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CAD-RADS^{TM} Coronary Artery Disease – Reporting and Data System. An Expert Consensus Document of the Society of Cardiovascular Computed Tomography (SCCT), the American College of Radiology (ACR) and the North American Society for Cardiovascular Imaging (NASCI). Endorsed by the American College of Cardiology

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CAD-RADS™

Coronary Artery Disease – Reporting and Data System: Collaboration of SCCT, ACR, ACC & NASCI

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Abstract
The intent of CAD-RADS - Coronary Artery Disease Reporting and Data System is to create a standardized method to communicate findings of coronary CT angiography (coronary CTA) in order to facilitate decision-making regarding further patient management. The suggested CAD-RADS classification is applied on a per-patient basis and represents the highest-grade coronary artery lesion documented by coronary CTA. It ranges from CAD-RADS 0 (Zero) for the complete absence of stenosis and plaque to CAD-RADS 5 for the presence of at least one totally occluded coronary artery and should always be interpreted in conjunction with the impression found in the report. Specific recommendations are provided for further management of patients with stable or acute chest pain based on the CAD-RADS classification. The main goal of CAD-RADS is to standardize reporting of coronary CTA results and to facilitate communication of test results to referring physicians along with suggestions for subsequent patient management. In addition, CAD-RADS will provide a framework of standardization that may benefit education, research, peer-review and quality assurance with the potential to ultimately result in improved quality of care.

Abbreviations
CAD-RADS = Coronary Artery Disease Reporting and Data System
Coronary CTA = coronary CT angiography
BI-RADS = Breast Imaging Reporting and Data System
LI-RADS = Liver Imaging Reporting and Data System
Lung-RADS = Lung CT Screening Reporting and Data System
PI-RADS = Prostate Imaging Reporting and Data System
ICA = invasive coronary angiography
CAD = coronary artery disease
ACS = acute coronary syndrome
N = non-diagnostic
S = stent
G = graft
V = vulnerability

1. Introduction

Coronary CT Angiography (coronary CTA) has made substantial progress since the introduction of 64-slice CT scanners approximately 10 years ago (1), both concerning imaging technology and clinical validation. In parallel, several professional societies have issued guidelines, expert consensus documents, and Appropriateness Criteria for coronary CTA (2-8). To maximize the clinical impact of coronary CTA, imaging protocols must be optimized with respect to image quality, diagnostic accuracy, and radiation dose. Training and interpretation standards are important. Finally, standardized reporting is helpful to decrease variability among practitioners and may provide further benefit by linking the final impression in the report with suggestions for further patient management.

Other fields in medical imaging (notably, breast imaging with BI-RADS) have introduced standardized reporting linked with actionable information to guide next steps in patient management (9). BI-RADS standardized reporting of screening mammograms allows clinicians to interpret the clinical relevance of reported findings and to take action. Moreover, BI-RADS facilitates collection of data for registries and databases, allowing better tracking of individual patient outcomes with specific imaging findings.

Next to BI-RADS, standardized reporting has been introduced for several other fields. They include, for example:

- LI-RADS™ (Liver Imaging Reporting and Data System) for standardization reporting in patients with chronic liver disease (10).
- Lung-RADS™ (Lung CT Screening Reporting and Data System) for standardization reporting of high-risk smokers undergoing CT lung screening (11).
- PI-RADS™ (Prostate Imaging Reporting and Data System) for multi-parametric MR imaging in the context of prostate cancer (12).

The purpose of this document is to describe a standardized reporting system for patients undergoing coronary CTA. The report system is named CAD-RADS (Coronary Artery Disease Reporting and Data System) and is applicable to coronary CTA in patients with suspected or known coronary artery disease either in the outpatient, inpatient or emergency department setting. It includes suggestions regarding further patient management, which, obviously will

always need to be seen in light of the full clinical information available to the treating physician. For the specific setting of coronary CTA in patients with acute chest pain presenting to the emergency department, certain management recommendations have been reported previously (13,14).

The goal of CAD-RADS, through standardization of report terminology for coronary CTA, is to improve communication between interpreting and referring physicians, facilitate research, and offer mechanisms to contribute to peer review and quality assurance, ultimately resulting in improvements to quality of care. Importantly, CAD-RADS does not substitute the impression section provided by the reading physician and should always be interpreted in conjunction with the more individual and patient-specific information found in the report.

2. Clinical Value of Coronary CT Angiography

Several recent prospective trials have evaluated the clinical utility of coronary CTA and the relevance of CT findings in the context of suspected stable coronary artery disease. They include the PROMISE (15) and SCOT-HEART (16) trials, which demonstrated that coronary CTA is clinically useful as an alternative to (PROMISE) or in addition to functional testing (SCOT-HEART).

Four large randomized trials (CT-STAT, ACRIN-PA, ROMICAT II and CT-COMPARE) compared coronary CTA to the current standard of care in patients with acute chest pain (17-20). Complemented by "real world" implementation data (21, 22), they consistently demonstrate the safety of a negative coronary CTA to identify patients for discharge from the emergency department.

There are some limitations to the currently mentioned available studies (for example, their over-representation of low risk patients). Other situations, such as the use of coronary CTA in patients with known coronary artery disease, have not been evaluated in appropriate clinical trials. Hence, while fully taking into account the available data, this document is based on expert consensus. This includes the suggested categories for reporting but also the suggestions for further patient management, which need to be interpreted in the context of other clinical information that is available in any given patient.

3. CAD-RADS Reporting System

3.1. CAD-RADS Categories

CAD-RADS categories depend on stenosis severity. For the grading of stenosis severity, a classification system suggested by the Society of Cardiovascular Computed Tomography is used (see table 1). Tables 2 and 3 list the categories of the CAD-RADS reporting system for stable chest pain (table 2) and acute chest pain (table 3). They range from CAD-RADS 0 (absence of atherosclerosis) to CAD-RADS 5 (presence of at least one total occlusion) in both settings. Categories should reflect the clinically most relevant finding per patient. **Figures 1 through 9** provide examples of CAD-RADS categories and sub-categories. It is important to note that CAD-RADS classification is meant to be complementary to the final impression of the report, particularly because the report will provide specific information regarding the location and extent of coronary plaque and stenosis.

