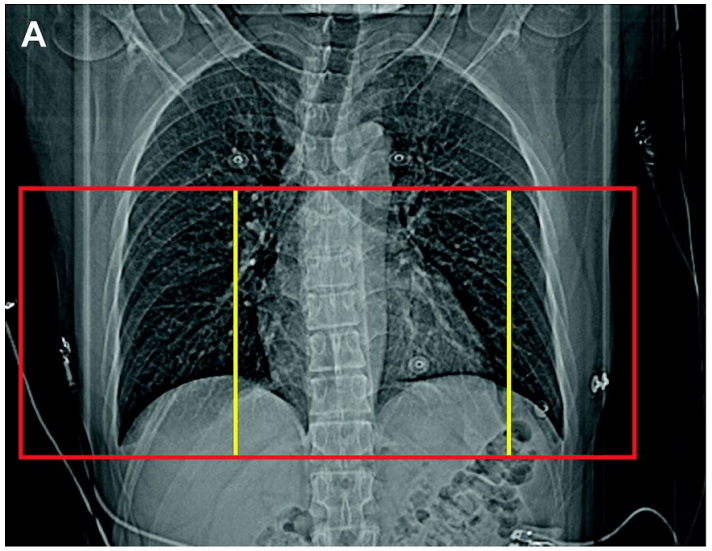
CARDIAC CTA

AMID BITAR, MD

ORIGINS

- The CT scanner was developed by Godfrey Hounsfield
- Got him the Nobel Prize!
- Interest in evaluating the coronary arteries began in the 1990s
- This was made possible by helical CT and tech advancment
- We have come a long way since then.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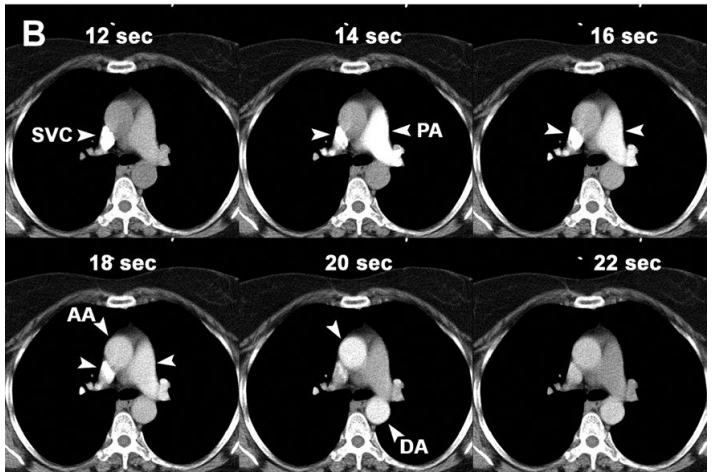
B
12 sec
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SVC
PA
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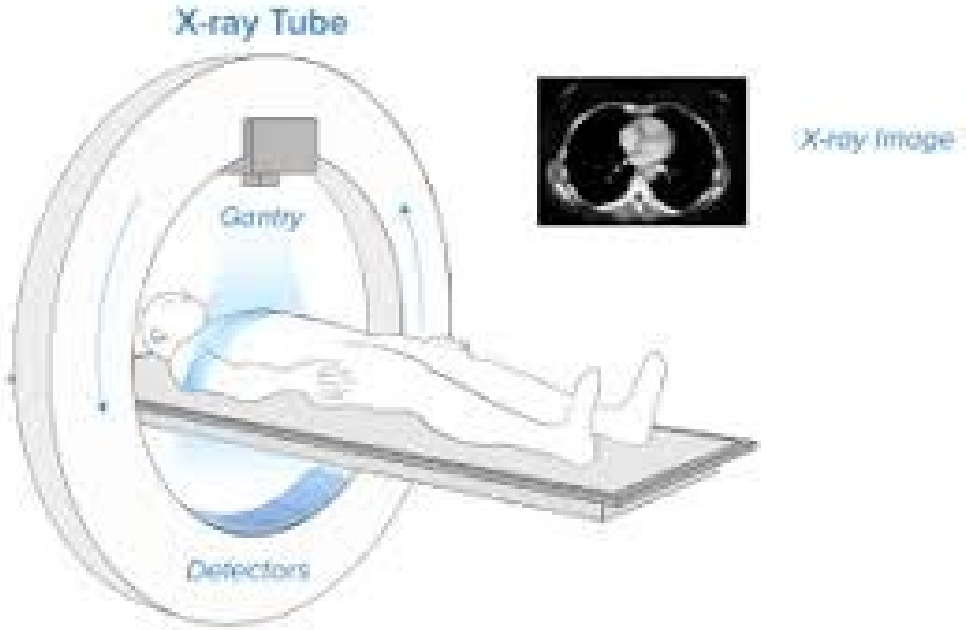
AA
DA


X-ray Tube
X-ray Image
Gantry
Detectors

LATE 2000S. THE EVIDENCE.

Diagnostic Performance of Coronary Angiography by 64-Row CT

Authors: Julie M. Miller, M.D., Carlos E. Rochitte, M.D., Marc Dewey, M.D., Armin Arbab-Zadeh, M.D., Hiroyuki Niinuma, M.D., Ph.D., Ilan Gottlieb, M.D., Narinder Paul, M.D., +8, and João A.C. Lima, M.D. Author Info & Affiliations

Published November 27, 2008 | N Engl J Med 2008;359:2324-2336 | DOI: 10.1056/NEJMoa0806576

Assessment by Coronary Computed Tomographic Angiography of Individuals Undergoing Invasive Coronary Angiography - ACCURACY

Nov 10, 2008

ELSEVIER

Journal of the American College of Cardiology

Volume 52, Issue 25, 16–23 December 2008, Pages 2135-2144

Clinical Research

Clinical Trial

Diagnostic Accuracy of 64-Slice Computed Tomography Coronary Angiography: A Prospective, Multicenter, Multivendor Study

Measure of Accuracy	Patient-Based Detection	
	Quantitative MDCTA (N=291)	Visual MDCTA (N=291)
AUC — median (95% CI)	0.93 (0.90–0.96)	0.93 (0.89–0.95)
Stenosis by CCA — no.	163	163
Stenosis by MDCTA — no.	152	146
False positive — no.	13	11
False negative — no.	24	28
Sensitivity — % (95% CI)	85 (79–90)	83 (76–88)
Specificity — % (95% CI)	90 (83–94)	91 (85–96)
Positive predictive value — % (95% CI)	91 (86–95)	92 (87–96)
Negative predictive value — % (95% CI)	83 (75–89)	81 (73–87)

For detection of stenoses greater than 50%, the sensitivity and specificity of 64-multidetector row CT were 95% and 83%, and for stenoses greater than 70%, sensitivity and specificity were 94% and 83%, respectively.

The positive and negative predictive values for detecting a 50% stenosis were 64% and 99%, and for detecting 70% stenoses they were 48% and 99%, respectively.

