



Challenges and Shifting Paradigms

1

CARDIAC STRESS TESTING
APPLYING THE CANADIAN GUIDELINES

ASCVD

Secondary Prevention

The Standard of Care

Poll Question

What is Secondary Prevention?

Treatments that improve outcomes in patients who:

- a) Have been admitted to hospital with a heart attack
- b) Have had a prior heart attack, stroke, or any other vascular event
- c) Have established atherosclerotic cardiovascular disease or heart failure

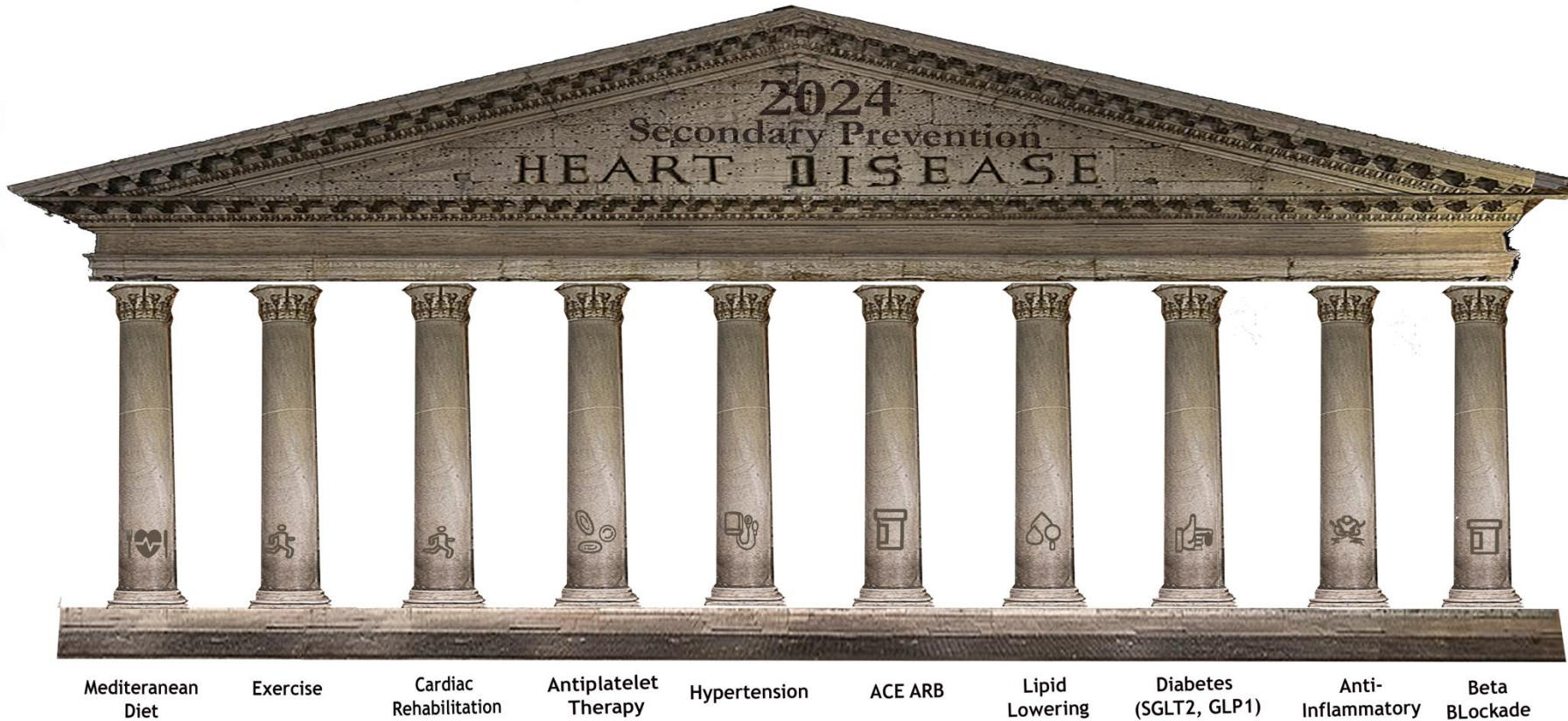
Global Cardiovascular Risk

In one Generation

- Global CVD mortality has fallen >50%
- Myocardial Infarction Mortality declined from 30% to 4%
- > 80% decline in cardiovascular risk factors

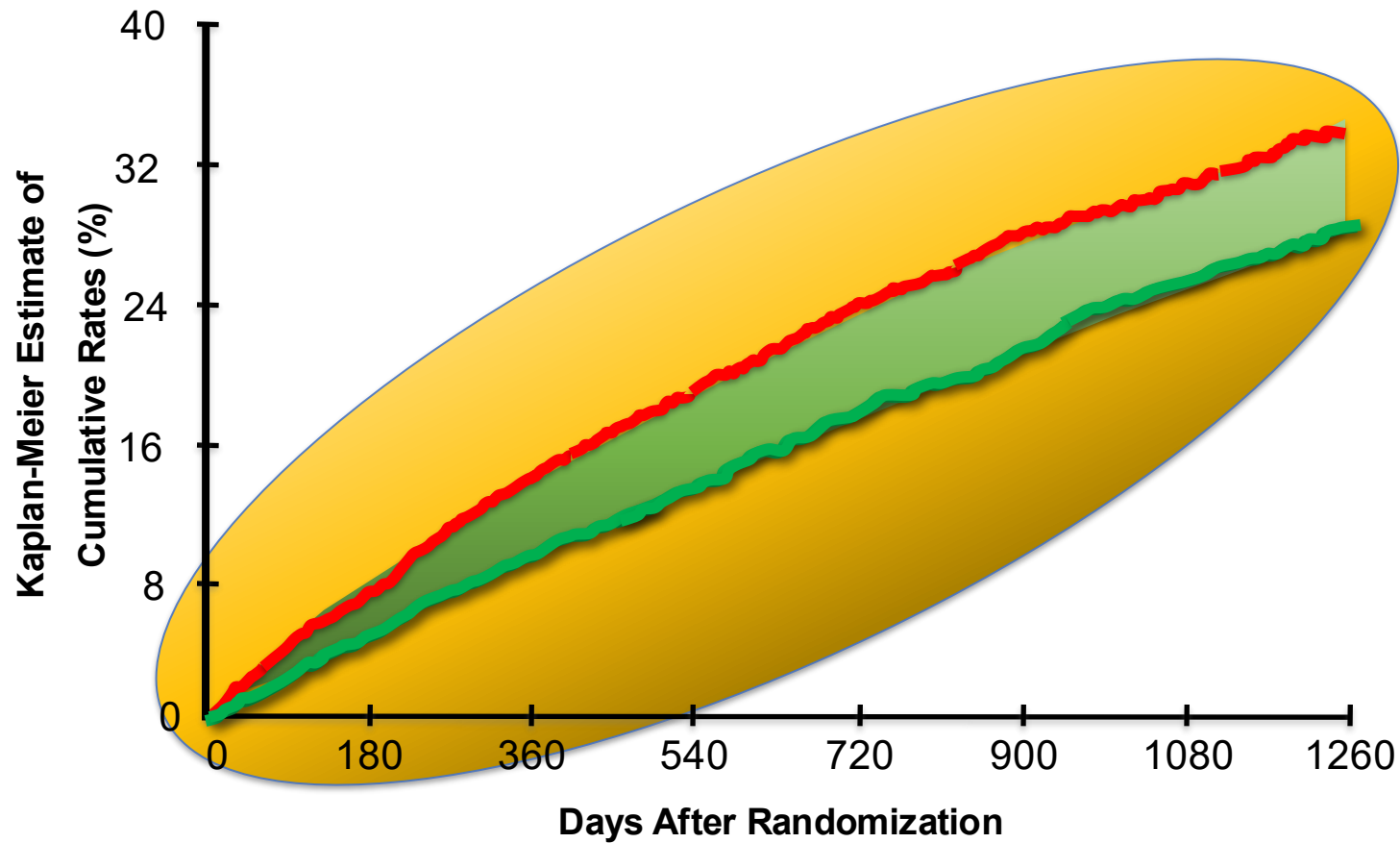
55% of the outcome improvement
Due to medical secondary prevention therapies

The Pillars Of Prevention



| | Risk Reduction |
|------------------------|----------------|
| Exercise | 25% |
| Diet | 25% |
| Hypertension | 25% |
| Anti-Platelet | 25% |
| Lipid Management | >30% |
| ACE | 25% |
| SGLT2 | 25% |
| GLP1 | 20% |
| Anti-Inflammatory | 25% |
| Beta Blockers | 15% |
| Overall Benefit | +80% |

