CARDIOVASCULAR RISK STRATIFICATION WITH ADVANCED CARDIAC IMAGING

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How do we identify patients who are at risk for ASCVD (primary prevention) or those who are at risk for having another cardiac event (secondary prevention)?

- What imaging modalities can help us?
- How do we choose the right study for our clinical scenario?
- Are there any new technologies which can improve our risk assessment?

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A 55 year old man with history of HTN and obesity presents with intermittent chest pain. He is not sure if this is related to exertion as he is sedentary at baseline. His father had a history of coronary stents at age 57.

Vitals:

HR 75, BP 138/74,

SpO2 100% on RA

EKG unremarkable except for LVH

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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: Low ≤15% | Intermediate–High >15%

B Pretest probability based on age, sex, symptoms, and CAC score*: ≤15% | >15%–50% | >50%

CAC 1–99 | CAC ≥100–999 | CAC ≥1,000

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- Figure 11. Pretest Probabilities of Obstructive CAD in Symptomatic Patients According to Age, Sex, and Symptoms Modified from Juarez-Orozco et al1 and Winther et al2 1) The pretest probability shown is for patients with anginal symptoms. Patients with lower-risk symptoms would be expected to have lower pretest probability. 2) The darker green– and orange-shaded regions denote the groups in which noninvasive testing is most beneficial (pretest probability >15%). The light green–shaded regions denote the groups with pretest probability of CAD ≤15% in which the testing for diagnosis may be considered based on clinical judgment.1 3) If CAC is available, it can also be used to estimate the pretest probability based on CAC score.2 CAC indicates coronary artery calcium; and CAD, coronary artery disease.

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IMAGING MODALITIES

Stress test:
- Exercise and EKG only?
- Echo?
- Nuclear?
  - SPECT
  - PET

CT scan:
- CT calcium score?
- CT Angiogram?
- CT with FFR or perfusion?

MRI?

Coronary Angiogram?

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Pretest likelihood of CAD	Low → No testing necessary → Option for CAC for ASCVD risk stratification		
	Intermediate-high → Younger patient (<65 y of age)	OR	Less obstructive CAD suspected ↔ CCTA favored
	Intermediate-high → Older patient (≥65 y of age)	OR	More obstructive CAD suspected ↔ Stress testing favored

	Favors use of CCTA	Favors use of stress imaging
Goal	• Rule out obstructive CAD • Detect nonobstructive CAD	• Ischemia-guided management
Availability and expertise	• High-quality imaging and expert interpretation routinely available	• High-quality imaging and expert interpretation routinely available
Likelihood of obstructive CAD	• Age <65 y	• Age ≥65 y
Prior test results	• Prior functional study inconclusive	• Prior CCTA inconclusive
Other compelling indications	• Anomalous coronary arteries • Require evaluation of aorta or pulmonary arteries	• Suspect scar (especially if PET or stress CMR available) • Suspect coronary microvascular dysfunction (when PET or CMR available)

Stress testing information					
	ETT	Stress echocardiography	SPECT MPI	PET MPI	Stress CMR MPI
Patient capable of exercise	✓	✓	✓		
Pharmacologic stress indicated		✓	✓	✓	✓
Quantitative flow				✓	✓
LV dysfunction/scar		✓	✓	✓	✓

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Does the patient have resting ECG abnormalities?

- Ventricular pacing
- LBBB
- ST depression at rest
- LVH with ST abnormalities
- Ventricular pre-excitation (WPW)

Can the patient exercise to reach 85% age-predicted maximum HR?

- If so, exercise stress test is always preferred to pharmacologic stress test.
- Pharmacologic stress test may be preferred in patients with LBBB or paced rhythm (not always)
  - Contraindications to vasodilators: severe asthma or bronchospasm, significant hypotension, sinus node dysfunction/high degree AVB without PPM
  - Contraindications to dobutamine: frequent ventricular arrhythmia or Afib with RVR, recent MI, significant LVOT obstruction, severe HTN

In patients with low probability of coronary disease (young patients, no risk factors), ETT is appropriate

In patients with intermediate to high probability of coronary disease, adding imaging increases sensitivity and specificity for detecting obstructive CAD

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A QUICK REFRESHER

SENSITIVITY: Ability to identify true positives ("rule in").

A highly sensitive test has few false negatives

SPECIFICITY: Ability to identify true negatives ("rule out").

A highly specific test has few false positives.

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STRESS ECHO

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Compare regional wall motion between rest and stress.

