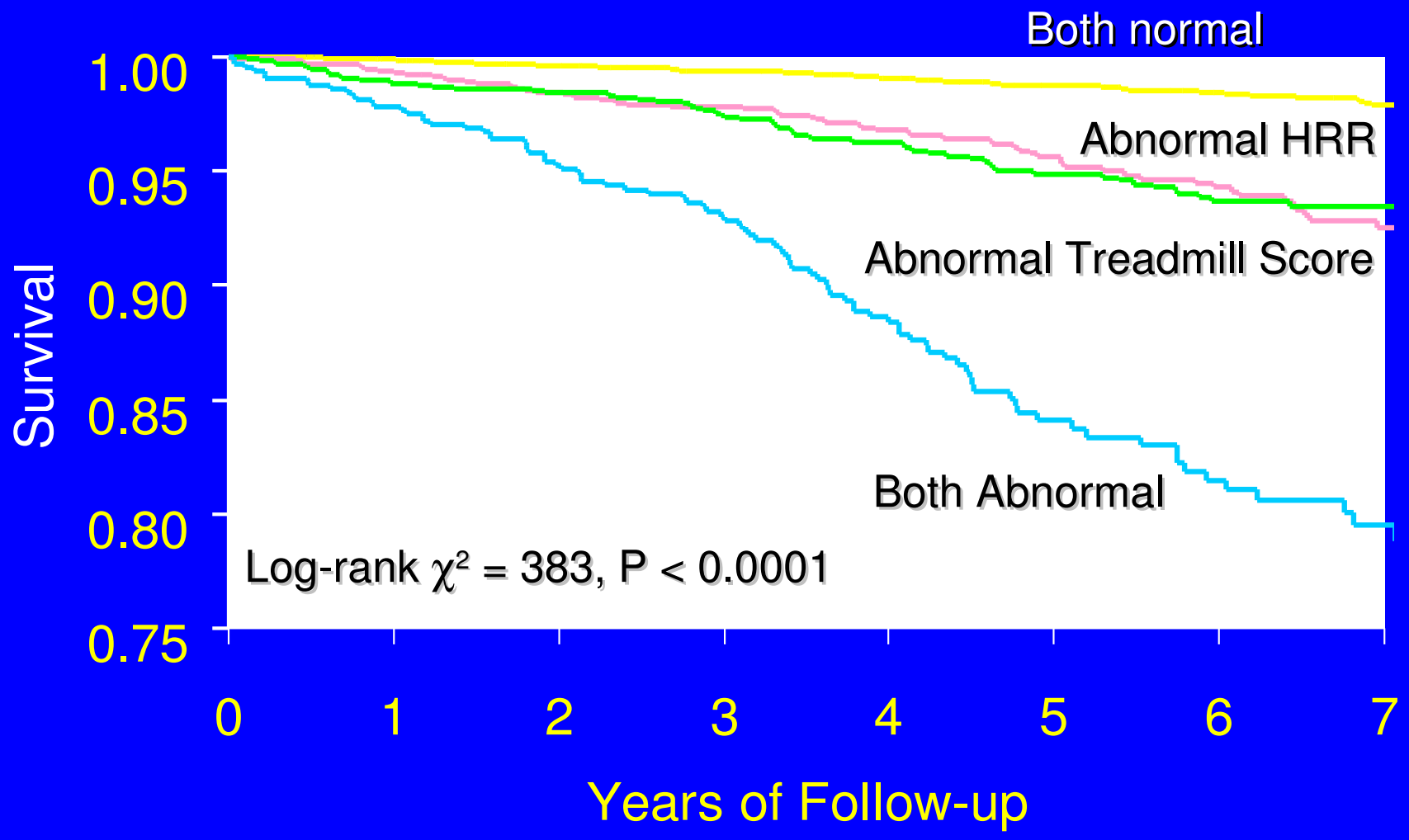
Heart Rate Recovery and Mortality



Cole, Lauer. N Engl J Med 1999;341:1351

HRR and Duke Exercise Score



Nishime, Lauer, JAMA 2000;284:1392-1398