Time Under Treatment Matters

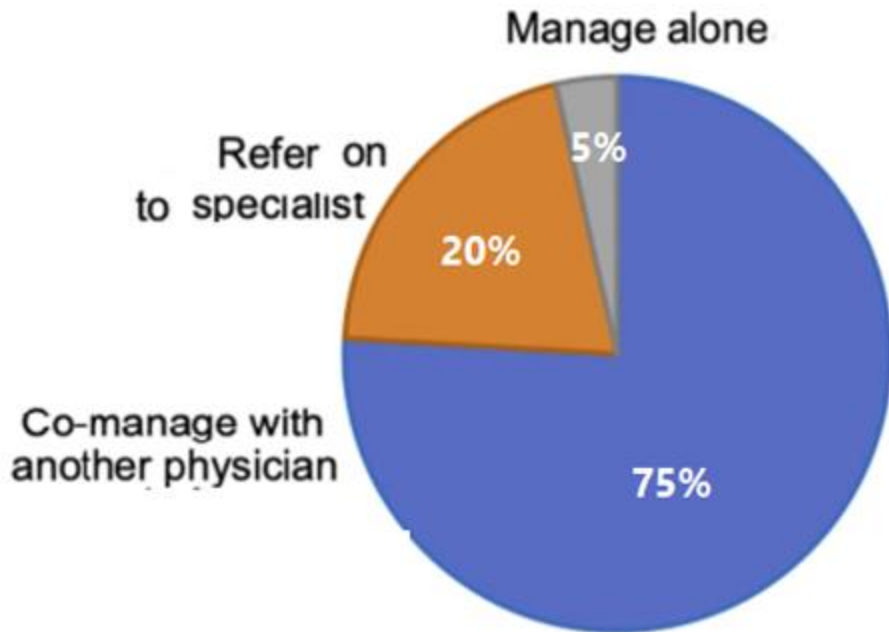


Benefits start early

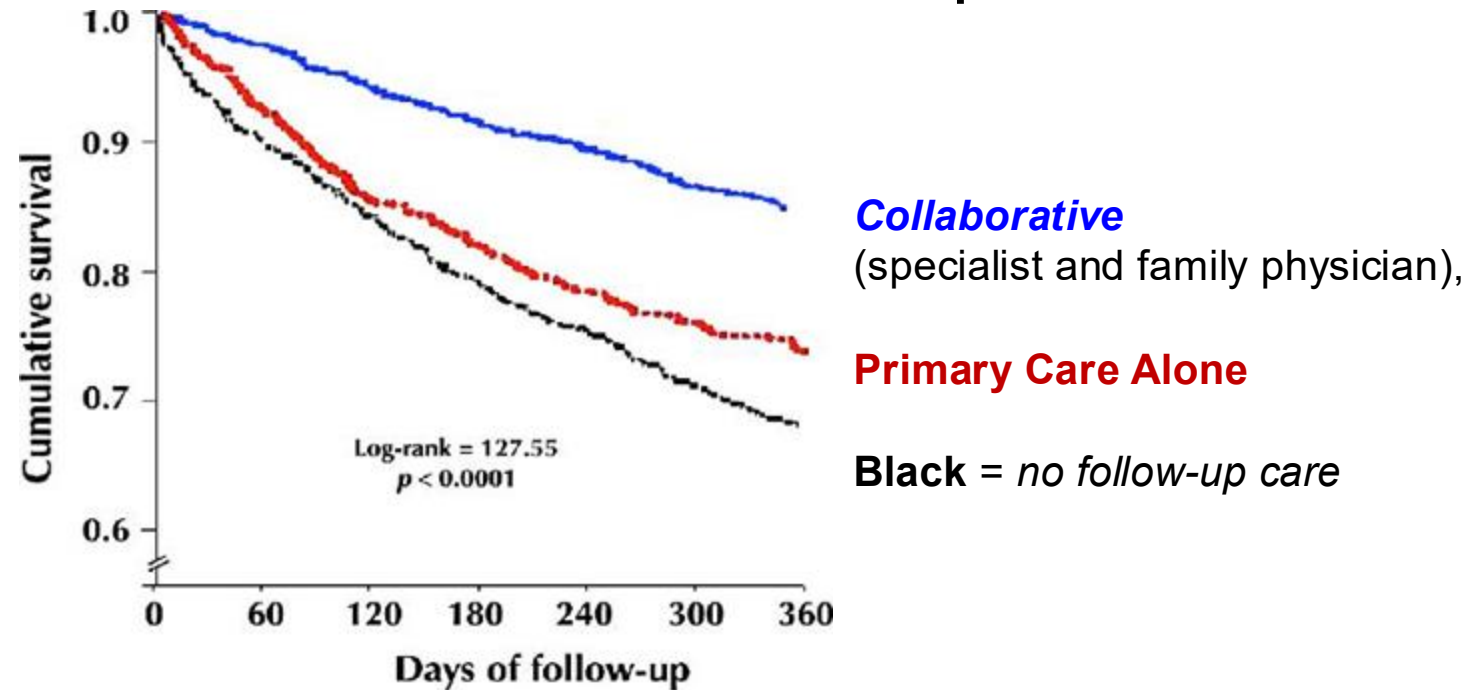
& increase over time

Expect Primary Care & Specialist Alignment

Co-Management

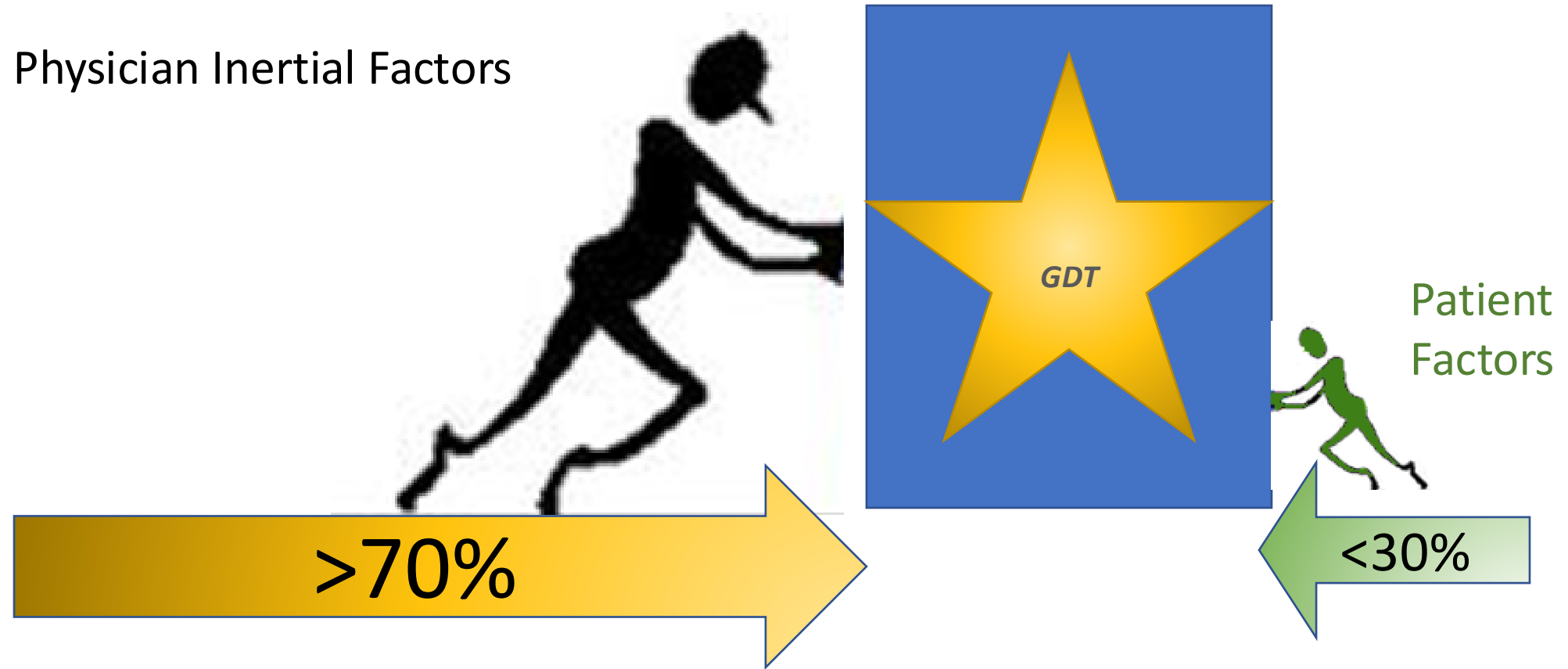


- Provide Collaboration Improves

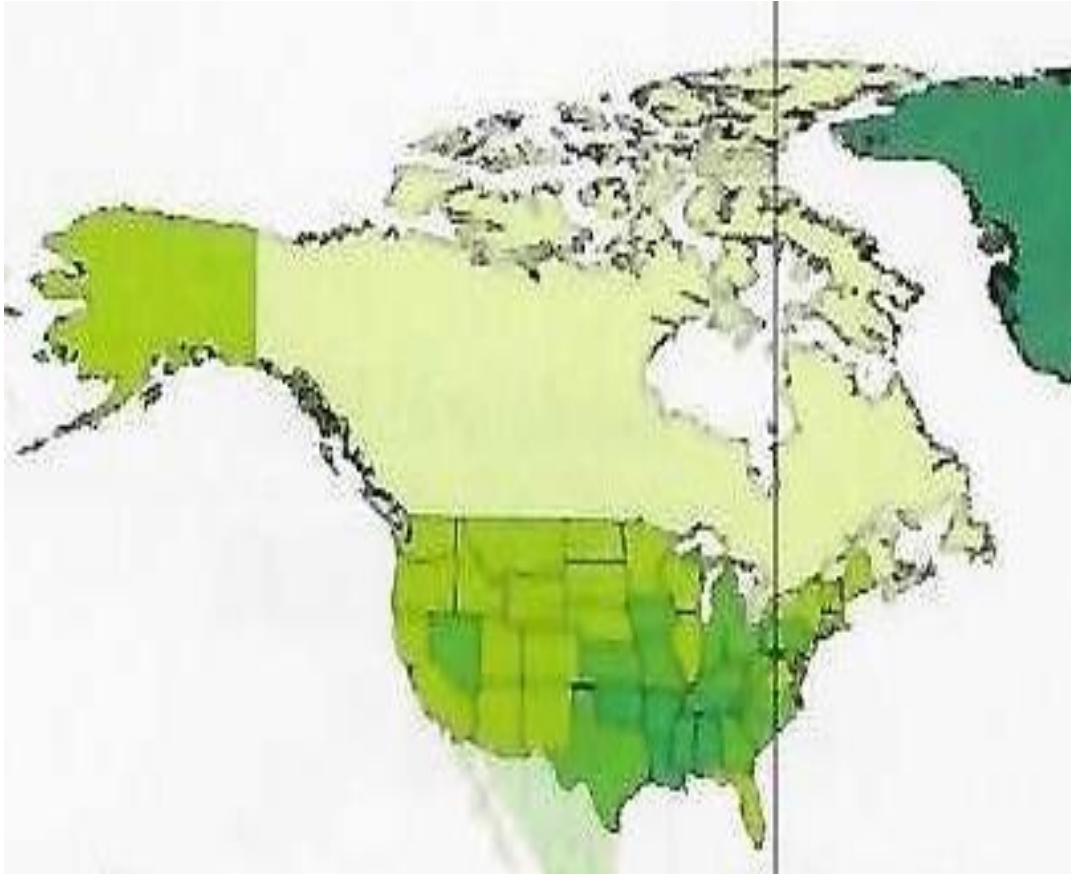


Physicians Drive Patient Outcome

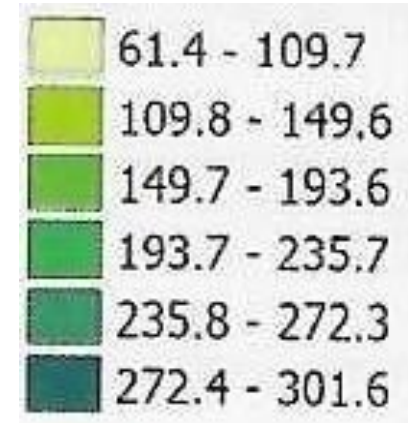
Physician Inertial Factors



Canada As A Leader



Age Standardized Cardiovascular Mortality
Per 100,000 population > 40 years of age



ASCVD Secondary Prevention

The Standard of Care

Every Day Counts

INITIATE Secondary Prevention Strategies

From the **FIRST DAY** the Diagnosis of ASCVD is made

at the **EARLIEST OPPORTUNITY**

and at **EVERY VISIT**

For the **REST OF YOUR PATIENTS' LIFE**

A Lifelong Journey that Starts with the 'First Step'



- Making the Diagnosis of ASCVD

Why do Stress Testing?

Diagnosis of ASCVD

Is there ASVD?

Prognosis

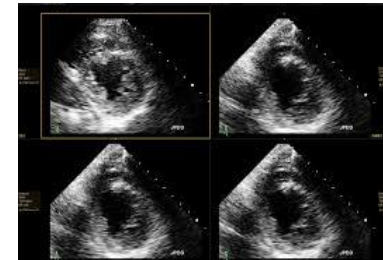
How much ASCDV?

Stress Test Options

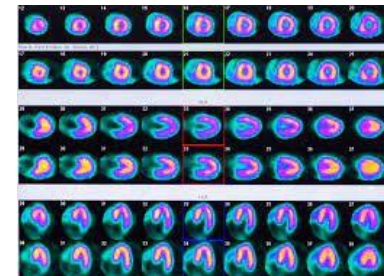
Exercise EKG treadmill test



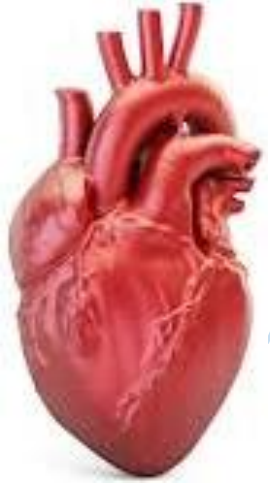
Stress echocardiography



Stress myocardial perfusion imaging



Principles of Cardiac Stress Testing



Measure the cardiac state at rest

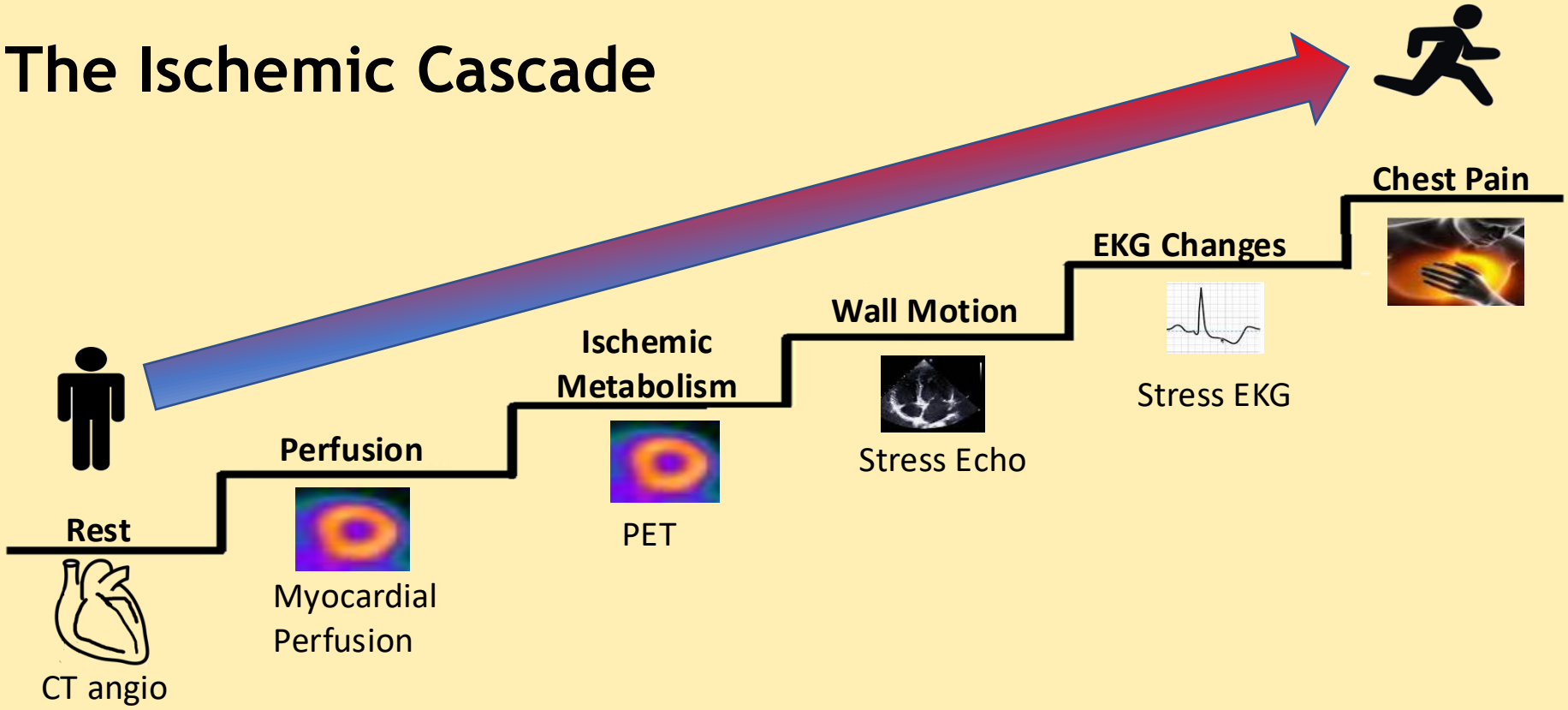


Stress the Heart (Exercise or Drugs)



Measure the impact of the stress

The Ischemic Cascade



Types Of Cardiac Stress

- Treadmill Exercise
- Pharmacologic
 - Dobutamine
 - Persantine
 - Adenosine*

* Not available in Ontario

Poll Question

Paul

35 Male

No risk factors

Sharp chest pain lasting <1 minute for past 4 weeks.

Non-exertional and unpredictable

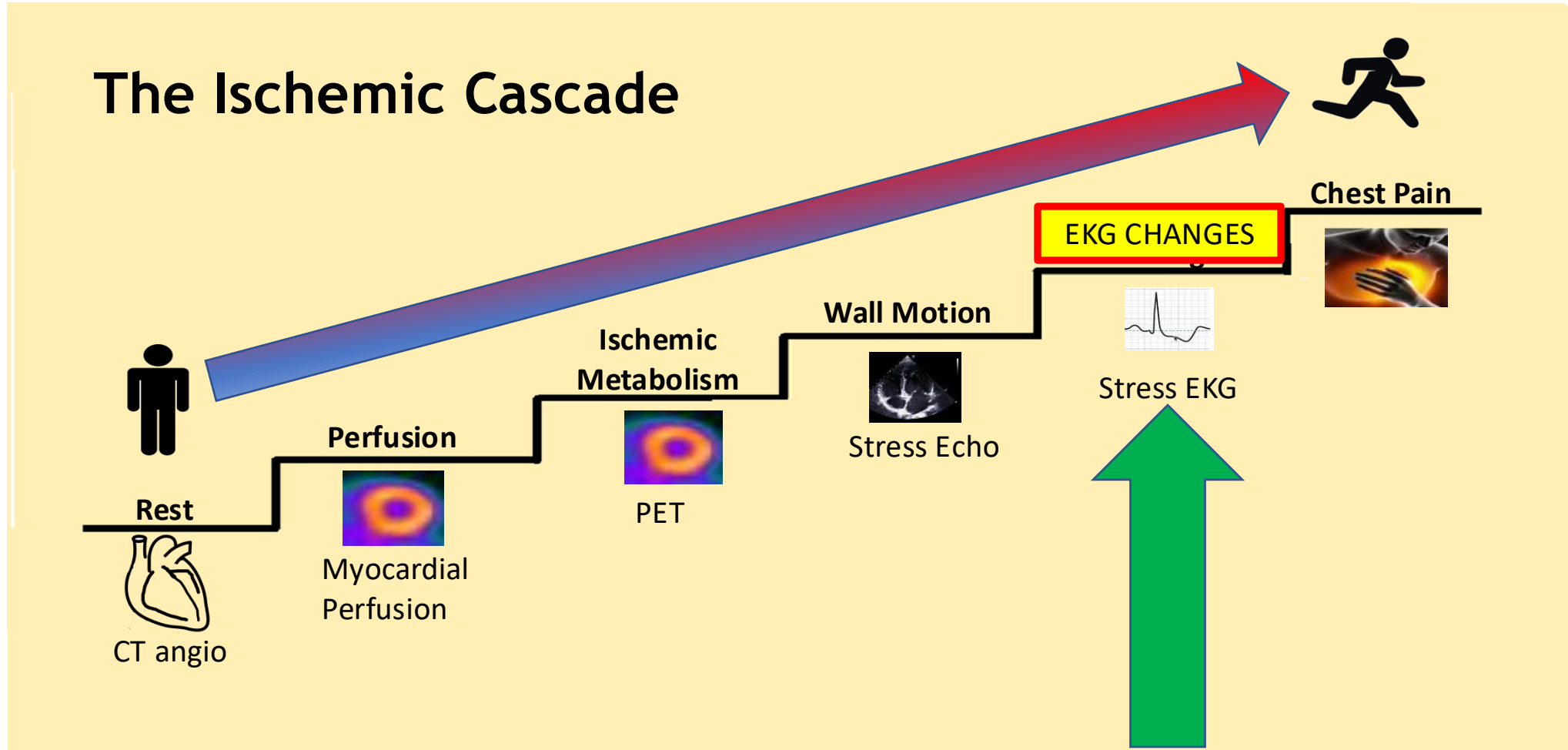
PMH GERD and Work related Stress

Physical examination negative

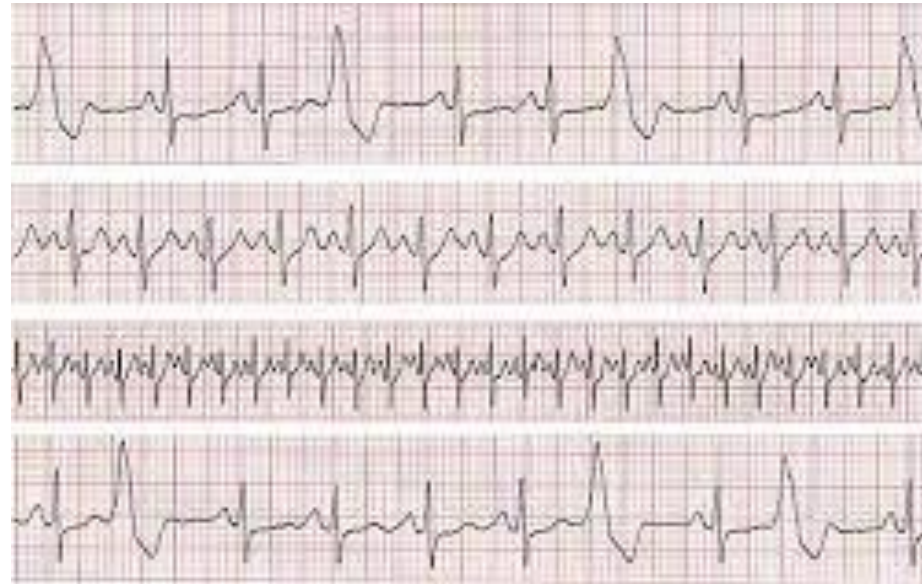
Which Test Would You Order

- a) GXT
- b) Stress Echo
- c) Myocardial Perfusion Scan
- d) PET scan
- e) CT coronary Angiogram
- f) None

