



Guidelines

CAC-DRS: Coronary Artery Calcium Data and Reporting System. An expert consensus document of the Society of Cardiovascular Computed Tomography (SCCT)



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ABSTRACT

The goal of **CAC-DRS: Coronary Artery Calcium Data and Reporting System** is to create a standardized method to communicate findings of CAC scanning on all noncontrast CT scans, irrespective of the indication, in order to facilitate clinical decision-making, with recommendations for subsequent patient management. The **CAC-DRS** classification is applied on a per-patient basis and represents the total calcium score and the number of involved arteries. General recommendations are provided for further management of patients with different degrees of calcified plaque burden based on **CAC-DRS** classification. In addition, **CAC-DRS** will provide a framework of standardization that may benefit quality assurance and tracking patient outcomes with the potential to ultimately result in improved quality of care.

1. Introduction

Radiology has pioneered the generation of documents describing the appropriate reporting and management of several disease states. This remarkable effort began with the landmark BI-RADS (Breast Imaging Reporting and Data System) for breast cancer screening mammograms, continued with LI-RADS (Liver Imaging Reporting and Data System) for patients with chronic liver disease, Lung-RADS (Lung CT Screening Reporting and Data System) for those undergoing CT lung screening for lung cancer, and PI-RADS (Prostate Imaging Reporting and Data System) for MR imaging for prostate cancer. More recently, CAD-RADS (Coronary Artery Disease Reporting and Data System) was developed for patients undergoing coronary computed tomographic imaging for the evaluation of coronary artery disease as an expert consensus document from the Society of Cardiovascular Computed Tomography (SCCT), the American College of Radiology (ACR) and the North American Society for Cardiovascular Imaging (NASCI), and endorsed by the American College of Cardiology.¹ The concept of standardized reporting and treatment through more relevantly structured and comprehensive databases and registries was designed to facilitate clinical communication, including the evaluation of prognosis following particular imaging results and the implementation of appropriate patient management, as well as to facilitate quality improvement.

As coronary artery calcium (CAC) scanning has been integrated into atherosclerotic cardiovascular disease (ASCVD) risk assessment of asymptomatic patients, with incorporation into numerous guidelines and appropriateness criteria, including recently by the Society of Cardiovascular Computed Tomography (SCCT) and Society of Thoracic Radiology (STR),^{2–6} it has become increasingly important to provide a uniform reporting system and easily implemented management recommendations. The **CAC-DRS: Coronary Artery Calcium Data and**

Reporting System will apply to all dedicated CAC scans, as well as to all nongated non-contrast chest CT scans irrespective of the indication, for which CAC analysis has been recommended by the SCCT and STR Guideline.⁵ In addition to the obvious direct clinical benefits, there are implications for research facilitated by the enhancement of databases and registries provided by structured reporting.

2. Clinical value of coronary artery calcium

Risk assessment forms the cornerstone of a personalized approach to ASCVD prevention. While current guidelines recommend initiating risk assessment using a risk factor-based global risk assessment tool, such as the Pooled Cohort Equations,⁷ it is now widely recognized that patients at so-called “intermediate risk”, in whom the decision to treat with preventive therapy is uncertain, may need additional testing for the most appropriate risk stratification.⁸ Indeed, the majority of ASCVD events occur in patients who would have otherwise been considered intermediate risk.⁹ The 2017 SCCT Expert Consensus Statement recommends consideration of CAC testing within the context of shared decision making when the 10-year ASCVD risk using the Pooled Cohort Equations is between 5 and 20%, and in select patients with < 5% 10-year risk including those patients with a strong family history of ASCVD. It also provides treatment recommendation which are adopted in the present document.⁶

CAC is appealing because it is a simple and highly reproducible, low radiation test that offers a direct assessment of the total burden of coronary calcified plaque, integrating the upstream effects of all risk and genetic factors over the life of an individual patient. CAC thereby helps overcome inherent challenges in one-time measures of individual risk factors, e.g., blood pressure, which form the basis for the Pooled Cohort Equations and may be highly variable over time.

