GXT Interpretation Skills Workshop

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Absolute Contraindications to Stress Testing—Should Not Do Them or Expect Them

- Acute MI w/in 48 hours
- Unstable AP not yet medically controlled
- Uncontrolled CV arrhythmia w/hemodynamic consequence, like VT
- Severe (symptomatic?) AS, aortic dissection, PE, pericarditis
- Known multivessel CAD (left main) thought likely to produce MI w/stress test
- Decompensated CHF
- Uncontrolled hypertension (some say > 200/110)
- Severe pulmonary hypertension
- Acute illness for other reasons

Contraindications from Guidelines for Exercise Testing and Prescription, 4th Edition--1991

Table 4–1. Contraindications to Exercise Testing.

Absolute Contraindications

1. A recent significant change in the resting ECG suggesting infarction or other acute cardiac events
2. Recent complicated myocardial infarction
3. Unstable angina
4. Uncontrolled ventricular dysrhythmia
5. Uncontrolled atrial dysrhythmia that compromises cardiac function
6. Third-degree A-V block
7. Acute congestive heart failure
8. Severe aortic stenosis
9. Suspected or known dissecting aneurysm
10. Active or suspected myocarditis or pericarditis
11. Thrombophlebitis or intracardiac thrombi
12. Recent systemic or pulmonary embolus
13. Acute infection
14. Significant emotional distress (psychosis)

Relative Contraindications from Exercise Testing and Prescription, 4th Edition--1991

Relative Contraindications

1. Resting diastolic blood pressure > 120 mm Hg or resting systoli pressure > 200 mm Hg
2. Moderate valvular heart disease
3. Known electrolyte abnormalities (hypokalemia, hypomagnesemia
4. Fixed-rate pacemaker (rarely used)
5. Frequent or complex ventricular ectopy
6. Ventricular aneurysm
7. Cardiomyopathy, including hypertrophic cardiomyopathy
8. Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis edema)
9. Chronic infectious disease (e.g., mononucleosis, hepatitis, AID
10. Neuromuscular, musculoskeletal, or rheumatoid disorders tha erbated by exercise
11. Advanced or complicated pregnancy

Inadequate TMs for Interpretation--I Did Them and They Didn't Help Me

- Inadequate HR = < 85% predicted for age
  - Beta blockers
  - CCBs (esp. diltiazem and verapamil)
  - Antiarrhythmics (esp. amiodarone and sotalol)
  - Digoxin (HR and ST segment changes)
  - Nitrates (blunt the ischemic response)
  - The atrial fibrillation problem w/HR

So What Do the Experts Say?

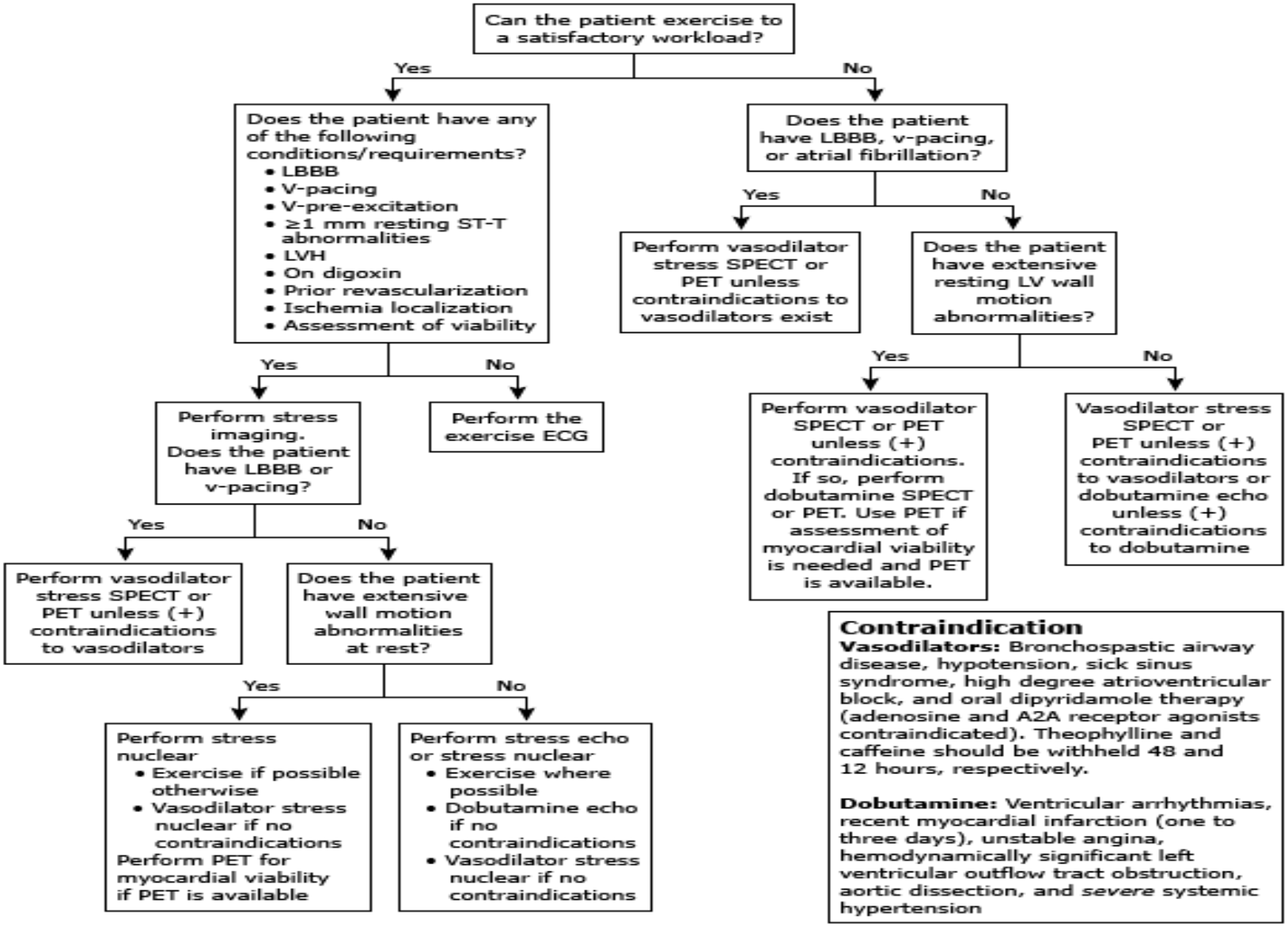
- Who should have a plain TM test?
- The ACC/AHA recommendations for this are in the usual Class I, IIa, IIb, III format
- If you are not doing a plain TM, what stress test can you use?

ACC/AHA guideline summary: Exercise ECG testing without an imaging modality for the diagnosis of obstructive coronary heart disease (CHD)

Class I – There is evidence and/or general agreement that exercise ECG testing for the diagnosis of CHD is indicated in patients with:
• An intermediate pretest probability of CHD based upon age, gender, and symptoms, including patients with complete right bundle branch block or less than 1 mm ST depression, in the absence of the exceptions listed in class IIb and class III.
Class IIa – The weight of evidence or opinion is in favor of the usefulness of exercise ECG testing for the diagnosis of CHD in patients with:
• Suspected variant (vasospastic) angina.
Class IIb – The usefulness of exercise ECG testing for the diagnosis of CHD is less well established in patients with:
• A high or low pretest probability of CHD.
• Digoxin therapy and less then 1 mm of ST segment depression at baseline.
• Electrocardiographic evidence of left ventricular hypertrophy and and less then 1 mm of ST segment depression at baseline.
Class III – There is evidence and/or general agreement that exercise testing for risk assessment and prognosis in patients at intermediate or high probability of CHD is not useful in the following settings:
• Patients with the following baseline ECG abnormalities:
1. Preexcitation (Wolff-Parkinson-White) syndrome.
2. Electronically paced ventricular rhythm.
3. More than 1 mm of ST segment depression at rest.
4. Complete left bundle branch block.
• An established diagnosis of CHD due to prior myocardial infarction or coronary angiography. However, testing may be warranted in such patients to assess functional capacity and prognosis.

Data from Gibbons RJ, Abrams J, Chatterjee K, et al. ACC/AHA 2002 guideline update for the management of patients with chronic stable angina--summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on the Management of Patients With Chronic Stable Angina). Circulation 2003; 107:149.

Algorithm for choosing the optimal cardiac stress test



ECG: electrocardiogram; LBBB: left bundle branch block; LVH: left ventricular hypertrophy; PET: positron emission tomography; SPECT: single photon emission computed tomography; V: ventricular.

Warning

- At AAIM, we are not in the business of colluding between companies; we are in the business of educating and assuring quality assessments based on good scientific evidence.
- Remember different companies use different manuals and have different internal policies and pricing philosophies so even if we could “grade” a test/case, it might well not imply the same conclusions.
- Please refrain from questions or statements about exact ratings on impairments or cases; limit it to a “preferred status” or “standard” or “low or higher substandard” status in a general way.

Two Patients' Bruce TMs—how would you rate these applicants?

- 1 mm ST depression in Stg. 1-2, HR < 120, 4.5 – 7 METS

- < 1 mm ST depression, went into Stg. 4, HR 160, 10-13 METS

BTW, What is a MET?

- It = metabolic equivalent of O2 consumption at rest = 3.5 ml O2/kg weight/minute, burned at rest

- There is considerable evidence that MET level is a strong independent predictor of stratification into a low risk outcome group (as compared to "double product" or HR achieved or exercise duration)→Chest 1999 Apr: 115 (4), 1166-1169.

Treadmill exercise testing protocols

Protocol name	Stage	Grade (percent)	Speed (mph)	Total time (min)	O2 uptake (mL/kg/min)	METS*
Modified Bruce•	0	0	1.7	3	9	2.3
	1/2	5	1.7	3	13	3.4
Bruce	1	10	1.7	3	17	4.5
	2	12	2.5	6	25	7
	3	14	3.4	9	35	10
	4	16	4.2	12	47	13
Cornell	1	0	1.7	2	7	2
	2	5	1.7	4	11	3
	3	10	1.7	6	17	4.5
	4	11	2.1	8	19	5.5
	5	12	2.5	10	25	7
	6	13	3.0	12	30	8.5
	7	14	3.4	14	35	10
	8	15	3.8	16	40	11.5
	9	16	4.2	18	47	13
Naughton	1	0	2.0	2	7	2
	2	3.5	2.0	4	10.5	3
	3	7.0	2.0	6	14	4
	4	10.5	2.0	8	17.5	5
	5	14.0	2.0	10	21.0	6
	6	17.5	2.0	12	24.5	7
	7	12.5	3.0	14	28	8

* Metabolic equivalents - 1 MET = 3.5 mL O2/kg/min.
• Stages 1 through 4 of the Modified Bruce protocol are identical to stages 1 through 4 of the standard Bruce protocol.

METS in Males, Females and CV patients from Exercise Testing and Prescription, 4th Edition--1991

BRUCE PROTOCOL

Stage	MPH	Grade	Min	MET Requirement* Men	Women	Cardiac
I	1.7	10%	1	3.2	3.1	3.6
			2	4.0	3.9	4.3
			3	4.9	4.7	4.9
II	2.5	12%	4	5.7	5.4	5.6
			5	6.6	6.2	6.2
			6	7.4	7.0	7.0
III	3.4	14%	7	8.3	8.0	7.6
			8	9.1	8.6	8.3
			9	10.0	9.4	9.0
IV	4.2	16%	10	10.7	10.1	9.7
			11	11.6	10.9	10.4
			12	12.5	11.7	11.0
V	5.0	18%	13	13.3	12.5	11.7
			14	14.1	13.2	12.3
			15	15.0	14.1	13.0

Height: 69 in
Weight: 190 lbs

Protocol: Bruce

TIME	PHASE	MPH	GRADE	HR	BP	RPP	METS	ECTOPIC
00:00	Exercise	0.6	0.0	75	96/54	72	1.0	
01:00	Exercise	1.7	10.0	97			2.0	1
02:00	Exercise	1.7	10.0	100			4.4	
03:00	Exercise	1.7	10.0	101	122/60	123	4.6	
04:00	Exercise	2.5	12.0	112			5.7	
05:00	Exercise	2.5	12.0	115			7.0	
06:00	Exercise	2.5	12.0	115	138/60	158	7.0	
07:00	Exercise	3.4	14.0	126			8.3	
08:00	Exercise	3.4	14.0	132			9.8	
09:00	Exercise	3.4	14.0	133	154/66	204	10.1	
10:00	Exercise	4.2	16.0	149			11.4	
10:24	Max Exer.	4.2	16.0	149			12.2	
01:00	Recovery	0.0	0.0	132			5.5	1
02:00	Recovery	0.0	0.0	102	138/60	140	1.2	1
03:00	Recovery	0.0	0.0	93			1.0	
04:00	Recovery	0.0	0.0	89	100/66	89	1.0	

Two Patients Bruce TM—how would you rate these applicants?