Exercise Stress EKG



Exercise Stress EKG: How It's Done



Baseline ECG

ECG at Stage 1

ECG at Stage 2

ECG at recovery

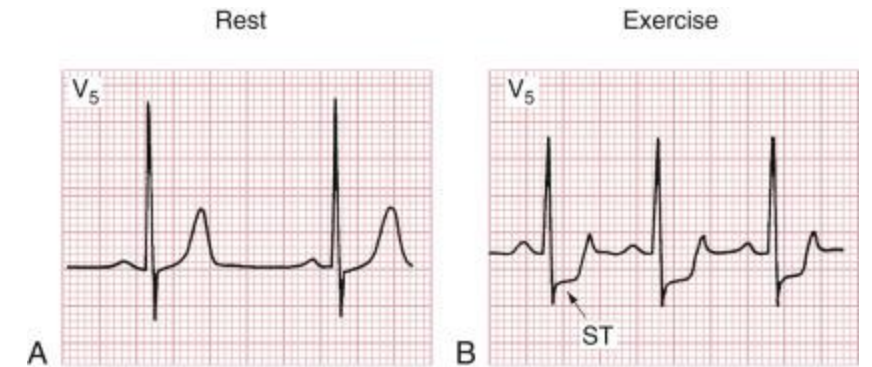
Value of an Exercise Stress EKG

1. Baseline ECG
2. Exercise capacity (METs - metabolic equivalent)
3. Symptoms related to stress
4. Blood pressure at rest and exercise
5. Negative predictive value
6. Prognosis via Duke Treadmill Score



Advantages of Exercise Stress EKG

- Rapidly available
- Inexpensive
- Safe (1 in 10,000 mortality)
- Good negative predictive value for low risk individuals
- Good prognostic value (Duke Treadmill Score)



Recommended First Line in low risk individuals!

Duke Treadmill Score (DTS) Predicts Prognosis Accurately

Time on treadmill in min - 5 x (mm ST depression) - 4 x (angina index*)

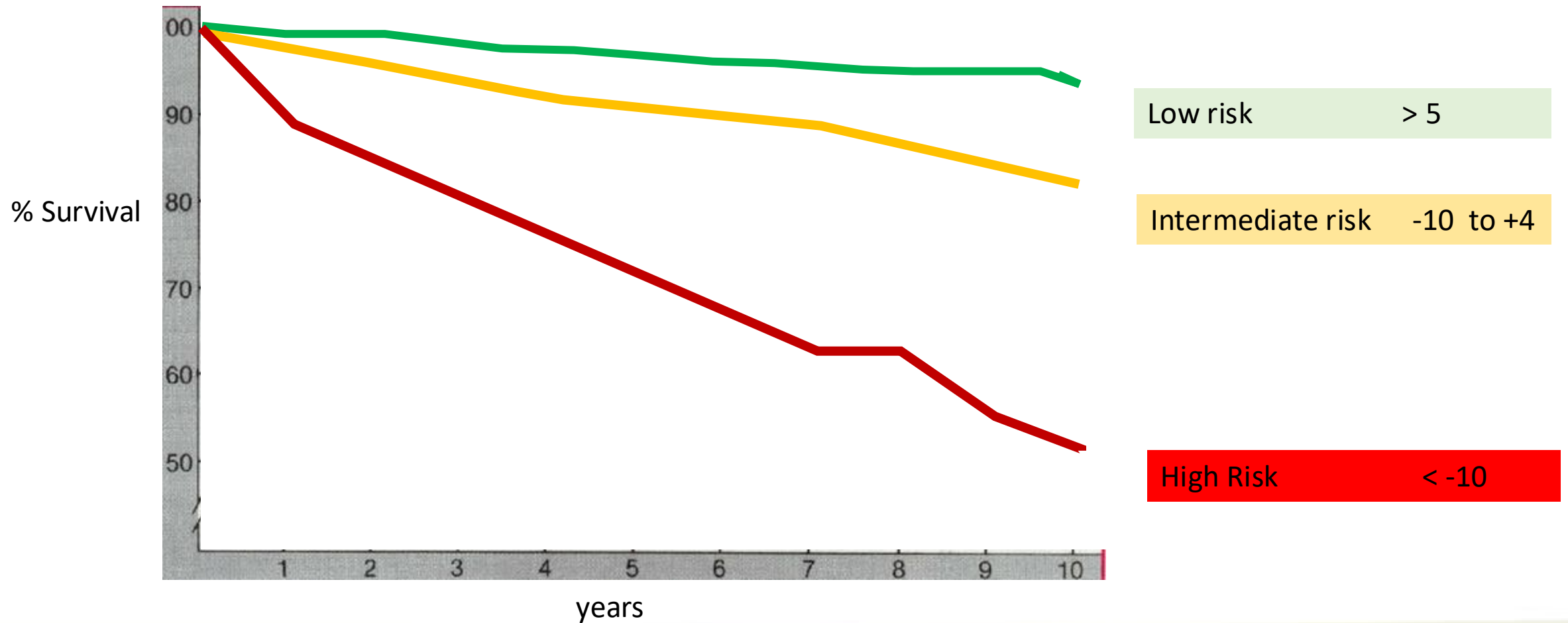
| Risk | Score | Annual CV Mortality |
|--------------|------------|---------------------|
| Low | ≥ 5 | < 1% |
| Intermediate | 4 to -10 | 1-3% |
| High | ≤ -11 | > 3% |

* 0 No chest pain

1 Chest pain not limiting exercise

2 Chest pain limiting exercise

Duke Treadmill Score (DTS) Predicts Prognosis Accurately



Stress EKG: Not Valuable For Diagnosis if...

EKG Is Not Interpretable

- LBBB
- Pacemaker

Inability to exercise to target heart rate or >10Mets

- Poor fitness
- Cardiac abnormality limiting exercise
- Physical or Cognitive disability
- Blunted heart rate (medication, thyroid)

High Pretest likelihood

- Diagnosis ASCVD already likely

High False positive Rate

- Female
- Resting abnormal ECG - ST
- Digoxin
- Hypertension/LVH

Contraindications to Stress EKG

- Unstable coronary disease
- Decompensated Ventricular Function / Heart failure
- Uncontrolled cardiac arrhythmia
- Active endocarditis
- Suspected aortic dissection

Poll Question

David

35 year old Male

Chest pressure after meals and exercise

Exercises regularly without symptoms

PMH Hypertension x 5 years, Family History MI

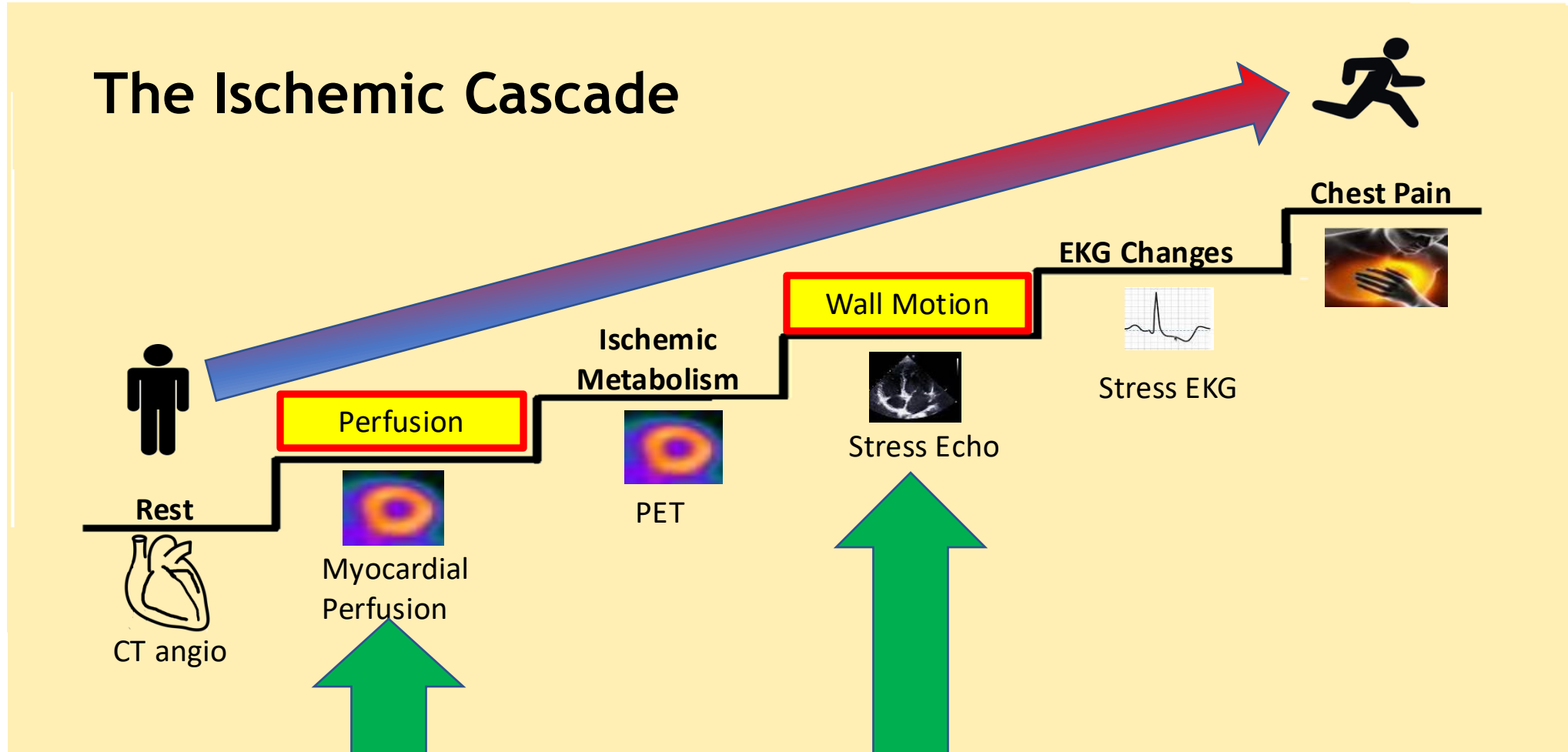
GXT 2021 negative

Physical examination negative

Which Test Would You Order

- a) GXT
- b) Stress Echo
- c) Myocardial Perfusion Scan
- d) CT coronary Angiogram
- e) None

Functional Stress Testing



The Value of Combining Imaging & Stress

| | |
|-----------------------------|--|
| Sensitive | Better in intermediate or higher risk patients |
| Specific | More Specific Diagnosis (Fewer False positive) |
| Anatomy | Provides location of ischemia |
| Non-Exercise Options | Pharmacologic stress |
| Prognosis | Myocardial ischemia Burden and Severity |

When to Use Functional Stress Testing

Pretest probability Intermediate or higher

To assess Myocardial Ischemic Burden and Prognosis

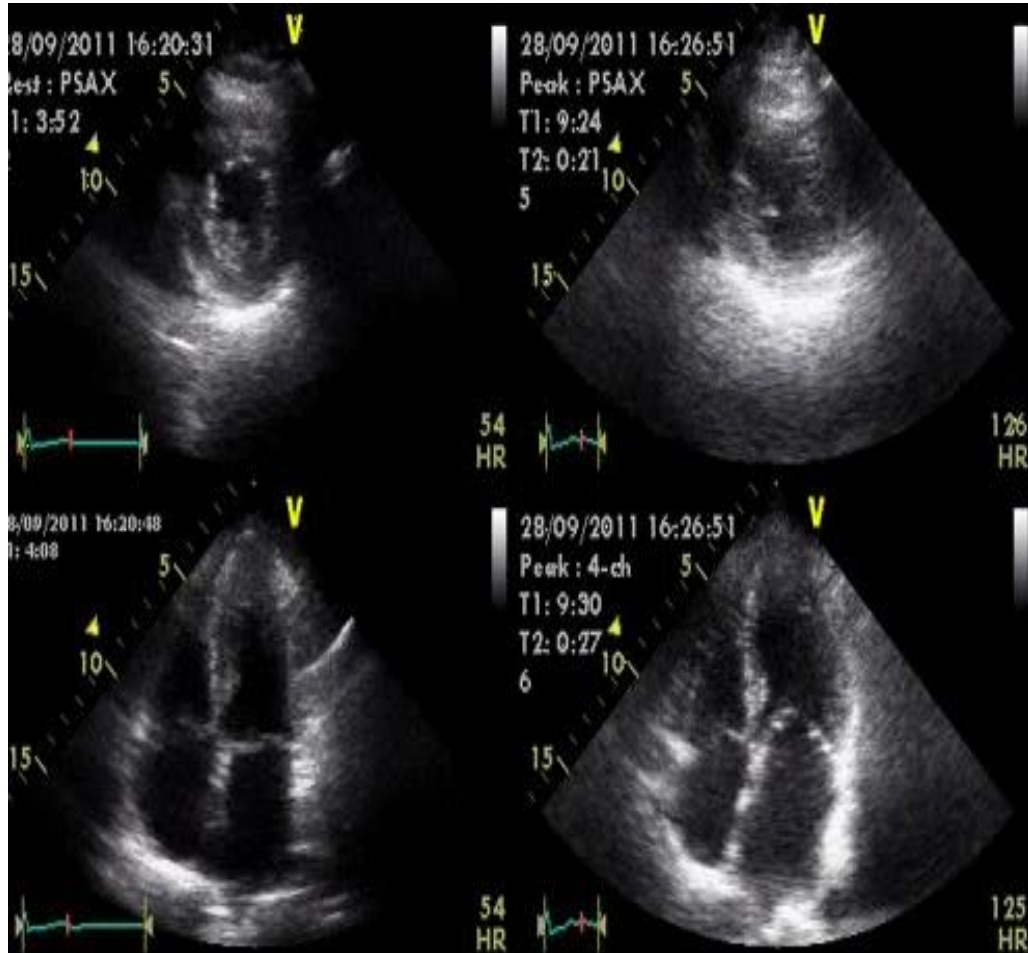
Where Stress EKG Accuracy is limited

- Submaximal exercise
- Non specific “False Positive” stress positive EKG
 - Women
 - hypertension
 - Abnormal baseline EKG
- Non Interprettable Stress EKG
 - LBBB
 - Pacing