Table 1
CAC-DRS category determined risk classifications and treatment recommendations.

a. Agatston Score			
	CAC Score	Risk	Treatment Recommendation
CAC-DRS 0	0	very low	statin generally not recommended*
CAC-DRS 1	1–99	mildly increased	moderate intensity statin
CAC-DRS 2	100–299	moderately increased	moderate to high intensity statin + ASA 81mg
CAC-DRS 3	> 300	moderately to severely increased	high intensity statin + ASA 81mg
b. Visual Score			
	CAC Score	Risk	Treatment Recommendation
CAC-DRS 0	0	very low	statin not recommended*
CAC-DRS 1	1	mildly increased	moderate intensity statin
CAC-DRS 2	2	moderately increased	moderate to high intensity statin + ASA 81mg
CAC-DRS 3	3	moderately to severely increased	high intensity statin + ASA 81mg

*excluding familial hypercholesterolemia.

CAC has substantial high quality evidence substantiating its role as one of the strongest individual tests for determining long-term ASCVD risk in an asymptomatic patient.^{2,3,5,6} More than any other test, CAC improves the discrimination of risk when added to the Pooled Cohort Equations.⁹ The absence of CAC (CAC = 0) is the strongest negative risk marker in clinical practice, identifying patients at very low 10-year risk.¹⁰ Elevated CAC appears to identify patients who might not have been considered candidates for preventive pharmacotherapy, but who may be likely to receive a net benefit from treatment.¹¹ There is now strong data across many studies pointing to a continued value of CAC for risk stratification up to 15 years after testing and beyond.^{12,13} CAC has value for predicting myocardial infarction and stroke, and data points to the value of CAC for predicting other outcomes including dementia and heart failure, as well as hip fracture, pneumonia, and chronic kidney disease^{14,15} or as a generalized marker of overall health. An updated summary of the data supporting the prognostic value of CAC is supplied in the most recent guideline and consensus documents on CAC from the SCCT.^{5,6}

In clinical practice, CAC is used to inform the discussion between clinicians and patients about the likelihood of receiving net benefit from preventive pharmacotherapy with aspirin and statins, but in some cases CAC may also guide a discussion about the intensity of therapy, such as LDL and blood pressure goals. For example, patients with CAC = 0 are much less likely to receive a net benefit from lifetime use of statin and aspirin therapy, while patients with CAC > 100 are at higher ASCVD risk and may be more likely to benefit from therapy.

According to two major cost-effectiveness analyses, CAC is considered to be cost-effective when used in this way in selected intermediate risk patients.^{16–18}

3. CAC-DRS

3.1. Agatston scoring of gated and nongated CT scans (Table 1a)

The Agatston score, a summed score based on calcified plaque area and the maximal density of individual calcified lesions, has been the CAC metric of choice and may be applied to both gated and nongated studies acquired with 120 KV at 2.5–3 mm slice thickness.¹⁹ CAC percentiles based on age, gender and ethnicity, are also routinely reported.²⁰ The traditional CAC risk categories are: 0 = very low risk, 1–99 = mildly increased, 100–299 = moderately increased, 300–1000 = moderate to severely increases and > 1000 = severely increased. Since the management recommendations are the same for 300–1000 and > 1000, they have been combined into a single > 300 category.⁶ The CAC-DRS categories, (Table 1), therefore, range from CAC-DRS 0 for a 0 CAC to CAC-DRS 3 for CAC > 300, with the corresponding management recommendations of the SCCT.⁶

3.2. Visual estimation of non-gated CT examinations (Table 1b)

Visual estimation of the extent of CAC in each artery is simple to perform and has significant prognostic value.²¹ For visual assessment