Table 5 Diagnostic Performance of 64-Slice CTCA for the Detection of ≥50% Stenosis on QCA in the Per-Vessel Analysis (95% CI)

	Prevalence of Disease, %	N	TP	TN	FP	FN	Sensitivity, %	Specificity, %	PPV, %	NPV, %
Vessel-based analysis	26	1,440	354	821	245	20	95 (92–97)	77 (74–80)	59 (55–63)	98 (96–99)
Right coronary artery	39	360	132	170	50	8	94 (90–98)	77 (71–82)	73 (66–79)	96 (92–98)
Left main coronary artery	2	360	5	338	16	1	83 (50–100)	95 (93–97)	24 (8–44)	100 (99–100)
Left anterior descending coronary artery	37	360	133	126	100	1	99 (97–100)	56 (49–63)	57 (51–63)	99 (97–100)
Circumflex coronary artery	26	360	84	187	79	10	89 (83–95)	70 (65–76)	52 (45–60)	95 (92–98)

Cardiac computed tomography guided treatment strategy in patients with recent acute-onset chest pain

Results from the randomised, controlled trial: CArdiac cT in the treatment of acute CHest pain (CATCH)

Coronary Computed Tomography Angiography Versus Radionuclide Myocardial Perfusion Imaging in Patients With Chest Pain Admitted to Telemetry: A Randomized Trial

Authors: Jeffrey M. Levsky, MD, PhD, Daniel M. Spevack, MD, MS, Mark I. Travin, MD, Mark A. Menegus, MD, Paul W. Huang, MD, Elana T. Clark, MD, Choo-won Kim, MD, Esther Hirschhorn, BS, Katherine D. Freeman, DrPH, Jonathan N. Tobin, PhD, and Linda B. Haramati, MD, MS | AUTHOR, ARTICLE, & DISCLOSURE INFORMATION

ELSEVIER

Journal of the American College of Cardiology

Volume 58, Issue 14, 27 September 2011, Pages 1414-1422

Clinical Research

Clinical Trial

The CT-STAT (Coronary Computed Tomographic Angiography for Systematic Triage of Acute Chest Pain Patients to Treatment) Trial

The NEW ENGLAND JOURNAL of MEDICINE

Outcomes of Anatomical versus Functional Testing for Coronary Artery Disease

Authors: 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., +13, for the PROMISE Investigators* Author Info & Affiliations

NAL ARTICLE

Calcium imaging and selective computed tomography angiography in comparison to functional testing for suspected coronary artery disease: the multicentre, randomized CRESCENT trial FREE

Marisa Lubbers ✉, Admir Dedic, Adriaan Coenen, Tjebbe Galema, Jurgen Akkerhuis, Tobias Bruning, Boudewijn Krenning, Paul Musters, Mohamed Ouhlous, Ahno Liem ...
Show more

European Heart Journal, Volume 37, Issue 15, 14 April 2016, Pages 1232–1243,

THE LANCET

CT coronary angiography in patients with suspected angina due to coronary heart disease (SCOT-HEART): an open-label, parallel-group, multicentre trial

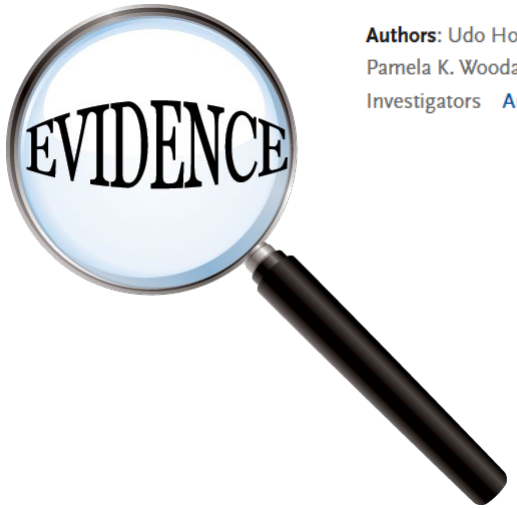
JACC JOURNALS

Selective Referral Using CCTA Versus Direct Referral for Individuals Referred to Invasive Coronary Angiography for Suspected CAD: A Randomized, Controlled, Open-Label Trial

The NEW ENGLAND JOURNAL of MEDICINE

Coronary CT Angiography versus Standard Evaluation in Acute Chest Pain

Authors: Udo Hoffmann, M.D., M.P.H., Quynh A. Truong, M.D., M.P.H., David A. Schoenfeld, Ph.D., Eric T. Chou, M.D., Pamela K. Woodard, M.D., John T. Nagurney, M.D., M.P.H., J. Hector Pope, M.D., +15, for the ROMICAT-II Investigators Author Info & Affiliations



The NEW ENGLAND JOURNAL of MEDICINE

Coronary CT Angiography and 5-Year Risk of Myocardial Infarction

Author: The SCOT-HEART Investigators* Author Info & Affiliations

CTA WORKS!!

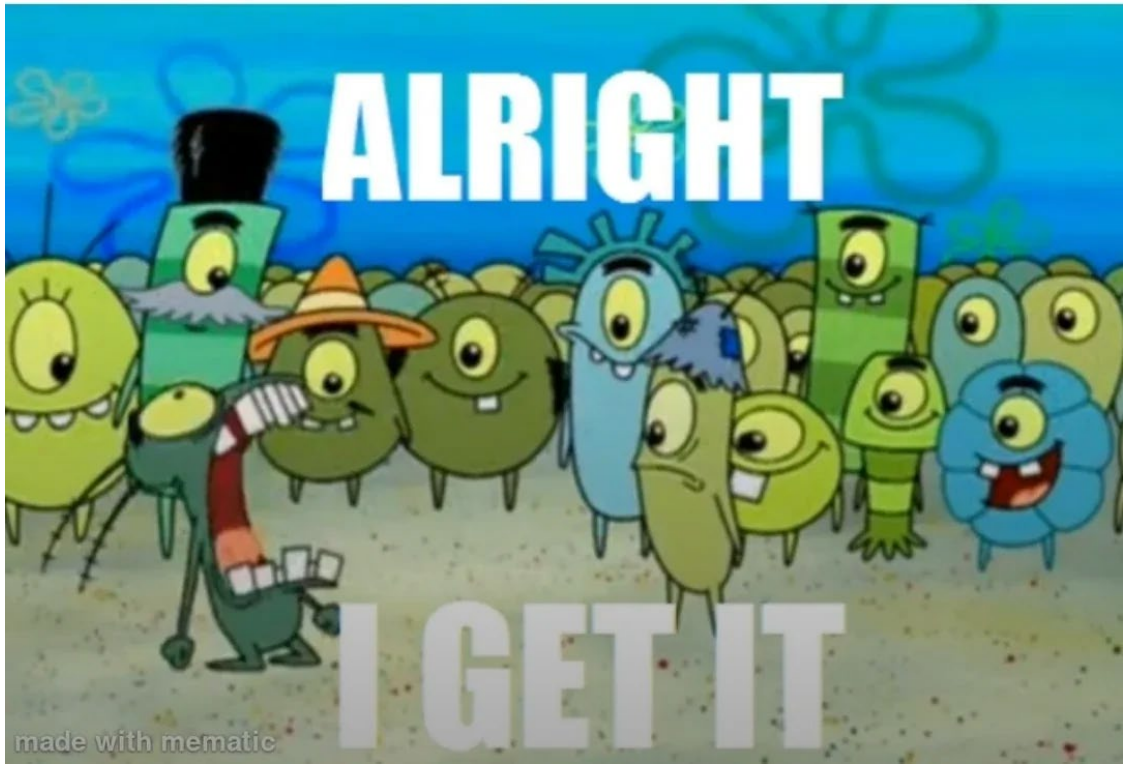
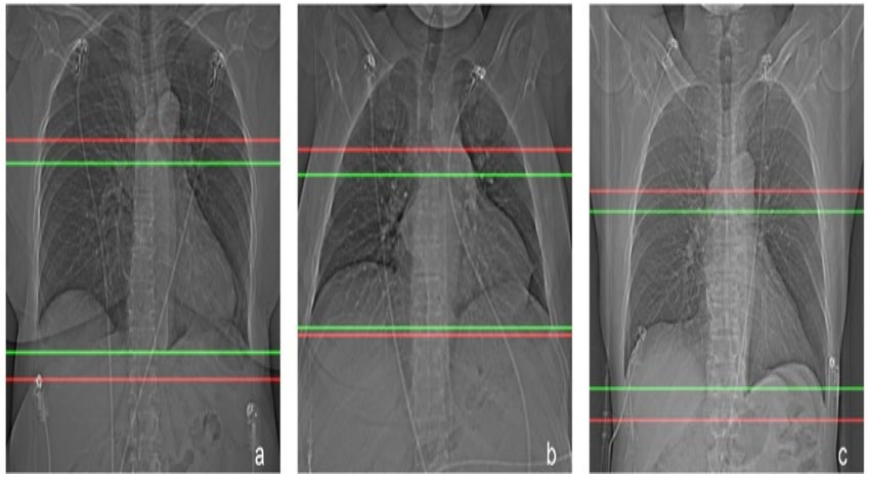
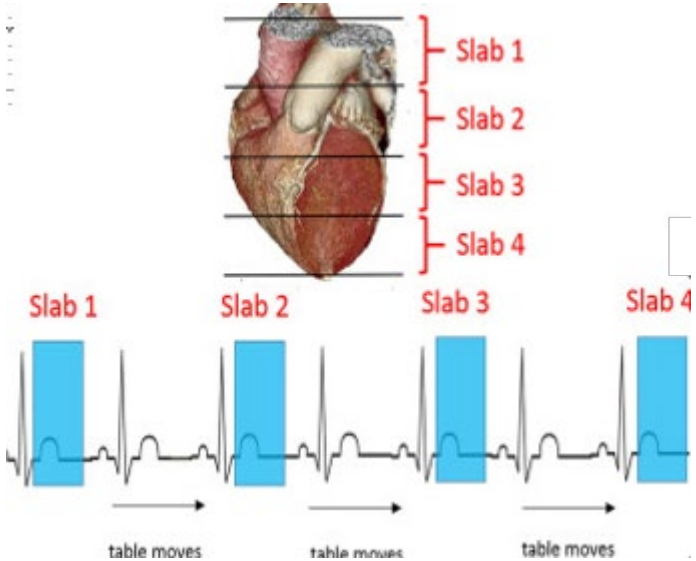