How Different Stress Tests Compare

| | <u>Sensitivity</u> | <u>Specificity</u> |
|---------------|--------------------|--------------------|
| GXT | ~70% | ~75% |
| Stress Echo | ~85% | ~90% |
| Nuclear (MPI) | ~90% | ~85% |

How Stress Echo is Done



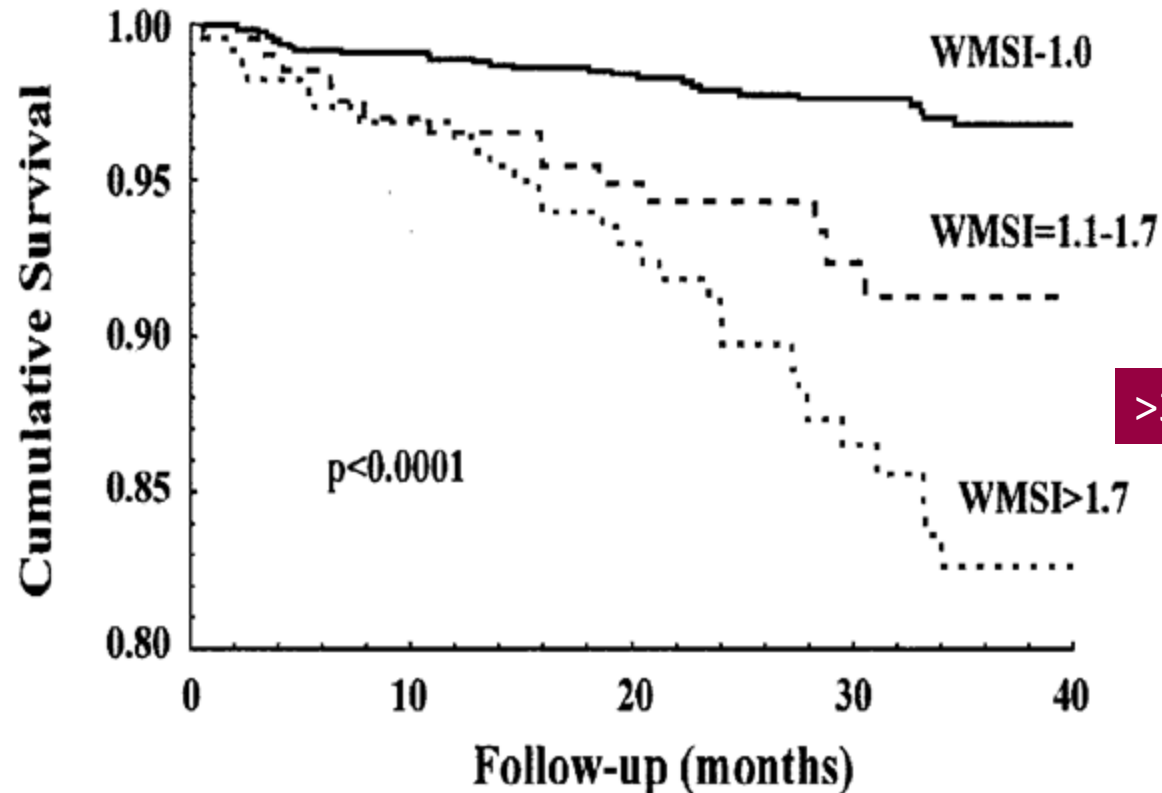
- Baseline echo
- Stress
 - Exercise
 - Dobutamine
- Immediate post stress echo
- New wall motion abnormalities upon stress indicate regions of ischemia

Positive Stress Echo: High Risk Features

- Inducible ischemia in 2 or more segments
- Fall in Ejection Fraction to $<45\%$

Stress Echocardiography

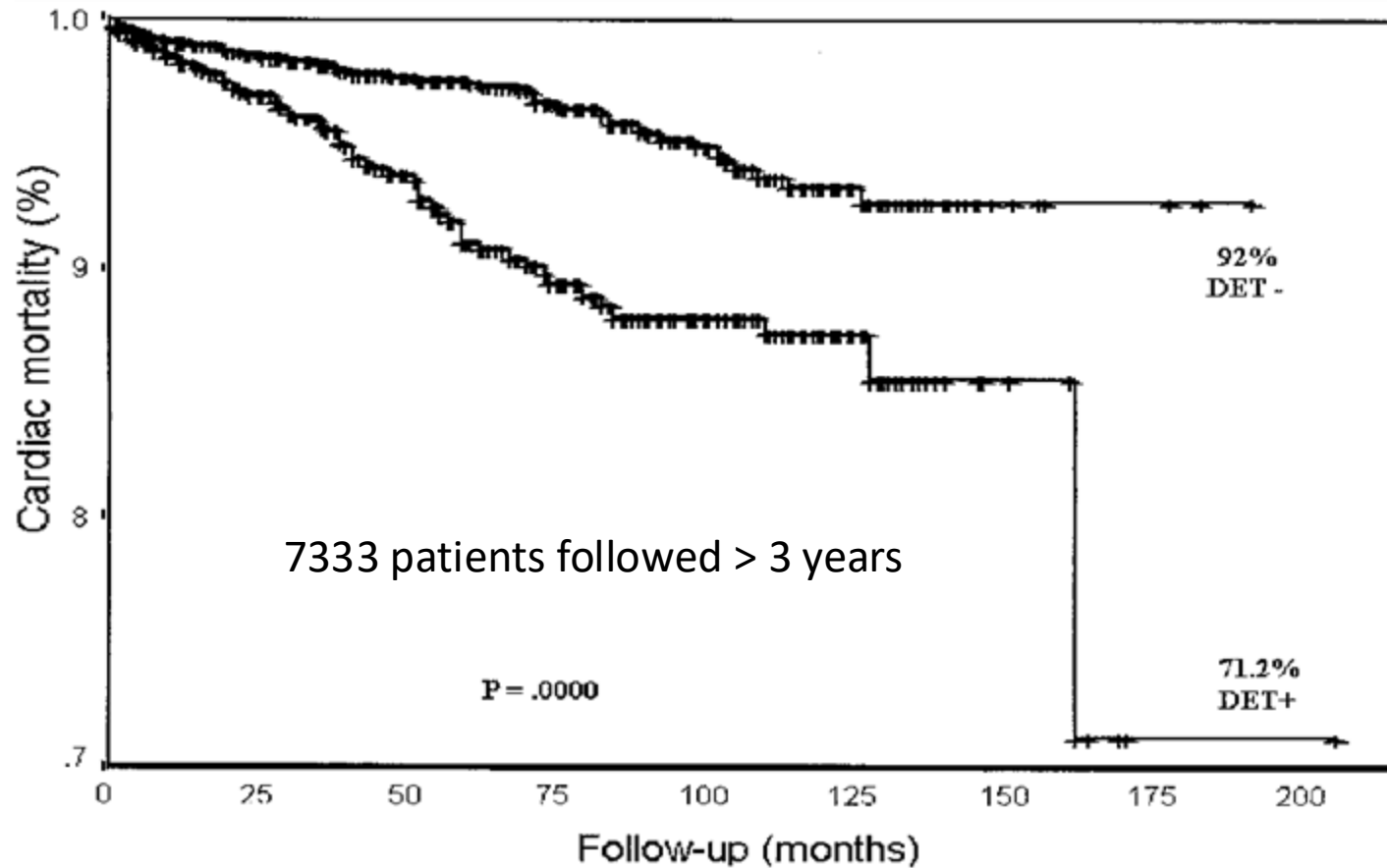
Prognosis predicted by Wall motion score



>3% annual mortality with 2 or more segments affected

Stress Echocardiography

Normal Study Predicts Excellent Prognosis



Normal dobutamine stress predicts

<1% annual mortality

Stress Echocardiography

Pros

- Access
- Good Specificity
- Good prognosticator
- Dobutamine for patients who can't exercise
- No ionizing radiation
- Safe for serial testing
- Complete structural assessment of heart

Cons

- Image quality an issue with larger patients
- Not recommended for LBBB, paced patients
- Sensitivity reduced for single vessel disease
- Difficult to interpret with significant LV dysfunction

Poll Question

Anne

62 Female

Chest pressure after meals and exercise

Chest pain walking after 2 blocks or stairs

PMH Hypertension x 5 years

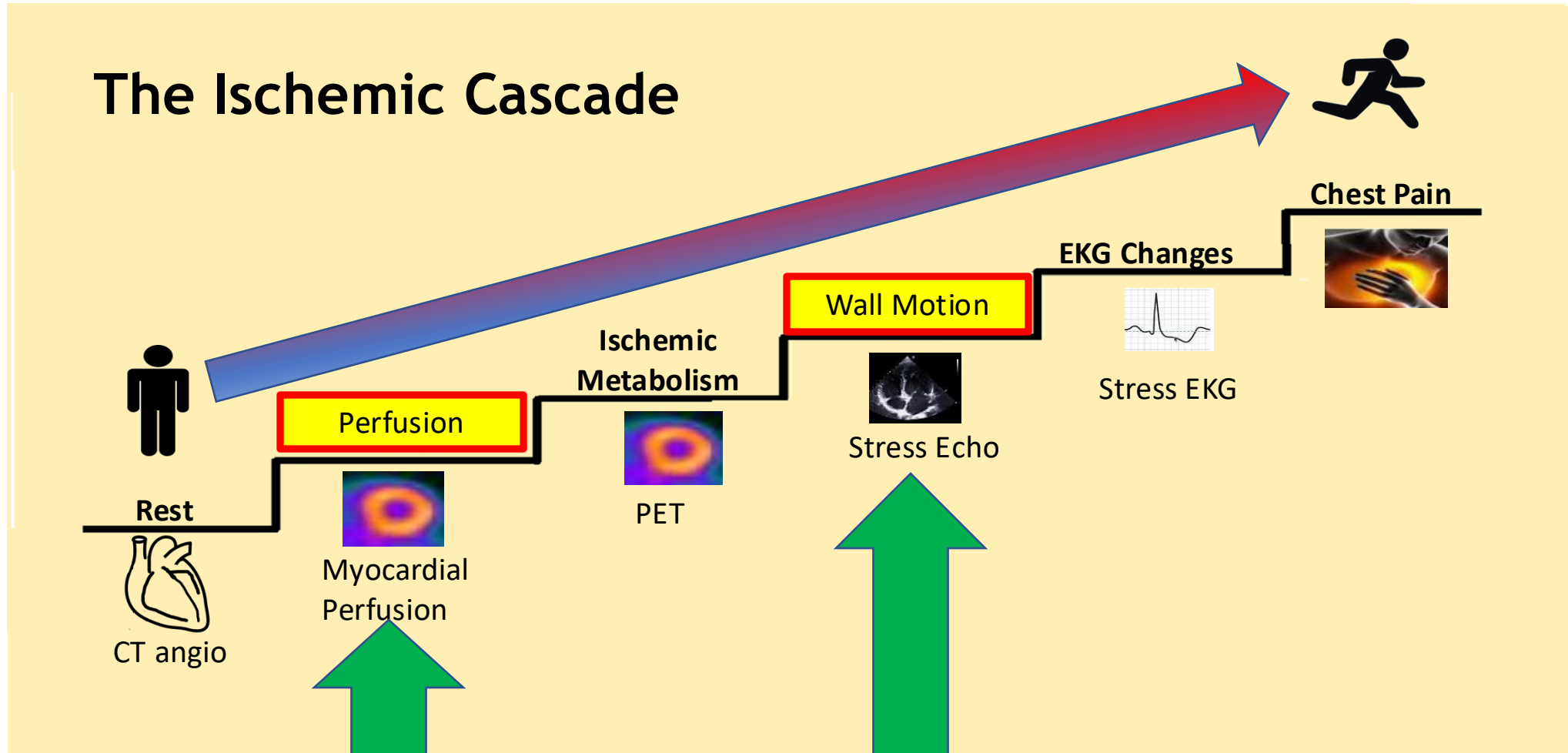
Diabetes x 10 years

Physical examination negative

Which Test Would You Order

- a) GXT
- b) Stress Echo
- c) Myocardial Perfusion Scan
- d) CT coronary Angiogram
- e) None

Functional Stress Testing

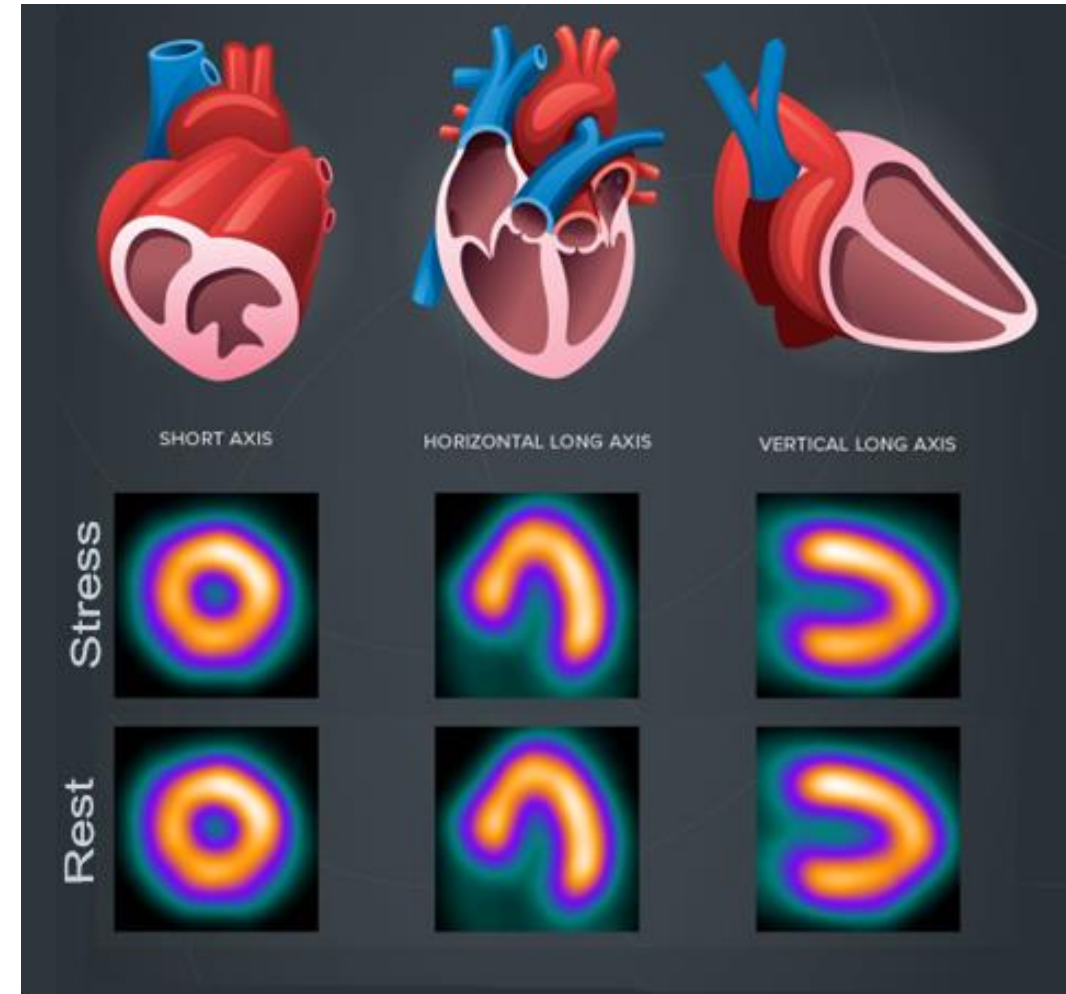


What is Myocardial Perfusion Imaging (MPI)

