HOW TO INTERPRET THE EXERCISE STRESS TEST

Nora Goldschlager, M.D.
MACP, FACC, FAHA, FHRS
SFGH Division of Cardiology
UCSF, San Francisco

Disclosures: None
ST SEGMENT RESPONSES DURING EXERCISE TESTING: PATHOPHYSIOLOGY

• Primary ↑ in myocardial oxygen demand (usually produces ST depression)
• Primary ↓ in myocardial oxygen supply (can produce ST elevation)
ECG RESPONSES DURING EXERCISE TESTING

• ST segment abnormalities
  - Depression (downsloping, horizontal, slowly upsloping)
  - Elevation
  - Scooping
  - Alternans
• ST depression in exercise PVCs
Positional ST-T wave abnormalities
Evolution of downsloping ST-T segment response

- **REST V5**
- **STAND**
- **STAGE I 1-1/2'**
- **STAGE I 3'**
- **STAGE II 1-1/2'**

**Evolution over time:**
- **REC. 0 sec**
- **REC. 30 sec**
- **REC. 1 min**
- **REC. 1-3/4 min**
- **REC. 3 min**
- **REC. 4 min**
- **REC. 5 min**
- **REC. 6 min**

**EKG recordings:**
- **V₁, V₂, V₃, V₄, aVR**

**Annotations:**
- Some arm pain
- 4 nitro given
Pseudo-ST depression due to baseline artifact
Pseudo-ST elevation due to artifact
TIMED 12 LEAD REPORT

Protocol: Bruce-UCSF  Stg Time: 00:01  0.0 MPH  HR: 148  Date: 08/29/21
Stage: Recov  Exr Time: 10:00  0.0 % Grade  BP:  Time: 15:59:3
ST-T alternans
54 y.o. male - recent admission for unstable angina; isordil, β-blocker on discharge
0 seconds recovery. Exercise duration 3 minutes.

40 mm Hg drop in systolic pressure
2 minutes recovery
45 y.o. woman with chest pain and hypertension
ECG RESPONSES
DURING EXERCISE TESTING

• T wave abnormalities, isolated
  - Inversion
  - Normalization
    . Prevalence: pts with CAD = 27%, pts without CAD = 57%
    . In over 90% of pts with CAD, exercise test will show evidence of ischemia
      . In pts without CAD, exercise test will be normal
    . T wave normalization does not interfere with ischemic response
    . May indicate myocardial viability
  - ↑ amplitude (“coronary Ts”)
T WAVE NORMALIZATION AS A PREDICTOR OF MYOCARDIAL VIABILITY*

* PET

Mobilia et al    JACC 7.98   N = 40

- Sensitivity
- Specificity
- Accuracy

Any workload
- < 50 watts
- Anterior MI, < 50 watts
ECG RESPONSES DURING EXERCISE TESTING

• U waves
  - Inversion
  - Enhancement
• QT dispersion
• Axis shifts
• Rate dependent bundle branch block
• QRS duration changes
• ↑ in P wave duration (LA) or amplitude (RA) in II
BUNDLE BRANCH BLOCK IN TREADMILL TESTING

• Predictive accuracy depends on prevalence of coronary disease in population studied.
  + PA is about 20% in asx subjects
• Predictive accuracy of intermittent, rate-dependent and newly acquired BBB is unknown
• Criteria for ischemia apply in lateral leads in RBBB, not in LBBB, although sensitivity is reduced due to the secondary ST-T abnormalities
Rate-dependent LBBB

REST

STAGE V/1/2 min

REC. 2 min.
Rate-dependent LBBB
EXERCISE TEST RESPONSES PREDICTING SEVERE CAD

- ST segments: downsloping, elevated
- Early onset of ischemic ECG changes (1st 3 min)
- Prolonged duration of ischemic ECG changes in recovery (> 7 min)
- Hypotension associated with evidence of ischemia
EXERCISE TEST RESPONSES NOT HELPFUL IN PREDICTING SEVERE CORONARY ARTERY DISEASE

