Cardiac Computed Tomography: Pearls and Perils

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Objectives

- Recognize high risk plaque features on cardiac computed tomography
- Evaluate the 2021 Chest Pain Guidelines
- Learn to interpret cardiac computed tomography reports

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Pearl #1

- **Plaque Characterization can predict vulnerable plaques**

- Defined as:
  - Low attenuation plaque = Hounsfield Units < 30
  - Spotty Calcification
  - Napkin ring sign
  - Positive remodeling

- Features directly correlate with thin-cap fibroatheroma seen on intravascular ultrasound, and confers to a heightened risk of acute coronary syndrome.

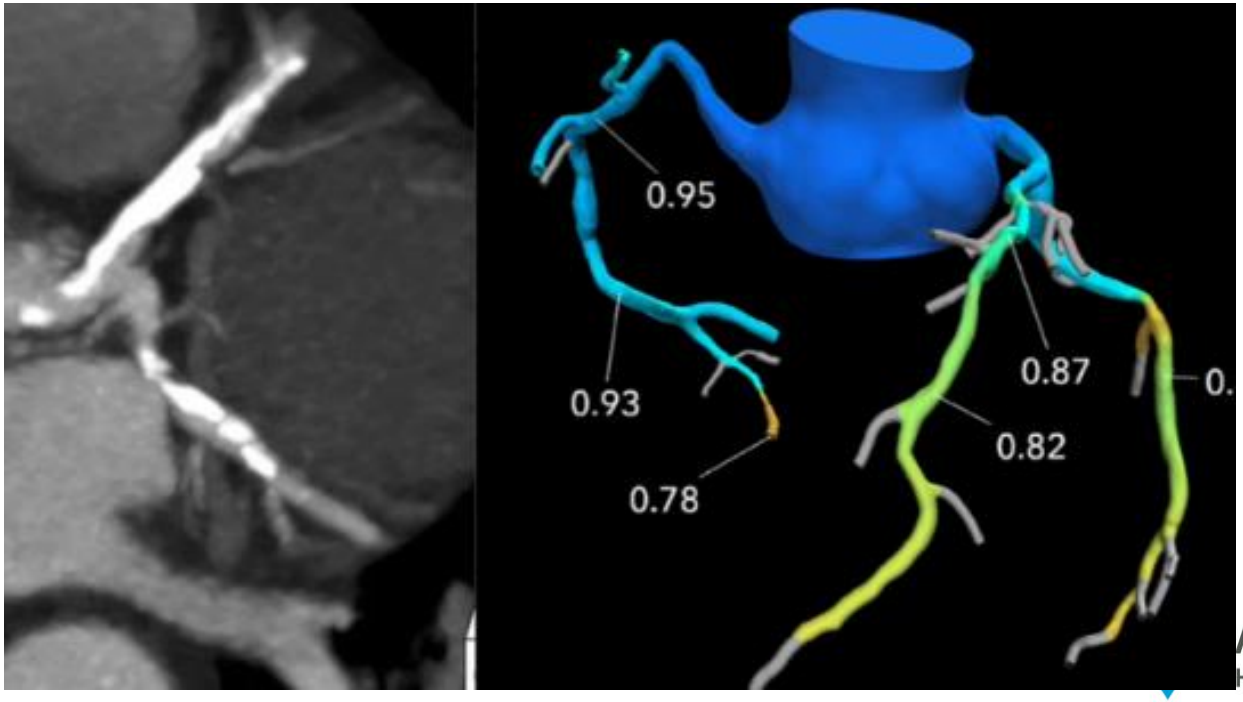
Pearl #1

- In 2015, Motoyoma reviewed 3158 patients for high-risk plaque features
    - Of these patients, the event rate was 16% over a period of 4 years
    - Statin rate after initial CCTA was 40%
- Comparatively, in a separate study of 630 patients, it was shown that vulnerable plaque caused acute coronary syndrome in 3.5% of instances over a median follow-up period of 9.2 years compared with 0.6% of other plaques
    - Statin rate of ~ 80%

Pearl #2

- **FFRct is a maturing modality, giving insight into the hemodynamic significance of coronary plaque**

- This metric involves an integration of computational fluid dynamics, in addition to the anatomical data from coronary CTA, to allow the calculation of a 3-dimensional pressure map



Pearl #2

- **FFRct is a maturing modality, giving insight into the hemodynamic significance of coronary plaque**

- PACIFIC sub-study which showed FFRct to be the most accurate modality for the discrimination of lesion specific ischemia, with significant improvement in accuracy compared to CTA, SPECT and PET alone.