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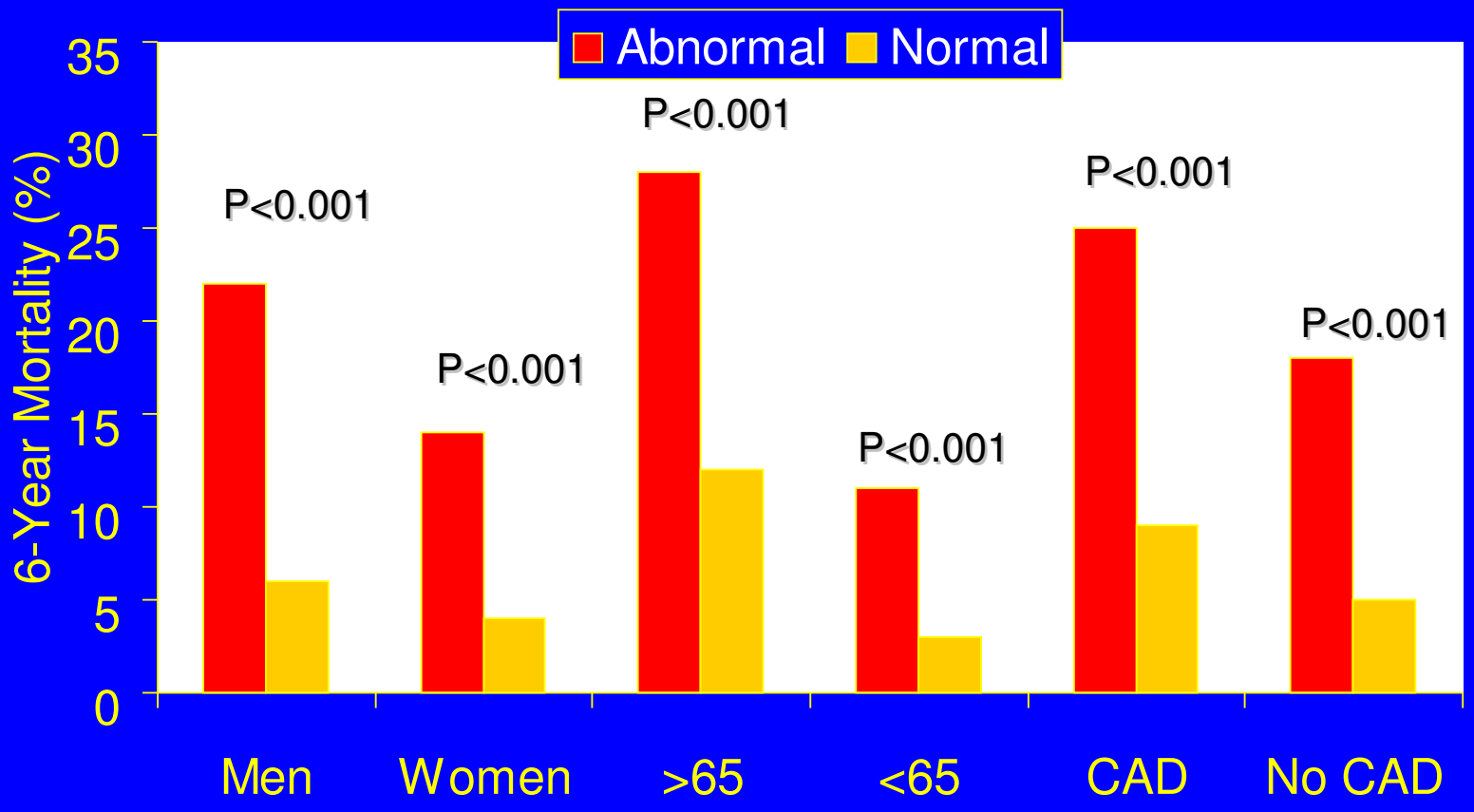
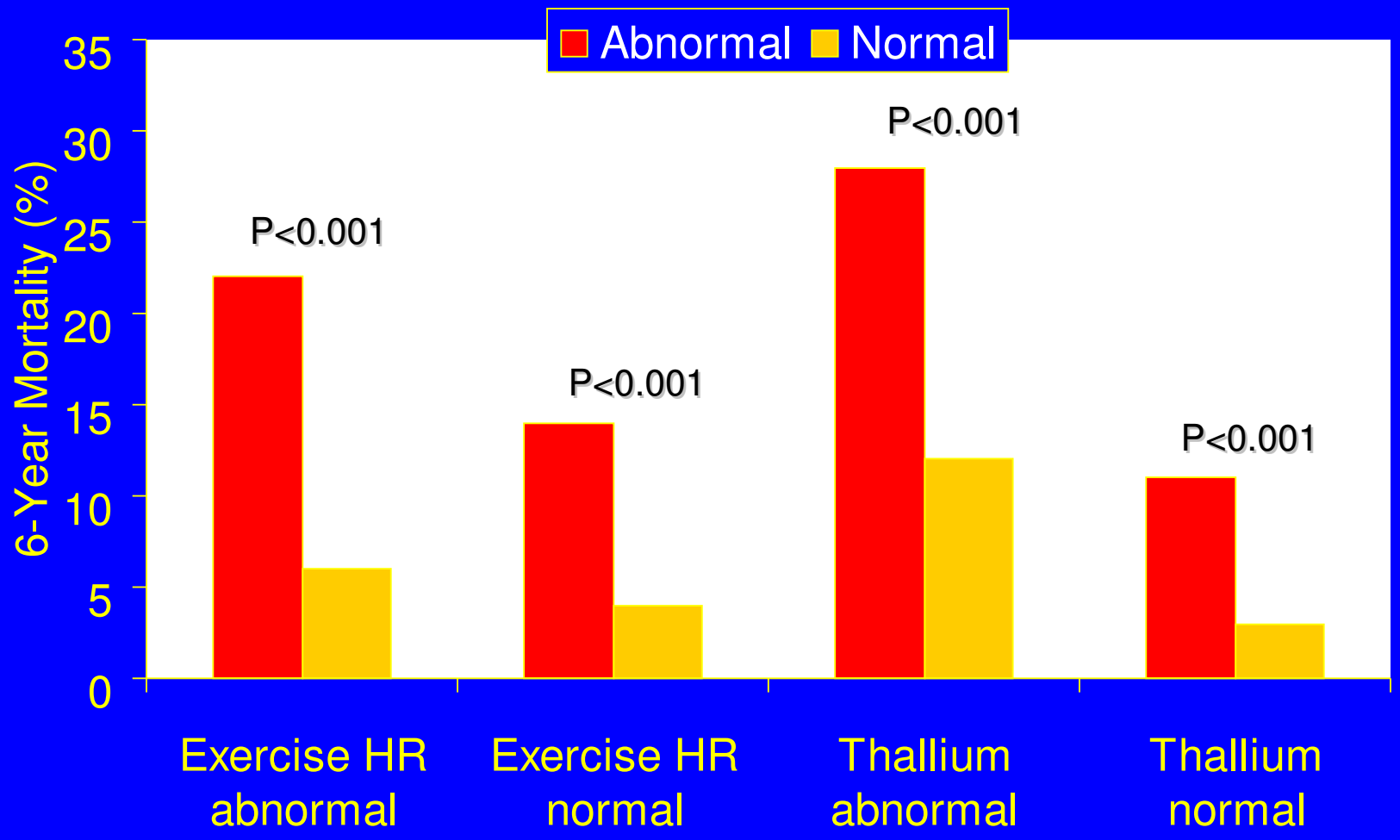
Demographic Subsets



