The Family Physicians' Guide to
CARDIAC STRESS TESTING

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Disclosures

None

I have no conflicts of interest in relation to this program/presentation

Objectives

Review the various types of noninvasive stress testing modalities

Review stress testing terminology and concepts

Understand basic indications and contraindications to stress testing

Articulate the risks and benefits of various stress testing modalities

Understand the differences between stress test modalities and which test to order

Purpose of Stress Testing

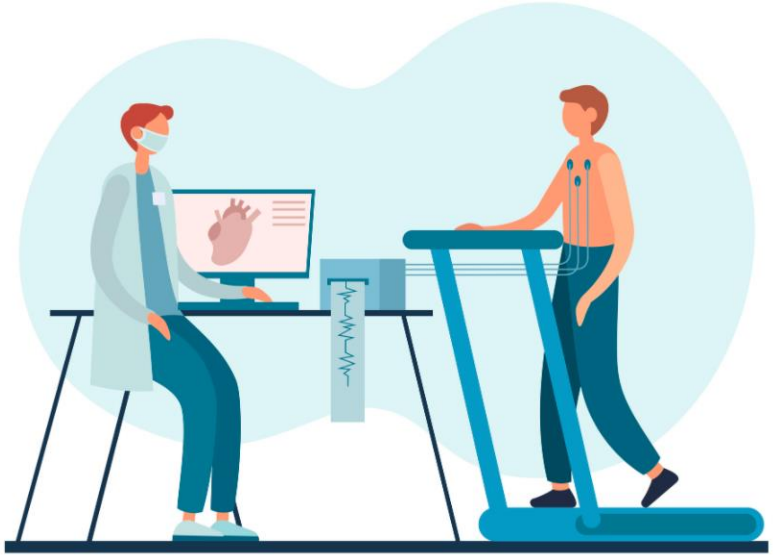
The basic principle of stress testing is to provoke ischemia

Stress testing is designed to detect *obstructive* coronary artery disease in patients with chest pain syndromes (or symptom equivalents)

- Stress testing will not detect nonobstructive CAD

Other uses:

- Assessment of response to medical therapy
- Evaluation of exercise-related symptoms
- Assessment of chronotropic competence and arrhythmias



3 Basic Questions

1. **What is the pretest probability of CAD?**
    a. Age
    b. Sex
    c. Characterization of chest pain
2. **Are there conditions precluding a diagnostic exercise ECG stress test?**
3. **Can the patient exercise?**

Chest Pain

Chest pain is the chief complaint in 1% of outpatient visits[1]

Chest pain is a diagnostic challenge given the wide array of possible etiologies

Distinguishing between serious and benign causes of chest pain is imperative

1. Rui P, Okeyode T. National Ambulatory Medical Care Survey: 2016 national summary tables. Available at: https://www.cdc.gov/nchs/data/ahcd/namcs_summary/2016_namcs_web_tables.pdf (Accessed on February 26, 2021).

How to perform an appropriate chest pain evaluation:

- Utilize a stepwise approach

Step 3: Determine the Most Appropriate Stress Test Modality

Step 2: Determine Pretest Probability of CAD

Step 1: Assess the Clinical Classification of Chest Pain

Chest Pain Classification – Is it “typical”?

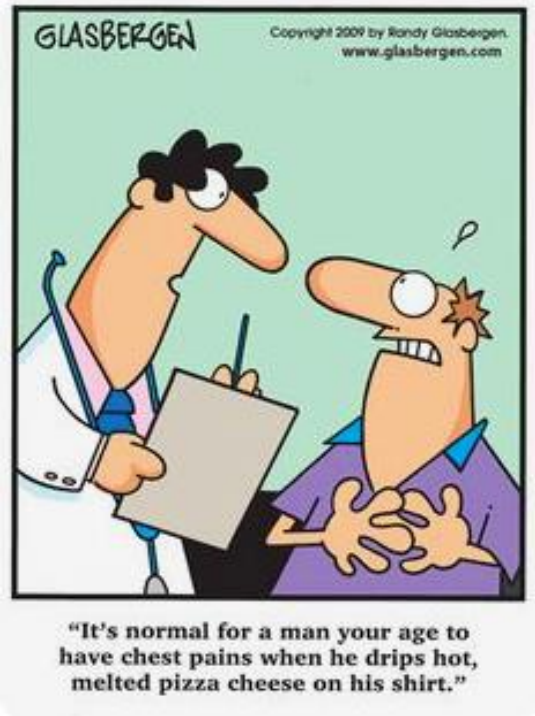
What is angina?