- The area under curve for identification of ischemia-causing lesions was 0.94 for FFRct
  - In comparison with coronary CTA (0.83, $p < 0.01$)
  - SPECT 0.70, $p < 0.01$
  - PET (0.87, $p < 0.01$)

Pearl #2

- **FFRct is a maturing modality, giving insight into the hemodynamic significance of coronary plaque**

- Most recently, the ADVANCE FFRCT Registry demonstrated favorable prognosis in patients with a negative FFRct, with lower rates of CV death or MI and less revascularization.

- At 1 year follow up, the rates of adverse events including CV death or MI, was higher in patients with FFR CT ≤ 0.80 compared with those who had an FFR CT > 0.80 (25 [0.80%] vs. 3 [0.20%]; RR: 4.22; p = 0.01)

- In addition, 92.9% of individuals in which medical therapy was recommended remained free from revascularization or major adverse cardiac events at 1 year.

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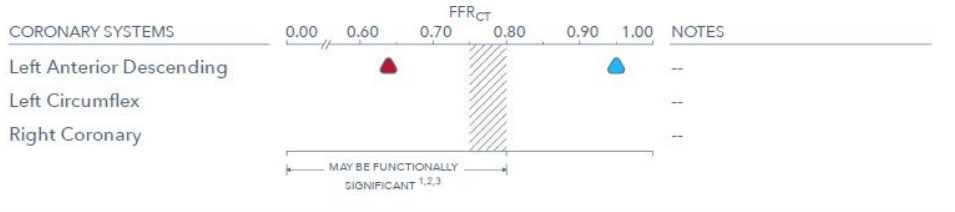
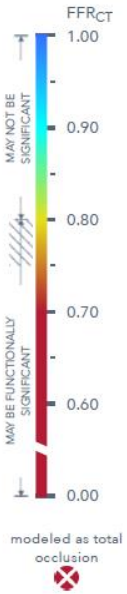
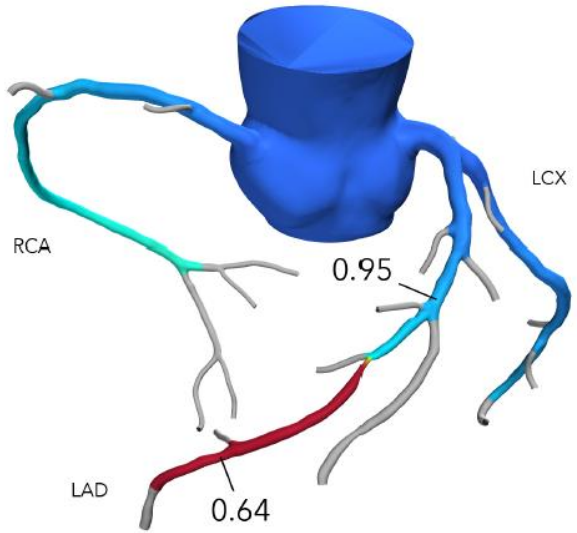
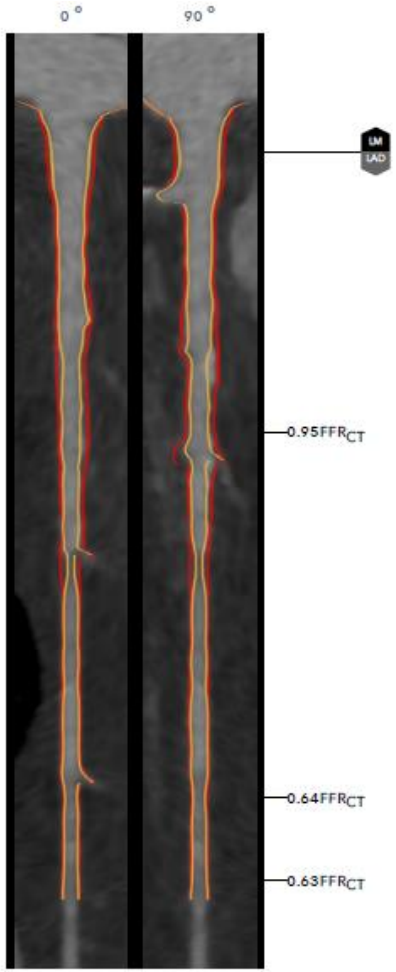
Pearl #2

