History of Stress Testing

- Key persons and events in stress testing
- Key concepts
- Late-breaking methods

Historical Note

- The “cornerstone” of modern stress testing was the recognition of the importance of ST segment changes to predict the presence of coronary artery disease (CAD)

Historical Highlights

- 1918: ST depression first noted during angina (Bousfield)
- 1928: ST changes during exercise (sit ups) are associated with chest pain & decreased cardiac blood flow (Feil & Siegel)
- 1929: Master’s Step test, first “standard” exercise protocol—submaximal w/o EKG (Master)
- 1932: ST depression is present in only 75% of patients with angina during exercise (similar to percentages today). (Goldhammer & Scherf)
- 1938: First to use maximal exercise testing to test for CAD—climbing stairs (Missal)

Historical cont.

- 1940: Continuous EKG monitoring, depression > 1.0 mm is clinically significant (Risman et al.)
- 1941: EKG changes after exercise can be useful to detect CAD (Master & Jaffe)
- 1942: The Harvard Step Test used to assess fitness from HR during recovery (Johnson et al.)
- 1950: Maximal exercise (stair climbing) was more sensitive (88%) to detect CAD than submaximal exercise (39%) (Master’s test) (Wood et al.)

Historical cont.

- 1952: Treadmill testing used with set criteria to screen for CAD (Yu et al.)
  - ST depression > 1.0 mm
  - Change in T wave (upright - inverted)
  - Increase T wave amplitude & Q-T duration
- 1954: Cycle tests used to predict fitness (Astrand)
- 1956: Bruce established the guidelines used today: treadmill, with EKG, during exercise
- 1969: Refined interpretation of ST changes (V5 or CM5 most sensitive leads) (Blackburn et al.)

Bruce Treadmill Protocols

- Modiﬁed Bruce (Lauer et al. 1970)
  - 3 mph, 5% incline + 0.5% incline per min
  - 3 min = normal
  - 6 min = high risk
  - 9 min = high risk

- Stages:
  - M1: 2.2 mph, 5% incline
  - M2: 2.7 mph, 10% incline
  - M3: 3.3 mph, 15% incline
  - M4: 3.9 mph, 20% incline
  - M5: 4.5 mph, 25% incline

- PerNormal and High Risk (Lauer et al. 1970)
  - Initial work load: 1.7 mph, 0% incline
  - Initial work load: 1.7 mph, 3%, 0 mm
V5 and CM5 leads

- Bi-polar Limb Leads
  - I, II, and III
- Uni-polar Limb Leads
  - AVR, AVL, AVF
- Uni-polar precordial leads (V1 to V6)
- Modified bi-polar leads (CC5, CM5, CS5, CA, CB) (+ electrode in V5)

CM4 lead

see pg 105 in text

General Concepts Today

- Computer-based analysis of 12-lead EKG changes
- Combination of ST changes with other exercise data (HR, BP)
- Imaging methods (echocardiography, nuclear methods)
- Bayesian Analysis approach, ST interpretation must be consistent with risks of the patient population

Bayes Theorem (1970s and 1980s)

- The probability of a “true” positive stress test depends on the pre-test risk of the patient

70-yr old man vs 30-yr old woman, both with suspicious chest pain and ST depression

90% 10%

Current breaking advances

- Appreciate there are various types of ischemia
  - occlusive, vasospastic, blood flow redistribution
  - ST doesn’t need to correlate to angiography occlusion
- Newer EKG leads and imaging techniques to localize diseased vessels
- predictive value of traditional (cholesterol, LDL) and non-traditional (ApoB, C reactive protein) biochemical markers