Isotope (tetrofosmin or MIBI)

Distributes in heart based on blood flow

- Ischemia: Reversible Defect post stress
- Scar: Fixed defect at rest and stress



How Myocardial Perfusion Testing is Done



Inject isotope at rest

Acquire SPECT images



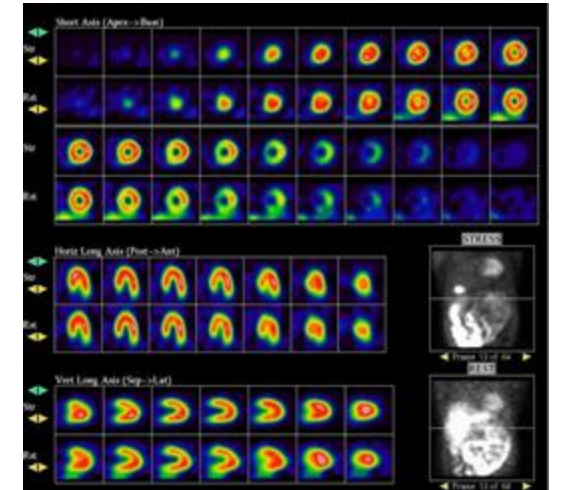
Stress the Patient

- exercise or
- Pharmacologic

Inject isotope

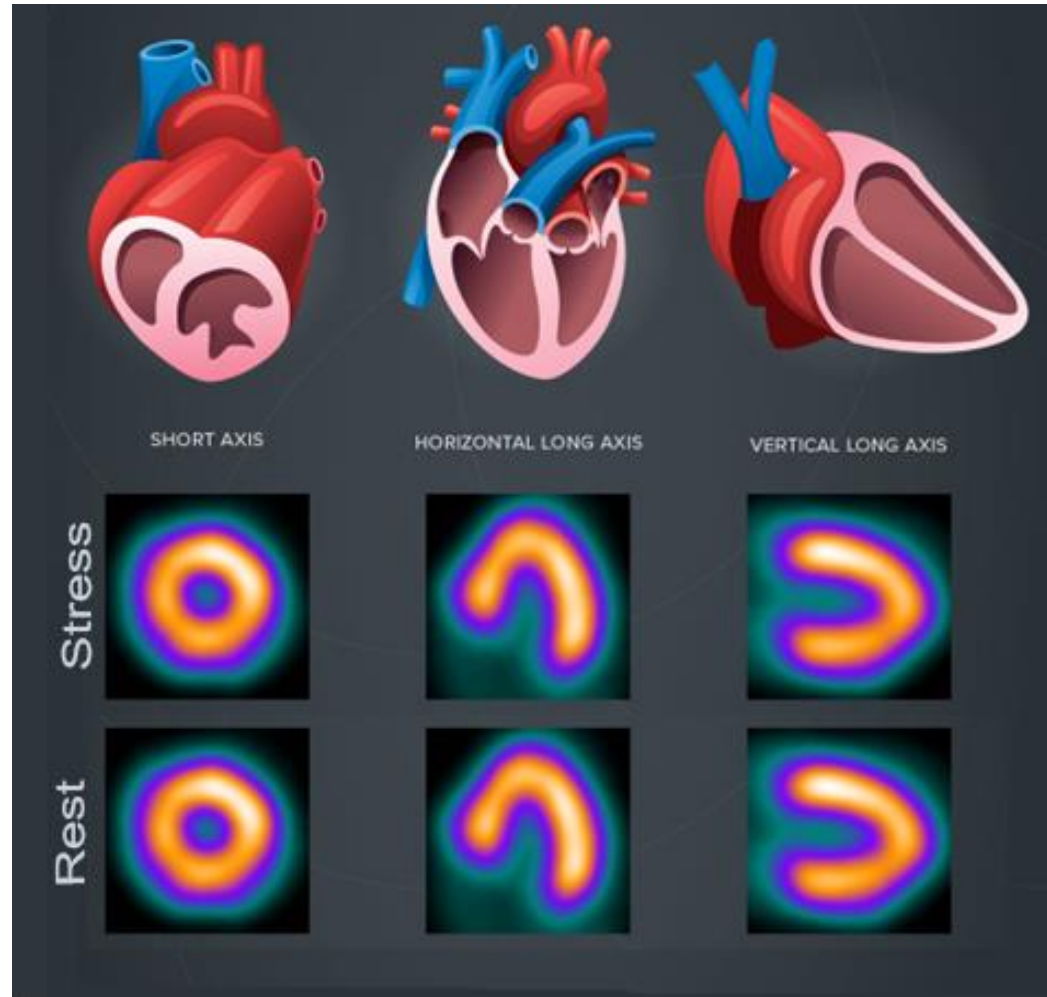


Acquire SPECT images

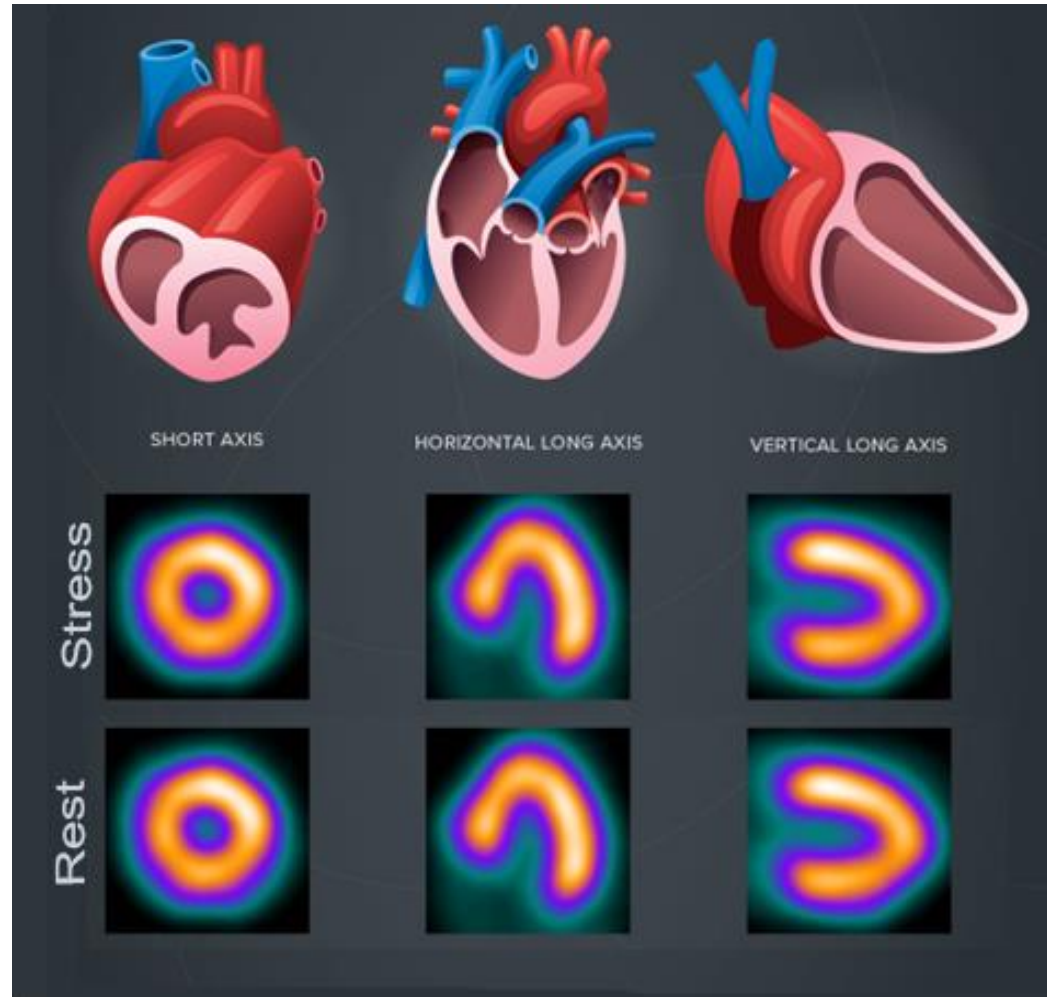


Compare rest versus stress

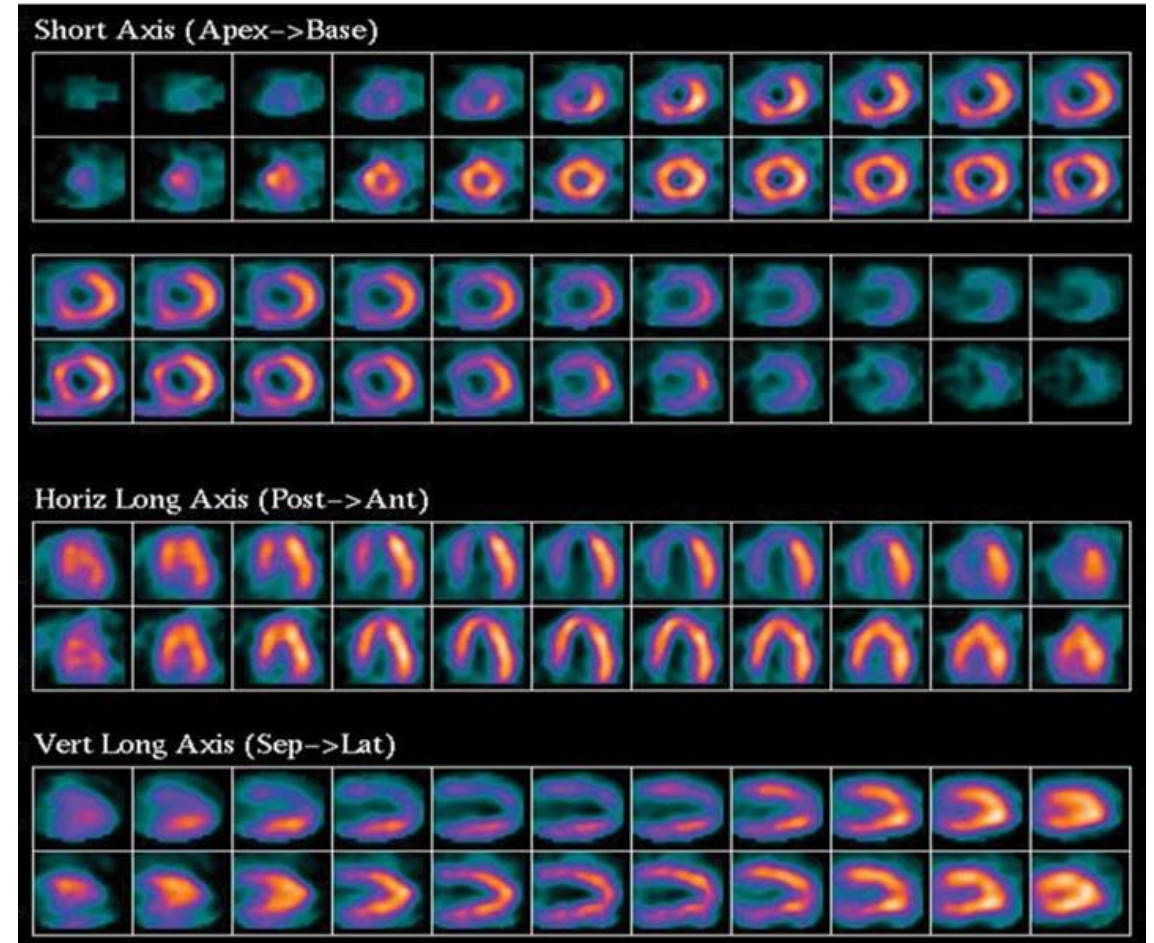
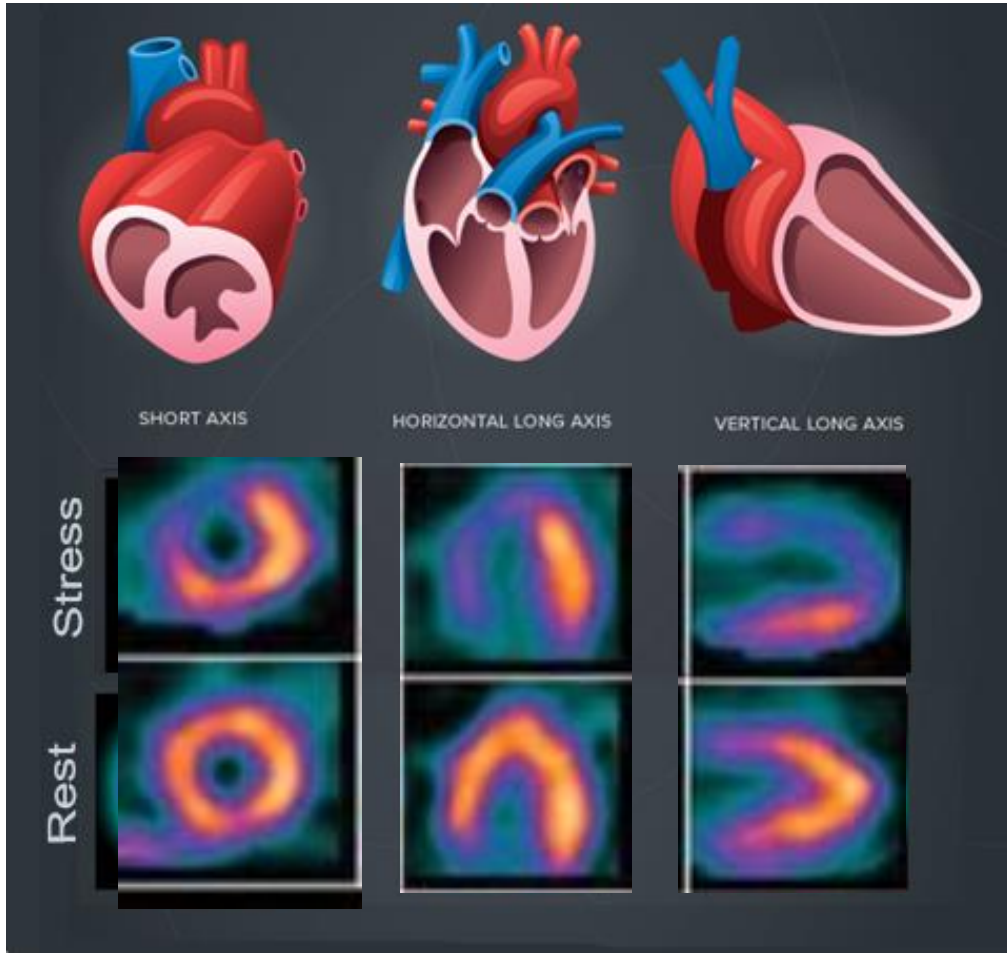
Normal Myocardial Perfusion Images