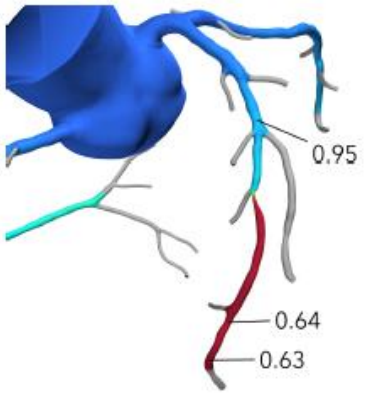
- **FFRct is a maturing modality, giving insight into the hemodynamic significance of coronary plaque**











Pearl #3

- **Cardiac CTA is an excellent modality coronary artery bypass graft evaluation, but has limitations in evaluation of coronary stents.**
- The 2010 multi-societal Appropriate Use Criteria (AUC) defined coronary CTA as "Appropriate" for the evaluation of coronary artery bypass graft (CABG) patency in patients with ischemic symptoms
- Barbero et al (2016) performed meta analysis of > 2000 patients
  - Sensitivity for the presence of any CABG stenosis >50% was 0.98 (95% CI, 0.97–0.99)
  - Specificity for the presence of CABG stenosis > 50% was 0.98 (95% CI, 0.96–0.98)
- Importantly, the accuracy was consistent regardless of graft conduit type (arterial or venous).

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Pearl #3

- **Cardiac CTA is an excellent modality for coronary artery bypass graft evaluation, but has limitations in evaluation of coronary stents.**

- PCI with intracoronary stent implantation is the most commonly performed technique for coronary revascularization worldwide and post PCI symptoms are frequently encountered.

- Factors known to negatively impact the accuracy of coronary CTA in patients with stents include:
  - Motion and beam hardening artifacts
  - Volume averaging related to stent struts and superimposed calcified plaque that limit lumen visualization in stented segments
  - Frequent presence of extensive, calcified, coronary atherosclerosis of non-stented segments.

Pearl #3

- **Cardiac CTA is an excellent modality for coronary artery bypass graft evaluation, but has limitations in evaluation of coronary stents.**

- Prior studies have suggested that up to 11% of stents may be deemed non-evaluable. FFRct is not validated for stented vessels, however is available on non-stented vessels.

- Recent updated meta-analysis assessed per-stent accuracy of ≥64 slice coronary CTA for the detection of in-stent restenosis ≥50% on ICA, across 35 studies involving 2656 patients (4131 stents).
  - The study demonstrated a per-stent sensitivity, specificity of 0.90 (95% CI, 0.85–0.94), 0.94 (95% CI, 0.91–0.96), suggesting that coronary CTA is accurate for assessing most stents.

- The authors demonstrated that overall accuracy was significantly reduced by stent strut thickness ≥100 μm, stent diameter <3.0 mm, scans performed at heart rates ≥65 bpm and bifurcation stents.

