Cardiovascular Imaging in the Evaluation of Chest Pain and Coronary Disease

Justin Penn, MD
Center For Cardiovascular Health at St Michael Medical Center

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Agenda

Symptoms of coronary disease

Developing a pre-test probability

Choosing an appropriate test

Management

Scope

4 million outpatient visits for chest pain each year

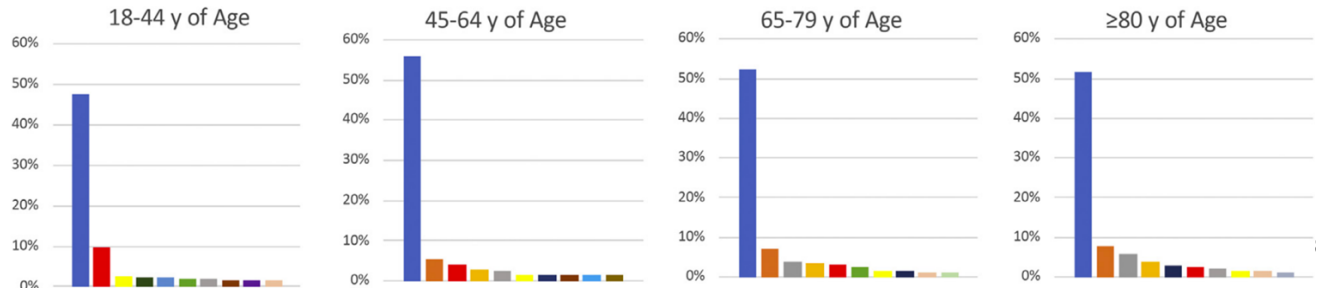
> 6.5 million emergency department visits for chest pain each year

- Only 5.1% will have ACS (STEMI/NSTEMI/UA)

> 18 million people have coronary artery disease

- Majority of patients with chest pain will not have coronary disease

FIGURE 3 Top 10 Causes of Chest Pain in the ED Based on Age (Weighted Percentage)



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Cardiac Chest Pain

Focus of this presentation is for patients with suspected coronary disease with new or chronic symptoms

Will not be covering imaging of acute life threatening chest pain in ER settings

I.e. Not STEMI, NSTEMI, ACS, Aortic Dissection, PE, Pneumothorax

Symptoms of Coronary Disease

Symptoms

Take a history!

Location

Character

Duration

Relationship to exertion

Exacerbating or alleviating factors

Location

In general substernal but…

Can be a sensation from nose to navel and out to the fingertips

Including the back

May radiate up to the neck or out to the arms

Character

Do not ask about pain - ask about discomfort

Often described as:

Pressure

Tightness

Heaviness

Strangling

Constricting

Burning

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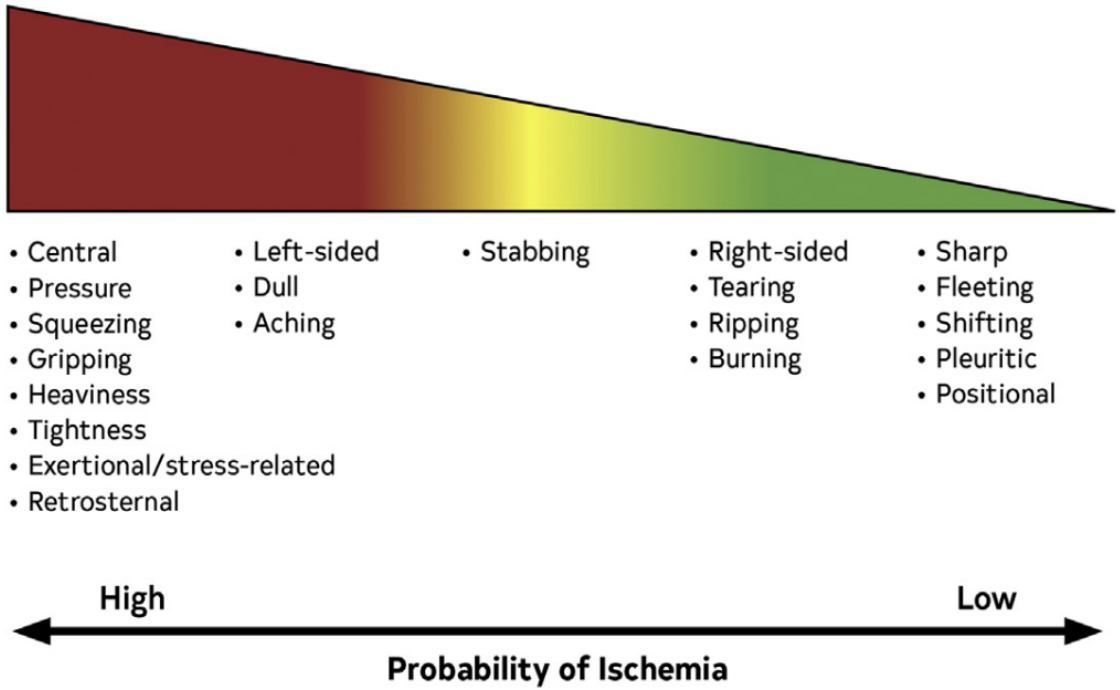
Character



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Duration

Typically symptoms are brief < 10 minutes

Symptoms that are fleeting or short, lasting seconds are unlikely cardiac

Similarly symptoms lasting hours or days are unlikely cardiac

- I.e. Sharp short chest pains not related to exertion especially if can point with 1 finger are highly unlikely due to CAD
- I.e. In a post ED follow up for discomfort lasting for hours and hours with normal ECG and negative troponins unlikely has ischemic chest pain

Exertion

Typically symptoms are worsened with exertion

Especially with walking up inclines or in cold weather

Usually resolves within a few minutes of rest

Some will have ‘warm-up angina’ when they first start they notice it but if they rest and resume it may not recur or be as notable

Alleviating/Aggravating Factors

Symptoms related to breathing or position unlikely related to CAD

Palpable chest pain unlikely related to CAD

Response to NTG is not reliable diagnostically but…

- Nitroglycerin should rapidly resolve the symptom within 1-3 minutes as the NTG dissolves
- If resolves 30 minutes later or as soon as the NTG touches their tongue less likely

Suspected cardiac symptoms vs angina

Angina

In 1979 Diamond & Forrester analyzed angiograms and categorized chest discomfort into angina, atypical angina, and non-anginal pain

The descriptions of the symptoms, age, and gender were categorized and the prevalence of obstructive CAD was calculated

Three symptoms of prominence: Substernal chest discomfort, relation to exertion/emotional stress, and if relieved by rest or nitroglycerin

Typical angina: All 3

Atypical angina: Only 2 of the 3

Nonanginal: Only 1 of the 3

1350 THE NEW ENGLAND JOURNAL OF MEDICINE June 14, 1979

ANALYSIS OF PROBABILITY AS AN AID IN THE CLINICAL DIAGNOSIS OF CORONARY-ARTERY DISEASE

GEORGE A. DIAMOND, M.D., AND JAMES S. FORRESTER, M.D.

Unstable vs Stable Angina

Many patients will not be able to be classified as unstable or stable angina, they will just have CP or shortness of breath until further testing is performed

For patients with typical symptoms of angina for > 2 months = stable angina

For patients with typical symptoms of angina for < 2 months = unstable angina

Unstable or New Angina can be further refined as Low risk or High risk

Unstable Angina

High Risk Unstable angina

- Rest angina, i.e. pain of characteristic nature and location occurring at rest and for prolonged periods (>20 min)
- New-onset angina, w/in 2 mo, **moderate-to-severe** angina
- Crescendo angina, angina that increases in severity and intensity, and at a lower threshold, over a short period of time
- In general should be triaged as an ACS scenario or expedited fashion - non-invasive testing *may* be considered - depending on clinical factors stress testing may be inappropriate

Low Risk Unstable angina or Stable angina - will fall under our utilization of non-invasive testing

- New-onset angina that occurs with strenuous activity but resolves with rest
- Angina not complicated by severe valve disease, HF, or new arrhythmia (Afib with RVR)

Initial Evaluation

12 lead ECG

Examination - Is there severe AS? Elevated neck veins and edema? Is there pallor?

CBC, Lipids, A1c, BMP, +/- TSH

Resting echocardiogram (Alternative causes of angina, WMA ? MI, EF)

CXR (If atypical symptoms, ? of HF, suspicion of lung disease)

Develop a Pre-test probability

Historical Context

Table 3. Pretest Likelihood of Coronary-Artery Disease in Symptomatic Patients According to Age and Sex.*

Age	Nonanginal Chest Pain		Atypical Angina		Typical Angina	
yr	men	women	men	women	men	women
30–39	5.2±0.8	0.8±0.3	21.8±2.4	4.2±1.3	69.7±3.2	25.8±6.6
40–49	14.1±1.3	2.8±0.7	46.1±1.8	13.3±2.9	87.3±1.0	55.2±6.5
50–59	21.5±1.7	8.4±1.2	58.9±1.5	32.4±3.0	92.0±0.6	79.4±2.4
60–69	28.1±1.9	18.6±1.9	67.1±1.3	54.4±2.4	94.3±0.4	90.6±1.0

*Each value represents the per cent ±1 standard error of the per cent, calculated from the data in Tables 1 & 2 as described in the Appendix.

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ANALYSIS OF PROBABILITY AS AN AID IN THE CLINICAL DIAGNOSIS OF CORONARY-ARTERY DISEASE

George A. Diamond, M.D., and James S. Forrester, M.D.

Prevalence of abnormal stress tests

Cedars-Sinai assessed 39,515 patients undergoing nuclear stress tests from 1991-2009.

Exclude patients with history of CAD.

Prevalence of abnormal stress tests dropped from **40.9% in 1991** to **8.7% in 2009**, while number of patients per 5 year period increased.