- Substernal chest discomfort
- Provoked by exertional or emotional stress
- Relieved by rest or nitroglycerin

3/3 = TYPICAL ANGINA

2/3 = ATYPICAL CHEST PAIN

1/3 = NONCARDIAC CHEST PAIN



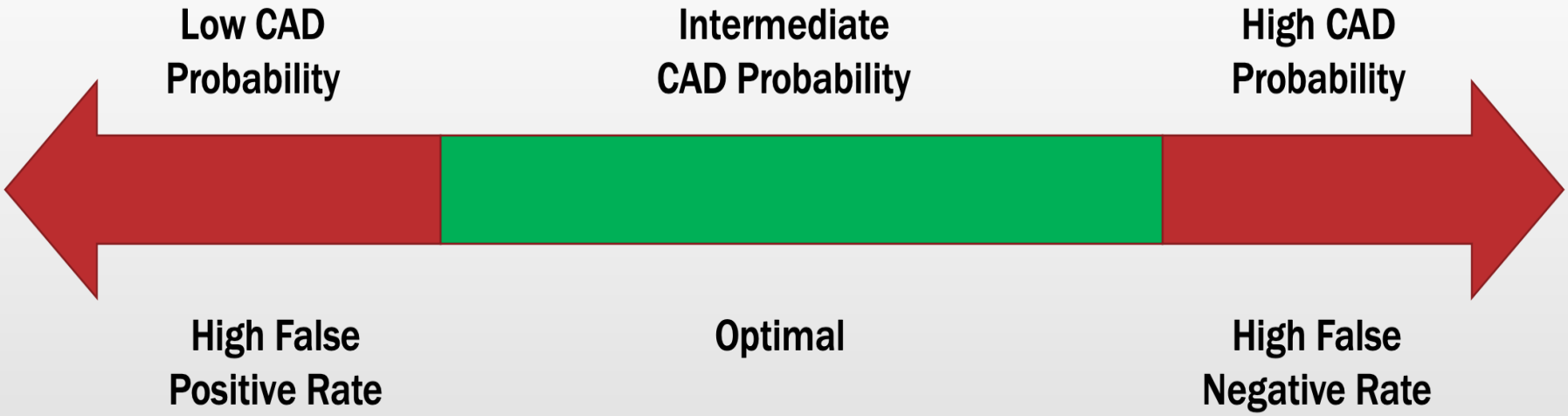
Determine Pre-Test Probability of CAD

Age	Gender	Typical	Atypical	Noncardiac	Asymptomatic
30-39	Men	Intermediate	Intermediate	Low	Very low
	Women	Intermediate	Very low	Very low	Very low
40-49	Men	High	Intermediate	Intermediate	Low
	Women	Intermediate	Low	Very low	Very low
50-59	Men	High	Intermediate	Intermediate	Low
	Women	Intermediate	Intermediate	Low	Very low
60-69	Men	High	Intermediate	Intermediate	Low
	Women	High	Intermediate	Intermediate	Low

Very low < 5% | Low 5-10% | Intermediate 10-90% | High > 90%

Determine Pre-Test Probability of CAD

Diagnostic power of stress testing is maximal when pre-test probability is intermediate



Determine Stress Test Modality

Factors that influence choice of stress test modality:

- Patient's ability to exercise
- Resting ECG
- Clinical indication to perform the test
- Body habitus
- History of prior revascularization

Methods of Stress

Exercise

- Treadmill
- Bicycle

Vasodilator Pharmacologic Stress Agent

- Regadenoson
- Adenosine
- Dipyridamole

Chronotropic Pharmacologic Stress Agent

- Dobutamine

Methods to Detect Ischemia

Electrocardiography

Echocardiography

Myocardial Perfusion SPECT Imaging

Myocardial Perfusion PET Imaging

Magnetic Resonance Perfusion Imaging

Ischemic Findings on Stress Testing

Signs and symptoms

- Reproduction of chest symptoms
- Hypotensive response to stress

ST elevation or depression on ECG

Regional wall motion abnormality on echocardiography

Perfusion defect on myocardial perfusion imaging

Potential Complications

While rare, stress testing can be associated with serious complications

- Musculoskeletal injury
- Hypertension
- Arrhythmia (atrial fibrillation, SVT, VT, VF)
- Myocardial infarction
- Stroke
- Death

The frequency of serious adverse cardiac events (ie myocardial infarct, sustained ventricular arrhythmia or death) is approximately 1 in 2500.[1]

1. Gibbons RJ, et al. ACC/AHA 2002 guideline update for exercise testing: summary article. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. J. Am. Coll. Cardiol. Oct 16 2002;40(8):1531-1540.