Pearl #4

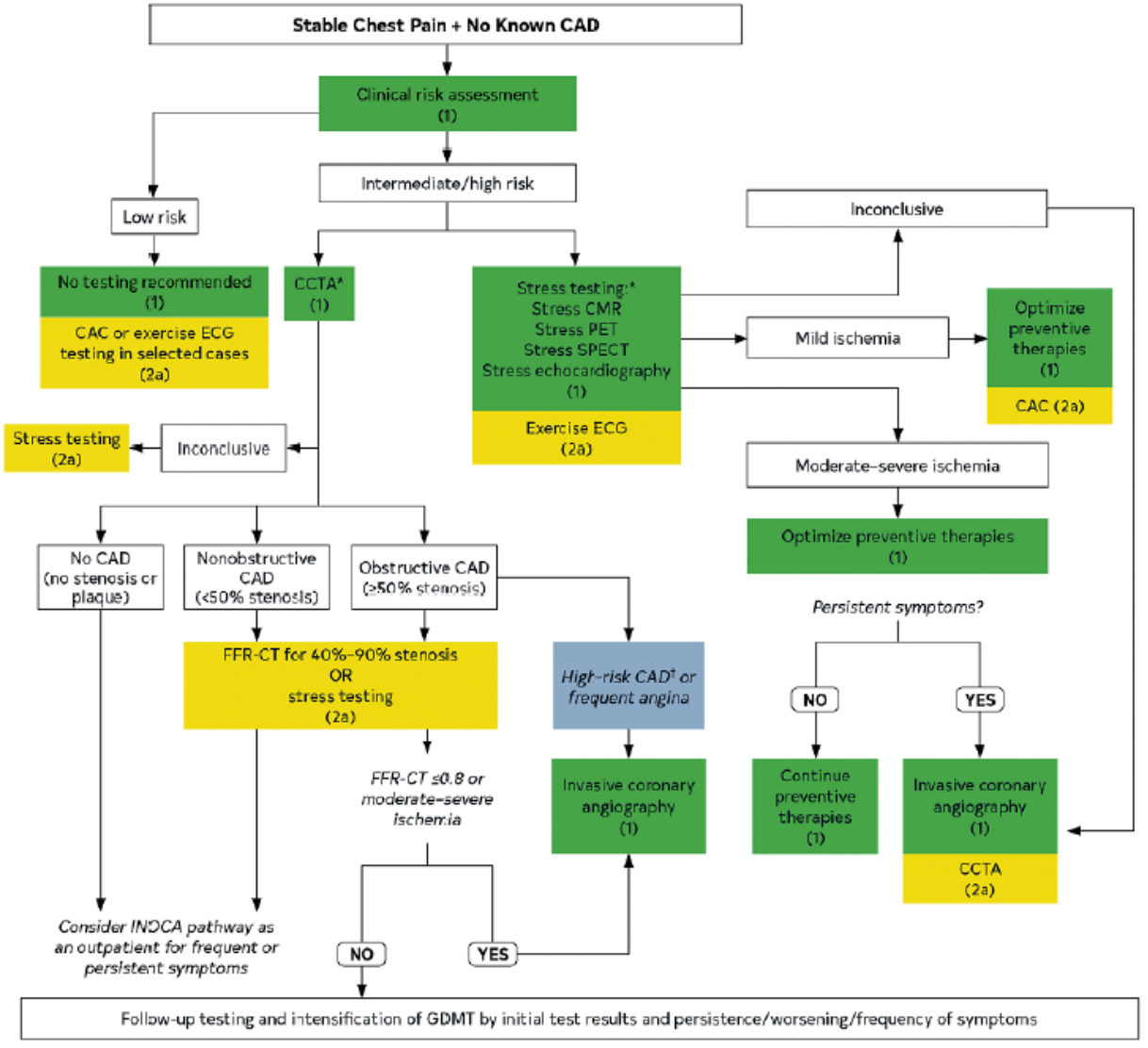
- **2021 Chest Pain Guidelines – Coronary CTA Class I Indication**

- The PROMISE trial, a comparative effectiveness trial of CCTA vs functional testing enrolled 10,003 patients with stable chest pain, and demonstrated non-inferiority of CCTA over functional testing, after a follow-up of 25 months.

- Although no differences were found between testing strategies regarding the primary outcome, the rate of MI and death at 12 months was significantly lower in patients who underwent CCTA (HR 0.66, $p = 0.049$).