Normal Myocardial Perfusion Images



Abnormal Myocardial Perfusion Images



Predictors of Poor Outcome with MPI

Large Ischemic burden

- Sum Stress Score >8
- Sum Difference Score >8
- % of LV myocardium ischemic

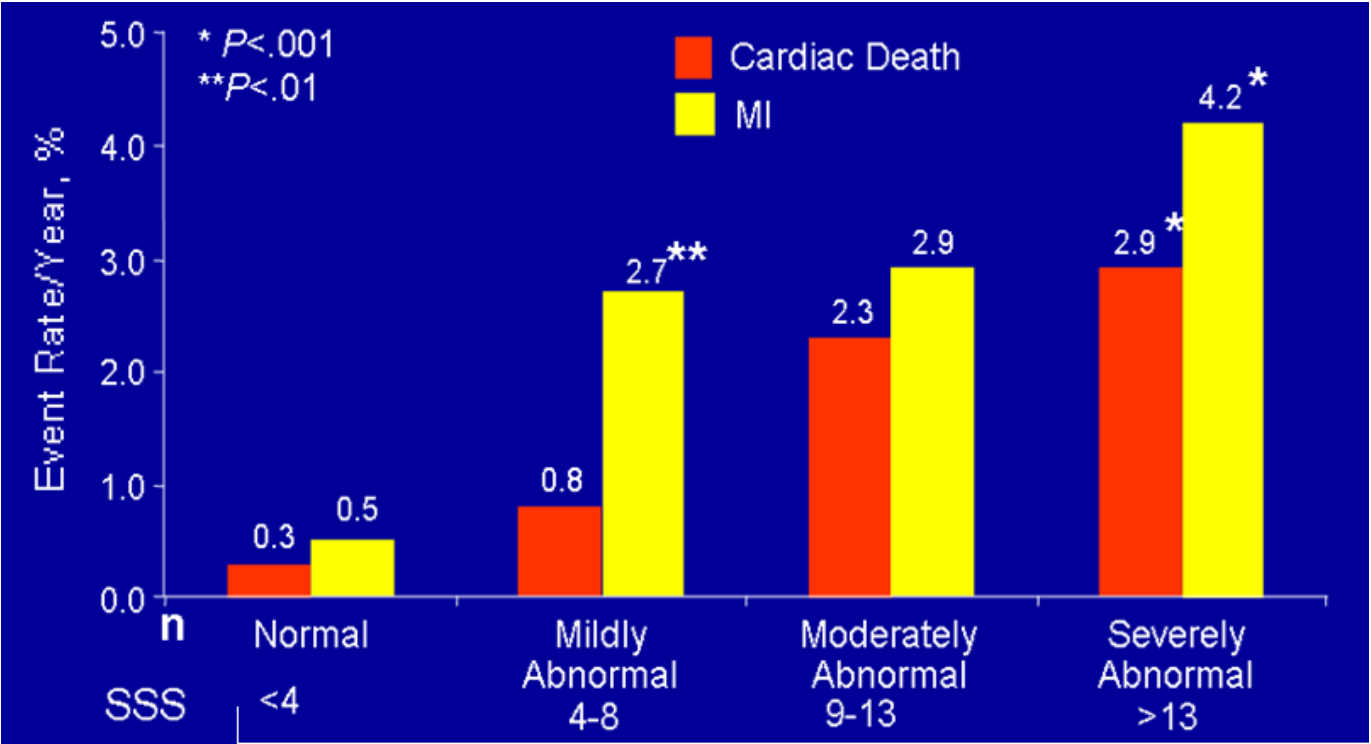
ST changes on Persantine stress

Stress Ejection Fraction falls below $< 45\%$

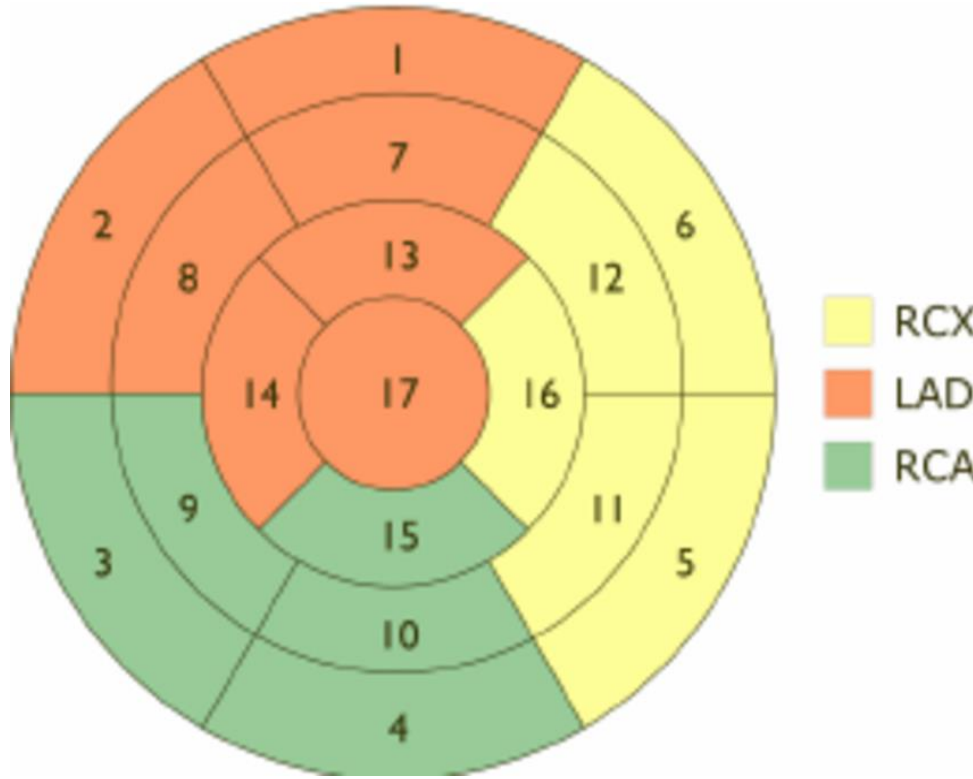
Transient Ischemic Dilation (TID) > 1.2

Predictor of Poor Outcomes

More Segments = Worse Prognosis

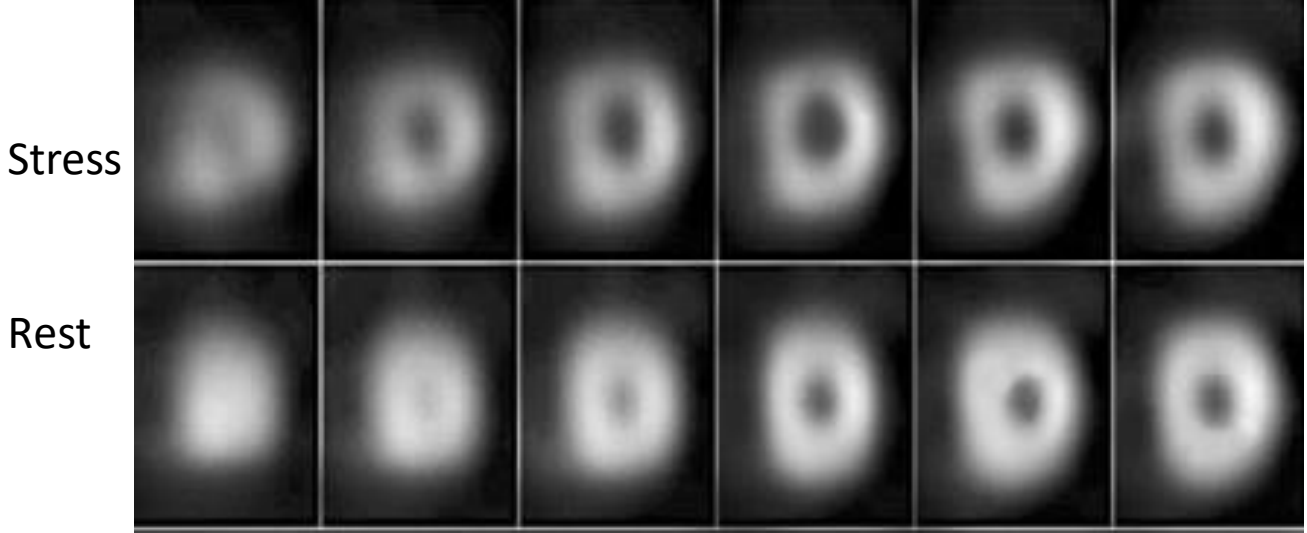
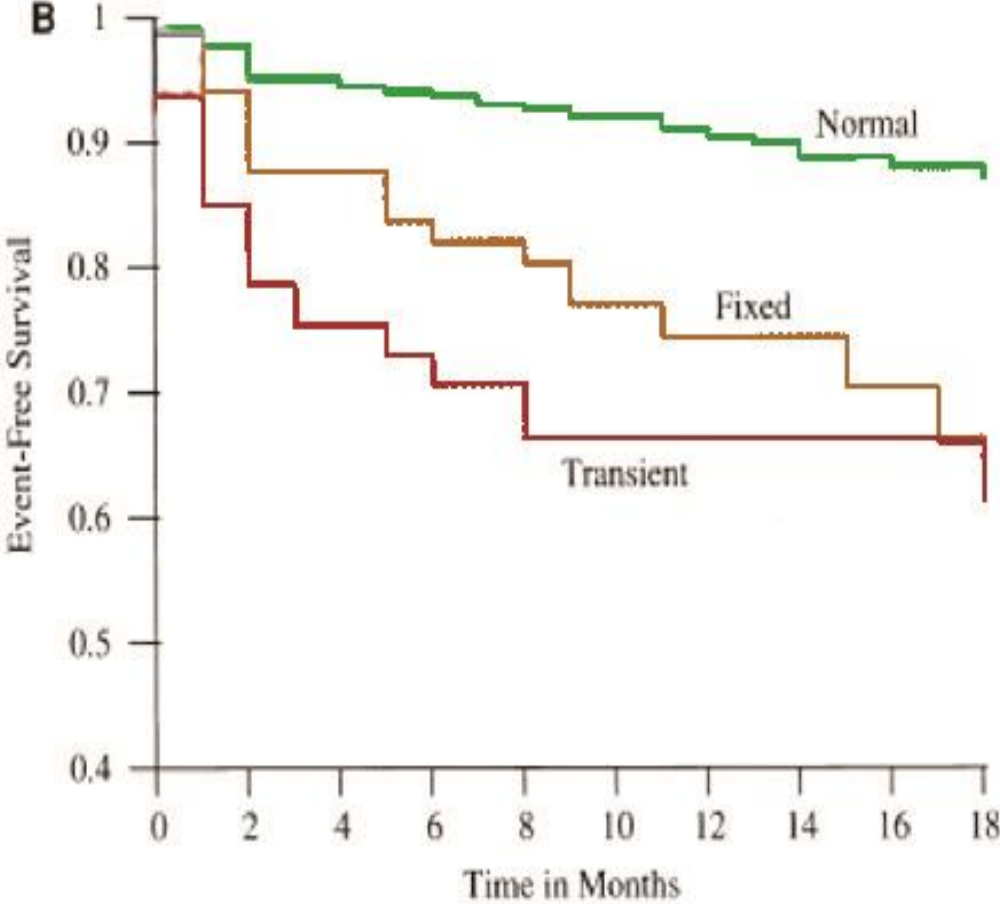


Sum Stress Score > 8 correlates with Higher Risk



- Hachamovitch et al: Circulation 1996;93:905-914

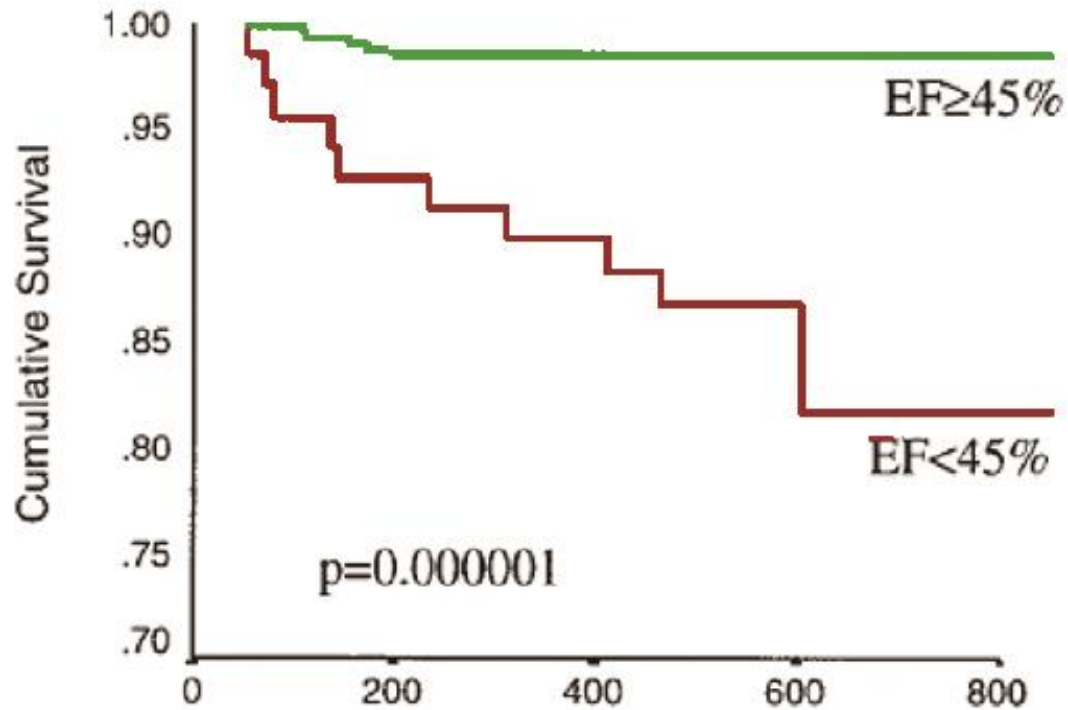
Cardiac Dilatation (TID) Predicts High Risk



McLellan et al: Am J Cardiol 1997;79:600-605

Fall in Ejection Fraction Predicts increase Mortality

MPI Ejection Fraction & Prognosis



Dominant determinant of mortality

Poll Question

Jonathan

65 Male

Typical Angina only at highest workload

Risk Factors: BMI 28, Diabetes, Hypertension, HPL

Physical examination negative

Negative myocardial perfusion scan

What is Most Likely?