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Temporal Trends in the Frequency of Inducible Myocardial Ischemia During Cardiac Stress Testing

1991 to 2009

Alan Rozanski, MD,* Heidi Gransar, MS,†‡ Sean W. Hayes, MD,†‡ James Min, MD,†‡ John D. Friedman, MD,†‡ Louise E. J. Thomson, MBChB,†‡ Daniel S. Berman, MD†‡

New York, New York; and Los Angeles, California

Prevalence of abnormal testing

10,003 patients presented with chest discomfort

Randomized to cardiac CTA vs stress testing

Patients had a predicted 53.3% pre-test probability of obstructive CAD

Overall event rate was 3.2% for Death, MI, hospitalization for UA, procedural complication

The prevalence of obstructive disease on interpretable CTA was 8.2%

The prevalence of abnormal stress test was 11.7%

The NEW ENGLAND JOURNAL of MEDICINE

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Outcomes of Anatomical versus Functional Testing for Coronary Artery Disease

Pamela S. Douglas, M.D., Udo Hoffmann, M.D., M.P.H., Manesh R. Patel, M.D., Daniel B. Mark, M.D., M.P.H., Hussein R. Al-Khalidi, Ph.D., Brendan Cavanaugh, M.D., Jason Cole, M.D., Rowena J. Dolor, M.D., Christopher B. Fordyce, M.D., Megan Huang, Ph.D., Muhammad Akram Khan, M.D., Andrzej S. Kosinski, Ph.D., Mitchell W. Krucoff, M.D., Vinay Malhotra, M.D., Michael H. Picard, M.D., James E. Udelson, M.D., Eric J. Velazquez, M.D., Eric Yow, M.S., Lawton S. Cooper, M.D., M.P.H., and Kerry L. Lee, Ph.D., for the PROMISE Investigators*

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Current Pre-Test Probability of CAD

	Typical		Atypical		Non-anginal		Dyspnoea[a]	
Age	Men	Women	Men	Women	Men	Women	Men	Women
30–39	3%	5%	4%	3%	1%	1%	0%	3%
40–49	22%	10%	10%	6%	3%	2%	12%	3%
50–59	32%	13%	17%	6%	11%	3%	20%	9%
60–69	44%	16%	26%	11%	22%	6%	27%	14%
70+	52%	27%	34%	19%	24%	10%	32%	12%

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ESC European Society of Cardiology
European Heart Journal (2019) **00**, 1–71
doi:10.1093/eurheartj/ehz425

ESC GUIDELINES

2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes

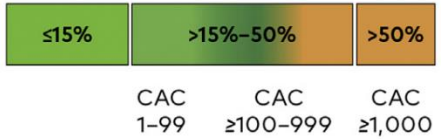
The Task Force for the diagnosis and management of chronic coronary syndromes of the European Society of Cardiology (ESC)

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†**



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CLINICAL PRACTICE GUIDELINE: FULL TEXT

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

When to test

Current guidelines recommend testing when pre-test probability is between 15-85%

Testing < 15% is of low value unless compelling reason

- Depending on the test negative test will be reassuring, positive test may represent false positive

Testing > 85% is of low value for ***DIAGNOSTIC purposes***

- Can be of value for ***prognostic purposes*** or confirmation

Develop Pre-Test Probability

Synthesize symptoms

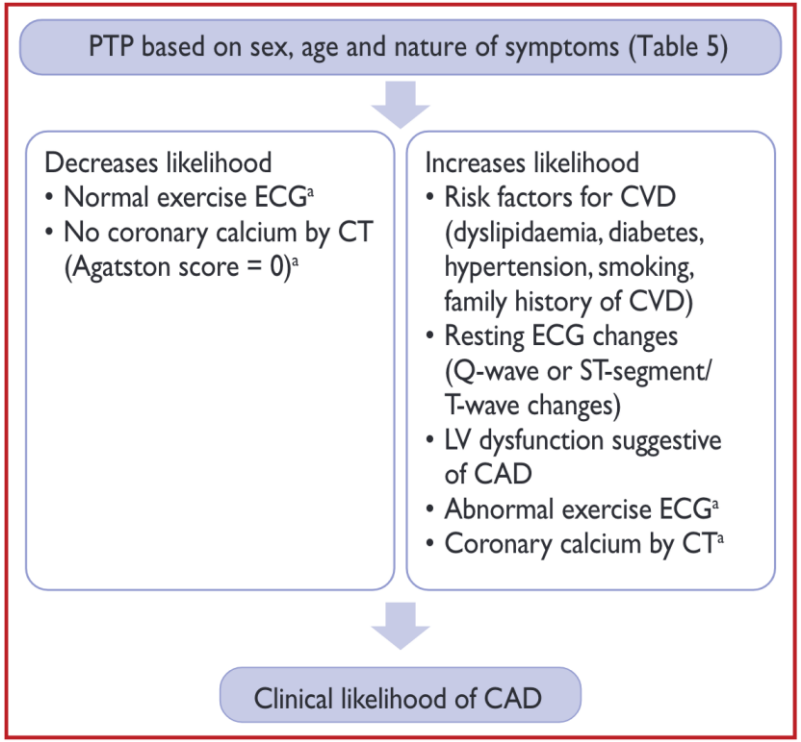
Incorporate risk factors (lipids, DM, HTN, smoking, Fam Hx)

Examination

ECG

Echo

Presence of coronary calcium



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Testing Basics

Cardiac Testing To Detect CAD

Functional Testing (Indirect Testing)

Relies on evoking the ischemic cascade

Exercise or pharmacological

ECG

Echocardiography

Nuclear Imaging

SPECT

PET

MRI

Anatomical Testing (Direct Testing)

Relies on directly imaging coronary arteries

Coronary CTA (Non-invasive)

Coronary angiography (Invasive)

FFR-CT (Non-invasive)
iFR/FFR (Invasive)

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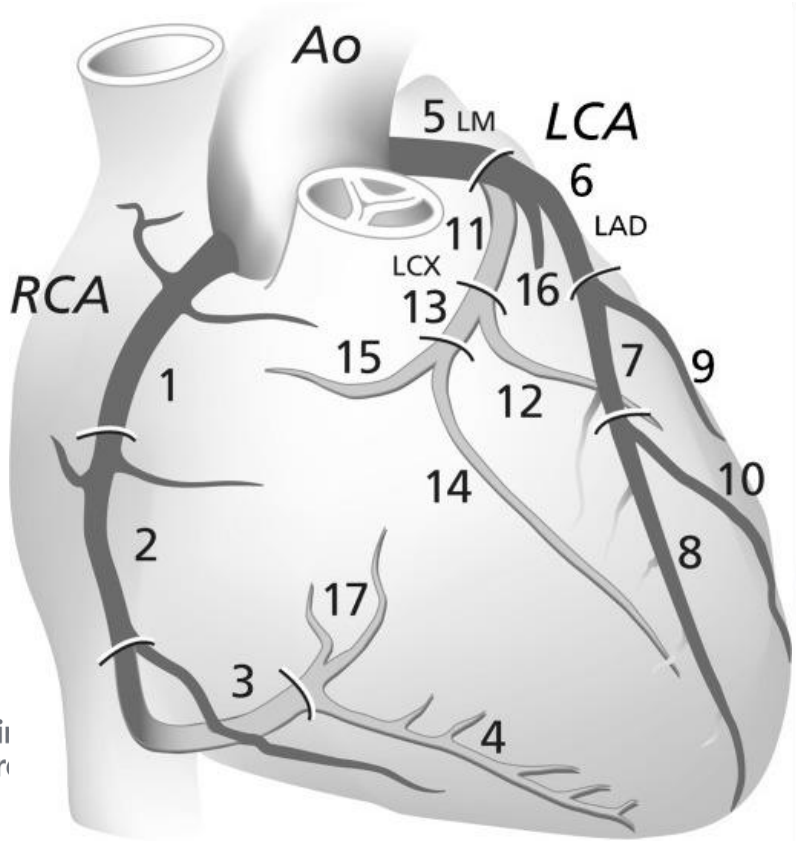
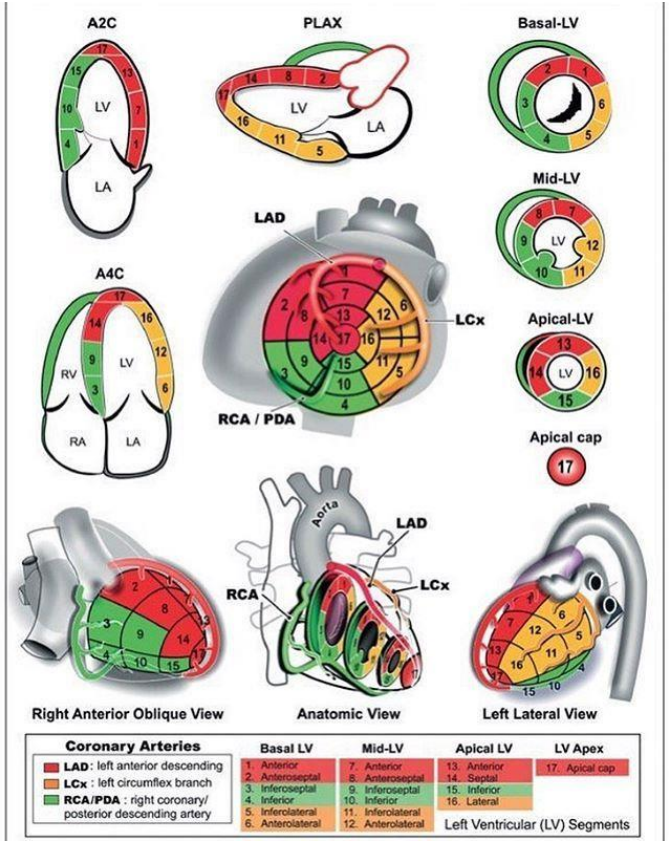
Functional Imaging Tests





Ischemia Cascade Functional Testing

With ↑ cardiac work - myocardial O2 demand ↑

With ↑ HR coronary flow ↑

When coronary stenosis ↑

- Progressive mismatch between O2 demand and O2 delivery
- This results in molecular changes in ATP availability

Greater stenosis results in greater mismatch and greater degrees of ischemia

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Ischemia and Coronary Stenosis

Fluid dynamics teaches us that flow, resistance, and pressure are all intimately related.

