UT Southwestern Medical Center

Cardiac Evaluation of Chest pain

Rafic F. Berbarie, MD
Associate Professor
Division of Cardiology
University of Texas Southwestern Medical Center

Question

- What is the criteria for concluding an exercise treadmill stress test is positive for inducible myocardial ischemia?

A. 1-2 mm up slopping ST segment depression.
B. >= 1mm horizontal or down sloping ST segment depression 0.08msec after the J-point for 3 consecutive beats.
C. Chest pain while on the treadmill.
D. Frequent premature ventricular contractions.
E. New T wave inversions during exercise.

Question

- Chest pain consistent with angina pectoris usually has which of the following qualities?

A. Pain is located only below the epigastric area.
B. Pain sensation is worth with deep breaths.
C. Pain sensation is sharp or stabbing.
D. Exertional pain described as pressure or tightness located retrosternal.
E. Pain sensation is positional, worse with movements of the chest.

Objectives

- Determine the probability of CAD in patients with chest pain by history
- Describe the complementary aspects of non-invasive imaging-functional vs. anatomic
- Recognize the contra-indications, ECG abnormalities and high risk markers on treadmill stress testing
- List the strengths and weaknesses of non-invasive cardiac testing
- Know guideline ratings for non-invasive cardiac testing

Introduction

2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR Guideline for the Evaluation and Diagnosis of Chest Pain: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

Martha Gulati, Phillip D. Levy, Debabrata Mukherjee, Ezra Amsterdam, Deepak L. Bhatt, Kim K. Birtcher, Ron Blankstein, Jack Boyd, Renee P. Bullock-Palmer, Theresa Conejo, Deborah B. Diercks, Federico Gentile, John P. Greenwood, Erik P. Hess, Steven M. Hollenberg, Wael A. Jaber, Hani Jneid, José A. Joglar, David A. Morrow, Robert E. O'Connor, Michael A. Ross and Leslee J. Shaw

Originally published 28 Oct 2021 | https://doi.org/10.1161/CIR.0000000000001029 | Circulation. 2021;144:e368–e454

Introduction

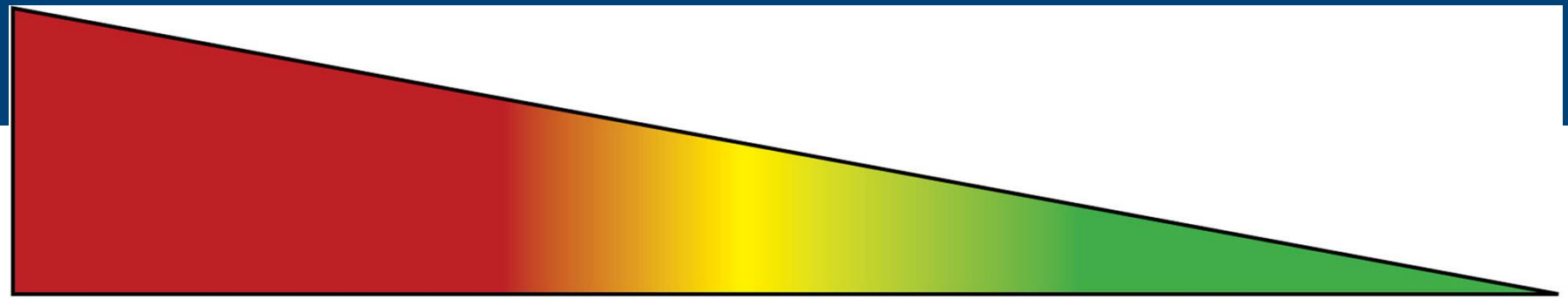
- Angina common problem, increases with age
- In ER's in the US, CP accounts for >6.5 million visits, or 5% of all ED visits
- 4 million outpatient visits in the US annually
- New stable CP results in 4 million annual stress tests
- Non cardiac CP patients
  - 1/3 of patients who die from CV cause or have ACS event over next 5 years
- Improved diagnostic testing and risk prediction still needed

Fordyce CB, et al. JACC 2016;667:843-52
Gulati, M, et al. Circulation. 2021;144:e368–e454

ACC/AHA Guideline Grading

- I: Useful and effective
- II: Conflicting evidence
  - IIa: Evidence favors
  - IIb: Evidence less well established
- III: Not useful and maybe harmful

History



- Central
- Pressure
- Squeezing
- Gripping
- Heaviness
- Tightness
- Exertional/stress-related
- Retrosternal

- Left-sided
- Dull
- Aching

- Stabbing

- Right-sided
- Tearing
- Ripping
- Burning

- Sharp
- Fleeting
- Shifting
- Pleuritic
- Positional

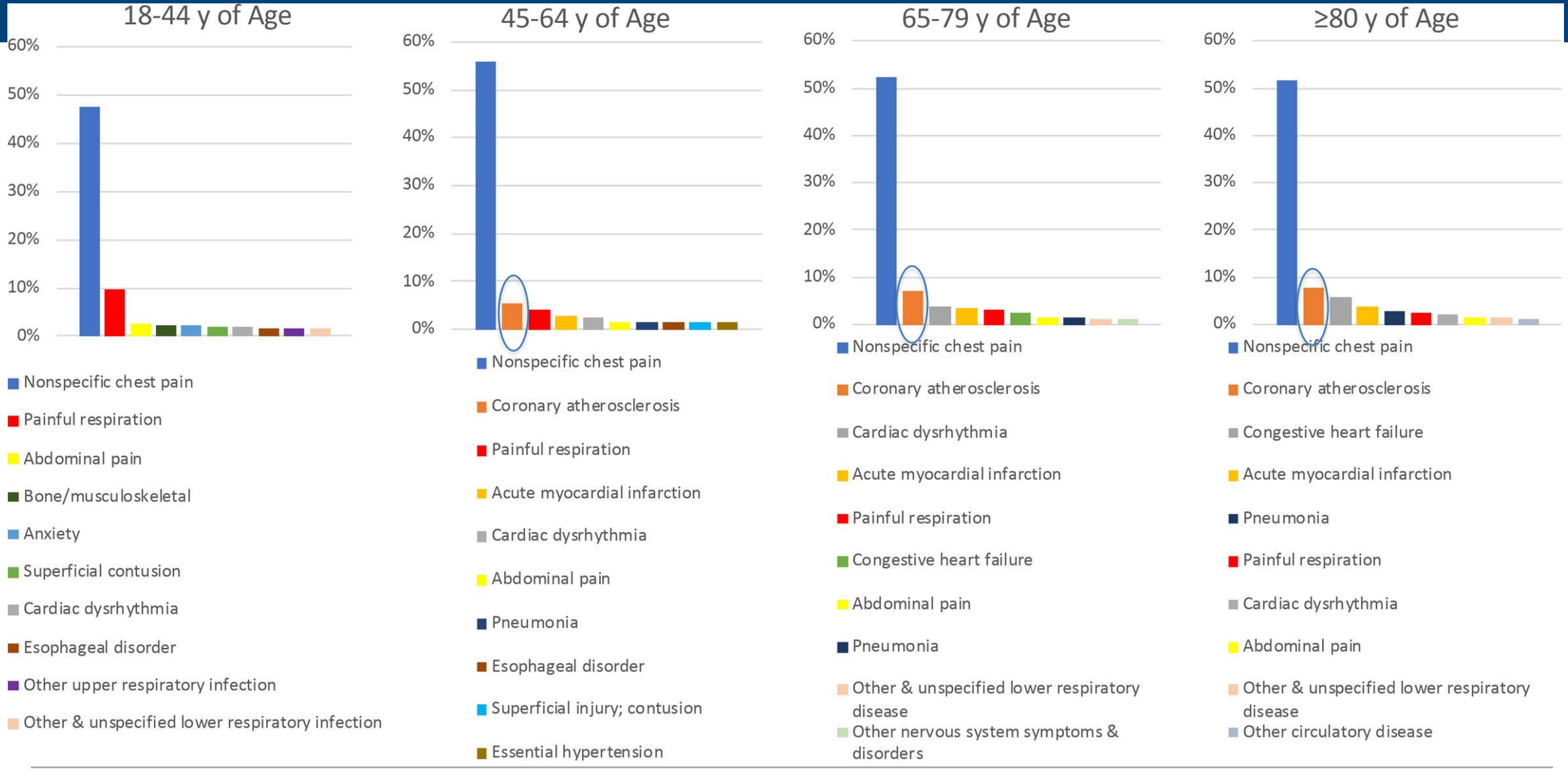
High ← → **Low**

Probability of Ischemia

- Use “cardiac,” “possible cardiac,” and “noncardiac”

Gulati, M, et al. Circulation. 2021;144:e368–e454

History



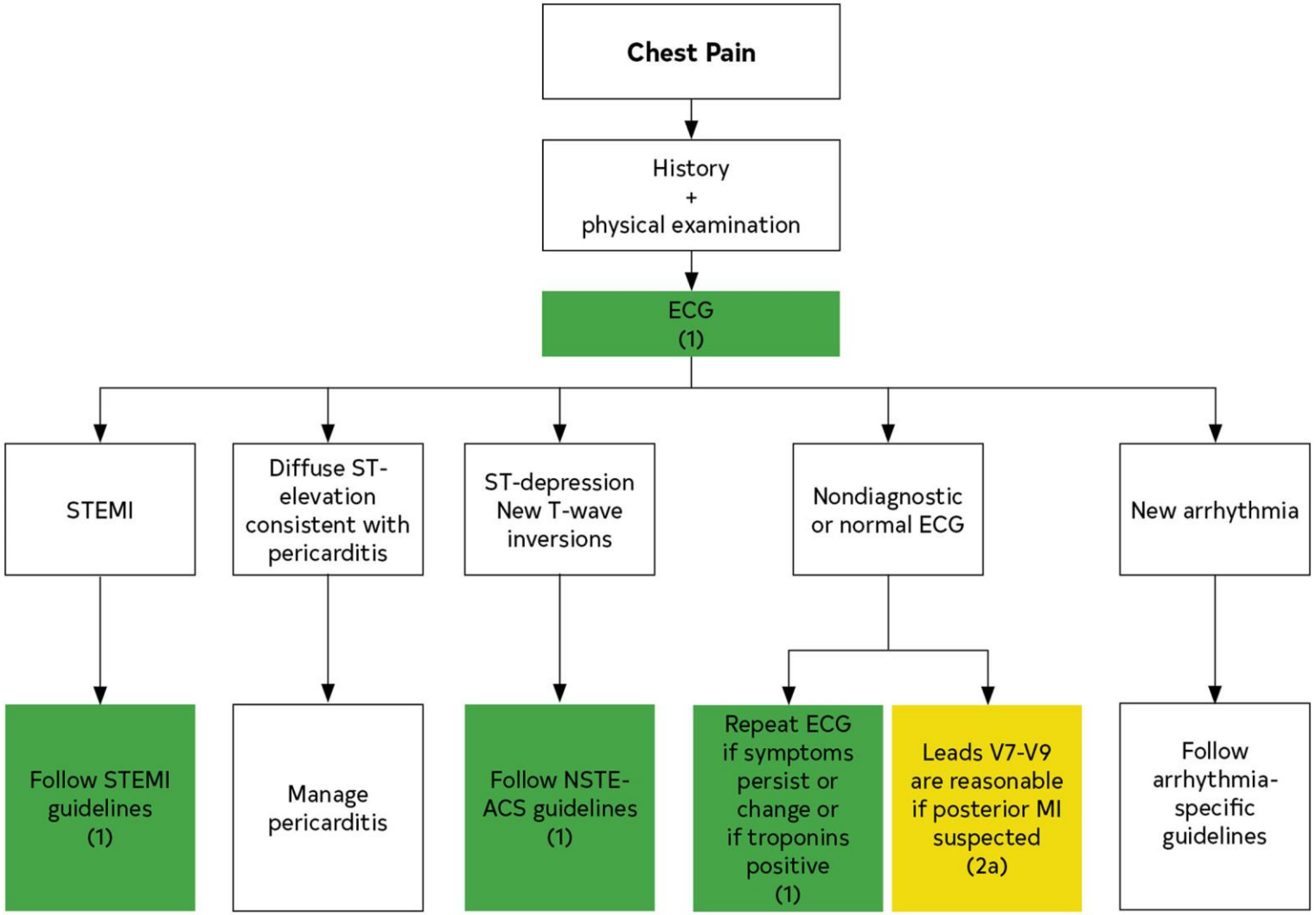
Gulati, M, et al. Circulation. 2021;144:e368–e454

