Updates on Chest Pain and Cardiac CT

Blair Suter, M.D.
Assistant Professor of Clinical Medicine
Cardiovascular Disease
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The Ohio State University
Wexner Medical Center

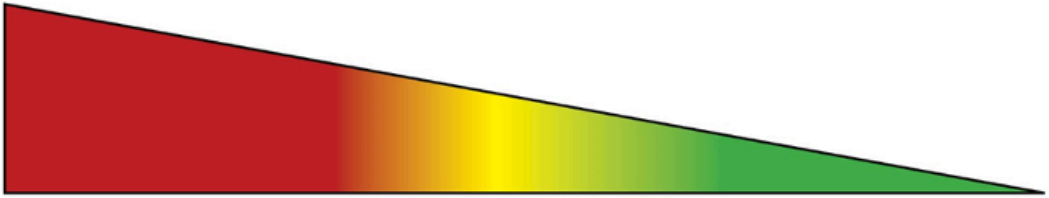
Objectives

- Understand updates in 2021 Chest Pain Guidelines and how to apply these to clinical practice
- Understand how to decide which assessment is most appropriate for chest pain in your patient – ED/IM/Family Medicine
- Understand basic aspects of Cardiac CT acquisition and what would make a patient a poor candidate for cardiac CT

Outline

- Possible Cardiac Chest Pain
- ED Evaluation / Troponin
- Stable Chest Pain
- Performing CCTA
- Interpreting CCTA

Possible Cardiac Chest Pain



- Central
- Pressure
- Squeezing
- Gripping
- Heaviness
- Tightness
- Exertional/stress-related
- Retrosternal

- Left-sided
- Dull
- Aching

- Stabbing

- Right-sided
- Tearing
- Ripping
- Burning

- Sharp
- Fleeting
- Shifting
- Pleuritic
- Positional

High — Low

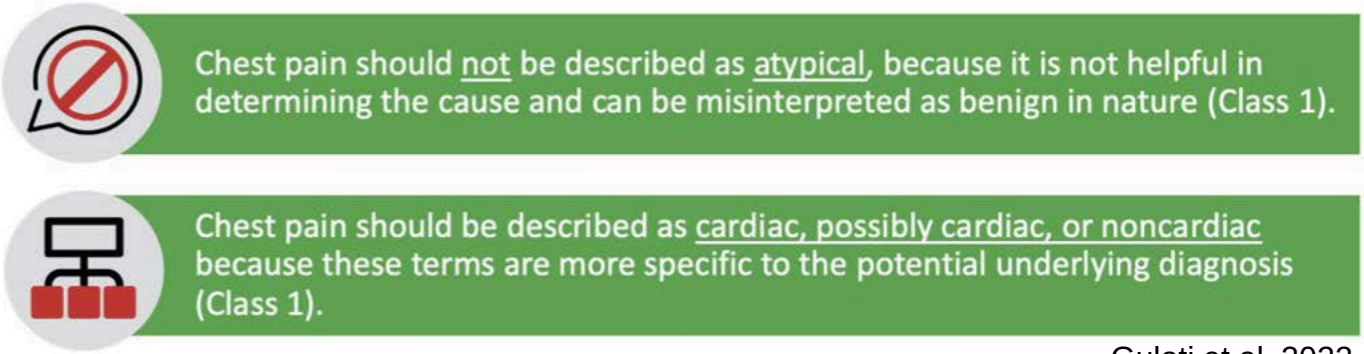
Probability of Ischemia

Gulati et al. 2022

Atypical is Out

- Anginal CP (how I was taught)
  1. Left sided pressure radiating to shoulder/jaw
  2. Worse with exertion
  3. Improves with nitro or rest
- I was taught that atypical means you had “some” (two of these features)
- Ambiguous term that different people used differently to describe angina

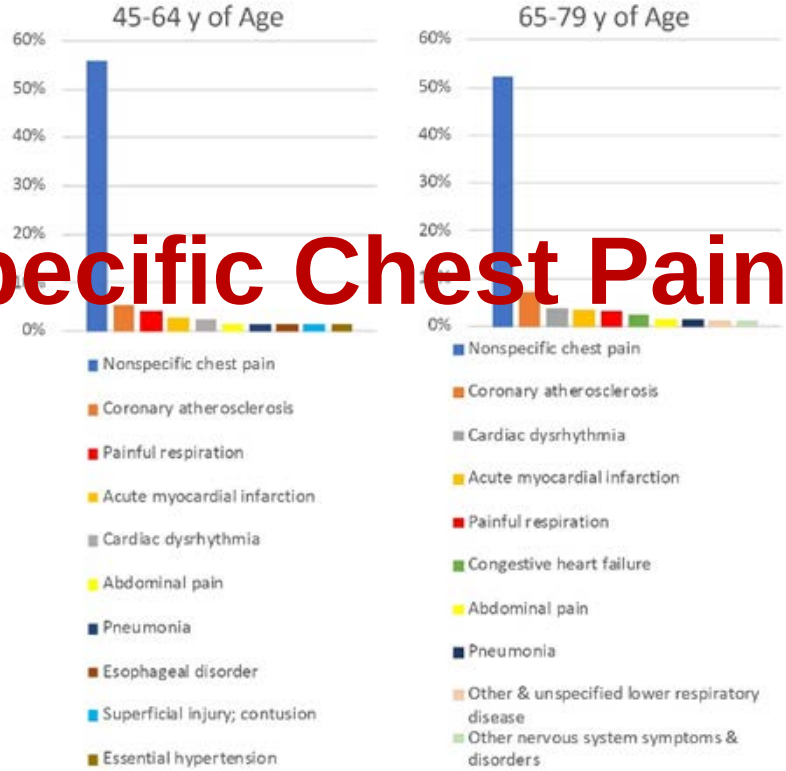
Noncardiac is in



Gulati et al. 2022

- 90% of men and women with myocardial ischemia have typical symptoms
- People used atypical as possibly cardiac or noncardiac

Top 10 Causes of Chest Pain in the ED by Age



Nonspecific Chest Pain >50%

Hsia et al. 2016

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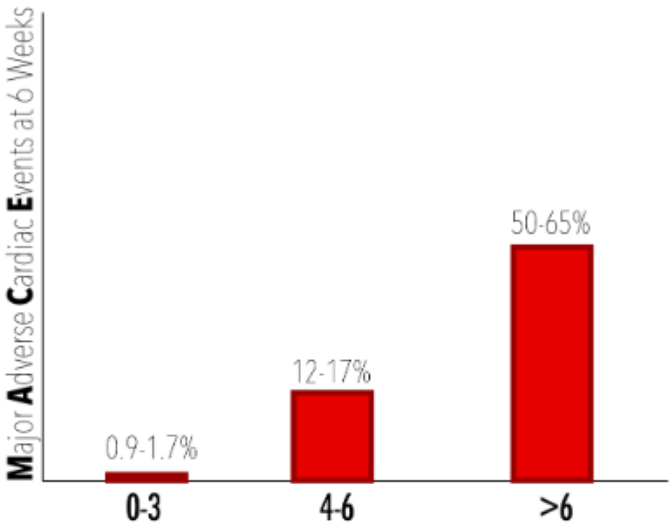
Initial ED work-up (1)

- EKG to review for STEMI within 10 minutes
  - Consider leads V7-V9 for posterior MI (COR 2a)
    - Improved sensitivity of PMI from 32 to 57% in LCx [2]
  - STEMI, NSTEMI, nondiagnostic, pericarditis, arrhythmia
- cTn as soon as possible
  - FU 1-3h high-sensitivity (ng/mL), 3-6h conventional (ng/L)
- CXR
- Clinical Decision Pathways – all for suspected ACS
  - Increase ED DC without missed MACE (usually 30d) →HEART, EDACS, ADAPT, NOTR
  - Early detection of AMI → 2020 ESC/hs-cTn, 2016 ESC/GRACE

Gulati et al. 2022, [2] van Gorselen et al. 2007

Heart Score
Increased DC without missed MACE

HEART Score		
History	Slightly suspicious	0
	Moderately suspicious	1
	Highly suspicious	2
EKG	Normal	0
	Non-specific repolarization disturbance	1
	Significant ST deviation	2
Age	< 45	0
	45-64	1
	≥ 65	2
Risk Factors	No known risk factors	0
	1-2 risk factors	1
	≥ 3 risk factors OR atherosclerotic disease	2
Initial troponin	Less than upper limit of normal	0
	1 to 3x normal limit	1
	> 3x normal limit	2
	TOTAL:	