- → 1 mm ST dep. in Stg. 1-2, HR< 120, 4.5-7 METS
  - 12 month survival <85%
  - 25% chance LM CAD
  - 60% chance 3 vessel CAD

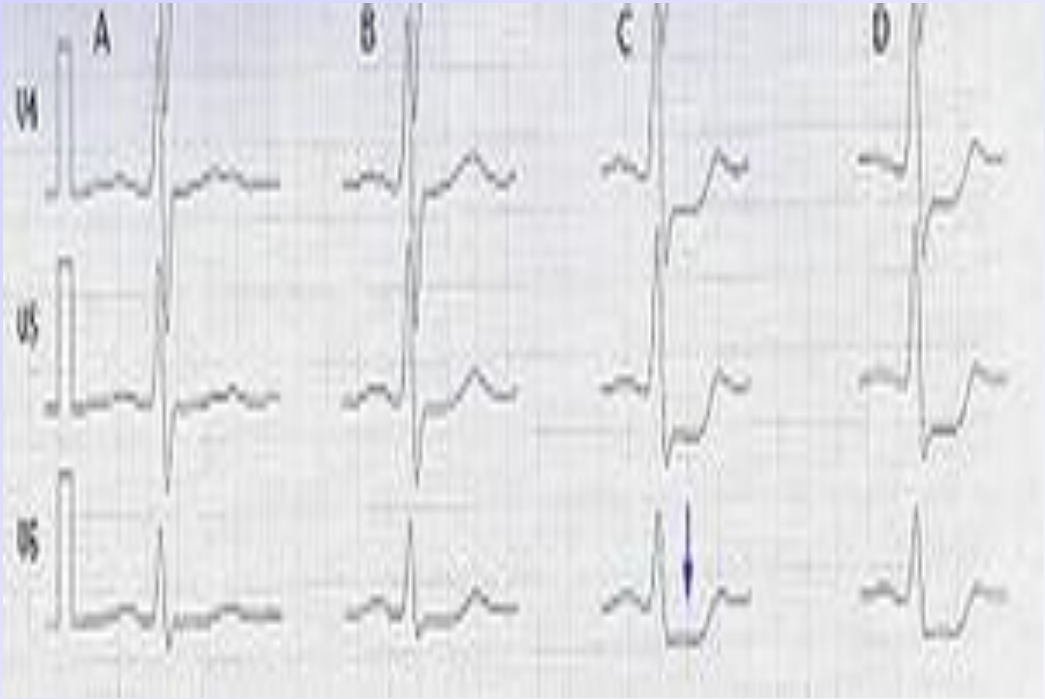
  →to 10 METS into Stg. 4, HR > 160, < 1mm ST, 10-13 METS

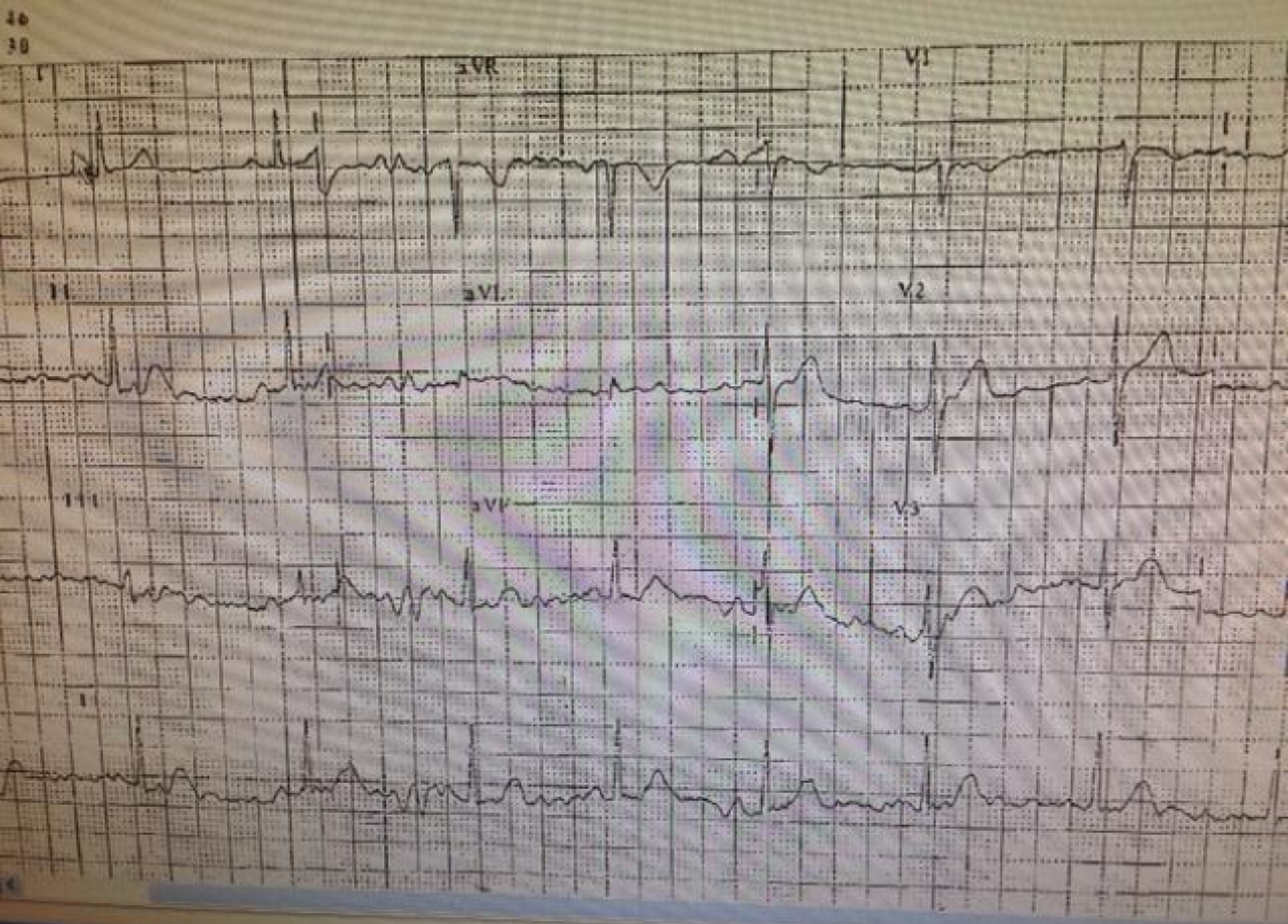
  --12 month survival > 99%

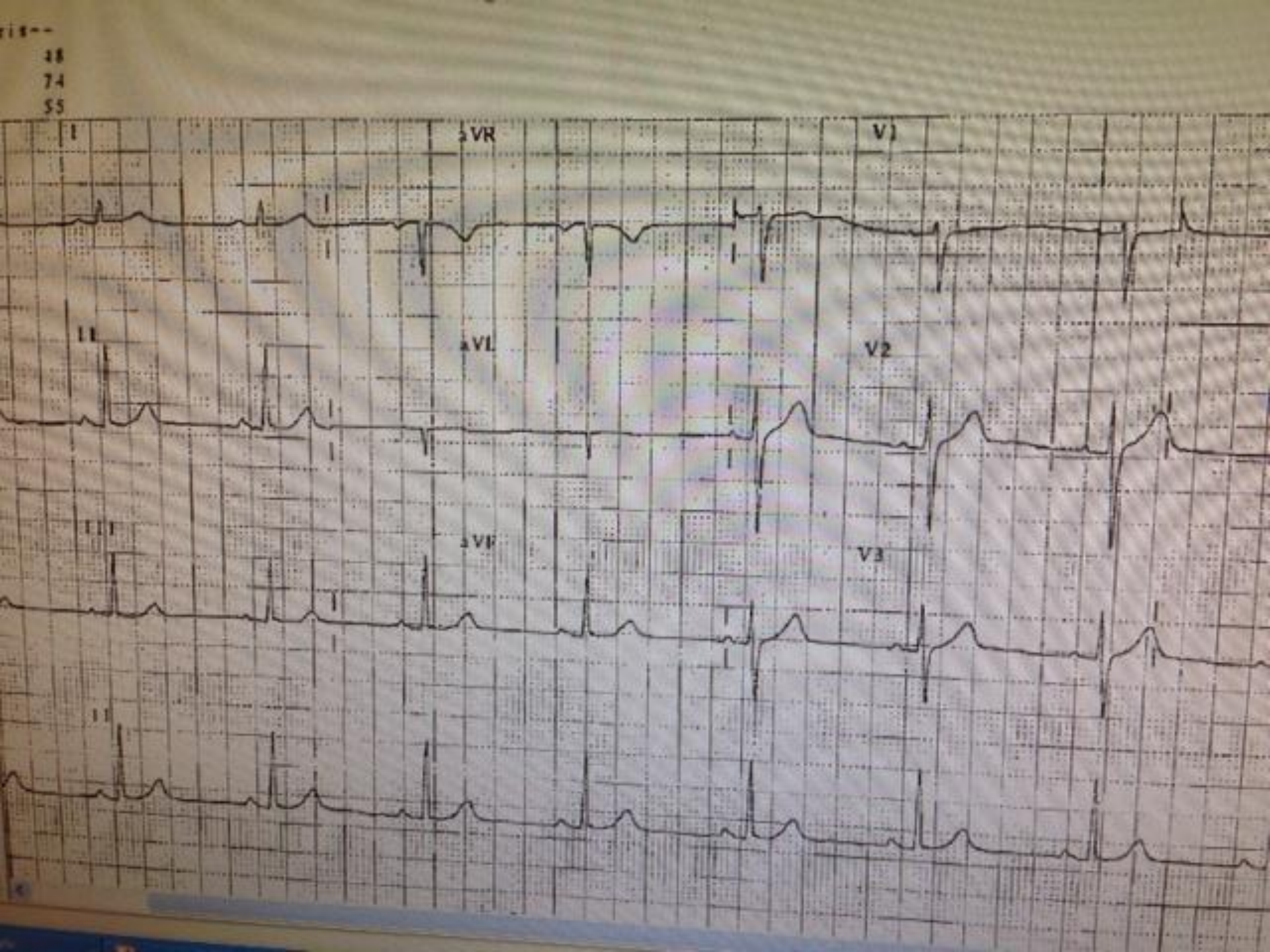
  --< 1% LM CAD

  --< 15% 3 vessel CAD

Baseline EKG Abnormalities and ST Interpretation—oh if only they all looked like this…

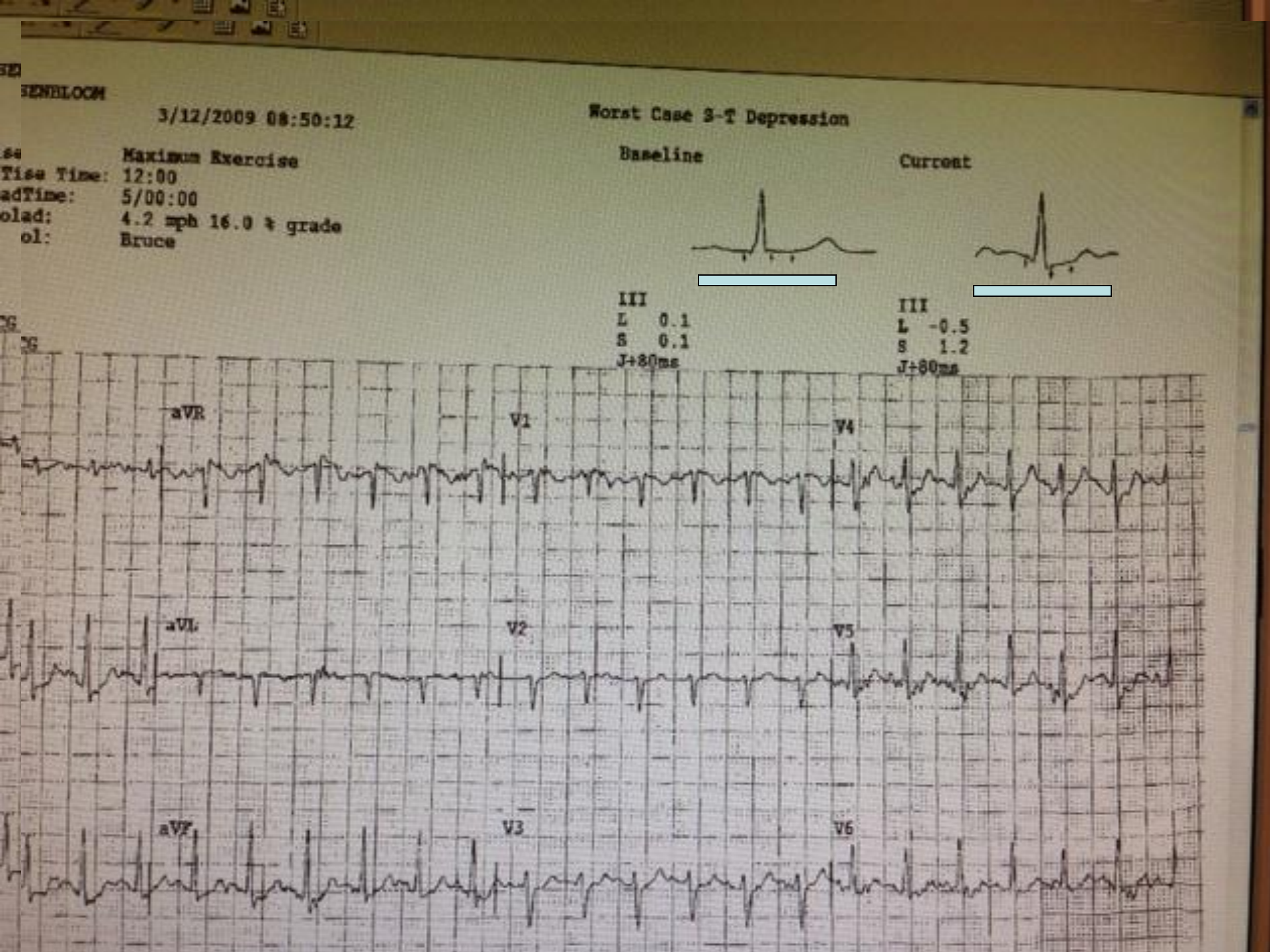



aVR
V1
aVL
V2
aVF
V3


I
aVR
V1
II
aVL
V2
III
aVF
V3
II

The two preceding EKGs are on the same patient at the start of a TM

- What made the difference between those 2 EKGs?
- Will this make STsegment interpretation vary?
- The importance of “averaged beat analysis”


3/12/2009 08:50:12
Maximum Exercise
Tise Time: 12:00
adTime: 5/00:00
olad: 4.2 mph 16.0 % grade
ol: Bruce
Worst Case S-T Depression
Baseline
Current
III
L 0.1
S 0.1
J+80ms
III
L -0.5
S 1.2
J+80ms
aVR
V1
V4
aVL
V2
V5
aVF
V3
V6

Topics in TM Interpretation

- How do baseline EKG abnormalities affect ST interpretation?
- What is the EKG difference and mortality difference between normal, borderline, and abnormal TM interpretations?
- What affects prognosis besides ST segments: actual MET level, pseudonormalization of T waves, LBBB, AVB, PVCs, hypotension?
- How does HR recovery play a role?
- What is a hypertensive response and what does it mean?
- What are the predictors of mortality or poorer prognosis?