UT Southwestern Medical Center

Physical Exam

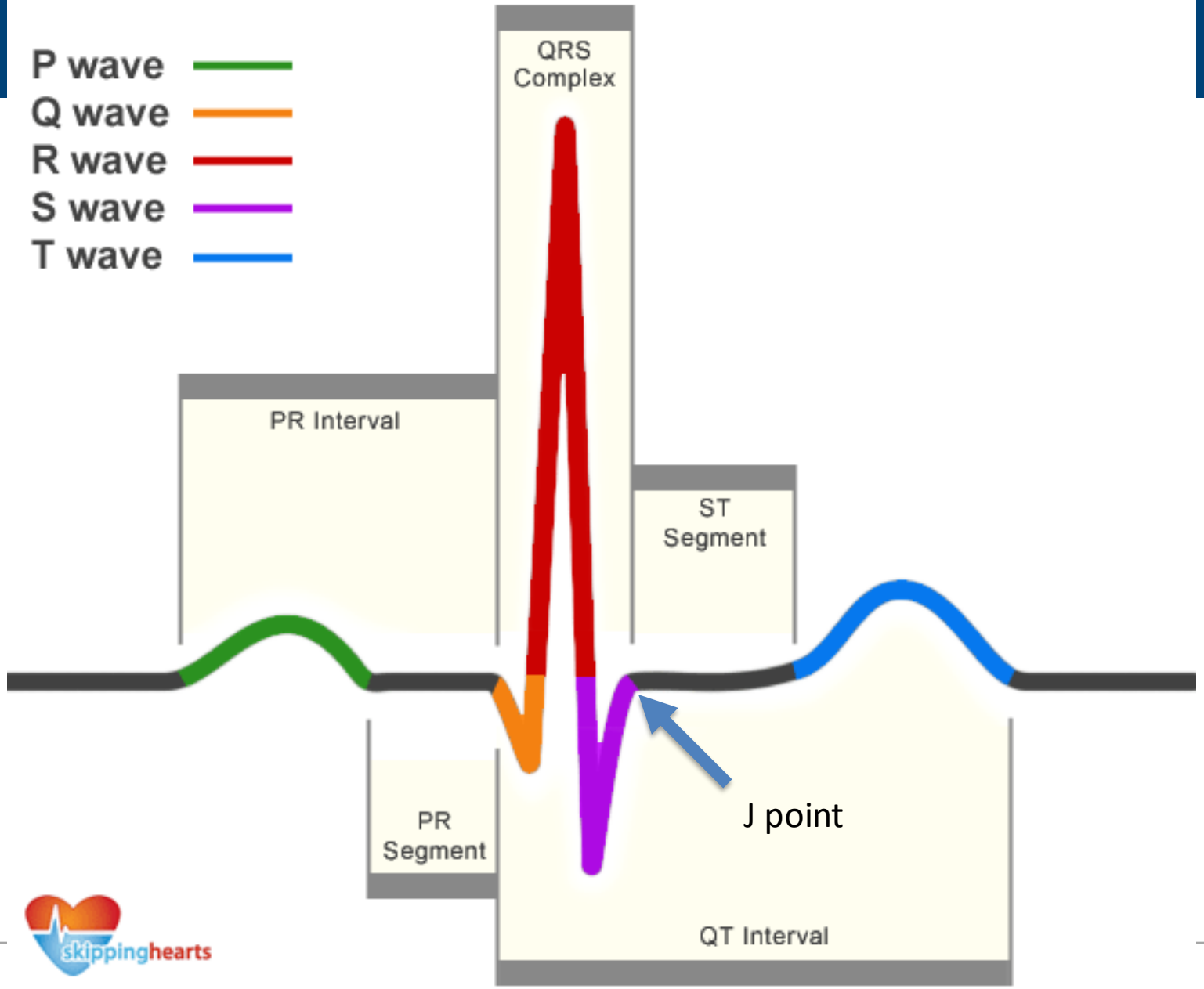
- Diaphoresis, tachypnea, tachycardia, hypotension, crackles, S3, MR murmur; examination may be normal in uncomplicated cases
- Think about other causes