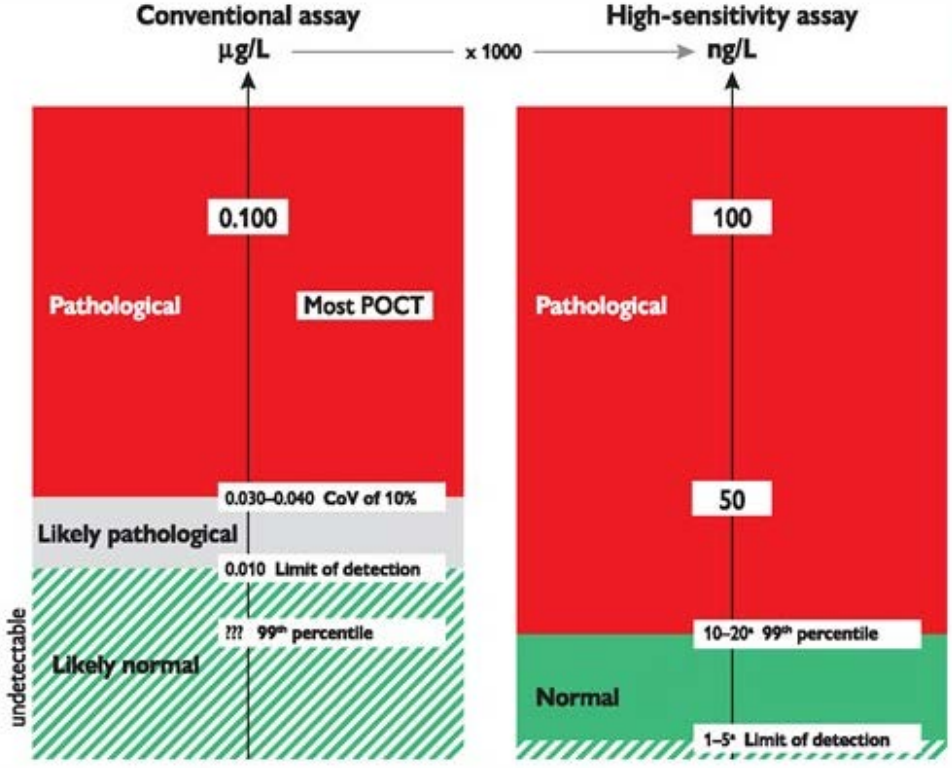


**HTN, DM, HLD must be Dx prior
**Good inter-observer reliability

Backus et al. 2010, 2013

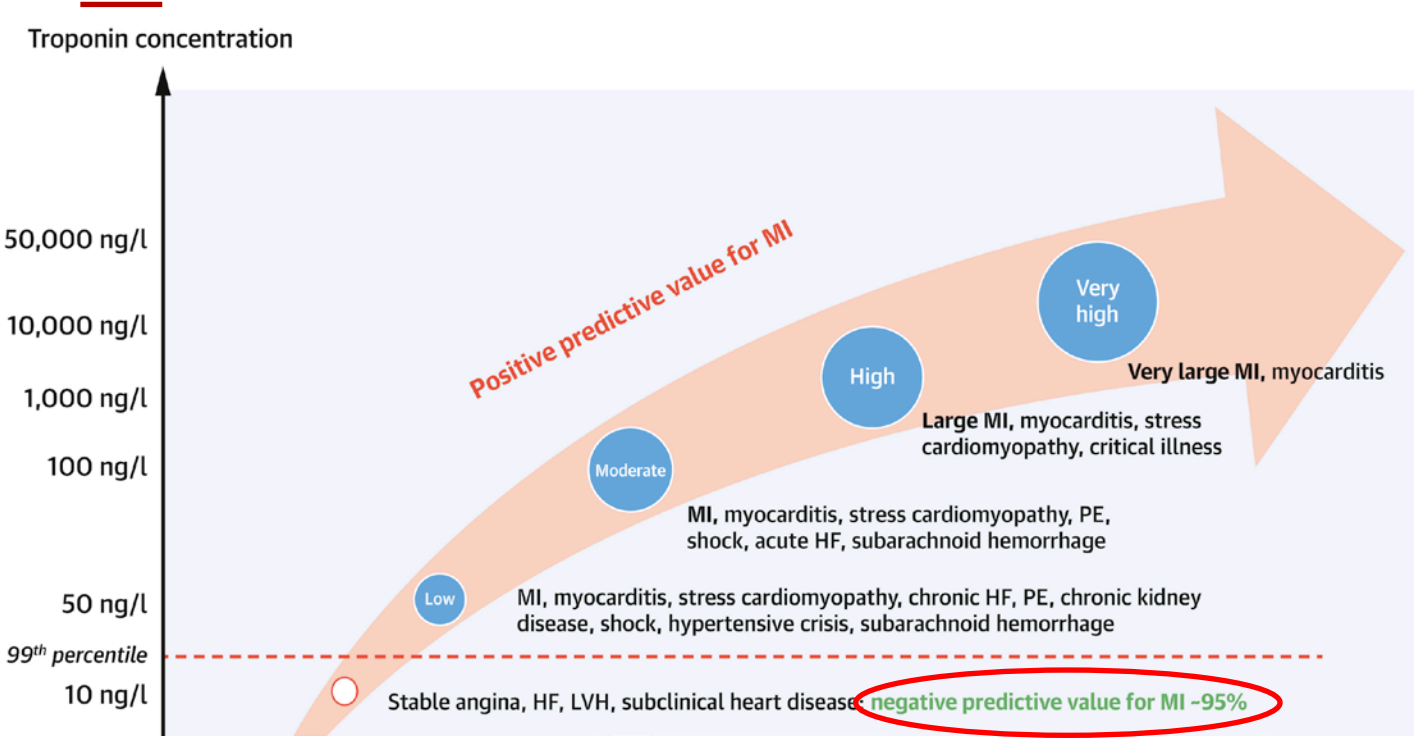
ESC/hs-cTn 2020
Early detection of AMI

Conventional (ng/mL) = High sensitivity (ng/L)/1000



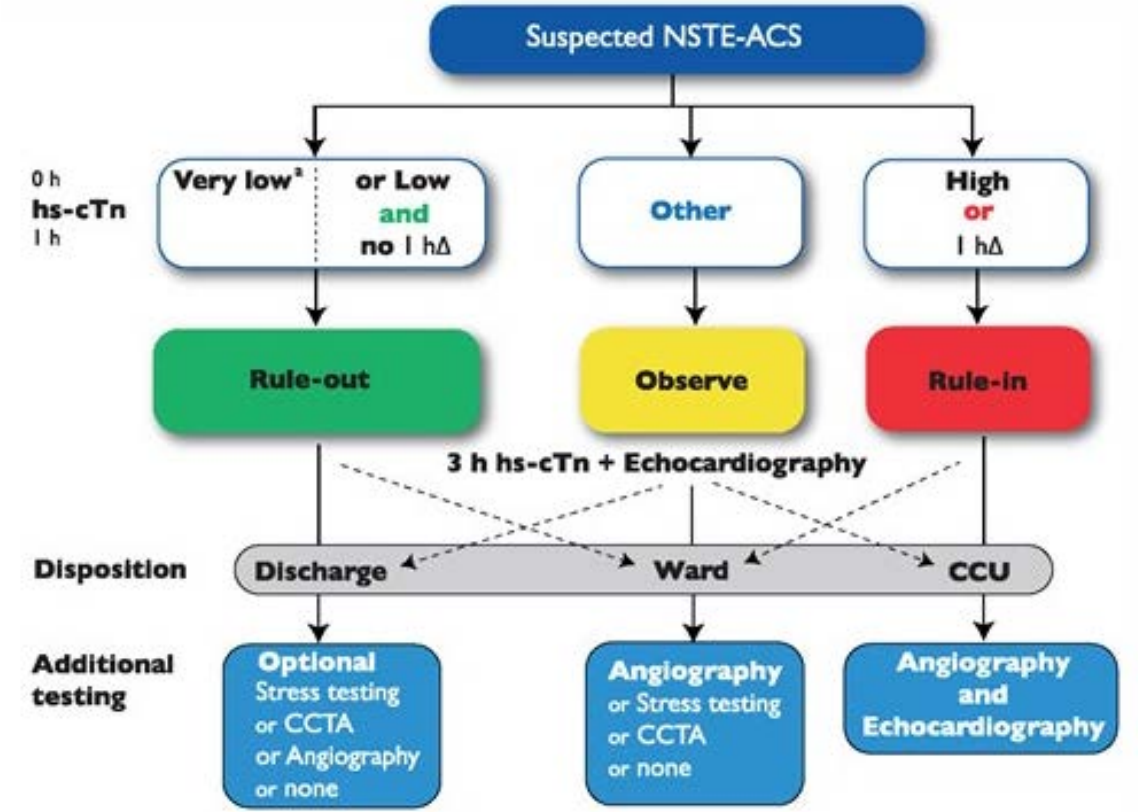
Collet et al. 2021

Helpful to rule out. Rule in with caution.