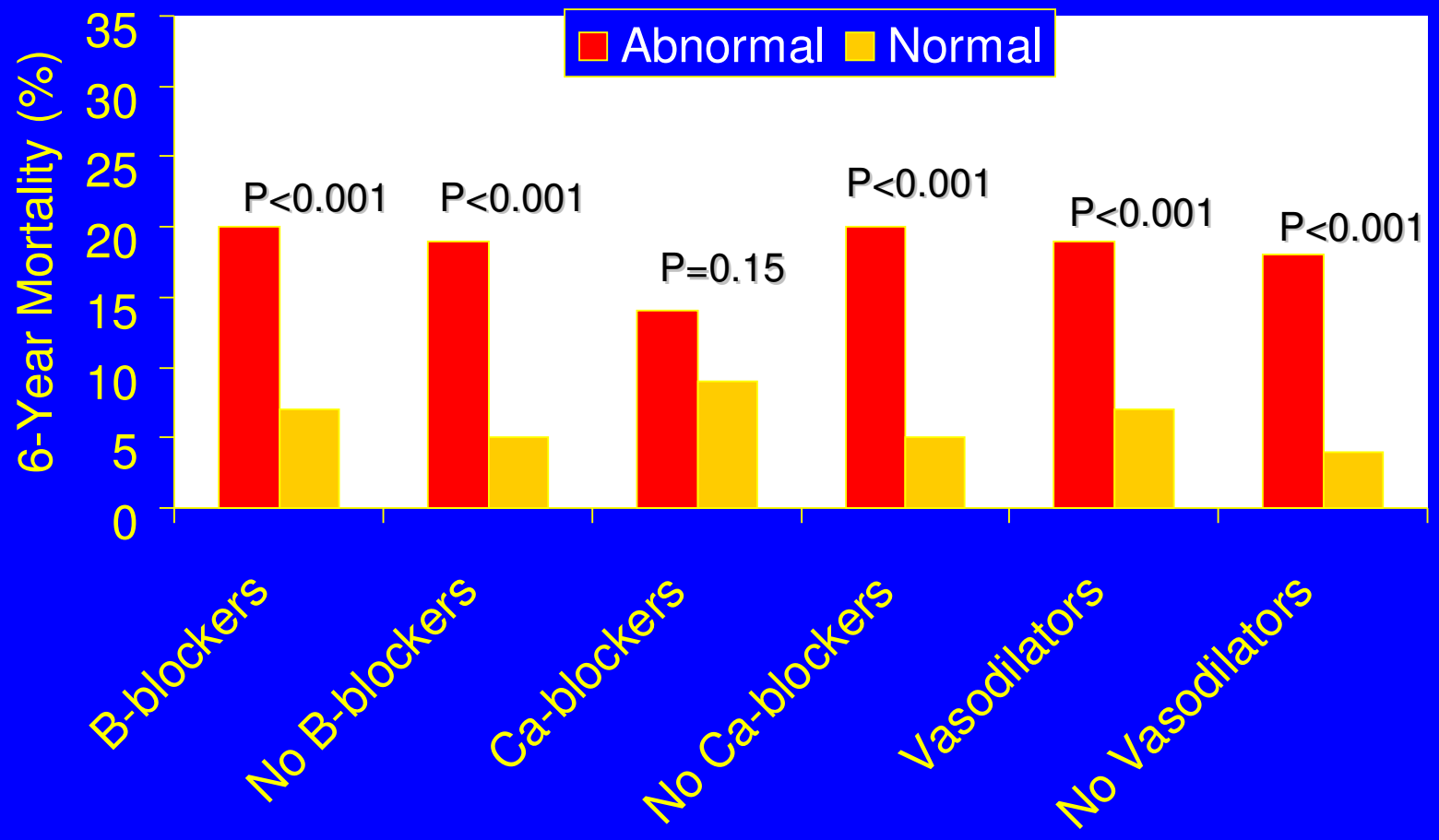
Cole, Lauer. N Engl J Med 1999;341:1351

Test Subsets

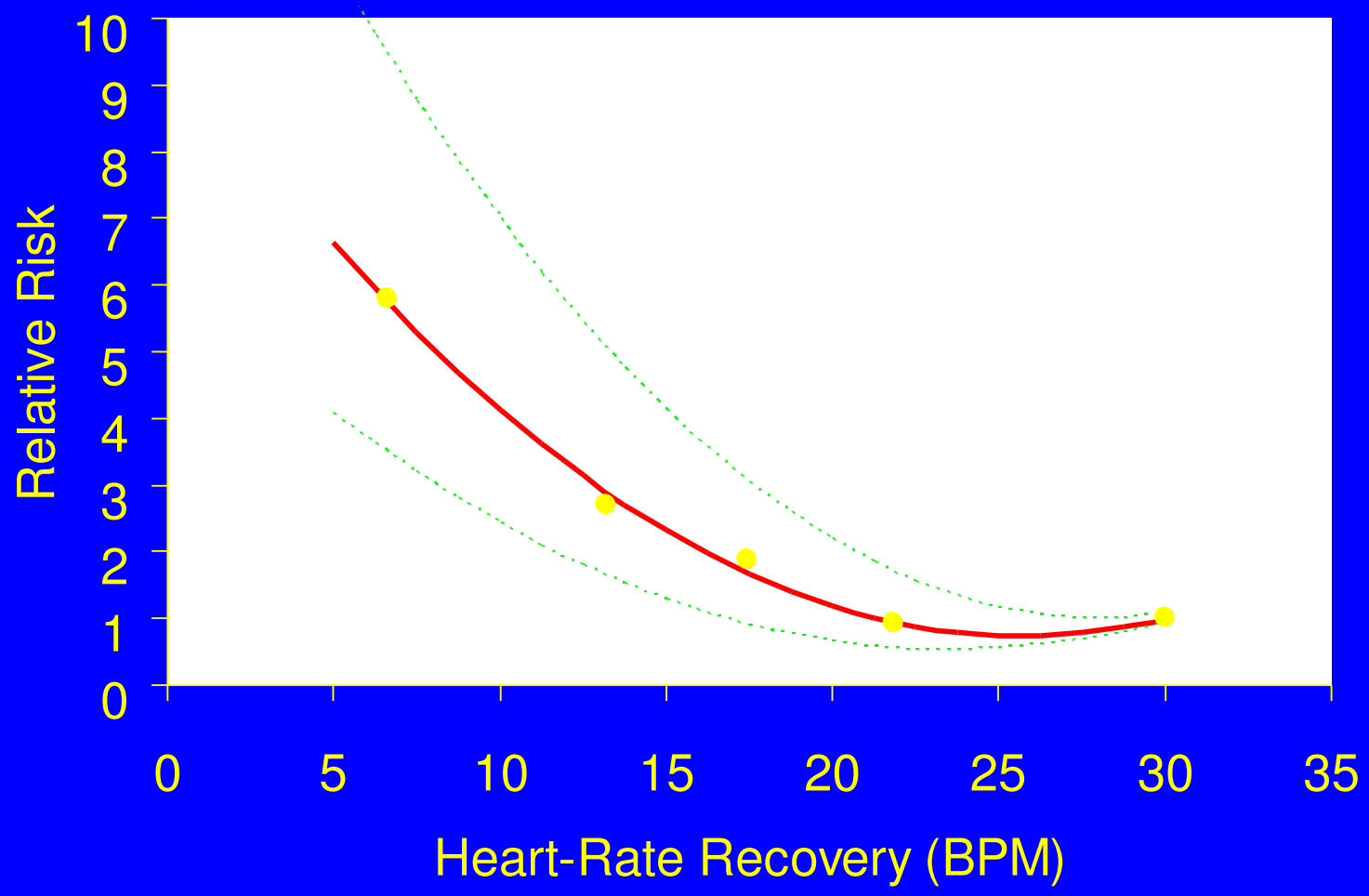


Cole, Lauer. N Engl J Med 1999;341:1351