CAD-RADS categories 4 and 5 require some further consideration. For CAD-RADS 4, recommendations may vary depending on whether the left main or severe obstructive three-vessel disease (>70%) is affected or not. If a left main coronary artery stenosis greater than 50% is suspected or if the examination demonstrates three-vessel obstructive disease, then further evaluation with invasive angiography and possible revascularization is recommended. For this reason, **CAD RADS 4** is sub-divided into A and B**:**

CAD RADS 4A – Single-vessel or two-vessels demonstrating severe stenosis (70-99%).

CAD RADS 4B - This indicates presence of left main stenosis greater than 50% or three-vessel obstructive disease (>70%). Further evaluation with ICA and possible revascularization is usually recommended.

The clinical relevance of CAD-RADS 5 (total coronary occlusion) varies widely depending on the clinical context. It may be acute or chronic, and, in the context of chronic occlusion, factors such as lesion length, calcification particularly at the proximal cap, and degree of collateralization may be of relevance for management decisions (**Figure 8**).

3.2. Patients with known CAD

Management recommendations with regard to patients with previously known CAD deserve special consideration. The main clinical benefit of coronary CTA is derived from its high sensitivity and negative predictive value. The positive predictive value of coronary CTA is

lower, and especially intermediate lesions may be overestimated regarding their relevance. Many patients with previously known CAD will include lesions that fall into this category, so that coronary CTA will need to be complemented by further tests. Additionally, coronary CTA has low accuracy for diagnosis of in-stent restenosis, particularly in stents smaller than 3.0 mm diameter. Thus, the use of coronary CTA in patients with previously known CAD should be carefully considered. Management decisions derived from coronary CTA results depend on other clinical findings as well as the patient-specific previous history, and should be made on an individual basis.

3.3. Modifiers

CAD-RADS categories can be complemented by modifiers to indicate that a study is not fully evaluable or non-diagnostic (N) or to indicate the presence of stents (S), grafts (G), and vulnerable plaque (V).

I. *Modifier N – Non-diagnostic study*

"**N**" can be used as a modifier or as a CAD-RADS category, depending on context. If the study is not fully diagnostic (i.e. not all segments > 1.5 mm diameter can be interpreted with confidence) and a stenosis is present in a diagnostic segment, the highest stenosis should be graded in addition to the modifier N if CAD-RADS is greater than 3. For example, a patient with moderate stenosis (50-69%) in one segment and one or more non-diagnostic remote segments should be graded as **CAD-RADS 3/N (Figure 10)** and not **CAD-RADS N**, since further evaluation is needed, possibly with functional imaging, and patient recommendations for anti-ischemic and preventive management apply. However, for a patient with no stenosis (zero), minimal (1-24%), or no more than mild stenosis (25-49%) in interpretable segments, **CAD-RADS N** should be used since Coronary CTA cannot be used to guide patient management and further evaluation to exclude obstructive coronary artery disease is still needed.

II. *Modifier S - Presence of a stent*

The modifier "**S"** indicates the presence of at least one coronary stent anywhere in the coronary system. For example, if a patient has a patent stent in the proximal left anterior descending coronary artery (LAD) with no significant in-stent restenosis or occlusion and demonstrates mild non-obstructive disease (25-49%) in the left circumflex artery (LCX) and right coronary artery

(RCA), the case would be classified as: **CAD-RADS 2/S.** If a patient demonstrates significant in-stent restenosis of a stent in the proximal LAD, then the case would be classified as: **CAD-RADS 4A/S (Figure 11)**. Similarly, a non-stenotic stent in the LAD and a new severe stenosis in the RCA would be classified as **CAD-RADS 4A/S.** Finally, if a stent were non-evaluable, the case would be classified as **CAD-RADS N/S** if there is no other stenosis greater than 50% in the coronary tree**.** Note: CAD-RADS was created to guide management recommendations, so it does not matter whether it is the stent or a non-stented vessel that has a severe stenosis. Rather, what matters is that the patient has a severe stenosis and needs further work-up.

III. ***Modifier G = Presence of coronary bypass grafts:***

The modifier "**G**" indicates the presence of at least one coronary-artery bypass graft **(Figure 12)**. A stenosis bypassed by a fully patent graft is not considered for the CAD-RADS classification. For example, if a patient has a graft to LAD, with absence of significant stenoses in the graft, distal anastomosis and run-off vessel, and demonstrates non-obstructive lesions (25-49%) in the LCX and RCA, in addition to the "expected" proximal LAD severe stenosis, then the case would be classified as: CAD-RADS 2/G. If a patient demonstrates total occlusion of a saphenous vein graft (SVG) to the RCA, and a patent LIMA to LAD and SVG to LCX, then the case would be classified as: CAD-RADS 5/G. The interpretation is that a total occlusion is present and further investigation and/or management may be required.

IV. ***Modifier V = Presence of "vulnerable" or high-risk plaque features***

Data from recent coronary CTA studies have described vulnerable plaque characteristics that are independently associated with future ACS. They include positive remodeling, low-attenuation plaque, spotty calcification, and the napkin-ring sign (23, 24).

If a coronary plaque clearly demonstrates two or more high-risk features by coronary CTA, the modifier "V" (vulnerability) should be added **(Figures 13 and 14)**. High-risk features include: low attenuation plaque (less than 30 Hounsfield Units), positive remodeling, spotty calcification, and the "napkin ring sign" (**see Figure 13**).

For example, **CAD RADS 2/V** should be used for a patient with diameter stenosis between 25-49% and demonstrating plaque with two or more high-risk features (large non-calcified plaque, positive remodeling, spotty calcification, low HU values and napkin ring sign) **(Figure 14)**. The

features should be described, particularly in patients presenting to the emergency department with acute chest pain. There is not enough published data to guide the management of such patients. However, clinical and laboratory correlation and close observation is recommended. Consider hospital admission in high-risk clinical settings. If the patient is discharged, short-term clinical follow-up within a week is suggested in the outpatient setting with a cardiologist or primary care physician.