Resistance across a coronary atheroma is related to not just the diameter of the stenosis, but the length of the atheroma, and the flow through that artery.

Example: A 50-60% long proximal LAD lesion serving 50% of the LV myocardium may cause a greater degree of ischemia than a 70% diagonal branch that supplies a 10% of the myocardium.

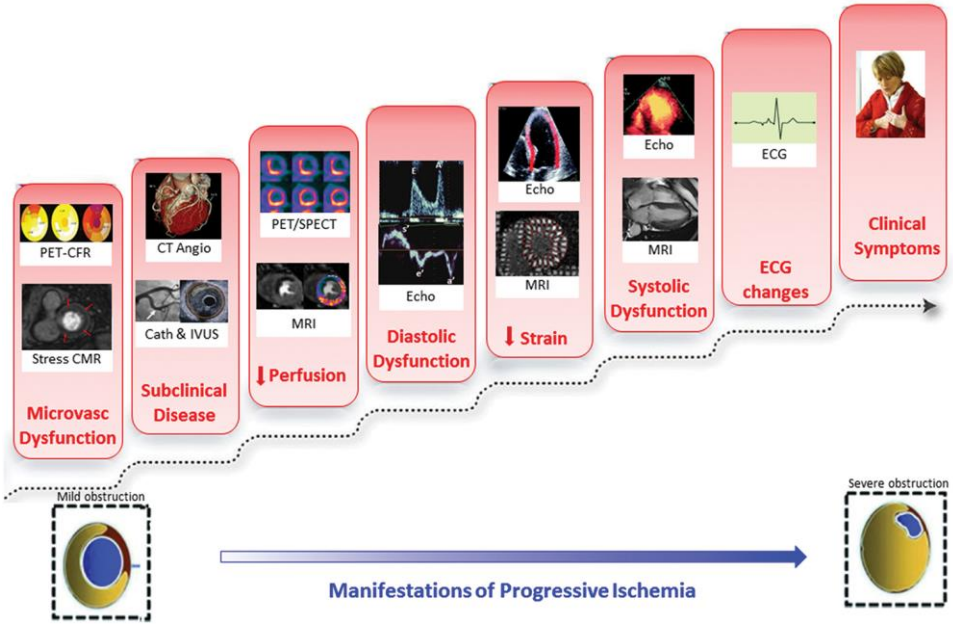
Ischemia Cascade - Functional Testing

Early - detect changes in perfusion (coronary flow with SPECT/PET)

Systolic dysfunction - wall motion abnormalities in coronary distribution (Echo or MRI)

ST depressions on ECG

Late - clinical symptoms of angina



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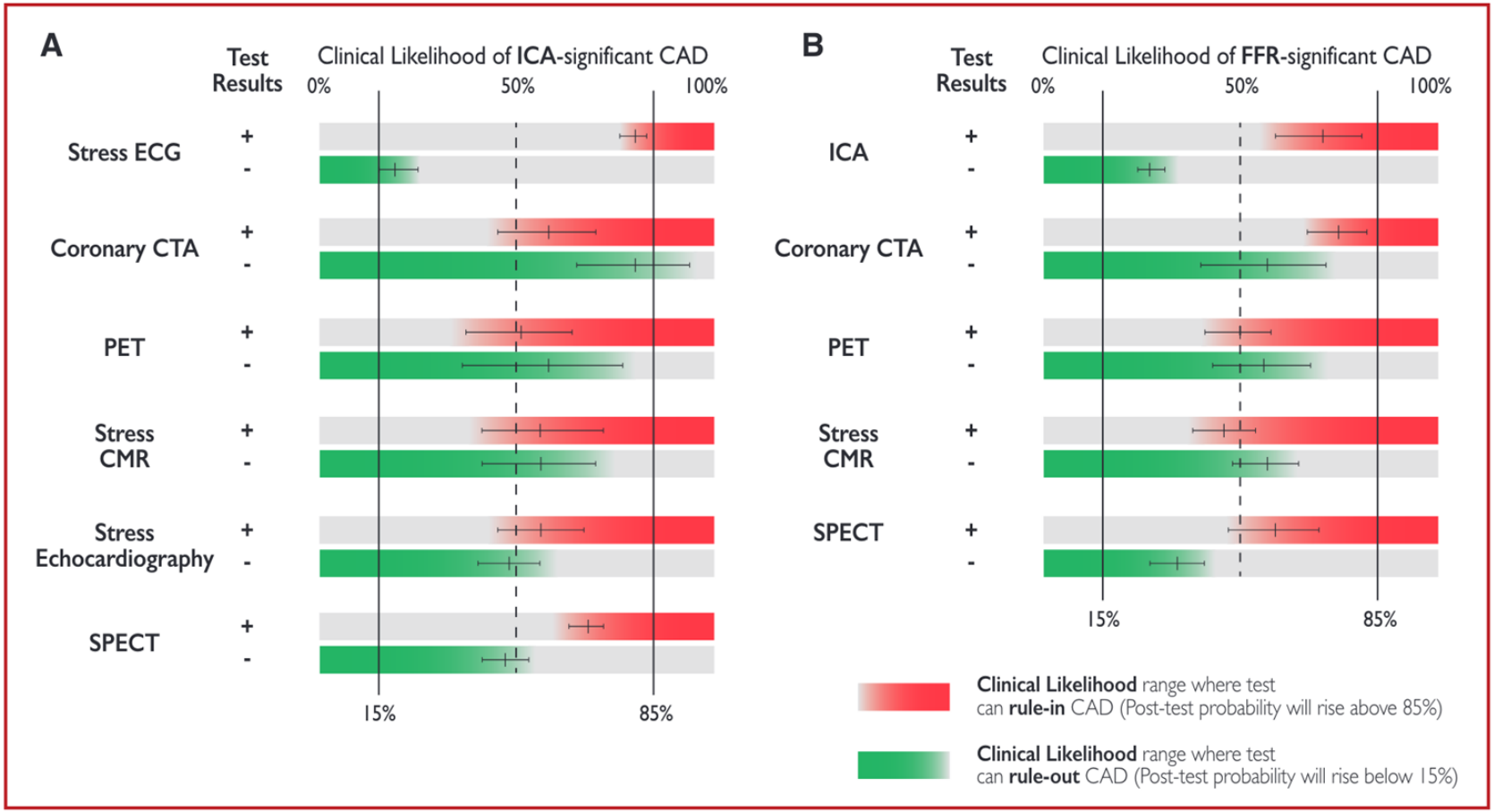
Anatomical Testing

Coronary CTA

- IV Contrast
- CT Scanner has ECG leads
- The images are synchronized with the heart rhythm
- Create 3D data set
- Visualize atherosclerosis at varying degrees and detect luminal narrowing
- Includes subclinical athero

Coronary Angiogram

- Catheter inserted through artery advanced to coronary artery os
- Contrast directly injected to artery
- Fluoroscopy performed in multiple views
- Visualize the narrowing of the arteries



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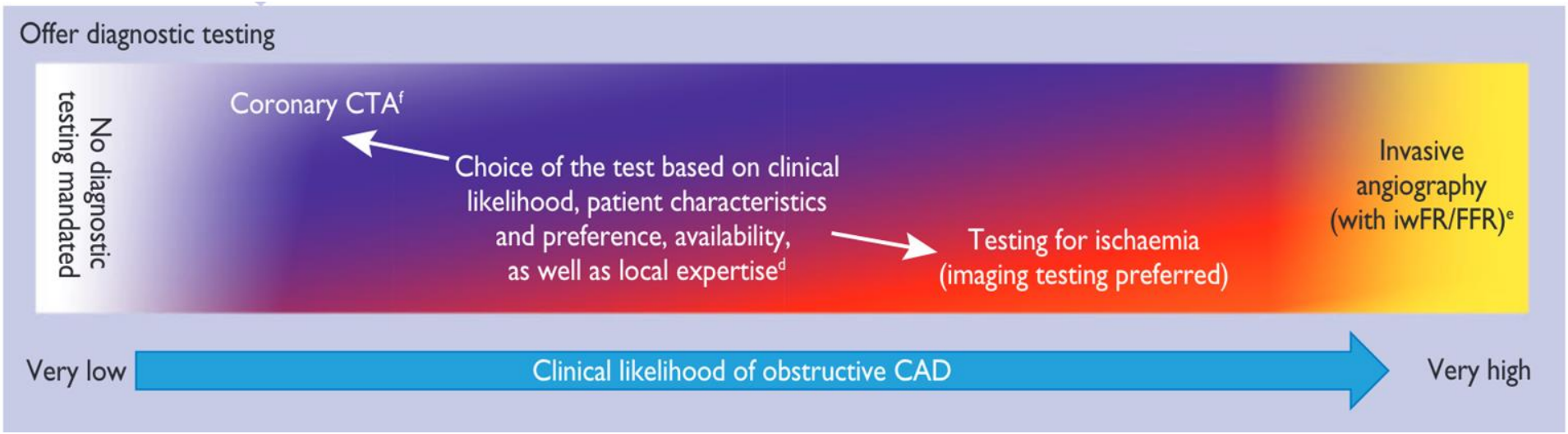

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Prognostic Information

Functional and anatomical testing both provide estimates of future risk

Annual risk of death or myocardial infarction

Historically risk was estimated into three cohorts

1. Low Risk < 1%
2. Moderate Risk 1-3%
3. High Risk > 3%

TABLE B Noninvasive Risk Stratification

High risk (>3% annual death or MI)

1. Severe resting LV dysfunction (LVEF <35%) not readily explained by noncoronary causes
2. Resting perfusion abnormalities ≥10% of the myocardium in patients without prior history or evidence of MI
3. Stress ECG findings including ≥2 mm of ST-segment depression at low workload or persisting into recovery, exercise-induced ST-segment elevation, or exercise-induced VT/VF
4. Severe stress-induced LV dysfunction (peak exercise LVEF <45% or drop in LVEF with stress ≥10%)
5. Stress-induced perfusion abnormalities encumbering ≥10% myocardium or stress segmental scores indicating multiple vascular territories with abnormalities
6. Stress-induced LV dilation
7. Inducible wall motion abnormality (involving >2 segments or 2 coronary beds)
8. Wall motion abnormality developing at low dose of dobutamine (≤10 mg/kg/min) or at a low heart rate (<120 beats/min)
9. CAC score >400 Agatston units
10. Multivessel obstructive CAD (≥70% stenosis) or left main stenosis (≥50% stenosis) on CCTA