Medication Subsets

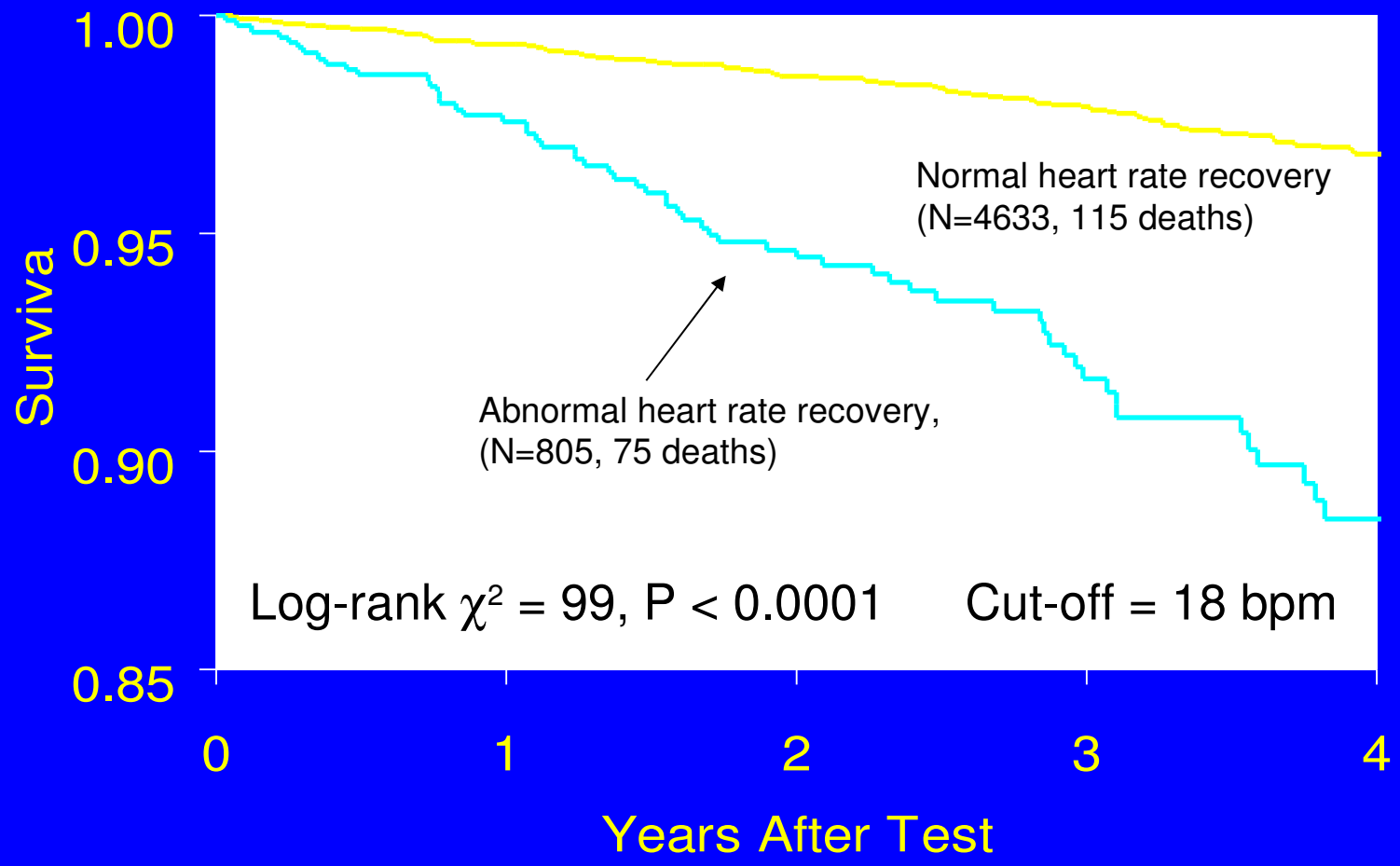


Cole, Lauer. N Engl J Med 1999;341:1351



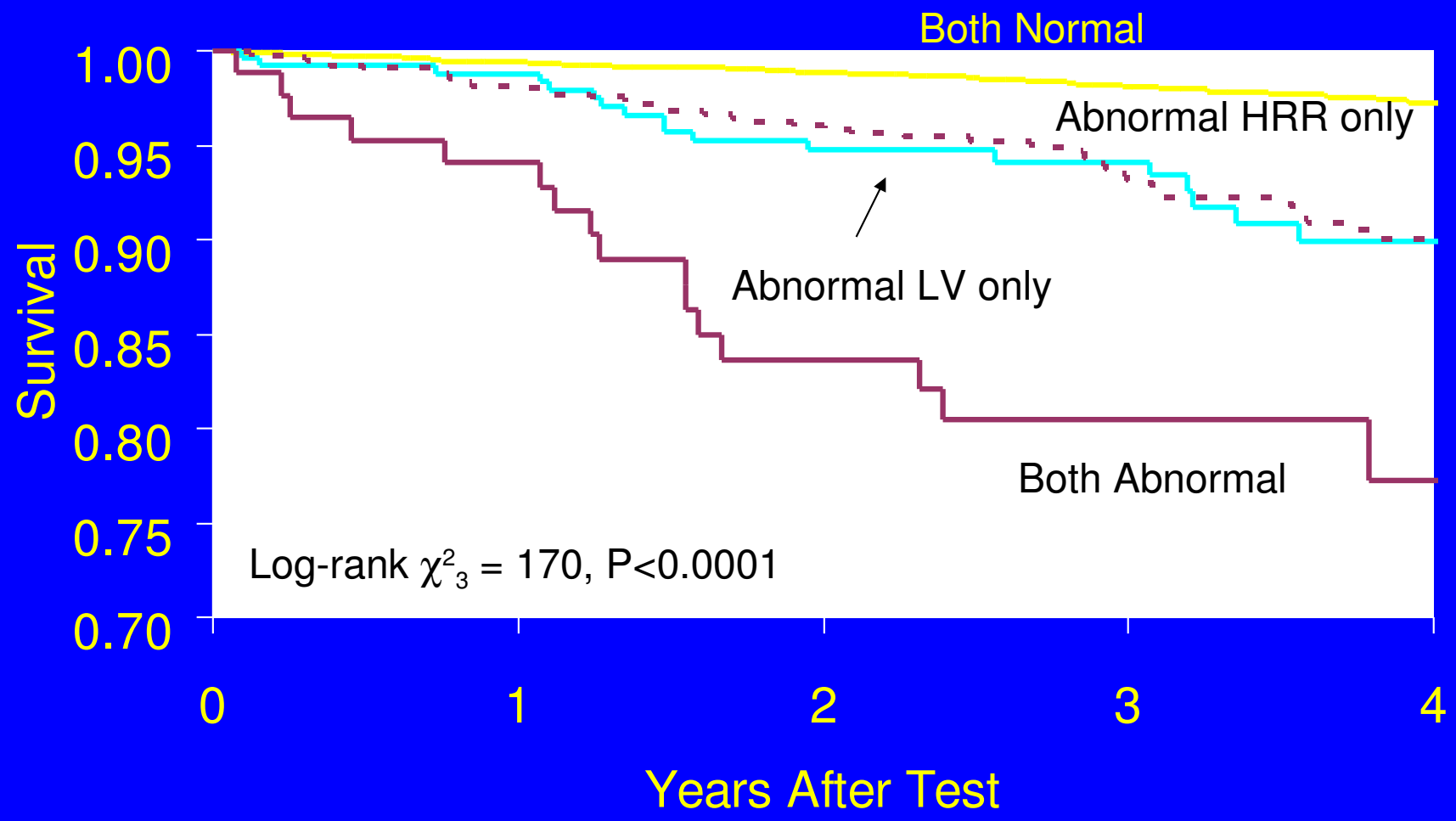