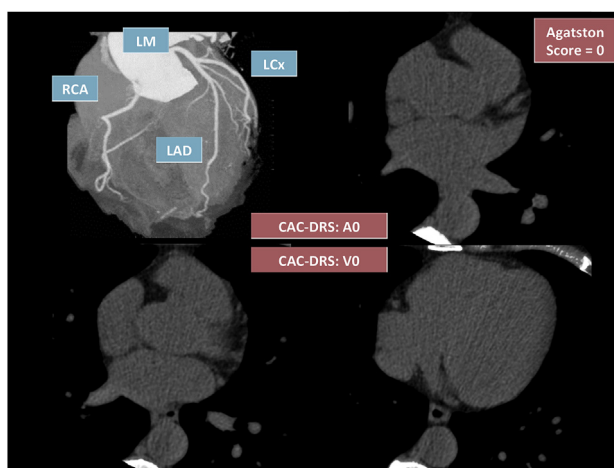


Fig. 1. CAC-DRS category A0 and V0 example. CAC is absent on Agatston (A0) and visual (V0) analyses. Upper left: Absence of CAC in all 4 vessels in volumetric image. Upper right, lower left and right: representative axial images demonstrating absence of CAC at multiple levels. Abbreviation: CAC = coronary artery calcium.

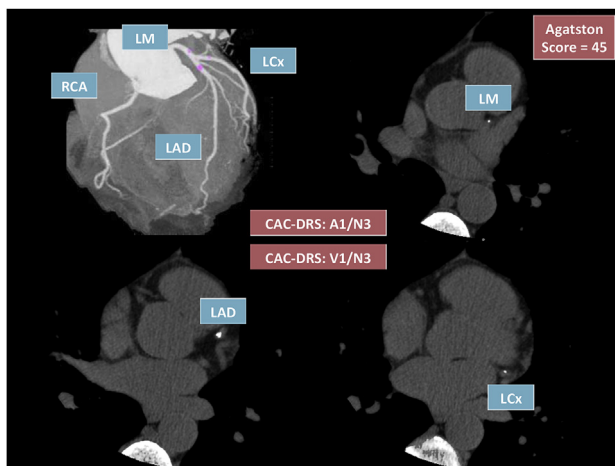


Fig. 2. CAC-DRS category A1/N3 and V1/N3 example. CAC is mild (45) on Agatston (A1) and visual (V1) analyses with 3 vessel involvement (N3). Upper left: Volumetric image- CAC in LM, LAD and LCx. Upper right: Axial image- CAC in LM. Lower left: Axial image- CAC in LAD. Lower right: Axial image- CAC in LCx; Abbreviations: CAC = coronary artery calcium LAD = left anterior descending. LCx = left circumflex LM = left main.

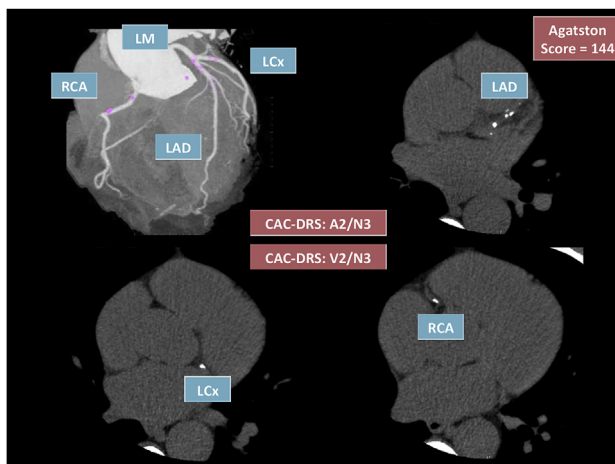


Fig. 3. CAC-DRS category A2/N3 and V2/N3 example. CAC is moderate (144) on Agatston (A2) and visual (V2) analyses with 3 vessel involvement (N3). Upper left: Volumetric image- CAC in LAD, LCx and RCA. Upper right: Axial image- CAC in LAD. Lower left: Axial image- CAC in LCx. Lower right: CAC in RCA. Abbreviations: CAC = coronary artery calcium LAD = left anterior descending. LCx = left circumflex LM = left main RCA = right coronary artery.

