



# RadioGraphics Update: Pictorial Guide to CAD-RADS 2.0

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**Editor's Note.**—RadioGraphics Update articles supplement or update information found in full-length articles previously published in RadioGraphics. These updates, written by at least one author of the previous article, provide a brief synopsis that emphasizes important new information such as technological advances, revised imaging protocols, new clinical guidelines involving imaging, or updated classification schemes.

## Introduction

The Coronary Artery Disease Reporting and Data System (CAD-RADS) was first published in 2016 to standardize reporting of coronary CT angiography (CTA) examinations (1). Newer CTA guidelines, the results of clinical trials, and the development of technologies such as CT fractional flow reserve (FFR) and myocardial CT perfusion (CTP) prompted an updated CAD-RADS 2.0, which has been recently published with endorsements by the Society of Cardiovascular Computed Tomography, the American College of Cardiology, the

American College of Radiology, and the North America Society of Cardiovascular Imaging (2). In this article, we describe the changes in CAD-RADS 2.0 (Fig 1) as an update to the previously published article by Canan et al (3).

## CAD-RADS Categories

The CAD-RADS category is still determined by the highest grade of luminal narrowing (diameter reduction) in any coronary artery segment greater than 1.5 mm in diameter. There are seven categories: 0 (no stenosis), 1 (<25% stenosis), 2 (25%–49% stenosis), 3 (50%–69% stenosis), 4A (single- or two-vessel 70%–99% stenosis), 4B (three-vessel 70%–99% stenosis or left main stenosis >50%), 5 (total occlusion), and N (nondiagnostic) (2).

## Plaque Burden Classification

Emerging data demonstrate that higher plaque burden is associated with higher event risk in patients with both obstructive and nonobstructive coronary artery disease (4). Therefore, a

	CAD-RADS 1.0	CAD-RADS 2.0	Definition	Comments
Category	0	0	No plaque, stenosis	No change
	1	1	<25% stenosis	
	2	2	25%–49% stenosis	
	3	3	50%–69% stenosis	
	4	4	70%–99% stenosis	
	5	5	Total occlusion	
	N	N	Nondiagnostic	
Plaque amount	NA	P1	Mild	New plaque amount assessment
		P2	Moderate	
		P3	Severe	
		P4	Extensive	
Modifiers	Modifier N: Nonevaluable	Modifier N	Presence of nonevaluable segment	No change
	Modifier S: Stent	Modifier S	Presence of stent	No change
	Modifier G: Graft	Modifier G	Presence of coronary bypass grafts	No change
	Modifier V: vulnerable plaque	Modifier high-risk plaque (HRP)	HRP; two or more of the following features in the same plaque: <ul style="list-style-type: none"><li>• Positive remodeling</li><li>• Spotty calcification</li><li>• Napkin ring sign</li><li>• Low attenuation</li></ul>	Modifier name changed, but the definition is unchanged
	NA	Modifier I: Ischemia	Indicates CT FFR or myocardial CTP shows lesion-specific ischemia, reversible perfusion defect or peri-infarct ischemia	New modifier
	NA	Modifier E: Exceptions	Reflects any nonatherosclerotic narrowing of coronary arteries	New modifier
Order of modifiers	N/S/G/V	N/HRP/I/S/G/E		New order of modifiers

**Figure 1.** Chart shows the original CAD-RADS compared with CAD-RADS 2.0. Red text indicates the changes in CAD-RADS 2.0. NA = not applicable.

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**Content Codes:** CA, CT

**Abbreviations:** CAD-RADS = Coronary Artery Disease Reporting and Data System, CTA = CT angiography, CTP = CT perfusion, FFR = fractional flow reserve, HRP = high-risk plaque

new descriptor for plaque burden (P) has been added. In the absence of any plaque, no P descriptor needs to be reported since CAD-RADS 0 also implies the absence of plaque. When plaques are present, this is reported by using one of the following categories: 1, mild; 2, moderate; 3, severe; and 4, extensive plaque volume.