Studies coded with CAD-RADS 3/V (the presence of high risk plaque with 50-69% diameter stenosis, excluding left main lesions) should prompt consideration for more aggressive management than studies coded with CAD-RADS 3, particularly in patients presenting to the emergency department with acute chest pain. This includes consideration of further testing with invasive coronary angiography instead of non-invasive functional testing. However, management decisions should ultimately be made on an individual basis taking into consideration all supporting clinical and laboratory data.

V. If more than one modifier is present, the symbol "/" (slash) should follow each modifier in the following order:

i. First: modifier **N (non-diagnostic)**

ii. Second: modifier **S (stent)**

iii. Third: modifier **G (graft)**

iv. Fourth: modifier **V (vulnerability)**

For example:

i. Non-interpretable coronary stent without evidence of other obstructive coronary disease: **Modifier S = CAD-RADS N/S**

ii. Presence of stent and a new moderate stenosis showing a plaque with high-risk features: **Modifiers S and V = CAD-RADS 3/S/V (Figure 15)**

iii. Presence of stent, grafts and non-evaluable segments due to metal artifacts: **Modifiers S and G = CAD-RADS N/S/G**

iv. Presence of patent LIMA to the LAD and expected occluded proximal LAD. Mild non-obstructive stenosis in the RCA and LCX. **Modifier G = CAD-RADS 2/G.**

v. For a patient with severe stenosis (70-99%) in one segment and a non-diagnostic area in another segment, the study should be graded as **CAD-RADS 4/N.**

3.4. Presence of other cardiac or extra-cardiac findings

Patients undergoing coronary CTA may demonstrate other significant, potentially significant or non-significant cardiac or extra-cardiac findings. CAD-RADS is intended to focus solely on the classification of coronary artery stenosis and further management. However, other cardiac and extra-cardiac findings of relevance should be reported in coronary CTA studies and should be mentioned in the report text. Specific follow-up and recommendations should be included depending on the pathology.

Finally, **Figure 16** provides a sample standardized reporting template for coronary CTA incorporating CAD-RADS coding.

4. DISCUSSION

The use of coronary CTA to assess patients with stable chest pain in the outpatient setting or acute chest pain presenting to the Emergency Department has been validated in various clinical trials. Major guidelines are incorporating the use of coronary CT angiography as appropriate for assessing low to intermediate risk patients presenting with chest pain. Decreasing the variation in reporting is one aspect that will contribute to wider dissemination in clinical practice, minimize error and to ultimately improve patient outcome. The main goal of the CAD-RADS classification system is to propose a reporting structure that provides consistent categories for final assessment, along with suggestions for further management.

CAD-RADS is intended to be a ”living document” that undergoes continued development to provide up-to-date, evidence based recommendations to achieve its goal of being a tool that imagers can use to communicate with clinicians and to convey concise findings using unambiguous and standardized terminology. Next to its utilization in clinical reporting, CAD-RADS will allow reliable and reproducible data collection, storage and retrieval for future research trials and audits.

Similar to other larger registries, such as the National Radiology Data Registry (NRDR) and National Cardiovascular Data Registry (NCDR), CAD-RADS can provide the framework for standardize collection of coronary CTA reports across multiple sites for quality improvement and

benchmarking. Further, it can provide the framework for collecting outcome data in each of several sub-categories of CAD-RADS, such as:

1- Follow-up of disposition of patients with positive coronary CTA results;
2- Rate of downstream testing;
3- Correlation with ICA;
4- Rate of revascularization (percutaneous coronary intervention and coronary artery by-pass graft surgery)
5- Major adverse cardiac events, including cardiovascular death and myocardial infarct.

Therefore, it is strongly encouraged that every coronary CTA examination includes the CAD-RADS classification for a final assessment. Residency and Fellowship trainees should be required to use the CAD-RADS terminology, assessment categories and management recommendations.

Similar to BI-RADS, peer-reviewed radiology and cardiology journals may also find the CAD-RADS terminology useful for standardized classification of coronary CTA results, which in turn will further promote the use of CAD-RADS nationally and internationally.

Finally, standardization in reports and management recommendations will not only improve the clarity of communication and comprehension of imaging results by all members of the clinical care team, but also will improve communication between humans and computer-based systems. This will allow the development of decision support technologies and serve as the basis for developing artificial intelligence algorithms.

5. CONCLUSION

In conclusion, CAD-RADS has been developed based on scientific data, expert guidance from leaders in cardiac imaging and a multi-disciplinary effort involving radiology and cardiology societies (Society of Cardiovascular Computed Tomography, American College of Radiology, American College of Cardiology and North American Society for Cardiac Imaging). It is meant to be an evolving document that will undergo continuous updates as new data are acquired. The main goal of CAD-RADS is to create report standardization terminology for coronary CTA results, and to improve communication of results to referring physicians in a clear and consistent fashion with a final assessment and suggestions for further management. In addition, CAD-

RADS will provide a framework to standardize education, research, peer-review, quality assurance and ultimately result in improvement to patient care. Finally, compiling imaging data in a standardized manner will allow to link imaging findings with specific treatments and to better assess the impact on patient outcomes.

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Table 1 - SCCT grading scale for stenosis severity:

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

Table 2. CAD-RADS Reporting and Data System for patients presenting with stable chest pain.

	Degree of maximal coronary stenosis	Interpretation	Further Cardiac Investigation	Management
CAD-RADS 0	0% (No plaque or stenosis)	Documented absence of CAD*	None	- Reassurance. Consider non- atherosclerotic causes of chest pain
CAD-RADS 1	1- 24% - Minimal stenosis or plaque with no stenosis**	Minimal non-obstructive CAD	None	- Consider non- atherosclerotic causes of chest pain - Consider preventive therapy and risk factor modification
CAD-RADS 2	25- 49% - Mild stenosis	Mild non-obstructive CAD	None	- Consider non- atherosclerotic causes of chest pain - Consider preventive therapy and risk factor modification, particularly for patients with non-obstructive plaque in multiple segments.
CAD-RADS 3	50-69% stenosis	Moderate stenosis	Consider functional assessment	- Consider symptom-guided anti-ischemic and preventive pharmacotherapy as well as risk factor modification per guideline-directed care*** - Other treatments should be considered per guideline-directed care***
CAD-RADS 4	**A** - 70-99% stenosis or **B** - Left main >50% or 3- vessel obstructive (≥ 70%) disease	Severe stenosis	A: Consider ICA**** or functional assessment B: ICA is recommended	- Consider symptom-guided anti-ischemic and preventive pharmacotherapy as well as risk factor modification per guideline-directed care*** - Other treatments (including options of revascularization) should be considered per guideline-directed care***
CAD-RADS 5	100% (total occlusion)	Total coronary occlusion	Consider ICA and/or viability assessment	- Consider symptom-guided anti-ischemic and preventive pharmacotherapy as well as risk factors modification per guideline-directed care*** - Other treatments (including options of revascularization) should be considered per guideline-directed care***
CAD-RADS N	Non-diagnostic study	Obstructive CAD cannot be excluded	Additional or alternative evaluation may be needed	

The CAD-RADS classification should be applied on a per-patient basis for the clinically most relevant (usually highest-grade) stenosis.

