

# International Heart Consortium: Cardiac Evaluation and Treatment of Chest pain

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# Question

- What is the criteria for concluding an exercise treadmill stress test is positive for inducible myocardial ischemia?
  - A. 1-2 mm up sloping ST segment depression.
  - B.  $\geq 1$ mm 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 worse 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

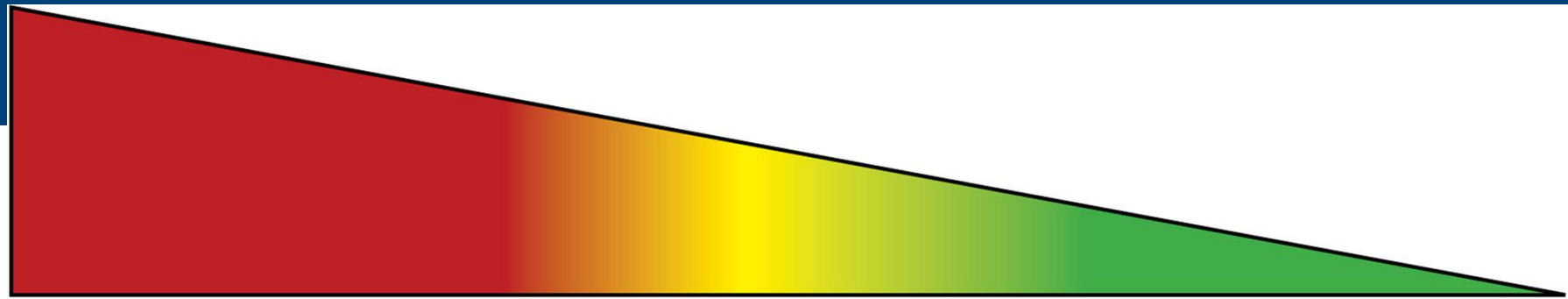
# Introduction

- 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

# 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**

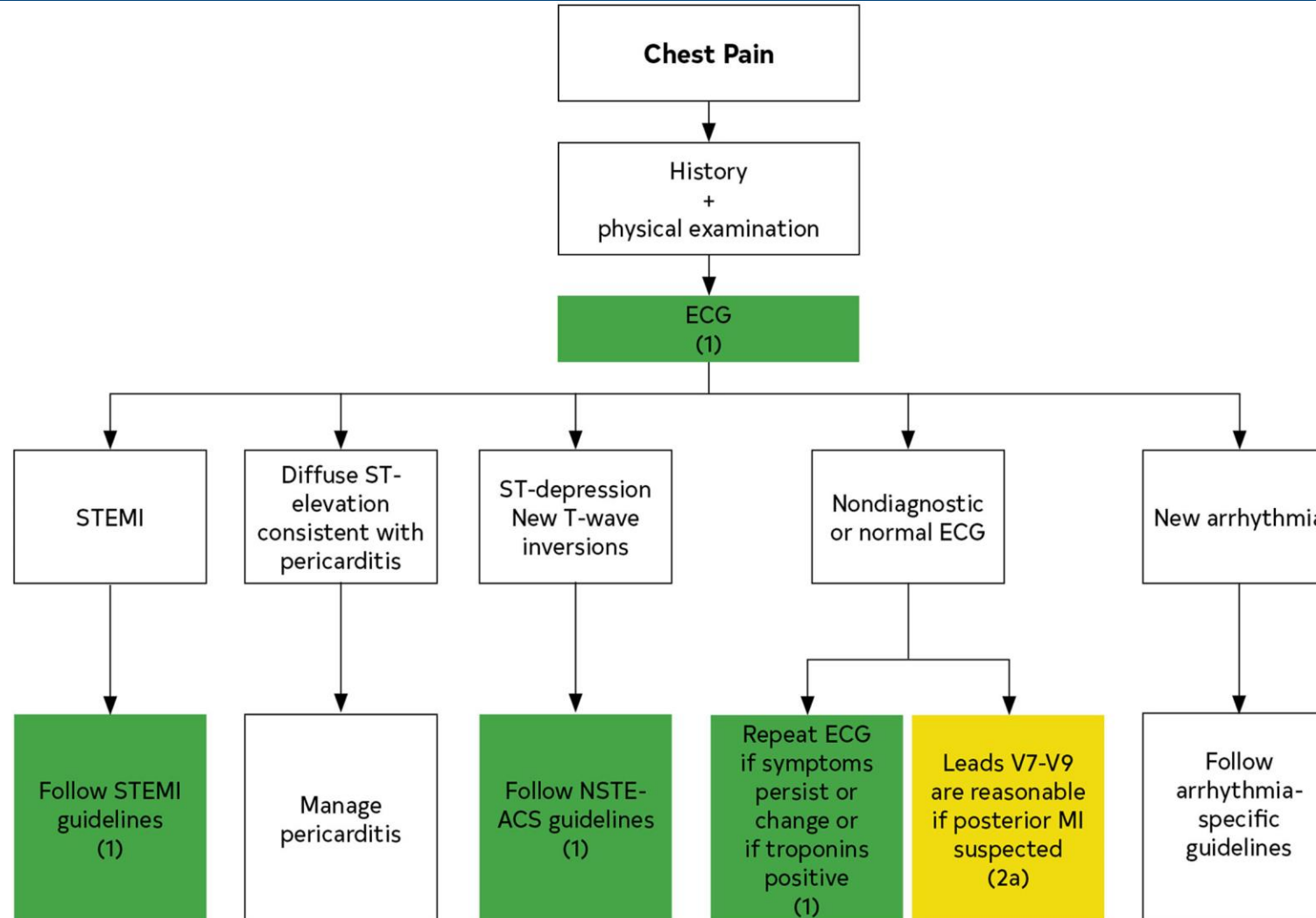
- Use “cardiac,” “possible cardiac,” and “noncardiac”



# Physical Exam

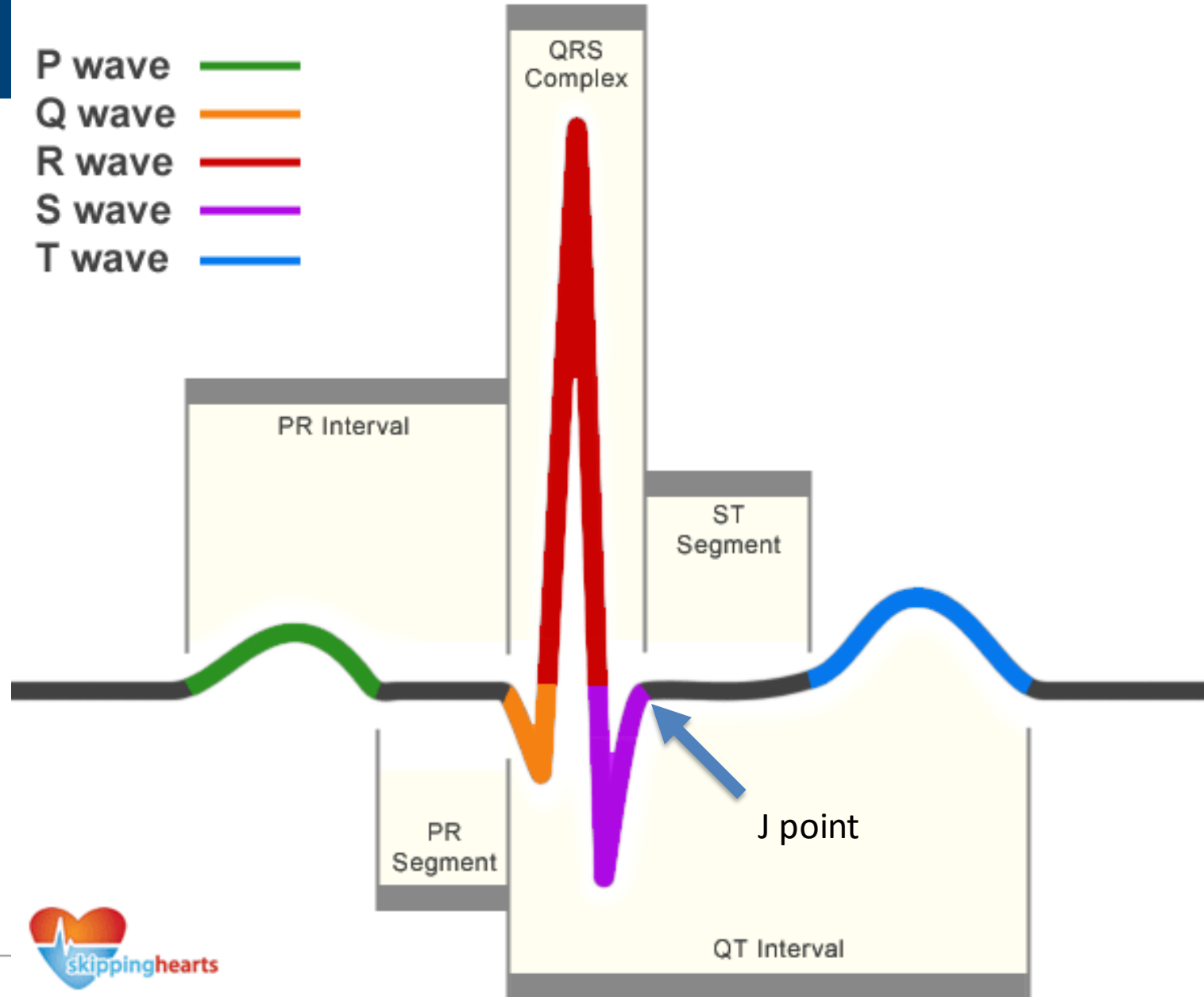
- Diaphoresis, tachypnea, tachycardia, hypotension, crackles, S3, MR murmur; examination may be normal in uncomplicated cases
- Think about other causes

