CAD-RADS: A Giant First Step Toward a Common Lexicon?

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Coronary computed tomographic angiography (CTA) use is growing rapidly, and multiple studies have shown its value in improving patient care. However, CTA providers range across the cardiology and radiology specialties and have developed their own styles of reporting. This can bring some variability in the way test results are reported. The presence of a common lexicon linking reporting phrases to actionable recommendations will simplify reporting structure and communication to end users. Such standardized, terminology-based recommendations have been adopted in breast, liver, and prostate imaging, and such an approach greatly helps clinicians understand what a report means and what should be done next. Despite some early teething troubles and controversy (1,2), these programs have come to stay and have possibly improved patient care. Nothing similar exists for CTA.

The Coronary Artery Disease - Reporting and Data System (CAD-RADS), published in this issue of iJACC (3), is a first step in this direction. It is a welcome collaborative effort by the radiology and cardiology communities, supported by other involved societies, an exemplary attempt to take the best ideas from all stakeholders with an eye toward improving patient care. The inclusion of diverse parties in the development process helped promote consensus and facilitated acceptance of the first reporting and data system, the Breast Imaging Reporting and Data System (BI-RADS), and we are sure this collaborative effort will bear similar fruit.

CAD-RADS is a living document curated by an outstanding team of CTA investigators and is likely to evolve rapidly as new data become available. We are surely excited about this first effort, but we are also cautious, as there may be varying viewpoints among our readership regarding the place, strengths, and limitations of this consensus document. Numerous items might need deeper reflection: How similar is using CTA for coronary artery disease (CAD) to using imaging for cancer? Who will use these recommendations? Is such a hierarchical classification of severity valid? Can a global per patient score sufficiently capture all the useful information in a data-rich modality such as CTA to make a “what to do next” recommendation? To begin a healthy discussion, the editors of iJACC endeavored to summarize areas of uncertainty in current practice and create a wish list of what we would like to see in the future as this document updates itself.

ADVANTAGES OF THE REPORTING AND DATA SYSTEM APPROACH FOR CTA

The benefit of a well-defined and common lexicon is immediately obvious, and creating a uniform language has enormous implications; it forms the basis of consistent expression, enhances communication, suggests the best course of action in patient care, and generates uniformity in the acquisition of research data. Linking specific diagnoses to logical recommendations for downstream actions on the basis of current best evidence is likely to improve consistency in patient care across the spectrum of care providers with varying expertise. Although this document does not specifically endorse formal structured reporting,
it certainly will help in auditing, data mining, and education.

**DOES AN APPROACH SUCH AS BI-RADS REALLY FIT A DISEASE SUCH AS CAD?**

The intent of CAD-RADS involves 3 central elements: 1) a standardized method of reporting coronary CTA; 2) providing a single per patient severity score that is the highest grade coronary artery lesion in any major vessel (i.e., compressing information of the whole angiogram into 1 code that is thought to have a direct, evidence-based linkage to a downstream actions); and 3) providing management recommendation(s) to the referring physician that are linked to the severity score. This philosophy directly emanates from the successful BI-RADS experience.