Plaque burden can be quantified by using different qualitative or quantitative methods. Three main methods are acceptable: coronary artery calcium (CAC) score, segment involvement score (SIS), and visual assessment (Fig 2). CAC scoring uses the Agatston method to estimate the amount of coronary calcification but does not quantify noncalcified plaques. Hence, it should be incorporated with the option of using additional qualitative methods to represent total plaque burden. The SIS is the sum of each coronary artery segment with detectable plaques, calcified and noncalcified. A score of 1 or 0 is assigned for each of the 16 coronary segments with or without plaque, respectively, and SIS is defined as the summation of the individual scores (5). SIS is a surrogate of coronary plaque burden and is associated with higher risk of cardiac events (6). Visual assessment can also be used to express overall plaque burden on the basis of the number of vessels in-

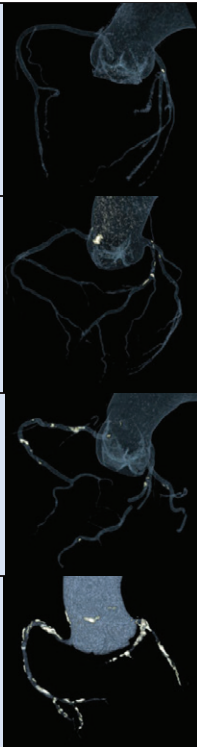
involved and the amount of plaque. Although multiple existing software platforms can provide quantitative estimates of total plaque volume, there is no consensus on the preferred technique in CAD-RADS 2.0.

CAD-RADS 2.0 Modifiers

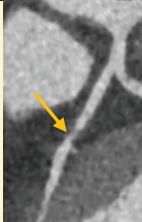
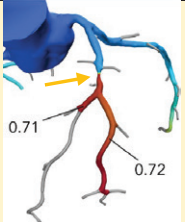
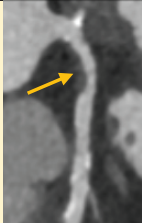
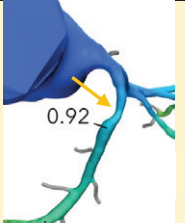

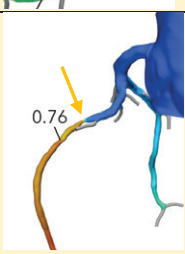
Four modifiers were described in the original system to indicate the presence of nonevaluable segments (N), stents (S), grafts (G), and vulnerable plaque (V). In CAD-RADS 2.0, the modifiers N, S, and G are unchanged. The modifier high-risk plaque (HRP) has replaced the term *vulnerable plaque*, but the definition remains the same, requiring the presence of at least two of the following features in the same plaque: positive remodeling, spotty calcification, low attenuation, and napkin-ring sign (1,3). Additionally, two new modifiers, ischemia (I) and exceptions (E), have been included.

Modifier I

The use of modifier I indicates that additional testing for ischemia has been performed, either by using CT FFR or stress myocardial CTP. This modifier is not assigned based on perfusion defects identified at routine coronary CTA. Further ischemic evaluation with CT FFR or stress myocardial CTP may be considered for coronary artery stenosis ranging from 50% to 90% (CAD-RADS 3 and 4A) and for stenoses 40% or greater in a proximal coronary artery, including in the presence of HRP features (CAD-RADS 2/HRP). Regardless of the testing method used, three main categories of modifier I exist: I+ indicates the presence of ischemia, I- indicates the absence

	Definition	CAC	SIS	Visual	Example
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	
CAC: Coronary Artery Calcium, Agatston Score SIS: Segment Involvement Score					

**Figure 2.** Chart shows the three different methods of assessing plaque. Example images are three-dimensional volume-rendered images of segmented coronary arteries and the aorta with calcium overlay. The bright spots denote calcification.

Modifier	CT FFR result	Definition	Recommendations	CCTA	CT FFR
I+ (Abnormal-Ischemia present)	$\leq 0.75$	Anatomical stenosis with corresponding lesion-specific abnormal CT-FFR	Consider invasive angiography for those individuals likely to benefit from coronary revascularization		
I- (Normal- No ischemia)	$> 0.80$	Anatomical stenosis without lesion-specific abnormal CT-FFR	Defer invasive angiography and optimize medical therapy		
I± (Borderline/indeterminate)	0.76-0.80	Anatomical stenosis with borderline CT-FFR results	Consider invasive angiography based on symptoms, lesion location, and translesional pressure loss and individuals likely to benefit from coronary revascularization		