# ECG initial first test



# ECG of Normal Sinus Rhythm

- P wave ———
- Q wave ———
- R wave ———
- S wave ———
- T wave ———



# Normal ECG

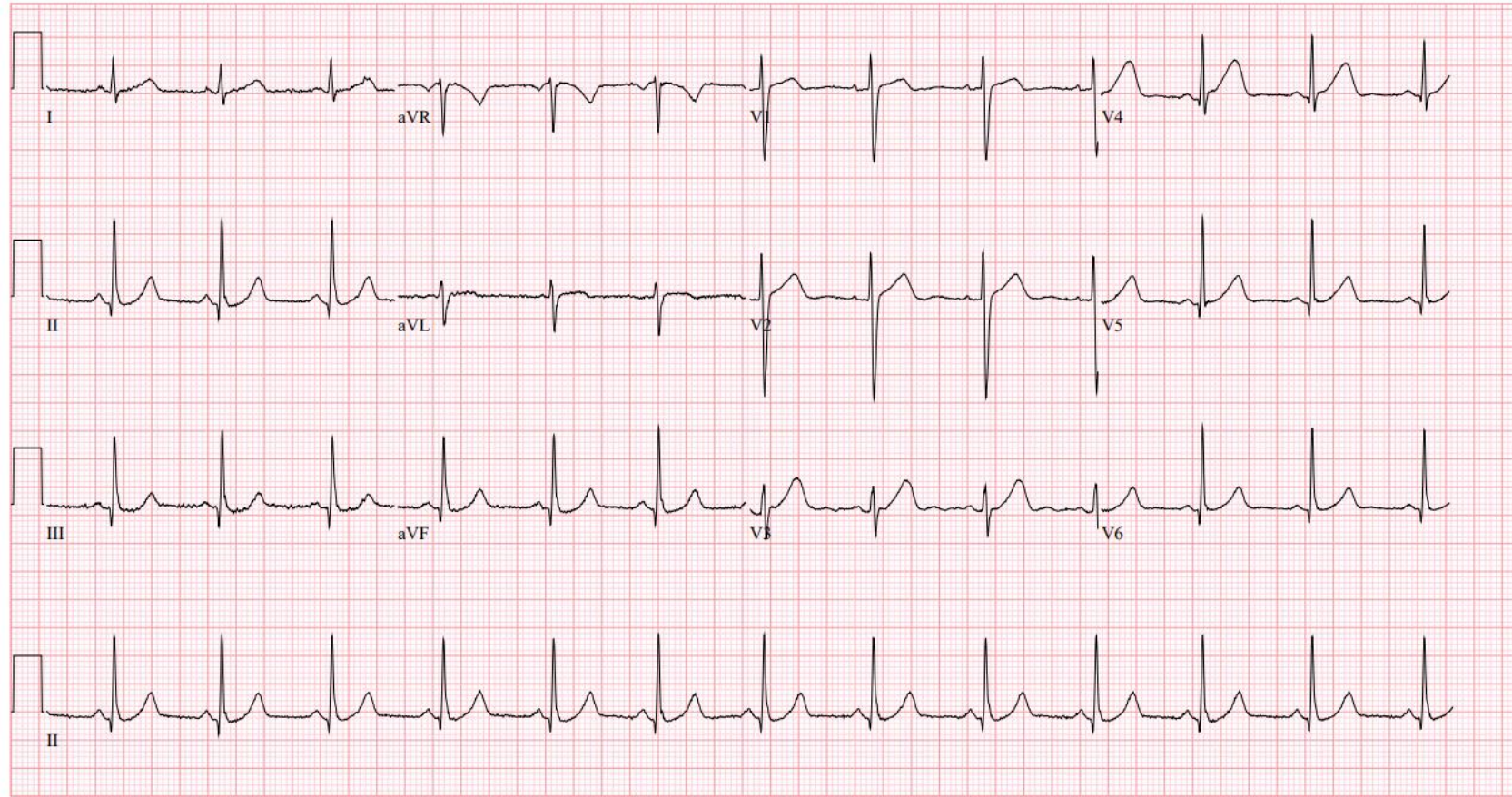
Technician: 62024  
Test ind:

REASON: Chest Pain

DIAGNOSIS:

DIAGNOSIS:

Unconfirmed

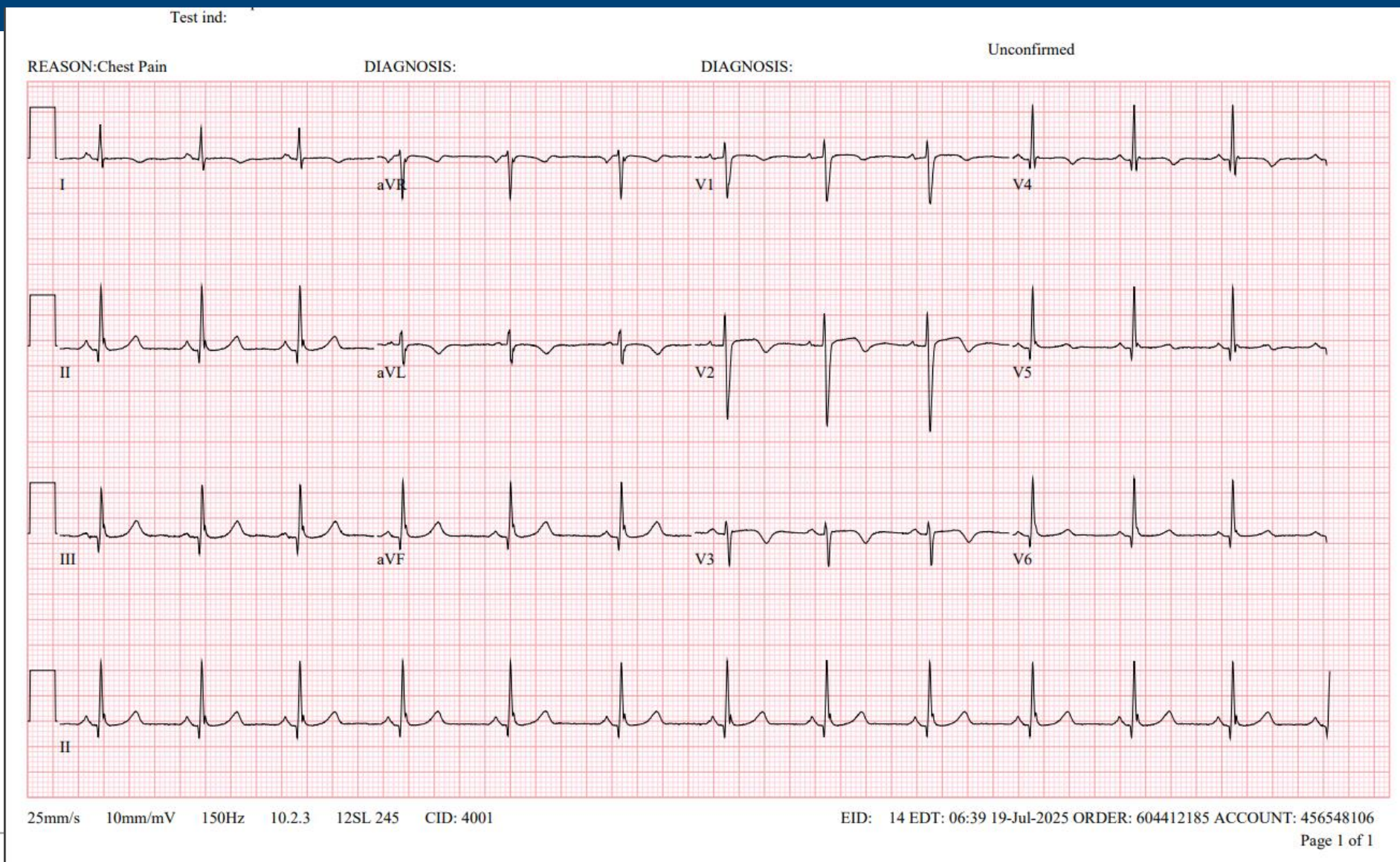


25mm/s 10mm/mV 150Hz 10.2.3 12SL 245 CID: 4045

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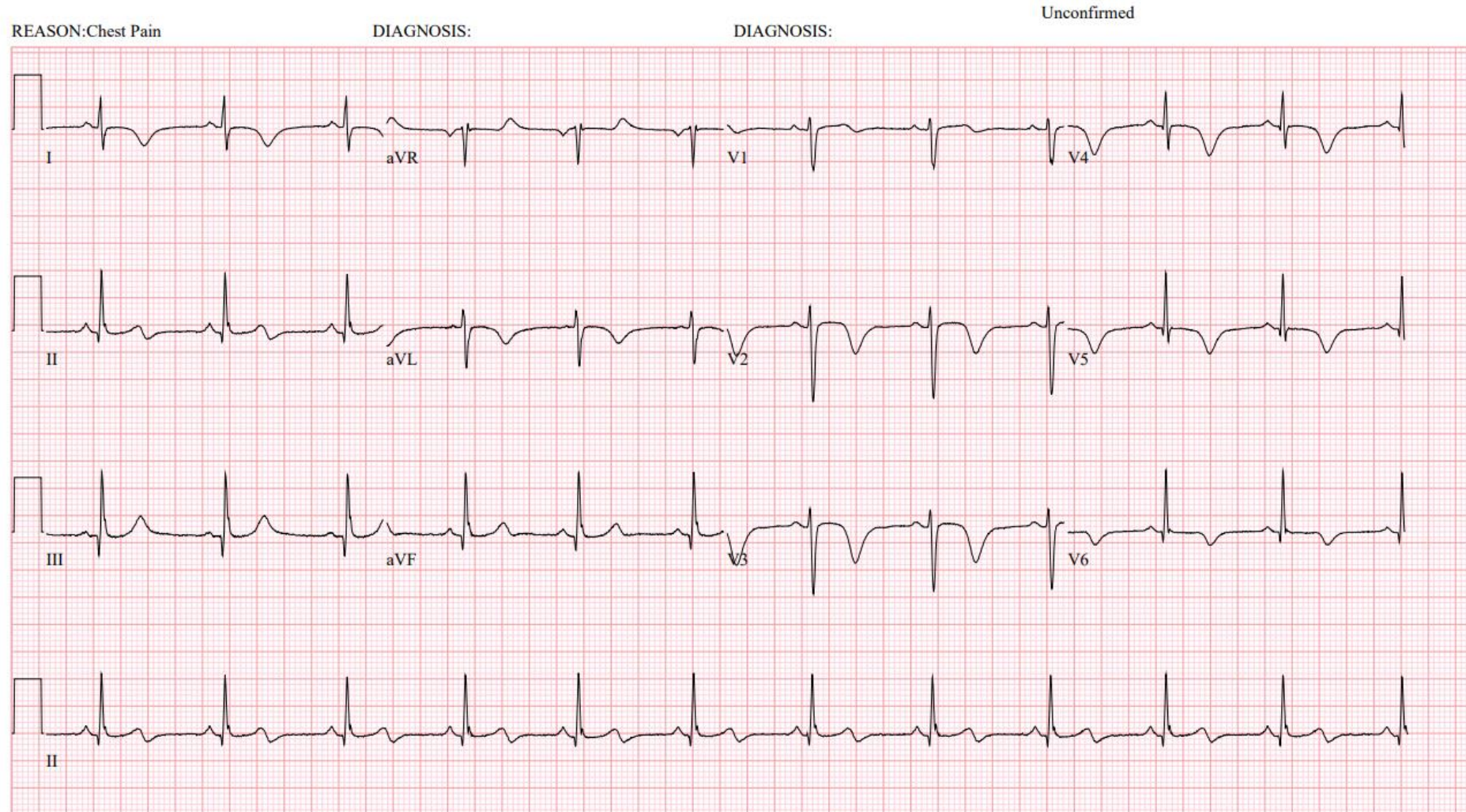
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# ECG in Acute Coronary Syndromes