ECG initial first test

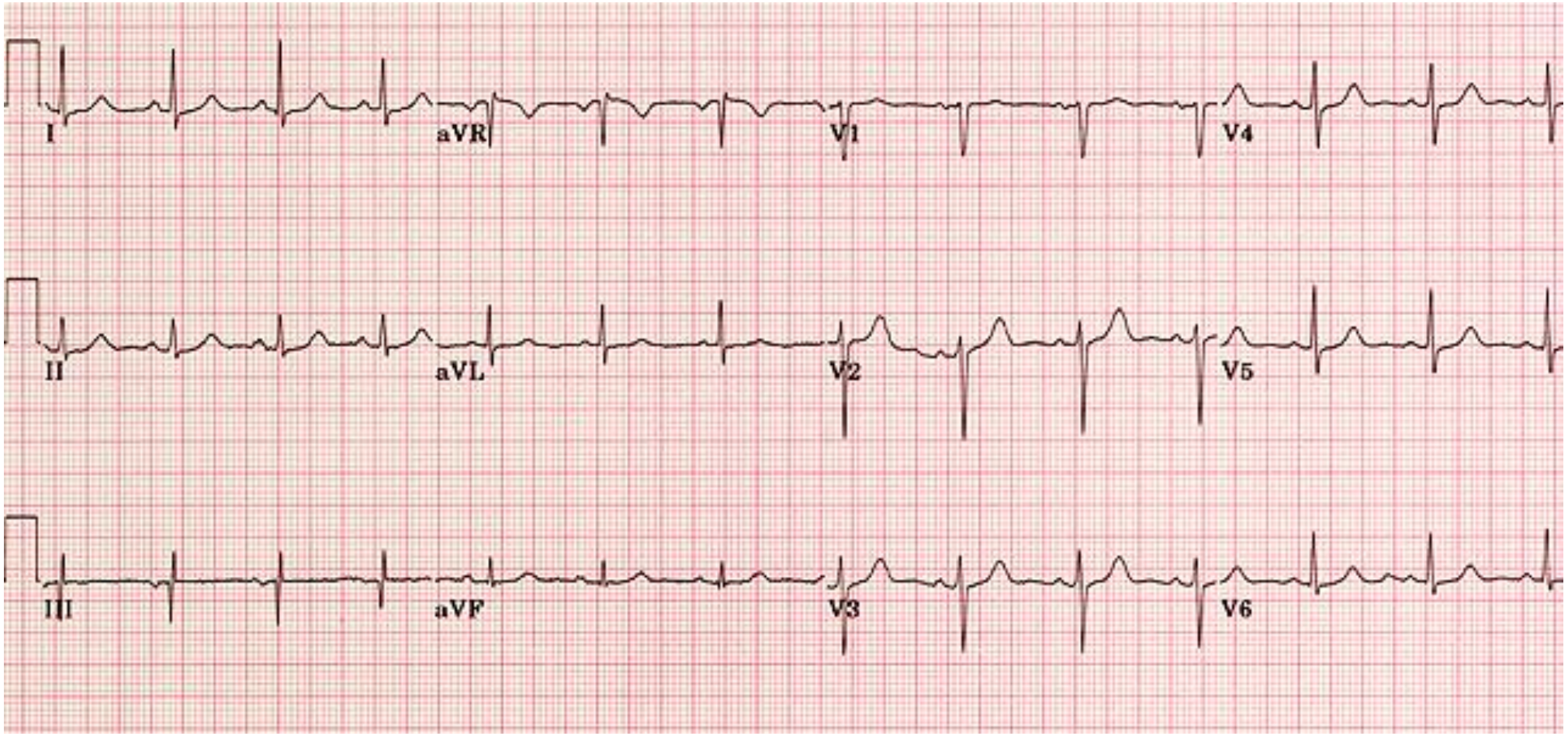


Gulati, M, et al. Circulation. 2021;144:e368–e454

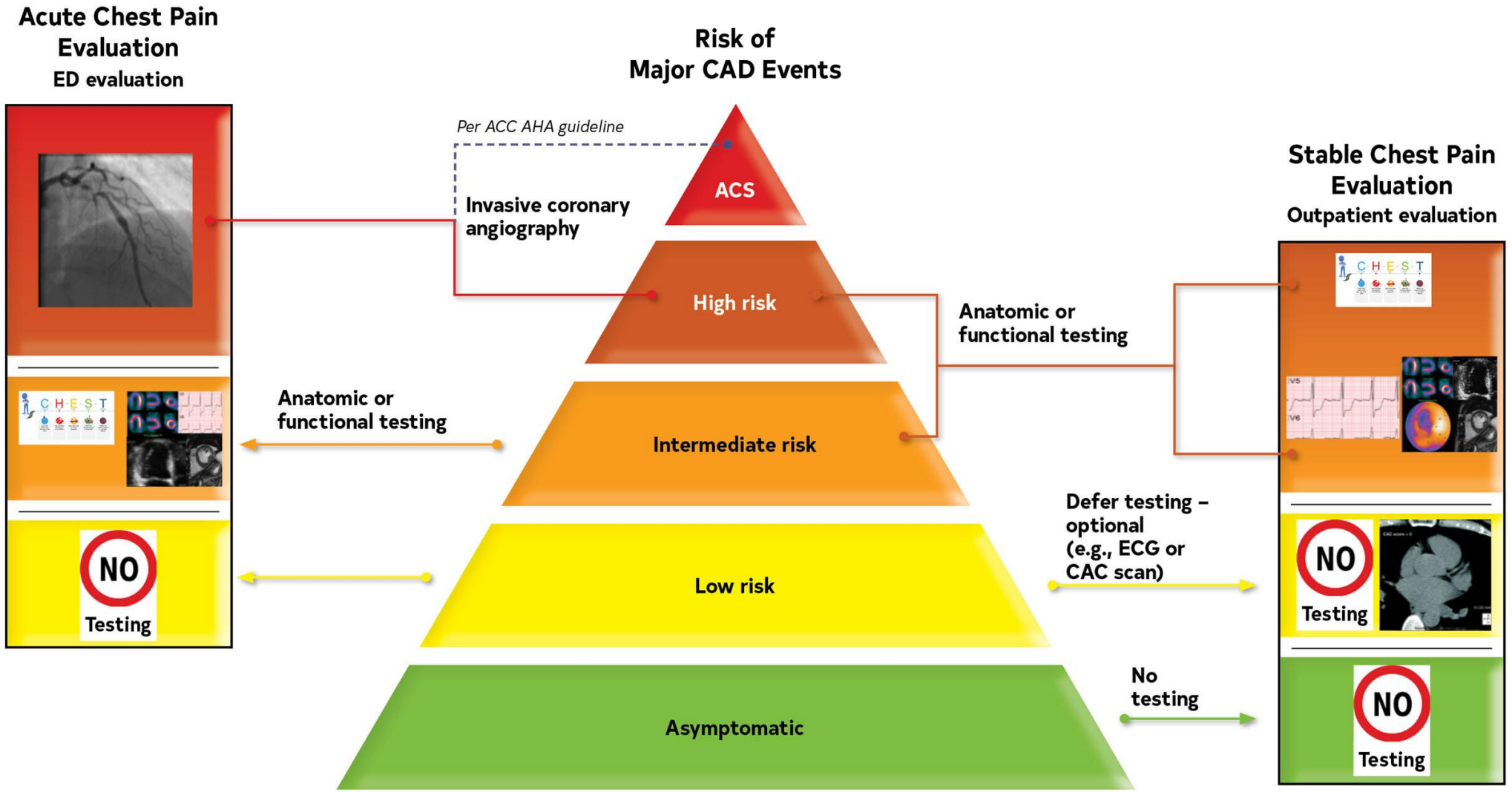
ECG of Normal Sinus Rhythm



Normal ECG



Chest Pain and Cardiac Testing Considerations



Gulati, M, et al. Circulation. 2021;144:e368–e454

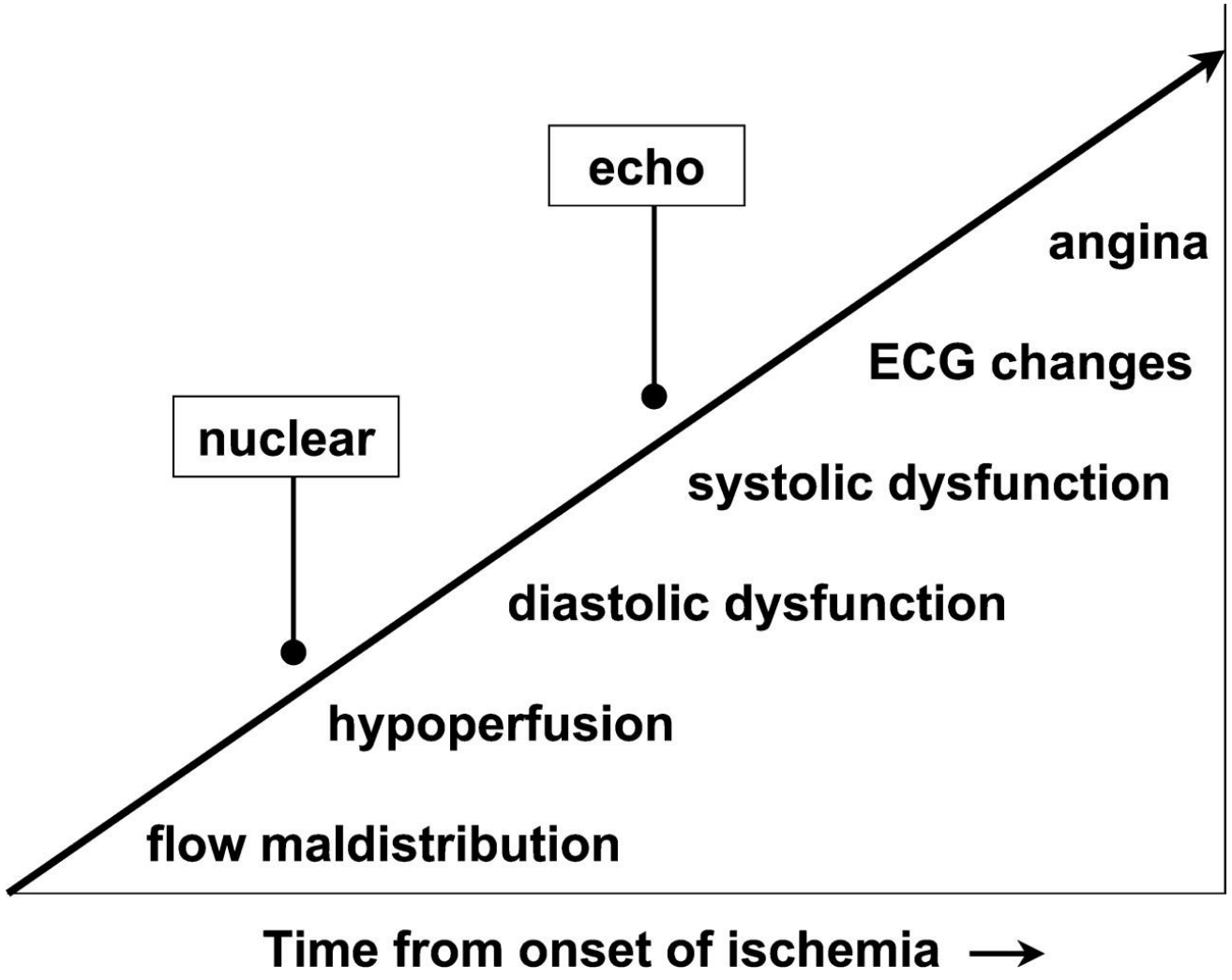
Non-invasive evaluation of suspected CAD

- Are patient's symptoms due to myocardial ischemia? (diagnosis)
- Is this patient going to experience an adverse Cardiac Event? (prognosis)
- Is an invasive intervention appropriate? (treatment)

Non-invasive evaluation of suspected CAD

- In the past, modalities have focused on detecting ischemia
- However, now anatomic imaging has become available
- Ischemia vs. atherosclerosis
- Changing paradigms to include anatomy

Ischemic Cascade

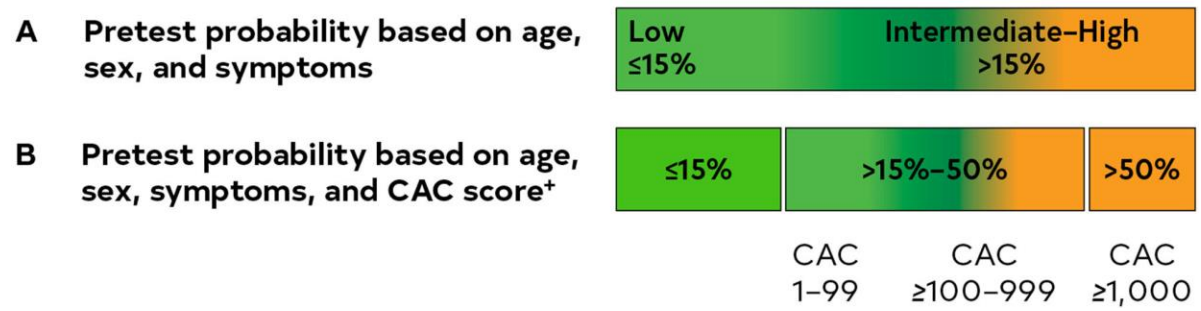


Schinkel A et al. Eur Heart J 2003;24:789-800

Patients With No Known CAD Presenting With Stable CP

Pretest Probabilities of Obstructive CAD in Symptomatic Patients
(A) according to age, sex, and symptoms;
(B) according to age, sex, symptoms, and CAC

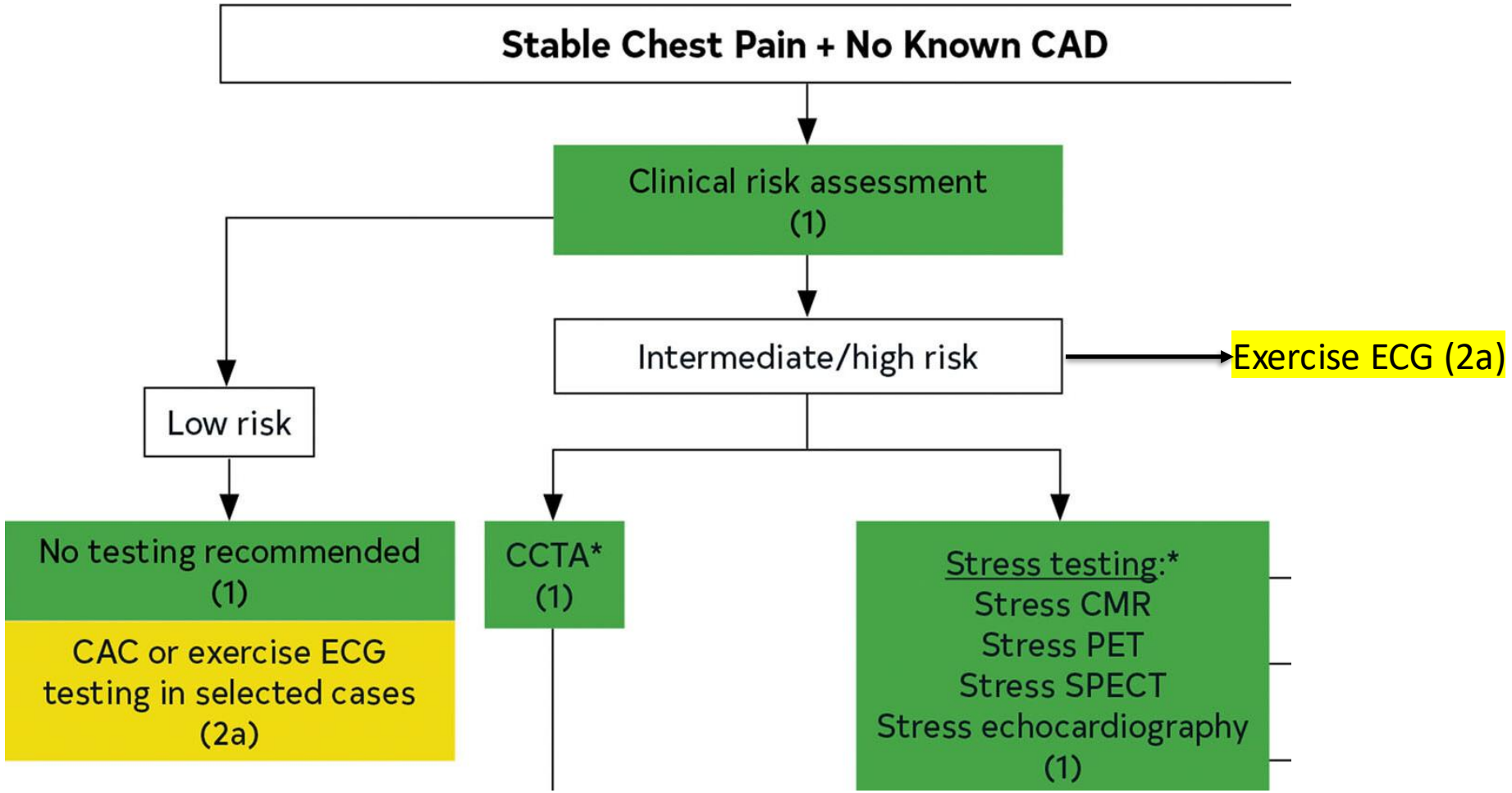
Age, y	Chest Pain		Dyspnea	
	Men	Women	Men	Women
30–39	≤4	≤5	0	3
40–49	≤22	≤10	12	3
50–59	≤32	≤13	20	9
60–69	≤44	≤16	27	14
70+	≤52	≤27	32	12



Gulati, M, et al. Circulation. 2021;144:e368–e454

UT Southwestern Medical Center

Patients With No Known CAD Presenting With Stable CP



Gulati, M, et al. Circulation. 2021;144:e368–e454

Absolute Contraindications to Stress Testing

Absolute contraindication
• Acute myocardial infarction or unstable angina
• Symptomatic severe aortic stenosis
• Cardiac arrhythmia with haemodynamic instability
• Active endocarditis
• Decompensated heart failure
• Acute myocarditis or pericarditis
• Acute pulmonary embolism, pulmonary infarction or deep vein thrombosis
• Acute aortic dissection

Gibbons, et al. Circulation 1999;99:2829-2848.