Intermediate risk (1% to 3% annual death or MI)

1. Mild/moderate resting LV dysfunction (LVEF 35% to 49%) not readily explained by noncoronary causes
2. Resting perfusion abnormalities in 5% to 9.9% of the myocardium in patients without a history or prior evidence of MI
3. ≥1 mm of ST-segment depression occurring with exertional symptoms
4. Stress-induced perfusion abnormalities encumbering 5% to 9.9% of the myocardium or stress segmental scores (in multiple segments) indicating 1 vascular territory with abnormalities but without LV dilation
5. Small wall motion abnormality involving 1 to 2 segments and only 1 coronary bed
6. CAC score 100 to 399 Agatston units
7. One vessel CAD with ≥70% stenosis or moderate CAD stenosis (50% to 69% stenosis) in ≥2 arteries on CCTA

Low risk (<1% annual death or MI)

1. Low-risk treadmill score (score ≥5) or no new ST segment changes or exercise-induced chest pain symptoms; when achieving maximal levels of exercise
2. Normal or small myocardial perfusion defect at rest or with stress encumbering <5% of the myocardium*
3. Normal stress or no change of limited resting wall motion abnormalities during stress
4. CAC score <100 Agaston units
5. No coronary stenosis >50% on CCTA

*Although the published data are limited; patients with these findings will probably not be at low risk in the presence of either a high-risk treadmill score or severe resting LV dysfunction (LVEF <35%).

Reproduced from Fihn et al. (3).

CAC indicates coronary artery calcium; CAD, coronary artery disease; CCTA, coronary computed tomography angiography; LV, left ventricular; LVEF, left ventricular ejection fraction; and MI, myocardial infarction.

Review of different testing modalities

Exercise Treadmill Testing

Poor test for the diagnosis of coronary disease

Sensitivity 58%, Specificity 62%

Payors appreciate this test as it is inexpensive

Does an excellent job of evaluating functional capacity

Contraindications to Exercise Testing

Unable to walk on a treadmill safely

Abnormal ST changes on baseline ECG (LBBB, WPW, V-paced, LVH, resting ST depressions, digoxin)

High risk unstable angina or AMI within 48 hours

Decompensated heart failure

Severe aortic stenosis (Unless testing for symptoms of AS)

Known HOCM with severe gradient

Severe hypertension (>/= 200/110 mmHg)

Acute illness (i.e. PE, myo/pericarditis, acute aortic dissection)

Uncontrolled arrhythmias

Uncorrected medical conditions

- Anemia, electrolytes, thyroid

Recent stroke

Known aortic dissection

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Exercise Treadmill Testing

BB may limit ability to achieve 85% MPHR - a cardiac workload to r/o presence of obstructive CAD.

Usually request to hold BB

Digoxin should be stopped for 2 weeks prior to study

BUT…if the goal is to assess functional capacity and presence of known CAD *ON* medical therapy than continue medications

Exercise Treadmill Testing

Multiple protocols are used

The Bruce protocol is the most common

Stages last 2-3 minutes to allow steady state

Treadmill increases in speed and incline until patient has reached an RPE of 9/10.

Patients need to achieve a MPHR of >85% to exclude ischemia

If sending patient for SOB and it presents at 75% MPHR and ischemia evaluation is negative - suggests the SOB is not due to ischemia.

EXERCISE		MPH	Incline
STAGE 1	03:00	1.7	10.0
STAGE 2	03:00	2.5	12.0
STAGE 3	03:00	3.4	14.0
STAGE 4	03:00	4.2	16.0
STAGE 5	03:00	5.0	18.0
STAGE 6	03:00	5.5	20.0
STAGE 7	99:00	6.0	22.0

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Exercise Treadmill Testing

Each stage is associated with a MET related to O2 consumption

1 MET = 3.5 ml/kg/min O2

FUNCTIONAL CLASS	CLINICAL STATUS	O_2 COST ml/kg/min	METS	BICYCLE ERGOMETER	TREADMILL PROTOCOLS						METS
				1 WATT = 6.1 Kpm/min	BRUCE MODIFIED 3 min Stages		BRUCE 3 min Stages		NAUGHTON		
				FOR 70 KG BODY WEIGHT Kpm/min	MPH	%GR	MPH	%GR			
NORMAL AND I	HEALTHY, DEPENDENT ON AGE, ACTIVITY				6.0	22	6.0	22			
					5.5	20	5.5	20			
					5.0	18	5.0	18			
		56.0	16								16
		52.5	15								15
		49.0	14	1500							14
		45.5	13		4.2	16	4.2	16			13
		42.0	12	1350							12
		38.5	11	1200					2 min Stages		11
		35.0	10		3.4	14	3.4	14	MPH	%GR	10
	SEDENTARY HEALTHY	31.5	9	1050					2	17.5	9
		28.0	8	900					2	14.0	8
		24.5	7	750	2.5	12	2.5	12			7
II	LIMITED	21.0	6	600					2	10.5	6
		17.5	5	450	1.7	10	1.7	10	2	7.0	5
III	SYMPTOMATIC	14.0	4	300	1.7	5			2	3.5	4
		10.5	3						2	0	3
		7.0	2	150	1.7	0			1	0	2
IV		3.5	1								1

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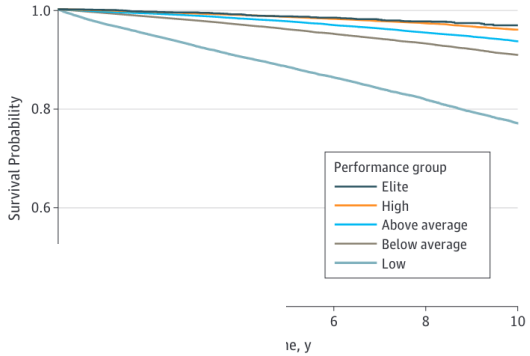
Fitness Outcomes

Table 2. Classification of Cardiorespiratory Fitness by Age and Sex[a]

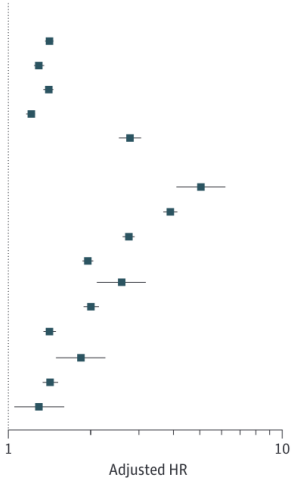
Age, y	Performance Group				
	Low	Below Average	Above Average	High	Elite
Women					
18-19	<10.0	10-11.0	11.1-12.9	13-14.9	≥15.0
20-29	<8.0	8.0-9.9	10-11.4	11.5-14.2	≥14.3
30-39	<7.7	7.7-9.3	9.4-10.8	10.9-13.6	≥13.7
40-49	<7.4	7.4-8.9	9.0-10.3	10.4-13.2	≥13.3
50-59	<7.0	7.0-8.0	8.1-9.9	10.0-12.9	≥13.0
60-69	<6.0	6.0-6.9	7.0-8.4	8.5-11.0	≥11.1
70-79	<5.0	5.0-5.9	6.0-6.9	7.0-9.9	≥10.0
≥80	<4.4	4.4-5.4	5.5-6.2	6.3-8.3	≥8.4
Men					
18-19	<10.8	10.8-12.9	13.0-13.9	14-16.2	≥16.3
20-29	<10.3	10.3-11.9	12.0-13.6	13.7-15.6	≥15.7
30-39	<10.0	10-11.1	11.2-12.9	13.0-14.9	≥15.0
40-49	<9.8	9.8-10.9	11.0-12.4	12.5-14.6	≥14.7
50-59	<8.2	8.2-9.9	10.0-11.3	11.4-13.9	≥14.0
60-69	<7.0	7.0-8.4	8.5-9.9	10.0-12.9	≥13.0
70-79	<6.0	6.0-6.9	7.0-8.4	8.5-11.4	≥11.5
≥80	<5.1	5.1-6.2	6.3-7.2	7.3-9.9	≥10.0

Figure 1. Patient Survival by Performance Group



C Comorbidities and performance groups

Variable	HR (95% CI)	*P* Value
Comorbidity		
Smoking	1.41 (1.36-1.46)	<.001
CAD	1.29 (1.24-1.35)	<.001
Diabetes	1.40 (1.34-1.46)	<.001
Hypertension	1.21 (1.16-1.25)	<.001
ESRD	2.78 (2.53-3.05)	<.001
Group comparison		
Low vs Elite	5.04 (4.10-6.20)	<.001
Low vs High	3.90 (3.67-4.14)	<.001
Low vs Above Average	2.75 (2.61-2.89)	<.001
Low vs Below Average	1.95 (1.86-2.04)	<.001
Below Average vs Elite	2.59 (2.10-3.19)	<.001
Below Average vs High	2.00 (1.88-2.14)	<.001
Below Average vs Above Average	1.41 (1.34-1.49)	<.001
Above Average vs Elite	1.84 (1.49-2.26)	<.001
Above Average vs High	1.42 (1.33-1.52)	<.001
High vs Elite	1.29 (1.05-1.60)	.02