# ECG in Acute Coronary Syndromes

Technician: Grace Manning  
Test ind:



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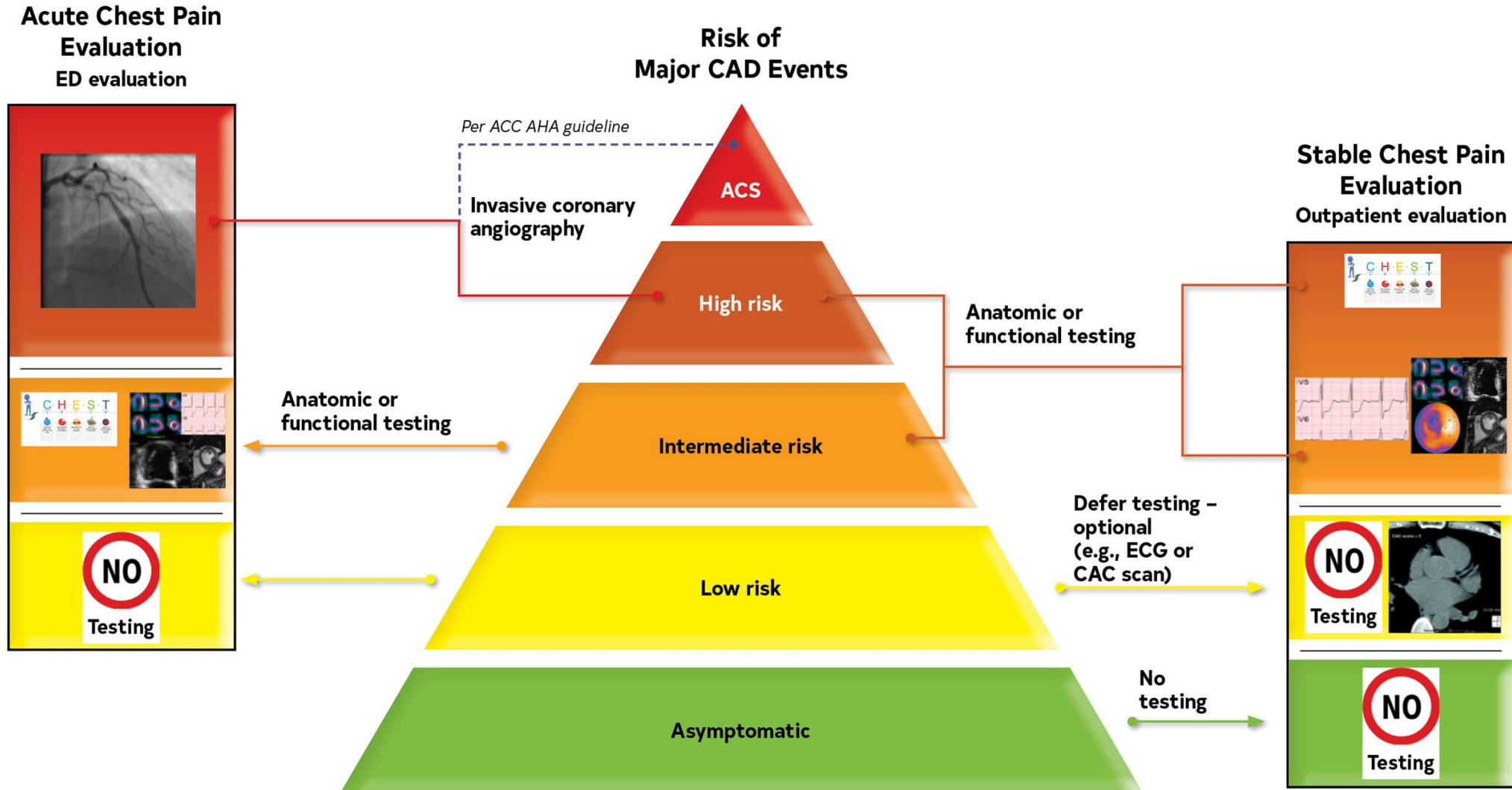
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# Risk Stratifying Chest Pain

The HEART Score for Chest Pain Patients in the ED		
<b>History</b>	<ul style="list-style-type: none"> <li>Highly Suspicious</li> <li>Moderately Suspicious</li> <li>Slightly or Non-Suspicious</li> </ul>	<ul style="list-style-type: none"> <li>2 points</li> <li>1 point</li> <li>0 points</li> </ul>
<b>ECG</b>	<ul style="list-style-type: none"> <li>Significant ST-Depression</li> <li>Nonspecific Repolarization</li> <li>Normal</li> </ul>	<ul style="list-style-type: none"> <li>2 points</li> <li>1 point</li> <li>0 points</li> </ul>
<b>Age</b>	<ul style="list-style-type: none"> <li>≥ 65 years</li> <li>&gt; 45 - &lt; 65 years</li> <li>≤ 45 years</li> </ul>	<ul style="list-style-type: none"> <li>2 points</li> <li>1 point</li> <li>0 points</li> </ul>
<b>Risk Factors</b>	<ul style="list-style-type: none"> <li>≥ 3 Risk Factors or History of CAD</li> <li>1 or 2 Risk Factors</li> <li>No Risk Factors</li> </ul>	<ul style="list-style-type: none"> <li>2 points</li> <li>1 point</li> <li>0 points</li> </ul>
<b>Troponin</b>	<ul style="list-style-type: none"> <li>≥ 3 x Normal Limit</li> <li>&gt; 1 - &lt; 3 x Normal Limit</li> <li>≤ Normal Limit</li> </ul>	<ul style="list-style-type: none"> <li>2 points</li> <li>1 point</li> <li>0 points</li> </ul>
<b>Risk Factors:</b> DM, current or recent (<one month) smoker, HTN, HLP, family history of CAD, & obesity		
<b>Score 0 – 3:</b> 2.5% MACE over next 6 weeks → Discharge Home		
<b>Score 4 – 6:</b> 20.3% MACE over next 6 weeks → Admit for Clinical Observation		
<b>Score 7 – 10:</b> 72.7% MACE over next 6 weeks → Early Invasive Strategies		

# Chest Pain and Cardiac Testing Considerations



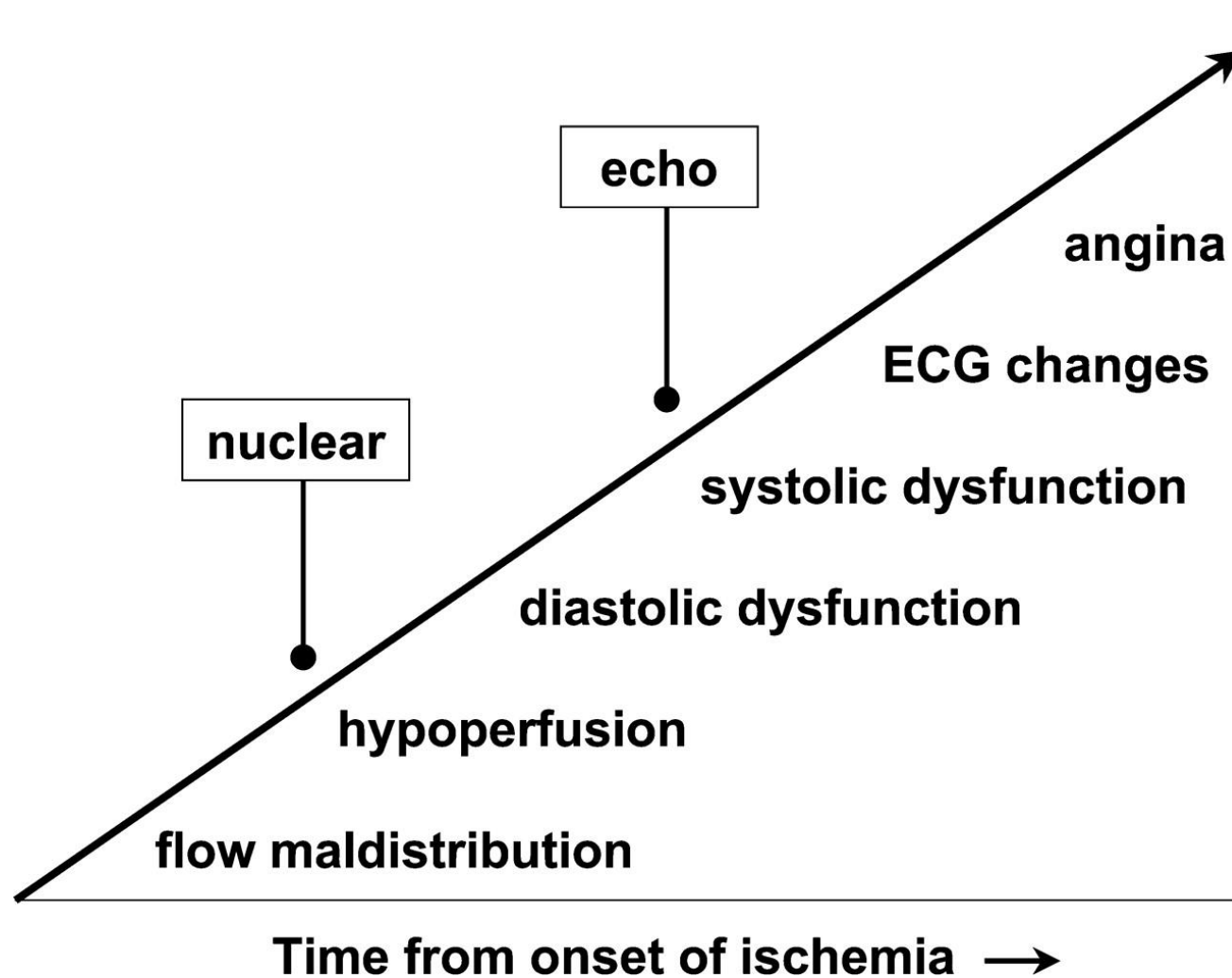
# Non-invasive evaluation of suspected CAD