Indications to Terminate Stress Testing

Absolute indications

- ST-segment elevation of > 1 mm in leads without pre-existing Q waves due to a prior myocardial infarction, other than aVR, aVL and V1
- Development of symptoms: moderate to severe angina, dizziness, near-syncope
- Sustained ventricular tachycardia or other arrhythmia, including second or third degree heart block that interferes with maintenance of cardiac output during exercise
- Drop in systolic blood pressure > 10 mmHg despite an increased workload, accompanied by other evidence of ischaemia
- Signs of poor perfusion (cyanosis, pallor)
- Neurological symptoms
- Individual's request to stop
- Technical difficulty in monitoring the ECG or systolic blood pressure

Gibbons, et al. Circulation 1999;99:2829-2848.

Exercise Treadmill Testing- Protocols

Standard Bruce Protocol

Stage	Min	MPH	Grade	METS
I	03:00	1.7	10%	5
II	03:00	2.5	12%	7
III	03:00	3.4	14%	10
IV	03:00	4.2	16%	13.5
V	03:00	5.0	18%	16+

Variations

Modified Bruce Protocol
- 2 warm-up stages

Naughton Protocol
- mostly fixed speed

Submaximal ETT
- Not to exceed 5 METS
- Not to exceed 70% MPHR

Adequate stress: 85% max predicted HR (220-age)

Gibbons, et al. Circulation 1999;99:2829-2848.

Diagnosis of Ischemia on Stress ECG

Positive test

- 1mm <u>horizontal</u> or <u>down</u> sloping ST segment depression 0.06-0.08msec after the j-point

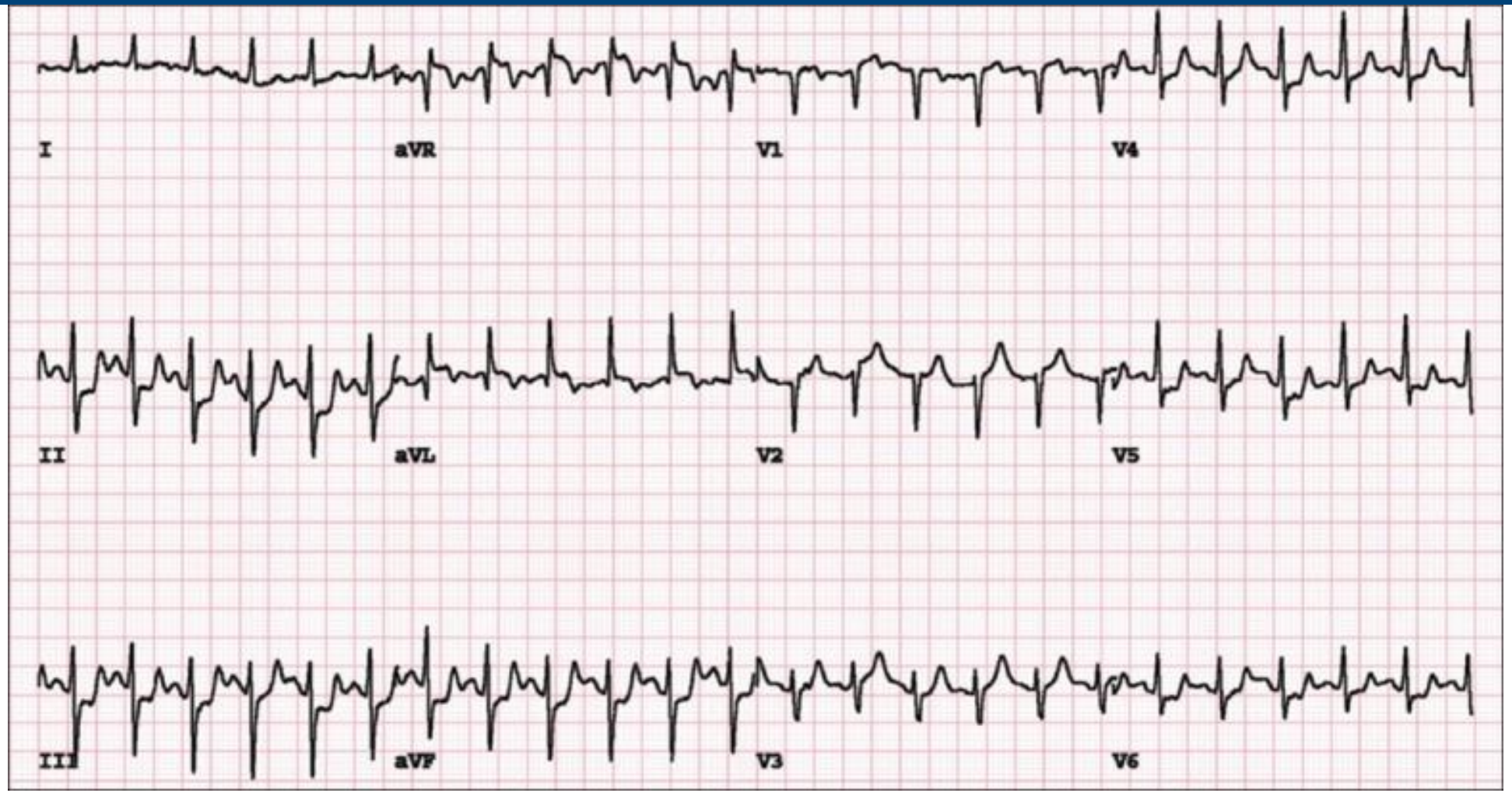
  (5% w/ CAD meet criteria in recovery alone)
- Lateral leads (V4-V6)

Up sloping

Horizontal

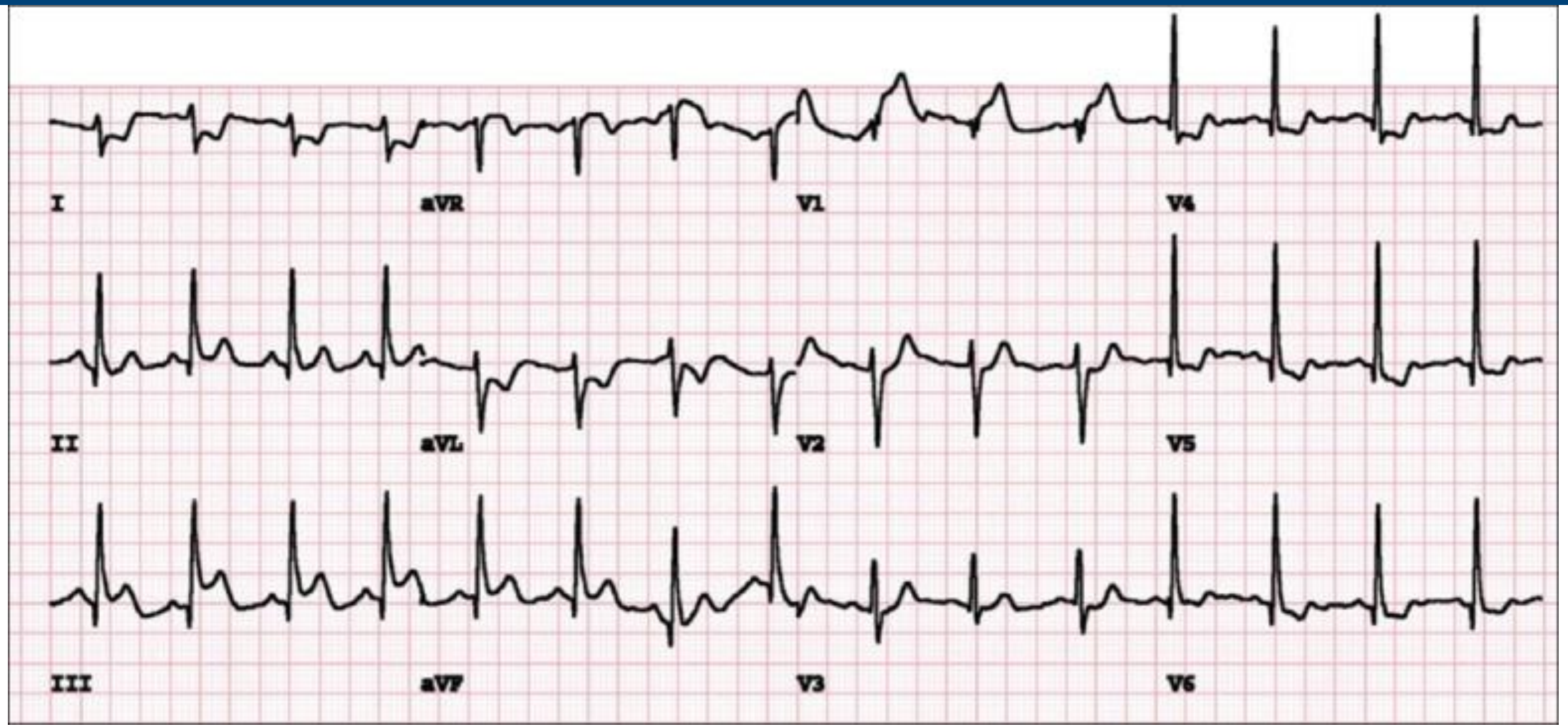
Down sloping

Abnormal stress ECG



Lim, YC, et al. Singapore Med J. 2016 Jul; 57(7): 347–353.

Abnormal stress ECG



Lim, YC, et al. Singapore Med J. 2016 Jul; 57(7): 347–353.