All vessels greater than 1.5mm in diameter should be graded for stenosis severity. CAD-RADS will not apply for smaller vessels (<1.5mm in diameter).

* CAD – coronary artery disease

** CAD-RADS 1 – This category should also include the presence of plaque with positive remodeling and no evidence of stenosis

*** Guideline-directed care per ACC Stable Ischemic Heart Disease Guidelines (Fihn et al. JACC 2012) (25).

**** ICA – invasive coronary angiography.

MODIFIERS: If more than one modifier is present, the symbol “/” (slash) should follow each modifier in the following order:

First: modifier **N (non-diagnostic)**
Second: modifier **S (stent)**
Third: modifier **G (graft)**
Fourth: modifier **V (vulnerability)**

Table 3. CAD-RADS Reporting and Data System for patients presenting with acute chest pain, negative first troponin, negative or non-diagnostic electrocardiogram and low to intermediate risk (TIMI risk score < 4) (emergency department or hospital setting).

	Degree of maximal coronary stenosis	Interpretation	Management
CAD-RADS 0	0%	ACS* highly unlikely	- No further evaluation of ACS is required. - Consider other etiologies.
CAD-RADS 1	1- 24%**	ACS highly unlikely	- Consider evaluation of non-ACS etiology, if normal troponin and no ECG changes. - Consider referral for outpatient follow-up for preventive therapy and risk factor modification.
CAD-RADS 2	25- 49% ***	ACS unlikely	- Consider evaluation of non-ACS etiology, if normal troponin and no ECG changes. - Consider referral for outpatient follow-up for preventive therapy and risk factor modification. - If clinical suspicion of ACS is high or if high-risk plaque features are noted, consider hospital admission with cardiology consultation.
CAD-RADS 3	50-69%	ACS possible	- Consider hospital admission with cardiology consultation, functional testing and/or ICA**** for evaluation and management. - Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modification. Other treatments should be considered if presence of hemodynamically significant lesion.
CAD-RADS 4	**A** - 70-99% or **B** - Left main >50% or 3-vessel obstructive disease	ACS likely	- Consider hospital admission with cardiology consultation. Further evaluation with ICA and revascularization as appropriate. - Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modification.

	Degree of maximal coronary stenosis	Interpretation	Management
CAD-RADS 5	100% (Total occlusion)	ACS very likely	- Consider expedited ICA on a timely basis and revascularization if appropriate if acute occlusion***** - Recommendation for anti-ischemic and preventive management should be considered as well as risk factor modifications.
CAD-RADS N	Non-diagnostic study	ACS cannot be excluded	Additional or alternative evaluation for ACS is needed

The CAD-RADS classification should be applied on a per-patient basis for the clinically most relevant (usually highest-grade) stenosis.

All vessels greater than 1.5mm in diameter should be graded for stenosis severity. CAD-RADS will not apply for smaller vessels (<1.5mm in diameter).

* ACS – acute coronary syndrome

** CAD-RADS 1 – This category should also include the presence of plaque with positive remodeling and no evidence of stenosis

*** CAD-RADS 2 - **Modifier 2/V** can be used to indicate vulnerable/ high-risk plaque

**** ICA – invasive coronary angiography.

***** Unless the total coronary occlusion can be identified as chronic (through CT and clinical characteristics or patient history)

MODIFIERS: If more than one modifier is present, the symbol “/” (slash) should follow each modifier in the following order:

First: modifier **N (non-diagnostic)**

Second: modifier **S (stent)**

Third: modifier **G (graft)**

Fourth: modifier **V (vulnerability)**

Figure legends

Figure 1. CAD-RADS 0. Normal left main, LAD, LCX and RCA without plaque or stenosis.

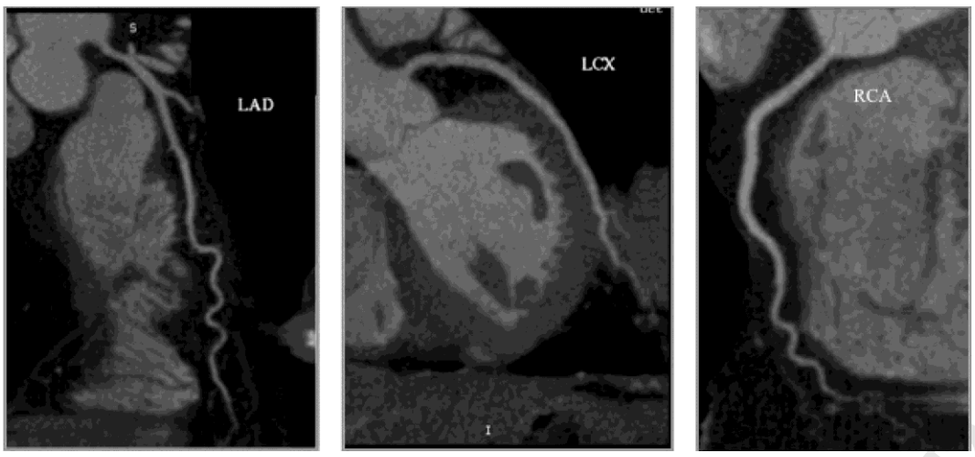

Figure 2. CAD-RADS 1. Minimal calcified plaque in the proximal LAD with minimal luminal narrowing (less than 25% diameter stenosis).