Cole, Lauer. N Engl J Med 1999;341:1351

Stress Echocardiography



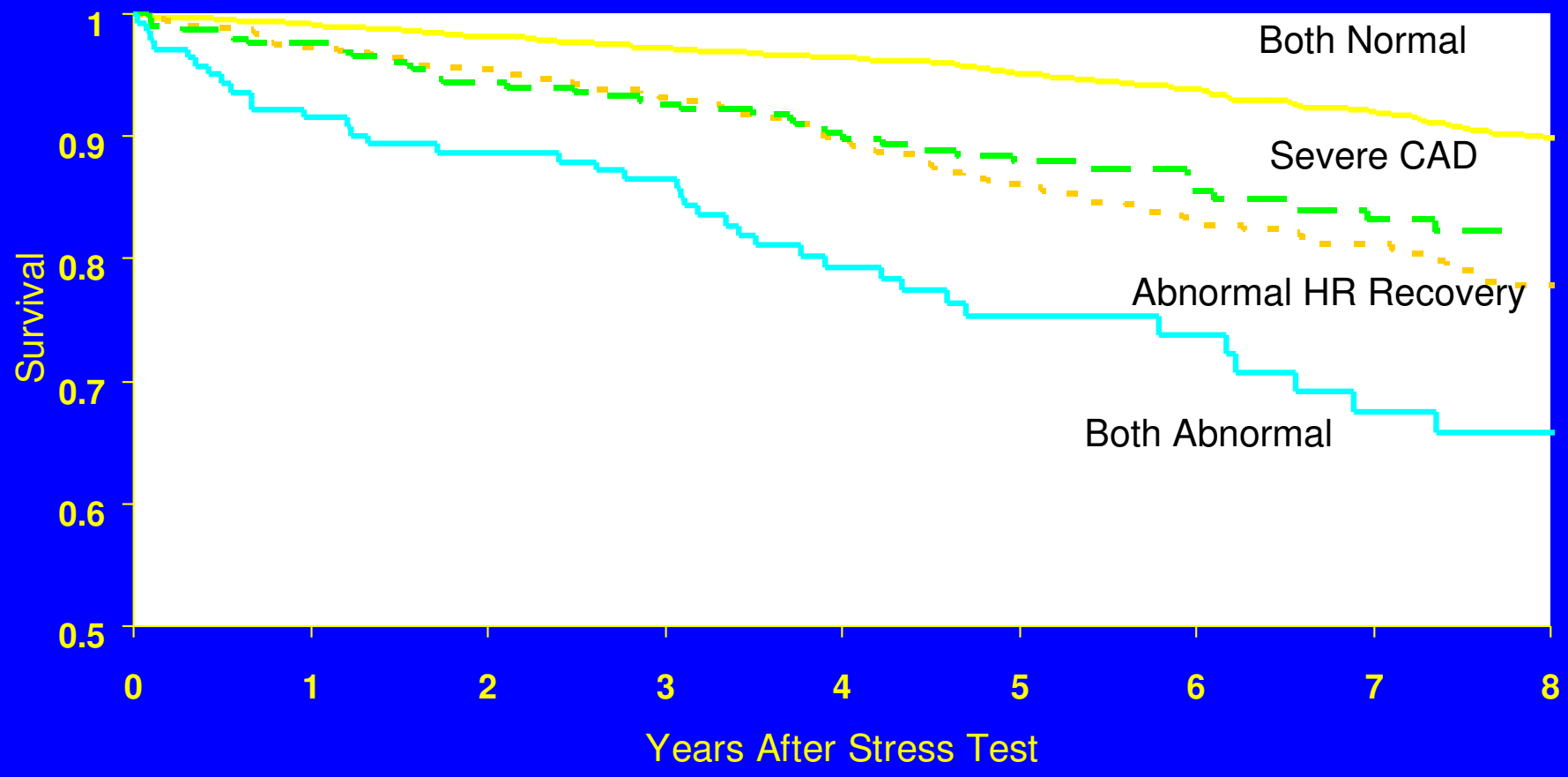
Watanabe, Lauer. Circulation 2001;104:1911-1917