Ischemia: contractile function goes from normal to hypokinetic, akinetic, or dyskinetic in at least 2 adjacent segments

Scar: resting hypokinesis or akinesis remains fixed

Viability: resting hypokinesis improves during stress

Can also assess diastolic function, PA pressures, and valvular disease

Highly dependent on quality of images and being able to quickly obtain images at peak HR

Echo contrast can help significantly

Typically 70s-mid 80s% sensitivity and 80s-90s% specificity

Stress echo is more specific than nuclear stress

Normal test confers <1%/year cardiac event rate

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STRAIN ECHO

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Assesses the magnitude of myocardial deformation in longitudinal (global longitudinal strain or GLS) or circumferential components using speckle tracking of the myocardium

If there is a clinical suspicion for CAD, strain echo provides a sensitivity of 86% and specificity of 73% for significant stenosis

Can provide information about subclinical dysfunction even when LVEF is in the normal range

Most commonly used in cardio-oncology and evaluation for infiltrative diseases such as amyloidosis at this time but can be applied in ischemic evaluations as well

Major limitation is having appropriate endocardial definition in apical windows

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NUCLEAR STRESS

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SPECT	PET
Measures gamma rays	Measures positrons
Exercise or vasodilator	Vasodilator only
Assess relative myocardial blood flow between stress/rest	Assess relative myocardial blood flow between stress/rest
Can assess viability	Can assess viability
	Can assess myocardial blood flow and myocardial flow reserve, which can identify microvascular disease
Sensitivity 82%, Specificity 76%	Sensitivity 91%, Specificity 89%
More commonly available	Shorter scan time Lower radiation dose Better attenuation correction (more accurate in women and obese pts) Higher spatial resolution Overall superior image quality
With normal MPI, 2 year event rate for cardiac death or MI is <1%	

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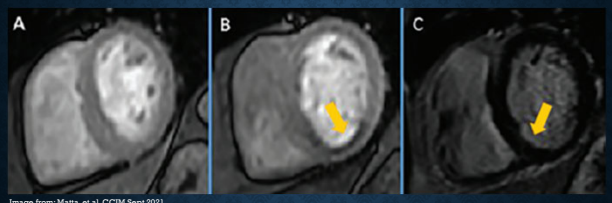

Image from: Matta, et al. CCJM Sept 2021

STRESS MRI

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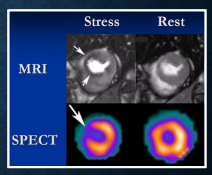
- Less commonly available
- Can use pharmacologic agents or exercise (bike)
- Good spatial and temporal resolution, wide field of view, ability to acquire images in different planes
- No radiation
- Complete information on function, infarct size and degree, perfusion, and viability
- Viability can also be determined using MRI with contrast but without stress
- Stress induced wall-motion abnormality has sensitivity of 83% and specificity of 86%
- Perfusion imaging has sensitivity of 91% and specificity of 81%
- Negative stress MRI is associated with <1% annual rate of cardiovascular death/MI



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ANATOMIC TESTING

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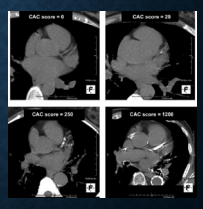
CALCIUM SCORING

- Measures the amount of calcium within the walls of the coronary arteries. Does not require contrast.
- One of the most validated tools for primary prevention in asymptomatic patients and helps stratify patients for risk factor optimization.
- Has been shown to predict premature CVD outcomes (Taylor et al, JACC 2005) and long-term mortality (Grandhi et all, JACC Card Imag 2020)
- Validated in MESA and Framingham populations and is an independent predictor irrespective of ethnicity or Framingham risk factors



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In symptomatic patients, a CAC score of 0 identifies a low-risk patient who may not need further testing.

- In the PROMISE trial, 84% of events occurred in patients with detectable CAC

When to use it:

- ACC/AHA and ESC guidelines suggest use in patients with intermediate risk for CAD.
- ACC/AHA guidelines recommend use only in patients who are undecided about statin therapy. Those with CAC >75th percentile should consider statin

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CORONARY CT ANGIOGRAPHY

- Assesses degree of stenosis and plaque characteristics
- To get ideal images, want HR<60 bpm and dilated coronary arteries
- Can assess for higher-risk plaque features such as low attenuation, positive remodeling, or spotty calcifications
- Sensitivity of 99%, specificity of 89%
- **The best test to rule out CAD**
- Can be hard to assess if moderate severity lesions (50-70%) is flow-limiting or non-obstructive
- Can be difficult to assess stents on CCTA

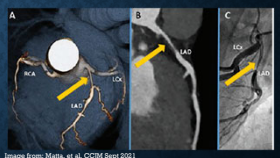

Image from: Matta, et al. CCJM Sept 2021

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A DRAWBACK OF ANATOMIC ASSESSMENT

Event free survival is not improved by revascularization based on invasive angiography alone, but does improve when angiography is combined with physiologic/hemodynamic measurements such as invasive FFR (Tonino et al. NEJM 2009).