Why are these topics worth your time as an insurance medical director?

- The insurance industry has identified the same parameters that clinical medicine uses to tell prognostically worse disease from more stable disease.
- Here are some charts from two insurance manuals detailing characteristics (without debits) important to prognostication:

Two Manuals on TM Testing

- Age of applicant
- Stress imaging or plain TM
- “for cause” test or screening
- Presence/absence of >/= 2 CV Risks

- Stress imaging or plain TM
- PACs or PVCs
- BBB, intermittent or rate-related
- ST elevation or depression
- T wave types and resolution
- Reason for stopping
- BP drop
- HR incompetence
- Aware of false +

Two Essential Points of Understanding in Treadmill Testing

- 1—Sensitivity and Specificity of the Tests themselves
- 2—Pre Test Probability of Disease (Bayes' Theorem)—especially important in understanding female test outcomes

Sensitivity and Specificity

- High sensitivity test will not miss many patients (few false negatives—high % of + tests among all w/disease)
- High specificity test will not identify a disease falsely (few false positives—high % of neg. test among all w/no disease)

Definitions of sensitivity, specificity, and positive and and negative predictive values

	Disease present	Disease absent
Test positive	A	B
Test negative	C	D
Sensitivity = A ÷ (A + C)		
Specificity = D ÷ (B + D)		
Positive predictive value = A ÷ (A + B)		
Negative predictive value = D ÷ (C + D)		

UpToDate®

Relationship in exercise ECG testing between sensitivity, specificity, and the amount of ST segment depression

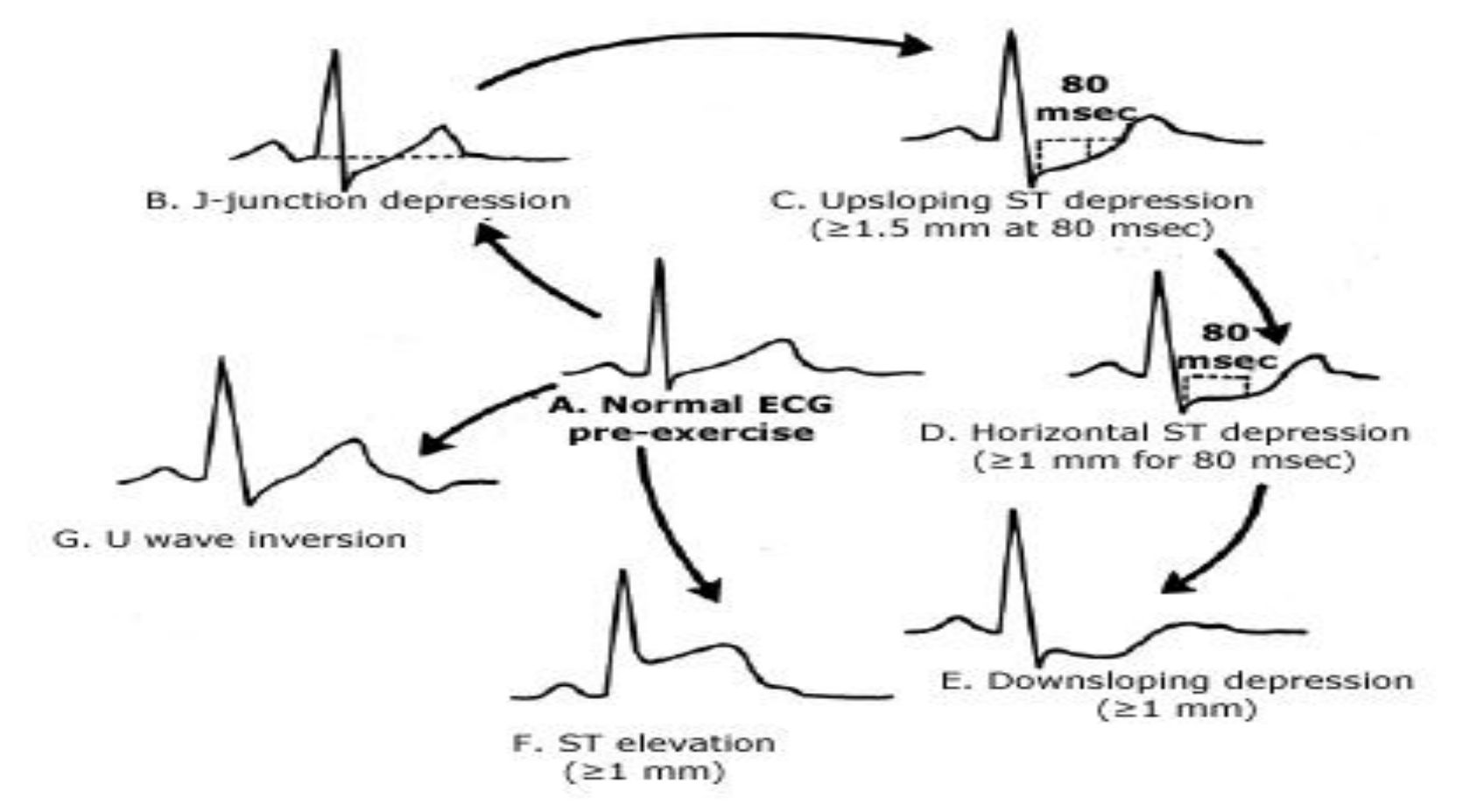
Amount of ST depression	Sensitivity, percent	Specificity, percent
0.5 mm	80	60
1.0 mm	60	90
2.0 mm	20	98

Female TM testing

Circulation 2010:122:2570-2580

- Sensitivity 31-71%
- Specificity 66-86%
- + pred. value (test is + & correctly identifies disease) 47% vs. 77% female to male
- - pred. value (test is – and correctly identifies no disease) 78% vs. 81% female to male
- Thus a negative test is very helpful, but a + test is much < helpful in a female (estrogen's "digoxin-like effect" on ST segments)
- Heavily dependent on pre-test probability in females since prevalence is << males

Spectrum of Ischemic EKG Changes—Up-to-Date Text



What to Remember About ST Segments

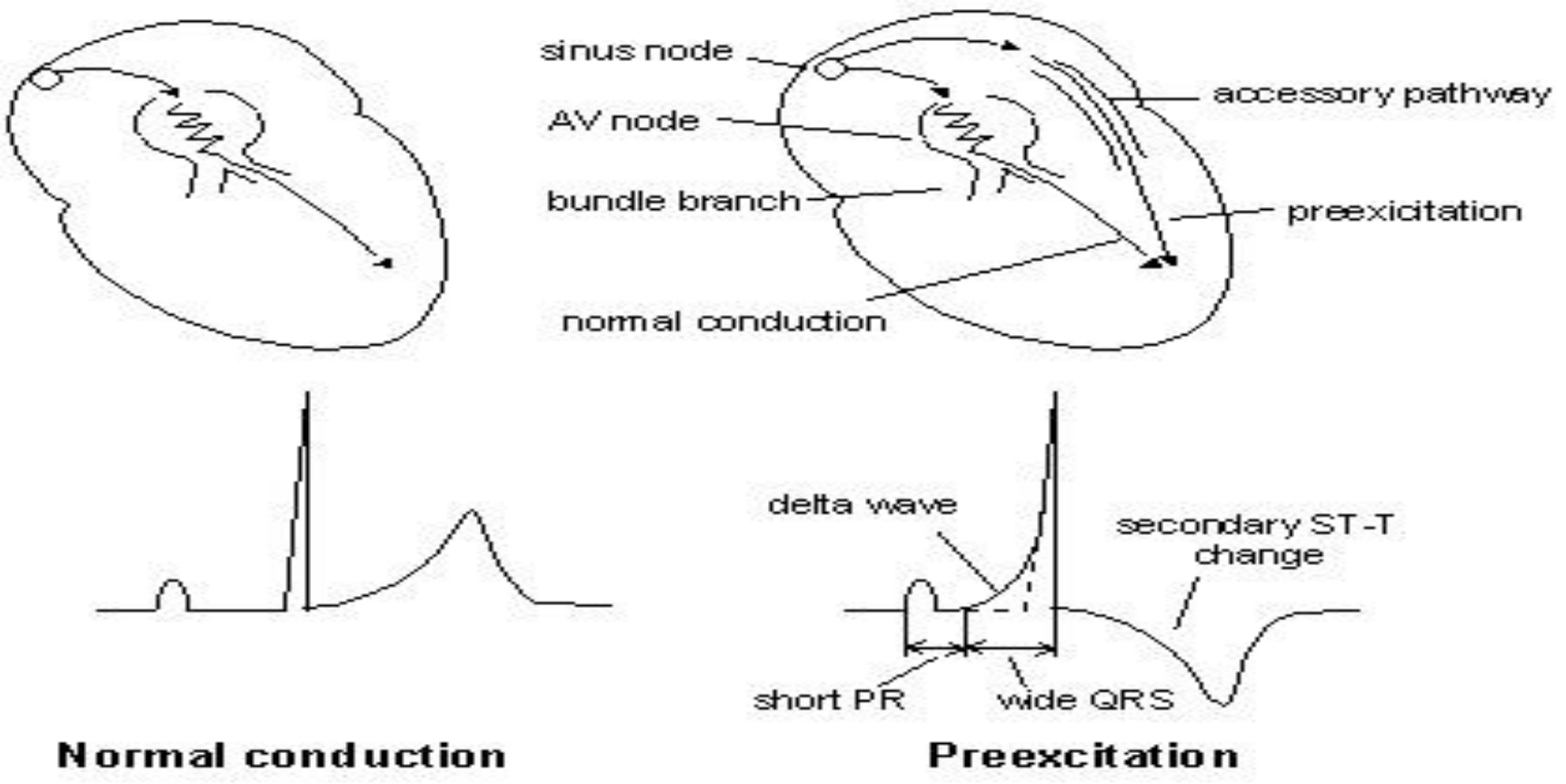
- Any time depolarization is abnormal…

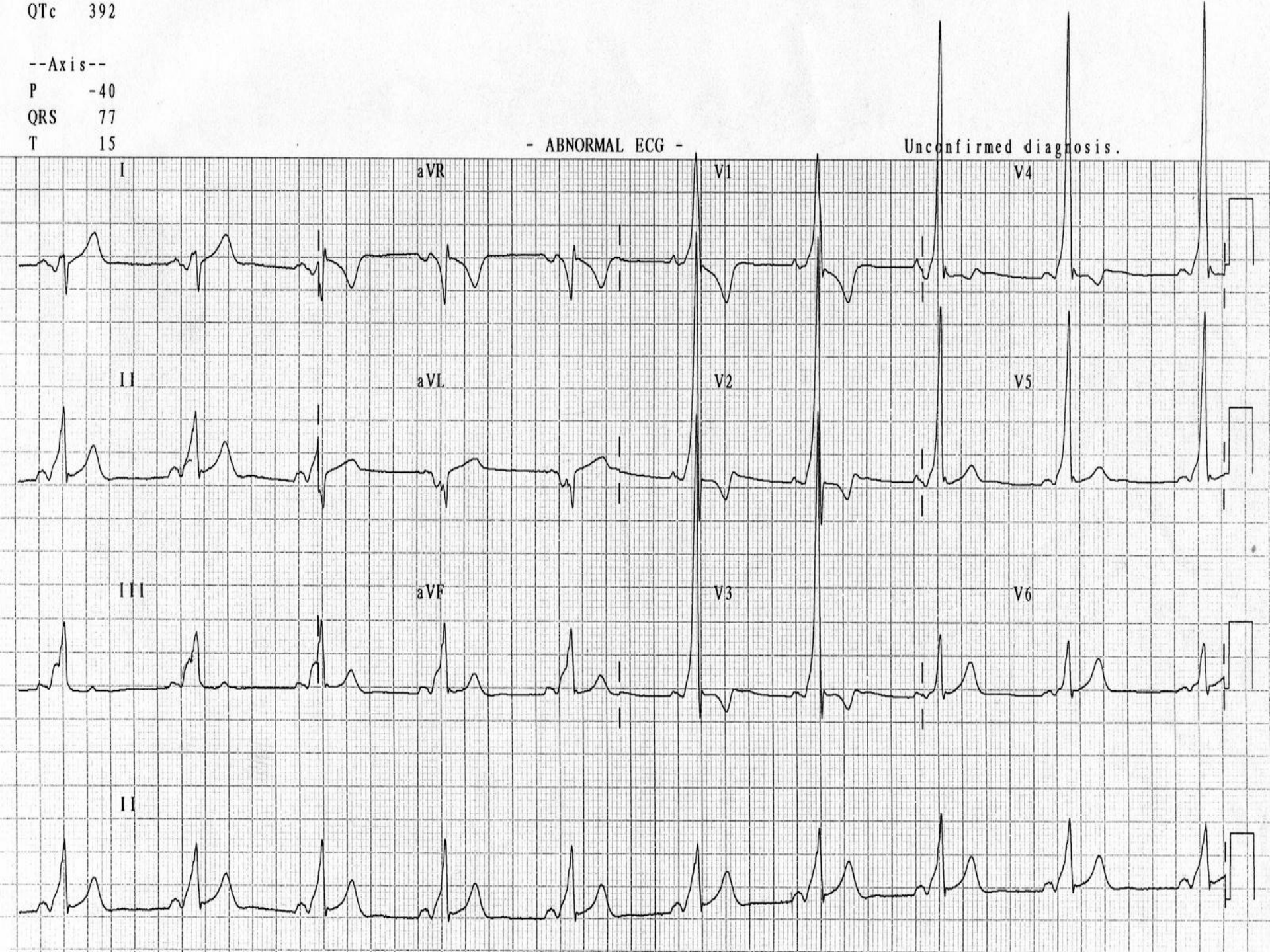
- Repolarization is also abnormal.