Absolute Contraindications

- Acute myocardial infarction (within 2 days)
- Ongoing unstable angina
- High risk (based on pretest probability) of unstable angina
- Uncontrolled cardiac arrhythmias
- Decompensated heart failure
- Symptomatic severe aortic stenosis
- Acute pulmonary embolus
- Acute myocarditis or pericarditis
- Acute aortic dissection

Relative Contraindications

- Known obstructive left main coronary artery stenosis
- Moderate to severe aortic stenosis with uncertain relationship to symptoms
- Tachyarrythmia with uncontrolled ventricular rates
- Acquired high degree or complete heart block
- Hypertrophy cardiomyopathy with severe resting gradient
- Recent CVA or TIA
- Cognitive impairment with limited ability to cooperate
- Resting BP >200/110

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Methods of Stress

Exercise

Exercise is the preferred method of stress

Provides physiologic data including heart rate response, blood pressure response and heart rate recovery

Allows for evaluation of exercise-induced arrhythmias

Contraindications:

- Significant orthopedic issues
- Unsteady gait
- Those unlikely to achieve 85% maximum predicted heart rate

Vasodilators

Vasodilate coronary arteries creating a steal phenomenon in stenosed vessels

Contraindications:

- Severe reactive airway disease
- Serious bradyarrhythmia/AV conduction defects

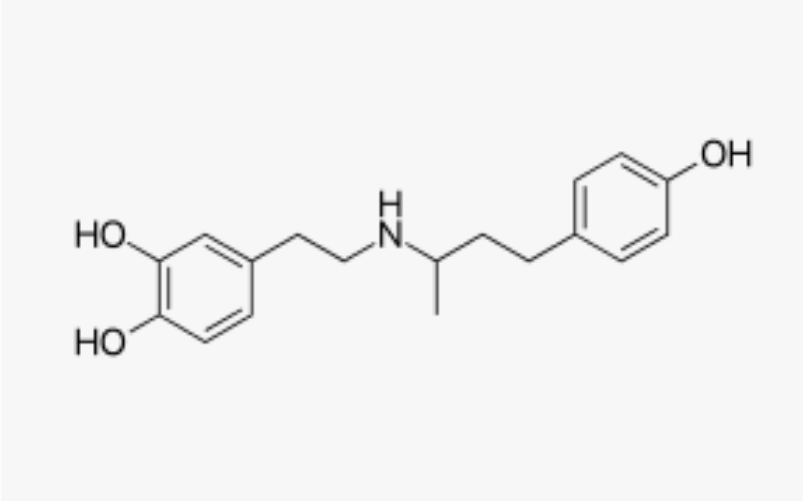
Caffeine interferes with effects – no caffeine for 24 hours prior

Dobutamine

Stimulates cardiac β_1-adrenoceptors to result in increased chronotropy and inotropy

Must hold β-blockers prior

Most serious contraindication is the presence of ventricular arrhythmia



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Methods to Detect Ischemia: Electrocardiography

Overview

Widely available and can be performed with limited expense

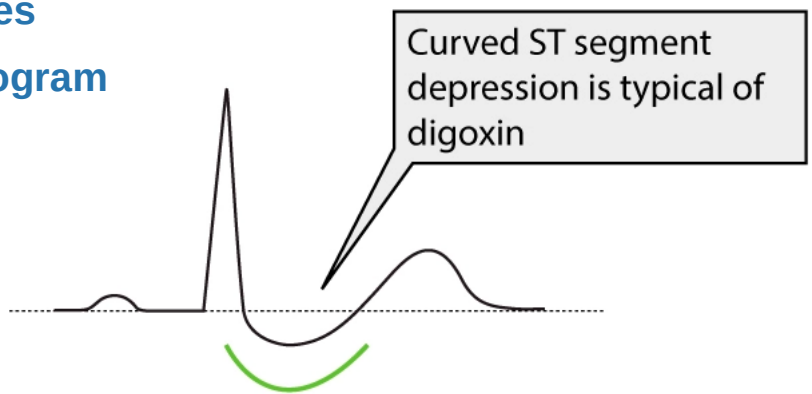
Provide important physiologic data

Exercise ECG testing alone is not useful for localizing the distribution or extent of myocardial ischemia