- 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



# 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

**A** Pretest probability based on age, sex, and symptoms

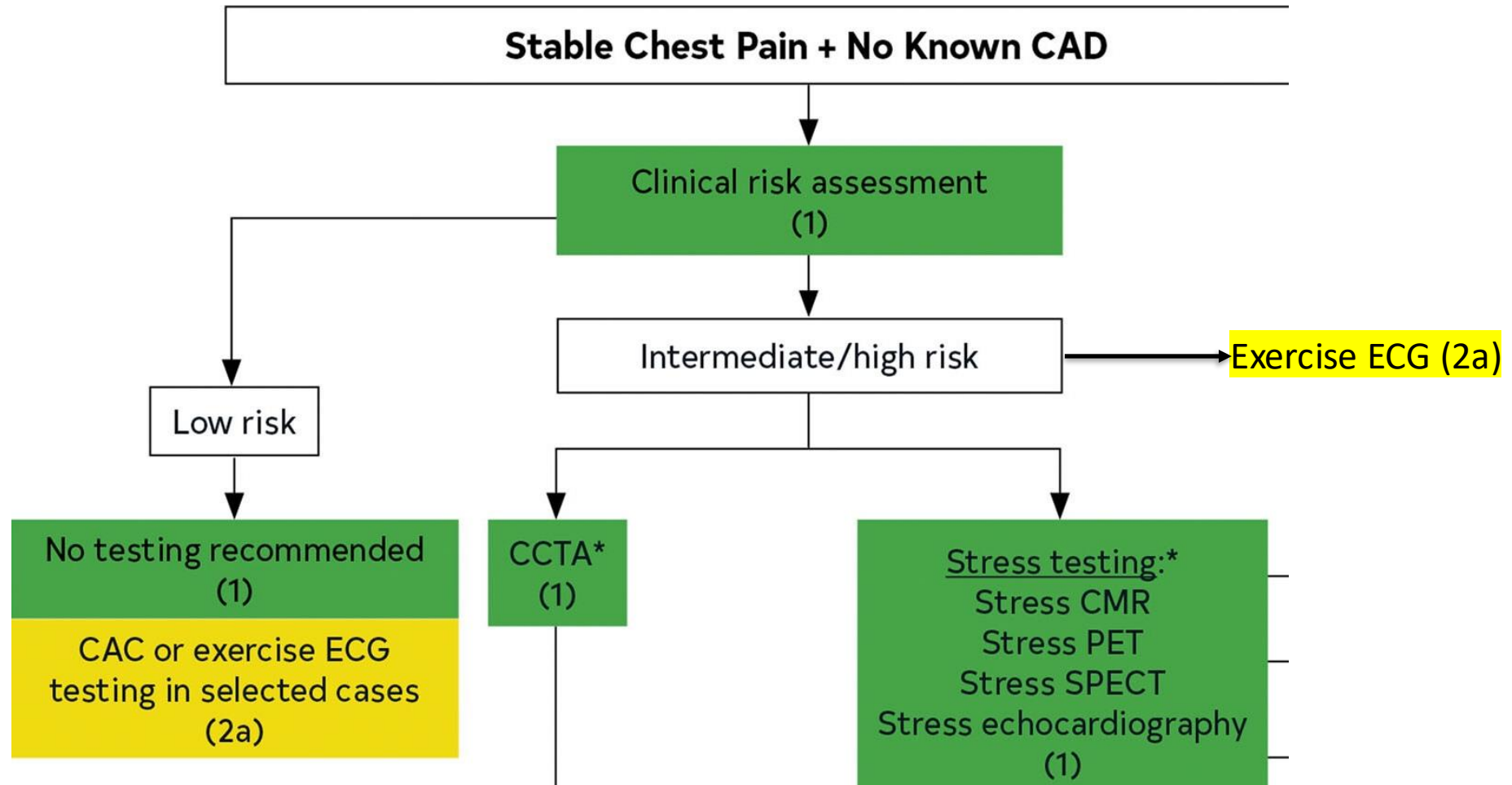


**B** Pretest probability based on age, sex, symptoms, and CAC score<sup>+</sup>



CAC 1-99      CAC ≥100-999      CAC ≥1,000

# Patients With No Known CAD Presenting With Stable CP



# 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

# 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

# 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% MPPHR

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