Pearl #4

- **2021 Chest Pain Guidelines – Coronary CTA Class I Indication**



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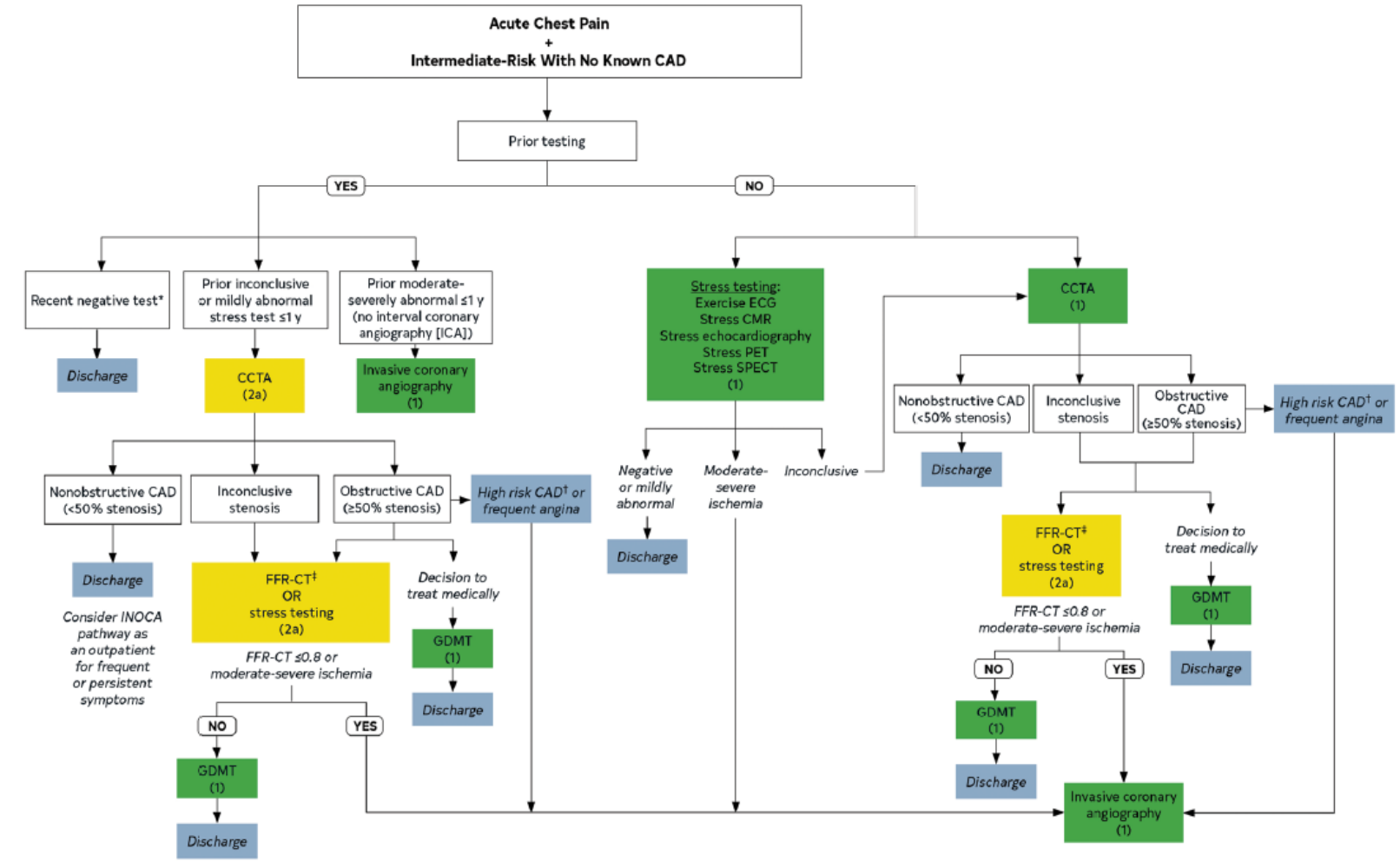