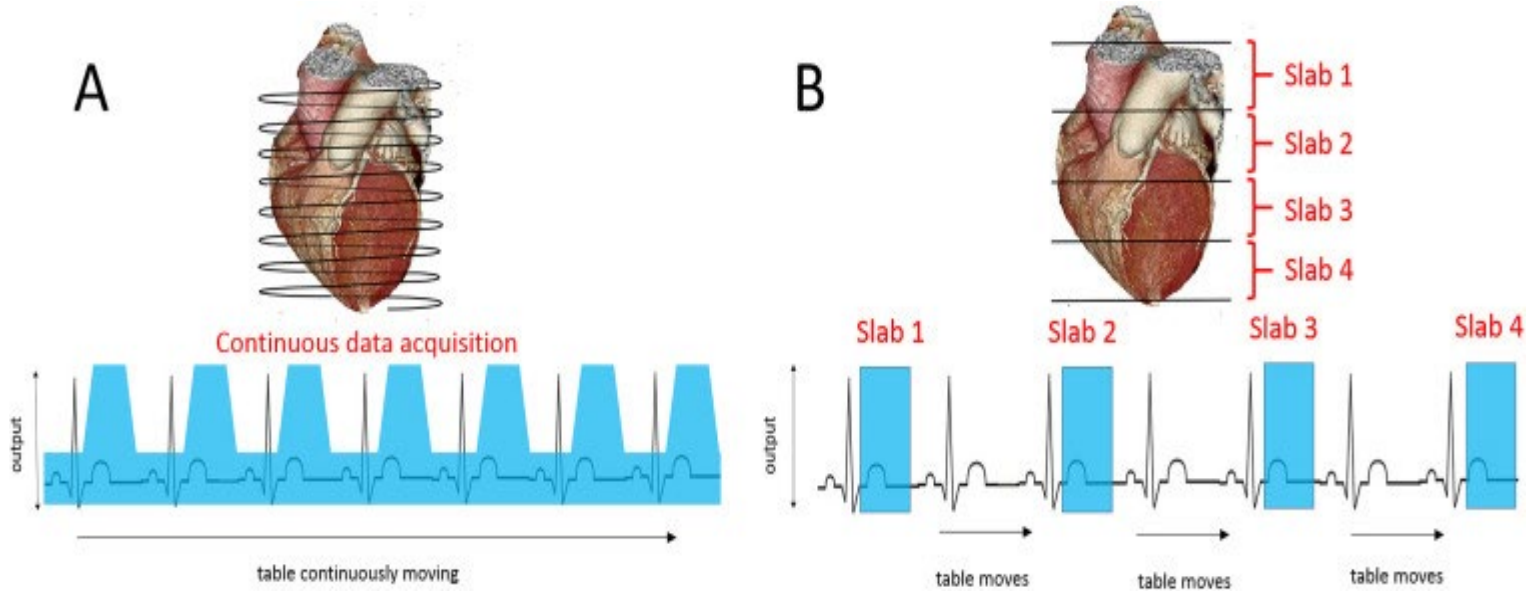
IMAGE ACQUISITION



- Scan range, carina to just below lower cardiac border. Can be extended.
- CAC. Noncontrast. Practice run!
- The faster the rotation, the better the temp resolution
- Axial mode, sequential mode, spiral



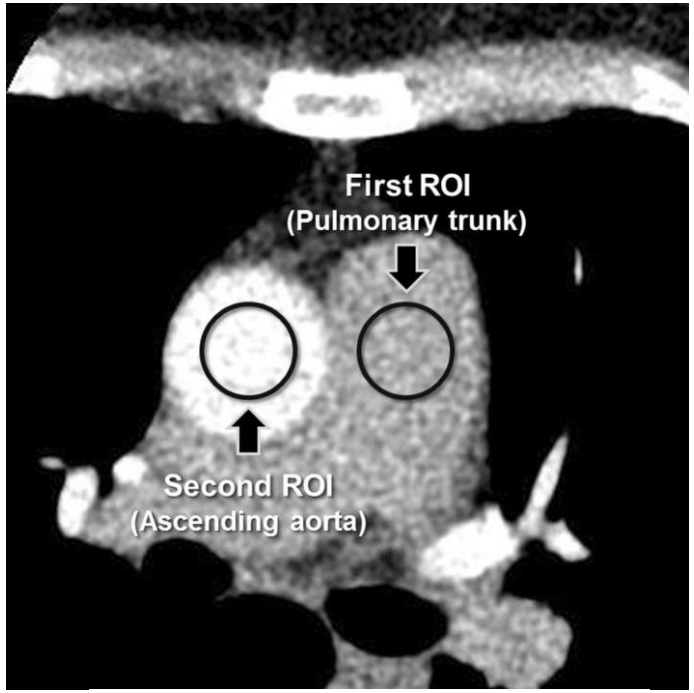
MODES OF ACQUITION

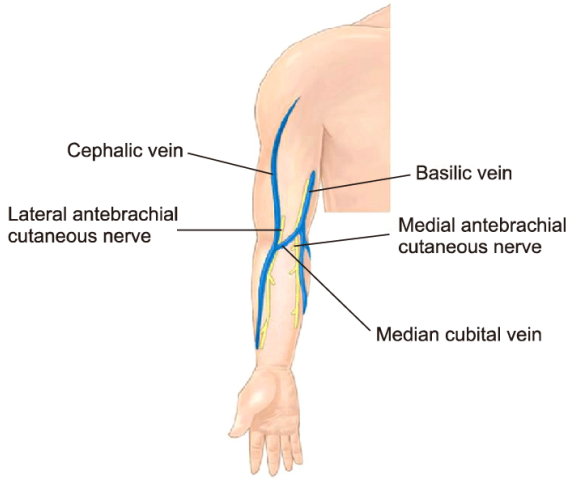


- Prospective gating (watch for motion and rhythm,)
- Retrospetcive (Watch for radiation. ECG tube modulation. Vent function)
- Prospective high pitch: least radiation < 2 msv

CONTRAST

- High iodine concentration is preferred
- A short 20-gauge IV catheter may be sufficient in normal or small patients, but an 18-gauge catheter is often necessary in adults.
- Injection rate between 4 and 7 cc/sec should be used
- The injection should last the duration of the scan
- Typical contrast volumes range from 50 to 120 cc.
- Test bolus vs bolus tracking (scan delay)





PATIENT PREP

- No food 3-4 hours prior. Not necessarily NPO after midgnight.
- Can drink clear liquids up to time of exam, but no caffeine for 12 hours (heart rate)
- Make sure the patient is hydrated!
- Review the patient's medications (metformin)
- Take all necessary medications, but avoid nephrotoxins (NSAIDS).
- IV access: 20 to 18 Gauge in the right AC or, less preferably, the left AC

MEDICATIONS

- Beta blockers are first line metoprolol or atenolol 1 hour prior
- 50-100 mg of metoprolol followed by IV boluses as necessary for heart rate less than 60.
- Ivabradine (only in sinus rhythm) 1-2 hours prior. Does not affect BP or contractility.
- Nitroglycerin (sublingual 400 mcg, 5 minutes prior)

THE PATIENT

- Images are obtained in inspiratory hold
- Arms ideally above head
- Training is encouraged
- Breast displacement
- Shielding

RADIATION

- ALARA
- Dependent on multiple factors: patient size, available machinery, heart rhythm, type of study……
- Now at the order of 1-10 msv. Can be from 5 to 30 mSv.
- For reference, sestamibi stress test is close to 10 mSv and diagnostic coronary angio is around 7-10 msv.
- Decreased by anatomy based or ecg gating (always on but higher during certain phases)
- Based on multiple sources, less than 100 msv above radiation appears safe.