# Diagnosis of Ischemia on Stress ECG

## Positive test

- 1mm horizontal or down 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

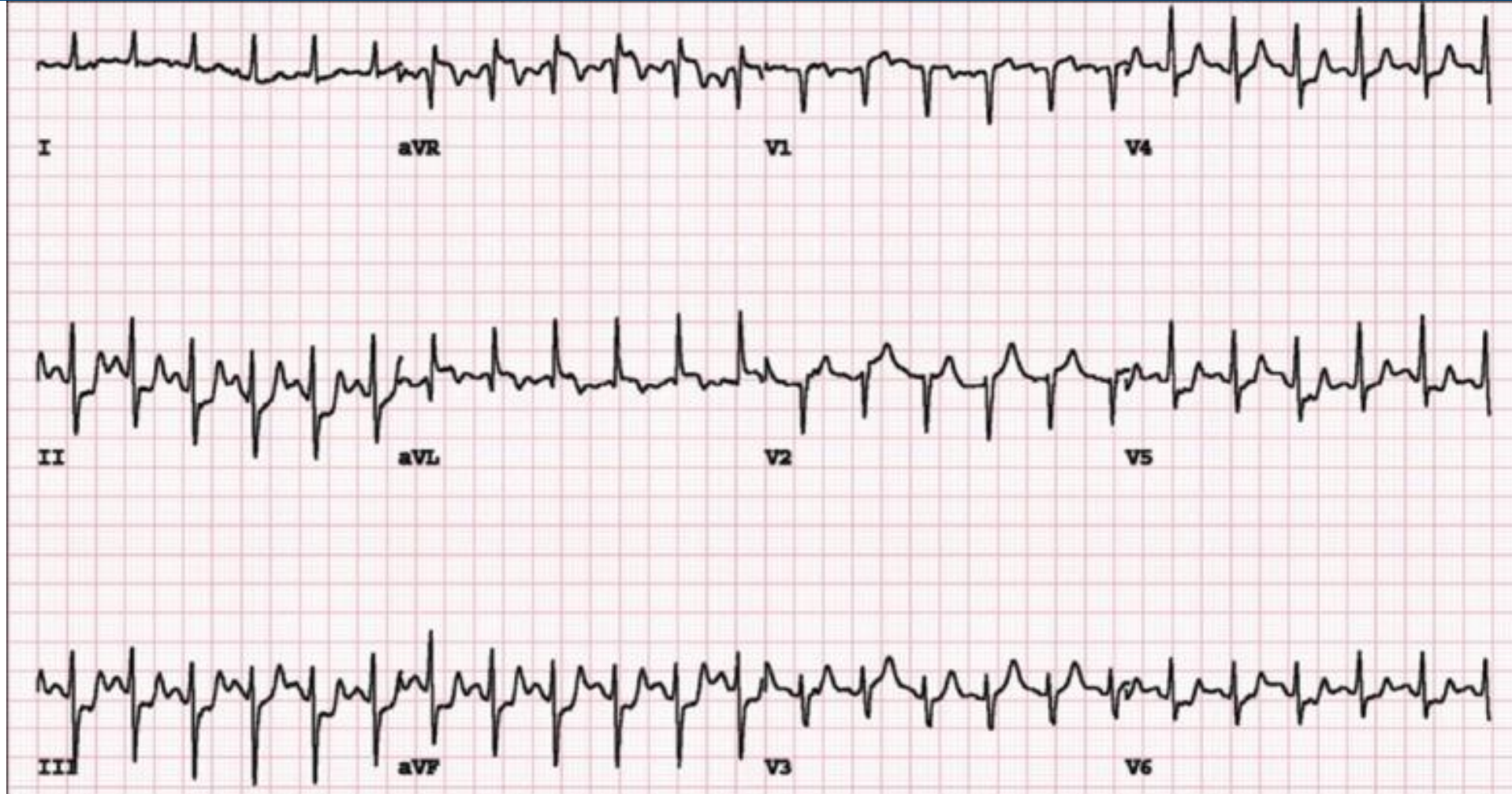


Horizontal

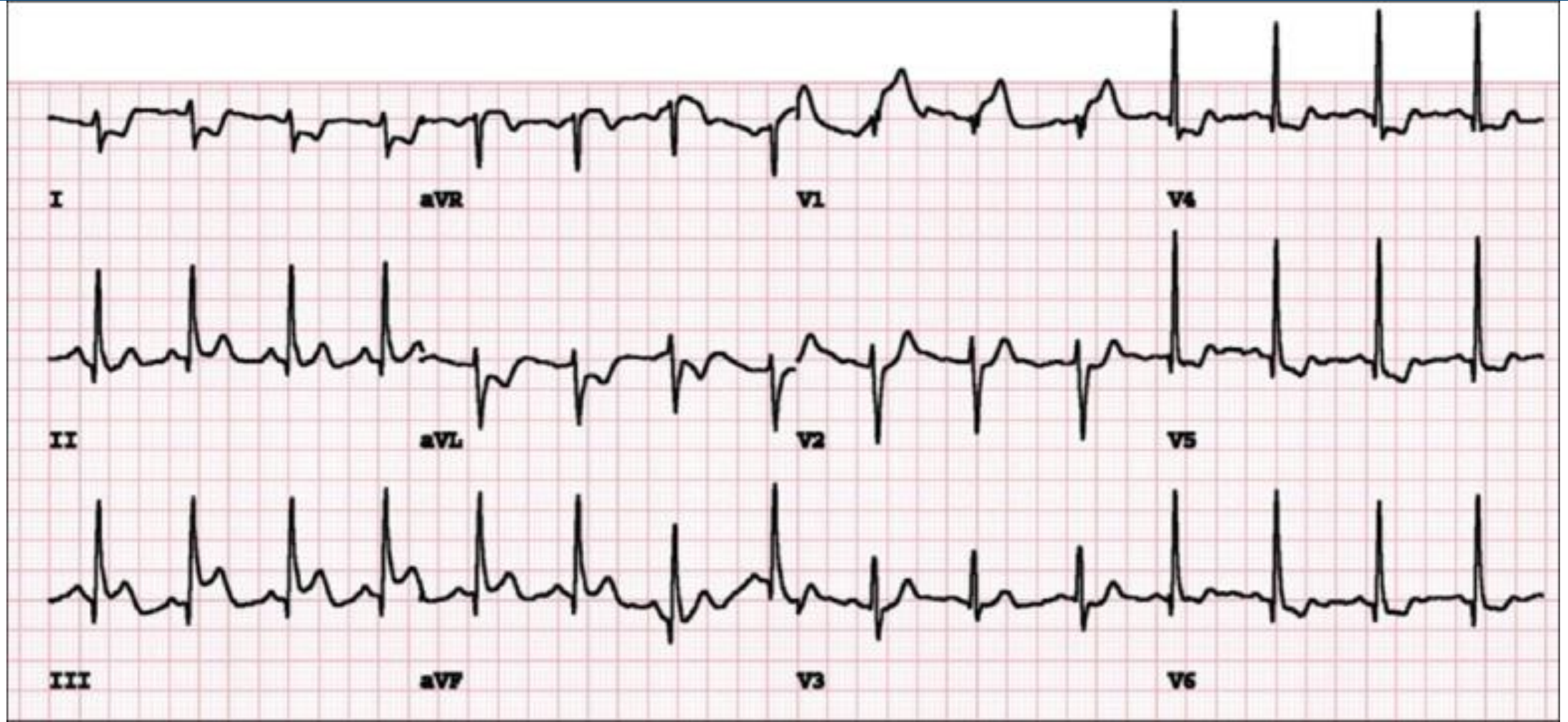


Down sloping

# Abnormal stress ECG



# Abnormal stress ECG



# 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

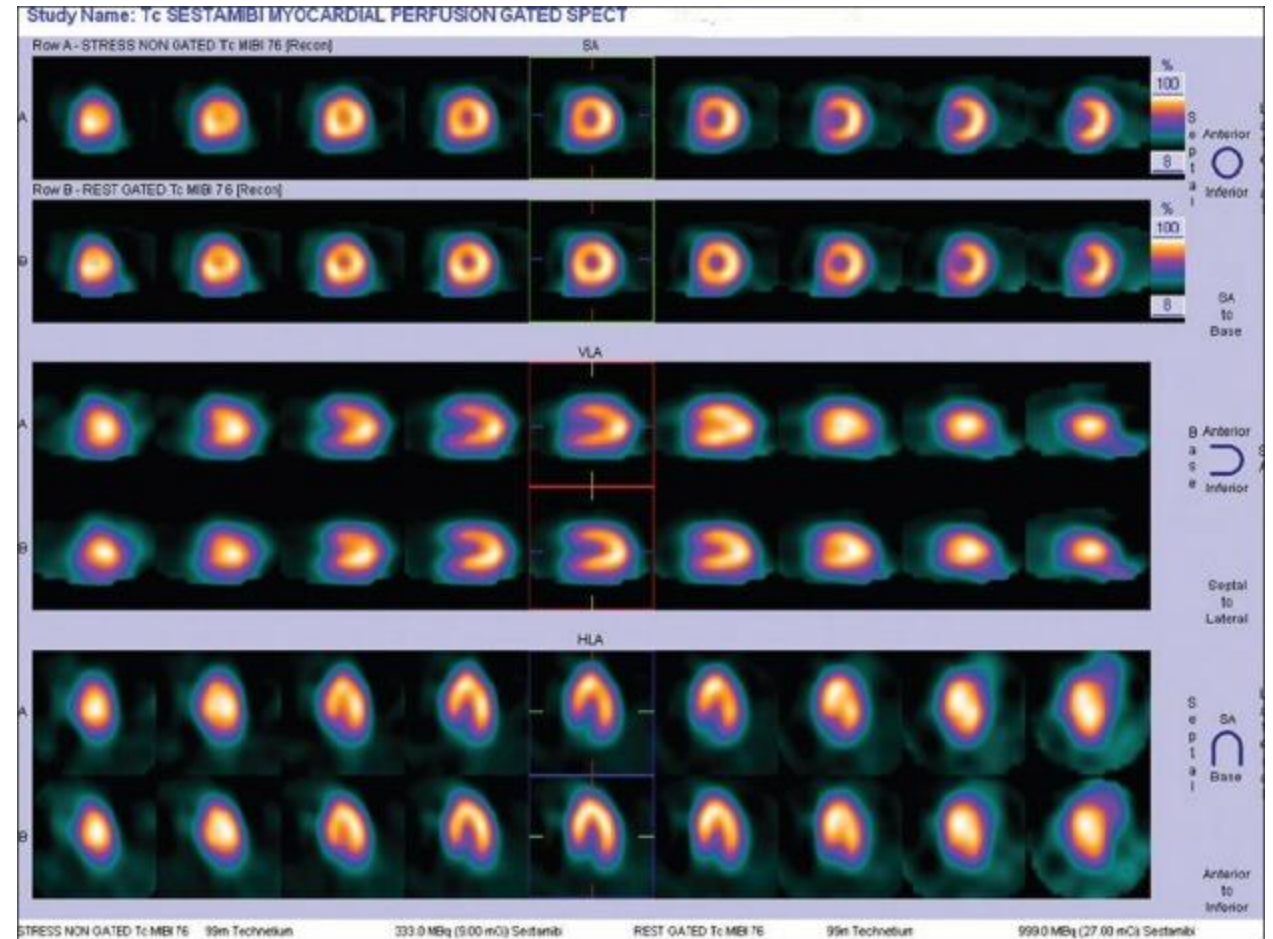
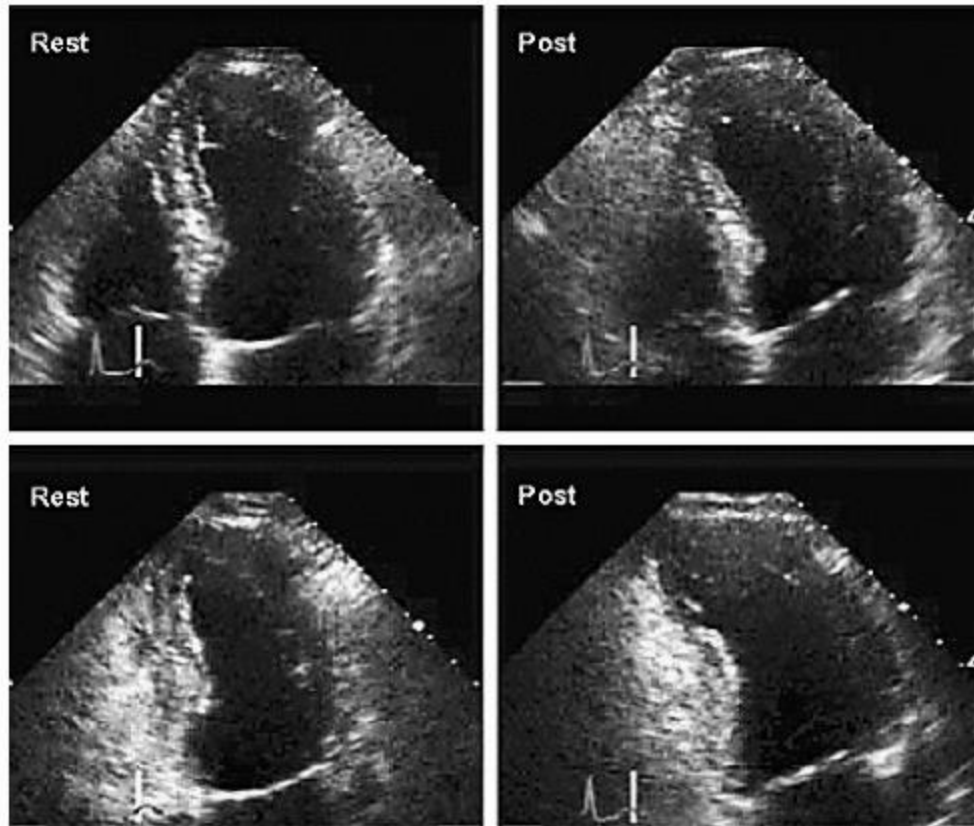
# When NOT to use Stress ECG alone

- 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

# Options-Echo and myocardial perfusion (nuclear)

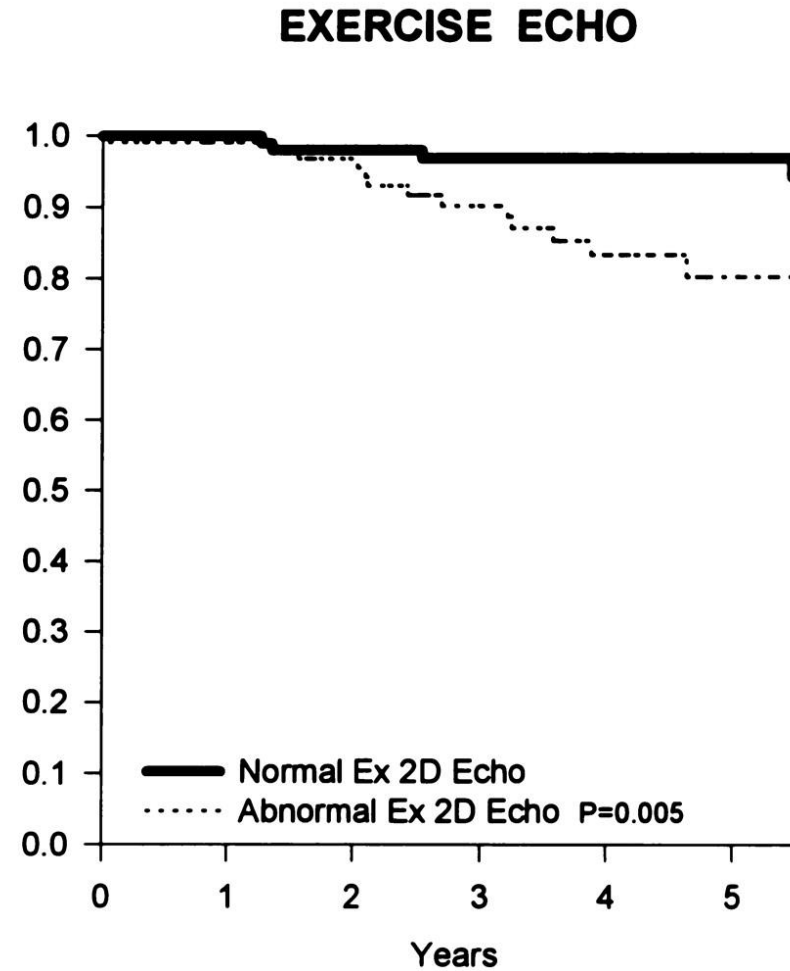
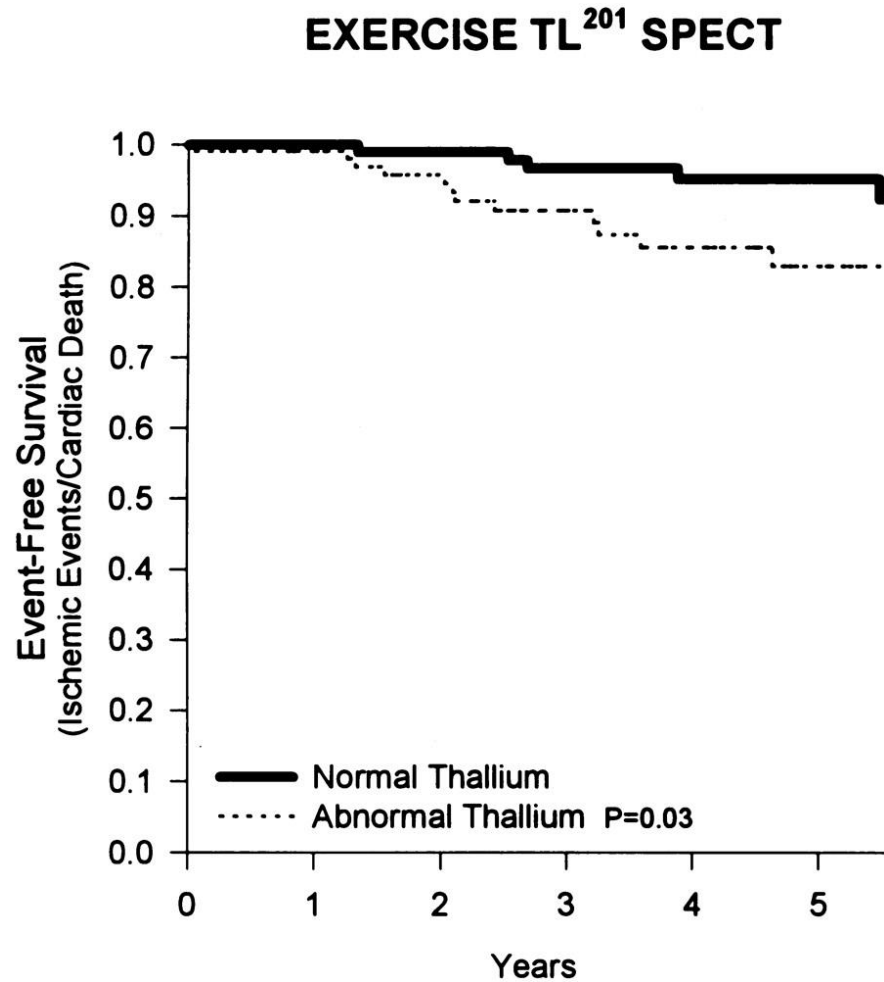