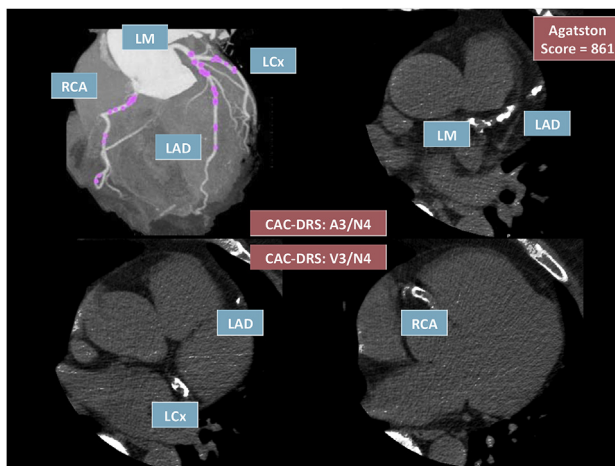


Fig. 4. CAC-DRS category A3/N4 and V3/N4 example. CAC is severe (861) on Agatston (A3) and visual (V3) analyses with 4 vessel involvement (N4). Upper left: Volumetric image- CAC in LM, LAD, LCx and RCA. Upper right: Axial image- CAC in LM and LAD. Lower left: Axial image- CAC in LCx. Lower right: CAC in RCA. Abbreviations: CAC = coronary artery calcium LAD = left anterior descending. LCx = left circumflex LM = left main RCA = right coronary artery.

Agatston Coronary Artery Calcium Report

EXAM: Coronary artery calcium (CAC) score.

INDICATION: Atherosclerotic cardiovascular disease (ASCVD) risk stratification.

Summary:

1. The Agatston CAC score is __ in the __ % for age, gender and ethnicity.
2. CAC is present in the [LM, LAD, LCx, RCA].
3. Extra-coronary calcification.
4. Other findings, if present

CAC-DRS Category [A_/N_]

Management Recommendation

Score	Risk	Treatment Recommendation
0	very low	statin not recommended
1-99	mildly increased	moderate intensity statin if < 75 th %; moderate intensity if ≥ 75 th %
100-299	moderately increased	moderate to high intensity statin; ASA 81mg
>300	moderate to severely increased	high intensity statin; ASA 81mg

TECHNIQUE: Using a [scanner type], a standard prospective cardiac-gated CAC scoring protocol was used for image acquisition. The CAC scan was interpreted using the Agatston score. An age/sex/race-adjusted score percentile was derived by comparison of the score with Multi-Ethnic Study of Atherosclerosis (MESA) reference population. The DLP was [].

TECHNICAL QUALITY: [excellent, good, adequate, poor]

FINDINGS:

The total Agatston CAC score is []. CAC is present in the [LM, LAD, LCx, RCA].

Vessel-level Agatston scoring: LM: [] LAD: [] LCx: [] RCA: []

PERICARDIUM: []

GREAT VESSELS (cm): Ascending aorta [] Descending aorta [] Pulmonary artery: []

EXTRA-CORONARY CALCIFICATION:

[no, mild, moderate, severe] aortic valve calcification.

[no, mild, moderate, severe] thoracic aortic calcification.

[no, mild, moderate, severe] mitral annular calcification

OTHER FINDINGS: No other findings, i.e. clinically significant lung nodules, were present.

Fig. 5. Sample Agatston coronary artery calcium scoring report.

analysis, 0 = none with very low risk, 1 = mild with mildly increased risk, 2 = moderate with moderately increased risk, and 3 = severe with moderately to severely increased risk and the corresponding CAC-DRS categories range from 0-3. Visual analysis may be utilized for noncontrast nongated studies but should not be applied to gated CAC scans.