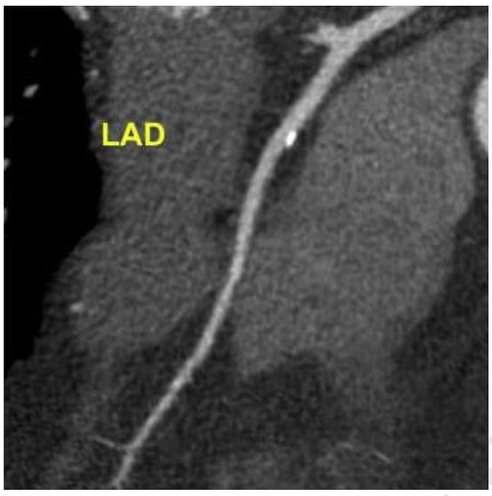

Figure 3. CAD-RADS 2. Predominantly calcified plaque in the proximal LAD with 25-49% diameter stenosis (left). Invasive coronary angiography confirming 25-49% stenosis (right).

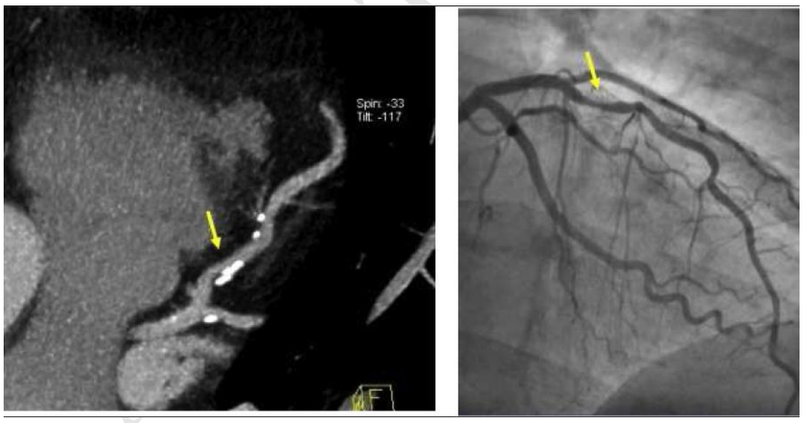

Figure 4. CAD-RADS 3. Predominantly calcified plaque in the mid LCX with 50-69% diameter stenosis. Left image: Coronary CTA. Right image: Invasive coronary angiography.

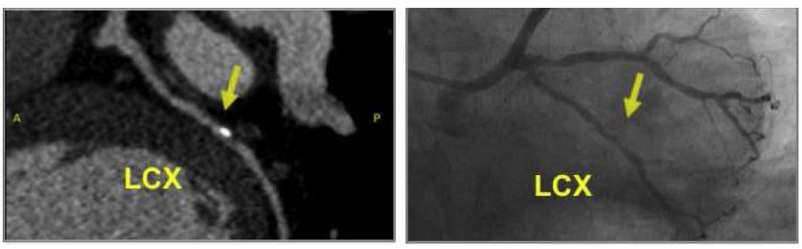

Figure 5. CAD-RADS 4A. Focal non-calcified plaque in the mid LAD (yellow arrow) with 70-99% diameter stenosis (left). Invasive coronary angiography confirming 70-99% stenosis in the mid LAD (yellow arrow, right).

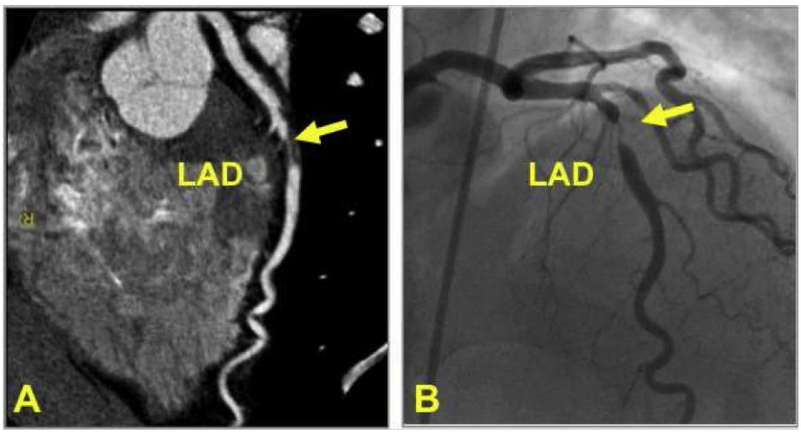

Figure 6. CAD-RADS 4B. Three-vessel obstructive disease (>70% stenosis), including in 70-99% stenosis of the proximal RCA (*left*), 70-99% stenosis of the proximal LAD (*middle*) andn 70-99% stenosis of the mid LCX (*right*).

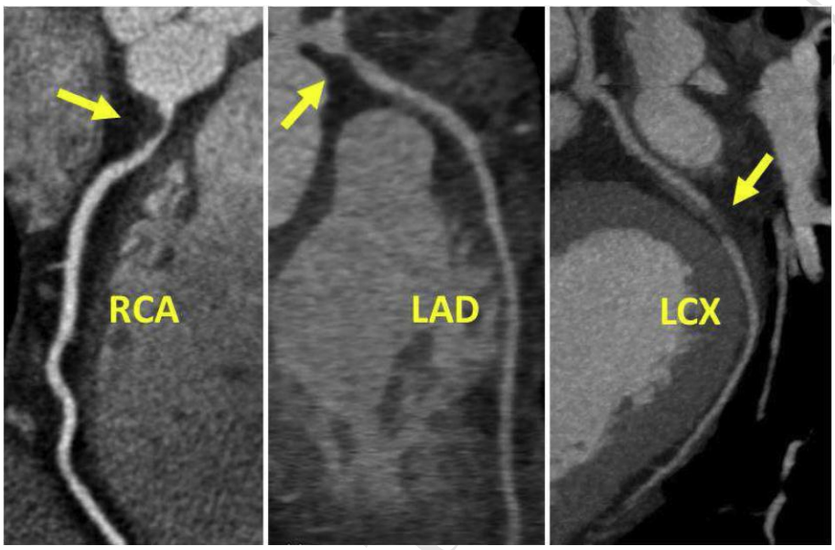

Figure 7. CAD-RADS 4B. Distal left main stenosis with circumferential calcified plaque resulting in > 50% stenosis (arrow). *Upper left panel*: oblique longitudinal plane of the left main coronary artery. *Lower left panel* – cross-sectional slice of the distal left main coronary artery. *Figures on the right* - Invasive coronary angiography confirming focal severe stenosis in the distal left main coronary artery.