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Exercise Treadmill Testing

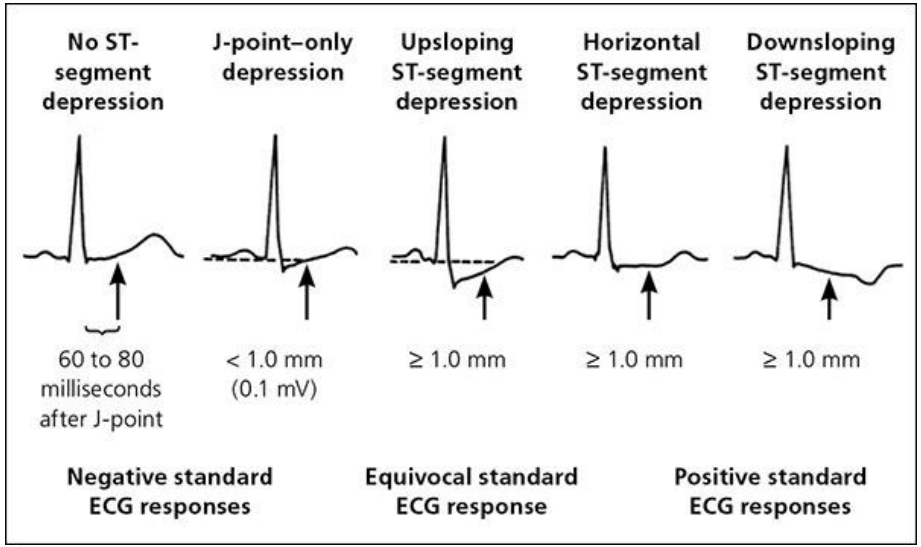
Ischemia will lead to ST segment depressions

Measured 80 ms from j-point

Abnormal 1mm depression from PR segment and horizontal or downsloping

If upsloping has to be 2mm depressed

ST depressions must be present for at least 3 beats and in at least 1 lead



Exercise Treadmill Testing

Prognosis

Duke Treadmill score = exercise time - (5 x max ST deviation) - (4 x angina score)

- Low risk >/= +5
- High risk < -10

Heart Rate Recovery

- Decrease in heart rate of 12 bpm at 1 minute indicates good prognosis

Stress Echocardiography

Improved diagnostic characteristics over ETT

Sensitivity 85%, Specificity 82%

No ionizing radiation

Contraindications to Stress Echo

Limited acoustic windows

Left bundle branch block or RV pacing limits interpretability

Previous myocardial infarctions

Left ventricular hypertrophy

Stress Echocardiography

Can utilize exercise or dobutamine

Baseline images of the LV are obtained

The patient then undergoes stress until test is ended and post-images are obtained within 90 seconds

The images are examined for the development of regional areas of hypokinesis

In cases of discordant results (normal images but abnormal ECG) - findings are normal

Dobutamine Stress Echocardiography

Dobutamine is a B1 receptor agonist

At low doses inotropic effects are seen

At increasing doses chronotropic effects are seen

Goal is to get the heart rate to 85% max predicted

Atropine is administered at different points of the test to reverse vagal tone and help achieve target heart rate

Dobutamine Stress Echocardiography

ECG is monitored during the test - ST segments and ventricular arrhythmias do not predict outcomes

Rest, low dose, peak dose, and recovery images over the LV are obtained

Stress Echocardiography

Prognosis

High risk - 2 or more hypokinetic areas and/or decrease in EF

Low risk - no hypokinetic areas and augmentation of EF

Nuclear Imaging

SPECT

Sensitivity 87%, Specificity 70%

PET

Sensitivity 90%, Specificity 85%

Uses ionizing radiation

- 10 mSv for SPECT
- 3 mSv for PET

3-4 mSv the average accumulated background radiation for 1 year for a person

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Contraindications to Nuclear

Vasodilator

- 2nd or 3rd degree AV block, or sinus bradycardia < 45 bp
- Known or suspected bronchospastic disease
- Use of dipyridamole (Aggenox)
- Use of aminophylline or caffeine w/in 12 hours

Vasodilator

Regadenoson (Lexiscan) - most commonly used, selective A2a receptor agonist

- Dipyridamole and adenosine also used

Causes a 4-5 x increase in coronary flow simulating increase in coronary flow with exercise with 30 seconds, lasts for 2-5 minutes

Chest pain, headache, nausea, flushing

AV block and bronchoconstriction can rarely occur

Nuclear Imaging

Relies on injection of a radioisotope at rest and during the stress phase

Isotope is delivered to and taken up by myocardium dependent on coronary artery blood flow

During the stress phase coronary blood flow will increase 4-5x over rest

A coronary stenosis will result in less flow and therefore less delivery of isotope to that vascular territory

Camera will capture construct 3D image of the heart - darker areas will correspond to less blood flow

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Nuclear Imaging

SPECT

Two types of cameras

- Classic Anger camera moves around the patient
- New Cadmium-Zinc-Telluride camera is a fixed arm that sits over the chest
    - More sensitive - less isotope is required - shorter acquisition time
    - Improved resolution

PET

Circular detector that absorbs isotope from 360 degrees

Typically use isotopes that are absorbed from the blood and better represent coronary flow

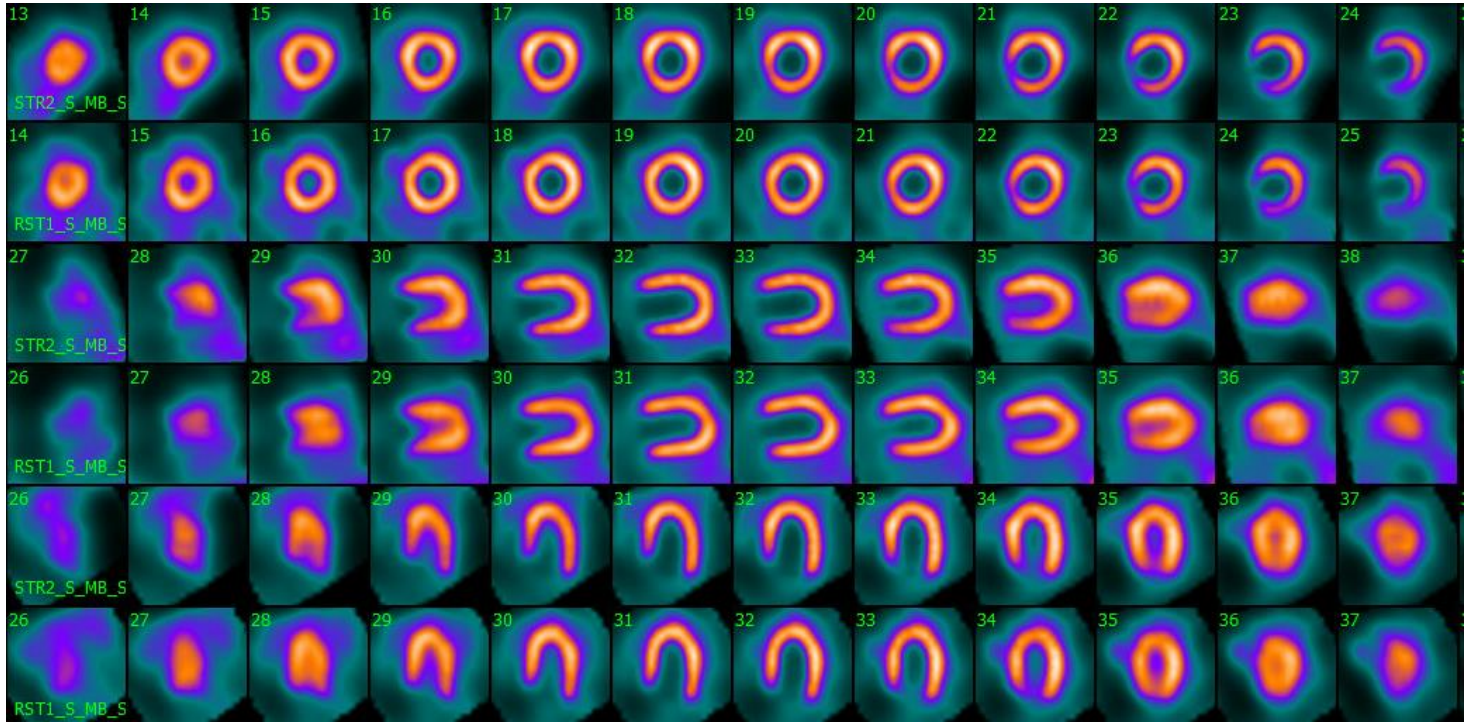
Rubidium most common isotope

Better resolution than SPECT

Example Normal Stress Test

Stress

Rest



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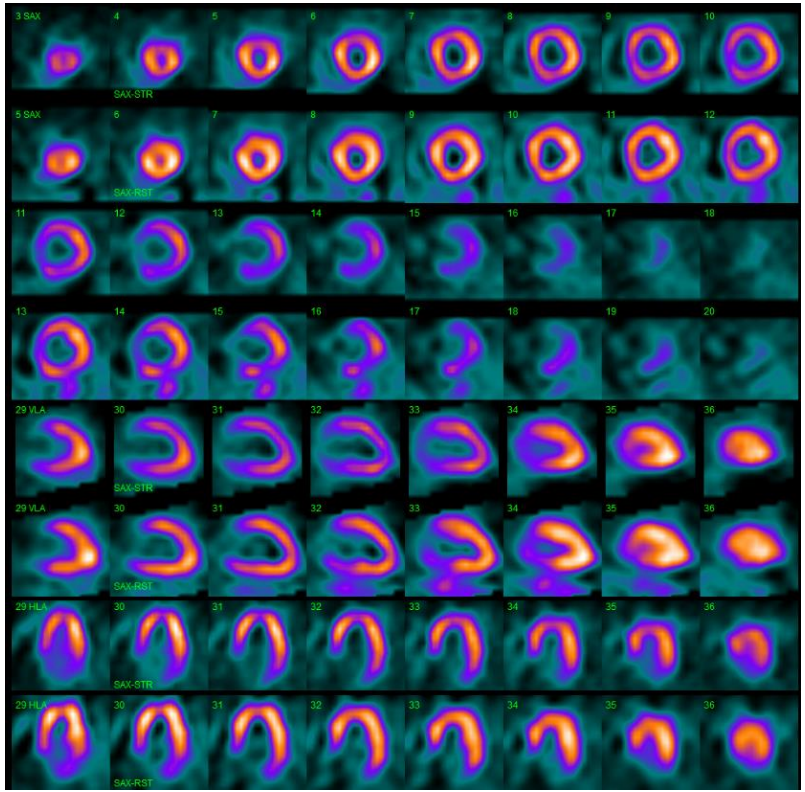
Examples Abnormal Stress Test