4. Modifiers

4.1. Scoring system

Even though the CAC-DRS categories have the same implications in the different scoring systems as detailed in Table 1, it is important for the employed scoring system to be documented. The first modifier describes the scoring system: A = Agatston, V = visual estimation.

Visual Coronary Artery Calcium Report

EXAM: Noncontrast Chest CT

INDICATION: []

Summary:

1. CAC is [absent, mild, moderate, severe].
2. CAC is present in the [LM, LAD, LCx, RCA]
3. Extra-coronary calcification.
4. Other findings, if present

CAC-DRS Category [V_/N_]

Management Recommendation

Score	Risk	Treatment Recommendation
None	very low	statin not recommended
Mild	mildly increased	moderate intensity statin if <75 th %; moderate intensity if ≥75 th %
Moderate	moderately increased	moderate to high intensity statin; ASA 81mg
Severe	moderate to severely increased	high intensity statin; ASA 81mg

TECHNIQUE: Using a [scanner type], a standard [image thickness], noncontrast, nongated chest protocol was used for image acquisition and analysis. The CAC scan was interpreted using a visual score. The DLP was [].

TECHNICAL QUALITY: [excellent, good, adequate, poor]

FINDINGS:

The total visual CAC score is []. CAC is present in the [LM, LAD, LCx, RCA].

Vessel-level scoring: LM: [] LAD: [] LCx: [] RCA: []

PERICARDIUM: []

GREAT VESSELS (cm): Ascending aorta [] Descending aorta [] Pulmonary artery: []

EXTRA-CORONARY CALCIFICATION:

[no, mild, moderate, severe] aortic valve calcification.

[no, mild, moderate, severe] thoracic aortic calcification.

[no, mild, moderate, severe] mitral annular calcification

OTHER FINDINGS: No other findings, i.e. clinically significant lung nodules, were present.

Fig. 6. Sample visual coronary artery calcium scoring report.

4.2. Number of involved vessels

The number (modifier N) of vessels with CAC ($n = 1-4$) (Table 1) has been noted to be prognostically additive to the total CAC in a multivariate analysis of the MESA population, particularly in the CAC range of 1-300.²²⁻²⁵ While there are insufficient data to change risk categories based on this parameter, it may influence the aggressiveness of the management in individual cases, and should be reported. The modifier N is not necessary and should not be used if the CAC-DRS grade is 0.

The symbol “/” (slash) should be placed between the grade and the N modifier.

5. Examples

The following are examples for each scoring system, illustrated in Figs. 1–4.

Agatston scoring = A	Number of vessels = N
Case	CAC-DRS Category
i. CAC 0	CAC-DRS A0
ii. CAC 1–99 in LM, LAD and LCx	CAC-DRS A1/N3
iii. CAC 100–299 in LAD, LCX and RCA	CAC-DRS A2/N3
iv. CAC > 300 in LM, LAD, LCx and RCA	CAC-DRS A3/N4
Visual estimation = V	
Case	CAC-DRS Category
i. CAC 0	CAC-DRS V0
ii. CAC 1 in LM, LAD and LCx	CAC-DRS V1/N3
iii. CAC 2 in LAD, LCX and RCA	CAC-DRS V2/N3
iv. CAC 3 in LM, LAD, LCx and RCA	CAC-DRS V3/N4

6. Other cardiac and non-cardiac findings

Thoracic aortic, aortic valve, mitral annular and pericardial calcification and thickness should be reported as none, mild, moderate and severe but are not included in CAC-DRS scoring. Standard main pulmonary artery, ascending and descending aortic measurements should be provided. Non-cardiovascular findings should be reported with specific follow-up and recommendations.

7. Reports

Sample standardized reporting templates for Agatston and visual CAC-DRS scoring systems are provided in Figs. 5 and 6.