Higher false-positive rate in women

Contraindications

- LBBB
- LVH with repolarization changes
- Digoxin therapy
- Ventricular paced rhythm
- Wolff-Parkinson White/pre-excitation syndromes
- >1mm ST depression on baseline electrocardiogram
- History of prior revascularization



Exercise Stress Test Measurements

Heart rate response and recovery

Blood pressure

Symptoms

Exercise capacity

- Measured as METs – metabolic equivalent of task

Age-Predicted Maximal Heart Rate

Maximal Heart Rate (MHR) = 220 - age (in years)

Adequate test 85-100% MHR

Submaximal test <85% MHR

- Nondiagnostic for obstructive CAD

Metabolic Equivalent of Task (METs)

Measure of functional capacity

Poor exercise capacity (<5 METS) identifies a high-risk population

Achieving 10 METs predicts good prognosis

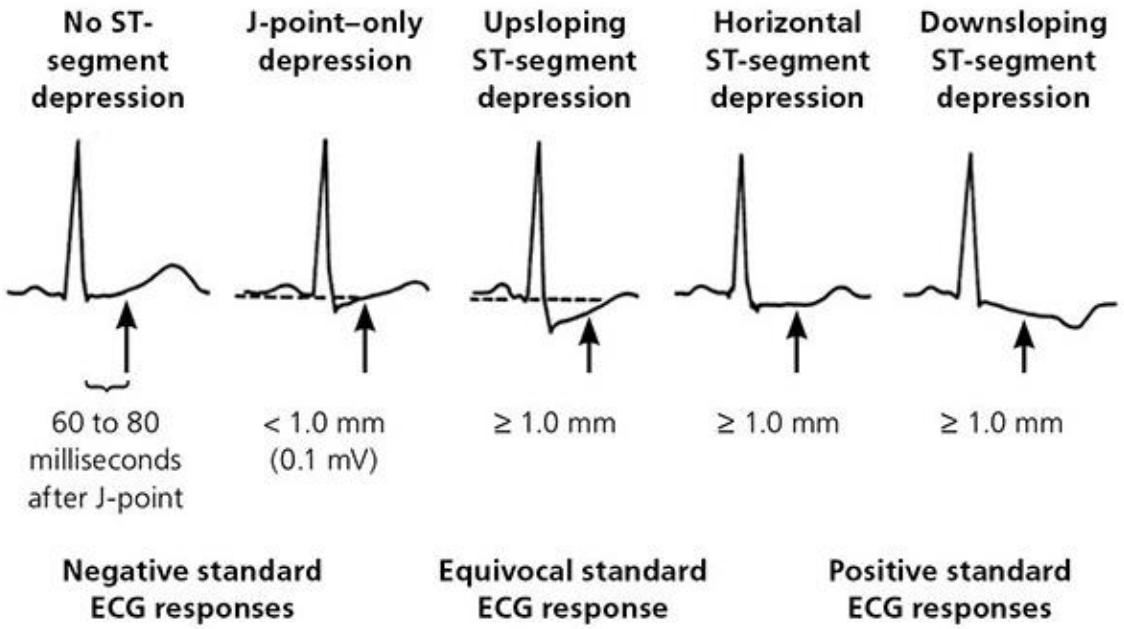
Examples:

- 1 MET = watching television
- 2.3 METs = slow stroll on flat ground
- 4 METs = light housework, climb a flight of stairs, walking 4mph on flat ground
- 7 METS = jogging
- 10 METS = competitive soccer

Ischemic ECG Abnormalities

Positive exercise stress test is defined as:

- ≥1.0 mm horizontal or downsloping ST depression 60-80 ms after the J point



Duke Treadmill Score (DTS)

DTS = exercise time – (5 x max ST deviation in mm) – (4 x treadmill angina index)

Helps clinicians decide whether to refer patients for further evaluation or intervention