Raber et al. 2021

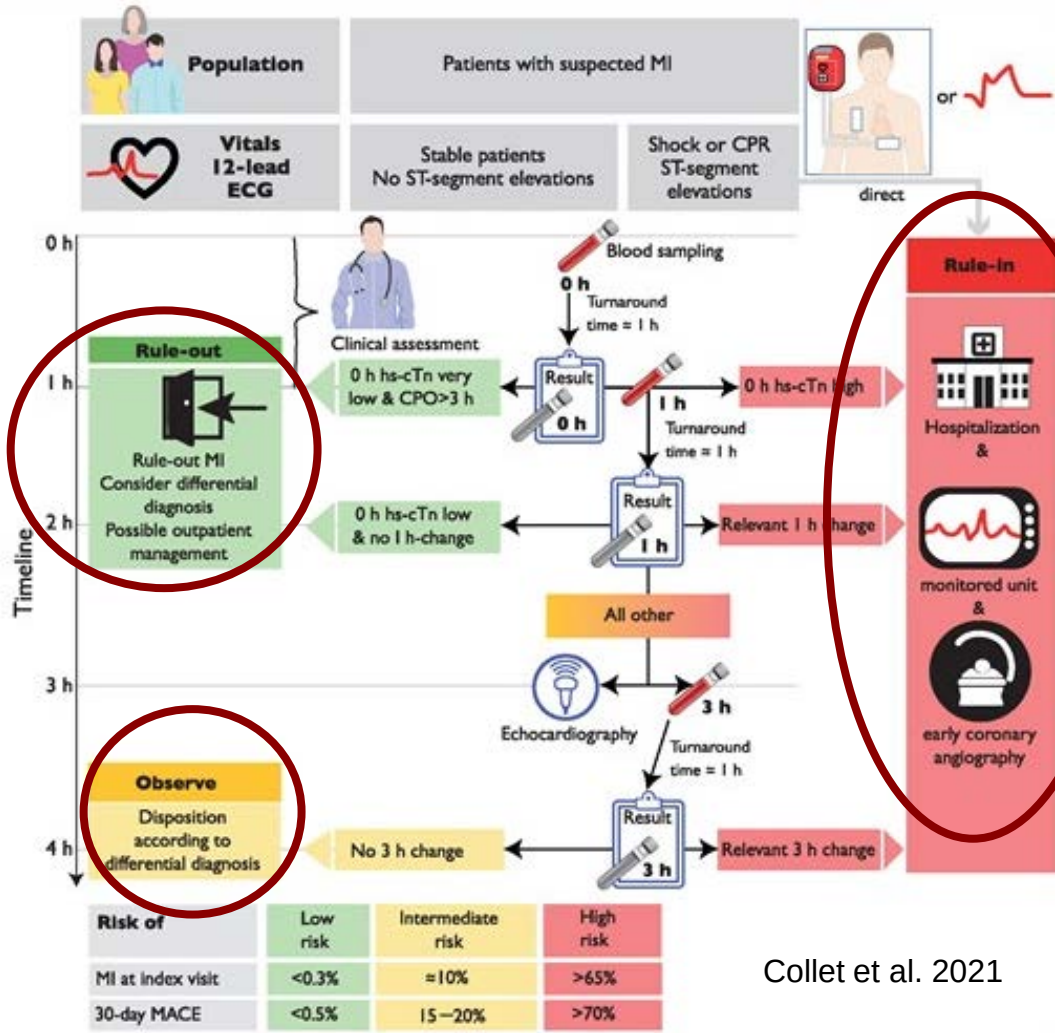
ESC/hs-cTn 2020



Collet et al. 2021

ESC/hs-cTn 2020

T-0 hs-cTn and 1- or 2-h delta are both low → >99% NPV for 30d MACE



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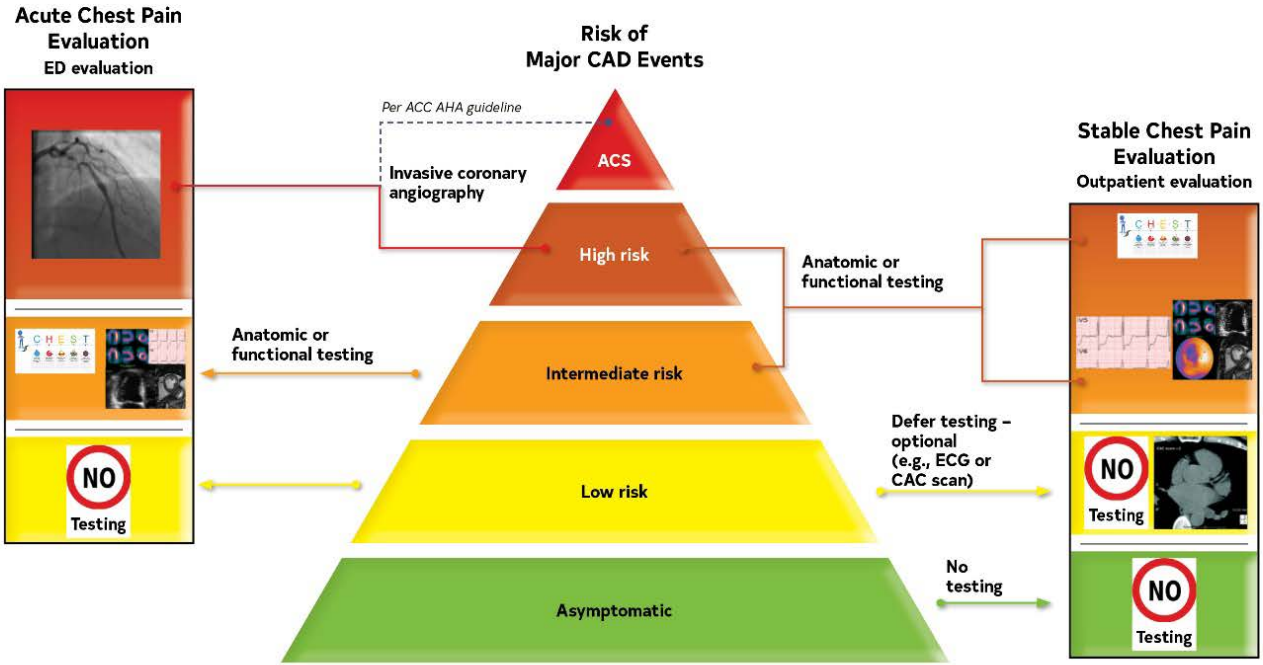
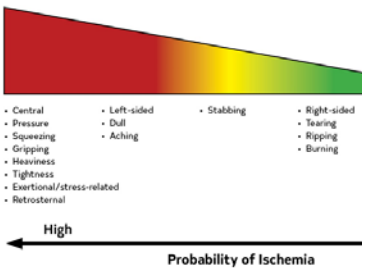


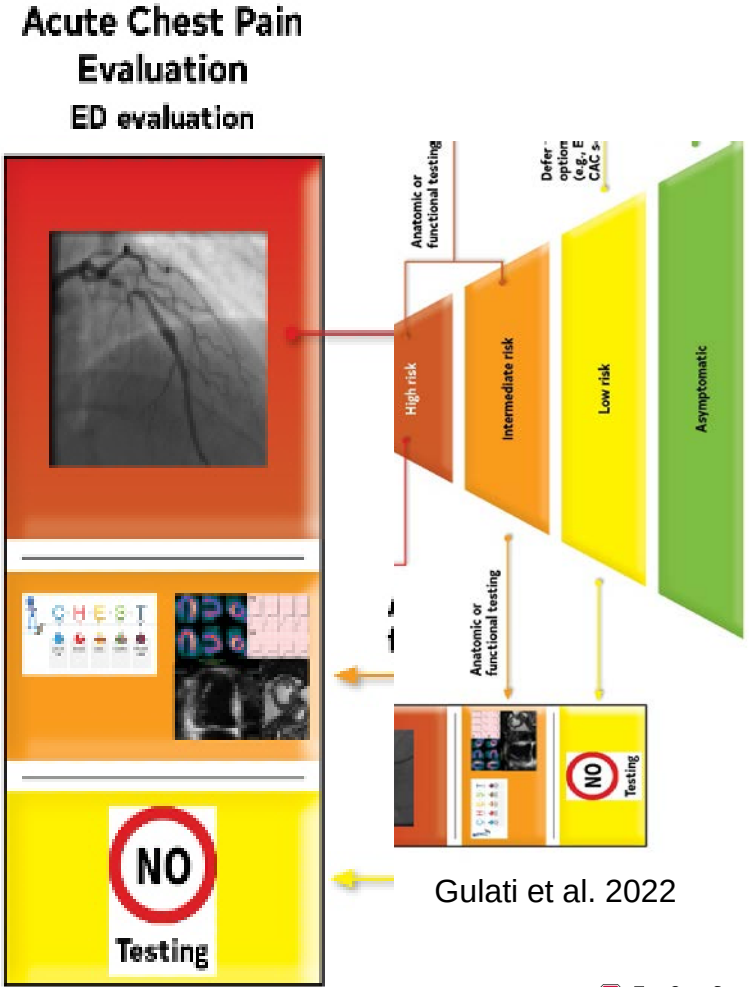
Gulati et al. 2022

Inpatient

Figure 2. Index of Suspicion That Chest "Pain" Is Based on Commonly Used Descriptors.



Plus your pathway :
-Heart Score
-ESC hs-trop



Gulati et al. 2022

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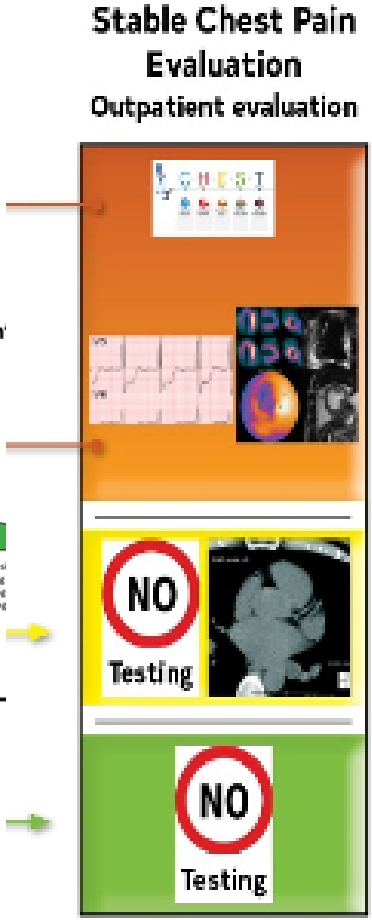

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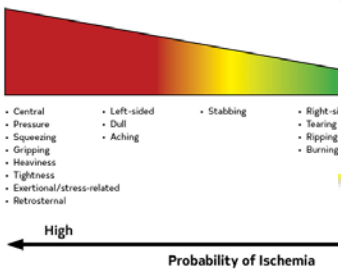
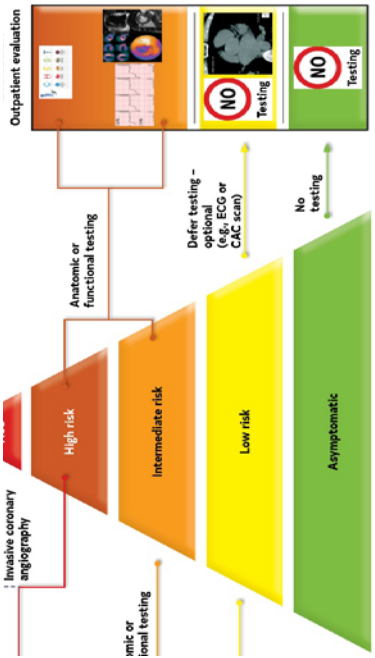




Gulati et al. 2022

Non-invasive Options

Pretest likelihood of CAD	Low →	No testing necessary →	Option for CAC for ASCVD risk stratification		
	Intermediate-high →	Younger patient (<65 Years)	**OR**	Less obstructive CAD suspected →	CCTA favored
	Intermediate-high →	Older patient (≥65 Years)	**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 exert interpretation routinely available	• High quality imaging and expert interpretation routinely available
Likelihood of obstructive CAD	• Age <65	• Age ≥65
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		✓	✓	✓	✓

Gulati et al. 2022

To review: Who's high risk for AMI → Cath / ICA

- EKG changes
- New EF<40%
- cTn injury
- Moderate-severe ischemia on stress
- Hemodynamic instability
- High risk CDP