Duke Treadmill Score

DTS calculator = Exercise time in minutes-
5X ST segment depression (mm)-
4x angina index (0-no angina, 1-non limiting angina, 2-limiting angina

Example: Patient walks 6 minutes, has 2 mm ST segment depression and has limiting angina
DTS= 6-10-8= -12, high risk

Score	4 year survival	Annual mortality
Low (>5)	99%	0.25%
Intermediate (-10 to 4)	95%	1.25%
High (<-10)	79%	5%

High risk Stress ECG

- ST ↓ >2.0 mm
- ST ↓ appearing at low workload
- ST ↓ lasting >5 min in recovery
- Low change in heart rate from rest to exercise
- Abnormal BP response
- Achieve <6 METs workload
- Exercise-induced VT
- Abnormal heart rate decline post-exercise

When NOT to use Stress ECG alone

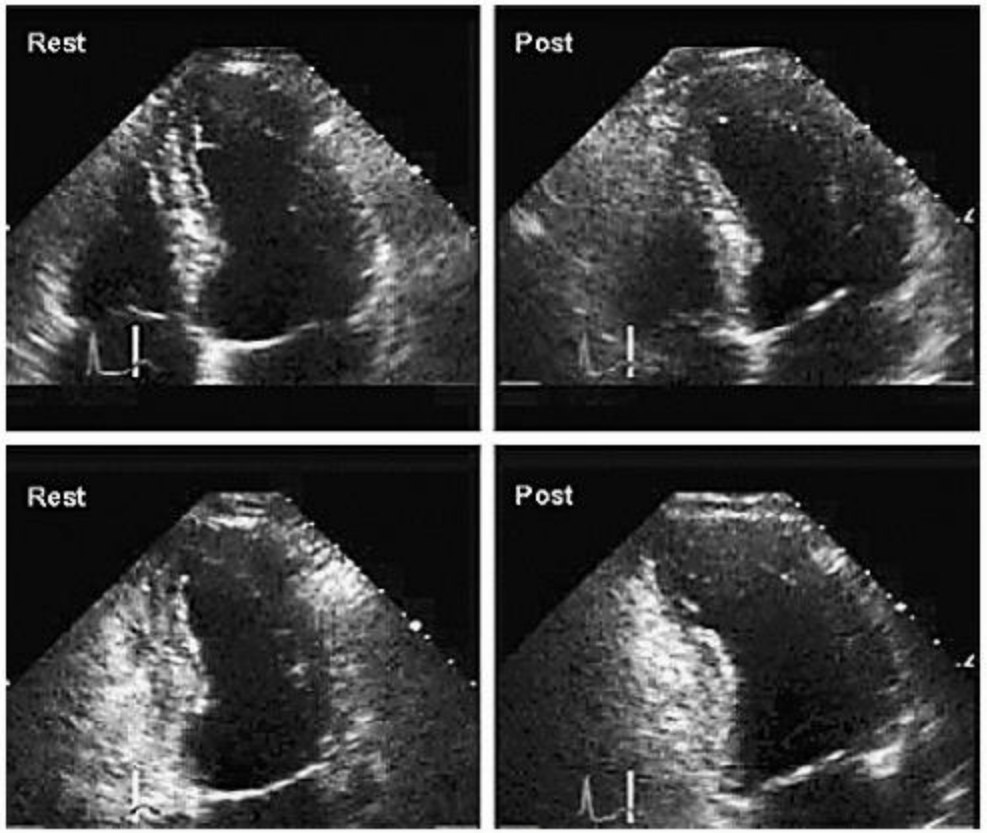
- Preexcitation (Wolff-Parkinson-White) syndrome.
- LVH with ST depression.
- Digoxin and associated ST segment changes.
- Electronically paced ventricular rhythm.
- More than 1 mm of rest ST depression.
- Complete left bundle-branch block.

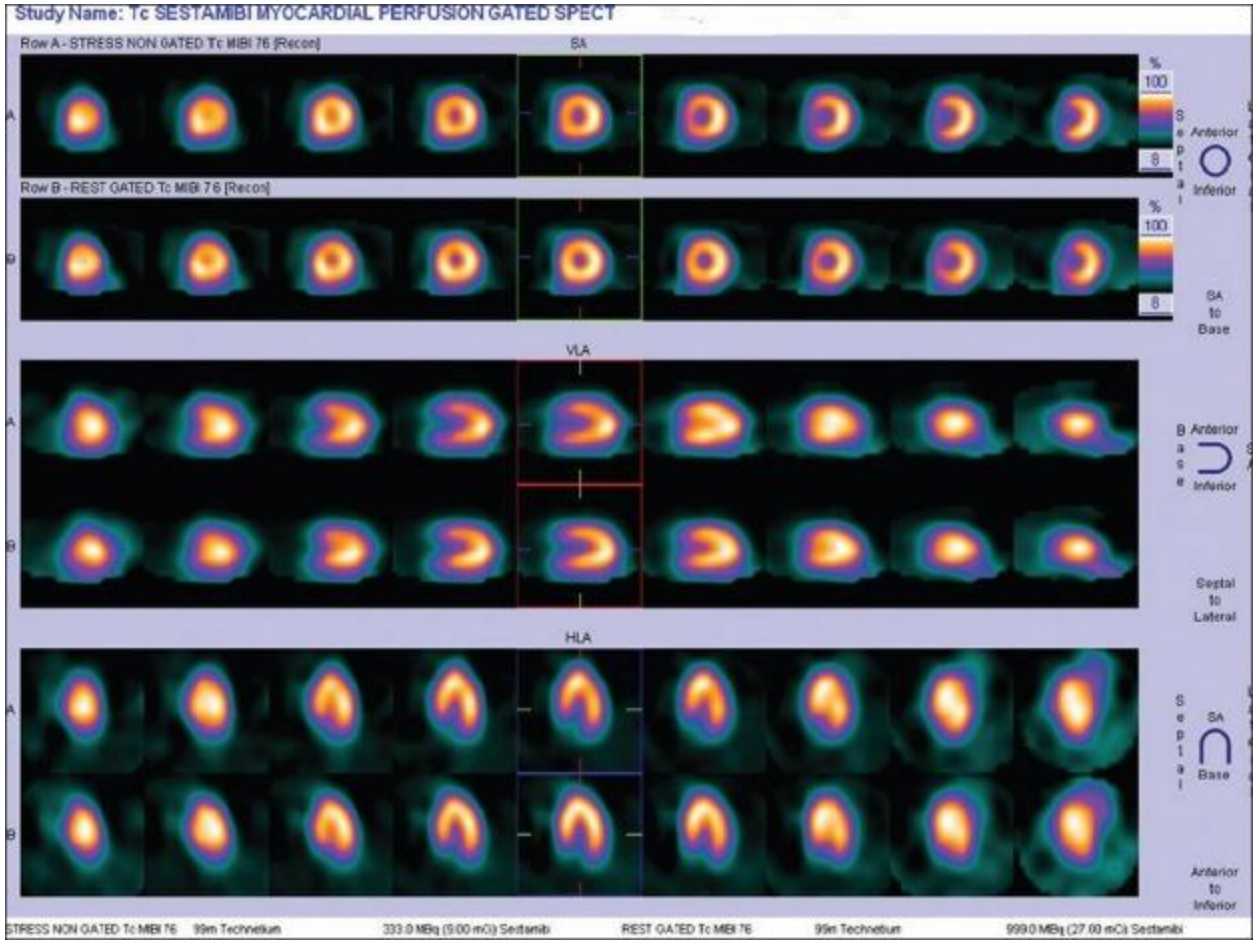
Why add imaging to stress ECG?

- In the cases of previous slide
- Intermediate to high risk pre-test
- Higher sensitivity and specificity than exercise ECG alone for detecting CAD
- Functional information
  - Area of myocardium at risk

Gibbons, et al. Circulation 1999;99:2829-2848.

Options-Echo and myocardial perfusion (nuclear)



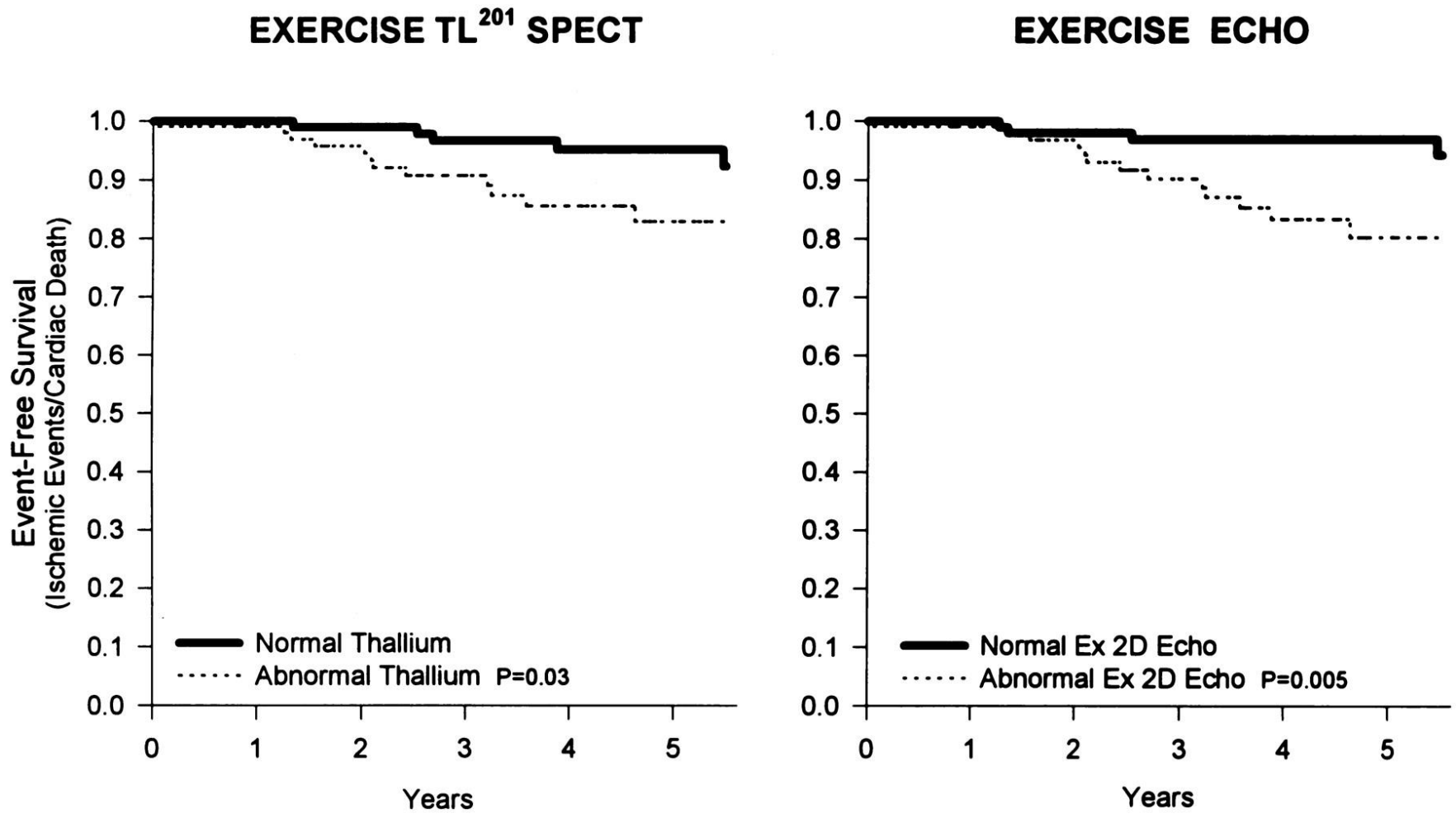


Diagnosis of flow limiting CAD

Study	MPI Sens (%)	Echo Sens (%)	MPI Spec (%)	Echo Spec (%)
O'Keefe JH, et al. 1995	83	78	77	86
Fleischmann KE, et al. 1998	87	85	64	77
Schinkel AF, et al. 2003	84	80	77	86