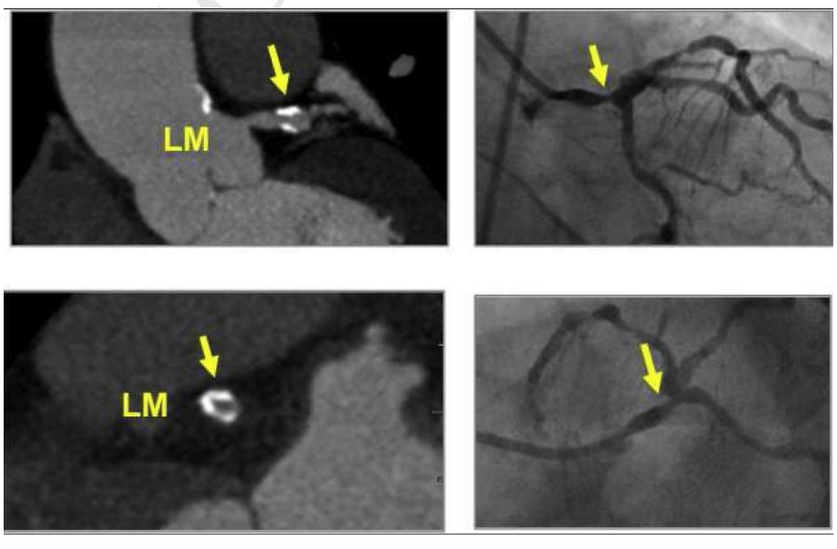

Figure 8. CAD-RADS 5. Two examples of cases coded as CAD-RADS 5. *Left:* Focal, non-calcified occlusion of the proximal RCA (*arrow*). *Right*: Total occlusion of the proximal LCX (*arrow*). A small focus of "orphan" calcium along the distal LCX supports the diagnosis of chronic total occlusion.

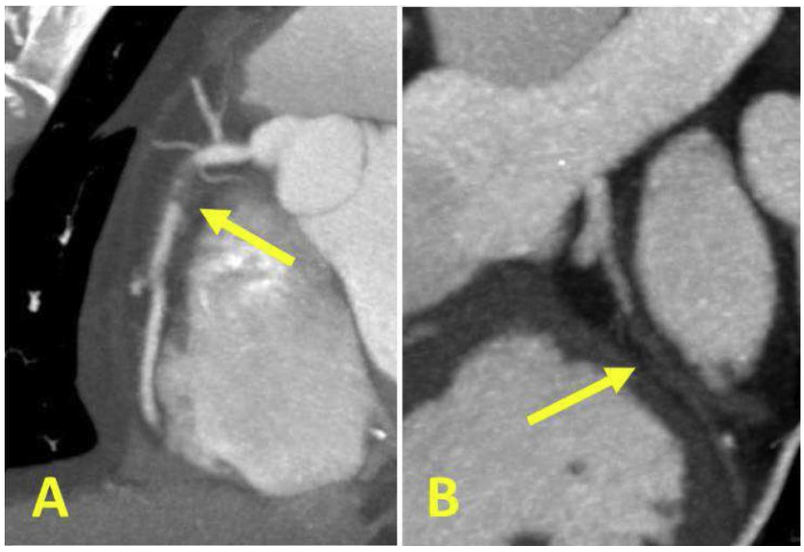

Figure 9. CAD-RADS N. Motion artifacts obscuring the left main, LAD and LCX arteries, which renders these segments non-diagnostic (left). Motion artifacts in the mid RCA (right).

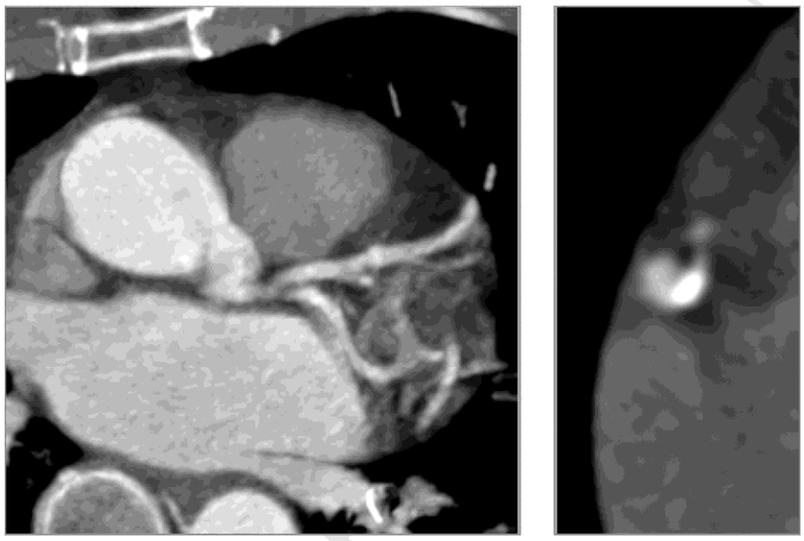

Figure 10. CAD-RADS 3/N. Motion artifact obscuring the mid RCA (*left, arrow*), which renders this segment non-diagnostic. There is also stenosis of the mid LAD with 50-69% luminal narrowing (*right, arrow*), qualifying this lesion as CAD RADS 3. Although the mid RCA segment is non-diagnostic, the presence of suspected obstructive disease within the LAD should be coded as CAD RADS 3/N. If the LAD lesion were mild (less than 50% diameter stenosis), and no other plaques were identified, the patient would be coded as CAD RADS N.