HR Recovery and LVEF



Watanabe, Lauer. Circulation 2001;104:1911-1917

HR Recovery and Angiography



Vivikenathan D and Lauer MS, J Am Coll Cardiol 2003;42:831-8

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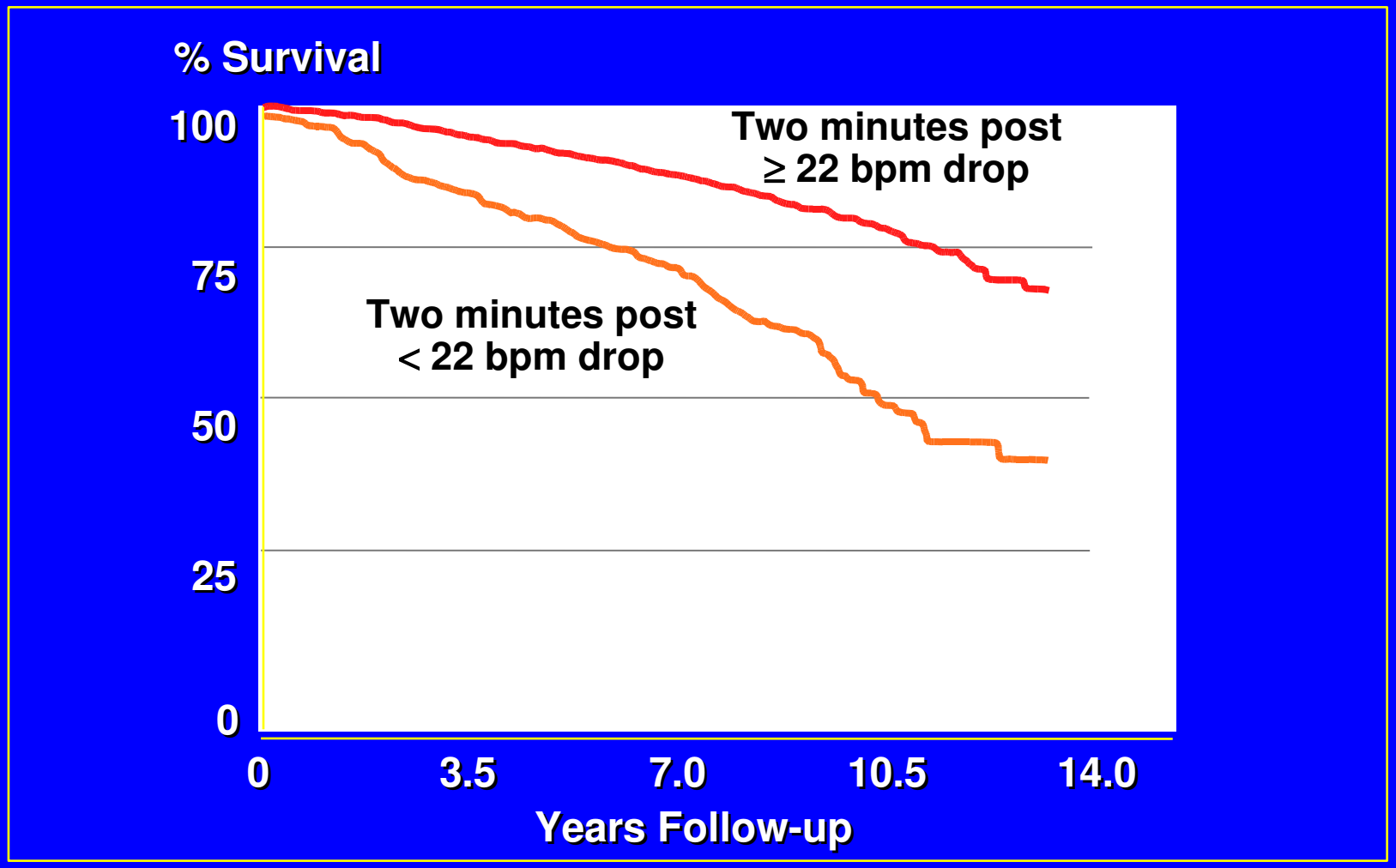
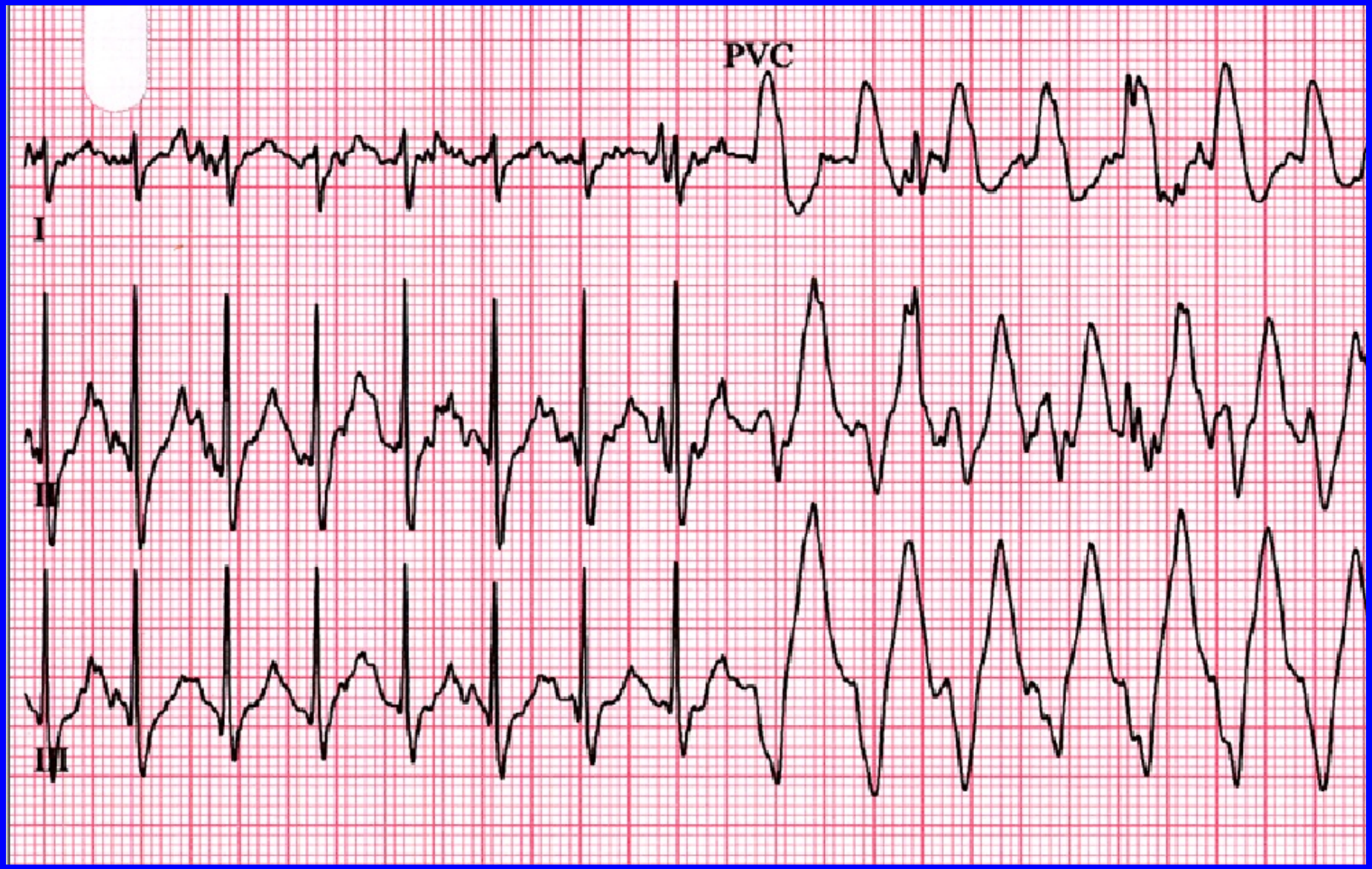
External Validation: Stanford