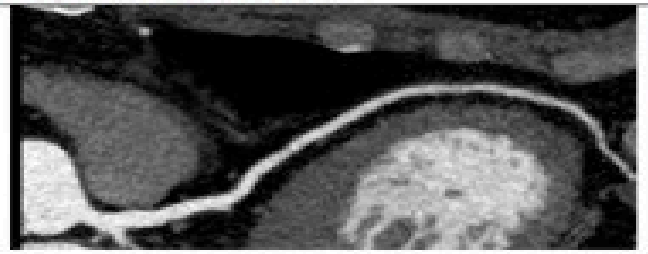
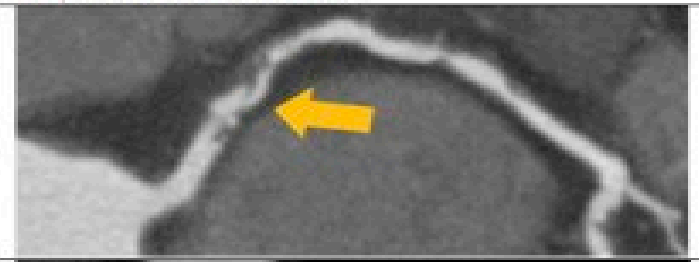
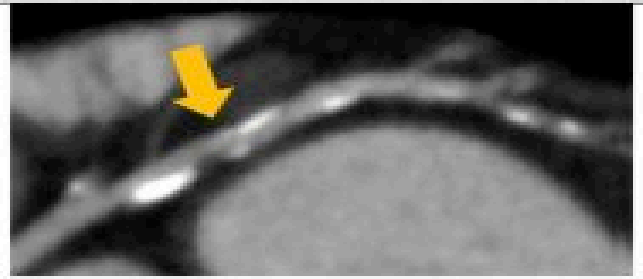
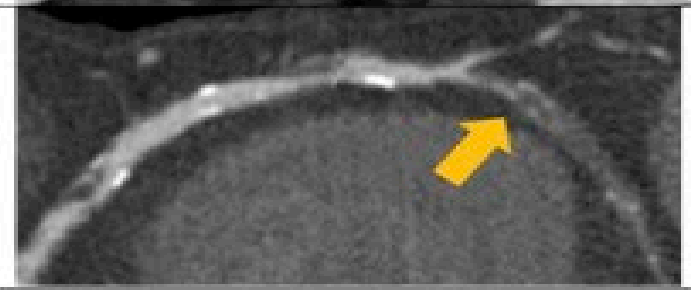
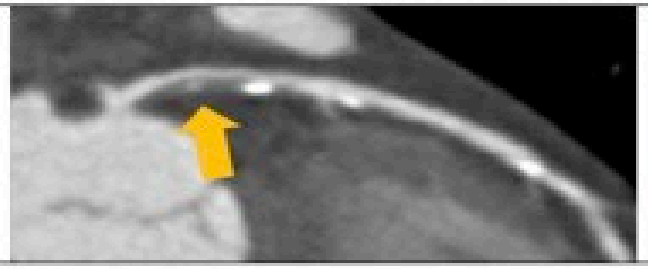
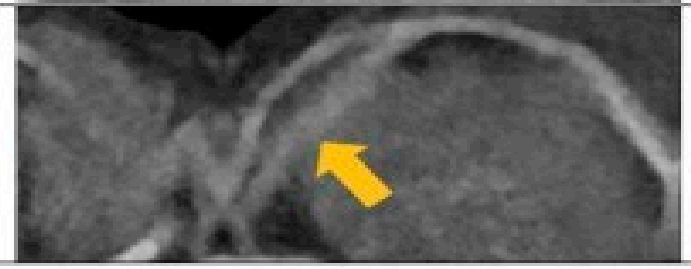
CONTRAINDICATIONS

- Severe and/or anaphylactic contrast reaction
- Inability to cooperate with scan acquisition and/or breath-hold instructions
- Pregnancy; clinical instability
- Renal impairment as defined by local protocols.

OTHER CONSIDERATIONS

- Elevated BMI
- Positioning
- Medication intolerance

REPORTING:

Category	Representative Case	Category	Representative Case
CAD-RADS 0 -no plaque or stenosis *		**CAD-RADS 4A** -max stenosis 70-99 % * (severe)	
CAD-RADS 1 -max stenosis 1-24% * (minimal) -includes plaque with positive remodeling and no stenosis		**CAD-RADS 4B** -left main stenosis >50% *or* -3-vessel obstructive (≥70%) disease *	
CAD-RADS 2 -max stenosis 25-49% * (mild)		**CAD-RADS 5** -100% stenosis (total occlusion)	
CAD-RADS 3 -max stenosis 50-69%** (moderate)		**CAD-RADS N** -non-diagnostic study (not all segments >1.5 mm diameter can be interpreted with confidence)	

CADRADS 2

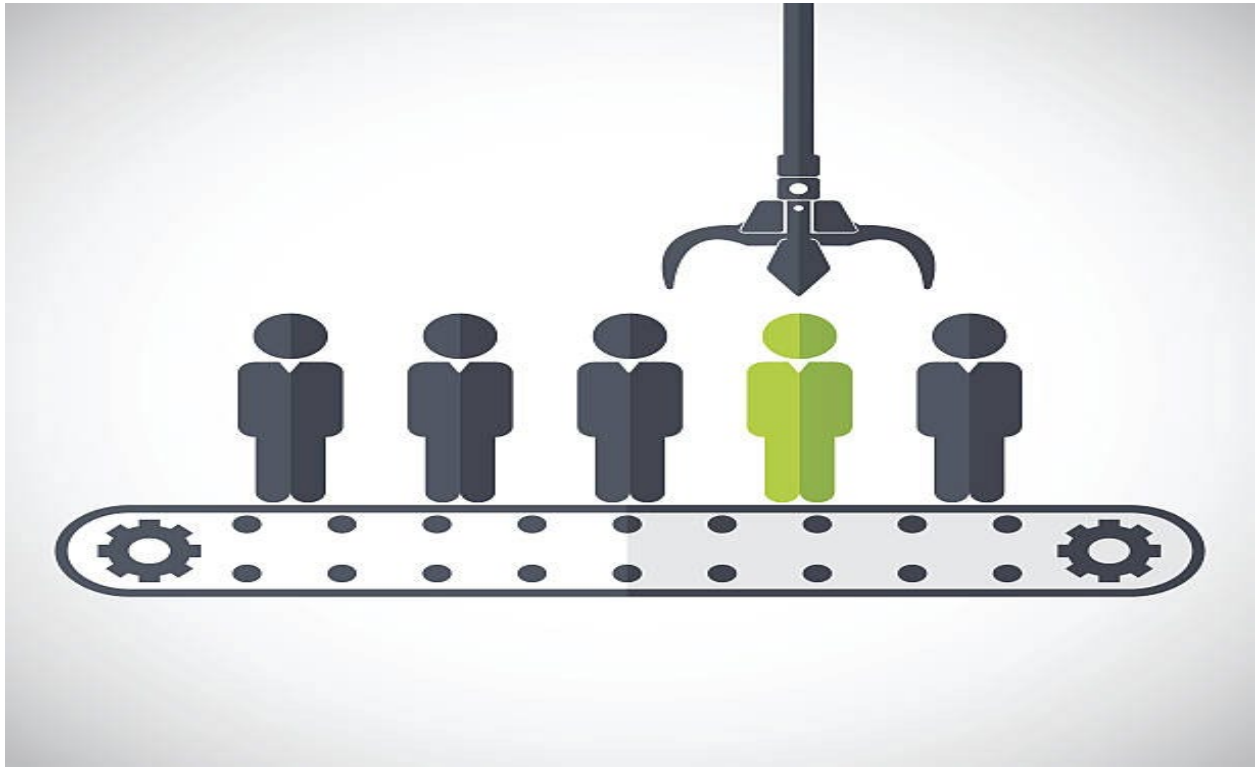
Table 1: Grading scale for stenosis severity, plaque burden and ischemia.