Strongest predictive value is in patients classified as high or low risk

- Low risk patients have excellent prognosis- further evaluation is generally unnecessary
- Moderate risk patients should be referred for stress testing enhanced with imaging
- High risk patients have poor prognosis and should be referred for coronary angiography

Duke Treadmill Score: Prediction Of Coronary Heart Disease In A Patient With Chest Pain Undergoing A Treadmill Stress Test		
NOTE: This score is not applicable if patient is known to have CHD.		
Exercise Test variables		
Exercise Time - In Minutes - Standard Bruce Protocol	8	min
Maximum ST deviation - In mm - At 80 msec after the J-Point	1	mm (always a positive figure, no matter if positive or negative deviation)
Angina Score During Exercise	Non-Limiting	
Duke Treadmill Score	-1	
Probability of Significant CHD	41%	probability of >75% stenosis in at least 1 coronary artery
Probability of Severe CHD	31%	probability of 3 vessel CHD or >75% LMS
5-Year Mortality	22%	
Overall risk subcategory	Moderate Risk	
	Angiography may be indicated	

≥+5	Low risk
+4 to -10	Moderate risk
≤-11	High risk

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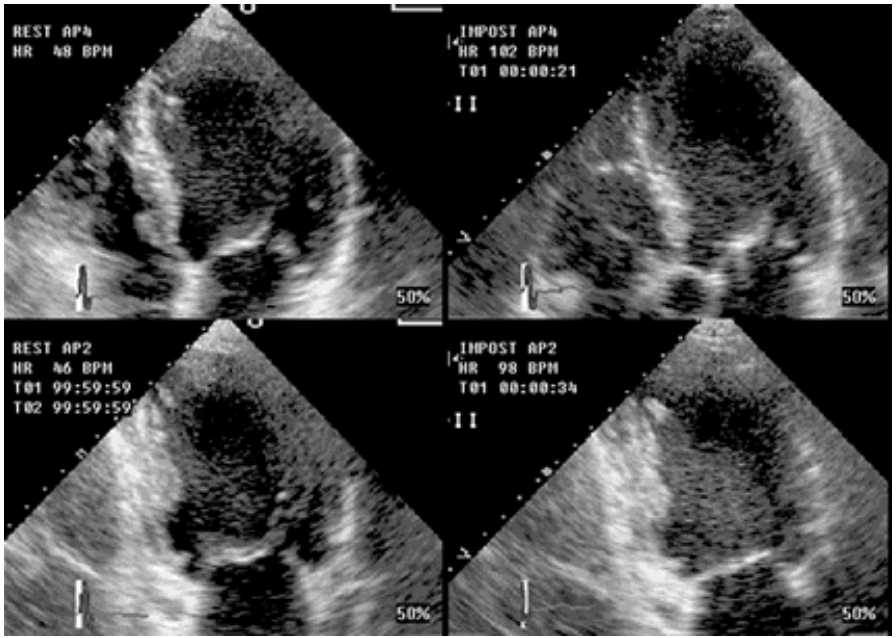
Methods to Detect Ischemia: Echocardiography

Overview

Widely available and can be performed at an intermediate cost

Provides pertinent information on the distribution and extent of coronary artery disease

Interpretation is subject to interobserver variability



Basics of Stress Echocardiography

Pre-exercise and post-exercise focused evaluation of left ventricular wall motion