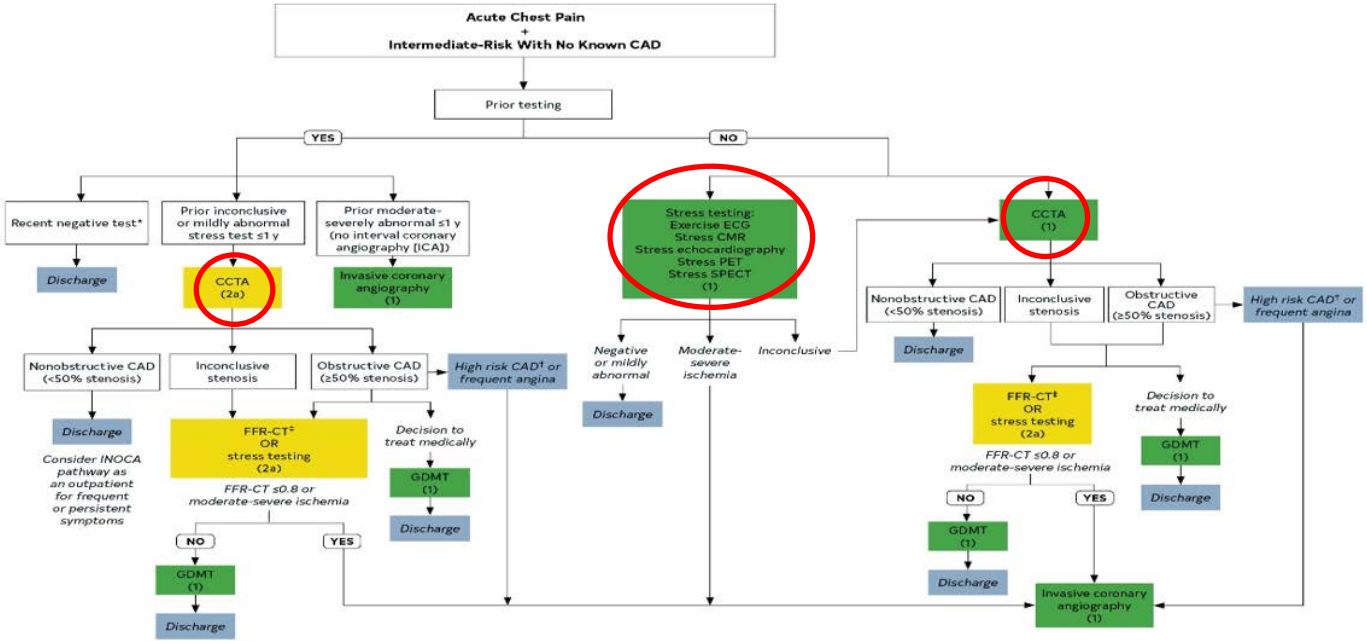
Gulati et al. 2022

AUC 2010 for CCTA

CAD				
1. Detection of CAD in Symptomatic Patients Without Known Heart Disease				
Indication		Appropriate use score		
Nonacute symptoms possibly representing an ischemic equivalent		Low pretest probability	Intermediate pretest probability	High pretest probability
1	ECG interpretable *AND* able to exercise	U (5)	A (7)	I (3)
2	ECG uninterpretable *OR* unable to exercise	A (7)	A (8)	U (4)
Acute symptoms with suspicion of ACS				
3	Normal ECG and cardiac biomarkers	A (7)	A (7)	U (4)
4	ECG uninterpretable	A (7)	A (7)	U (4)
5	Nondiagnostic ECG or equivocal cardiac biomarkers	A (7)	A (7)	U (4)
2. Detection of CAD/Risk Assessment in Asymptomatic Patients Without Known CAD				
6	CCS for global CHD risk estimation in the setting of family history ofpremature CHD	A (7)		
7	CCS for global CHD risk estimation in asymptomatic individuals with no known CAD	I (2)	A (7)	U (4)
3. Detection of CAD in Other Clinical Scenarios				
Newly diagnosed HF without prior CAD				
8	Reduced left ventricular ejection fraction	A (7)	A (7)	U (4)
Preoperative coronary assessment prior to noncoronary surgery				
9	Coronary evaluation before noncoronary cardiac surgery	U (6)	A (7)	I (3)
4. Use of Coronary CTA in the Setting of Prior Test Results				
10	Prior normal ECG exercise stress test with continued symptoms		A (7)	
11	Prior ECG exercise testing	I (2)	A (7)	I (3)
12	Discordant ECG exercise and imaging results		A (8)	
		Equivocal	Mild	Moderate or Severe
13	Prior stress imaging procedure	A (8)	U (6)	I (2)
		CCS ≤400	CCS 401-1000	CCS >1000
14	Diagnostic impact of coronary calcium on the decision to perform coronary CTA in symptomatic patients	A (8)	U (6)	U (4)
		Normal		Abnormal
15	Evaluation of new or worsening symptoms in the setting of past stress imaging study	A (8)		U (6)

Taylor et al. 2010

So what to do with the intermediate risk patient?



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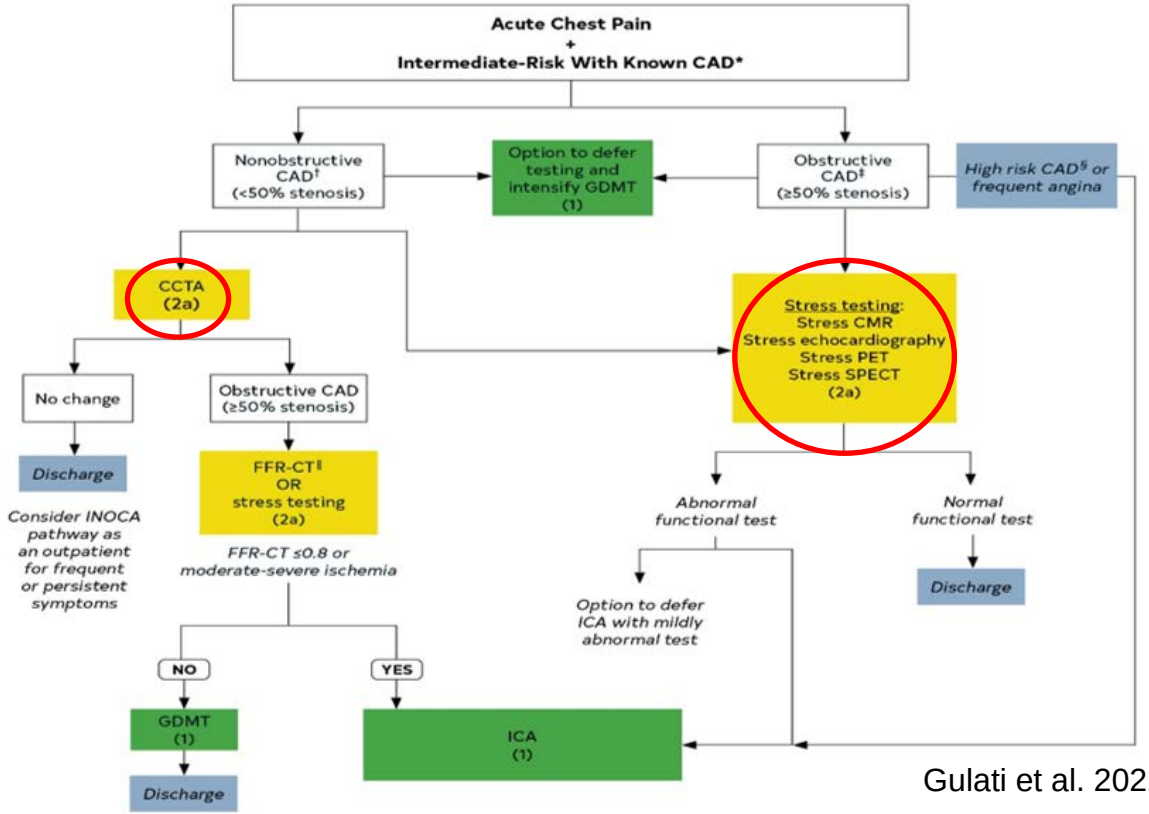

Gulati et al. 2022

Risk Classification

- Use non-invasive and invasive information + demographic, social, and medical variables
- Once you have diagnosed chronic coronary disease:
  - Low risk <1% risk of annual mortality
  - Intermediate risk 1-3%
  - High risk >3%

Virani et al. 2023

High Risk Patients (>3% death or MI/yr): Rest

- Severe resting LV dysfunction (<35%) not readily explained by noncoronary causes
- Resting perfusion abnormalities >10% of the myocardium in patients without prior history or evidence of MI
- Multivessel obstructive CAD (>70% stenosis) or LM stenosis (>50%) on CCTA
- CACS > 400

Topol et al. 2007

High Risk Patients (>3% death or MI/yr): Stress

- Stress ecg findings including >2mm of STD at low workload or persisting into recover, exercise-induced STE, or exercise-induced VT/VF
- High-risk treadmill score <-11
- Severe stress-induced LV dysfunction (peak exercise LVEF<45% or drop in LVEF with stress >10%)
- Stress-induced LV dilation
- Inducible wall motion abnormality (involving >3 segments or 2 coronary beds)
- MPI ischemia >10% or >2 coronary beds
- Wall motion abnormality developing at low dose dobutamine (<10 mg/kg/min) or at a low HR (120 bpm)

Topol et al. 2007

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Stable chest pain

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

1. The Pretest Probability shown is for patients with anginal symptoms. Patients with lower risk symptoms would be expected to have lower PTP
2. The darker green and orange shaded regions denote the groups in which non-invasive testing is most beneficial (pre-test probability >15%). The light green shaded regions denote the groups with pre-test probability of CAD ≤15% in which the testing for diagnosis may be considered based on clinical judgement
3. If CAC available, can use to estimate pretest probability based on CAC Score

Adapted and modified from Juarez-Orozc ESC 201920, 1198–1207
+ Winther, S. et al. *J Am Coll Cardiol.* 2020;76(21):2421–32.