8. Discussion

CAC scoring is a well-established tool with extremely robust capacity to stratify the risk of downstream cardiovascular events and death. In multiple large international registries CAC has been consistently shown to be the single best tool for risk discrimination. Unfortunately, despite its fairly straightforward methodology, the clinical reporting of CAC remains inconsistent, particularly at centers where it is infrequently performed and when semi-quantitative analysis is performed on non-ECG synchronized scans. This inconsistent documentation has limited the ability to report on the real world clinical integration of CAC

scoring and the potential incremental value of vessel based segmentation. Standardized reporting with clear designation of the findings offers the potential to assess the reproducibility of the findings in large academic collaborations and helps inform modifications in reporting and recommendations where necessary.

One of the current gaps in knowledge is the lack of robust outcome data across all populations. MESA provides important insight into the outcomes associated with nomographic distribution of calcium in 4 American ethnic populations. While invaluable, these outcomes are only truly applicable in an American healthcare model, and large gaps in ethnic populations persist. Standardized reporting enabling pragmatic data collection across international centers provides the opportunity to be informed about patients for whom there are currently large gaps in knowledge, e.g., South Asian and Middle Eastern individuals. In addition, while treatment recommendations are traditionally nation and healthcare model independent there may be meaningful differences based on care delivery models across the globe. This will offer the opportunity to help define optimal treatment strategies and enable shared learning to inform clinical guidelines with real world large scale knowledge.

Finally, it is important to recognize an inherent limitation of this first iteration of CAC-DRS. In an attempt to enhance clinical adoption we employed a somewhat simplistic approach, despite the many other added data elements and designations that were initially proposed, with the opportunity to mature in an organic fashion as needed.

9. Conclusions

Standardized reporting can help highlight key imaging variables associated with elevated patient risk and facilitate directed patient management. Combined with incorporation of appropriate patient selection based on ACR or ACC appropriate use criteria and SCCT guideline protocol acquisition and image interpretation, this standardized reporting and management completes a comprehensive approach to high quality imaging. Moreover, it allows for incorporation of CAC imaging into electronic health records for documentation of meaningful use and for potential continuous quality improvement programs or for tracking patient clinical outcomes. The SCCT looks forward to continuing the development of high quality clinical documents to impact patient care and patient-centered imaging.

Appendix. Conflict of interest statement

- Relationships to Industry.
- Michael Blaha- Advisory boards for Pfizer, Amgen, Novartis, Pozen, Special government employee of the FDA. Research grants from FDA, NIH, AHA, and the Aetna Foundation.
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- Harvey Hecht- Arineta scientific advisory board.
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- Leslee Shaw- None.

Harvey S. Hecht^{a,*}, Michael J. Blaha^b, Ella A. Kazerooni^c,
Ricardo C. Cury^d, Matt Budoff^e, Jonathon Leipsic^f, Leslee Shaw^g

^a Division of Cardiology, Icahn School of Medicine at Mount Sinai, and
Mount Sinai St. Luke's Medical Center, New York, NY, United States

^b The Johns Hopkins Ciccarone Center for the Prevention of Heart Disease,
Baltimore, MD, United States

^c Division of Radiology, University of Michigan Medical Center, Ann Arbor,
MI 48109, United States

^d Miami Cardiac and Vascular Institute, Baptist Hospital of Miami, 8900 N
Kendall Drive, Miami, FL 33176, United States

^e Division of Cardiology, Los Angeles Biomedical Research Institute at
Harbor-UCLA Medical Center, Torrance, CA, United States

^f Department of Medicine and Radiology, University of British Columbia,
Vancouver, Canada

^g Department of Medicine, Emory University School of Medicine, Atlanta,
GA, United States

E-mail address: harvey.hecht@mountsinai.org

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* Corresponding author.  Mount Sinai St. Luke's Medical Center, New York, NY 10025 , United States.