Obstructive CAD results in regional wall motion abnormalities

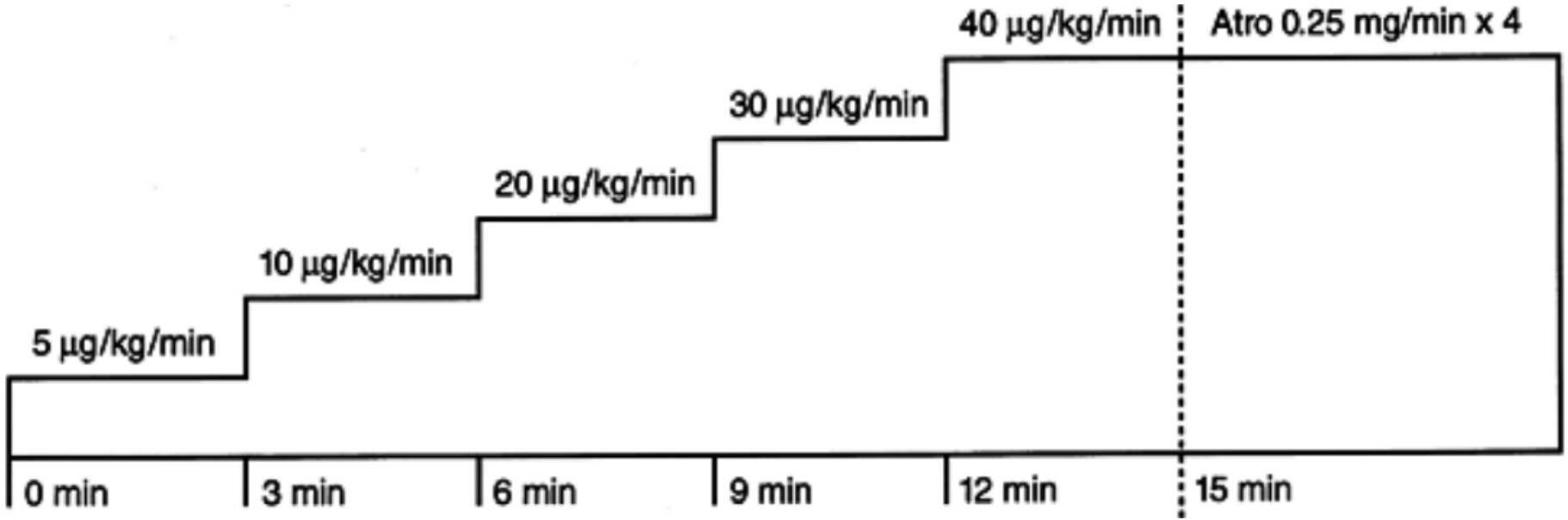
Treadmill/exercise requires rapid transfer of patient from treadmill to exam table

Limited examination – it does not include information about right-sided chambers or valves

Limitations:

- Body habits
- Lung disease
- Breast implants

Dobutamine Stress Protocol



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Methods to Detect Ischemia: Myocardial Perfusion SPECT Imaging

Overview

Underlying principle is that under conditions of stress, diseased myocardium receives less blood flow than normal myocardium.

Utilizes radioactive isotope that is absorbed and retained by viable cardiac tissue.

SPECT imaging performed after stress reveals the distribution of the radioisotope and therefore relative blood flow to the different regions of myocardium

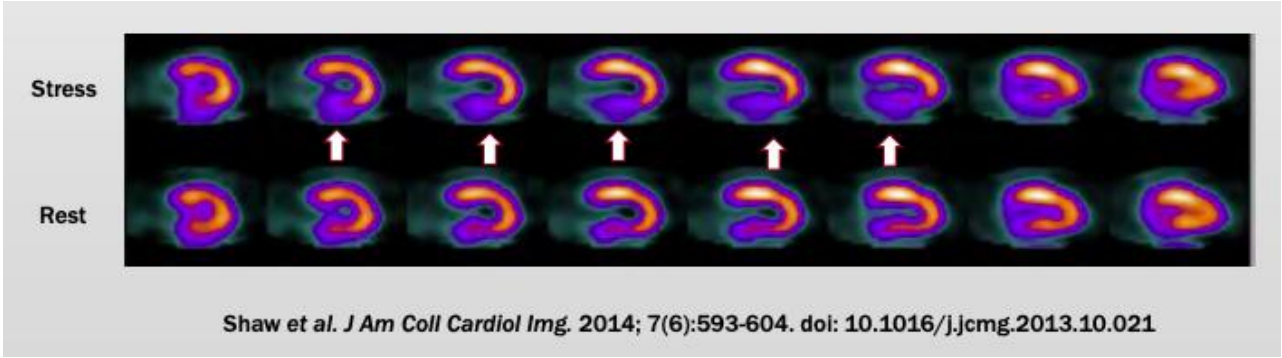
Compare stress images to rest images.