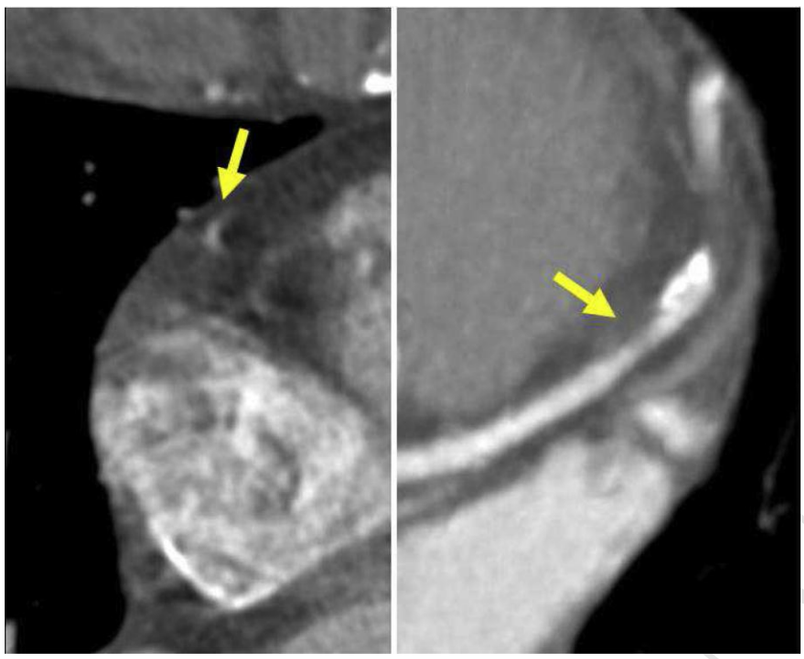

Figure 11. CAD-RADS 4A/S. In-stent stenosis of the proximal LAD with significant luminal narrowing (70-99% stenosis). Grading of in-stent stenosis should follow the grading of normal coronary arteries (0% stenosis, 1-24% stenosis, 25-49% stenosis, 50-69% stenosis, 70-99% stenosis, and >99% stenosis). In this case, severe in-stent restenosis designates a CAD-RADS 4A lesion, which would be followed by the stent modifier "S."

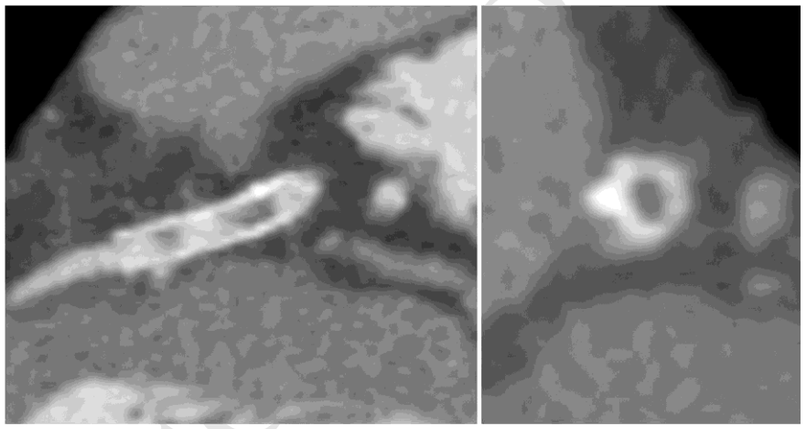

Figure 12. MODIFIER G. Coronary CTA demonstrating a patent left internal mammary artery to the LAD and patent saphenous vein grafts to the ramus intermedius and second obtuse marginal branch. No stenoses or luminal narrowing throughout the grafts (0% stenosis, left). Invasive coronary angiography demonstrating patent LIMA graft to the LAD (right). When evaluating coronary CTA of patients with bypass grafts, the native coronary artery segments *proximal* to the graft anastamoses should not be evaluated for purposes of CAD RADS coding. Only the grafts and the native coronary artery segments *distal to* and *including* the anastomosis should be evaluated for CAD RADS coding.

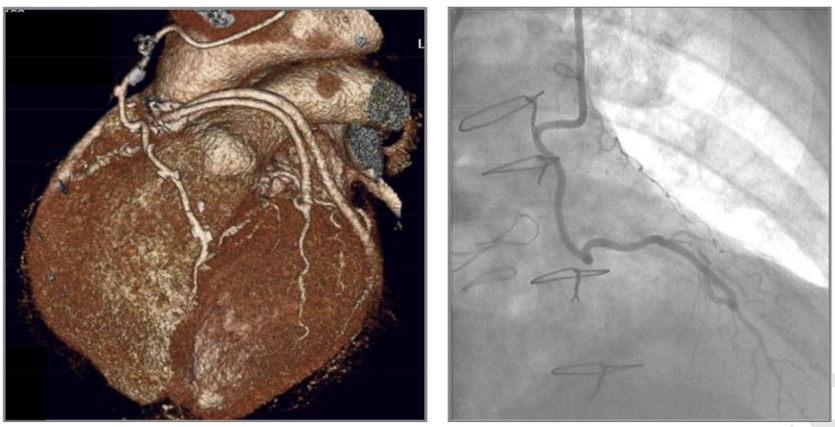

Figure 13. High-risk plaque features on coronary CTA. These include a) Spotty calcium, defined as punctate calcium within a plaque; b) "napkin ring sign", defined as central low attenuation plaque with a peripheral rim of higher CT attenuation (*arrows*); c) Positive remodeling, defined as the ratio of outer vessel diameter at the site of plaque divided by the average outer diameter of the proximal and distal vessel greater than 1.1, or Av/[(Ap + Ad)/2] >1.1; and d) Low attenuation plaque, defined as non-calcified plaque with internal attenuation less than 30 HU. Please note that a combination of two or more high-risk features is necessary to designate the plaque as high-risk for CAD-RADS.