Gulati et al. 2022

AUC 2010 CCTA

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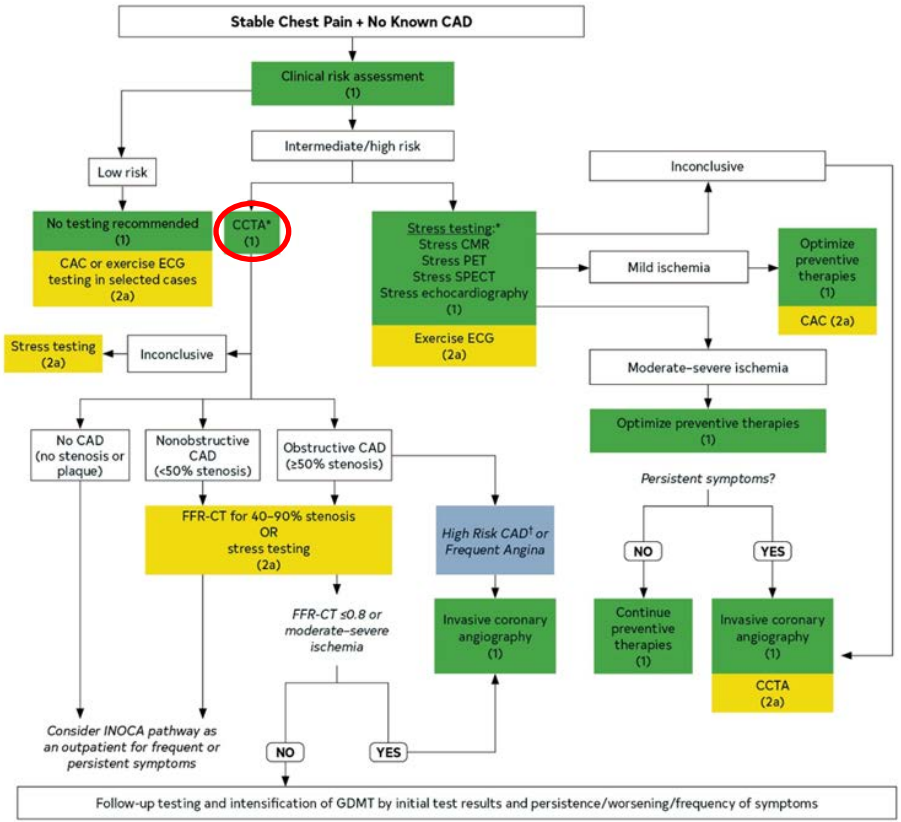
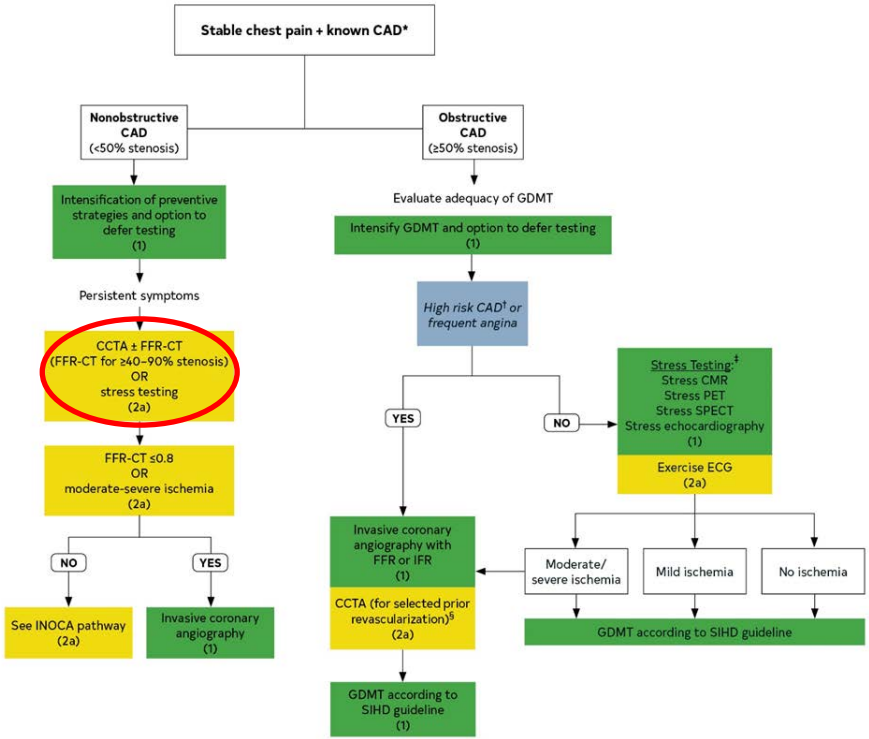
Taylor et al. 2010

Stable chest pain + no know CAD



Gulati et al. 2022

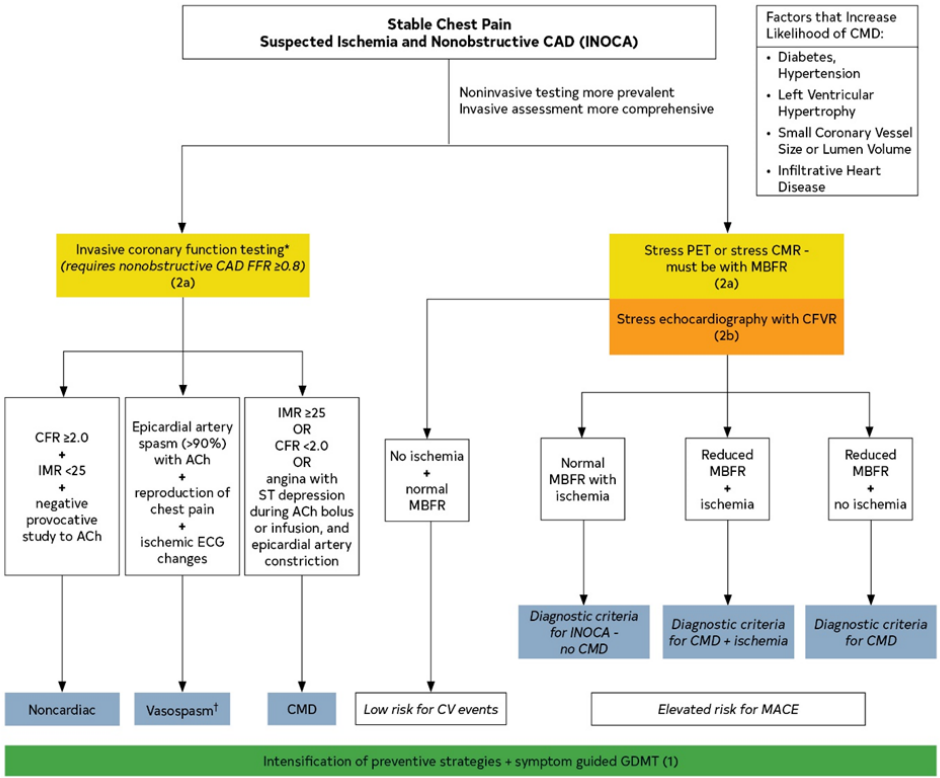
Stable chest pain + known CAD



Gulati et al. 2022

INOCA Microvascular Spasm

CCTA not recommended



Gulati et al. 2022

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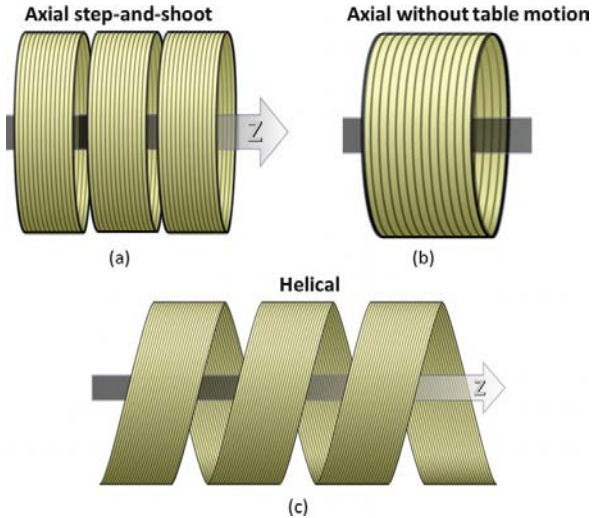
Other Non-invasive Test to Avoid

- Stress modality→ BP >200/110, ACS<2d
- Exercise ECG → abnormal ST baseline, digoxin, LBBB, WPW, V-paced, acute illness
- Stress nuclear
  - Vasodilator → arrhythmia, bronchospasm, caffeine <12h
- Stress Echo → poor windows (COPD, obesity)
  - Dob → arrhythmia, severe AS/LVOTO, acute illness
  - Atropine → narrow-angle glaucoma, MG, obstructive uropathy, obstructive GI
  - Contrast → hypersensitivity to perflutren, blood/albumin (optison)
- Stress CMR → GFR<30, claustrophobia

CCTA considerations

- Contrast allergy → pretreat
- Breath hold →10 seconds
  - Respiratory issues
  - Language barrier
  - Cognitive impairment
  - Encephalopathy
- Renal disease
  - Pre-hydrate GFR 30-60
  - Avoid GFR<30
  - 70-90cc of contrast (ICA is more controlled)



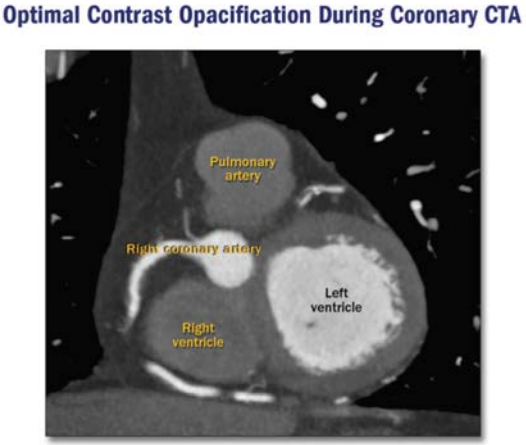
Yu et al. 2020

CCTA considerations

- BMI <40 → can increase keV
- HR variability/ arrhythmia → 256 Multidetector CTs image whole-heart in one beat
- Beta blocker
  - Chronotropic control → po/iv metoprolol and ivabradine
  - HR <90 bpm
  - Goal HR <70bpm with meds
  - Often tough if acutely sick for other reasons!
- Nitroglycerin given (0.4 or 0.8) → avoid with sildenafil