- Inappropriate sinus tachycardia
- Failure of heart rate to increase appropriately
- Failure of systolic blood pressure to rise
- Rise in diastolic blood pressure
- Ischemic ECG changes in exercise vs recovery
- Ventricular arrhythmias at high heart rate
- Atrial arrhythmias
- Bradyarrhythmias
SPECIFIC ST RESPONSES: ACCURACY IN IDENTIFICATION OF SPECIFIC CORONARY ARTERY INVOLVEMENT*

- ST elevation
  - AVR $\geq 0.5$ mm: 89% sensitive for LAD, 44% specific
  - $V_1 \geq 0.5$ mm: 70% sensitive for LAD, 100% specific
  - $V_{2-3}$: LAD
  - II, III, AVR: RCA
- ST depression:
  - $V_1$: 100% specific for LCX; sensitivity low

* Developed in 1-V CAD pts
VALUE OF V₄R IN EXERCISE ECG

• ↑ overall sensitivity by 10%
• ↑ sensitivity for RCA CAD by 15 - 20%
• May be only + lead in RCA subtotal occlusion
• No ↓ in specificity
CORRELATES OF U WAVE INVERSION DURING EXERCISE

- Anterior ST depression
- LVH and other resting ECG abnormalities
- Anterior MI (Q and non-Q)
- Collaterals to 99 - 100% occluded LAD in pts with MI
- Poor effort tolerance

Chikamori et al, AJC 9:97, N = 339 with left anterior descending CAD
Inverted U waves during exercise testing

Peak Ex  

Recovery 15 sec
U WAVE ENHANCEMENT WITH EXERCISE

Chikamori et al AJC 3:95
### PROMINENT U WAVES IN DETECTION OF LCx OR RCA OBSTRUCTION

<table>
<thead>
<tr>
<th>Site of prominent U-waves</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>+ prediction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limb leads</td>
<td>19</td>
<td>93</td>
<td>67</td>
</tr>
<tr>
<td>Right precordial leads</td>
<td>49</td>
<td>89</td>
<td>78</td>
</tr>
<tr>
<td>Right and left precordial leads</td>
<td>52</td>
<td>88</td>
<td>77</td>
</tr>
</tbody>
</table>

Chikamori et al., AJC 9.94, N = 311
Increased magnitude of U waves in all leads
Prominent U waves in all leads
Prominent U waves in limb leads
Prominent U waves in precordial leads

Insignif. CAD (n = 116)
LAD (n = 60)
LC (n = 21)
RCA (n = 24)
FEMALE, ATYPICAL CHEST PAIN, NORMAL CORONARY ARTERIES
INDICATIONS FOR STRESS SCINTIGRAPHY

• Exercise ECG uninterpretable for diagnosis of ischemia
  - LBBB
  - WPW
  - RBBB
  - LVH
  - Baseline ST-T abnormalities
• Exercise ECG of known low sensitivity
  - Post myocardial infarction
  - Single vessel CAD
• Exercise ECG of possible low specificity
  - Mitral valve prolapse
  - Vasoregulatory abnormalities
  - ? Women
• T wave normalization
Healthy 34 y.o. runner

6' EX. 12' EX. 14 METS

V₄

V₅

V₆

HEWLETT • PACKARD | MEDICAL ELEC | MEDICAL ELECTRONICS DIVISION | PERMAPAP
<table>
<thead>
<tr>
<th>Rest</th>
<th>Rest</th>
<th>Rest</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest</td>
<td>Rest</td>
<td>Rest</td>
<td>Rest</td>
</tr>
<tr>
<td>Rest</td>
<td>Rest</td>
<td>Rest</td>
<td>Rest</td>
</tr>
<tr>
<td>Rest</td>
<td>Rest</td>
<td>Rest</td>
<td>Rest</td>
</tr>
</tbody>
</table>
RBBB: Peak Exercise
UNANSWERED QUESTIONS IN TREADMILL TEST INTERPRETATION

• ST-T wave normalization during exercise
• P wave abnormalities developing during exercise
• QRS prolongation
• QT interval prolongation with exercise in patients without known LQTS
• Meaning of rate-dependent LBBB
• Prognostic significance of loss or maintenance of WPW pattern at rapid heart rates