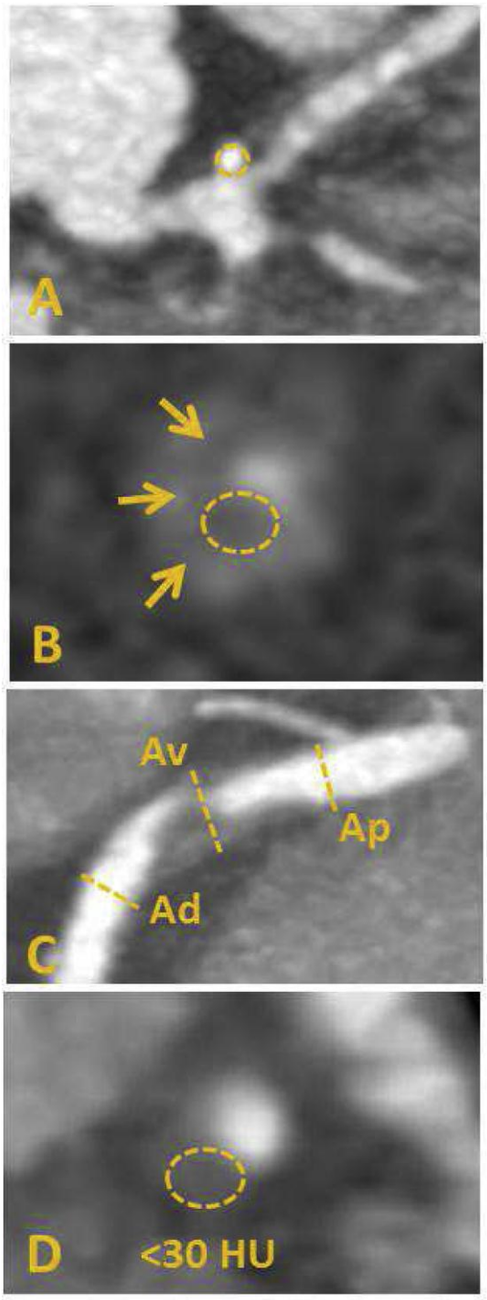

Figure 14. CAD-RADS 2/V. Focal non-calcified plaque in the mid RCA with 25-49% diameter stenosis. The plaque demonstrates two high risk features, low attenuation (<30 HU) and positive remodeling, thus coding with the modifier "V."

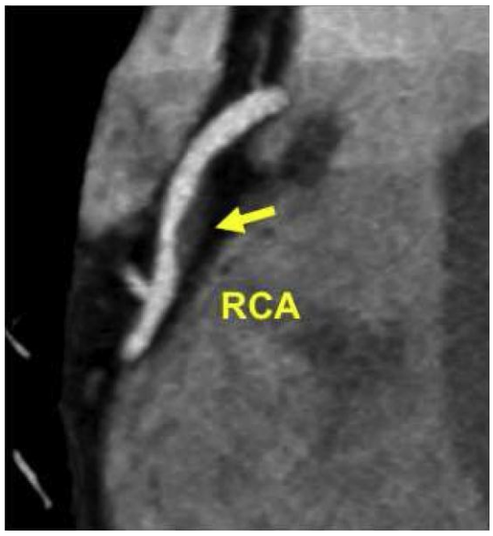

Figure 15. CAD-RADS 3/S/V. Example demonstrating a patent stent in the proximal RCA (0% stenosis) with high-risk plaque in the proximal LAD resulting in 50-69% stenosis. In isolation, the proximal LAD lesion would be coded CAD RADS 3/V. However, since CAD RADS is coded on a per-patient basis, and a RCA stent is present, this patient would be coded as CAD RADS 3/S/V.

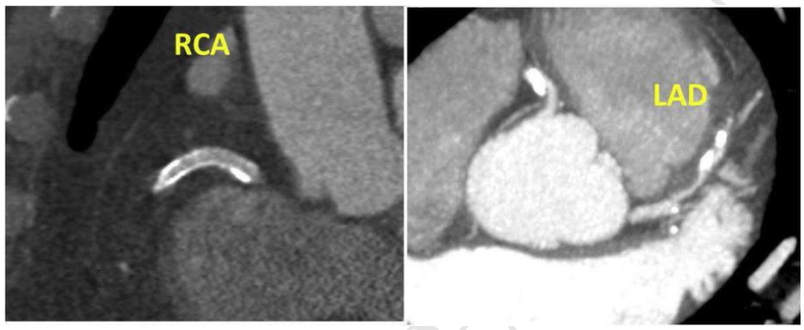

Figure 16. **Reporting template.** Sample standardized reporting template for Coronary CTA incorporating CAD-RADS coding.

EXAM: CORONARY CT ANGIOGRAPHY WITH CALCIUM SCORE

CLINICAL HISTORY: [ ]

COMPARISON: [ ]

TECHNIQUE: Using a [*scanner type*], a preliminary scout study was obtained, followed by coronary artery calcium protocol. Following administration of intravenous contrast, [*0.5*] mm collimated images were obtained through the coronary arteries. Data were transferred off-line for 3D reconstructions including Curved MPR and multi-planar imaging.

ACQUISITION: [*Prospective*; *Retrospective*>] ECG triggering was used. Heart rate at the time of acquisition was approximately [ ] bpm.

MEDICATIONS: [*100mg of oral metoprolol was administered prior to scanning*]. [0.*4mg sublingual nitroglycerine was administered immediately prior to scanning*].

TECHNICAL QUALITY: [*excellent, with no artifacts*; *good, with minor artifact but good diagnostic quality; acceptable, with moderate artifacts; poor/suboptimal, with severe artifacts*]

FINDINGS:
The total calcium score is zero indicating absence of calcified plaques in the coronary tree.

The coronary arteries arise in normal position. There is ____ (right/ left/ co) coronary artery dominance.

Left main: The left main coronary artery is a _____ (short/ medium/ large) size vessel and (bifurcates in LAD and LCX / or trifurcates in LAD, LCX and RI). It is patent with no evidence of plaque or stenosis.

LAD: The left anterior descending artery is patent with no evidence of plaque or stenosis. It gives off ____ patent diagonal branches.

LCX: The left circumflex artery is patent with no evidence of plaque or stenosis. It gives off ____ patent obtuse marginal branches.

RCA: The right coronary artery is patent with no evidence of plaque or stenosis. It gives off a patent posterior descending artery and a patent posterior left ventricular branch.

Cardiac valves: There is no thickening or calcifications in the aortic and mitral valves.

Pericardium: The pericardial contour is preserved with no effusion, thickening or calcifications.

Extra-cardiac findings: There are no significant extra-cardiac findings in the available limited views of the lungs and mediastinum.

IMPRESSION:
1- Total calcium score of zero.

2- No evidence of coronary stenosis or plaque by Coronary CT Angiography.

CAD RADS [0] - Management recommendation: Reassurance. Consider other non- atherosclerotic causes of chest pain.

Other: [ ]