Degree of luminal diameter stenosis	Terminology
0%	No visible stenosis
1–24%	Minimal stenosis
25–49%	Mild stenosis
50–69%	Moderate stenosis
70–99%	Severe stenosis
100%	Occluded
Grading Scale for plaque burden: Terminology	Overall plaque burden
P1	Mild amount of plaque
P2	Moderate amount of plaque
P3	Severe amount of plaque
P4	Extensive amount of plaque
Grading scale for Ischemia detection: Terminology	Meaning
Modifier I	Indicates that CT Ischemia test was performed either with CT-FFR or myocardial CTP
I+	Indicates that CT-FFR or CTP demonstrates lesion-specific ischemia or reversible perfusion defect
I−	Indicates that CT-FFR or CTP is negative for lesion specific ischemia or reversible ischemia[a]
I ±	Indicates that CT-FFR or CTP is borderline

[a] Patients with prior myocardial infarction and fixed perfusion defects without evidence of myocardial ischemia by CTP would be classified as I−. The presence of myocardial infarction should be documented in the impression of the

Category	coronary stenosis	Interpretation	Investigation	Management considerations
CAD-RADS 0	0% (No plaque or stenosis)	Absence of CAD[a]	None	Reassurance. Consider non-atherosclerotic causes of symptoms
CAD-RADS 1	1–24% (Minimal stenosis or plaque with no stenosis[a]	Minimal non-obstructive CAD[b]	None	- Consider non-atherosclerotic causes of symptoms - P1: Consider risk factor modification and preventive pharmacotherapy - P2: Risk factor modification and preventive pharmacotherapy - P3 or P4: Aggressive risk factor modification and preventive pharmacotherapy
CAD-RADS 2	25–49% (Mild stenosis)	Mild non-obstructive CAD	None	- Consider non-atherosclerotic causes of symptoms - P1 or P2: Risk factor modification and preventive pharmacotherapy - P3 or P4: Aggressive risk factor modification and preventive pharmacotherapy
CAD-RADS 3	50–69% (Moderate stenosis)	Moderate stenosis	Consider functional assessment[c]	-P1, P2, P3 or P4: Aggressive risk factor modification and preventive pharmacotherapy - Other treatments (including anti-anginal therapy) should be considered per guideline directed care[d] - When modifier I+, consider ICA, especially if frequent symptoms persist after guideline-directed medical therapy
CAD-RADS 4	A - 70–99% stenosis or B - Left main ≥50% or 3-vessel obstructive (≥70%) disease	Severe stenosis	A: Consider ICA[e] or functional assessment B: ICA is recommended	-P1, P2, P3 or P4: Aggressive risk factor modification and preventive pharmacotherapy. - Other treatments (including anti-anginal therapy and options of revascularization) should be considered per guideline directed care[c]
CAD-RADS 5	100% (total occlusion)	Total coronary occlusion or sub-total occlusion	Consider ICA, functional and/or viability assessment	P1, P2, P3 or P4: Aggressive risk factor modification and preventive pharmacotherapy. - Other treatments (including anti-anginal therapy and options of revascularization) should be considered per guideline directed care[c]
CAD-RADS N	Non-diagnostic study	Obstructive CAD cannot be excluded	Additional/alternative evaluation may be needed	