Any reading of the history of BI-RADS clearly shows why it was needed. Before BI-RADS, descriptors on a breast imaging report were somewhat vague and confusing; the probability of cancer after reading the report often remained unclear, hedged with loose, nonuniform terminology, and referring physicians did not clearly know the next course of action. Breast imaging needed a common lexicon and a definitive concluding statement of risk. CTA is generally not plagued with vague descriptors of stenosis; the severity may be debatable, but the presence or absence of stenosis (and/or atherosclerotic plaque) is rarely controversial, unlike the presence or absence of early cancer on breast imaging. Furthermore, cardiologists know exactly what to do when a certain anatomy is described. Thus, a CAD-RADS score, which constrains the rich information otherwise present in an angiography report into the 1 most severe number, may not be operatively useful in day-to-day cardiology practice. Although CTA reporting indeed had some problems common with older (pre-BI-RADS) breast imaging reports, these problems were not in the anatomic descriptors or what to do with descriptors such as “severe stenosis”; the problems have been associated with the validity of a positive result and our ability to accurately predict and classify stenosis severity with good specificity (4,5). Given that CAD-RADS and its recommendations are based heavily on an accurate positive predictive value, which happens to be lower for CTA in general, what CAD-RADS would add to clinical decision making will remain debatable until the positive predictive value of the test itself is improved. Second, in breast cancer imaging, BI-RADS suggests next steps, such as follow-up frequency, more imaging to clarify a suspicious region, or need for a definitive diagnostic test such as biopsy: a higher score predicts increasing likelihood of malignancy on the biopsy. In CAD, CTA itself is the definitive diagnostic test for CAD to a large extent, and a higher CAD-RADS score has little to do with the diagnosis of CAD. Finally, unlike breast or lung imaging, in which the pathology, such as the cancer, is central to what to do, calling out a lesion with CTA is but a small component in the chain of action in CAD. Thus, having a per patient severity level wrapped with a recommendation is less beneficial. In fact, the highest grade coronary artery lesion score in many cases might be the least important variable for recommending intervention. For instance, a chronic total occlusion of a non-LAD vessel might have the worst score (CAD-RADS 5) but the least urgency, with fewer proven and efficacious options than, say, an 80% lesion in the proximal left anterior descending coronary artery (CAD-RADS 4).

**CAD-RADS: DEFINING THE HIERARCHY OF SEVERITY**

CAD-RADS assumes a “hierarchy of badness” that may possibly be a bit misplaced in the clinical context. The most “severe” suspicious feature dominates the final assessment and recommendation in cancer imaging, but this may not be true with CAD; in fact, “severe stenosis” may not be the main attribute of a vessel associated with future hard events such as death and myocardial infarction (6), and a stenosis may predict risk not through its severity but by being a marker for extensive atheroma in the coronary tree (7). Furthermore, in a coronary bed with massive treelike arborization of vessels, stating the greatest severity level is but 1 cog in the whole prognostic and therapeutic wheel, which includes the location, severity, and nature of stenosis; the cumulative degree of obstructive pathology; microvascular structure and function; the health and viability of the subtended bed; the presence of ischemia; and how the physiology of the end organ is altered (e.g., left ventricular function). All of these combine to determine if, when, and how to intervene, as well as outcomes. All a single code could do is generate a referral from a less informed clinician.

Are we introducing a degree of precision into the report that the underlying method may not have, and will this generate unnecessary downstream testing? A coronary stenosis is meant to be graded into fine categories: 0%, 0% to 24%, 25% to 49%, 50% to 69%, >70%, and chronic total occlusion. How good is our ability to define this level of precision in grading stenosis, and is it at all clinically relevant? CTA is not a very good tool for predicting the precise degree of stenosis, even though it is an excellent test to exclude...
a flow-limiting stenosis (5). This is even truer in smaller vessels, calcified vessels, and stented segments. Most practices thus provide a range of stenosis severity (e.g., 0% to 30%, 30% to 70%, and >70%) rather than a precise number. Could we be introducing precision that is not to be, at least at present? From a practical viewpoint, if the intent is to provide a global recommendation to inform the decision of whether to refer or treat, a more clinically relevant range, such as flow-limiting, probably flow-limiting, and non-flow-limiting, might make it more relevant to primary care physicians and easier to adopt. Similarly, there is really little practical difference in recommendations for the various sub-50% stenosis categories anyway.

**CAD-RADS: WHO IS THE INTENDED END USER?**

It is also important to ask who is the intended end user of CAD-RADS. The diagnostician (imager) and treating clinician are often different for patients with breast cancer, while they can quite often be the same individual in CAD CTA (e.g., cardiology practices). Cardiologists very likely will find the CAD-RADS score a downgrade from what they can derive from CTA. Even those cardiologists who do not perform CTA are very familiar with coronary angiography (after which CTA is modeled), the nomenclature of which is the basis for intervention in CAD. These clinicians are again probably not informed by the CAD-RADS score.