ST Segment Misinterpretation

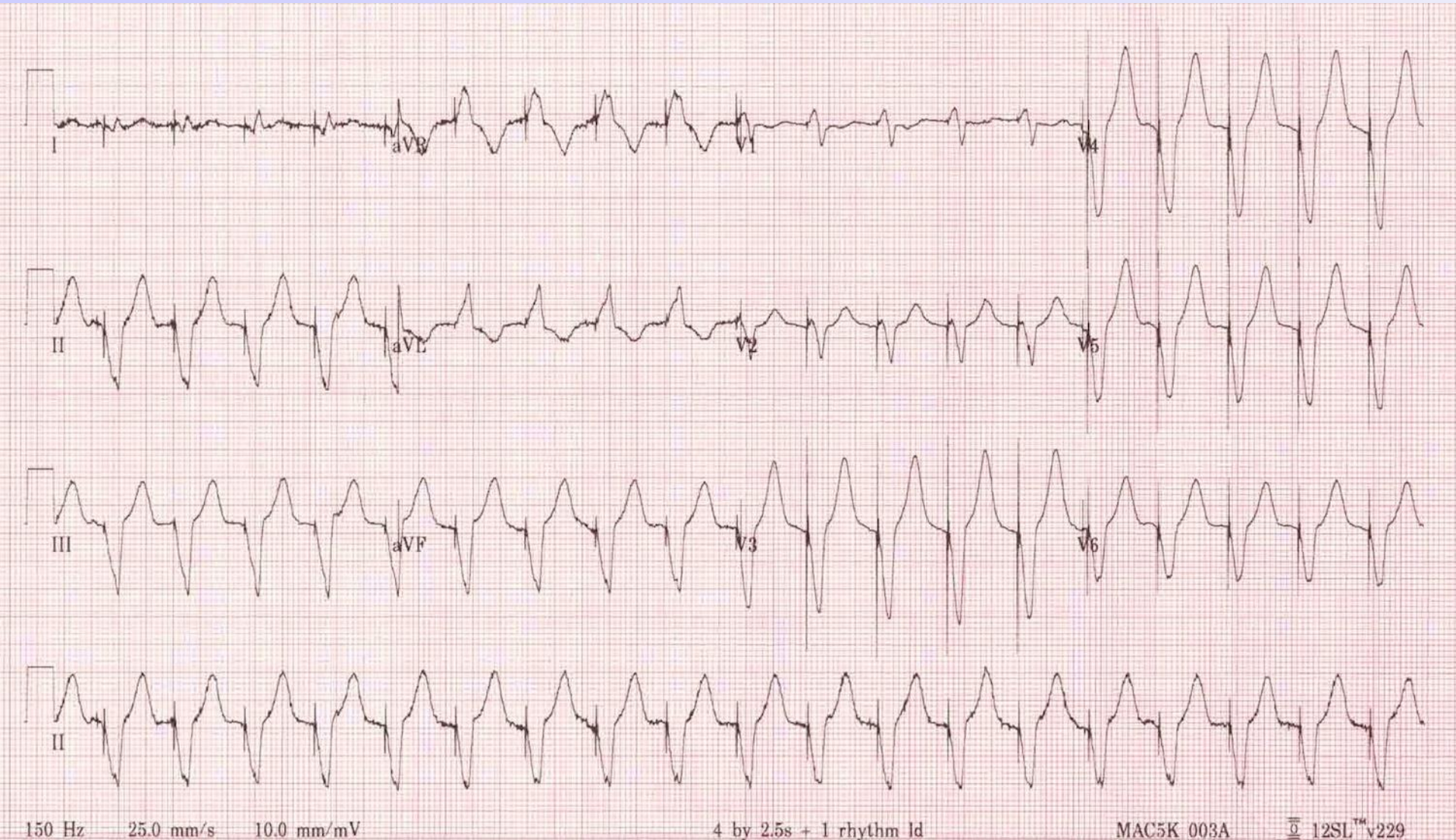
- WPW and attendant ST abnormalities
- Pacing and assoc. ST abnormalities
- LBBB
- > 1 mm ST depression at rest
- Digoxin use and effect on ST segments
- LVH
- Hypokalemia and ST abnormalities
- And some would even say… “female’s estrogen-like effects on ST segments”

Example WPW Lifeinthefastlane Web Site—this slide and next

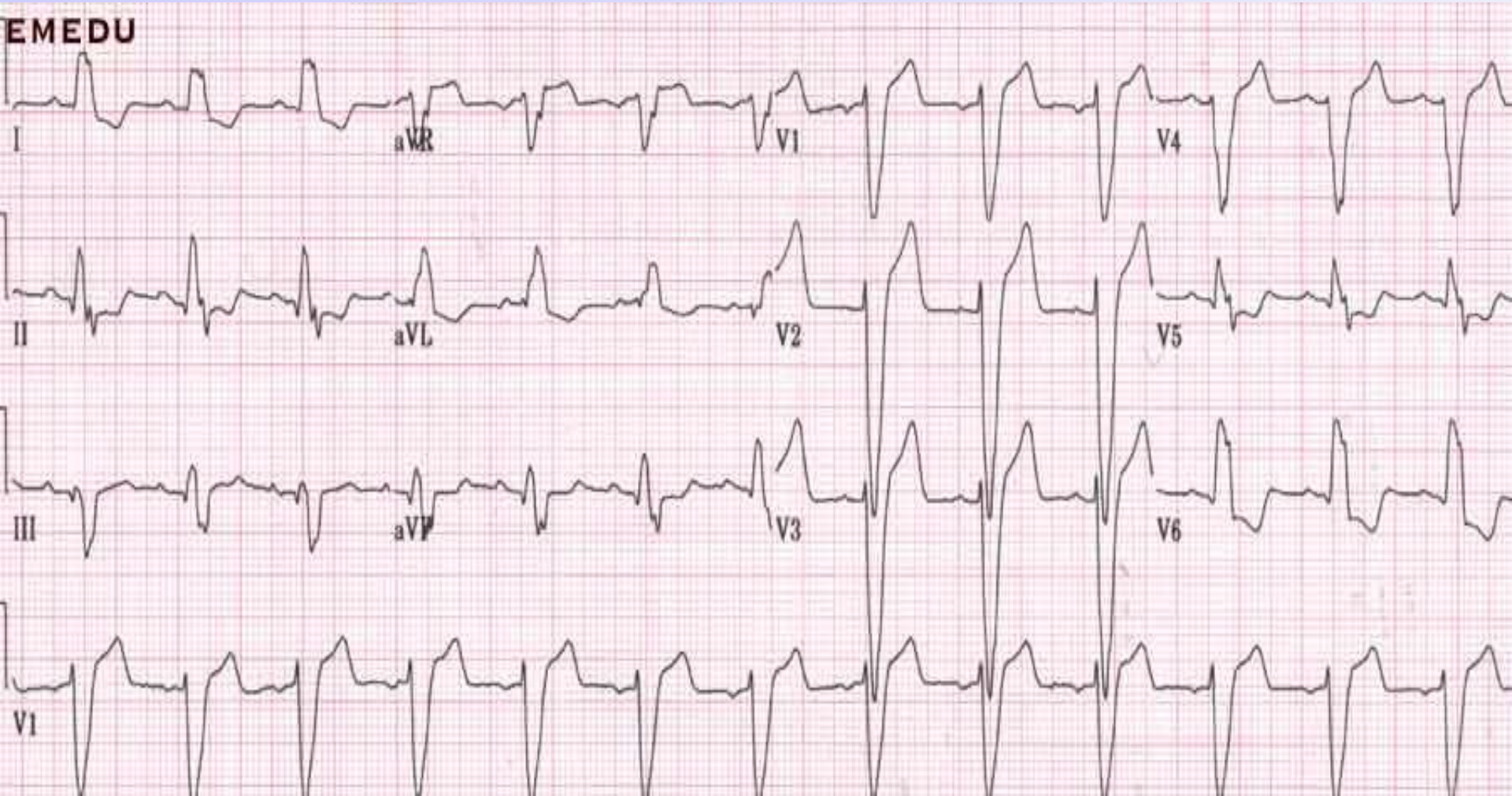



QTc 392
--Axis--
P -40
QRS 77
T 15
- ABNORMAL ECG -
Unconfirmed diagnosis.
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

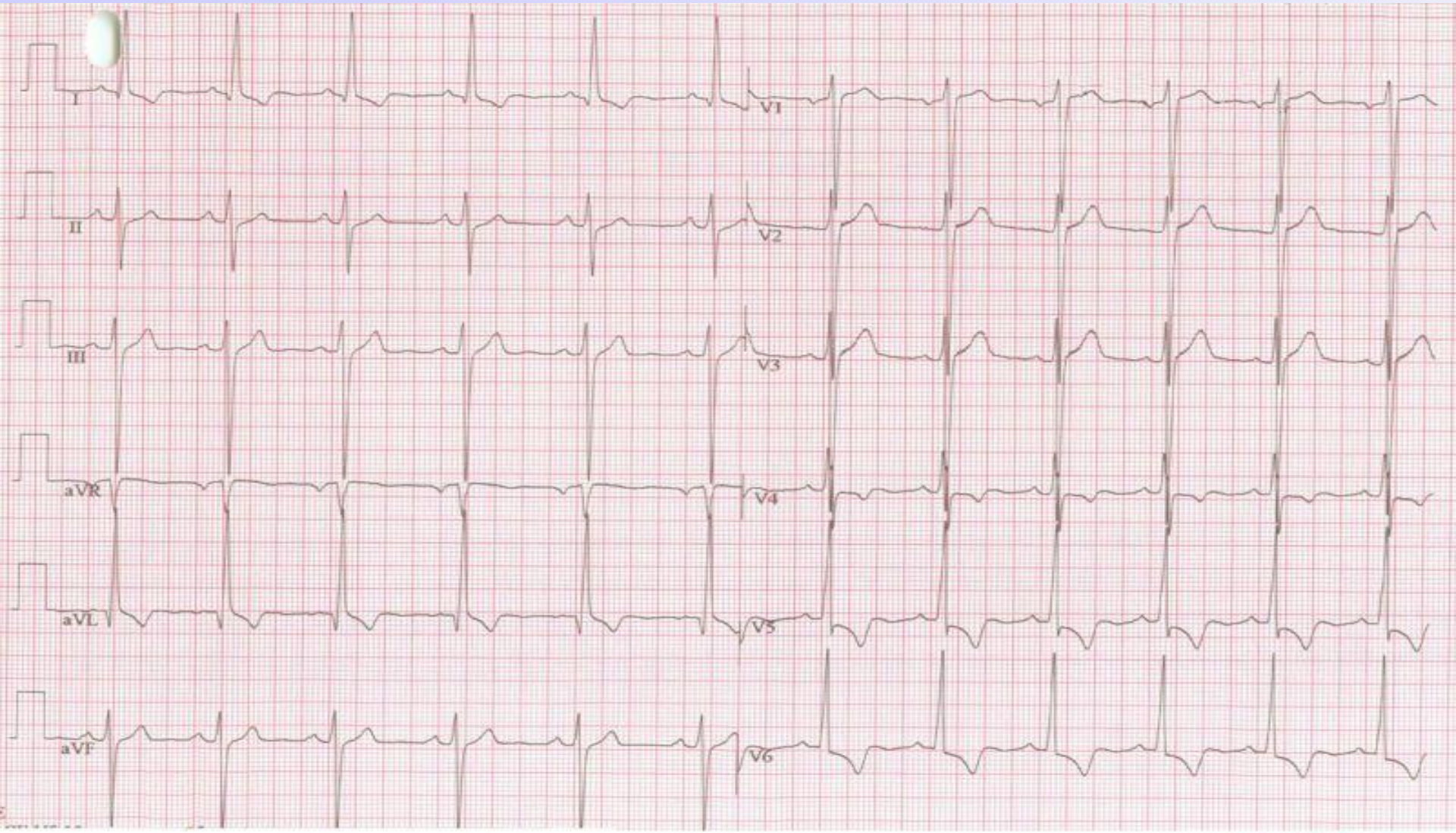
Example Ventricular Pacing EKG Lifeinthefastlane Web Site