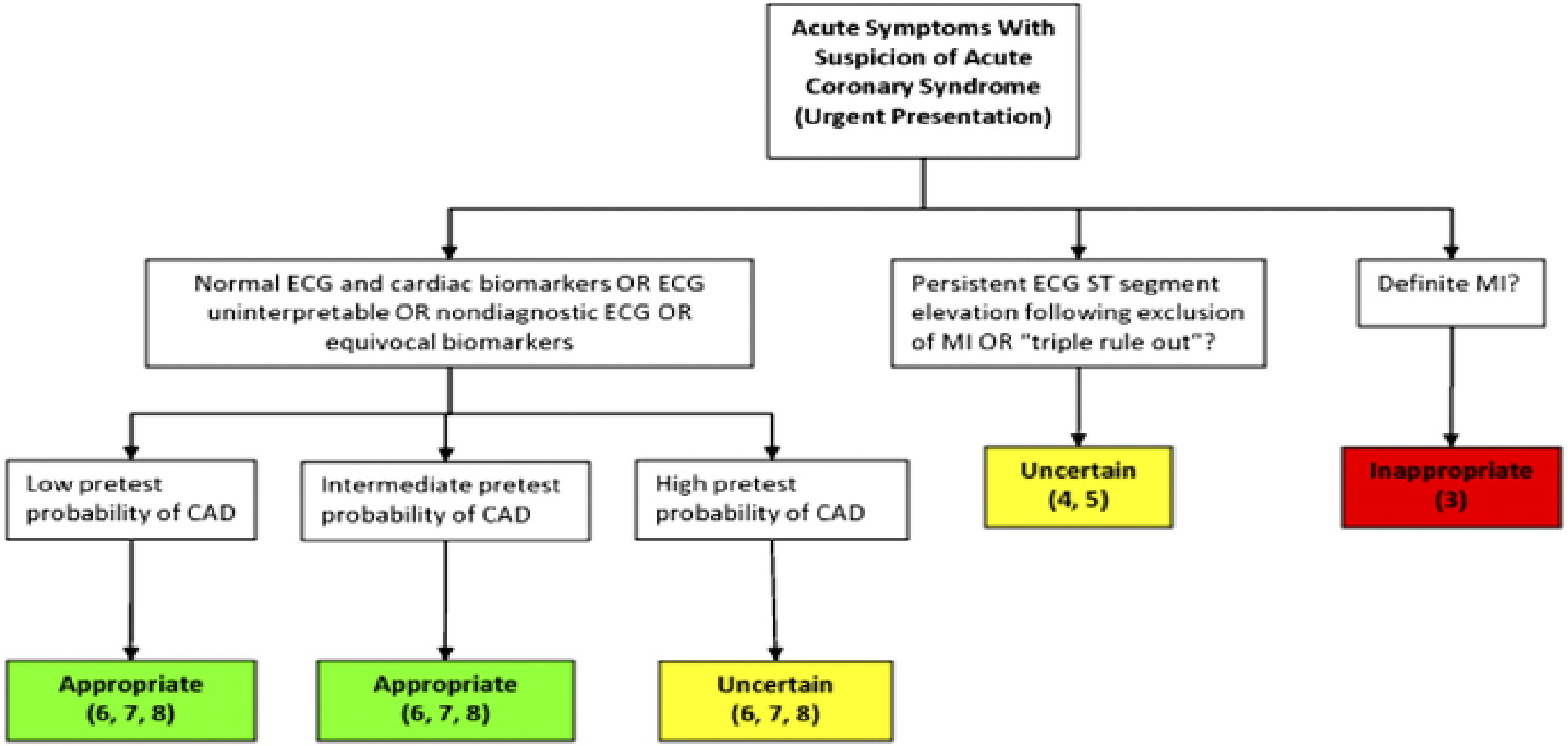
PATIENT SELECTION

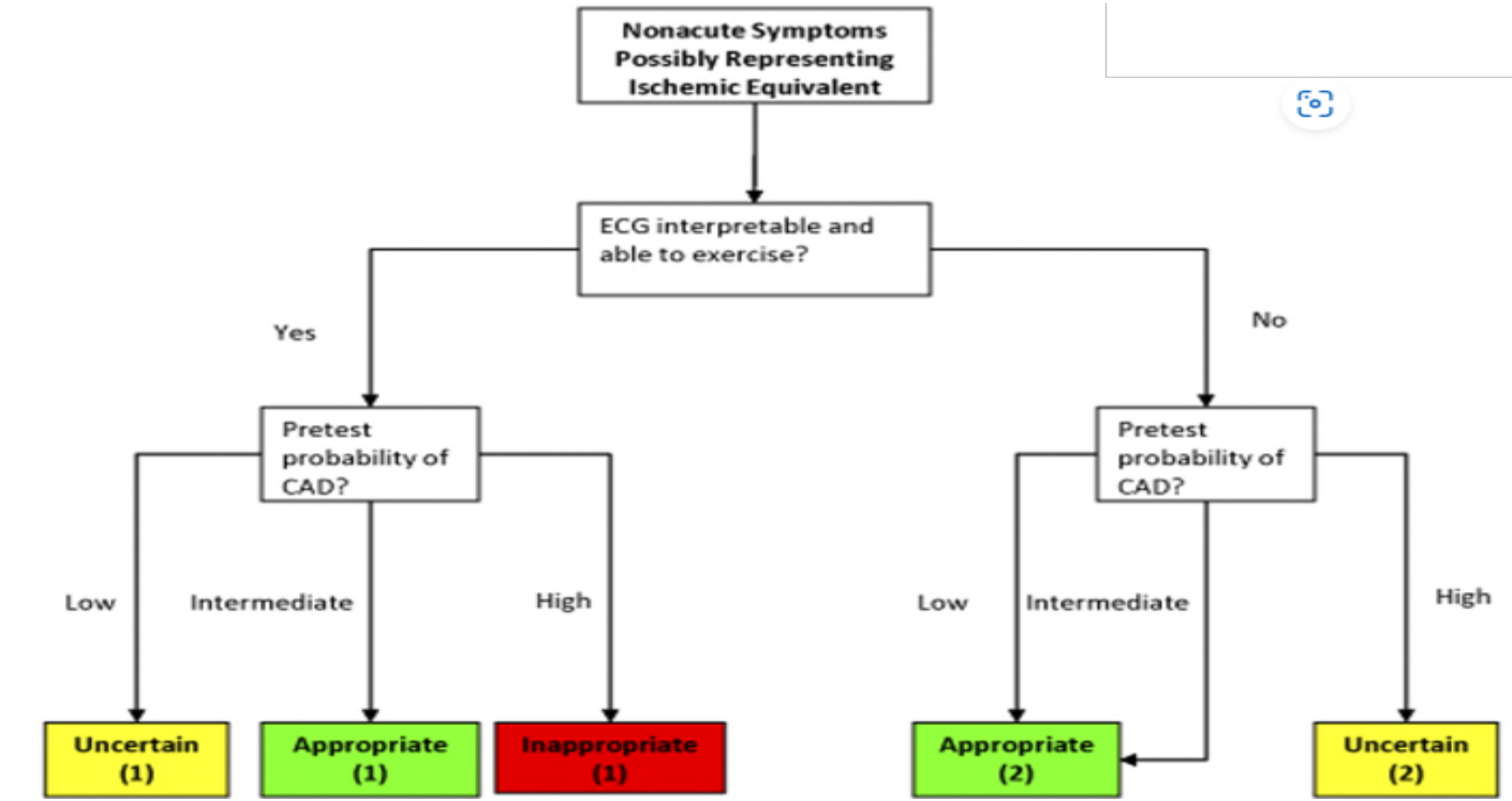


- How the guidelines evolved:

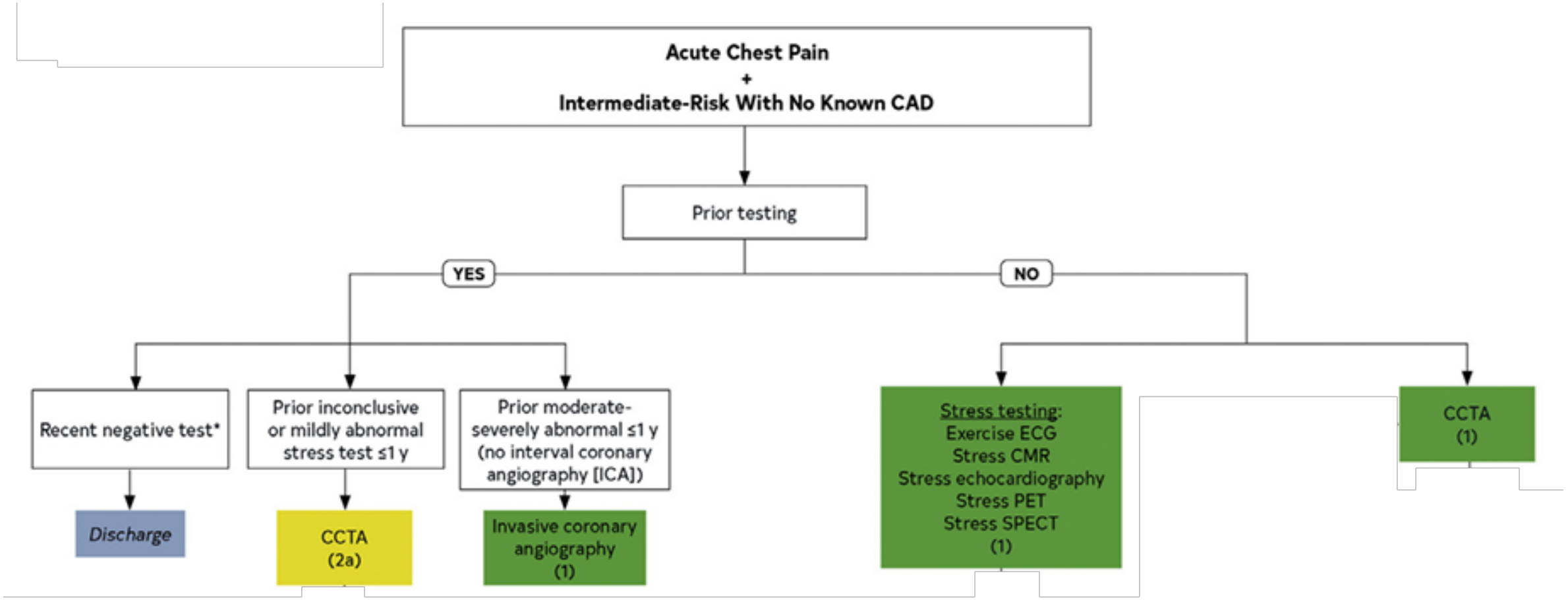
- 2012 SIHD: Class 2 b if unable to exercise and other stress testing is contraindicated
- 2021 Chest pain guidelines: Class 1 recommendations for acute stable pain