CCTA steps

- Rate control 1-2 hours prior (or from home)
  - Or on table with IV
- Triphasic/biphasic injection protocol
- Goal of sustained and unform contrast in coronaries / left heart
  - Contrast, diluted contrast, saline
- Anticubital vein, 20g IV
- Timing bolus vs. triggered bolus on HU (asc / desc Ao)
- Multiplanar reconstruction on limited FOV to maximize spatial resolution



Harfi et al. ACCSAP

Radiation Dose with CT

Calcium scan – 0.5-0.6 mSV
Mammography - 0.7 mSV
64 slice CT angiogram – 9 mSV
256 slice CT angiography – 1-3 mSV
Coronary angiogram – 8mSV (2-10)
Nuclear imaging – 9-41 mSv

Background radiation 3 mSV/year

Warranty

- Normal CCTA / normal LHC

→ 2 years

- Normal stress (adequate)

→ 1 year

Other Causes of Chest Pain Seen on CCTA

Respiratory	
	Pulmonary embolism
	Pneumothorax/hemothorax
	Pneumomediastinum
	Pneumonia
	Bronchitis
	Pleural irritation
	Malignancy
Gastrointestinal	
	Cholecystitis
	Pancreatitis
	Hiatal hernia
	Gastroesophageal reflux disease/gastritis/esophagitis
	Peptic ulcer disease
	Esophageal spasm
	Dyspepsia

Chest wall	
	Costochondritis
	Chest wall trauma or inflammation
	Herpes zoster (shingles)
	Cervical radiculopathy
	Breast disease
	Rib fracture
	Musculoskeletal injury/spasm
Psychological	
	Panic disorder
	Anxiety
	Clinical depression
	Somatization disorder
	Hypochondria

Other	
	Hyperventilation syndrome
	Carbon monoxide poisoning
	Sarcoidosis
	Lead poisoning
	Prolapsed intervertebral disc
	Thoracic outlet syndrome
	Adverse effect of certain medications (e.g., 5-fluorouracil)
	Sickle cell crisis

- COR 2a to refer for CBT or GI after negative myocardial ischemia work-up

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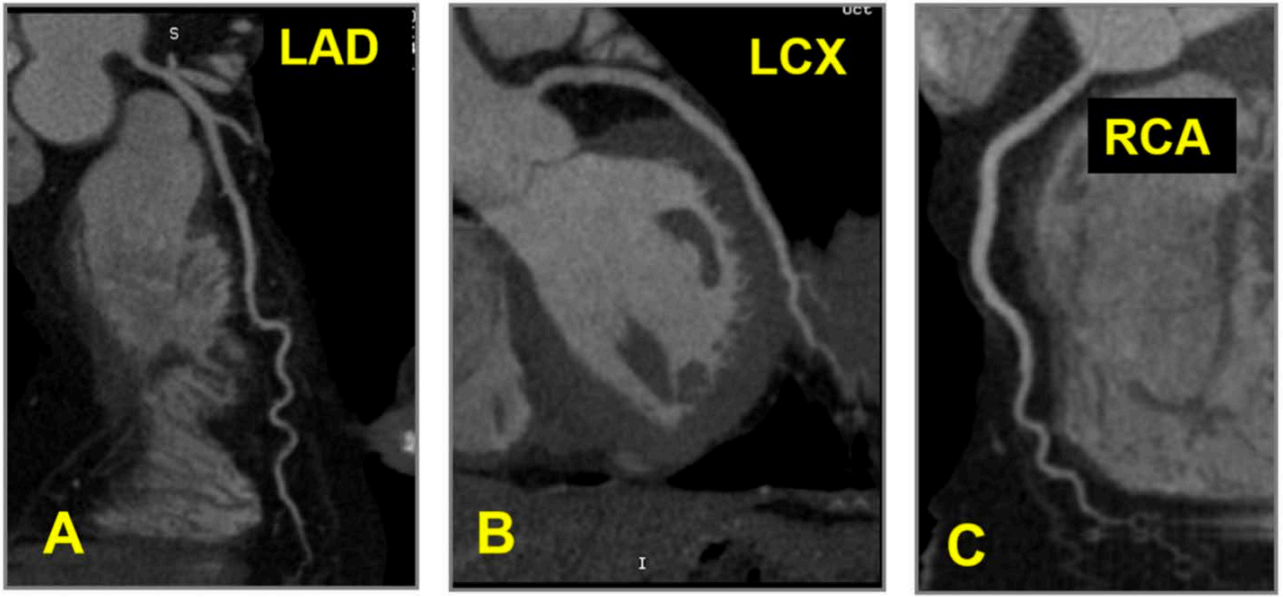
Reporting: CAD-RADS 2.0

- Scale 0-5
- Modifiers: Stent (S), G (graft), V (vulnerable)
  - Diagnostic accuracy of 92%
  - Moderate to high accuracy for stents >3mm
- High-risk /vulnerable plaque features
  - Low attenuation plaque
  - Positive remodeling
  - Napkin-ring sign
  - Spotty calcification
- ACCURACY trial (2008) → high NPV
  - PPV for 70% stenosis → 48%
  - NPV for 50% and 70% stenosis → 99% and 100%
- 50-69% → stress
- 70-99% → ICA