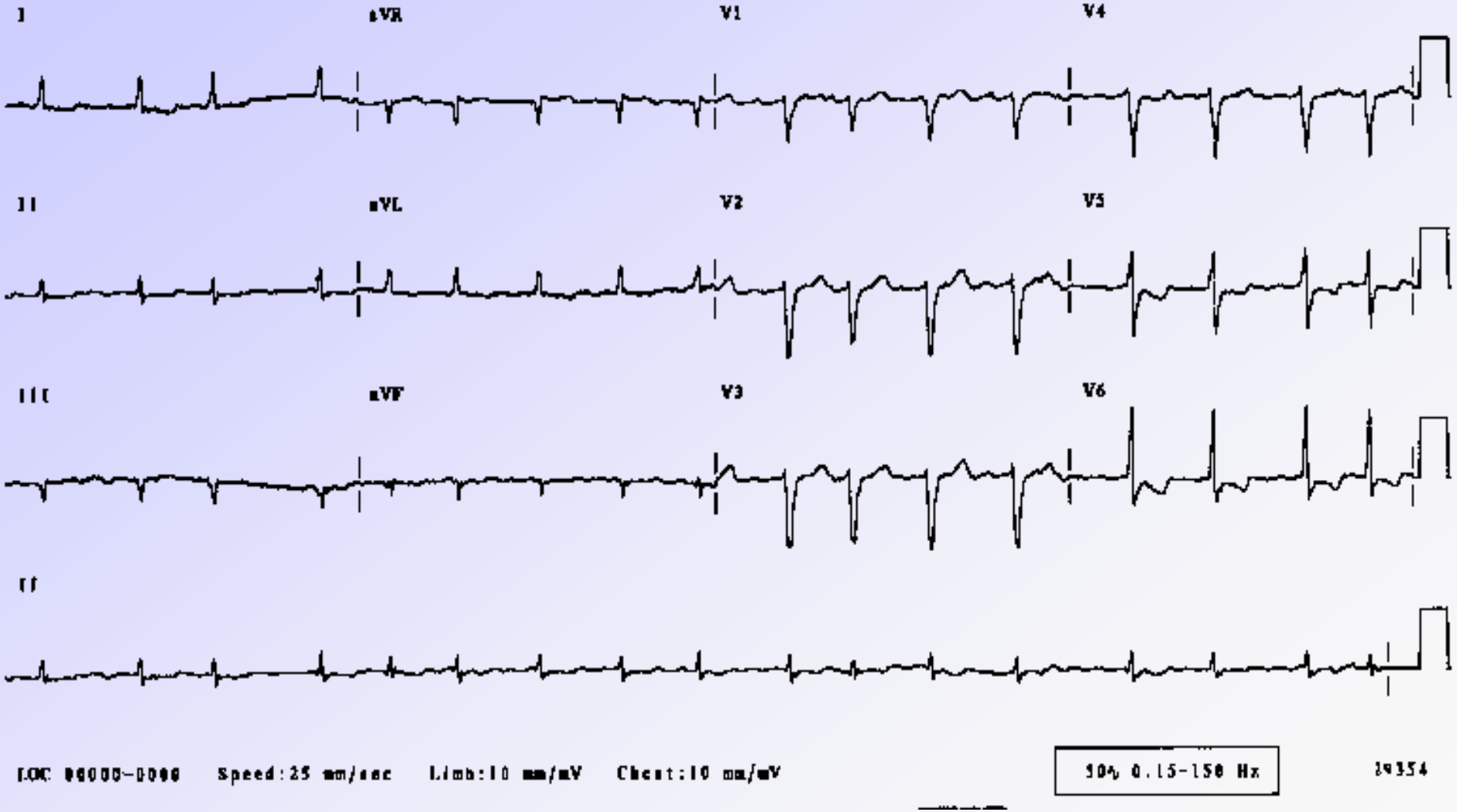
Example LBBB EKG
Emergency Electrocardiography
Online Training Module



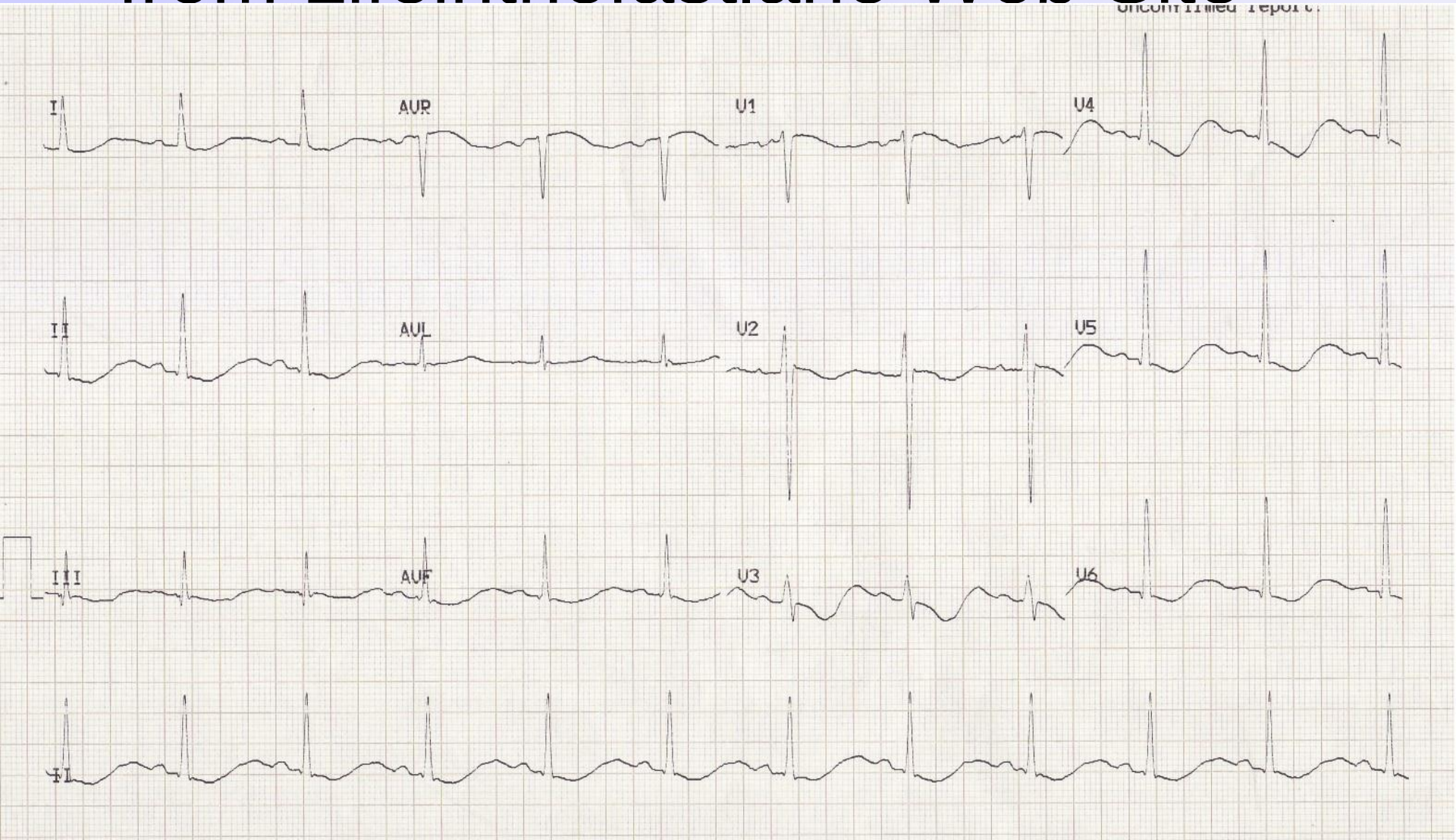
Example LVH
from ECGpedia.org



Example Digoxin Effect from ecglibrary.com



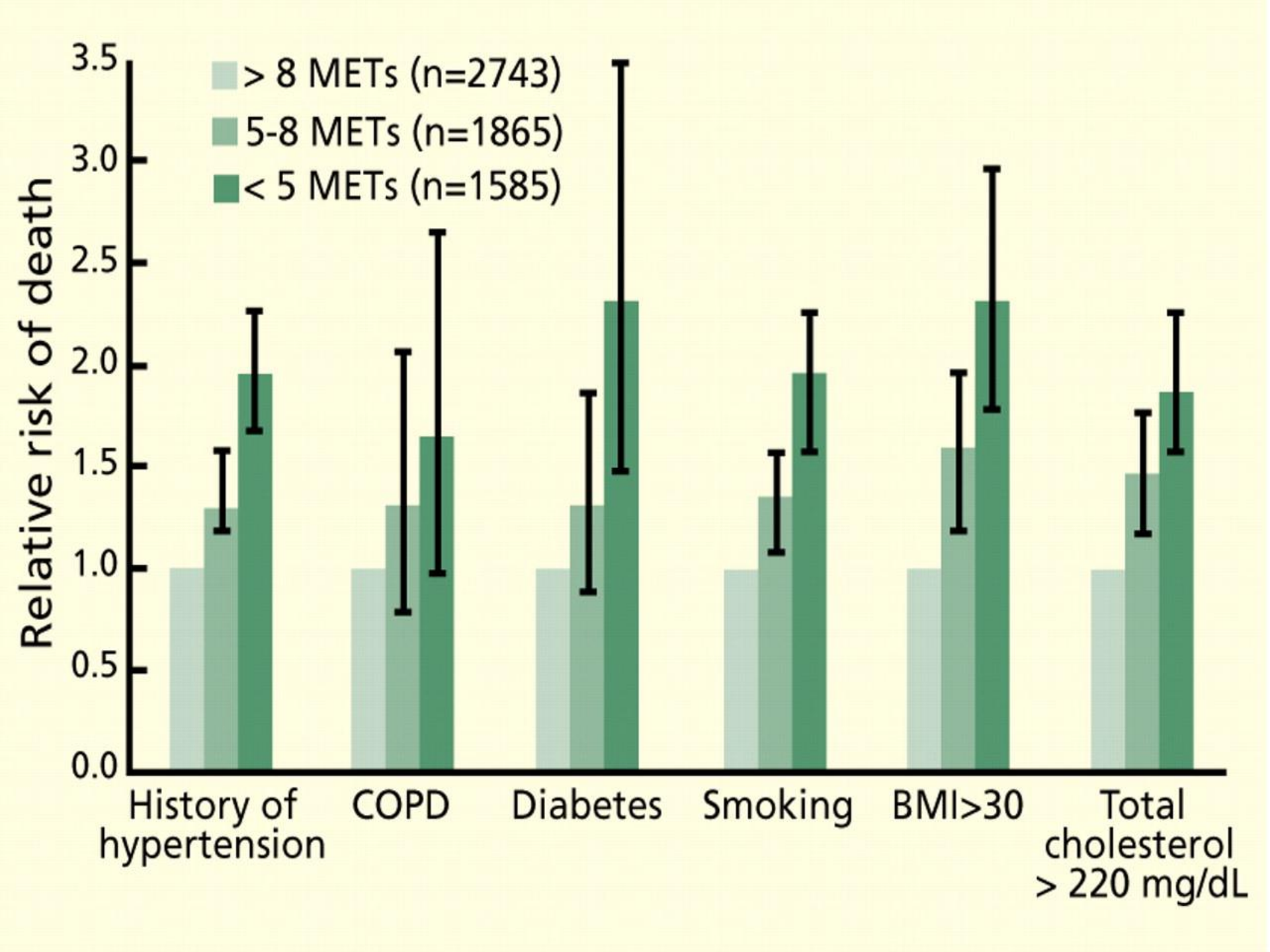
Example Hypokalemia and ST abnormalities from Lifeinthefastlane Web Site



ST Segments Aside…Do METS Matter?

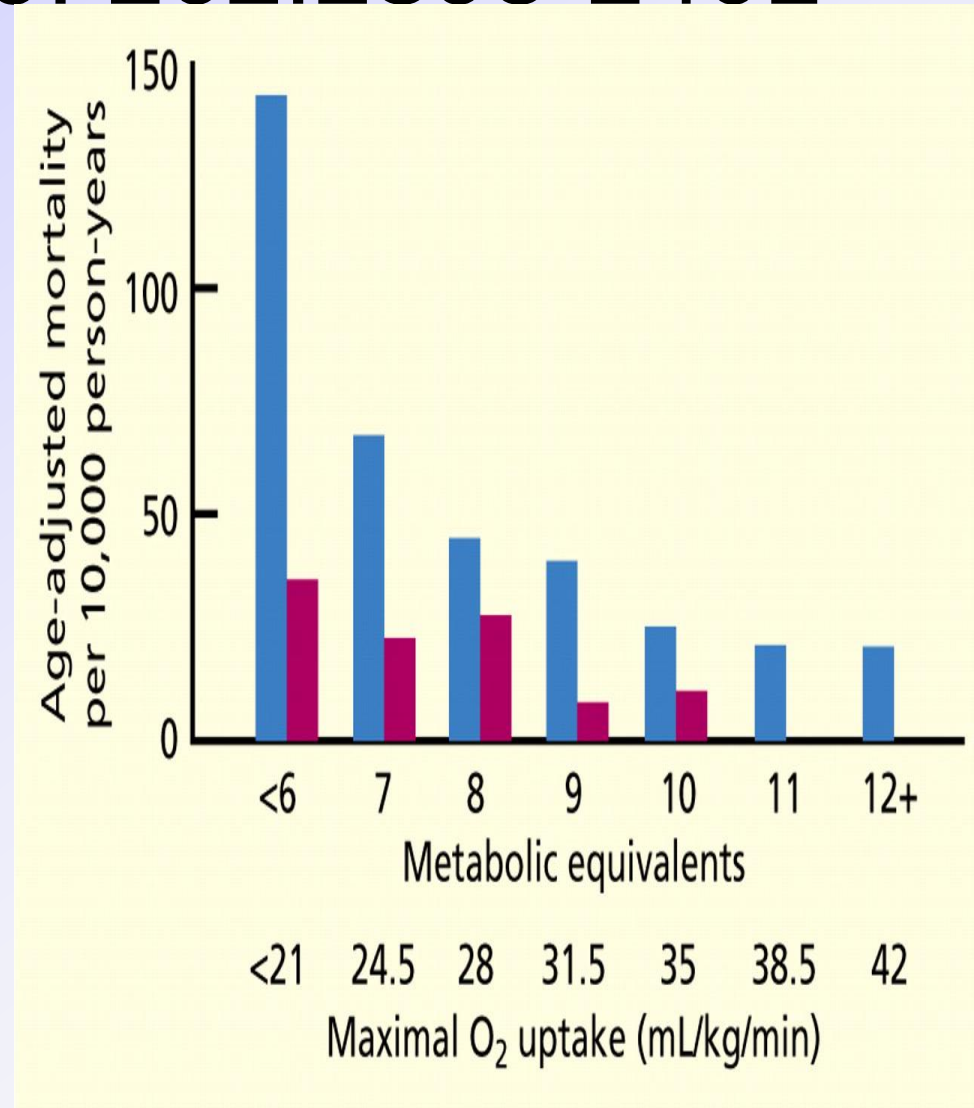
- Yes, one of the most powerful mortality predictors in a TM is adequate TM performance as a whole, with or without the ST segments analysis

Relative risks of death from any cause among subjects with various risk factors who achieved an exercise capacity of less than 5 metabolic equivalents (METs) or 5 to 8 METs, as compared with subjects whose exercise capacity was more than 8 METs. Error bars are 95% confidence intervals for the relative risks.
BMI = body mass index; COPD = chronic obstructive pulmonary disease.
MYERS J, PRAKASH M, FROELICHER V, DO D, PARTINGTON S, ATWOOD JE. EXERCISE CAPACITY AND MORTALITY AMONG MEN REFERRED FOR EXERCISE TESTING. N ENGL J MED 2002; 346:793–801.