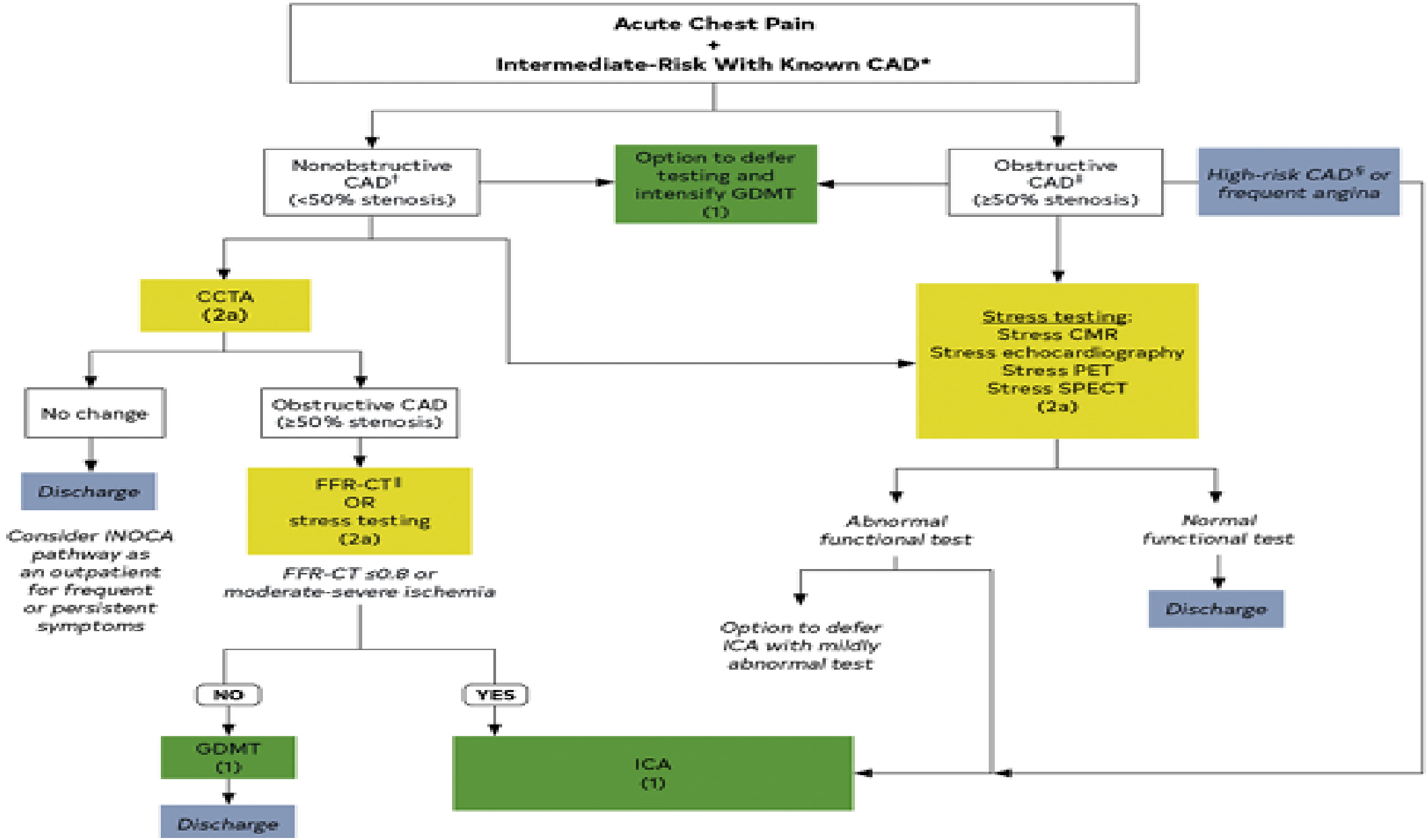
AUC, A 2010 DOCUMENT




Nonacute Symptoms Possibly Representing Ischemic Equivalent
ECG interpretable and able to exercise?
Yes
No
Pretest probability of CAD?
Pretest probability of CAD?
Low
Intermediate
High
Low
Intermediate
High
Uncertain (1)
Appropriate (1)
Inappropriate (1)
Appropriate (2)
Uncertain (2)

2021 CHEST PAIN GUIDELINES




Acute Chest Pain
+
Intermediate-Risk With Known CAD*
Nonobstructive CAD† (<50% stenosis)
Option to defer testing and intensify GDMT (1)
Obstructive CAD‡ (≥50% stenosis)
High-risk CAD§ or frequent angina
CCTA (2a)
Stress testing: Stress CMR Stress echocardiography Stress PET Stress SPECT (2a)
No change
Obstructive CAD (≥50% stenosis)
Discharge
Consider INOCA pathway as an outpatient for frequent or persistent symptoms
FFR-CT‖ OR stress testing (2a)
FFR-CT ≤0.8 or moderate-severe ischemia
Abnormal functional test
Normal functional test
Discharge
Option to defer ICA with mildly abnormal test
NO
YES
GDMT (1)
ICA (1)
Discharge

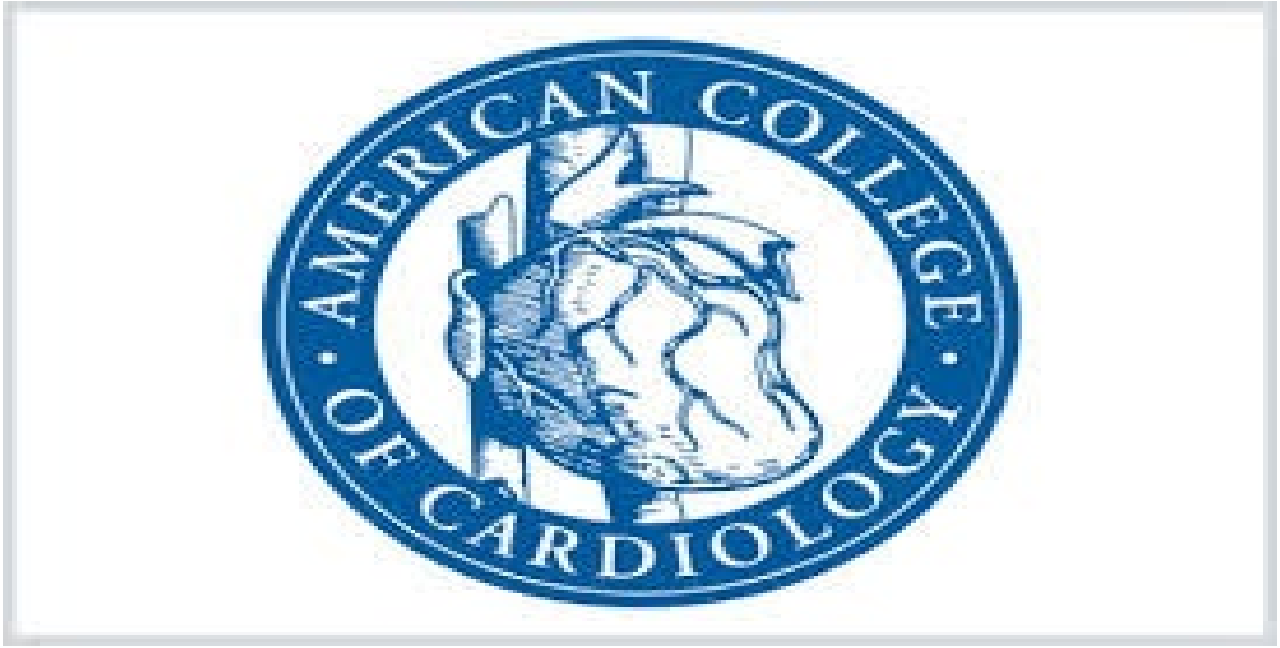
2021 CHEST PAIN GUIDELINES

1	A	1. For intermediate-risk patients with acute chest pain and no known CAD eligible for diagnostic testing after a negative or inconclusive evaluation for ACS, CCTA is useful for exclusion of atherosclerotic plaque and obstructive CAD (1-11).
2a	C-LD	3. For intermediate-risk patients with acute chest pain with evidence of previous mildly abnormal stress test results (≤1 year), CCTA is reasonable for diagnosing obstructive CAD
2a	B-NR	5. For intermediate-risk patients with acute chest pain and no known CAD, with a coronary artery stenosis of 40% to 90% in a proximal or middle coronary artery on CCTA, FFR-CT can be useful for the diagnosis of vessel-specific ischemia and to guide decision-making regarding the use of coronary revascularization (37-43).
2a	C-EO	6. For intermediate-risk patients with acute chest pain and no known CAD, as well as an inconclusive prior stress test, CCTA can be useful for excluding the presence of atherosclerotic plaque and obstructive CAD.
2a	C-EO	7. For intermediate-risk patients with acute chest pain and no known CAD, with an inconclusive CCTA, stress imaging (with echocardiography, PET/SPECT MPI, or CMR) can be useful for the diagnosis of myocardial ischemia.
1	A	1. For intermediate-high risk patients with stable chest pain and no known CAD, CCTA is effective for diagnosis of CAD, for risk stratification, and for guiding treatment decisions (1-12).