The document is centered on facilitating decision making at the level of the referring physician by giving a per patient level of most severe disease in the report. It does not matter where the most severe lesion is located, and the mere presence of one is enough to trigger downstream actions, including referral to an expert, ordering further noninvasive testing, or instituting guideline-based preventive therapy. If so, it will cater mainly to primary care physicians or general practitioners with modest expertise in managing CAD. Very few primary care physicians directly order CTA in a system in which a radiologist is not reading or coreading with a radiologist. CAD-RADS might appeal to them, but they would ordinarily base their primary prevention efforts on standard national guidelines (which are well validated) and not on the reporting and data system recommendations (which are expert opinion and not robustly validated, as are the Framingham, Adult Treatment Panel III, and pooled-cohort equations); anything more concerning on CTA is likely to generate a referral to a specialist anyway.

**CAD-RADS AND RECOMMENDATIONS FOR FURTHER NONINVASIVE TESTING**

Should CAD-RADS recommend further noninvasive testing in some circumstances, such as angiographic stenosis of 50% to 69% (CAD-RADS 3) or 70% to 99% (CAD-RADS 4A), as seen in Table 2 (3)? This might be rational but could result in test stacking in what is likely to be a large group of patients with CAD-RADS 3 (which is what high-quality imaging should prevent). Worse, it could in some instances become somewhat dangerous for the wrong audience, such as a general practitioner or an internist who orders a stress test in a patient with atypical chest pain and CAD-RADS 4A, which includes 70% to 99% lesions even in the proximal left anterior descending coronary artery, on the basis of the CAD-RADS recommendation. Myocardial ischemia strongly predicts long-term outcomes (8). Although there are fewer data for CTA, a similar association has been seen with events in proportion to plaque burden (9). Thus, recommending a noninvasive test for angiographic stenosis of 50% to 69% (CAD-RADS 3), apart from conveying uncertainty of the stenosis severity with CTA, could just end up layering diagnostic tests. Once the anatomy is known and high risk substrate is excluded (which CTA can do with fairly good confidence), many would ask why patients with CAD-RADS 3 should not be just treated medically, as an invasive approach is often not needed unless the patient is unresponsive to medical therapy. In fact, this highlights the spectrum of the problem with the global recommendations in CTA-RADS: a score of 3 could represent a largely benign condition (say, 50% to 69% stenosis of an obtuse marginal branch or a posterior lateral artery) or a more concerning condition needing further thought (say, 50% to 69% stenosis of the proximal left anterior descending coronary artery). In the same vein, in general, CTA is good for ruling out (high sensitivity and negative predictive value) rather than ruling in (low specificity and positive predictive value), and its performance, as with all diagnostic tests, depends on the pre-test probability of CAD in the patient, something CAD-RADS cannot account for. Thus, CAD-RADS 3 might in some hands generate more downstream testing than not doing CTA in the first place!