Budoff et al. 2008 Cury et al. 2022

CAD RADS 0: 0% stenosis

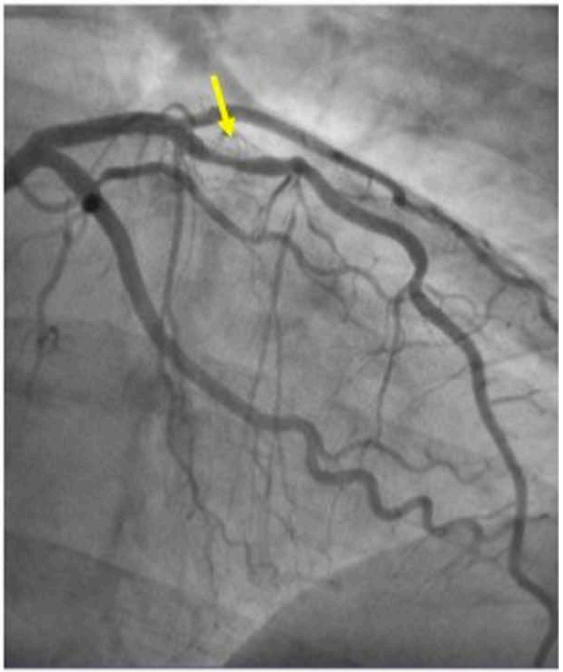


Cury et al. 2022

CAD RADS 1: <25% stenosis

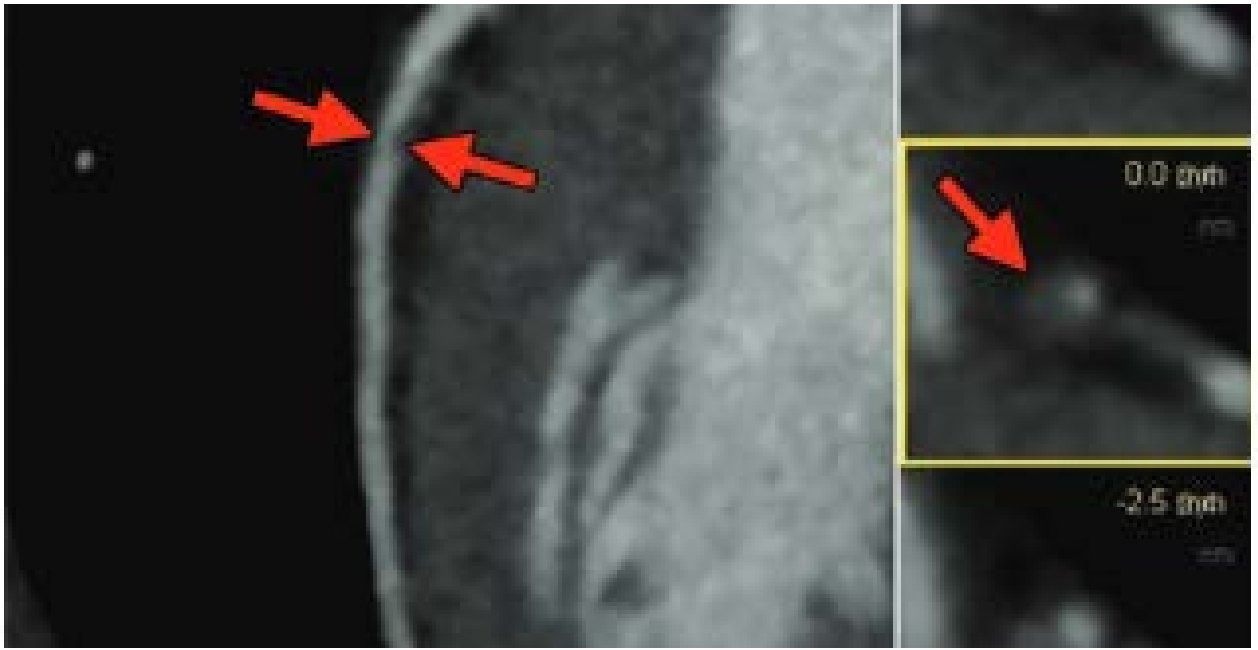
Cury et al. 2022

CAD RADS 2: 25-49% stenosis



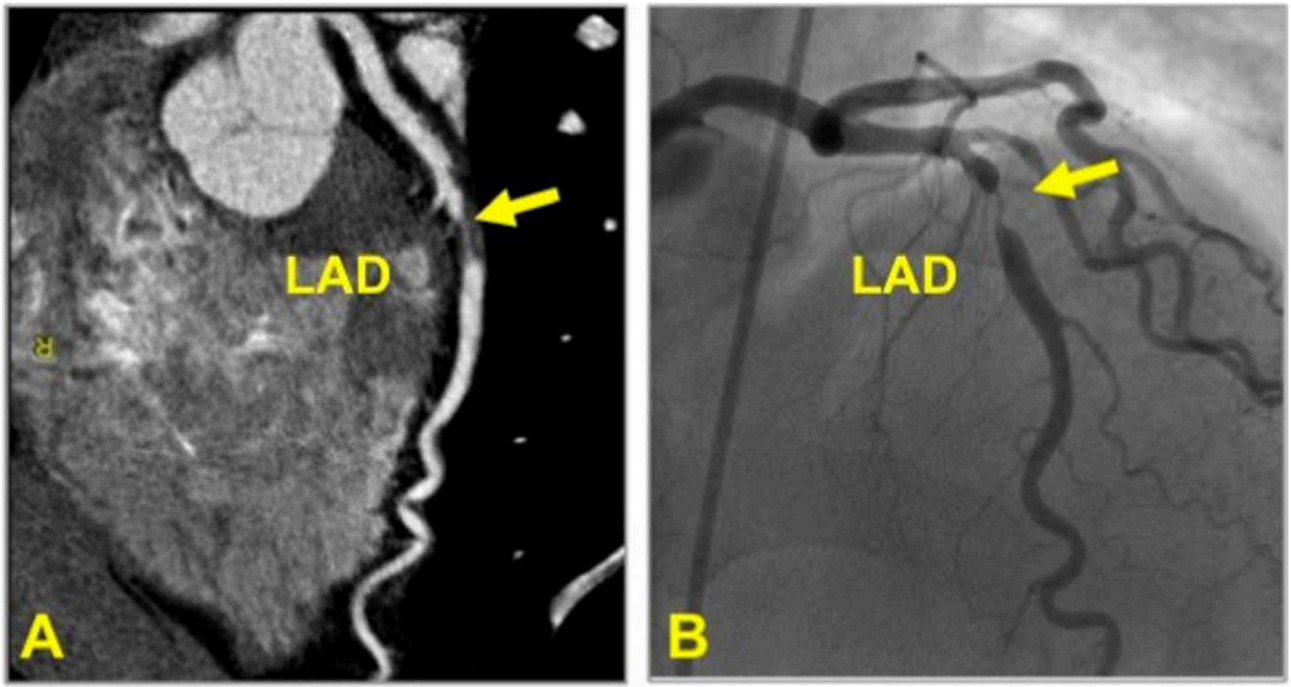
Cury et al. 2022

CAD RADS 3: 50-69% stenosis → CT-FFR/stress



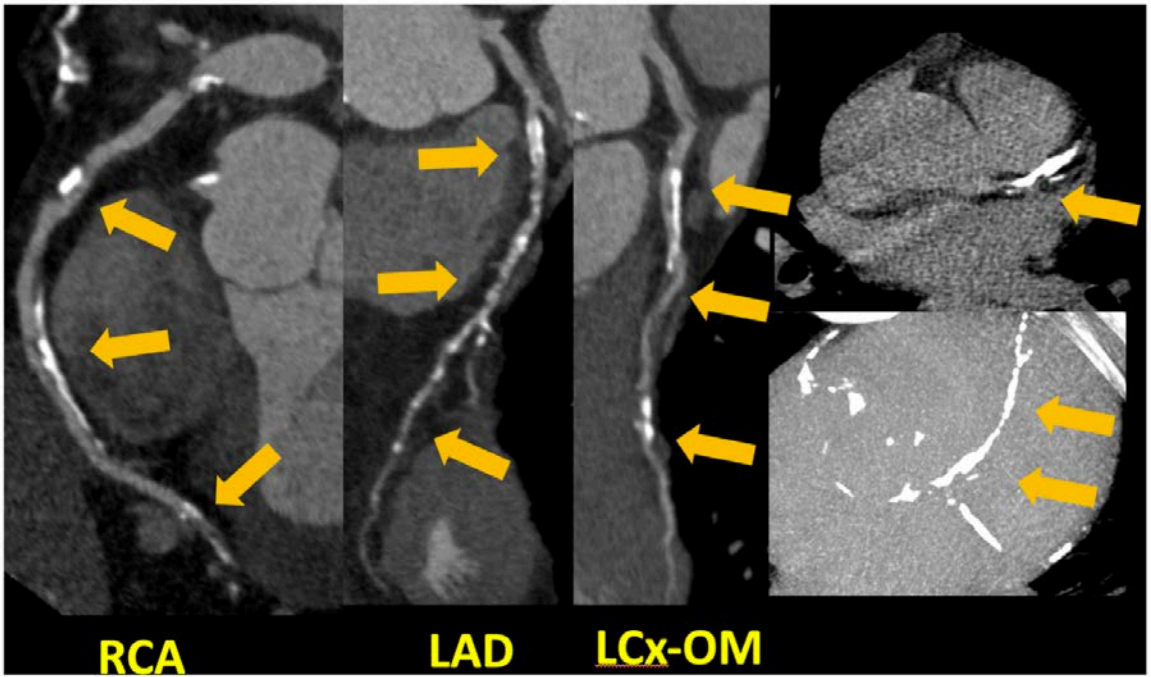
Canan et al. 2020

CAD RADS 4: >70% stenosis-soft plaque → ICA



Cury et al. 2022

CAD RADS 4: calcified plaque (>3k CACS) → ICA

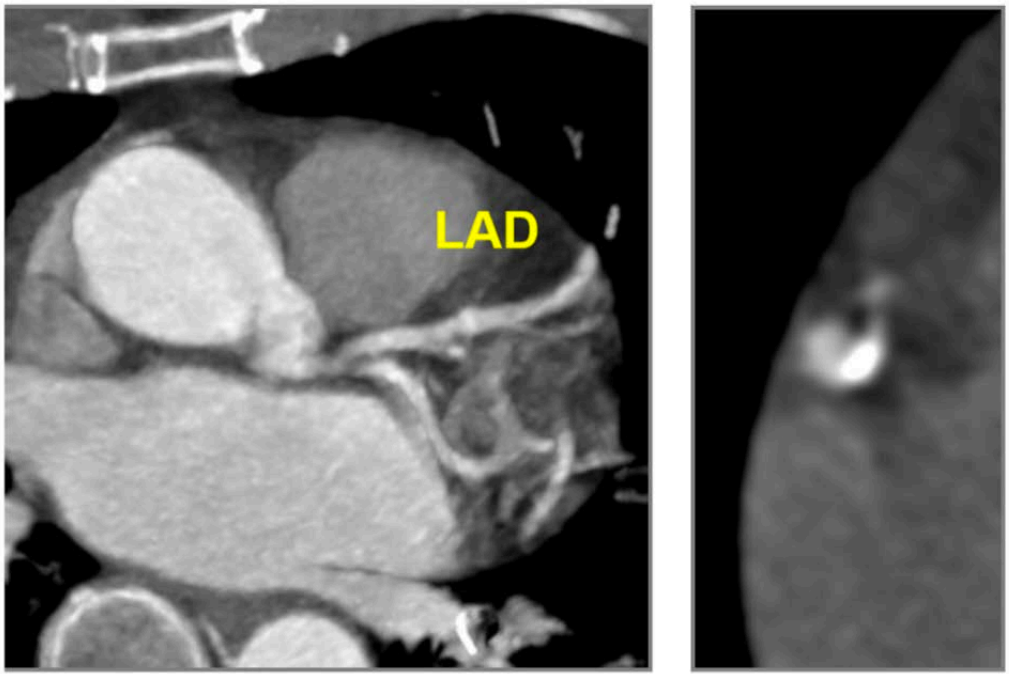


Cury et al. 2022

CAD RADS 5: Total occlusion → Assess!

Cury et al. 2022

CAD RADS N : nondiagnostic



Cury et al. 2022

CCTA: Preventative Health

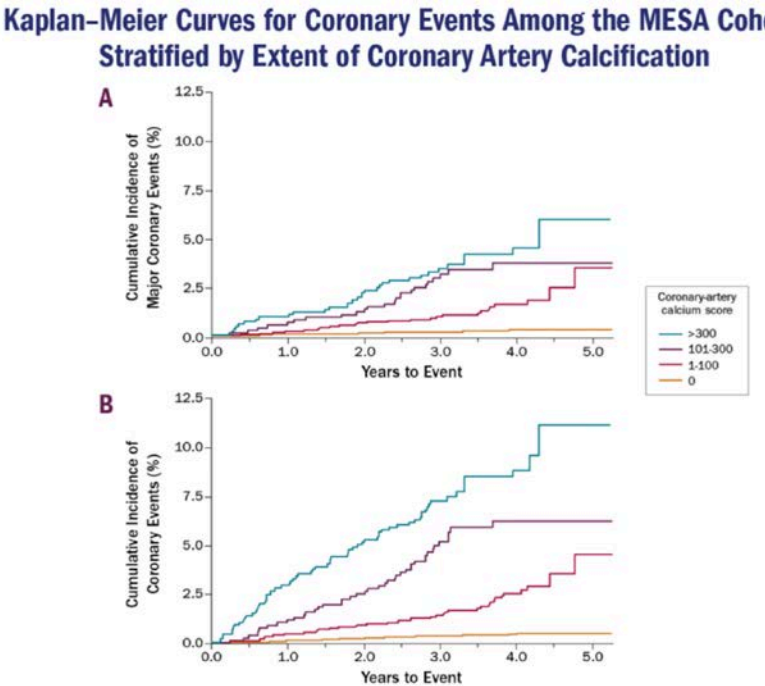
Table 2
Different methods to categorize the overall amount of coronary plaque.