- a) Jonathan does not have CAD
- b) The chest pain is not cardiac
- c) The Perfusion scan is a false negative
- d) Jonathan is low risk for cardiac events

Normal Myocardial Perfusion = Very Low Risk

Event rate < 0.5% per year

| Reference | Radionuclide Used | n | Mean Age (yrs) | Women (%) | Prior MI (%) | Mean Follow-Up (Months) | Event Rate After Negative Test (%) (95% CI) | Negative Predictive Value (%) (95% CI) | Annualized Event Rate (%) |
|----------------------------|-------------------|-------|----------------|-----------|--------------|-------------------------|---|--|---------------------------|
| Ambrosi et al. (157) | Tl | 84 | 59 | 28 | * | 46 | 3.6 | 96.4 | 0.93 |
| Boyne et al. (141) | MIBI | 155 | 58 | 50 | 27 | 19 | 1.3 | 98.7 | 0.81 |
| Chatziioannou et al. (142) | MIBI | 230 | 54 | 13 | 20 | 18 | 0 | 100 | 0 |
| del Val Gomez et al. (143) | Tl | 85 | 56 | 53 | * | 24 | 0 | 100 | 0 |
| Elhendy et al. (156) | MIBI | 218 | 53 | 50 | 6 | 89 | 5.0 | 95.0 | 0.68 |
| Galassi et al. (144) | Tetro | 106 | 58 | 22 | 55 | 38 | 2.8 | 97.2 | 0.89 |
| Hachamovitch et al. (155) | Tl/MIBI | 4,791 | 61 | 49 | 0 | 22 | 0.4 | 99.6 | 0.2 |
| Kaminek et al. (145) | Tl or MIBI | 147 | * | 28 | * | 24 | 0.7 | 99.3 | 0.34 |
| Olmos et al. (154) | Tl | 115 | 56 | 24 | 35 | 44 | 3.5 | 96.5 | 0.95 |
| Pattillo et al. (153) | Tl | 196 | 59 | 29 | 47 | 41 | 3.6 | 96.4 | 1.0 |
| Raiker et al. (152) | MIBI | 208 | 59 | 48 | 4.8 | 14 | 0.5 | 99.5 | 0.41 |
| Schinkel et al. (151) | Tetro | 294 | 56 | 33 | 27 | 48 | 1.0 | 99.0 | <0.3 |
| Soman et al. (150) | MIBI | 426 | 56 | 42 | 6 | 30 | 0 | 100 | 0 |
| Stratmann et al. (149) | MIBI | 206 | * | 2 | 35 | 13 | 0.5 | 99.5 | 0.45 |
| Sugihara et al. (148) | MIBI | 104 | 68 | 42 | 18 | 13 | 0 | 100 | 0 |
| Vanzetto et al. (147) | Tl | 388 | 55 | 25 | 24 | 72 | 2.1 | 96.6 | 0.56 |
| Zerahn et al. (146) | MIBI | 255 | 57 | 36 | 51 | 59 | 3.1 | 96.9 | 0.64 |
| Summary estimate | | 8,008 | 54.1 | 33.8 | | 36.1 | 1.21 (0.98-1.48) | 98.8 (98.5-99.0) | 0.45 |

Advantages of Myocardial Perfusion Imaging

Best predictive value

- high suspicion CAD

Less limited by poor images

- echo images due to body habitus (obesity)

Most Sensitive examination especially for low and high-risk patients

- single vessel disease
- Patient with abnormal LV function at rest

Abnormal EKG conduction

- Left Bundle Branch Block
- Permanent Pacemaker

Assessment of prognosis

- Ischemic burden
- Prognosis

Poll Question

Joseph

69 Male

Chest pressure after meals and exercise

Chest pain walking or climbing stairs

PMH bilateral hip replacements

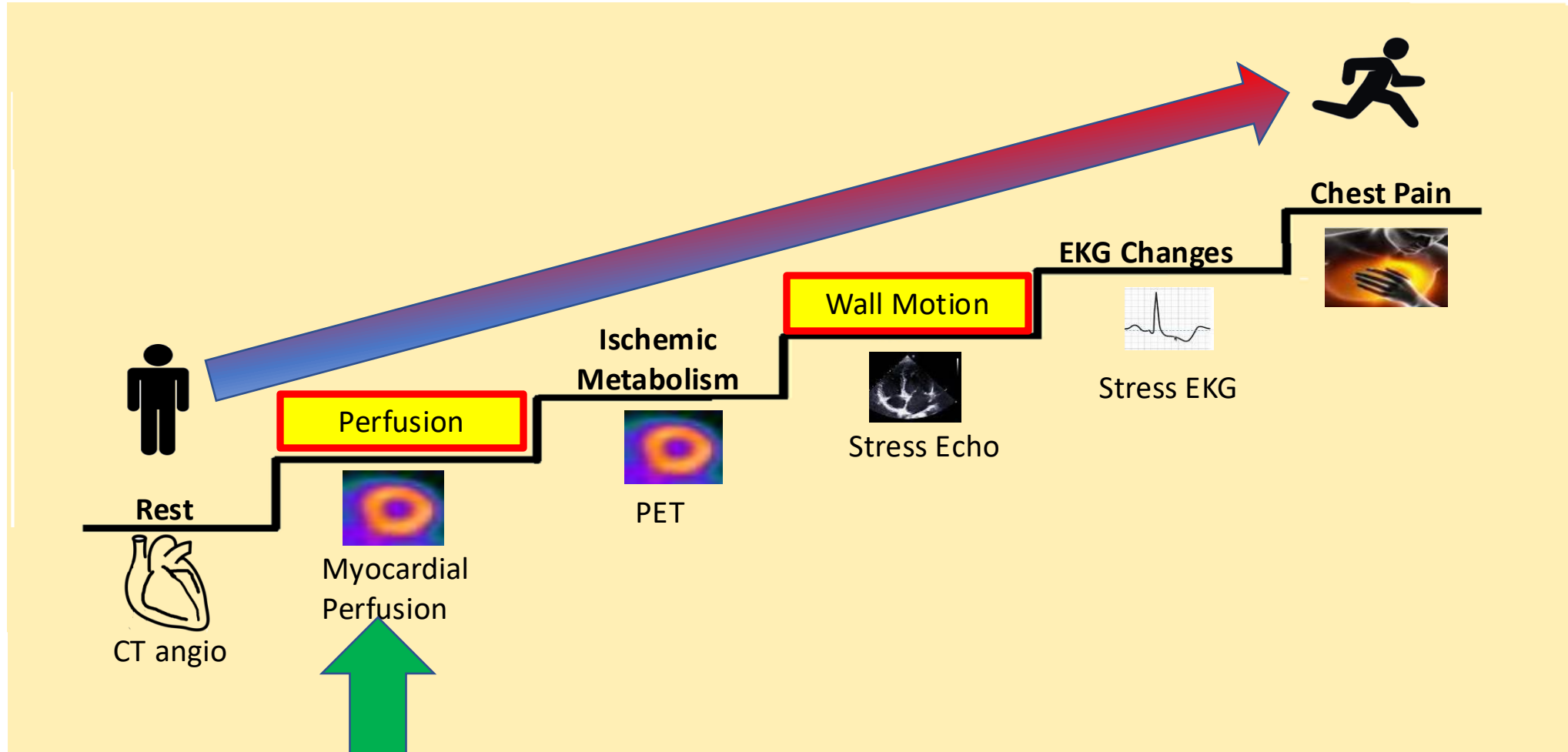
Physical examination negative

EKG Sinus with LBBB

Which Test Would You Order

- a) GXT
- b) Stress Echo
- c) Myocardial Perfusion Scan
- d) CT coronary Angiogram
- e) None

Functional Stress Testing



When to use Dipyridamole (Persantine)

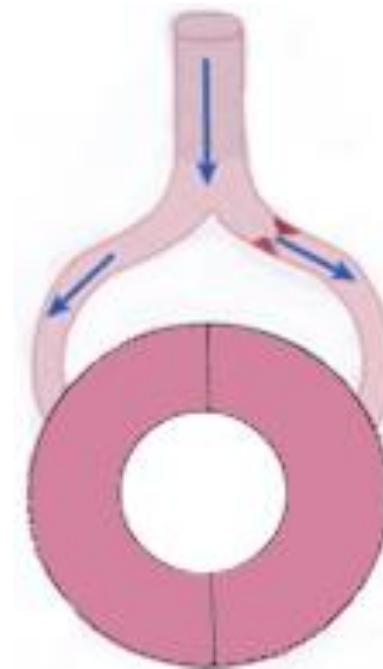
- Exercise Inadequate
 - Cannot achieve target (85% predicted maximum)

Persantine more accurate than stress or dobutamine

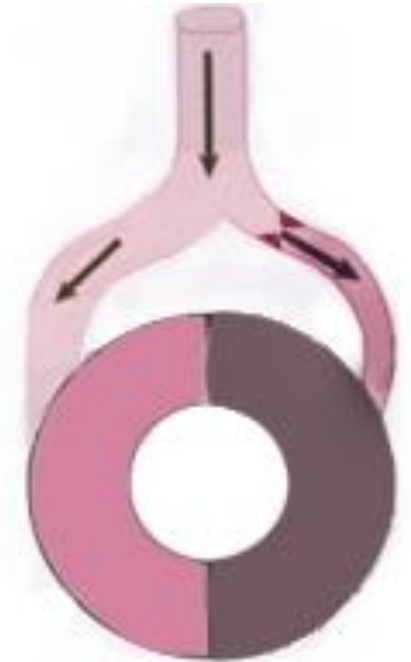
- LBBB
- LV Pacing

How does Dipyridamole (Persantine) work?

- Dipyridamole dilates coronary arteries
- Normal coronaries have reserve and can dilate significantly and increase blood flow
- Stenosed coronary arteries are already dilated to compensate and cannot dilate further
- The Dipyridamole causes ‘Steal’: flow increases to more to normal arteries than stenosed arteries
- The images then show the stenosed areas as having less blood flow.



Resting
Coronary
Flow



Post Persantine
Coronary
Flow

How Persantine MPI Testing is Done



Inject isotope at rest

Acquire SPECT images



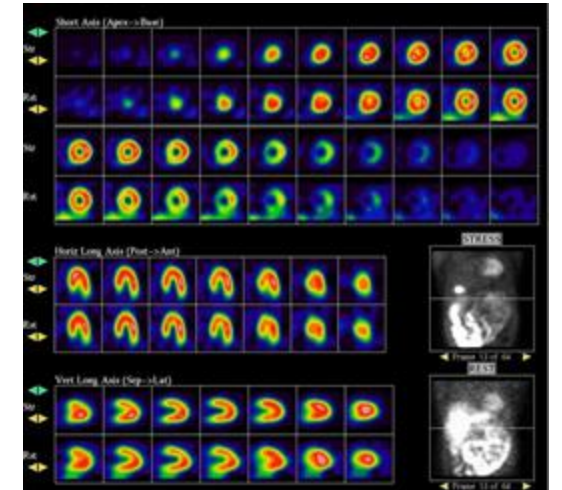
Stress the Patient

0.56 mg/kg Dipyridamole

Inject isotope



Acquire SPECT images



Compare rest versus stress

Where Perfusion Imaging is Preferred

- Patient with high suspicion CAD
- Poor echo images due to body habitus (obesity, COPD etc)
- Suspect single vessel disease
- Patient with abnormal LV function at rest
- Abnormal EKG conduction (LBBB, Pacemaker)
- Assessment of Ischemic burden