- Mean sensitivity 67%; mean specificity 72% for stress ECG alone
- Prognosis more important

Event-free survival curves for exercise SPECT and echo



Olmos LI, et al. Circulation. 1998;98:2679-2686

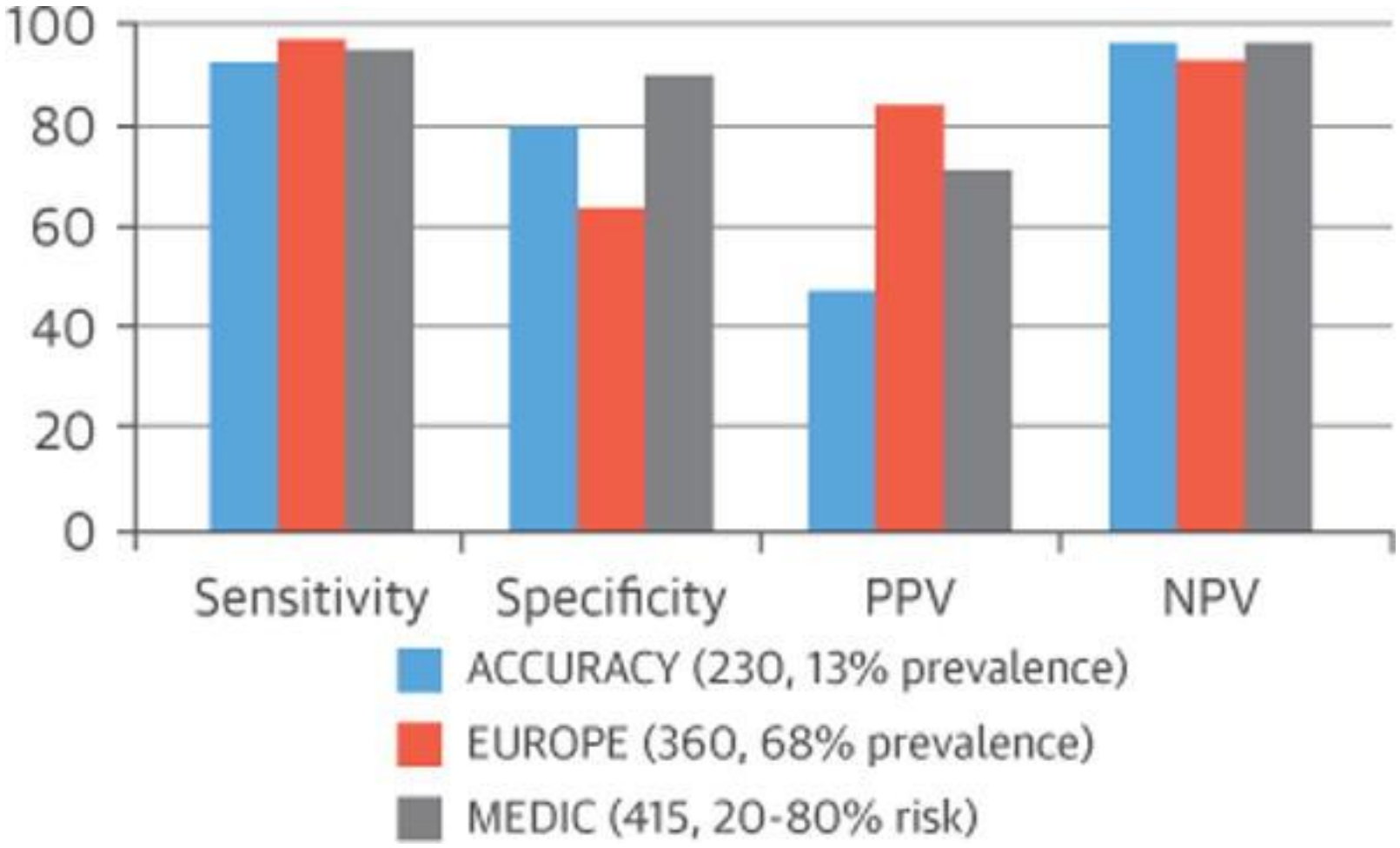
Comparing Stress echo vs MPI

	Advantages	Disadvantages
MPI (Nuclear)	Detects abnl flow reserve Peak-exercise images acquired Most studies complete Quantified LVEF and volumes Higher sensitivity	Longer time vs stress echo Radiation Lower spatial resolution Balanced ischemia missed
Stress ECHO	Safe No radiation Portable, faster Structural information Cheaper Higher specificity	Peak-exercise images difficult to acquire False-neg w/ rapid recovery 15% cannot assess entire myocardium Afib, LBBB

Coronary CT Angiography

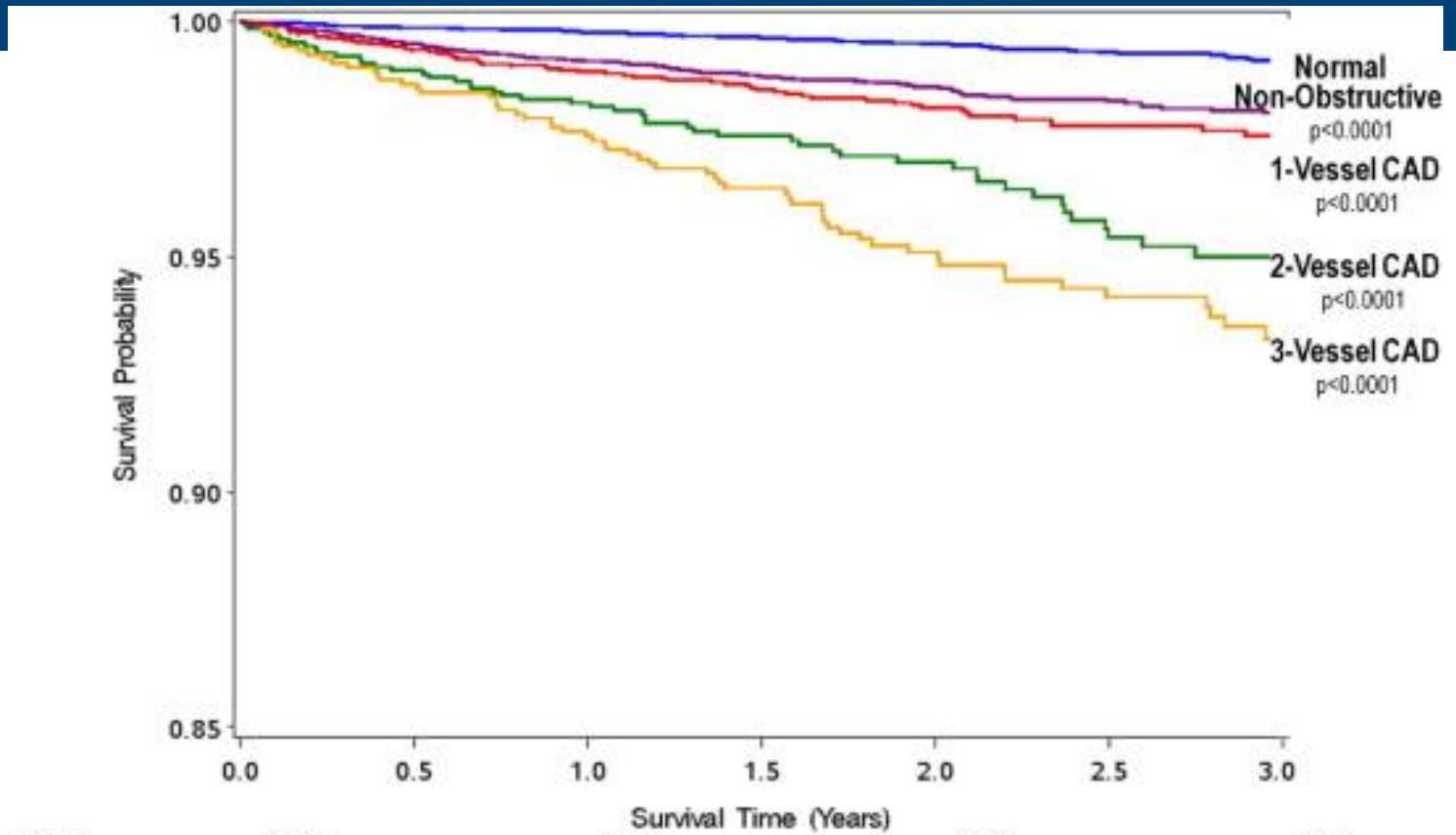
Schussler, JM, Grayburn PA. Heart. 2007 Mar;93(3):290-7.

Coronary CT Angiography Diagnosis



Marwick, TH, et al. JACC. 2015;65(25):2747-56.

Coronary CT Angiography Prognosis



At Risk	Year 0	Year 1	Year 2	Year 3
Normal	10146	9357	5800	2907
Non-Obstructive	8114	7437	4081	1930
1-Vessel	3118	2873	1747	782
2-Vessel	1346	1228	742	324
3-Vessel/Left Main	1130	1034	664	324