# Diagnosis of flow limiting CAD

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



# Comparing Stress echo vs MPI

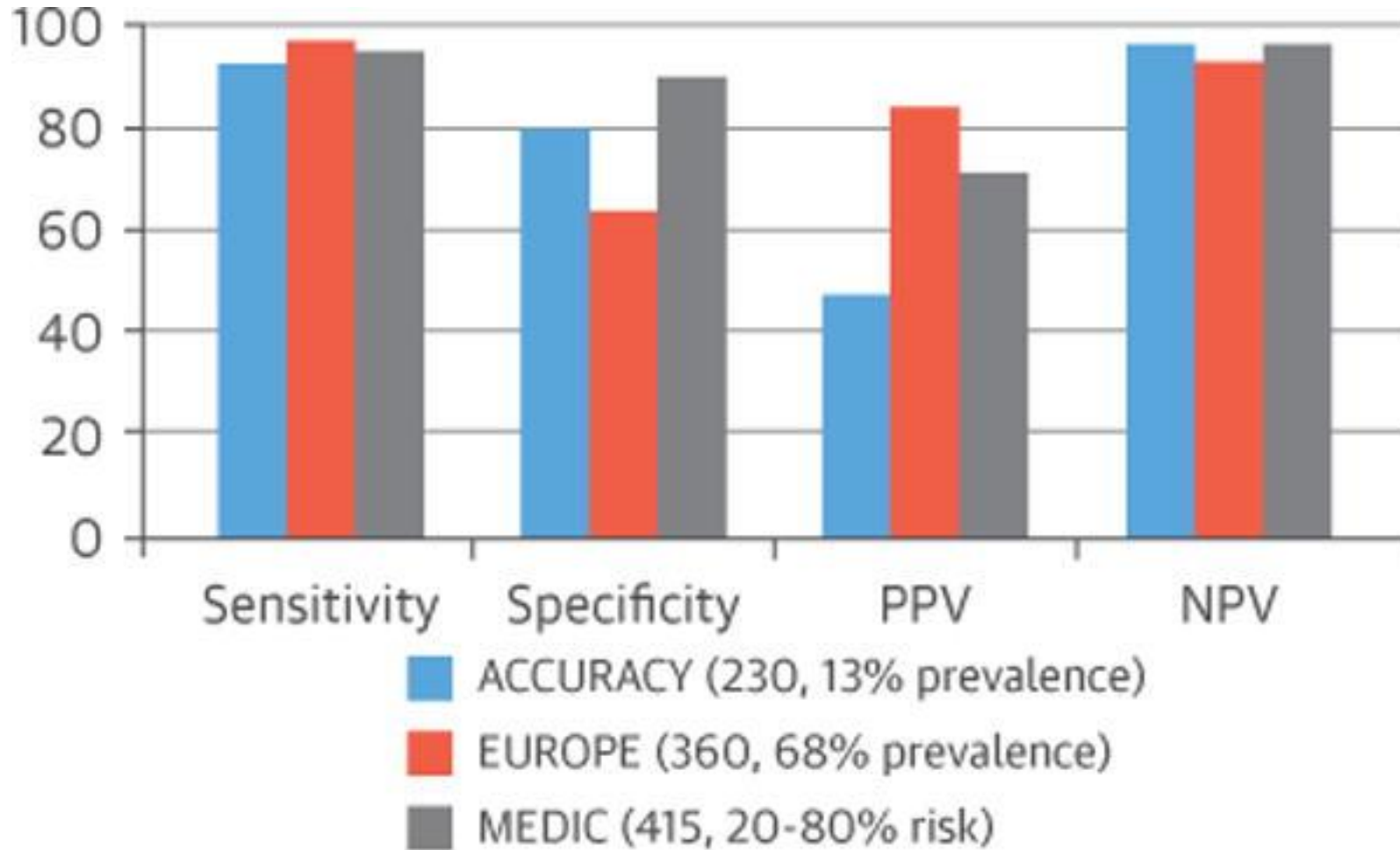
	Advantages	Disadvantages
<b>MPI (Nuclear)</b>	<ul style="list-style-type: none"><li>Detects abnl flow reserve</li><li>Peak-exercise images acquired</li><li>Most studies complete</li><li>Quantified LVEF and volumes</li><li>Higher sensitivity</li></ul>	<ul style="list-style-type: none"><li>Longer time vs stress echo</li><li>Radiation</li><li>Lower spatial resolution</li><li>Balanced ischemia missed</li></ul>
<b>Stress ECHO</b>	<ul style="list-style-type: none"><li>Safe</li><li>No radiation</li><li>Portable, faster</li><li>Structural information</li><li>Cheaper</li><li>Higher specificity</li></ul>	<ul style="list-style-type: none"><li>Peak-exercise images difficult to acquire</li><li>False-neg w/ rapid recovery</li><li>15% cannot assess entire myocardium</li><li>Afib, LBBB</li></ul>

# Coronary CT Angiography

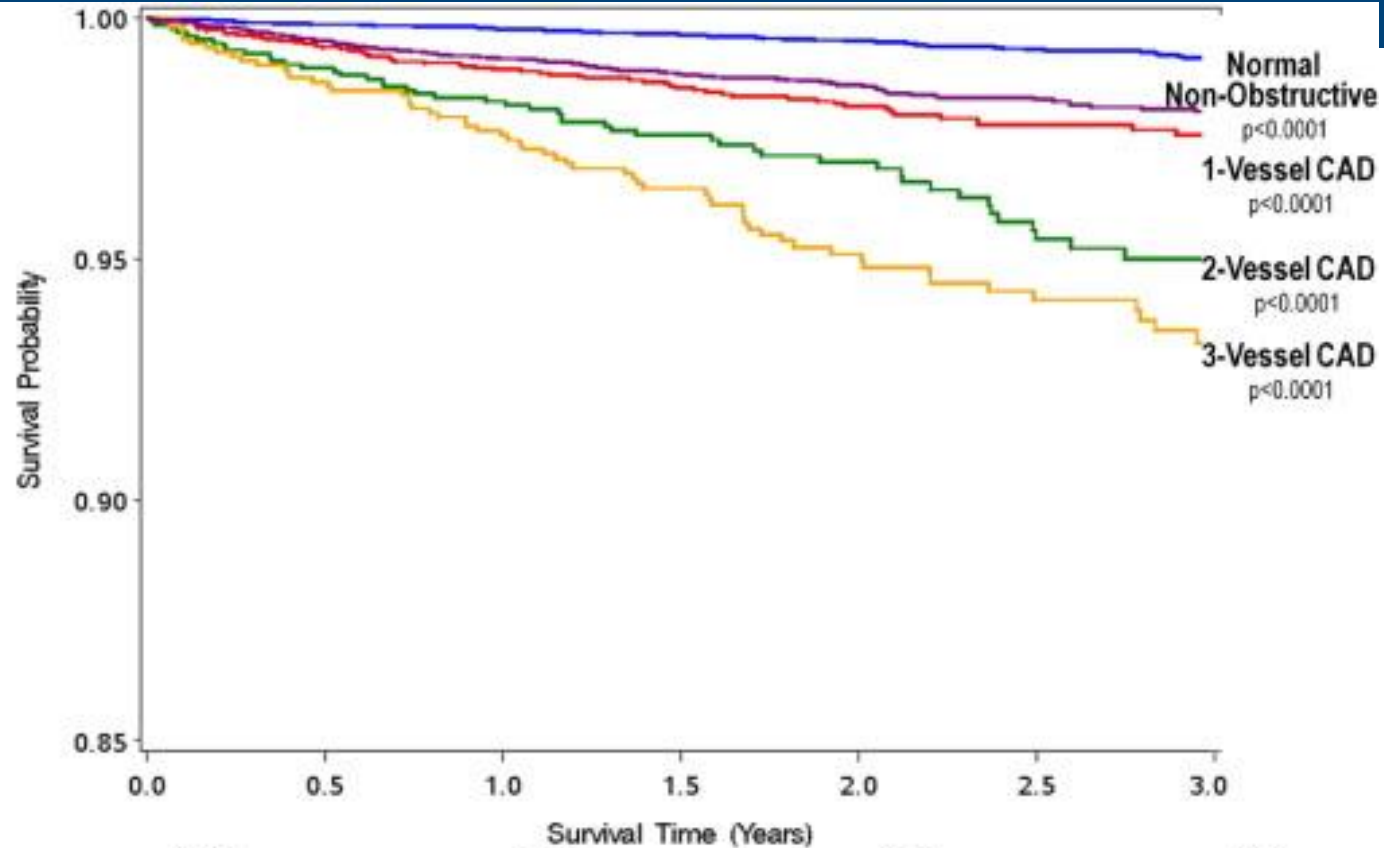


Schussler, JM, Grayburn PA. Heart. 2007 Mar;93(3):290-7.