Poll Question

Adrian

50 Male

Asymptomatic

PMH Familial hyperlipidemia

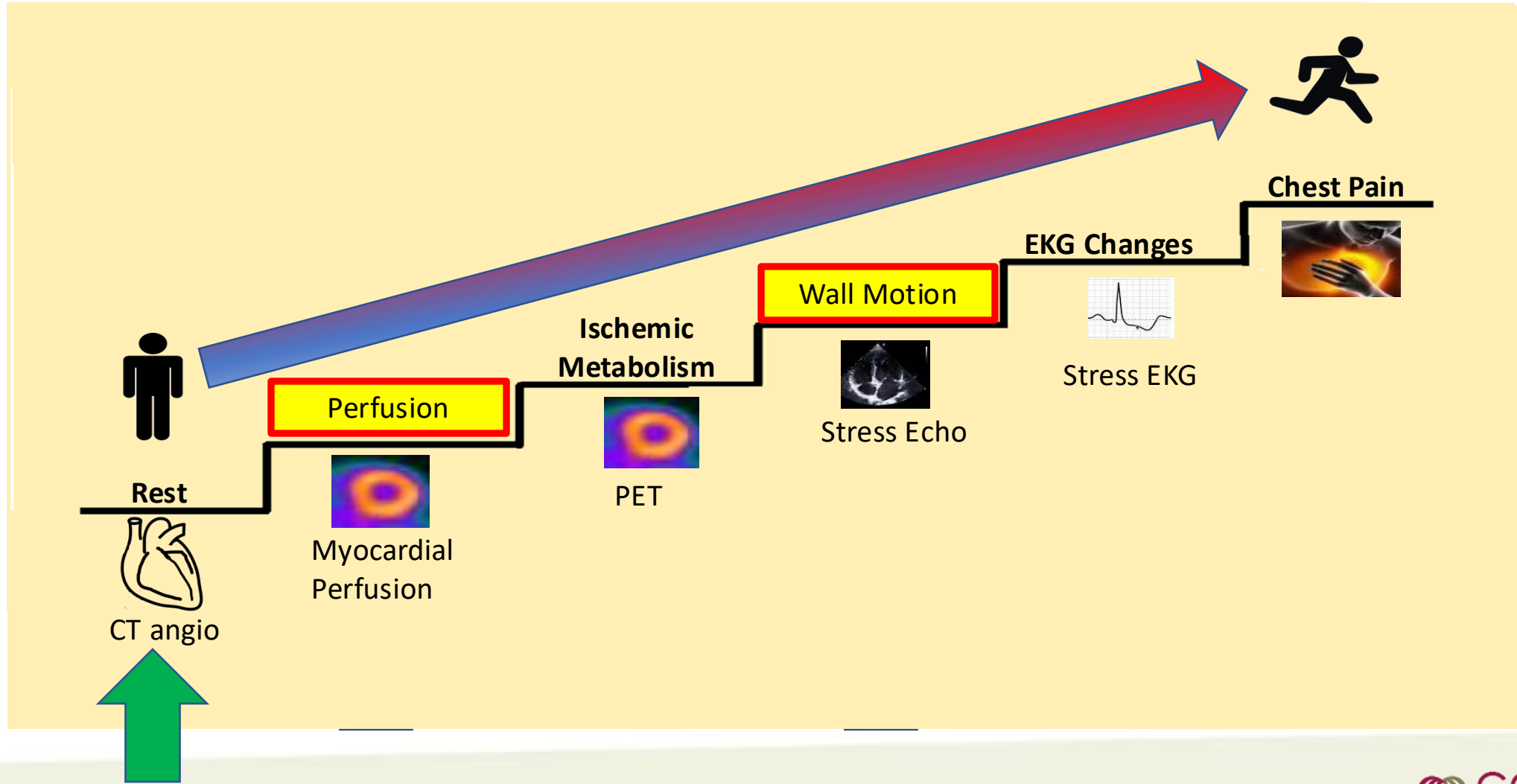
Negative myocardial perfusion scan 2020

Physical examination negative

Which Test Would You Order

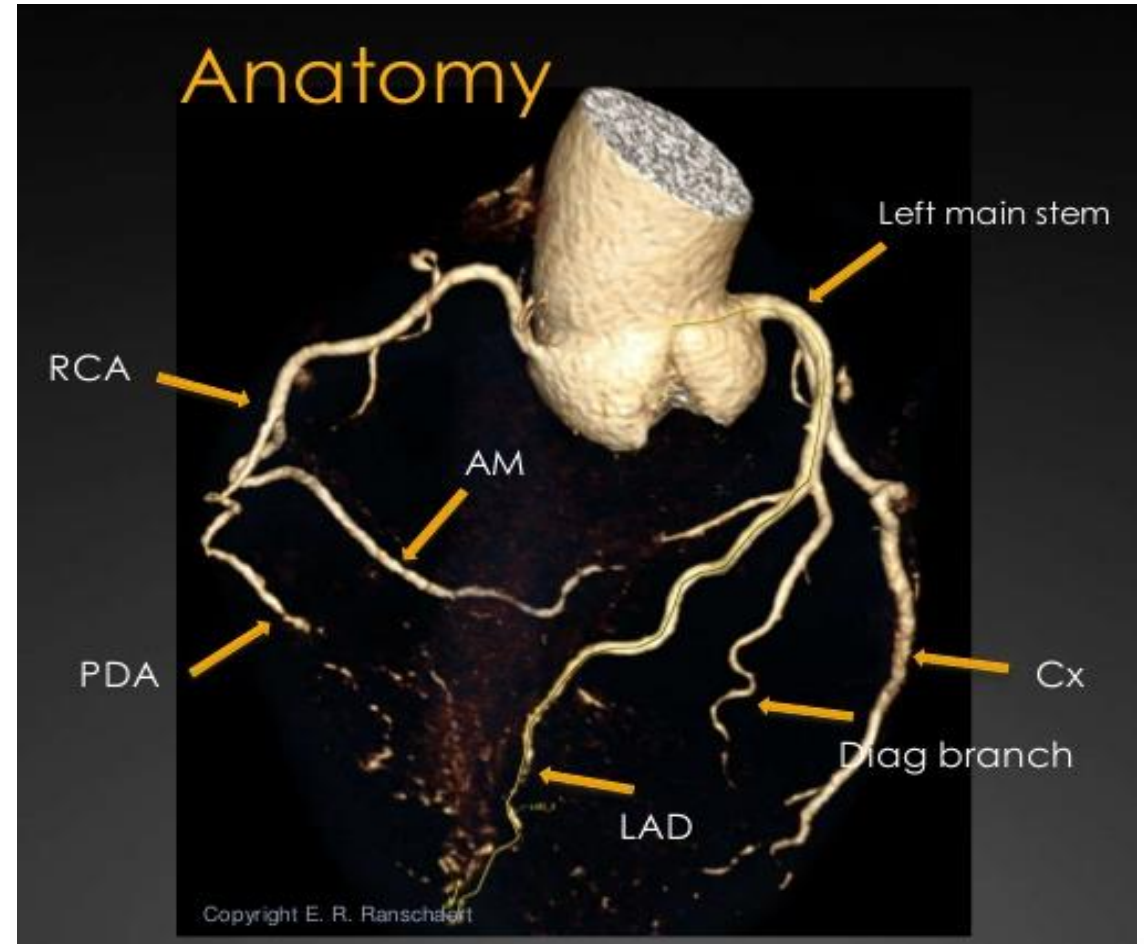
- a) GXT
- b) Stress Echo
- c) Myocardial Perfusion Scan
- d) CT coronary Angiogram
- e) None

Functional Stress Testing



CT Coronary Angiography

- Non-invasive CT scan
- Good visualization of the coronary vessels
- Normal findings 'exclude' significant CAD
- Complements perfusion imaging
(flow vs Anatomy)
- Added prognostic value
- Part of CCS lipid guideline strategy



Indications For CTA (CT Coronary Angiography)

Coronary Disease

CAD in low risk patients

CAD assessment in high risk asymptomatic patients (FH, DM)

'Tiebreaker' in patients with borderline indication for statin Rx

Rule out left main disease in patients with established CAD

Other

Bypass patency

Cardiac mass

Calcific Aortic Stenosis

Anomalous coronary anatomy

Patient Preparation for CTA

Renal Protection

- ✓ EGFR > 50
- ✓ Hydration
- ✓ Stop Metformin if GFR<60

Allergy

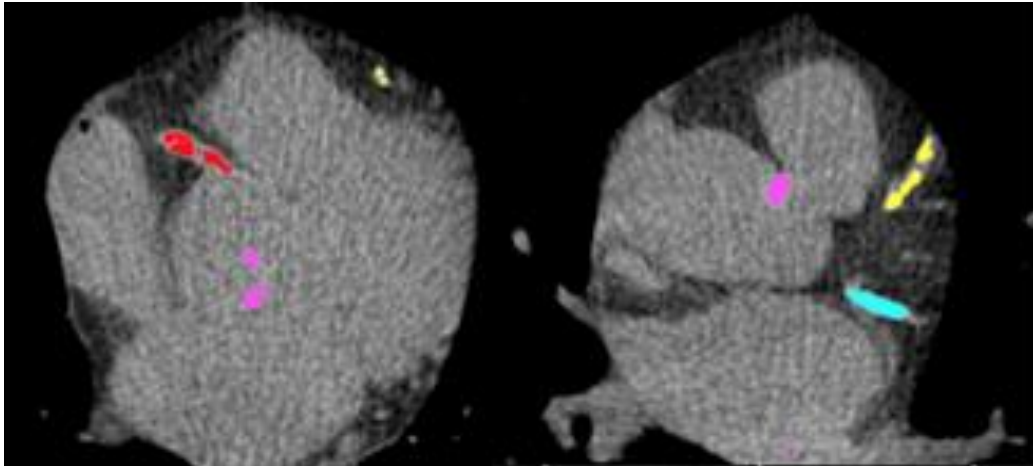
- ✓ Premedication for iodine, shellfish allergy

Heart Rate must be below 70 bpm during CT

- ✓ recommend bisoprolol 10 mg OD for 5 days prior to CTA



CALCIUM (AGASTON) Score



If Score > 800, test often cancelled
due to inability to assess CAD adequately

Measures total calcium content of Coronary Tree

Score 0

- low prevalence of obstructive CAD <5%
- low risk of death or non-fatal MI <1%

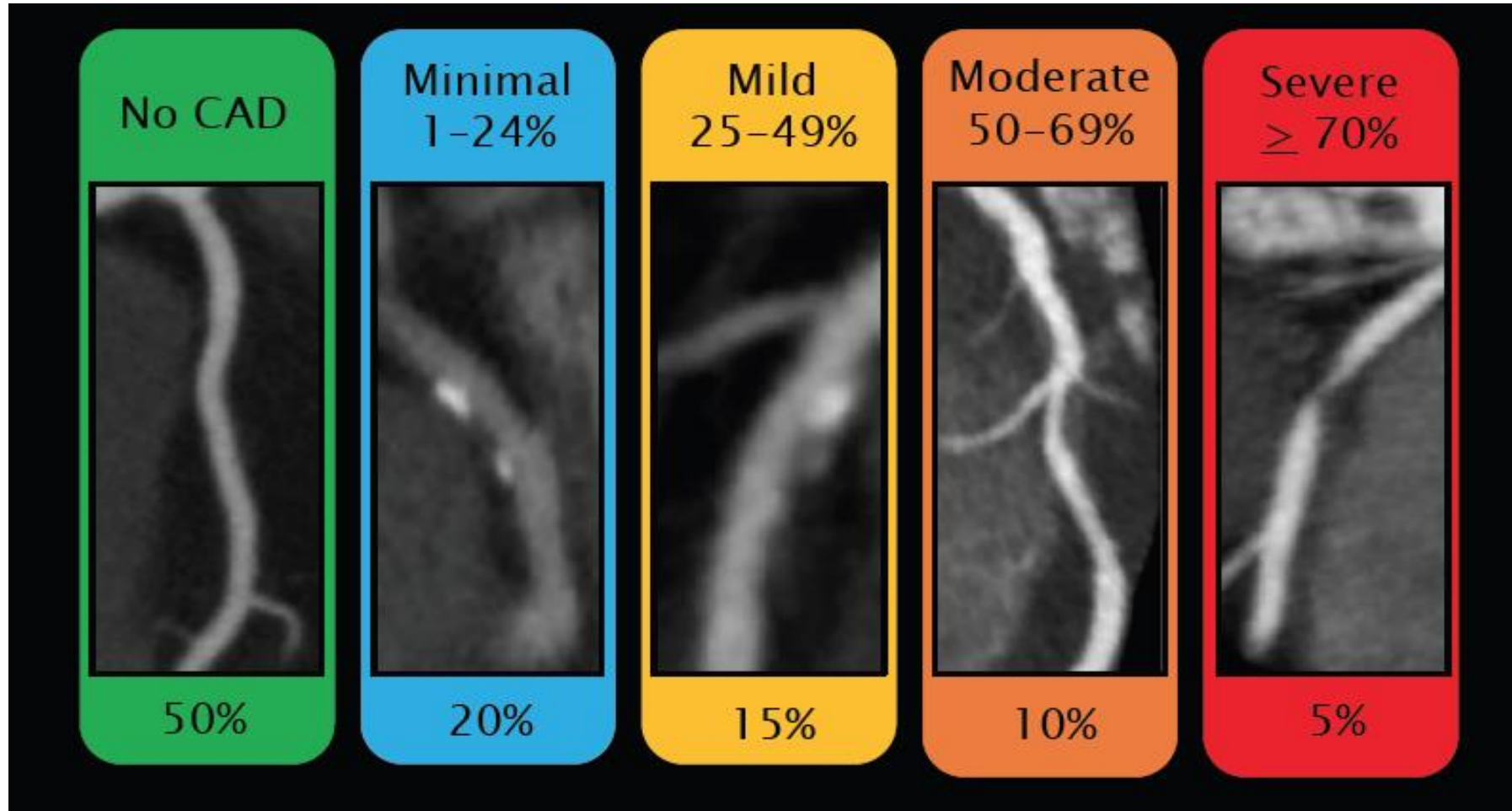
Ca Score >100

- Reclassifies patients to moderate risk

Score > 200

- Reclassifies patients to higher risk

CTA to assess Coronary Stenosis



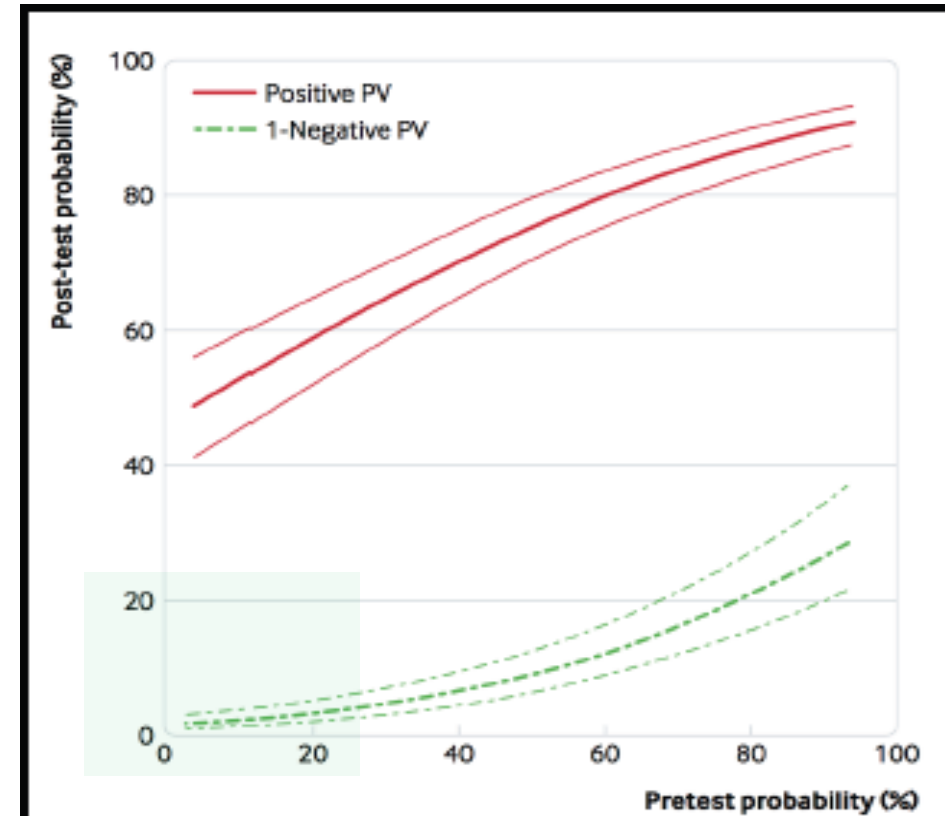
CT Coronary Angiography

Highly Accurate to Confirm Low Risk CAD

Metanalysis of 5332 patients in 65 prospective studies

- Sensitivity: 96-99%
- Specificity: 88-91%
- NPV Negative Predictive value >90%

**Ideal test to exclude Coronary disease
in low risk patients**



Advantages of CT Coronary Angiography

Pros

- Anatomic information
- Calcium score
- Diagnosis of atherosclerosis
- Degree of stenosis
- Plaque volume
- Plaque vulnerability

Cons

- Imaging poor with
 - Calcification
 - Tachycardia, irregular heart rate, afib, PVC
 - Obesity
- Lack of physiologic assessment

Summary: Which Test for Which Patient

Regular GXT

- Low to intermediate risk of CAD
- Normal resting ECG
- able to exercise

Stress Imaging

- Diagnosis:
 - Abnormal resting EKG, Pacemaker
 - Unable to Exercise
 - Abnormal GXT
- Prognosis in established ASCD

Summary: Stress Echo Preferred

- Younger patients <45 yrs
- Patient in whom you are *less suspicious* they have disease
- Follow-up prognostic studies
- Suspicious for other structural heart problems (ie pulmonary hypertension, valvular disease)

Summary: Perfusion Imaging Preferred

- High sensitivity for CAD especially if
 - Single vessel disease
 - LV function abnormal
- Recommended LBBB, PPM
- Patients who can't exercise
- Body Habitus issues (False positives uncommon with modern CTZ cameras)
 - Breast artifact - women
 - Diaphragm - men, obese

THANK YOU