LAD: Proximal stenosis 70% with a 60% mid LAD.
Cx: Marginal branch with 90% ostial stenosis.
RCA: 80% proximal RCA, distal RCA 60% stenosis

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Coronary CT Angiography

Sensitivity 97%, Specificity 78%

Previously not well covered by insurance but increasing with new guidelines

Contraindications to CCTA

Contrast allergy

Inability to follow breath-hold commands

Renal insufficiency

Contraindications to beta-blockers and no ability to slow heart rate with other means

Heart rate variability

Contraindications to nitroglycerin

Excessive BMI - > 40, relative contraindication > 35

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Coronary CT Angiography

Diagnostic accuracy highly dependent on multiple factors

Obesity significantly decreases quality of images

Motion artifact highly degrades diagnostic accuracy

- Need to have steady heart rate in the low 50's for optimal images

Dense coronary calcium creates blooming artifact obscuring lumen

Compared to ICA you see an entire plaque - tend to overestimate the severity of stenosis i.e. 70% on CT could be 30% on ICA

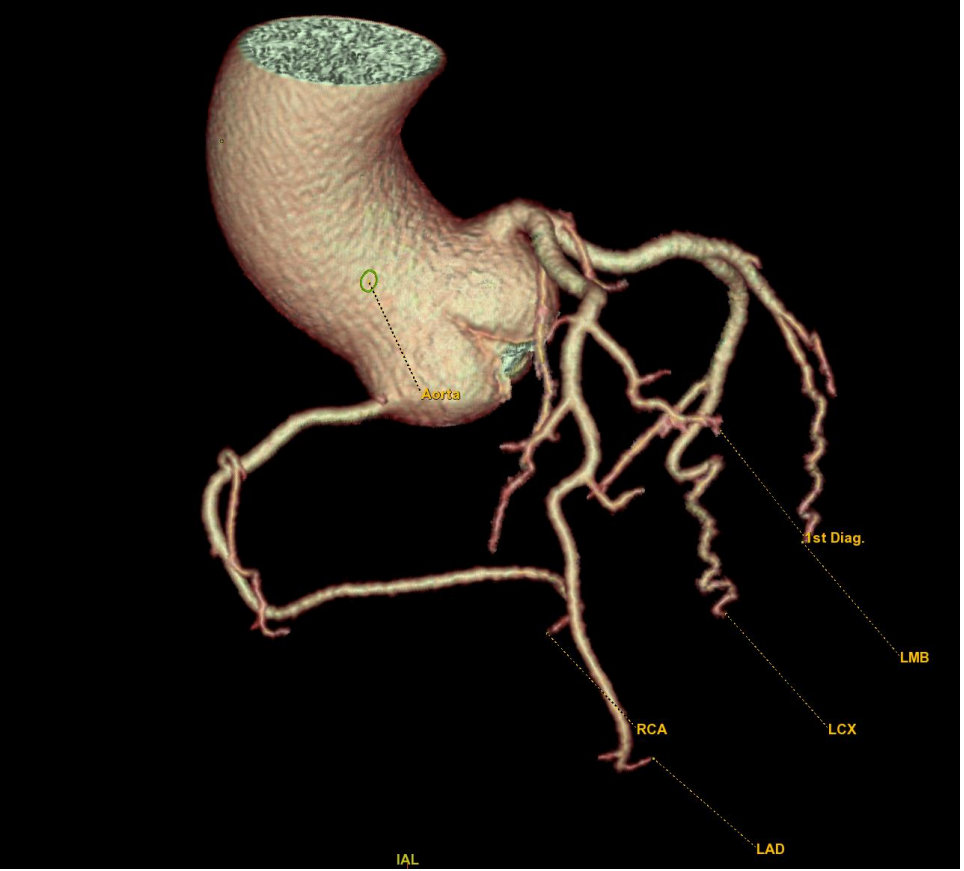
FFR-CT

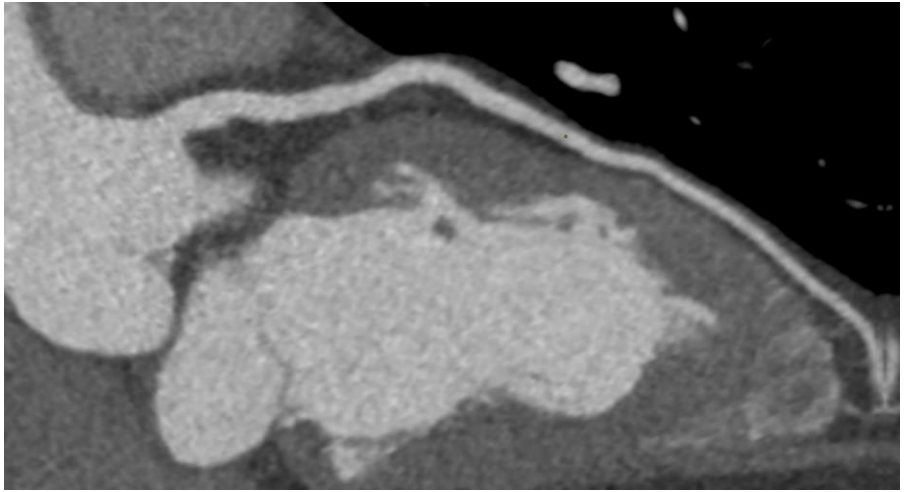
FFR-CT - performed by HeartFlow - creates a fluid-dynamic model of the coronary tree and myocardium to determine the functional significance of coronary stenosis by CTA.

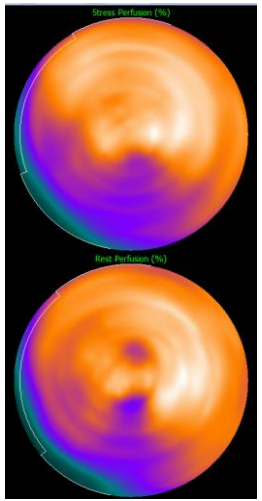
Proven to reduce the number of non-obstructive diagnostic angiograms

Correlates well with FFR during ICA.

Specificity of CCTA-FFR significantly improves







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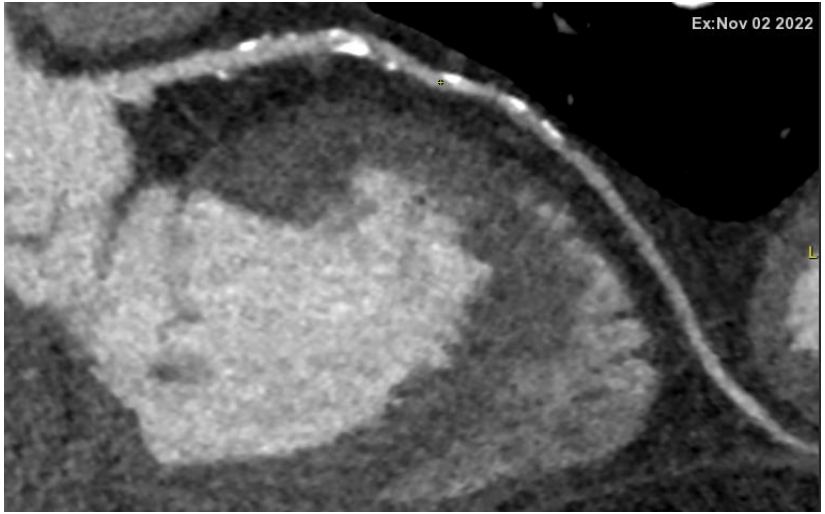
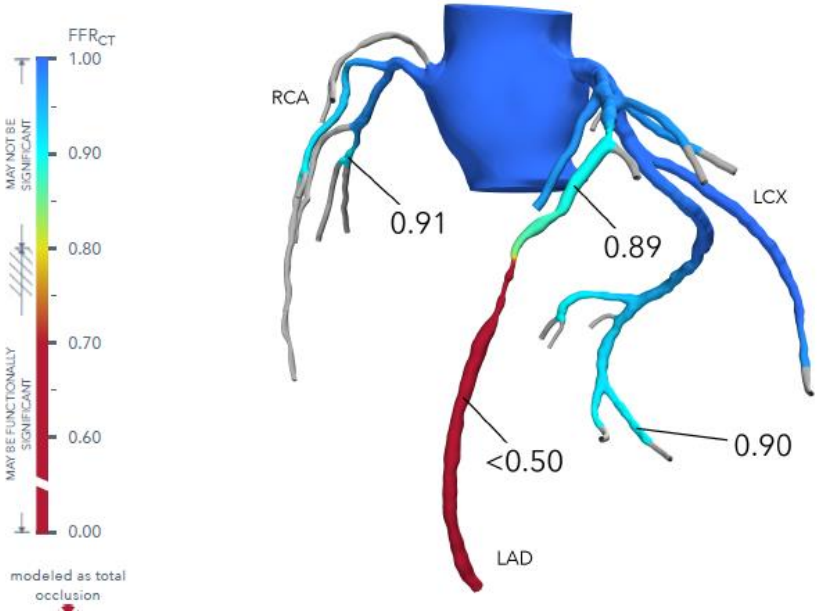
Examples of CCTA





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Calcium Score

Calcium scores should NOT be used for symptomatic patients

BUT…

58 yo woman, LDL of 145, controlled HTN, **with mother with MI at 55**. No ASA/Statin.