Min JK, et al. JACC. 58(8); 2011, 849–860

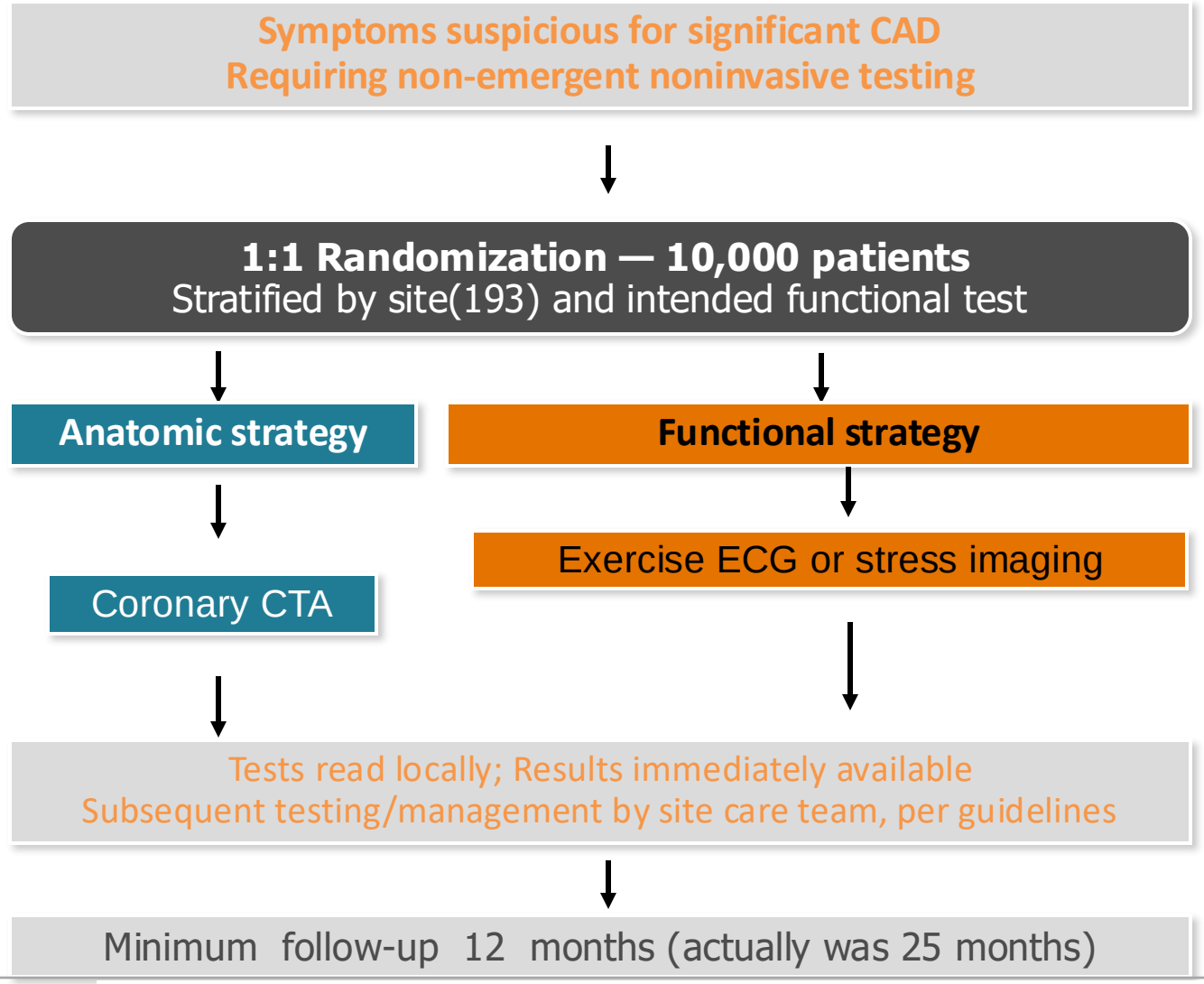
Coronary CT Angiography Limitations

- Not a test for every patient
- Possible contra-indications: Atrial fibrillation, chronic kidney disease
- Dense calcium
- Obesity
- Contrast and radiation exposure

PROMISE trial Prospective Multicenter Imaging Study for Evaluation of Chest Pain

Key Inclusion Criteria:

- Non-urgent, noninvasive CV testing clinically necessary
- No history of CAD or recent CAD evaluation
- Age ≥55 years (men) or ≥65 years (women) OR
- ≥45-54 years (men) or ≥50-64 years (women) with ≥1 major cardiac risk factor

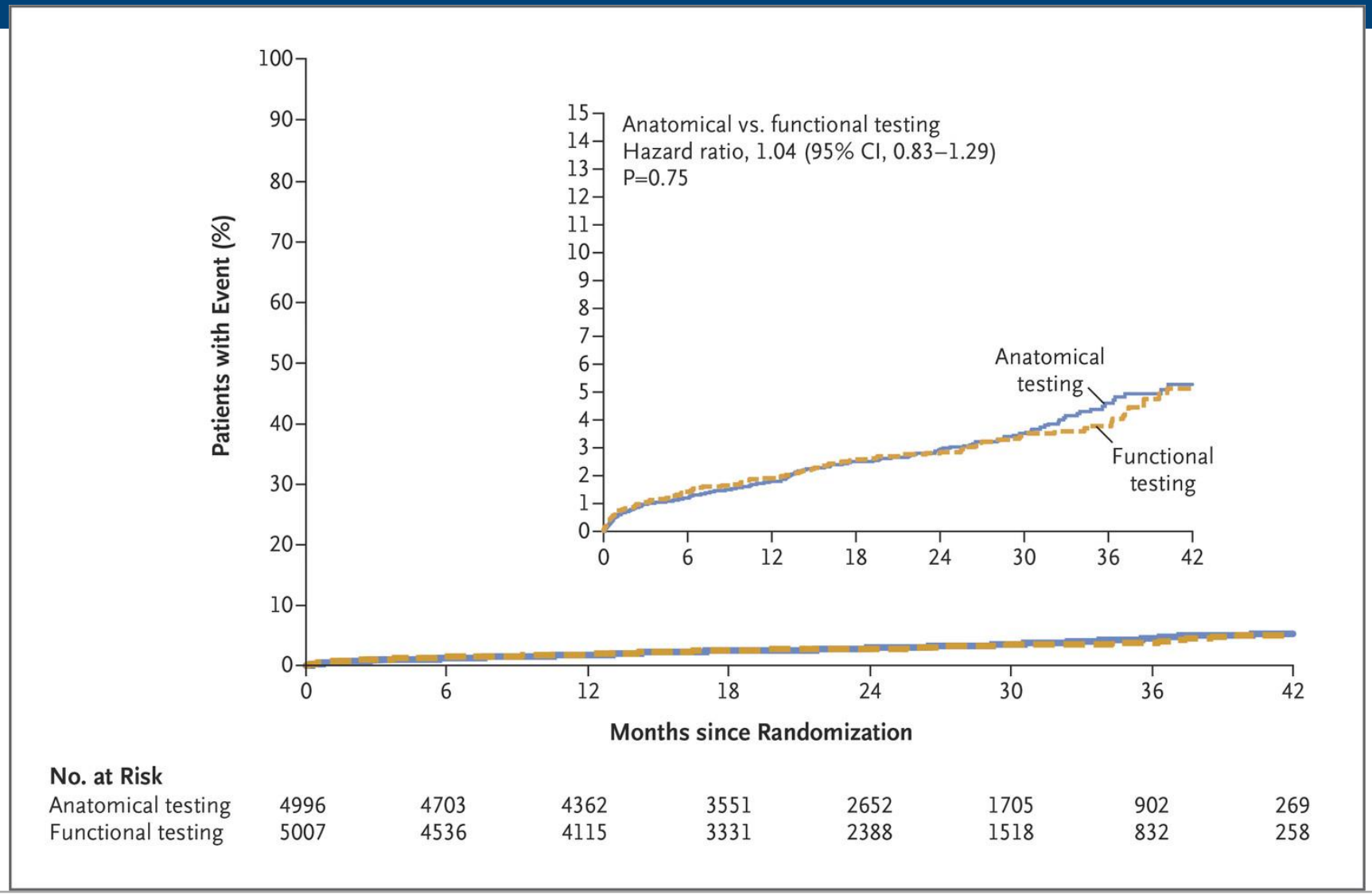


Douglas PS, et al. N Engl J Med 2015; 372:1291-1300.

UT Southwestern Medical Center

PROMISE trial

Primary composite end point (death from any cause, nonfatal myocardial infarction, hospitalization for unstable angina, or major procedural complication).



Douglas PS, et al. N Engl J Med 2015; 372:1291-1300.

UT Southwestern Medical Center

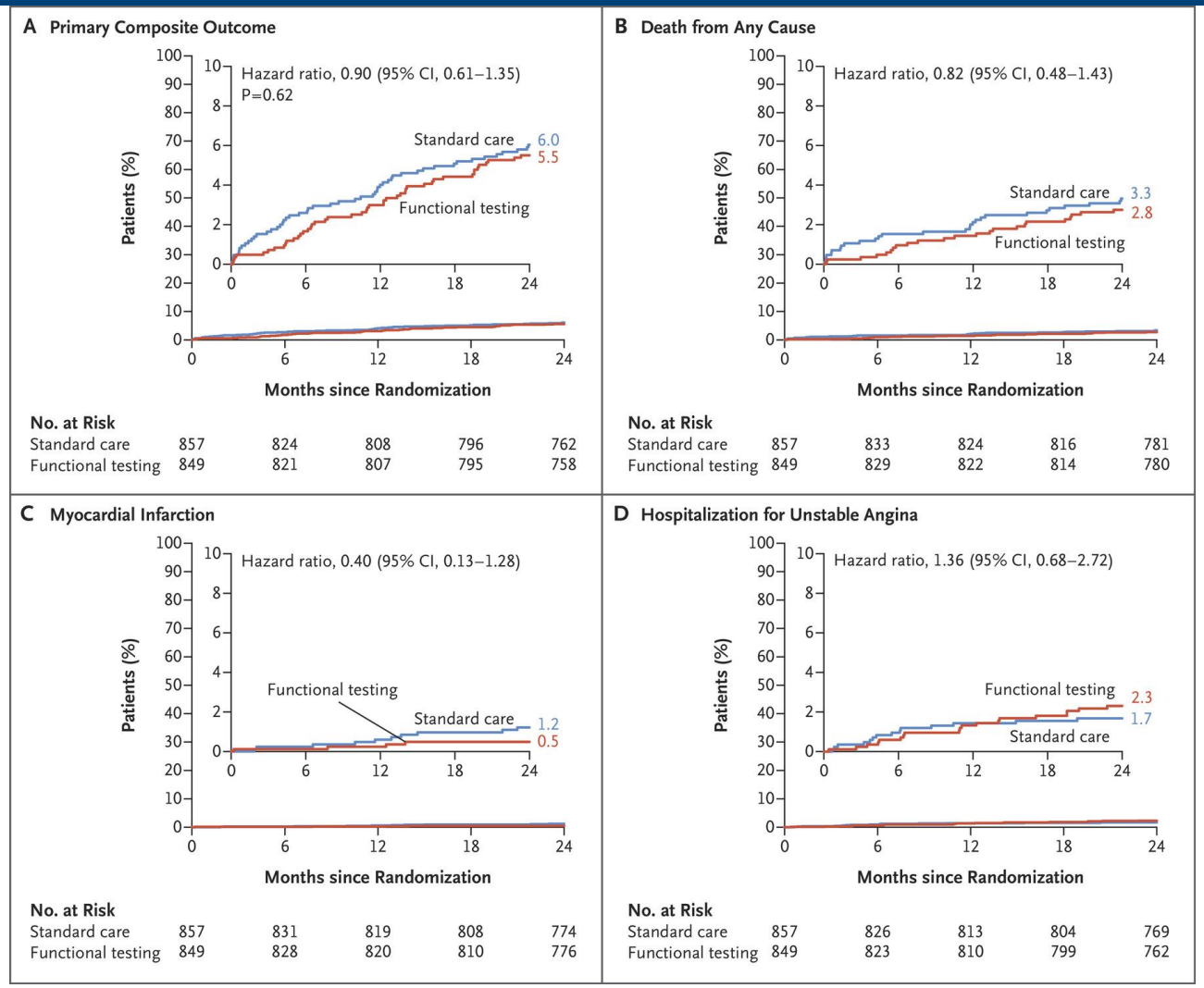
Diagnostic Testing Selection in CP with known CAD

- In patients with known CAD, and change in symptoms and/or functional capacity that persists despite GDMT
  - Class I indications:
    - stress imaging (nuclear or echo)
    - Invasive coronary angiography (ICA)

- Other testing to consider (Class 2a):
  - Exercise treadmill testing
  - Coronary CTA for larger stents (>3mm) or assess bypass patency