Perfusion Defects in MPI

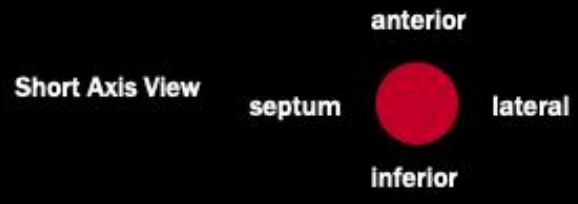
Compare resting images to stress images

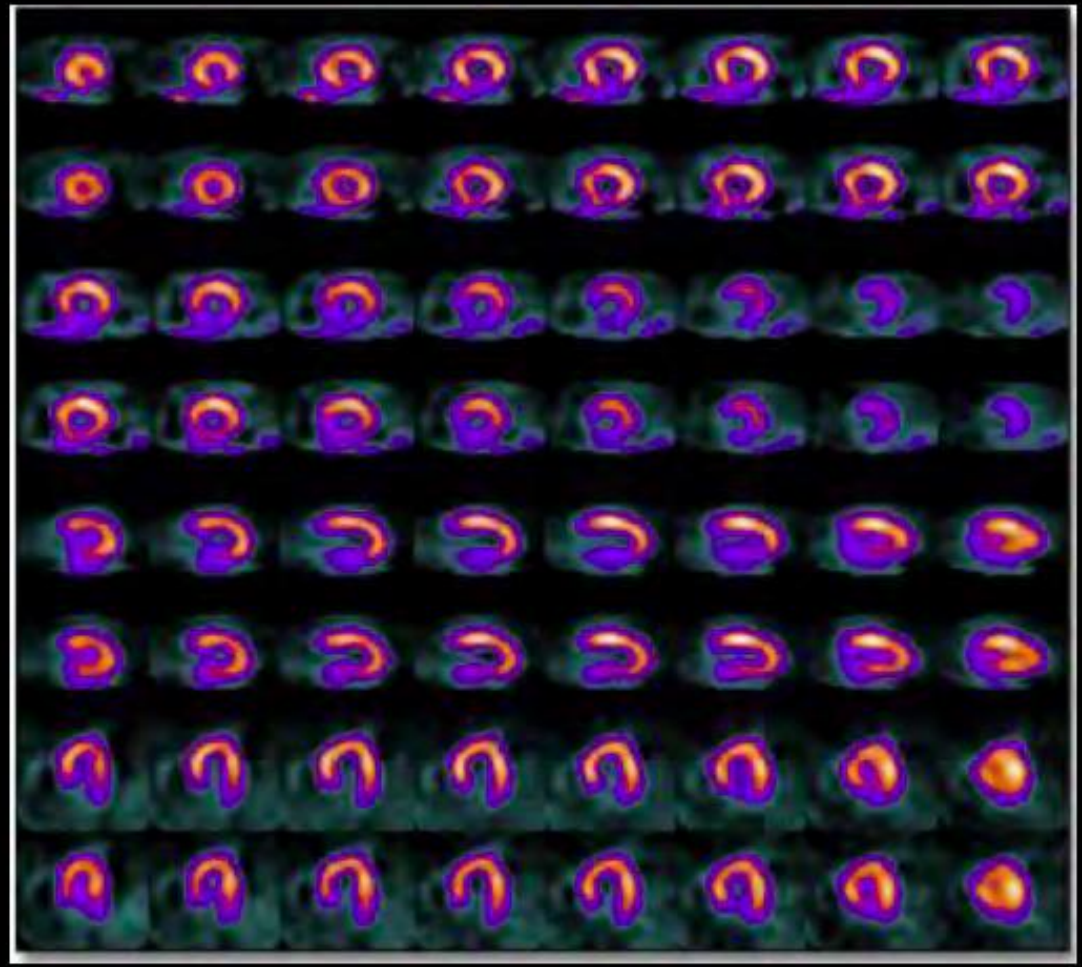
Rest and stress images look the same in a normal patient

Defects in the stress images suggest ischemia



Shaw *et al. J Am Coll Cardiol Img.* 2014; 7(6):593-604. doi: 10.1016/j.jcmg.2013.10.021





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Optimal Patient

Unable to perform treadmill stress test

Underlying LBBB

Pacemaker Dependent

Obese patients

Poor acoustic windows on echocardiography

Limitations

Expensive

Time-consuming

Artifacts due to breast tissue, diaphragm interference or extra cardiac tracer uptake

Balanced ischemia

Radiation exposure

In conclusion…

Comparison of Tests for Diagnosis of CAD

Modality	Sensitivity	Specificity
Exercise test	68%	77%
Nuclear Imaging *Coronary artery stenosis ≥ 50%	87-90%	73-89%
Stress Echo *Coronary artery stenosis ≥ 50%	68-98%	44-100%

CONCLUSION

3 Basic Questions

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CONCLUSION

Summary

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THANK YOU!!!

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