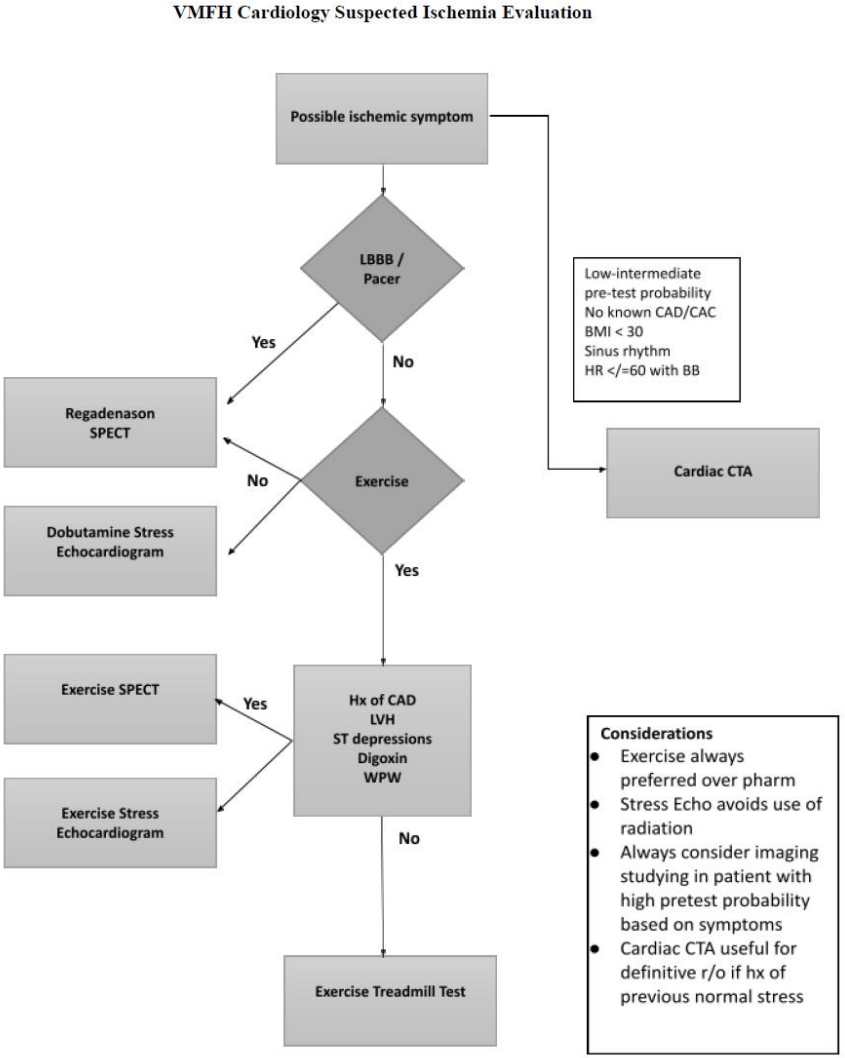
10 year risk of 5.4%

Presents with occasional chest discomfort at night lasting for few minutes. Not clearly exertional. Very concerned. Stress test is performed and is normal. In follow up symptoms resolved.

BUT DOES SHE HAVE CAD? - Calcium score can establish if she HAS the disease.

Calcium score of 145 comes back - 10 year risk now 11%. Initiate therapy.

Simple Algorithm



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Clinical Questions

What test is most accurate head-to-head?

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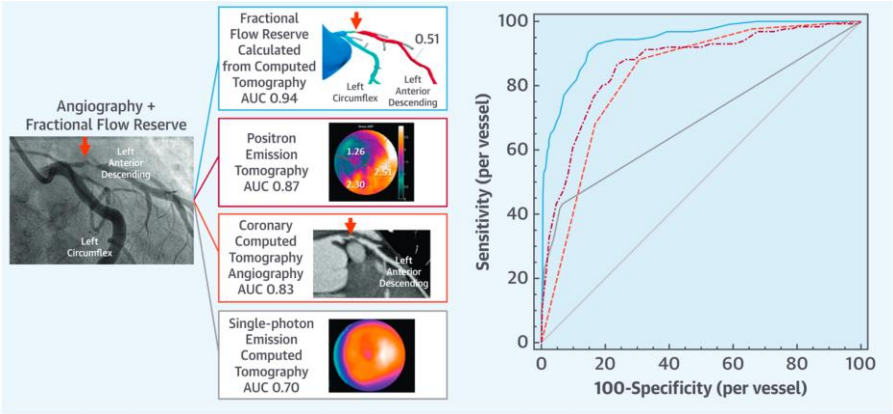
Pacific Trial

208 patients underwent CCTA with FFR, SPECT, PET and ICA

CCTA + FFR outperformed other tests at predicting abnormal FFR on ICA on per vessel basis (on vessels that could be analyzed)

Overall PET performed better when unanalyzable vessels were considered abnormal



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Comparison of Coronary Computed Tomography Angiography, Fractional Flow Reserve, and Perfusion Imaging for Ischemia Diagnosis

Roel S. Driessen, MD,[a] Ibrahim Danad, MD,[a] Wijnand J. Stuijfzand, MD,[a] Pieter G. Raijmakers, MD, PhD,[b] Stefan P. Schumacher, MD,[a] Pepijn A. van Diemen, MD,[a] Jonathon A. Leipsic, MD,[c] Juhani Knuuti, MD, PhD,[d] S. Richard Underwood, MD, PhD,[e] Peter M. van de Ven, PhD,[f] Albert C. van Rossum, MD, PhD,[a] Charles A. Taylor, PhD,[g,h] Paul Knaapen, MD, PhD[a]

I have a “high risk functional test” now what?

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ISCHEMIA Trial

Published 2020

5179 patients with moderate or severe ischemia randomized to cath + revascularization vs OMT

Most had CCTA during enrollment to r/o non-obs and LM dz

No significant difference in primary composite outcome, CV death/MI, death from any cause, or MI alone.

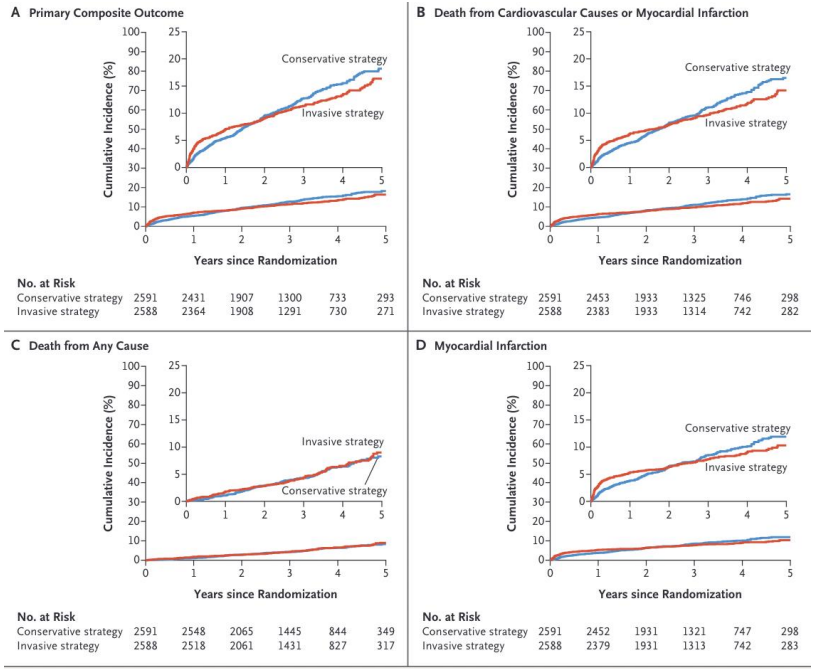

Figure 2. Time-to-Event Curves for the Primary Composite Outcome and Other Outcomes.

Panel A shows the cumulative incidence of the primary composite outcome of death from cardiovascular causes, myocardial infarction, or hospitalization for unstable angina, heart failure, or resuscitated cardiac arrest in the conservative-strategy group and the invasive-strategy group. Panel B shows the cumulative incidence of death from cardiovascular causes or myocardial infarction. Panel C shows the cumulative incidence of death from any cause, and Panel D shows the cumulative incidence of myocardial infarction. In each panel, the inset shows the same data on an enlarged y axis.

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 APRIL 9, 2020 VOL. 382 NO. 15

Initial Invasive or Conservative Strategy for Stable Coronary Disease

D.J. Maron, J.S. Hochman, H.R. Reynolds, S. Bangalore, S.M. O'Brien, W.E. Boden, B.R. Chaitman, R. Senior, J. López-Sendón, K.P. Alexander, R.D. Lopes, L.J. Shaw, J.S. Berger, J.D. Newman, M.S. Sidhu, S.G. Goodman, W. Ruzyllo, G. Gosselin, A.P. Maggioni, H.D. White, B. Bhargava, J.K. Min, G.B.J. Mancini, D.S. Berman, M.H. Picard, R.Y. Kwong, Z.A. Ali, D.B. Mark, J.A. Spertus, M.N. Krishnan, A. Elghamaz, N. Moorthy, W.A. Hueb, M. Demkow, K. Mavromatis, O. Bockeria, J. Peteiro, T.D. Miller, H. Szwed, R. Doerr, M. Keltai, J.B. Selvanayagam, P.G. Steg, C. Held, S. Kohsaka, S. Mavromichalis, R. Kirby, N.O. Jeffries, F.E. Harrell, Jr., F.W. Rockhold, S. Broderick, T.B. Ferguson, Jr., D.O. Williams, R.A. Harrington, G.W. Stone, and Y. Rosenberg, for the ISCHEMIA Research Group*

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ISCHEMIA Trial

Caveats

Events rate in patients with severe ischemia were lower than event rates in less than severe ischemia - concerns about some patients not included in the study.

MI events associated with procedures which may not carry the same implications as spontaneous MI's may cloud the interpretation of the results

Seems like CCTA is more accurate and gives you more information it must be better!?