Could the same be true for CTA?

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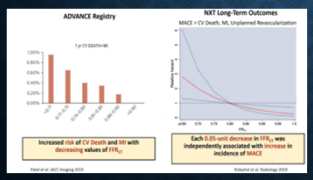
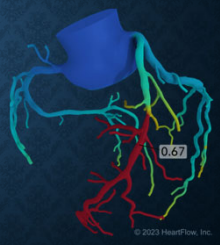
CTA WITH FRACTIONAL FLOW RESERVE

- If there are moderate lesions that need to be further assessed, images can be processed using HeartFlow software, which provides functional information





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CTA WITH FRACTIONAL FLOW RESERVE

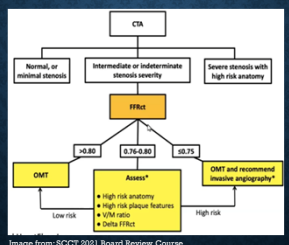

Image from: SCCT 2021 Board Review Course

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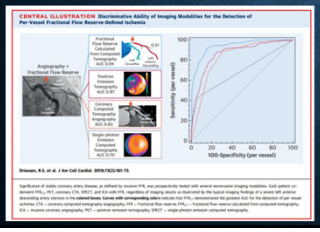
Comparison of Coronary Computed Tomography Angiography, Fractional Flow Reserve, and Perfusion Imaging for Ischemia Diagnosis



208 patients with only suspected CAD underwent coronary CTA with FFR, SPECT, PET, and ICA with FFR.

FFR-CT had higher diagnostic performance compared to standard CTA, SPECT, and PET for vessel-specific ischemia.

However, PET has the overall highest diagnostic performance, due to the rejection rates of FFR-CT.

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CT PERFUSION

Involves obtaining a rest coronary CTA plus a stress CT perfusion scan during vasodilator stress

Becomes similar to nuclear and MRI techniques but you also have anatomic information

Areas of scar will have delayed washout of contrast. Fibrosis and scar can be detected (with a third acquisition 5-10 minutes after contrast)

On a per vessel basis, MPI-CT (AUC 0.93) has similar diagnostic accuracy to MRI perfusion (AUC 0.94) and PET (AUC 0.93) and better than stress echo (AUC 0.82) and SPECT (AUC 0.83).

A stepwise approach may be used if CT-FFR is borderline, which improves diagnostic performance

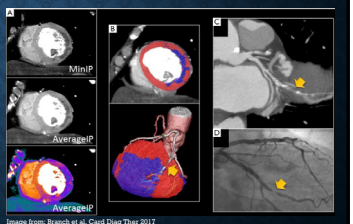

Image from: Branch et al, Card Diag Ther 2017

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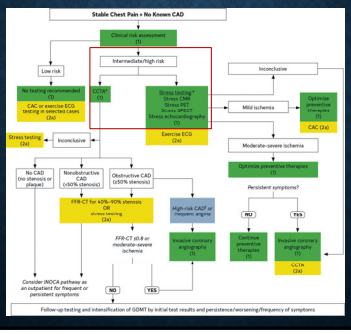
MAKING A DECISION



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MAKING A DECISION

There is typically no one right answer!

Understand your patient's pre-test probability of obstructive CAD

Have an informed conversation with your patient and determine what their preferences are

Understand the strength and limitations of each modality at your institution

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INFORMATIVE PAPERS/REFERENCES

- Matta et al. Stress testing and noninvasive coronary imaging: What's the best test for my patient? Cleveland Clinic Journal of Medicine September 2021, 88 (9) 502-515
- Wolk MJ et al. ACCF/AHA/ASE/ASNC/HFSA/ HRS/SCAI/SCCT/SCMR/STS 2013 multimodality appropriate use criteria for the detection and risk assessment of stable ischemic heart disease: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. J Am Coll Cardiol 2014; 63(4):380–406. doi:10.1016/j.jacc.2013.11.009
- Perone et al. Role of cardiovascular imaging in risk assessment: recent advances, gaps in evidence, and future directions. Journal of Clinical Medicine 2023; 12: 5563.

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QUESTIONS?

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