> 8 METs (n=2743)
5-8 METs (n=1865)
< 5 METs (n=1585)
Relative risk of death
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
History of hypertension
COPD
Diabetes
Smoking
BMI>30
Total cholesterol > 220 mg/dL

Cleveland Clinic J Med June 2008 Vol.75.6, 424-430 also JAMA 1989: 262:2395-2401

- Prospective study of 3100 females & 10000 males age-adj. all cause mortality per 10,000 person-years
- Aerobic Center Longitudinal Study in healthy men and women



Non ST segment TM changes in Females

- METS achieved→ for each additional MET in women a 17% mortality reduction (St. James' Women Take Heart study; also in LRC study)

Am Heart J 2011 May:161 (5): 908-914

Capacity	2.00	2.09	0.99	<0.01
HR Recover	1.71	1.70	1.71	0.96
CP	0.69	0.64	0.83	0.78
Signif. ST	1.10	1.09	1.12	0.93

END (Economics of Noninvasive Diagnosis) Study

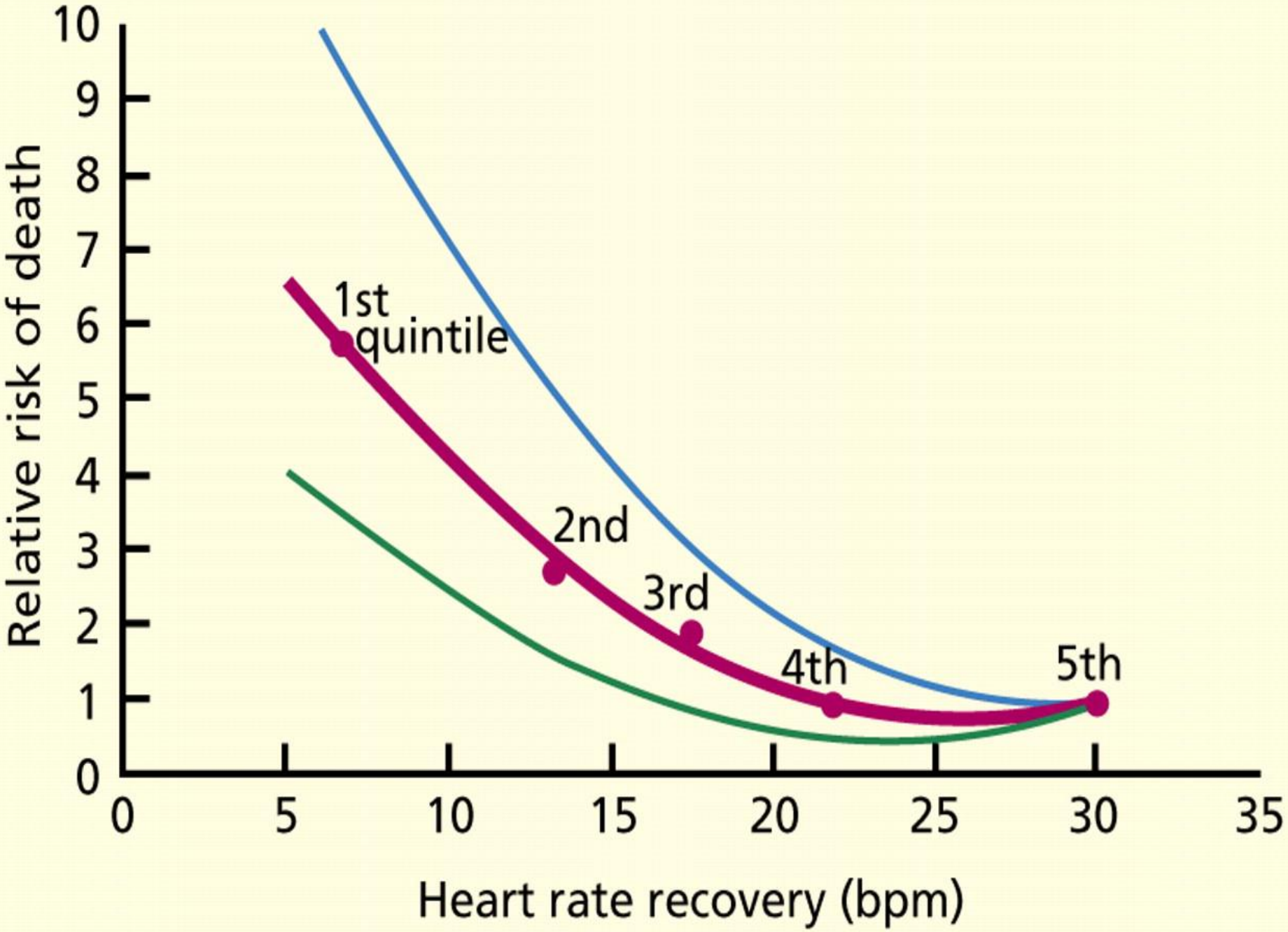
- Females achieving at least 85% max. HR compared to those w/< 85% had a ½ the death risk from any cause or CV cause
- St. James' Take Heart Study→ for every one bpm increase in HR achieved there was a 3% decrease in all cause mortality, and it remained at a 2% reduction in mortality even after controlling for CV risks and METS achieved

Hypertension and Hypotension

- Dubach in Circ 1988:78:1380-1387
  - Found a 3.2 x CV event rate over a 2 year period (P < 0.005) in those whose bp dropped 10 mm Hg over standing per TM bp
- Froelicher in Am J Med 1987: 83:1045-54
  - Found of the five exercise test responses, only an abnormal systolic blood pressure response and a poor exercise capacity predicted risk more frequently than by chance

LRC Study

- Abnormal HR Recovery (< 12 bpm drop in first minute post exercise) predicted mortality independently in females from CV or all cause mortality—Hazard Ratio 1.5

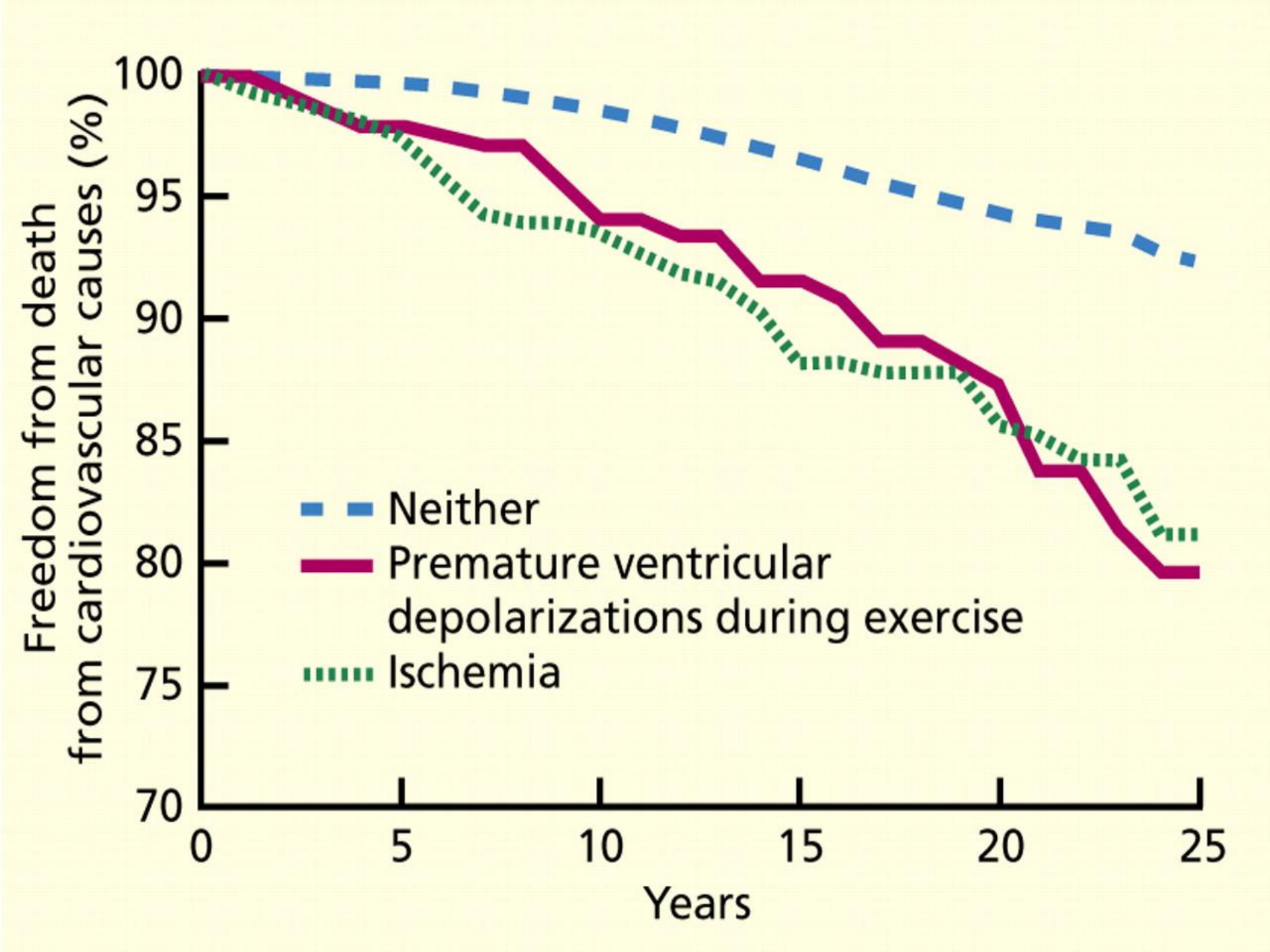

Relative risk of death
10
9
8
7
6
5
4
3
2
1
0
1st
quintile
2nd
3rd
4th
5th
0
5
10
15
20
25
30
35
Heart rate recovery (bpm)

Preceding Slide

- Estimates of the relative risk of death within 6 years according to heart rate recovery 1 minute after cessation of exercise. Circles represent the relative risk of death for each of the quintiles as compared with the quintile with the greatest reduction (5th). Blue and red lines represent the 95% confidence intervals.
- COLE CR, BLACKSTONE EH, PASHKOW FJ, SNADER CE, LAUER MS.
- HEART-RATE RECOVERY IMMEDIATELY AFTER EXERCISE AS A PREDICTOR OF MORTALITY. N ENGL J MED 1999; 341:1351–1357.

HR Recovery and Chronotropic Response

- Am Heart J. 2008 Oct;156(4):736-44. doi: 10.1016/j.ahj.2008.05.025.
- 9519 outpatients w/TMs 2001-2004
- Hazard ratio of 1.9 for predicting mortality
- adding this to a low Duke Treadmill Score risk group improved mortality prediction by a factor of 2.59


Freedom from death from cardiovascular causes (%)
100
95
90
85
80
75
70
0
5
10
15
20
25
Years
Neither
Premature ventricular depolarizations during exercise
Ischemia

Preceding Slide

- JOUVEN X, ZUREIK M, DESNOS M, COURBON D, DUCIMETIERE P. LONG-TERM OUTCOME IN ASYMPTOMATIC MEN WITH EXERCISE-INDUCED PREMATURE VENTRICULAR DEPOLARIZATIONS.
- N ENGL J MED 2000; 343:826–833. COPYRIGHT© 2000, MASSACHUSETTS MEDICAL SOCIETY.

Ventricular Arrhythmias

- ventricular arrhythmias prediction controversial
- A recent review found that ventricular ectopy during exercise testing or recovery was associated with an increased death rate in 13 out of 22 studies.
- Fifteen of these studies included patient populations with symptomatic or known coronary artery disease; the other 7 studies were in healthy people without symptoms (eg, being screened for employment).

PVCs more Important in Recovery

- Frolkis evaluated 29,244 patients referred to Cleveland Clinic for exercise treadmill testing and found a low prevalence of frequent ventricular ectopy (3% during exercise, 2% after exercise, and 2% both during and after exercise).

- The 5-year mortality rate was higher in patients with frequent ventricular ectopy during exercise vs those without (9% vs 5%, $P < .001$)
- was even higher in those with frequent ventricular ectopy in recovery vs those without (11% vs 5%, $P < .001$).