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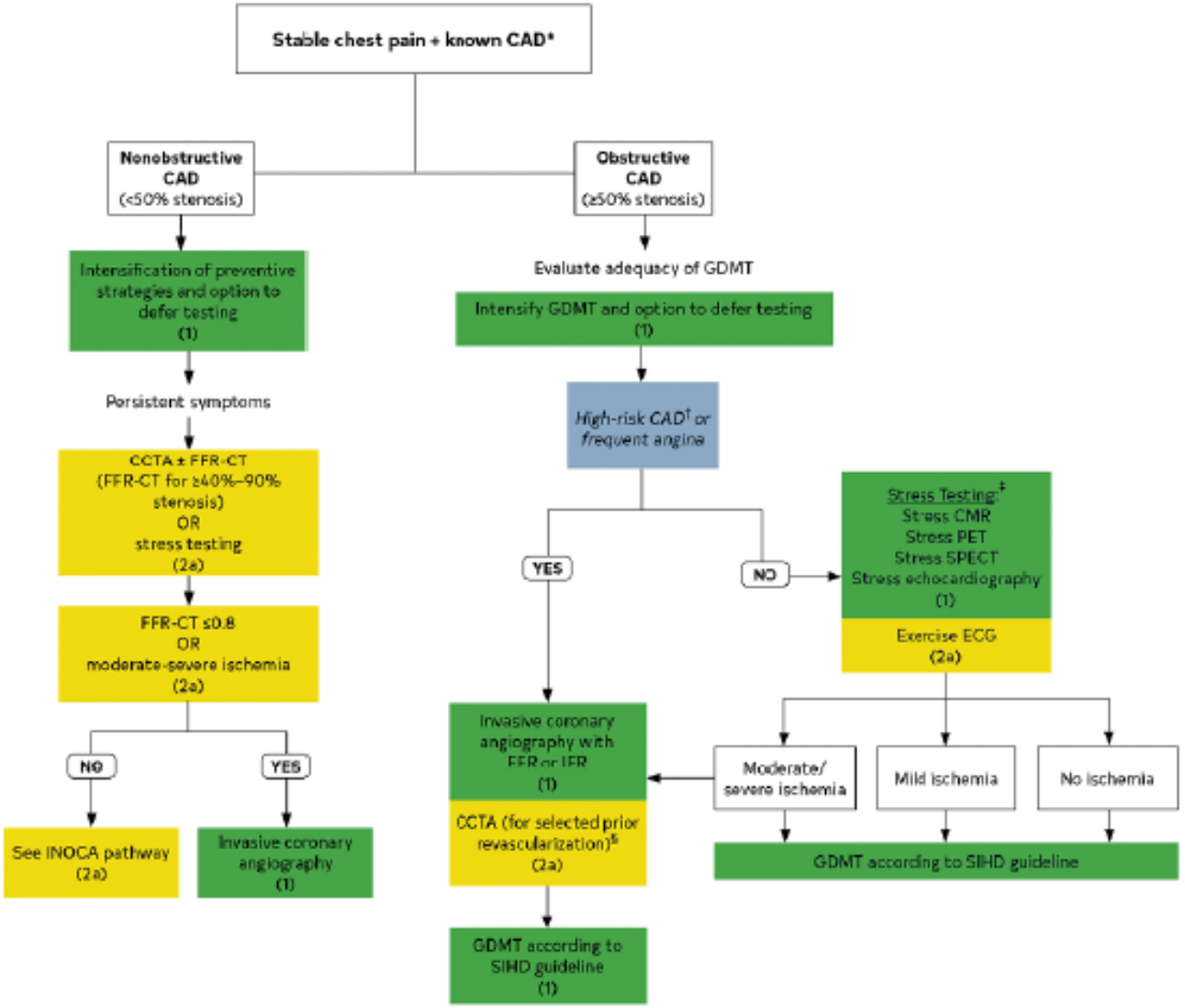

Pearl #5

- **Interpretation of Coronary CTA Reports**

Table 4 – Components of comprehensive-gated contrast-enhanced cardiac CT reporting.