# Coronary CT Angiography Diagnosis



# Coronary CT Angiography Prognosis



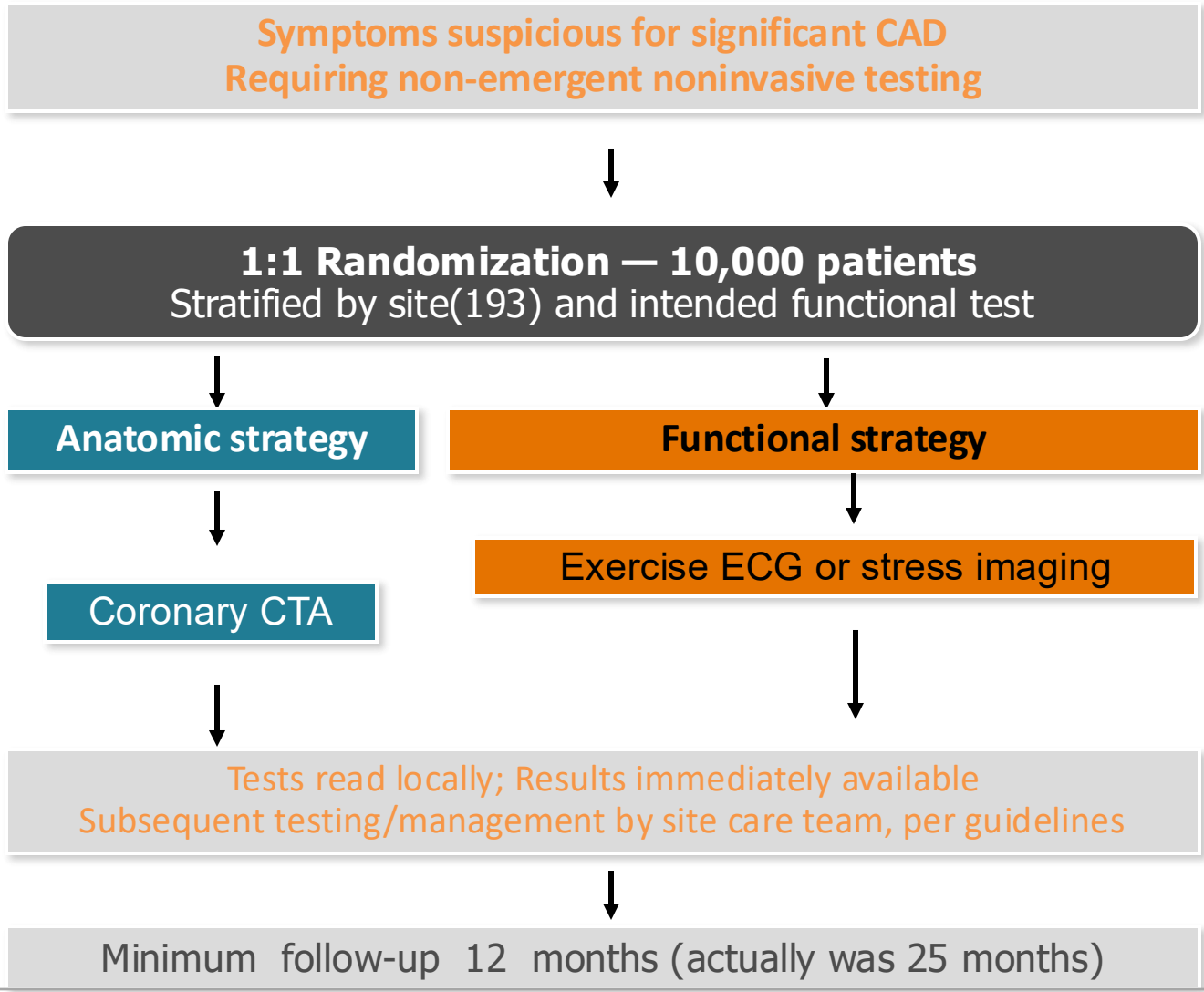
At Risk	Year 0	Year 1	Year 2	Year 3
Normal	10146	9357	5800	2907
Non-Obstructive	8114	7437	4081	1930
1-Vessel	3118	2873	1747	782
2-Vessel	1346	1228	742	324
3-Vessel/Left Main	1130	1034	664	324

# 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

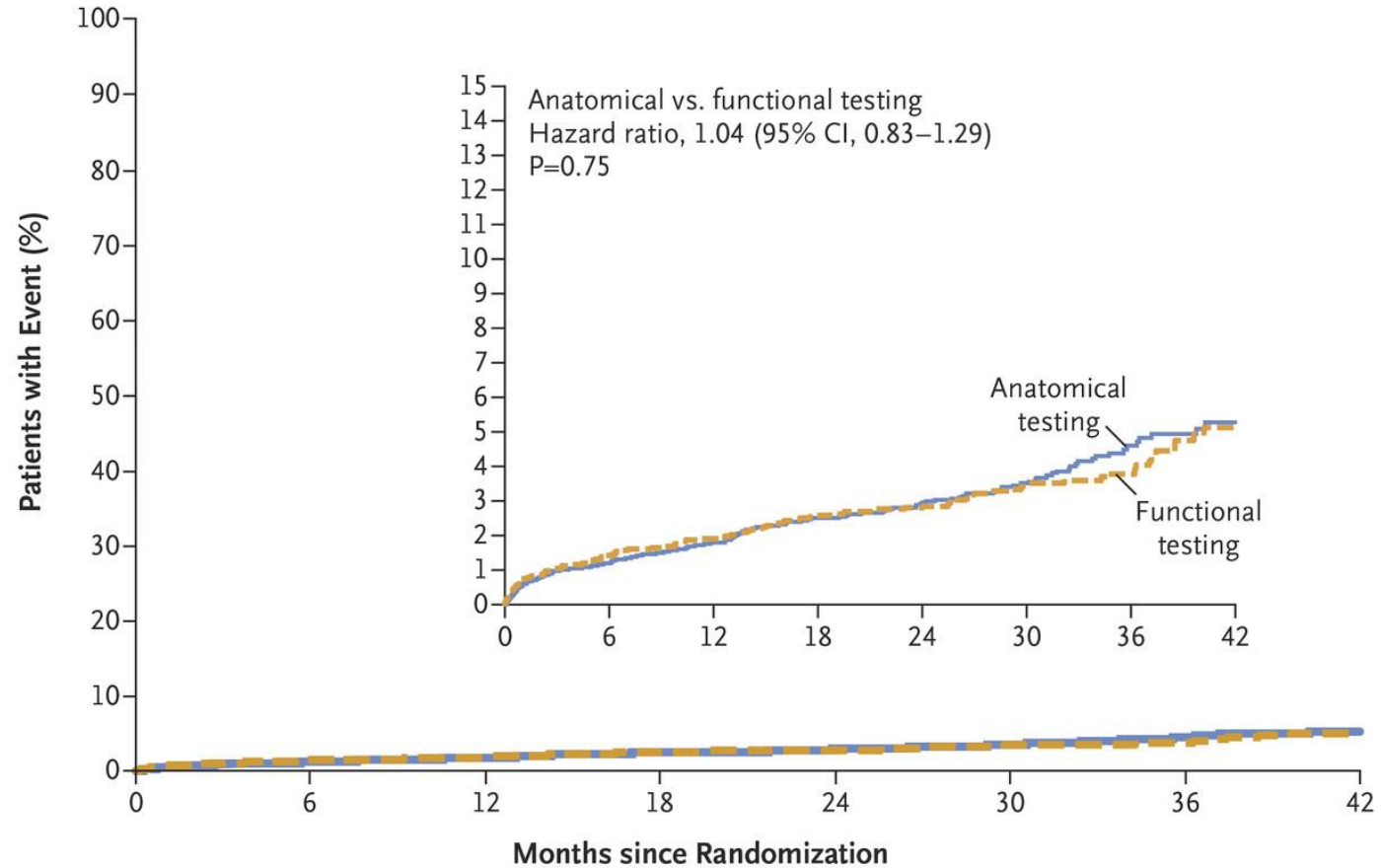
- Key Inclusion Criteria:**
- Non-urgent, noninvasive CV testing clinically necessary
  - No history of CAD or recent CAD evaluation
  - Age ≥55 years (men) or ≥65 years (women) OR
  - ≥45-54 years (men) or ≥50-64 years (women) with ≥1 major cardiac risk factor