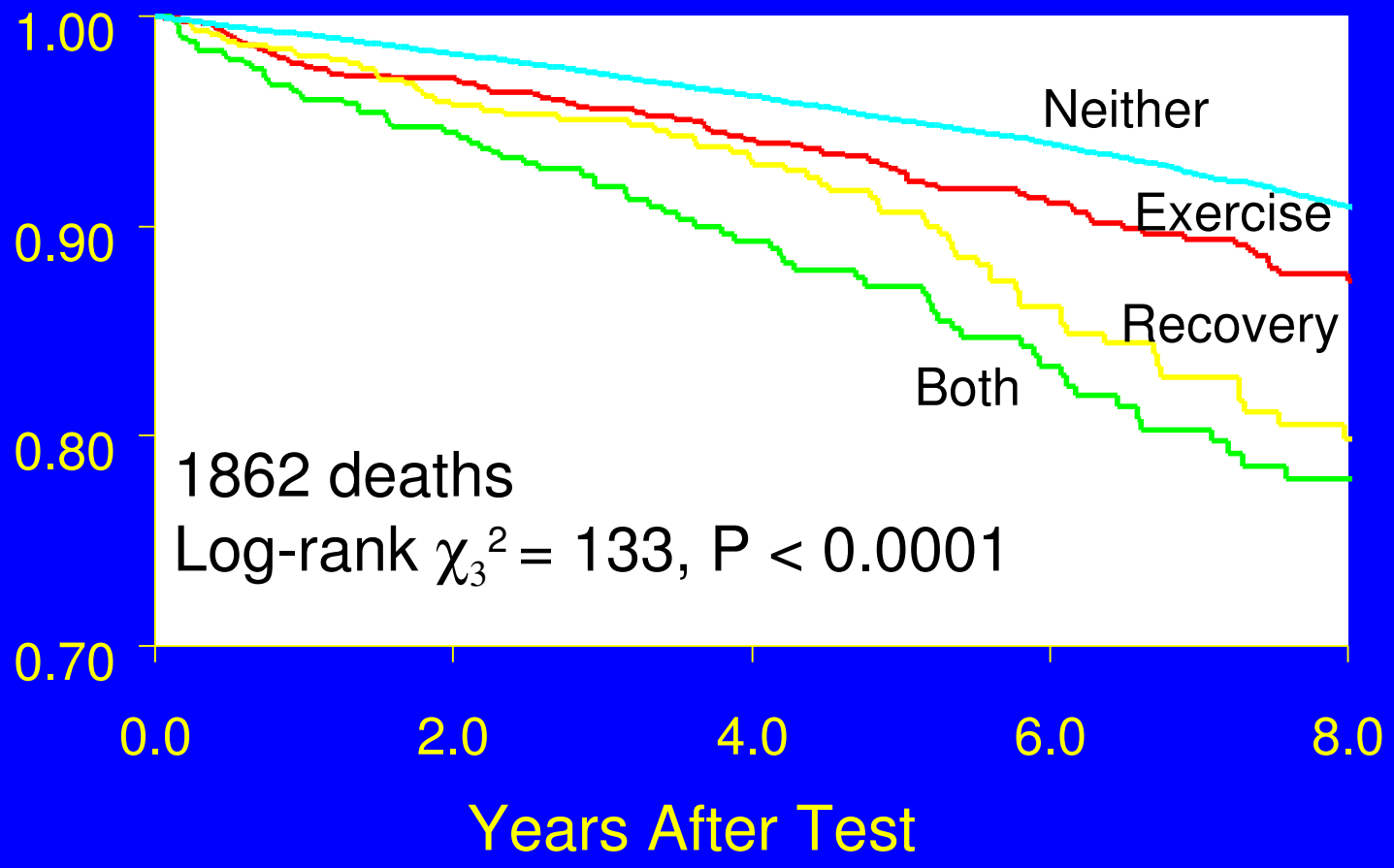
Shetler K. J Am Coll Cardiol. 2001;38:1980-1987.

Technical differences

- 1 minute vs. 2 minute recovery
- Cool down vs. supine recovery protocol


PVC
I
II
III

Ventricular Ectopic Activity



Frolkis JP, Lauer MS, N Engl J Med 2003;781-90.

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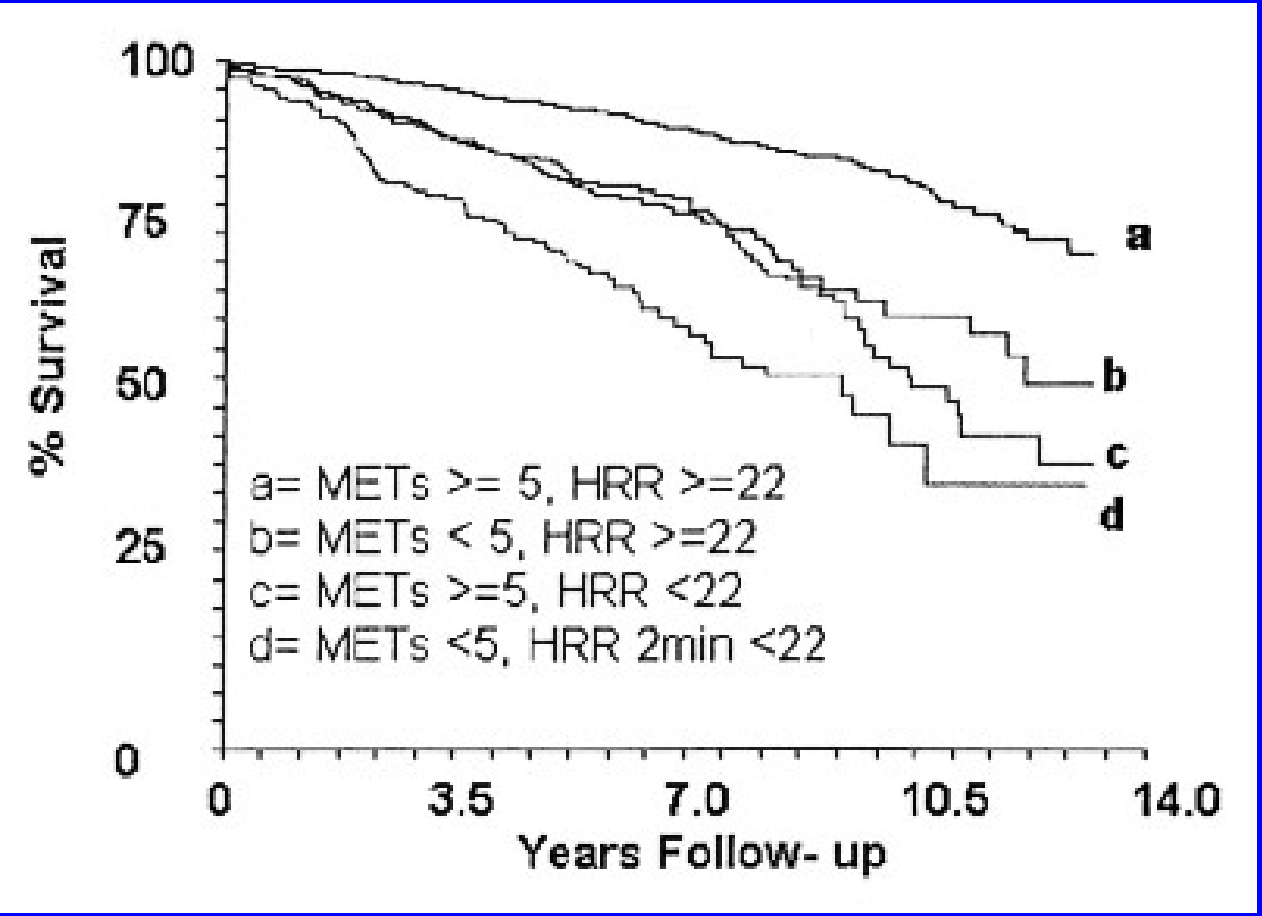
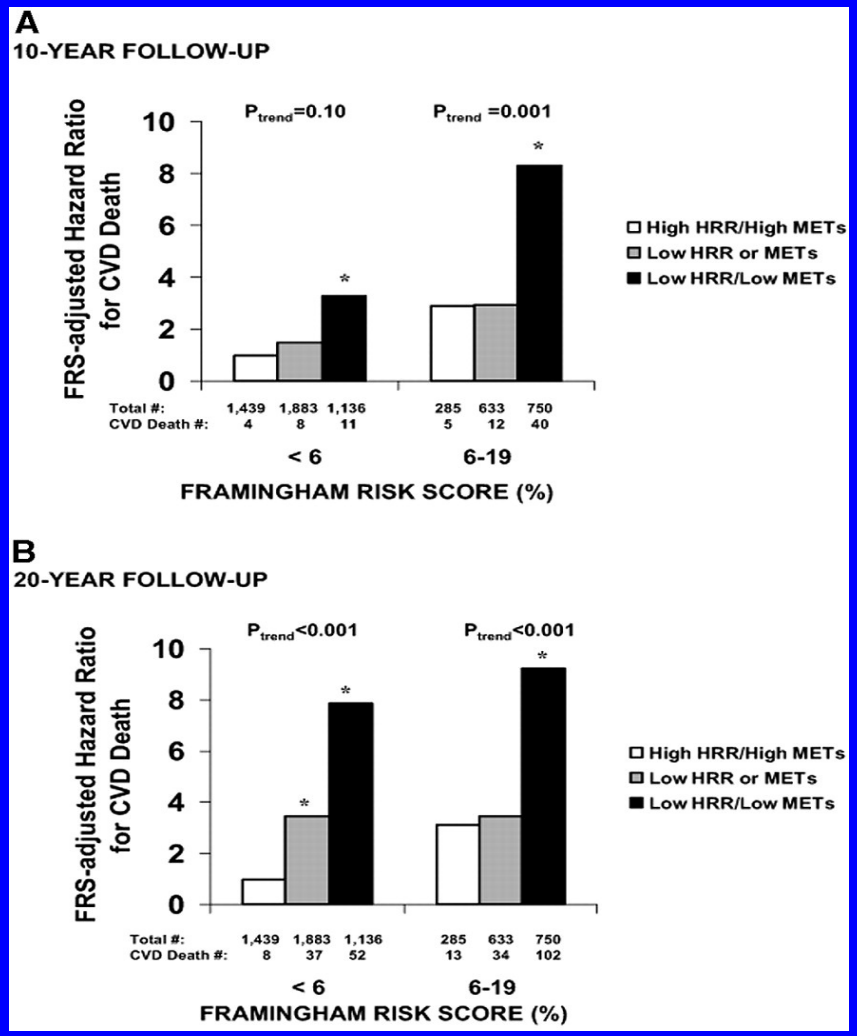
Combining Prognostic Indices: Function and HR recovery