Section	Specific component(s)	Necessity
Clinical data		
General	Indication or reason for test, procedure date	Required
Demographics	Name, date of birth, sex, referring clinician	Required
	Height, weight, BMI	Recommended
History	Symptoms, risk factors, relevant diagnostic test results	Recommended
Procedure data		
Description	Test type (eg, coronary CT angiography, calcium scoring, ventricular function, pulmonary vein, other)	Required
Equipment	Scanner type: number of detectors, number of x-ray sources, z-axis coverage	Recommended
Acquisition	Scan mode, ECG-synchronization, use of dual energy	Recommended
	Tube potential, tube current, dose modulation (if used)	Recommended
	Dose-length product	Recommended
Reconstruction	Scanned or reconstructed phase of the cardiac cycle	Recommended
	Slice thickness, slice increment, reconstruction filter	Optional
Medications	Beta-blockers, nitroglycerin, type and volume of contrast or any other, if given	Required
	Contrast injection rate	Optional
Patient parameters	Complication(s), if present	Required
	Heart rate, heart rhythm other than sinus rhythm, arrhythmia, if present	Recommended
Results		
Technical quality	Overall quality	Required
	Presence and type of artifact and effect on interpretation	Recommended
Coronary	Calcium score (if calcium scan performed)	Required
	Coronary anatomy: coronary dominance, anomalies (origins and course), dilation/aneurysms, (benign) anatomical variance, myocardial bridging	Required
	Stenosis location and severity	Required
	Uninterpretable segments, arteries, or overall study.	Required
	Stenosis plaque type: Calcified, predominant calcified, noncalcified, predominant non-calcified, outward remodeling	Recommended
	Stenosis extent: length, ostial, or branch involvement, positive remodeling, tortuosity	
	Use of SCCT stenosis severity classification	Recommended
	Use of SCCT axial coronary segmentation model	Recommended
	Calcium score percentile based on database representative of the cohort being assessed (if calcium scan performed)	Optional
	Use of AHA or CASS coronary segment model	Optional
Prior cardiac procedures	Prior PCI: location of stents, interpretability, patency	Required
	Prior CABG: type, location, course and anastomoses of bypass grafts, interpretability, patency, stenosis	

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Pearl #5

- **Interpretation of Coronary CTA Reports**

Noncoronary		
Vessels	Abnormalities of aorta, vena cavae, pulmonary arteries, pulmonary veins, if present	Required
Cardiac	Abnormal chamber dilation, masses, thrombus, shunts, and other structural disease, if present	Required
chambers	Ventricular and atrial sizes and volumes. (if function data obtained)	Optional
	Left ventricular ejection fraction (if functional data obtained)	Recommended
Myocardium	End-diastolic left ventricular wall thickness	Recommended
	Evidence of myocardial infarction—hypoperfusion, LV thinning (aneurysm), intramyocardial fat or calcifications	
Pericardium	Abnormal thickness, calcification, effusion, if present	Required
Valves	Abnormal aortic and mitral valve calcification, thickness, stenosis, incomplete closure, if present and required cardiac phases available	Recommended
	Prosthetic valves: type and location of replaced valves, pannus, thrombus, evidence of restricted mobility	
Other	Devices: type and location of ICD/PM wires, abnormalities	Required
Noncardiac	Abnormalities in lungs, mediastinum, esophagus, bony structures, chest wall, etc, if present	Required
Impressions and conclusions		
Images	Coronary interpretation	Required
	Abnormal noncoronary cardiac findings	Required
	Abnormal noncardiac findings	Required
	Correlation to other or prior cardiac studies	Recommended
	Documentation of communication to referring physician for urgent finding(s)	Recommended
	Clinical recommendations	Optional
	Representative images of identified pathology	Optional

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Pearl #5

- **Interpretation of Coronary CTA Reports**

INDICATIONS:
Chest pain/anginal equiv, ECGs and troponins normal; Chest pain/anginal equiv, ECGs and troponins normal;cad

COMPARISON:
No prior chest CT study.

TECHNIQUE:
Volumetric acquisition of the chest is first performed with a small field-of-view centered on the heart using prospective ECG gating for coronary calcification scoring purposes.

Contrast enhanced coronary CTA was performed with ECG gating. Curved multiplanar and 3D post processing is performed by the interpreting physician to better assess the anatomy and morphology of the coronary arteries and cardiac function.

This examination was performed on a CT scanner with automated exposure control.

The patient's vital signs remained stable throughout the procedure. The patient was monitored by a radiology nurse during the entire examination.

Medication: See Epic

Prospective systolic gated

Quality of study:Excellent, with no artifacts

Stenoses are reported as follows:

1-24% Minimal stenosis or plaque

25-49% Mild stenosis

50-69% Moderate stenosis

70-99% or Left main >50% Severe stenosis

All vessels greater than 1.5 mm in diameter are graded for stenosis severity.