2a B-NR	3. For intermediate-risk patients with acute chest pain and known nonobstructive CAD, CCTA can be useful to determine progression of atherosclerotic plaque and obstructive CAD
2a B-NR	4. For intermediate-risk patients with acute chest pain and coronary artery stenosis of 40% to 90% in a proximal or middle segment on CCTA, FFR-CT is reasonable for diagnosis of vessel-specific ischemia and to guide decision-making regarding the use of coronary revascularization

2a B-NR	4. For patients who have stable chest pain with previous coronary revascularization, CCTA is reasonable to evaluate bypass graft or stent patency (for stents ≥3 mm) (9-13).

CCTA IN THE ACC GUIDELINES



2024 PREOPERATIVE CV EVALUATION GUIDELINES

COR	LOE	RECOMMENDATIONS
2b	B-NR	1. For patients undergoing elevated-risk surgery with poor* or unknown functional capacity, and elevated risk for perioperative cardiovascular events based on a validated risk tool, coronary computed tomography angiography (CCTA) for the detection of high-risk coronary anatomy† may be considered.[1-4]
3: No benefit	B-NR	2. In patients who are at low risk for perioperative cardiovascular events, have adequate* functional capacity with stable symptoms, or who are undergoing low-risk procedures, routine CCTA before NCS is not recommended due to lack of benefit.[1,5]

2024 HOCM GUIDELINES

COR	LOE	RECOMMENDATIONS
1	B-NR	1. For patients with symptomatic HCM for whom there is uncertainty regarding the presence or severity of LVOTO on noninvasive imaging studies, invasive hemodynamic assessment with cardiac catheterization is recommended.[1-4]
1	B-NR	2. In patients with HCM who have symptoms or evidence of myocardial ischemia, coronary angiography (CT or invasive) is recommended.[5]
1	B-NR	3. In patients with HCM who are at risk of coronary atherosclerosis, coronary angiography (CT or invasive) is recommended before surgical myectomy.[6]

COR	LOE	RECOMMENDATION
2b	C-LD	1. In adult patients with suspected HCM, cardiac CT may be considered for diagnosis if the echocardiogram is not diagnostic and CMR imaging is unavailable.[1-3]

2. Chest discomfort is a common symptom in patients with HCM. For those patients with atherosclerotic coronary risk factors or in whom chest pain does not respond to medical therapy, the possibility of epicardial coronary artery disease (CAD) needs to be considered. Epicardial CAD may also be suspected based on noninvasive testing, although high false-positive and false-negative rates are associated with nuclear and echocardiographic stress testing. Coronary angiography is useful in patients with HCM when findings of CAD could aid in patient management.[6]

2023 CHRONIC CORONARY ARTERY DISEASE GUIDELINES

CCTA is accurate for the assessment of native vessel CAD and bypass graft patency with high accuracy (~96%) and concordance (82% to >93%) to ICA.

3: No benefit	B-R

2. In patients with CCD without a change in clinical or functional status on optimized GDMT, routine periodic testing with coronary CTA or stress testing with or without imaging is not recommended to guide therapeutic decision-making.[8-10]

2a	B-NR

6. In patients with CCD and a change in symptoms or functional capacity that persists despite GDMT, and who have had previous coronary revascularization, coronary CT angiography (CCTA) is reasonable to evaluate bypass graft or stent patency (for stents ≥3 mm).*[33-37]

2022 CHF GUIDELINES

Electrocardiographic-gated cardiac CT can also accurately assess ventricular size, EF, and wall motion abnormalities, but it is accompanied with ionizing radiation

2022 AORTIC DISEASE GUIDELINES

1	C-LD

4. In patients with a BAV and a dilated aortic root or ascending aorta, screening of all first-degree relatives by TTE is recommended to evaluate for the presence of a BAV, dilation of the aortic root and ascending aorta, or both; if the diameter and morphology of the aortic root, ascending aorta, or both cannot be assessed accurately or completely by TTE, a cardiac-gated CT or MRI of the thoracic aorta is indicated.[7]

2020 VALVULAR HEART DISEASE GUIDELINES

1	C-LD	3. In patients with a prosthetic valve replacement or prior valve repair and clinical symptoms or signs that suggest prosthetic valve dysfunction, additional imaging with TEE, gated cardiac CT, or fluoroscopy is recommended, even if TTE does not show valve dysfunction.
1	C-LD	2. In patients with BAV, CMR angiography or CT angiography is indicated when morphology of the aortic sinuses, sinotubular junction, or ascending aorta cannot be assessed accurately or fully by echocardiography. (4,5)
2a	B-NR	5. In patients with suspected low-flow, low-gradient severe AS with normal or reduced LVEF (Stages D2 and D3), measurement of aortic valve calcium score by CT imaging is reasonable to further define severity (14–18).
1	B-NR	1. In patients with suspected mechanical prosthetic valve thrombosis, urgent evaluation with TTE, TEE, fluoroscopy, and/or multidetector CT imaging is indicated to assess valve function, leaflet motion, and the presence and extent of thrombus (1–7).
1	C-EO	1. In patients undergoing TAVI, 1) contrast-enhanced coronary CT angiography (in patients with a low pretest probability for CAD) or 2) an invasive coronary angiogram is recommended to assess coronary anatomy and guide revascularization.

2018 BLOOD CHOLESTEROL GUIDELINES

IIa B-NR	6. In intermediate-risk or selected borderline-risk adults, if the decision about statin use remains uncertain, it is reasonable to use a CAC score in the decision to withhold, postpone or initiate statin therapy
IIa B-NR	7. In intermediate-risk adults or selected borderline-risk adults in whom a CAC score is measured for the purpose of making a treatment decision, AND ■ If the coronary calcium score is zero, it is reasonable to withhold statin therapy and reassess in 5 to 10 years, as long as higher risk conditions are absent (diabetes mellitus, family history of premature CHD, cigarette smoking); ■ If CAC score is 1 to 99, it is reasonable to initiate statin therapy for patients ≥55 years of age; ■ If CAC score is 100 or higher or in the 75th percentile or higher, it is reasonable to initiate statin therapy
IIb B-R	3. In adults 76 to 80 years of age with an LDL-C level of 70 to 189 mg/dL (1.7 to 4.8 mmol/L), it may be reasonable to measure CAC to reclassify those with a CAC score of zero to avoid statin therapy

2018 ADULTS WITH CONGENITAL HEART DISEASE GUIDELINES

I	B-NR	1. CMR or CTA is recommended for evaluation of partial anomalous pulmonary venous connection (S4.1.2-1-S4.1.2-4).
IIa	B-NR	3. It is reasonable to perform anatomic evaluation of coronary artery patency (catheter angiography, or CT or MR angiography) in asymptomatic adults with d-TGA with arterial switch
IIa	B-NR	2. In patients with a low or intermediate pretest probability of coronary artery disease (CAD), use of CT coronary angiography is reasonable to exclude significant obstructive CAD when cardiac catheterization has significant risk or because of patient preference (S3.4.6-5-S3.4.6-9).
I	C-LD	1. Aortic imaging using TTE, TEE, CMR, or CTA is recommended in adults with Williams syndrome or patients suspected of having supravalvular aortic stenosis (S4.2.5-1).
I	C-LD	2. Coronary imaging is recommended in patients with Williams syndrome and supravalvular aortic stenosis presenting with symptoms of coronary ischemia (S4.2.5-2-S4.2.5-4).

2014 NSTEMI GUIDELINES

CLASS IIa

3. In patients with possible ACS and a normal ECG, normal cardiac troponins, and no history of CAD, it is reasonable to initially perform (without serial ECGs and troponins) coronary CT angiography to assess coronary artery anatomy