POST PCI trial

Routine Functional Testing or Standard Care in High-Risk Patients after PCI



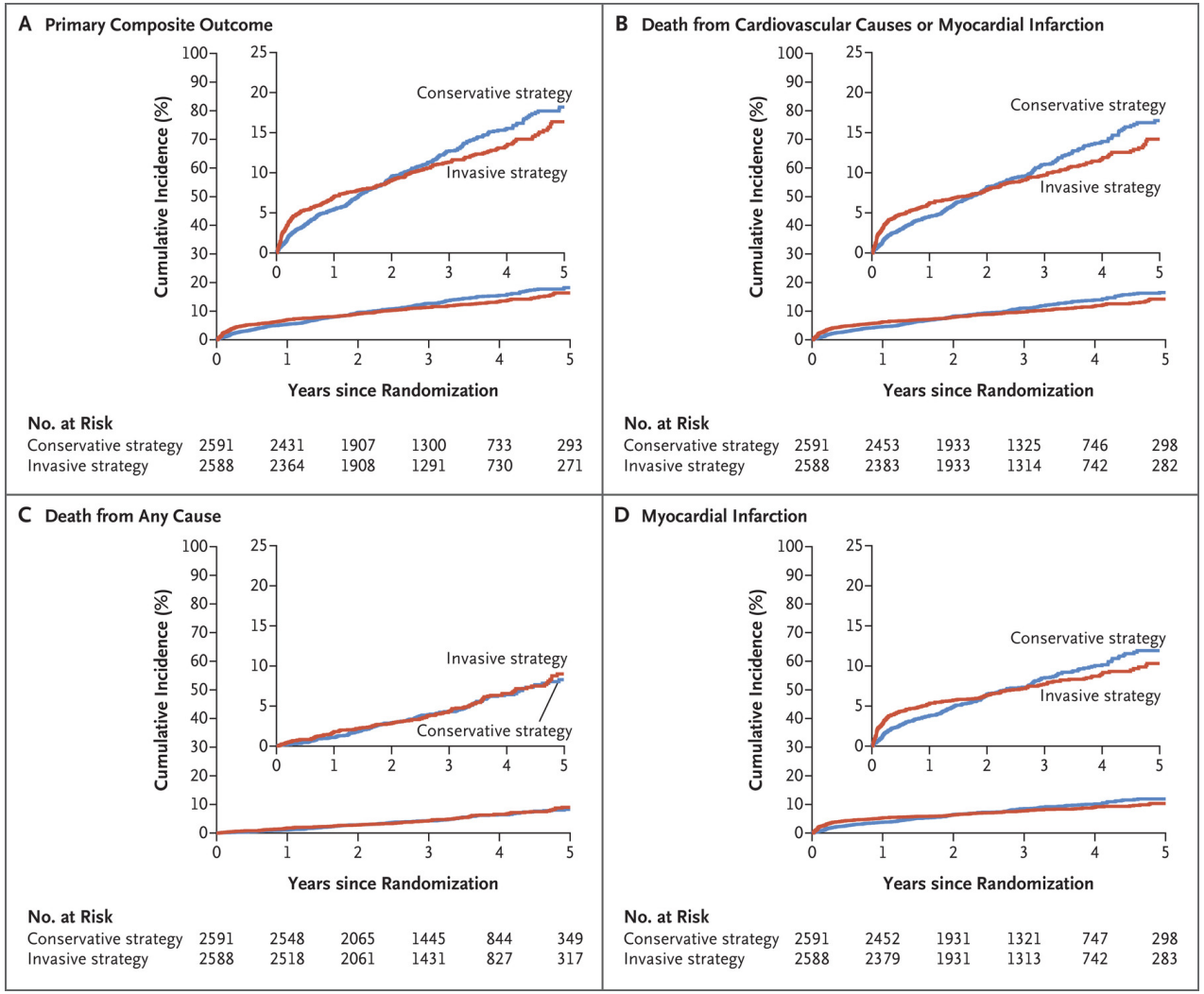
Park, DW, et al. N Engl J Med 2022; 387:905-915

Diagnostic Testing Selection

- *"In patients with CCD, if there is an opportunity to do so, clinicians should first intensify GDMT and defer testing."*
- Why make this recommendation?
- Three major RCTs including COURAGE, ISCHEMIA, and BARI-2D have shown no reduction in MACE with routine PCI/CABG.

ISCHEMIA Trial

- Initial Invasive or Conservative Strategy for Stable Coronary Disease
- Among patients with stable CCD and moderate or severe ischemia, an initial invasive strategy vs initial conservative strategy did not reduce the risk of ischemic CV events or death from any cause



Maron, DJ, et al. N Engl J Med 2020; 382:1395-1407

UT Southwestern Medical Center

Treatment of stable angina

- Aspirin
- Beta blockers
- Calcium channel blockers
  - Dihydropyridines-amlodipine
  - Non-DHP-verapamil and diltiazem
- Oral nitrates

- Secondary prevention of events: HIGH INTENSITY STATIN
  - Atorvastatin and rosuvastatin

Treatment of stable angina

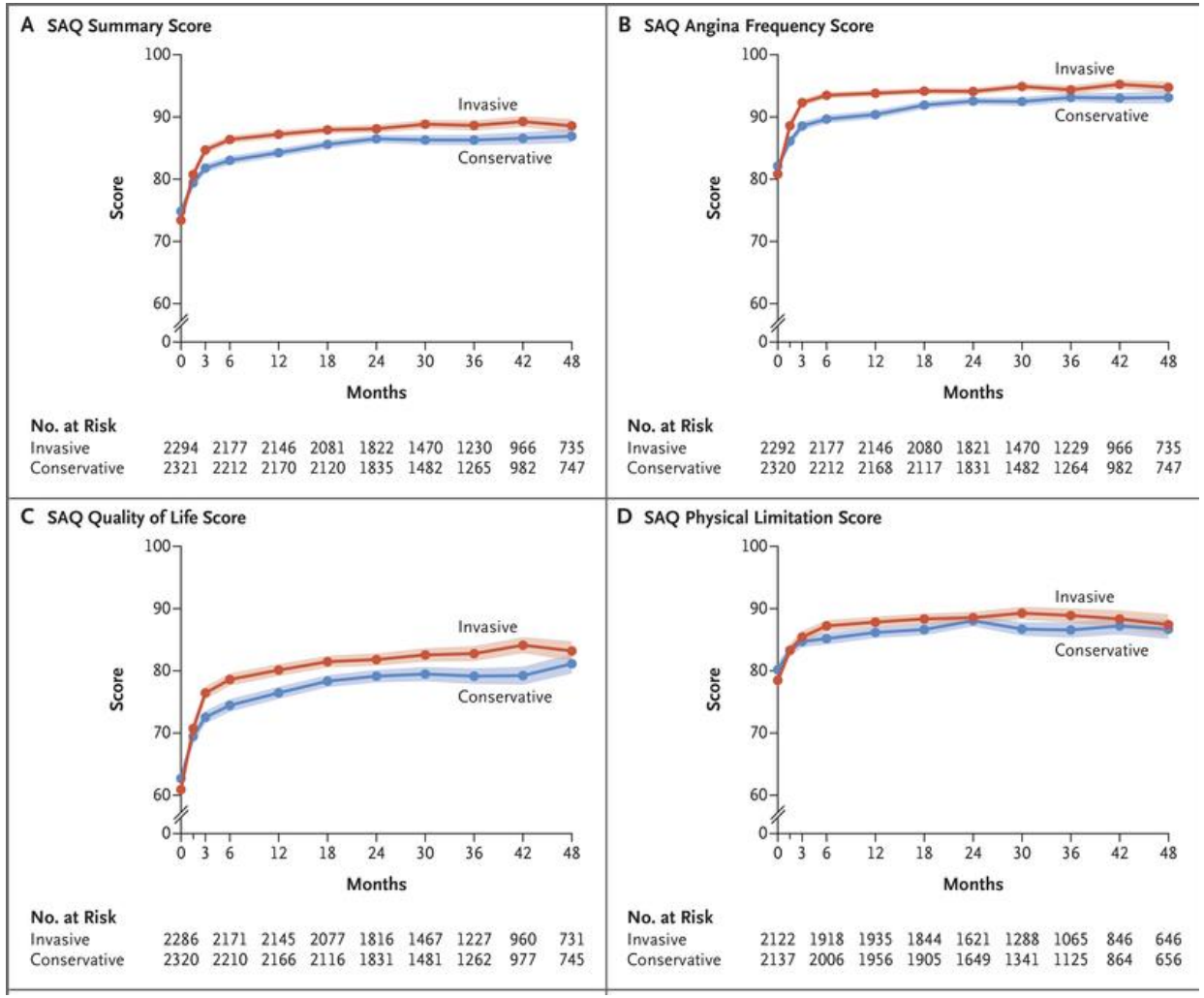
Drug	Mechanism of Action	Adverse effects	Common doses
Beta blocker	Slow HR Decrease myocardial contractility Lower afterload with lower BP	Bronchospasm Bradycardia Hypotension Fatigue Erectile dysfunction	Metoprolol 25-50 mg bid Atenolol 25-50 mg daily Carvedilol 3.125-6.25 mg bid
Calcium channel blockers-DHP	Arterial vasodilator Lower BP	Hypotension Peripheral edema	Amlodipine 5-10 mg daily
CCB-non DHP	As for DHPs Decrease myocardial contractility Slow HR	Avoid in depressed LVEF Bradycardia	Diltiazem 30 mg tid Verapamil 40 mg tid
Nitrates	Coronary vasodilator Reduce preload Lower BP	Headaches Nitrate tolerance Hypotension	Isosorbide mononitrate 60-120 mg daily Isosorbide dinitrate 10-20 mg tid

Revascularization in CCD

- For lifestyle limiting angina despite GDMT, coronary revascularization procedures are recommended (class 1)

ISCHEMIA trial and angina

- To assess angina-related health status among ISCHEMIA patients
- Patients randomly assigned to the invasive strategy had greater improvement in angina-related health status than those assigned to the conservative strategy.
- *Larger differences seen among patients who had more angina at baseline.*



Spertus JA, et al. N Engl J Med. 2020 Apr 9;382(15):1408-1419.

Question

- What is the criteria for concluding an exercise treadmill stress test is positive for inducible myocardial ischemia?

A. 1-2 mm up slopping ST segment depression.
B. >= 1mm horizontal or down sloping ST segment depression 0.08msec after the J-point for 3 consecutive beats.
C. Chest pain while on the treadmill.
D. Frequent premature ventricular contractions.
E. New T wave inversions during exercise.

Question

- Chest pain consistent with angina pectoris usually has which of the following qualities?

A. Pain is located only below the epigastric area.
B. Pain sensation is worth with deep breaths.
C. Pain sensation is sharp or stabbing.
D. Exertional pain described as pressure or tightness located retrosternal.
E. Pain sensation is positional, worse with movements of the chest.

Take Home Points

- Initial evaluation of chest pain patients by history important
- Exercise stress ECG still has an important role in evaluation of chest pain
- Stress ECG interpretation important for purposes of diagnosis and prognosis
- In stable chest pain patients, non invasive evaluation favored followed by medical therapy in patients with CAD
- Revascularization recommended for patients who have refractory symptoms despite medical therapy