FINDINGS:
CALCIUM SCORE: The observed Agatston Calcium Score of 73.9 is at percentile 72nd% for subjects of the same age, gender, and race/ethnicity who are free of clinical cardiovascular disease and treated diabetes.

The calcium score for each vessel is as follows:

Left main: 0

LAD: 63.7

Circumflex: 6.5

RCA: 3.7

NATIVE CORONARY ARTERIES: There is no evidence for anomalous coronary artery origin or course. There is rightcoronary artery dominance. The posterior descending artery (PDA) and the posterior left ventricular (PLV) branches originate from the RCA, respectively.

*Left Main (LM): No plaque or stenosis. The LM bifurcates into the LAD and circumflex.
*Left anterior descending (LAD): Calcified plaque in the mid LAD causes minimal stenosis. Calcified plaque in the distal LAD at the level of the origin of the 2nd diagonal branch causes minimal stenosis. Focal noncalcified low-attenuation plaque in the distal LAD at the level of the 2nd visualized septal perforator branch causes visibly severe stenosis. Two patent diagonal (D) branch(es) identified. The distal LAD wraps around the apex.
*Left circumflex (LCx): Calcified plaque in the proximal circumflex causes minimal stenosis. Two patent obtuse marginal (OM) branches identified. The sinoatrial nodal branch arises from the proximal circumflex coronary artery.
*Right coronary artery (RCA): No significant stenosis in the dominant right coronary artery.
FFR CT: FFR CT was used to further assess the significance of the noncalcified plaque in the distal LAD. FFR-CT values distal to the stenosis are 0.64, suggesting the lesion is hemodynamically significant.

CARDIAC: The right and left atria and ventricles are morphologically normal. The left atrium measures 38 mm in AP dimension.

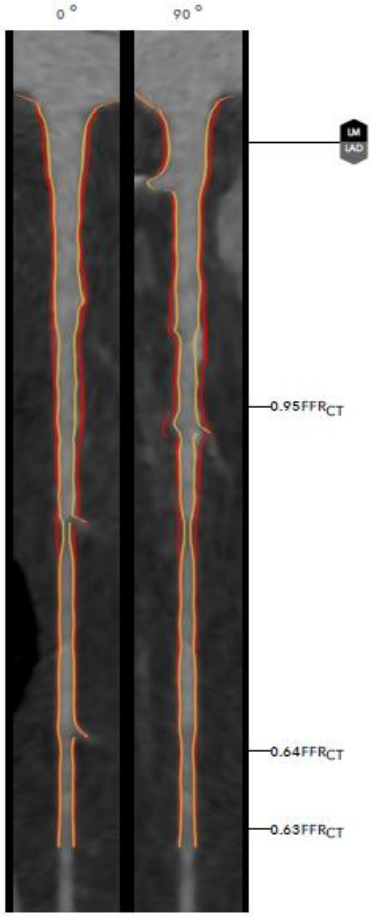
Pearl #5

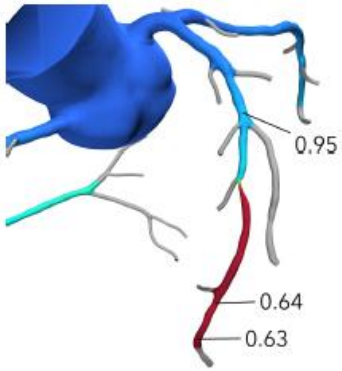
- **Interpretation of Coronary CTA Reports**

IMPRESSION:
Total calcium score measures 73.9. According to the MESA study on coronary arterial calcification, this places the patient at the 72nd percentile for subjects of the same age, gender, and race/ethnicity who are free of clinical cardiovascular disease and treated diabetes.

Severe stenosis in the distal LAD from noncalcified low-attenuation plaque. FFR CT values beyond the stenosis are 0.64, suggesting it is hemodynamically significant. Additionally, low-attenuation plaque is a high risk plaque feature. Recommend cardiology consultation, with consideration for left heart catheterization as warranted.

No significant stenosis is seen in the right coronary artery or circumflex coronary artery.





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