**CAD-RADS: RECOMMENDATIONS FOR REPORTING VULNERABLE PLAQUE**

Perhaps the most contentious segment in these recommendations might be those for “vulnerable
plaque.” The CAD-RADS guidelines recommend noting (using “V”) features of a high-risk plaque (HRP) (positive remodeling, low-attenuation plaque, spotty calcification, and the napkin-ring sign) and make definite recommendations, such as “consider hospital admission with cardiology consultation in the emergency room chest pain patients with 25-49% plaque (CAD-RADS 2V)” or “consider more aggressive management/further testing with invasive coronary angiography instead of non-invasive functional testing with CAD-RADS 3/V.” Although they appropriately caution that management decisions should ultimately be made on an individual basis, taking into consideration all supporting clinical and laboratory data, many would argue that there are few data supporting these recommendations. For one, although CTA studies have reported higher acute coronary syndrome event rates on follow-up associated with certain HRP characteristics, there is very low prevalence and low positive predictive value of these plaques (10,11). Furthermore, the total event rates over the long term are no different between the plaques with and those without the high-risk features. The event rate for HRP may be 10-fold higher than for non-HRP over up to 10-year follow-up, but the prevalence of the latter plaques is 10-fold higher (12). Only those plaques that progressively enlarge over time probably result in major adverse cardiovascular events during follow-up; we do not know the ideal interval for serial CTA, nor do we know which HRP or non-HRP is likely to progress and which will resolve. Nearly 90% of patients with HRP in the nonculprit vessel enrolled in the PROSPECT study remained event free over 3.4 years of follow-up. HRPs change or come and go all the time; in fact, most transform into low-risk plaques (13). Finally, we do not know which of the many plaques in a given patient will respond adequately to aggressive therapy with CTA-verified regression of the lipid-rich cores and which will not. While appending “V” to a score might be good for future research purposes, it is unlikely to have a clinical impact at present, and there is the danger that some might indulge in aggressive treatment approaches on the basis of CTA without a robust current evidence base to support it.

**CAD-RADS: WISH LIST FOR THE FUTURE**

We are without question enthusiastic supporters of the CAD-RADS concept, so what would we like to see in its next iteration? The committee could consider some of the following in their future deliberations:

1. If a reporting and data system score is still considered the best way to go forward, the committee could probably consider the following:
   a. Have a more focused concluding statement of risk on the basis of evolving data; this could be something like “this CTA anatomy has an X% chance of resulting in fractional flow reserve <0.8 or an X% chance of corresponding to a >10% ischemic territory on noninvasive imaging.” This will better clarify for nonspecialist referring physicians what the best next steps should be, on the basis of the CTA report. Fractional flow reserve by CTA and perfusion methods in the future might make this easy, and the committee may want to consider suitable modifiers for perfusion and computed tomographic fractional flow reserve for future use.
   b. Categorize the endpoint-specific downstream “next steps” into practically useful therapeutic subsets; something like “consider doing X for relief of angina or relief of ischemia” or, if and when future evidence permits, “consider doing X to mitigate hard endpoints such as death and myocardial infarction.”
   c. A CAD-RADS score for each of the 3 major vessels and territories would probably be more useful for estimating risk and future steps. It would also be consistent with emerging evidence if a descriptor for the size of the bed subtended or at jeopardy were added.

2. The committee might want to consider more focused recommendations concerning further testing. Recommend additional noninvasive testing only if the results of CTA are not definitive and pre-test probability is concerning. If a lesion is clearly in the probably flow-limiting range (50% to 69%) and there is no other clear reason for intervention, a recommendation for further noninvasive testing should be made only if there is another pressing reason. Similarly, recommending angiography should be restrained in a CTA report without active concerning ischemia, failure of medical therapy, or strong patient preference for the invasive route. That decision making is best left to the expert clinician dealing with the patient who knows the patient’s wishes.

3. Consider collapsing the categories of 0% to 25%, 25% to 50%, and so on, into actionable categories for primary care physicians referring patients for CTA, with flow-limiting, probably flow-limiting, and non-flow-limiting as an option. This would be in keeping with the current test performance evidence for CTA.
4. Import coronary artery calcium scoring and pre-test probability data, if possible, into the CAD-RADS recommendation; this will help guide non-specialists on what to do with the information.

5. Consider making CAD-RADS recommendations, as much as possible, harmonious with the American College of Cardiology and American Heart Association or European Society of Cardiology guidelines for statin therapy and similar primary prevention measures; some would argue that there are insufficient data at present concerning CTA parameters (especially those not related to coronary artery calcification) to prescribe or withhold statin therapy. Primary care clinicians are well adapted to using national guidelines, and CTA-based recommendations might confuse them and lead to the overuse of CTA for risk stratification.

6. Consider conducting validation studies similar to those performed during BI-RADS implementation to show that these reporting structures really make a difference. Consider simultaneously developing formal structured reporting elements for incorporation into machine-readable databases.

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REFERENCES