- After adjusting for confounding variables, only frequent ventricular ectopy in recovery, but not during exercise, was associated with an increased death rate (adjusted hazard ratio 1.5; 95% CI 1.1–1.9; $P = .003$).

How about combining TM findings and improving mortality prediction?

- Dr. Daniel Mark beat you to it…

Duke Treadmill Score

DOI: 10.1056/NE**Prognostic Value of a Treadmill Exercise Score in Outpatients with Suspected Coronary Artery Disease**

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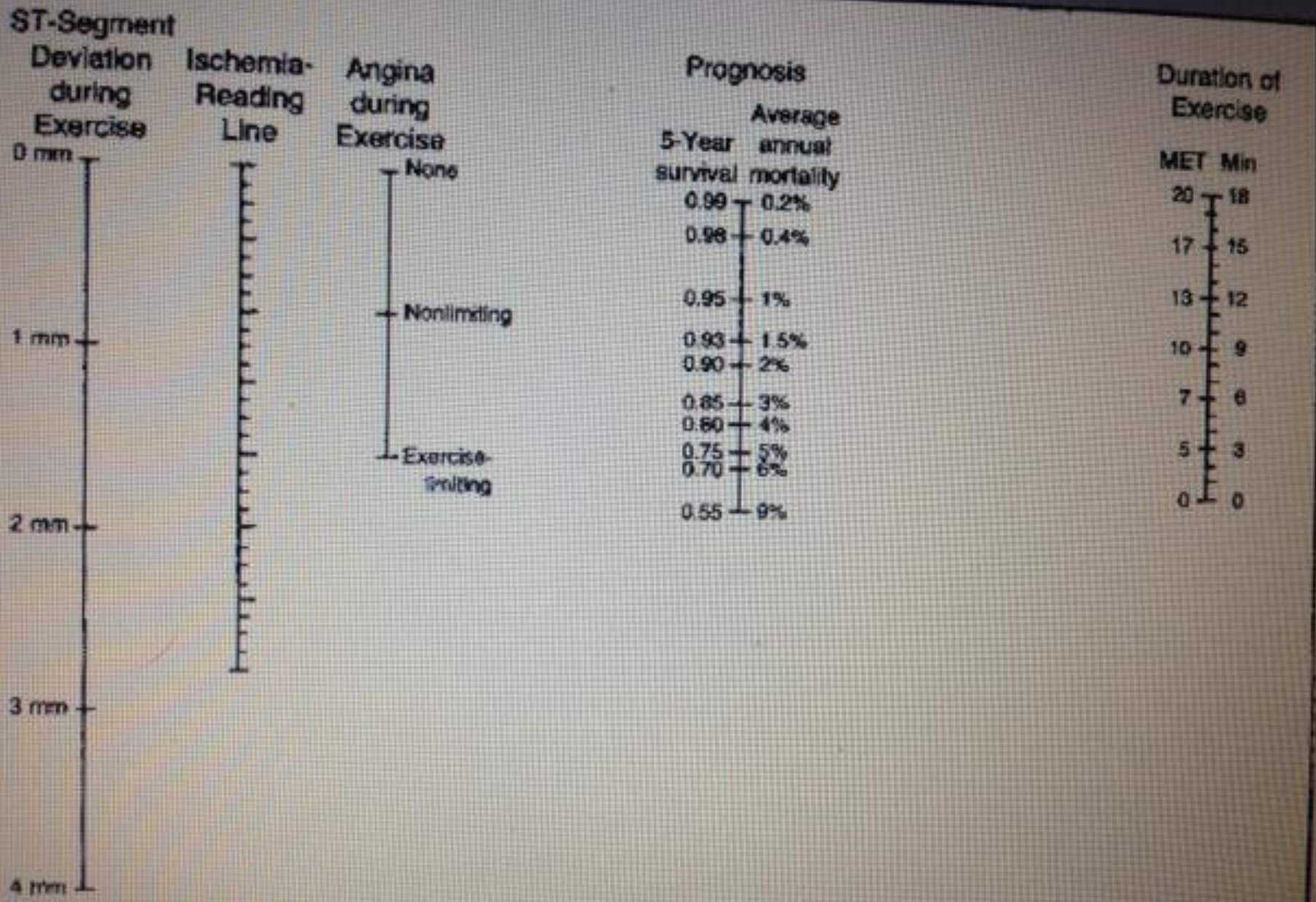
N ENGL J MED 1991; 325:849-853September 19, 1991DOI: 10.1056/NEJM199109193251204JM199109193251204

- The most widely used treadmill risk score, the Duke treadmill score can be calculated as:
- Exercise time (in minutes, Bruce protocol) minus 5 times the magnitude of ST-segment depression (in millimeters) minus 4 times the treadmill angina index (ie, 0 = no angina, 1 = nonlimiting angina, 2 = angina that is the reason for terminating exercise).


ST-Segment Deviation during Exercise
0 mm
1 mm
2 mm
3 mm
4 mm
Ischemia-Reading Line
Angina during Exercise
None
Nonlimiting
Exercise-limiting
Prognosis
5-Year survival
Average annual mortality
0.99 0.2%
0.98 0.4%
0.95 1%
0.93 1.5%
0.90 2%
0.85 3%
0.80 4%
0.75 5%
0.70 6%
0.55 9%
Duration of Exercise
MET Min
20 18
17 15
13 12
10 9
7 6
5 3
0 0

Duke Treadmill Score

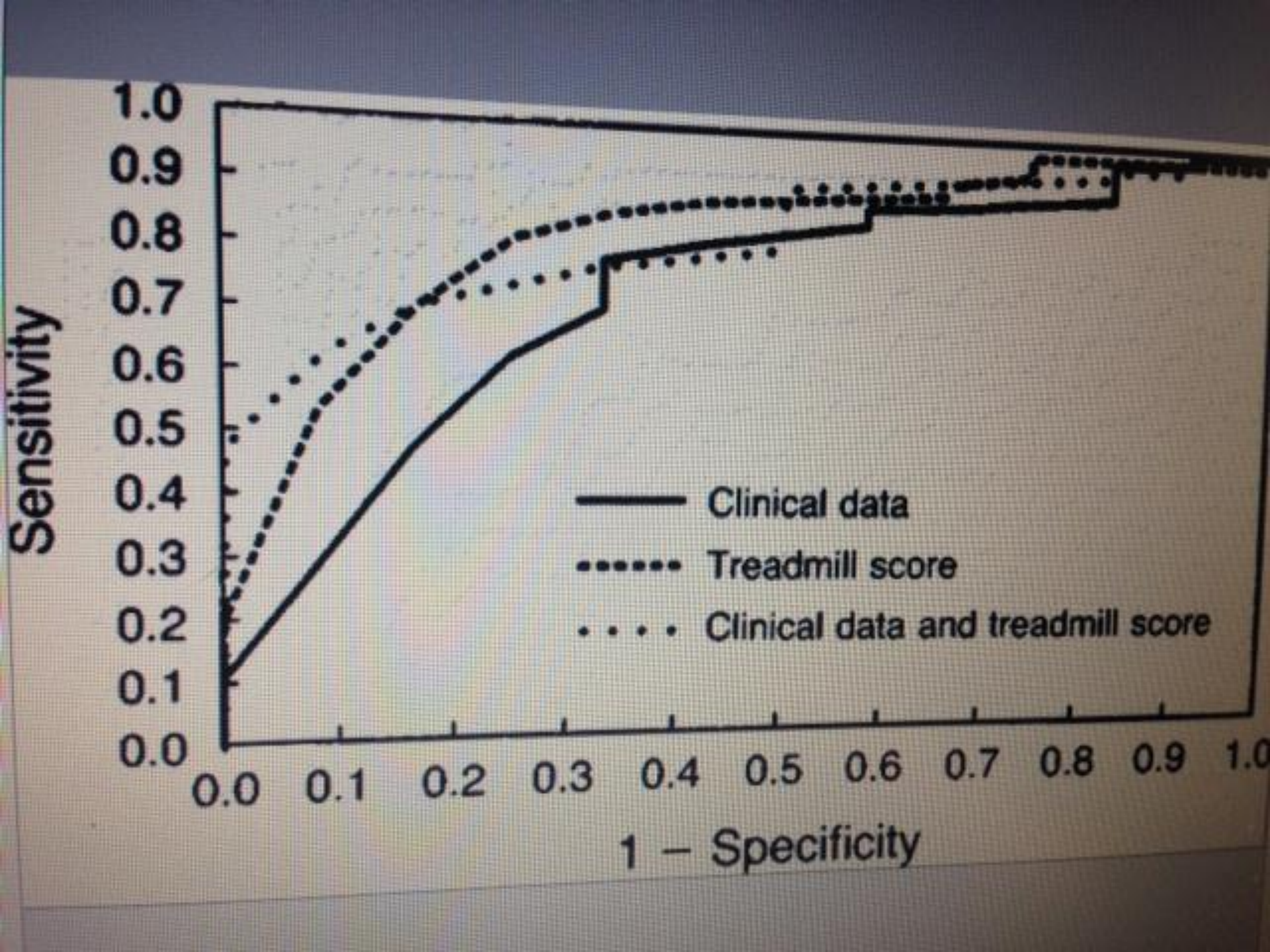
- Most widely used scoring system
- >2800 pt.s including 30% women
- Low risk DTS = >+5
- Intermediate risk DTS = -10 to +4
- High risk DTS = > -11

- High risk DTS has 376 x risk of low risk DTS

- In females, 81% of low risk DTS had no CAD and in high risk DTS, 46% females had 3 vessel or left main

- Low risk DTS annual mort. 0.25% vs. high risk 5%

- JACC, 1998: 98: 1622-1630.


Sensitivity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
1 – Specificity
Clinical data
Treadmill score
Clinical data and treadmill score

Cleveland Clinic/Kaiser Prediction Model

- Ann Int Med 18Dec 2007:147:12: 821-828
- Analytic based on CC 33,268 pts. w/normal EKGs; validation based on 5821 Kaiser pts. f/up 6.2 yrs
- Age/Sex/Smoking/bp/DM/AP and TM capacity/ST deviation/symptoms/HR recovery/PVCs in recovery
- Results P value < 0.0001 and performed better than Duke Score & reclassified some correctly as low risk

Alternatives to Exercise

- Adenosine/Regadenoson (Lexiscan)/Dipyridamole as coronary vasodilators (dilate the good artery and fail to dilate the partially blocked one→relative contraindication in reactive airways dis. (antidote = aminophylline)
- Dobutamine raises HR to simulate exercise effect (at peak, decreases bp rather than increases it)→ used for reactive airways disease pt.s (antidote = fluids and BB's)

Imaging Stress Tests

- Stress echo (especially in females) increases the sens/spec to = a male TM test→81-86% sens and 80-88% spec. in females over a plain TM (31-71% and 66-86%)
- SPECT nuclear stress (especially in females) increases the sens/spec to 78-88% and 64-91% over a plain TM

Weighted mean sensitivities and specificities of pharmacologic stress tests derived from a meta-analysis of 82 studies

Pharmacologic test	Sensitivity, percent	Specificity, percent
Adenosine echocardiography	72	91
Adenosine SPECT MPI	90	75
Dipyridamole echocardiography	70	93
Dipyridamole SPECT MPI	89	65
Dobutamine echocardiography*	80	84
Dobutamine SPECT MPI	82	75

SPECT: single photon emission computed tomography; MPI: myocardial perfusion imaging.
* One dobutamine echocardiographic study was not included because only multivessel disease was examined.
Data from Kim, C, Kwok, YS, Heagerty, P, Redberg, R, Am Heart J 2001; 142:934.

Prognosis in Imaging Stress Tests

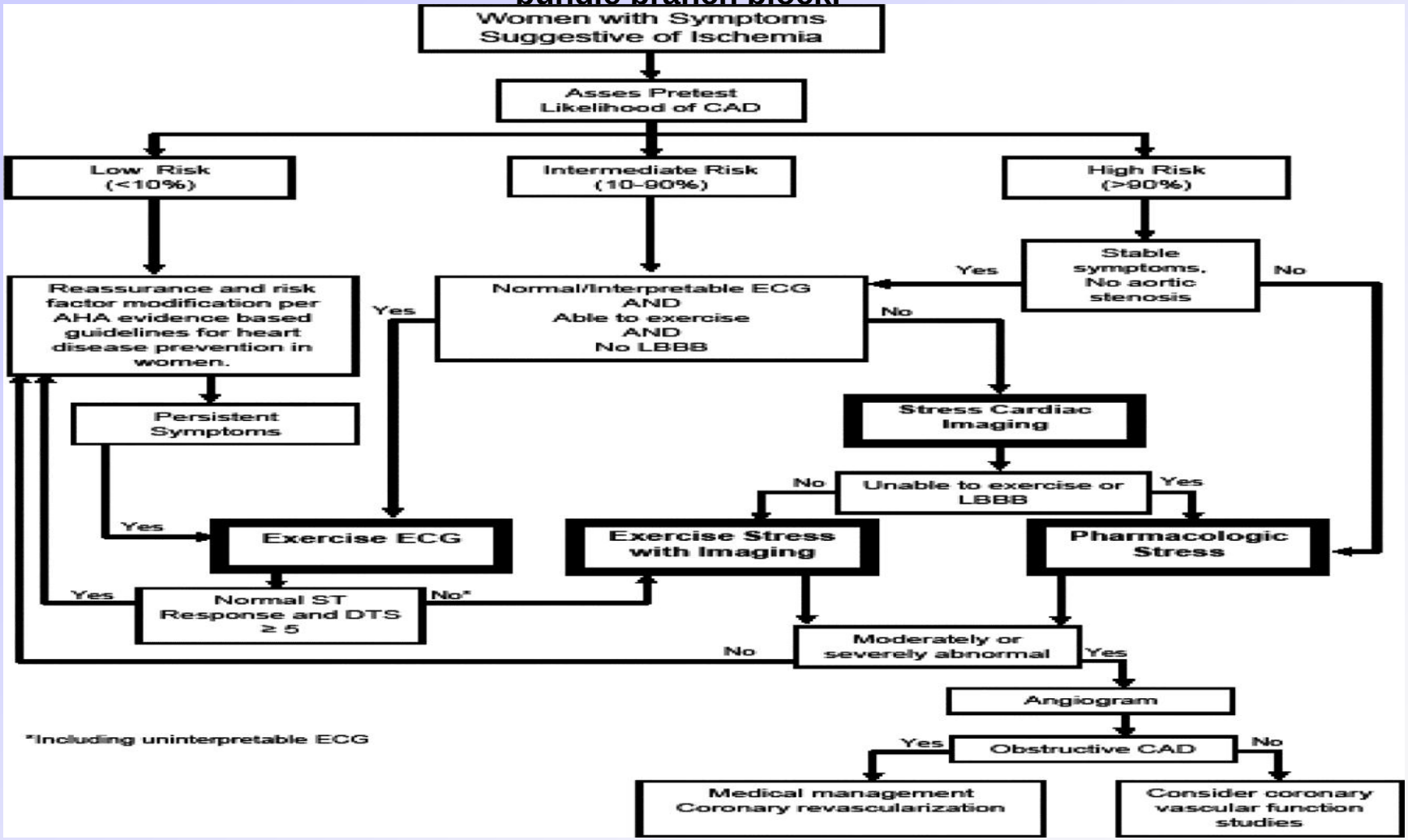
--Women w/negative stress echo had a 96% CV event-free survival over three years compared to 55% in women w/abnormal stress echoes