CCTA: Coronary CTA

**Figure 3.** CT FFR can be used for coronary stenosis (arrows) ranging from 50% to 90% (CAD-RADS 3 and 4A) to better define the hemodynamic significance of the lesion. It can also be considered in CAD-RADS 2 if the lesion is proximal and stenosis is 40% or greater, including in the presence of HRP features. For abnormal CT FFR values without a concordant anatomic coronary artery stenosis, the modifier I- is used if the reader is confident that the CT FFR result is false positive and the modifier I+/- is used if it is indeterminate.

of ischemia, and I± indicates that testing has been performed but the results are indeterminate or borderline for ischemia. Should the results of the ischemic test be abnormal (I+) or borderline (I±), further investigation with invasive angiography may be considered for patients likely to benefit from revascularization.

CT FFR provides hemodynamic information about coronary stenoses by using the computation of flows and pressure gradients along the coronary arterial tree based on the anatomic model derived from the original coronary CTA images (7). The results are based on the lesion-specific CT FFR values, with less than or equal to 0.75 being abnormal (I+), greater than 0.80 being normal (I-), and 0.76–0.80 being borderline (I±) (Fig 3). For lesions with an abnormal CT FFR but without a concordant anatomic stenosis, the modifier I- is used if the reader is confident of a false-positive test result and modifier I± is used if the reader is not confident. Abnormal CT FFR in a vessel that is not the one with the most anatomically significant stenosis should be described in the report.

Myocardial CTP can help evaluate myocardial ischemia based on images acquired both at rest and after pharmacologic stress. Reversible perfusion defect (seen only at stress CTP) or peri-infarct ischemia are classified as I+. The absence of perfusion defect on both stress and rest images or presence of a fixed perfusion defect (at both rest and stress) from myocardial infarction is designated as I-. Borderline or

indeterminate perfusion defects are designated as I± (Fig 4). Like CT FFR, a perfusion defect without a concordant anatomic lesion is labeled as I- if the reader is confident of a false-positive test result and I± if the reader is not confident. Modifier N can be applied to nondiagnostic CT FFR and myocardial CTP examinations.

### Modifier E

The original CAD-RADS classification system did not account for nonatherosclerotic coronary abnormalities such as dissection, fistula, aneurysms, and extrinsic compressions, among others (2,7). Although these processes are uncommon and may not cause significant hemodynamic obstruction, they are now increasingly recognized. Consequently, the modifier E has been introduced to indicate the presence of an exceptional situation.

### Management

With the implementation of plaque burden assessment, minor changes in management recommendations have also been introduced, including a more aggressive risk factor modification and preventive pharmacotherapy for patients with nonobstructive coronary artery disease (CAD-RADS 1 or 2) but P3 or P4 designations compared with those with P1 or P2. Additionally, for patients with CAD-RADS 3/I+, invasive angiography is recommended if they are likely to benefit from coronary revascularization.

	Rest CTP	Stress CTP	Definition	Interpretation
<b>I+</b> (Abnormal- Ischemia present)	 Negative	 Positive	Reversible perfusion defect	Myocardial ischemia in a defined coronary territory
	 Positive, small	 Positive, larger	Peri-infarct ischemia	Peri-infarct ischemia in a defined coronary territory
<b>I-</b> (Normal- No ischemia)	 Positive	 Positive	Fixed perfusion defect	Myocardial infarct but no ischemia in a defined coronary territory
	 Negative	 Negative	No perfusion defect	No evidence of myocardial ischemia in a defined coronary territory
<b>I+-</b> (Borderline/ indeterminate)				Borderline or indeterminate results for myocardial ischemia. Or discordance between perfusion defect and anatomical finding, with low diagnostic confidence

**Figure 4.** Modifier I in myocardial CTP. A perfusion defect at CTP without a concordant anatomic lesion can be classified as modifier I- if the interpreting reader is confident that the CTP result is positive. It is classified as modifier I+/- if the reader deems it indeterminate.

## Conclusion

CAD-RADS has been validated and has gained wide acceptance in the cardiac imaging community. The new iteration of CAD-RADS carries on with classification based on maximum degree of stenosis, adding new modifiers for plaque burden, ischemia, and exceptional situations.

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