	Overall amount of coronary plaque	CAC	SIS*	Visual*
P1	Mild	1–100	≤2	1-2 vessels with mild amount of plaque
P2	Moderate	101–300	3–4	1 -2 vessels with moderate amount; 3 vessels with mild amount of plaque
P3	Severe	301–999	5–7	3 vessels with moderate amount; 1 vessel with severe amount of plaque
P4	Extensive	>1000	≥8	2-3 vessels with severe amount of plaque

Cury et al. 2022

Preventive information from Cardiac CT: MESA

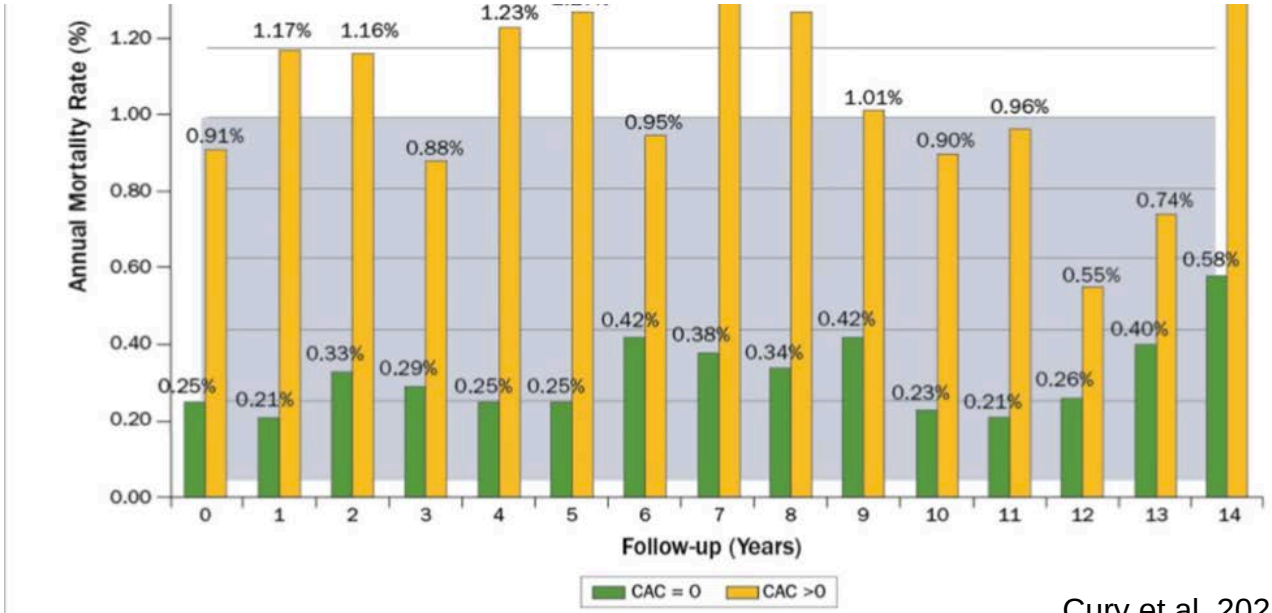
>6,000 people
Age 45-84
without CAD



Detrano et al. 2008

Power of zero

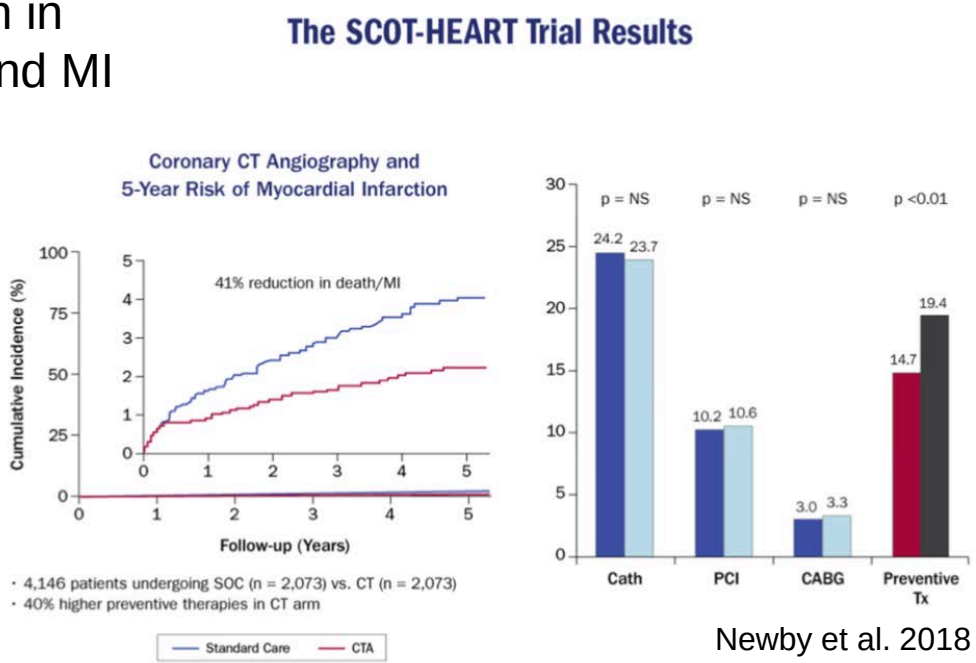
9,715 patients. Average age 52. Unaffected by age or sex.



Cury et al. 2022

Preventive: SCOT-HEART (2018)

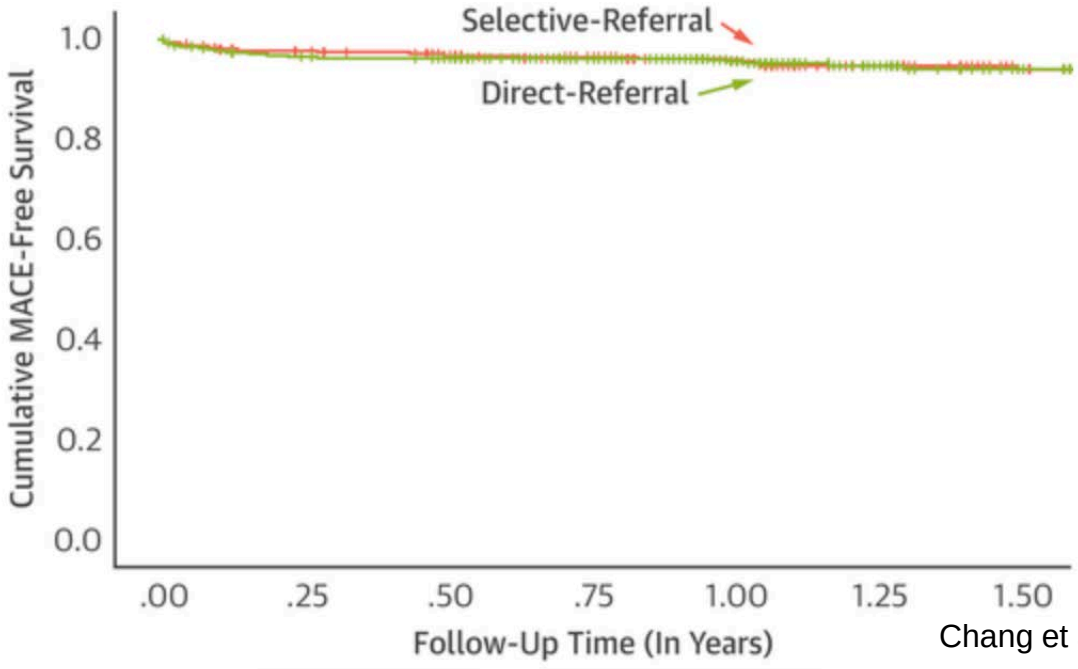
CCTA first vs. SOC resulted in 41% reduction in Cardiac death and MI



Newby et al. 2018

Preventive: CONSERVE (2019)

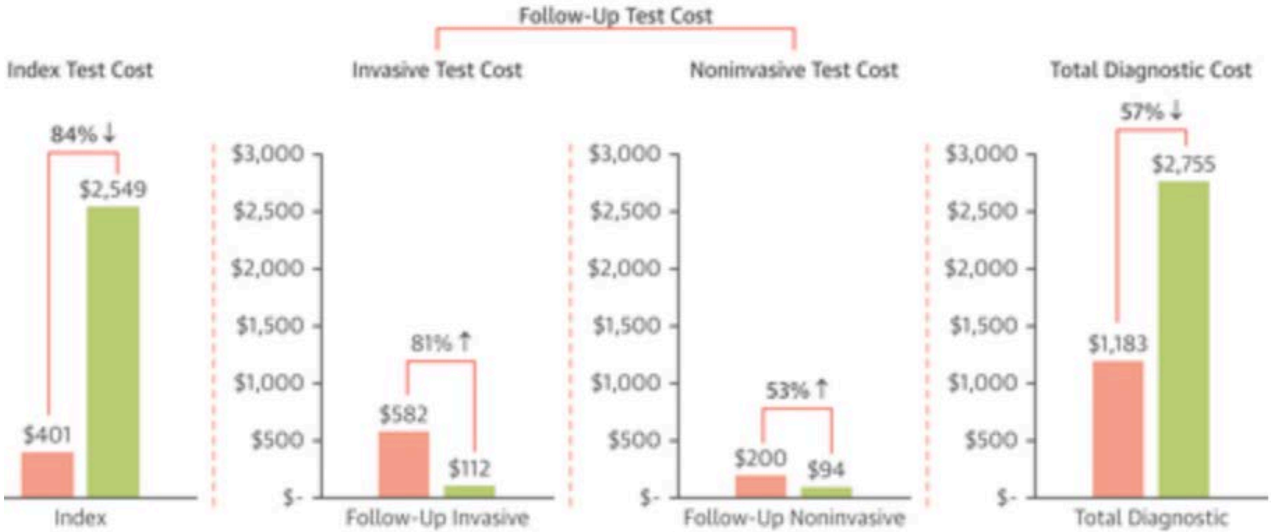
ICA vs. CCTA as initial strategy in eligible patients
Age 60, only 23% (vs. 61%) underwent ICA after CCTA, no increase in complications in ICA



Chang et al. 2019

Preventive: CONSERVE (2019)

CCTA first strategy decreased diagnostic test cost by 57% (~$1,600)



Chang et al. 2019

Five Points on Chest Pain and CCTA

- Chest pain is often nonspecific but can be possibly cardiac
- CCTA as an appropriate initial investigate in possibly cardiac chest pain especially if age <65
- Consider contrast and HR
- Great NPV, intermediate PPV
- Preventive information and treatment

Thank you!