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

# PROMISE trial

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



**No. at Risk**

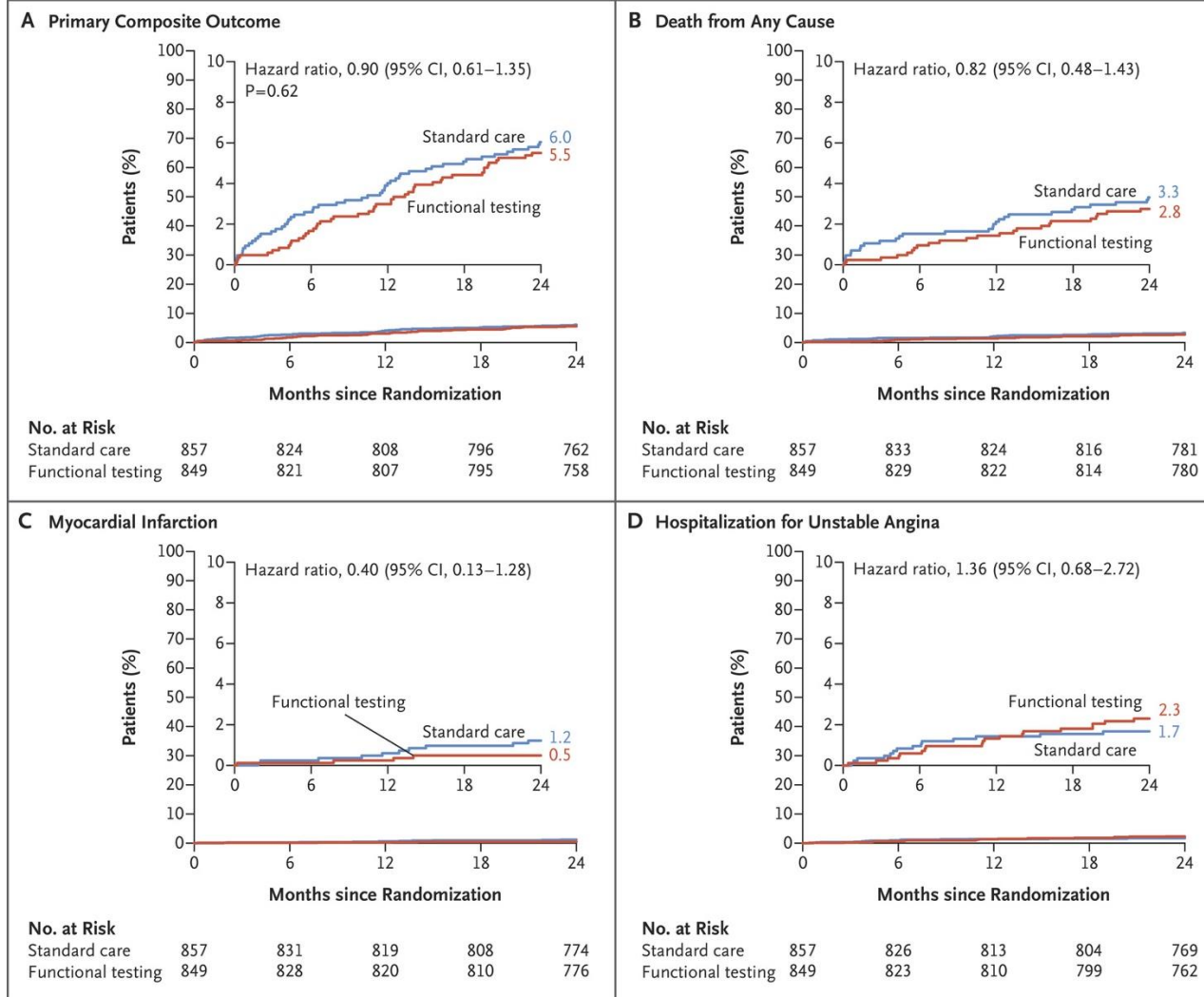
Anatomical testing	4996	4703	4362	3551	2652	1705	902	269
Functional testing	5007	4536	4115	3331	2388	1518	832	258

# 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

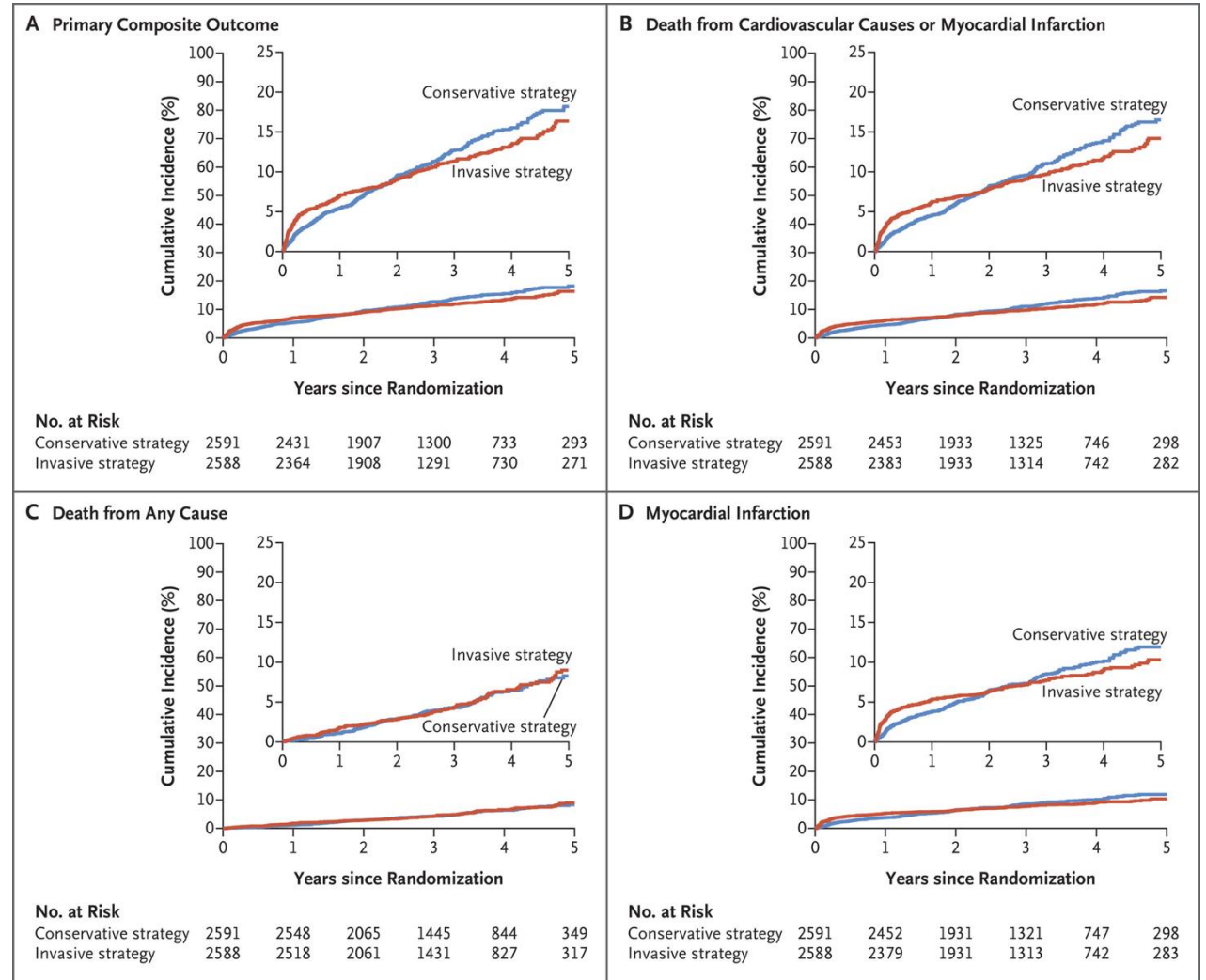


# Diagnostic Testing Selection

- *"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



# 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

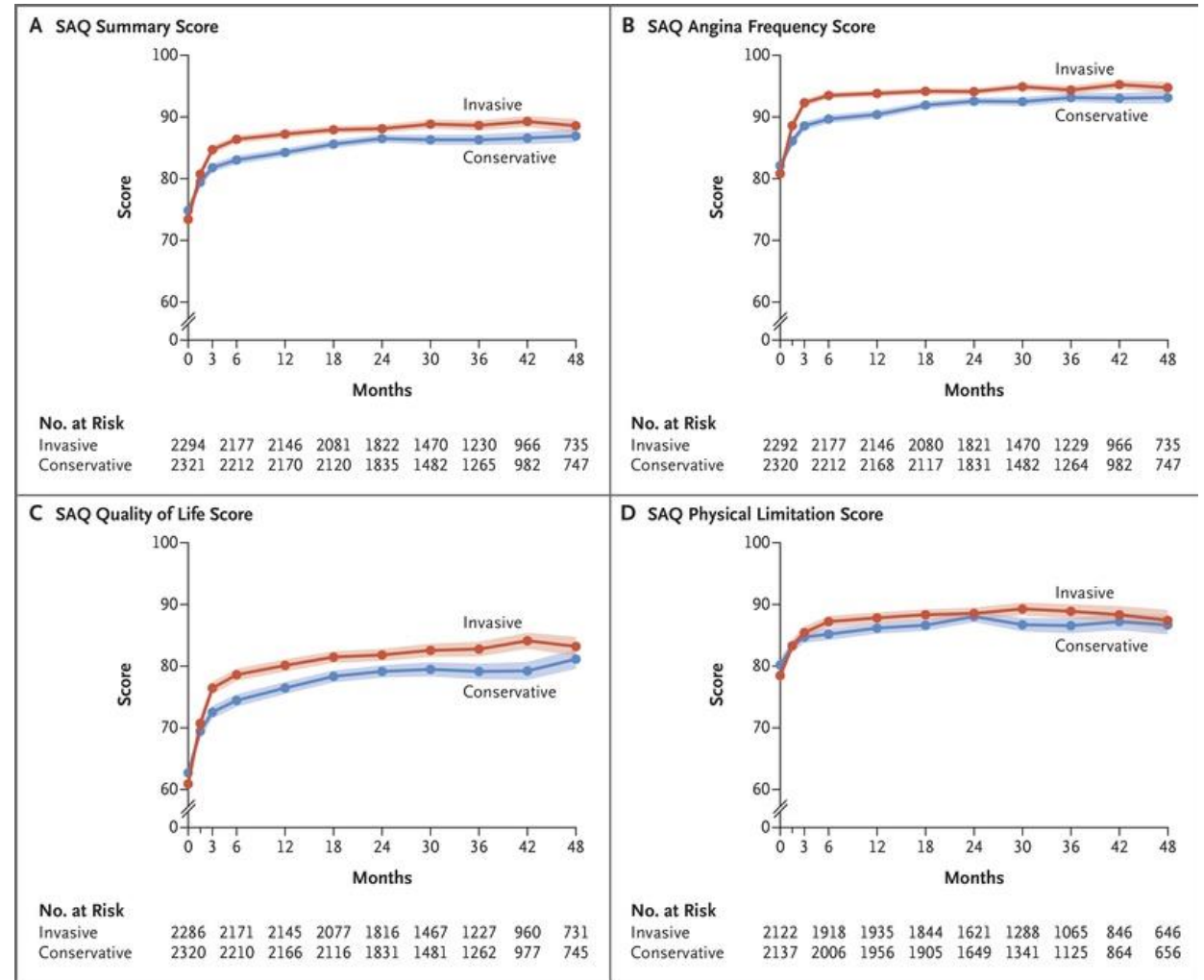
Drug	Mechanism of Action	Adverse effects	Common doses
Beta blocker	Slow HR Decrease myocardial contractility Lower afterload with lower BP	Bronchospasm Bradycardia Hypotension Fatigue Erectile dysfunction	Metoprolol 25-50 mg bid Atenolol 25-50 mg daily Carvedilol 3.125-6.25 mg bid
Calcium channel blockers-DHP	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.*



# Question

- What is the criteria for concluding an exercise treadmill stress test is positive for inducible myocardial ischemia?
  - A. 1-2 mm up sloping ST segment depression.
  - B.  $\geq 1$ mm 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.

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- 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 worse 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