JACC 1997: 30: 414-420

Am J Med 1999 Feb;106 (2): 172-178

- Economics of Noninvasive Diagnosis (END) study group
- 6 academic high volume nuclear CV labs studied 5000 males and 3400 females
- 39% males w/perfusion defects and 25% females
- 2.5 year f/up→143 CV deaths
- In females, # territories was strongest mortality predictor after adj. for exercise variables

Algorithm for stress testing in the evaluation of a symptomatic woman at low, intermediate, and high risk is determined by the patient's pretest probability of CAD. LBBB indicates left bundle branch block.



Kohli P , and Gulati M Circulation 2010;122:2570-2580

American Heart Association
Learn and Live

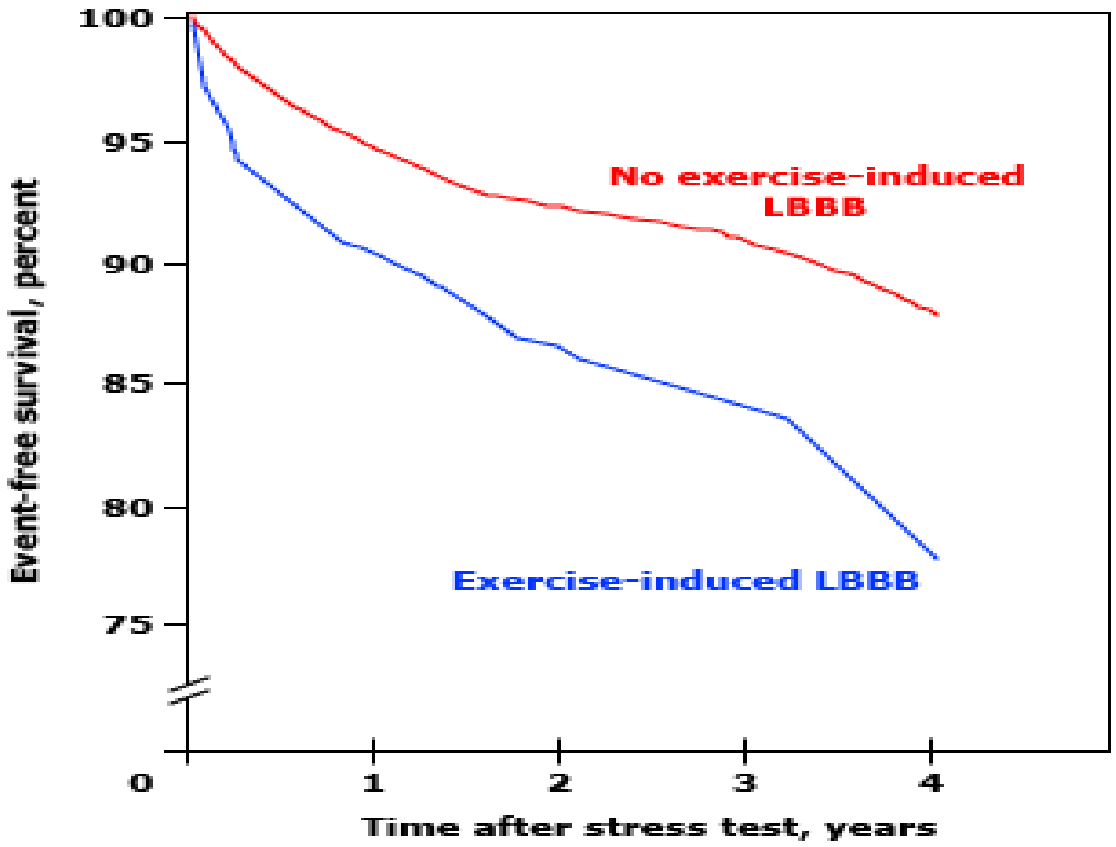
Why can patients have a “normal” stress test and go on to infarct or die a short time later?

- Stress tests detect (at the time of the test) the relative coronary flow, and high grade lesions, geographically, pre and post stress; they do not detect overall atherosclerosis and are poor at mild or subclinical disease (mild fat-laden plaques that are more prone to rupture and have acute events than calcific plaques- “vulnerable plaques”).

Exercise test endpoints

Patient-determined endpoints
Patient wants to stop
Significant chest discomfort
Marked fatigue or severe dyspnea
Other limiting symptoms (dizziness, leg cramps, joint discomfort, etc)
Provider-determined endpoints
Patient does not look well (eg, ataxia, confusion, pallor, cyanosis, etc)
Exertional hypotension (systolic BP below standing systolic BP measured at rest prior to test)
Systolic BP >250 mmHg
Diastolic BP >120 mmHg
ECG endpoints • Marked ST segment depression • New bundle branch block which cannot be distinguished from ventricular tachycardia • New high grade (ie, Mobitz 2 or complete) AV block • Ventricular tachycardia or fibrillation • Increasing ventricular ectopy (premature beats, couplets or nonsustained ventricular tachycardia), especially if ischemia present • Onset of supraventricular tachyarrhythmias
Equipment failure
Protocol-determined endpoints (submaximal tests)
Heart rate determined (eg, 120 to 140 bpm)
Workload determined (eg, 5 METs)

Exercise-induced left bundle branch block (LBBB) predicts worse outcomes



Among 17,277 patients who underwent exercise stress testing, patients who developed left bundle branch block (LBBB) during exercise testing had a significant reduction in cardiac event-free survival during follow-up.

Data from: Grady TA, Chiu AC, Snader CE, et al. JAMA 1998; 279:153.

AV Block

- No large trials of this either pre-TM or produced by the TM
- There is a fairly high likelihood that the pt. in question has nodal or infranodal conduction system disease and needs a pacemaker, not just CAD

Pseudonormalization of T waves

- Lots of case reports, few large or long term studies
- Remember localizes apical hypertrophy as a cause
- Can be with or without other TM+ findings
- As an isolated finding, few indications of mortality prediction

Patient Adverse Outcome Predictors

- < 5 METS
- Exercise-induced AP esp. w/low METS
- Low peak systolic bp or systolic bp fall of 10 mm Hg
- Chronotropic incompetence

TM Adverse Outcome Predictors

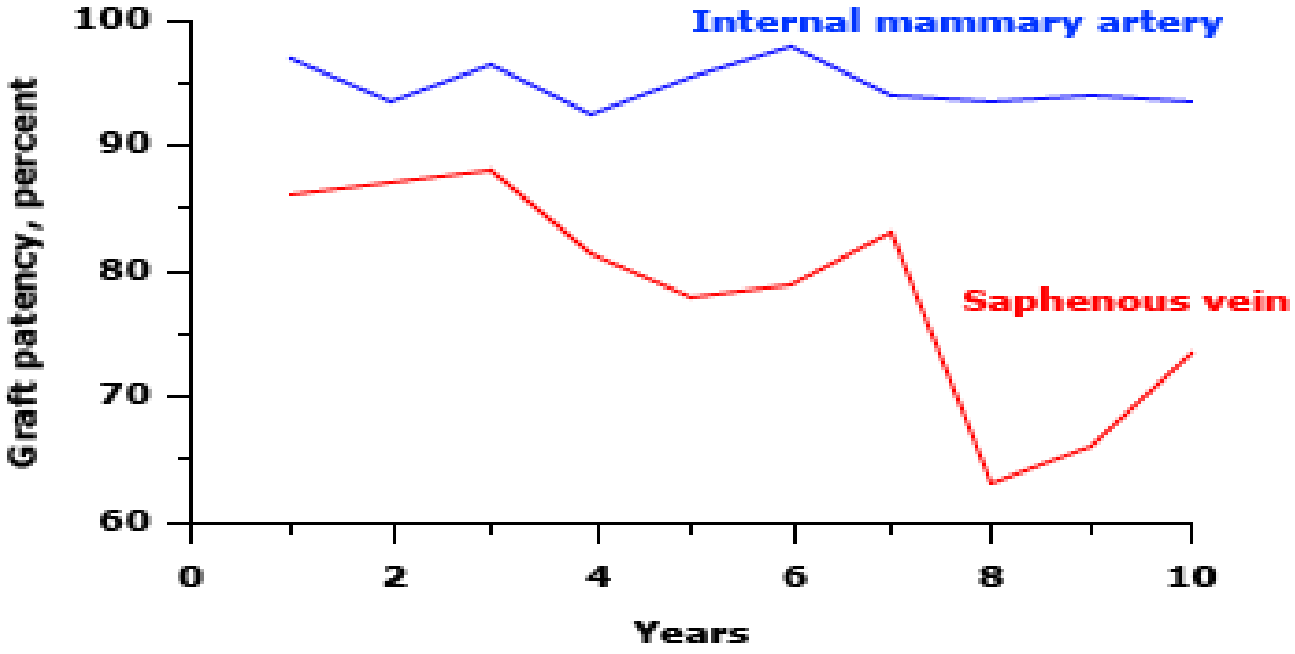
- > 1 mm downsloping/flat ST segments in exercise or recovery
- >2 mm ST depression in Stage 2 or < or with HR 130 or <
- Stage 1 or < 5 min. exercise ST depression
- > 5 leads w/ST depression
- ST elevation esp. leads w/no Q waves and not avR
- PVCs esp. couplets or VT new with exercise and decrease in recovery
- ST/HR slope of 6 mV/beat/min.

CASS Registry Study JACC 1986:8 (4): 741

- --12% of patients had > 1 mm ST depression on TMs and < first Stg.→annual mortality > 5%

- 34% of patients had < 1 mm ST depression on TMs and exercised into Stage 3→ annual mortality < 1%

Graft patency after CABG



Patency of internal mammary artery and saphenous vein grafts after coronary artery bypass surgery. The 10-year patency rate was significantly higher with the arterial grafts. There was a variable number of patients studied at each interval, accounting for the irregular shape of the curves.
Data from: Loop FD, Lytle BW, Cosgrove DM, et al, N Engl J Med 1986; 314:1.

...ough. No contrast protocol.
...es for ischemia in the setting of

...exlecan intervention.
...tion both at rest and post lexiscan

...n fraction.

...nd, but this study would rule out the
...ary disease in the patient at this time.
... and advised to continue regular medica
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J C A N L

Nuclear Cardiology

Accredited Nuclear Cardiology Laboratory

Nuclear Stress Test Buzz Words

- MPHR = maximum predicted HR (for age)
- Lung tracer uptake or lung: heart ratio
- Wall motion and thickening
- Inferior/apical esp. small and fixed defects
- Anterior esp. small and fixed defects
- Breast attenuation and attenuation correction
- SSS and SRS and SDS
- Rapidity of ST resolution post exercise
- LV dilation w/exercise or TID ratio
- Prone position
- What is a walking adenosine?

Summed Stress Score (SSS) Heart 2003 Nov 89 (11): 1291-1297

- A representative method of scoring the total ischemic burden is to calculate the “summed stress score” or SSS, using the method developed at Cedars-Sinai Hospital (Los Angeles, California, USA).23 In large studies (over 20 000 patients) the SSS predicted patient outcome. A normal summed stress score (0–3) was associated with a mortality of less than 1%, whereas an increasing SSS predicted higher cardiac mortality

In Summary

- METS matter… a lot…even if one cannot “read” the ST segments accurately
- ST segment misinterpretation happens with various drugs, LVH, underlying EKG abnormalities of other sorts
- PVCs matter less, but if so, more in recovery
- Hypotension is a poor sign especially if produced by exercise; hypertension < predictive

In Summary

- Risk scores like the Duke TM score and the Cleveland Clinic/Kaiser score are very useful to combine clinical and TM parameters to predict risk
- Female TMs are prone to misinterpretation unless imaging is also used; but a negative TM still has fair predictive value
- HR recovery is not as useful as thought—probably reflects conditioning

In Summary

- Other findings (except new LBBB) can occur with ischemia or with other causes, so not so useful
- Imaging stress tests are probably more accurate if produced in an ICANL or ICAEVL lab
- Remember the buzz words but also correlate with the total findings—i.e. the SSS in nuclears and WMA in echoes