Shetler et al. JACC.2001;38:1980-7

Risk for CV death according to FRS categories and HRR/METs groups

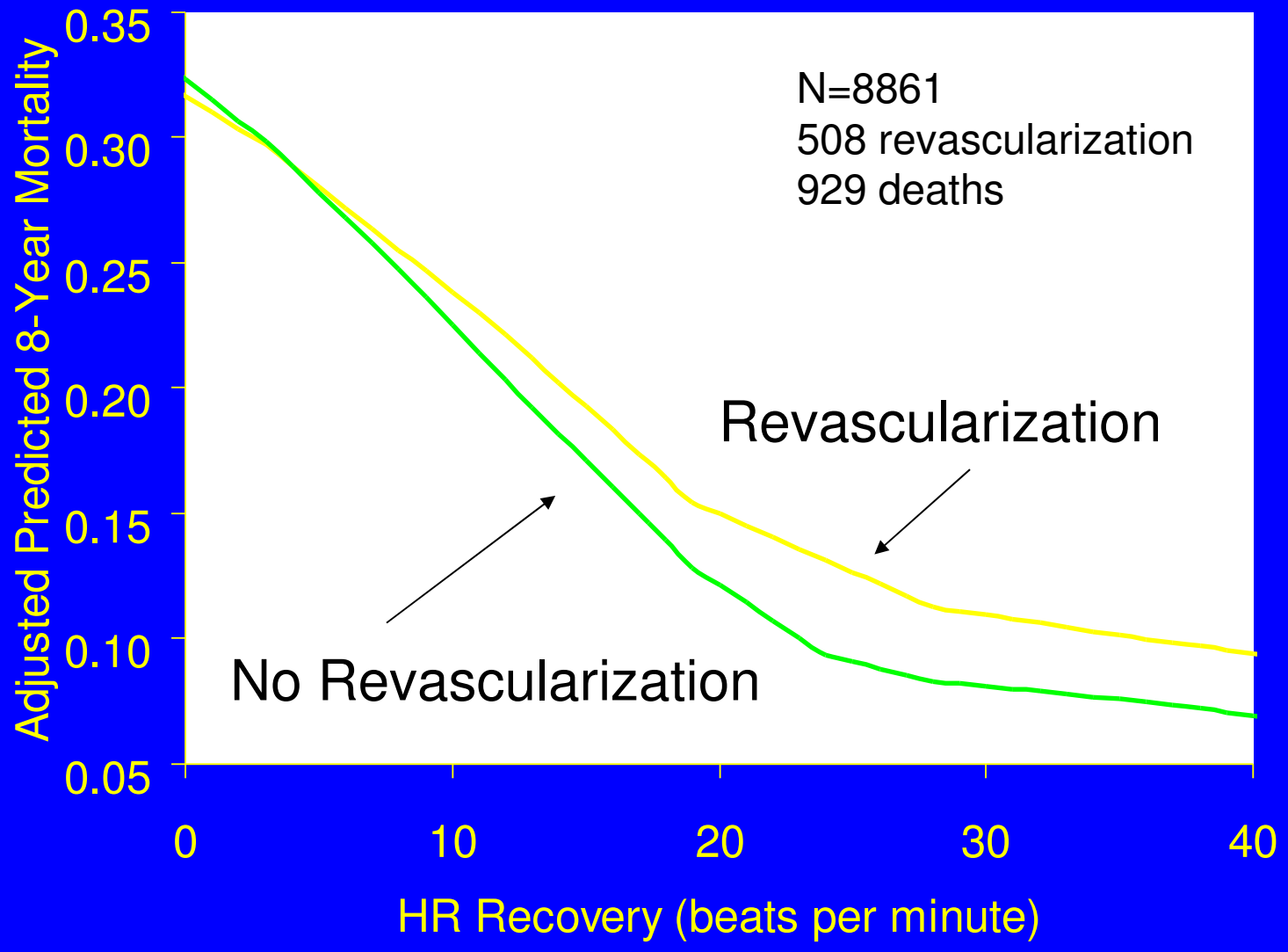


Mora, S. et al. Circulation 2005;112:1566-1572

Clinical Implications

- Does this supplant the emphasis on diagnostic testing with imaging?

Treatment Implications of HRR



Chen M, Lauer M Circulation 2004;110:2851-7.