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PROMISE Trial

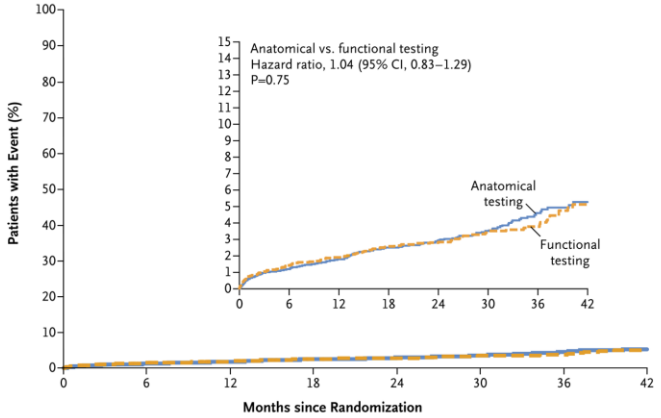
10,003 patients presented with chest discomfort

Predicted PTP of 50%

Randomized to cardiac CTA vs stress testing

Stress testing: ETT, Stress Echo, Nuclear

No different in primary outcome (death, MI, unstable angina)



No. at Risk								
Anatomical testing	4996	4703	4362	3551	2652	1705	902	269
Functional testing	5007	4536	4115	3331	2388	1518	832	258

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 APRIL 2, 2015 VOL. 372 NO. 14

Outcomes of Anatomical versus Functional Testing for Coronary Artery Disease

Pamela S. Douglas, M.D., Udo Hoffmann, M.D., M.P.H., Manesh R. Patel, M.D., Daniel B. Mark, M.D., M.P.H., Hussein R. Al-Khalidi, Ph.D., Brendan Cavanaugh, M.D., Jason Cole, M.D., Rowena J. Dolor, M.D., Christopher B. Fordyce, M.D., Megan Huang, Ph.D., Muhammad Akram Khan, M.D., Andrzej S. Kosinski, Ph.D., Mitchell W. Krucoff, M.D., Vinay Malhotra, M.D., Michael H. Picard, M.D., James E. Udelson, M.D., Eric J. Velazquez, M.D., Eric Yow, M.S., Lawton S. Cooper, M.D., M.P.H., and Kerry L. Lee, Ph.D., for the PROMISE Investigators*

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SCOT-HEART Trial

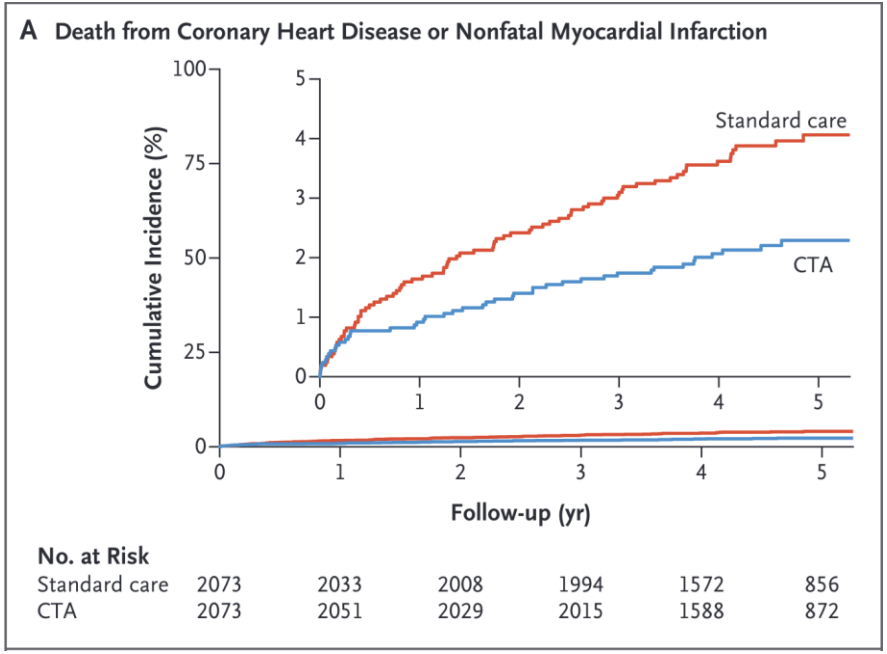
4146 patients with chest pain randomized standard care vs standard care + CCTA

A clinical risk score was supplied to treating physicians with therapy recommendations.

Patients who were randomized to get CCTA their physicians received results.

Patients in CCTA arm more likely to be prescribed statins - almost twice.

Significant problems with trial such as open label design and issues with adjudications of end points.



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ORIGINAL ARTICLE

Coronary CT Angiography and 5-Year Risk of Myocardial Infarction

The SCOT-HEART Investigators*

Initial Management

Initiate medical therapy for treatment of atherosclerosis and risk factors

- ASA 81, atorva 40-80 or rosuva 20-40

Initiate medical therapy for ischemia

- BB, CCB, NTG

Consider CCTA with FFR to confirm diagnosis and r/o LM or 3VD

If symptoms refractory to medical therapy then angiography and revascularization

Ischemia Treatment

	Standard Therapy	High heart rate (e.g. >80 b.p.m)	Low heart rate (e.g. <50 b.p.m)	LV dysfunction or heart failure	Low blood pressure
1st step	BB or CCB[a]	BB or non-DHP-CCB	DHP-CCB	BB	Low-dose BB or Low-dose non-DHP-CCB
2nd step	BB + DHP-CCB	BB and non-DHP-CCB	LAN	Add LAN or ivabradine	Add low-dose LAN
3rd step	Add 2nd line drug	Add ivabradine	DHP-CCB + LAN	Add another 2nd line drug	Add ivabradine, ranolazine, or trimetazidine
4th step			Add nicorandil, ranolazine or trimetazidine		

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Cases!

Case 1

40 yo woman with chest pressure

Lasts “all day”

Aggravated by kids and work

Not worse with exercise

No CRF

PTP? Stress/Image?

But…dad had MI had 45

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

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Case 2

75 yo diabetic man

Over last month has throat tightness when walking up stairs. Resolves when he rests.

Attenuated S1/S2, 2/6 SEM

ECG - NSR

No anemia, Cr 1.3, A1c 7.5, LDL 100

PTP?

Test?

Triage?

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	
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60–69	≤44	≤16	27	14
70+	≤52	≤27	32	12

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Case 3

68 yo woman, LDL 160, father with CABG

Avid hiker

Noticed on last few hikes she was very short of breath, had to stop multiple times.

Exam nl

ECG nl

Labs nl

PTP?

Test?

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	
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Case 3 cont

Referred for an ETT

6 minutes, stops due to DOE

1mm ST segment depression in inferior leads at minute 4 and resolves in recovery

Now what?

Case 3 cont

Antianginals started - patient reports feeling much better - back to hiking

CCTA performed

CAC of 103

Mixed plaque in mid LAD < 25% and RCA < 25%

Now what?

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Case 4

75 yo diabetic man

On BB, CCB, ASA, atorva 80, insulin

Over last 8.5 weeks has throat tightness when walking up stairs. Resolves when he rests.

Normal exam

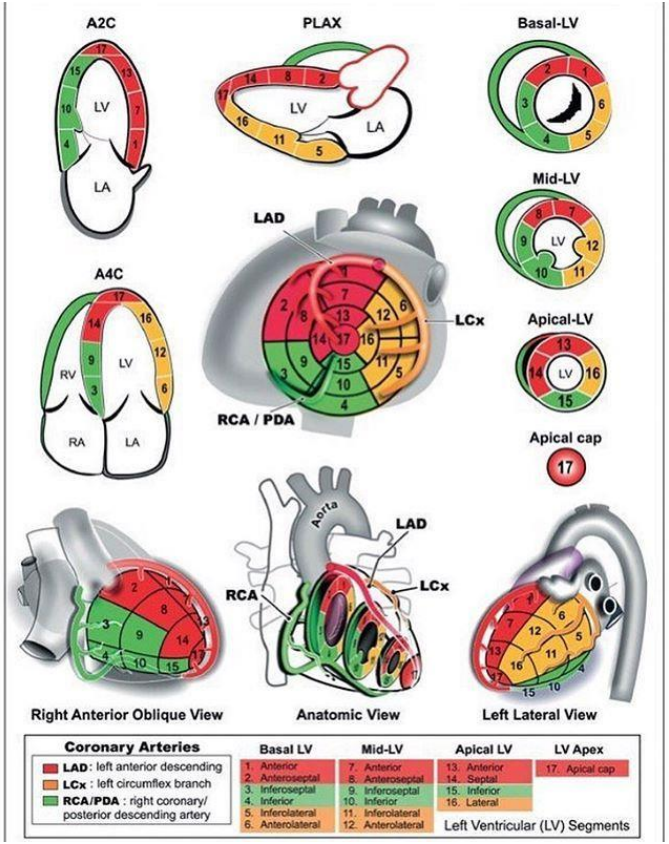
ECG with TWI V1-V4

Referred for stress echocardiogram

4 min, 1mm ST depressions V5-V6, EF 60-> 50

Mid and apical septum, mid and apical anterior, apical cap and apical inferior wall akinetic.

Now what?



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Case 5

85 yo woman with 3 years of dyspnea on exertion with ADLS - making the bed when walking out to the car

HTN, HLD on BP meds and statin

Exam Nl

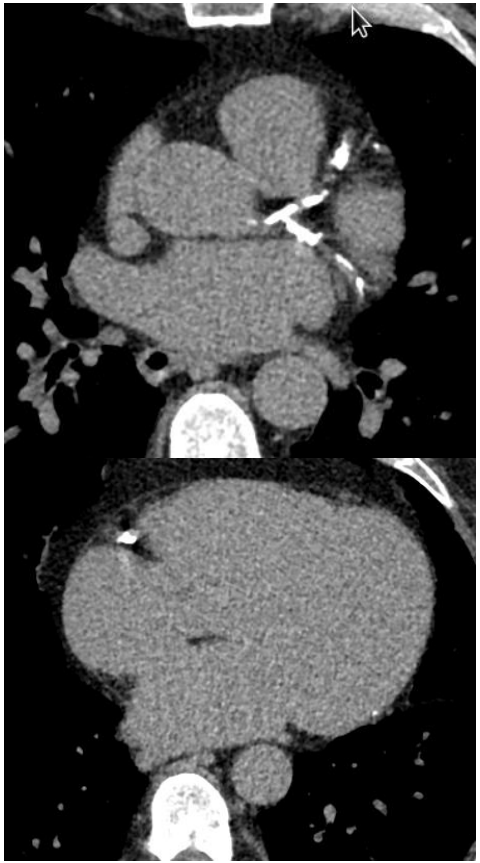
Cr 1.4

Echo normal, grade 2 diastolic dysfunction

Normal SPECT 1 year ago and 5 years ago

Chest CT from 2 years ago...

Next steps?



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Thank You!

Justin Penn, MD
justin.penn@vmfh.org

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