

Consensus Update on the Appropriate Usage of Cardiac Computed Tomographic Angiography

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Introduction and Purpose

The consensus statement outlined here was formulated following a roundtable meeting among clinical experts in the fields of radiology and cardiology held in Miami, Florida, in June 2007. This group was gathered under the auspices of two key specialty societies supporting the field of computed tomographic angiography (CTA): the Society of Cardiovascular Computed Tomography (SCCT) and the North American Society for Cardiac Imaging (NASCI).

The purpose of the roundtable meeting was to produce an updated consensus on CTA's utility and appropriateness in everyday clinical practice among radiologists and cardiologists. This work does not represent a clinical guideline, rather, it serves as a follow-up consensus statement to the CTA component of the ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR 2006 Appropriateness Criteria for Cardiac Computed Tomography and Cardiac Magnetic Resonance Imaging, and the 2006 AHA Scientific Statement on the Assessment of Coronary Artery Disease by Cardiac Computed Tomography.

Specifically, this consensus statement aims to propose a unified approach for clinicians to adopt in their everyday practice with regard to CTA and its role in diagnosing and evaluating coronary artery disease. It offers updated information on this new, rapidly advancing technology for practitioners who want to incorporate this noninvasive imaging modality into their daily practice. A number of ongoing controversial topics are examined in this document, and a consensus opinion is provided on each

of them in the hopes of guiding practitioners toward more appropriate utilization of this new imaging technology. Whether coronary artery calcium (CAC) scoring should be done prior to CTA, and whether CAC is helpful in determining risk of future cardiovascular events in asymptomatic patients are two such topics covered here, as is the importance of contrast agent selection in CTA. This statement also offers an opinion on the usefulness of CTA in evaluating patients in various clinical scenarios: asymptomatic patients, symptomatic patients with suspected or known coronary artery disease (CAD), patients presenting with acute coronary syndromes in the emergency room (ER), and symptomatic patients with CAD who have undergone previous coronary artery stenting or coronary artery bypass graft surgery (CABG).

A. The Role of Coronary Artery Calcium (CAC) Measurement in Asymptomatic Patients

Consensus

1. CAC is useful in the detection of subclinical atherosclerosis in all ethnic groups.
2. CAC is most useful for risk stratification of patients with an intermediate Framingham risk of future cardiovascular events (10–20% 10-year risk), in whom a high-risk CAC score may prompt an increase in aggressive medical therapy.
3. As set forth by the SHAPE Task Force, CAC screening is recommended for all asymptomatic men 45–75 years of age and women 55–75 years of age who do not have very-low-risk characteristics (absence of any traditional cardiovascular risk factors) or a documented history of cardiovascular disease.
4. In general, CAC cannot at this time be recommended for general screening in unselected individuals or on the basis of self-referral, as it is of limited clinical value in patients at low risk for cardiovascular events (rate < 1.0% per year), and also cannot be used to exclude high-risk patients from medical therapy, even if their CAC score is zero.
5. Routine monitoring of CAC progression through the use of serial CT scanning cannot be recommended at this time.

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Endorsements: This consensus statement is endorsed by The Society of Cardiovascular Computed Tomography (SCCT) and the North American Society for Cardiac Imaging (NASCI).

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B. The Role of Coronary CTA in Asymptomatic Patients

Consensus

1. CTA offers more information than calcium scanning regarding coronary atherosclerosis.
2. We do not have any data on how to and to what level we should treat patients with noncalcified plaques shown on CTA. This is true in general, but is especially relevant for patients with a zero calcium score.
3. Equally, no data exist that would support *not* treating a patient at high clinical risk who has a normal CTA.
4. Although CTA may contribute to refined risk assessment in certain subsets of the population, there are currently no clinical data to support its use or upon which to base therapeutic recommendations. Therefore, it is currently not recommended to use CTA for screening purposes.
5. In a small subset of patients with a very strong family history of premature CAD, *e.g.*, early or sudden death due to heart disease and multiple risk factors, CTA may have a role in early detection and prevention of CAD. However, there are no data to support this.
6. CTA for plaque characterization appears to be feasible in selected patients, but impractical in the general population, due to the high degree of variation in CTA image quality, and because whatever criteria are developed based on high-quality scans cannot be extended to low-quality scans.
7. Plaque volume may be determined with CTA and may be proportional to the degree of coronary risk. It is hypothesized that plaque rupture is associated with a larger plaque volume. The degree of positive remodeling is also associated with an increased risk of having a cardiac event. Involvement of more proximal segments probably carries higher risk than distal segments.
8. It would be useful to develop a system for quantifying noncalcified plaque.
4. Data in symptomatic patients are not available to predict the likelihood of future adverse cardiovascular events based on the presence of calcified or noncalcified plaques on CTA.
5. When compared to conventional angiography, CTA offers additional information regarding the vessel wall that may affect treatment strategy. However, data are not yet available to support this.
6. CTA has high negative predictive value, and the result may provide clinical guidance for a longer period of time than other noninvasive imaging modalities.
7. Physicians may use the calcium score and noncalcified plaque information from CAC and CTA to decide if aggressive lipid-lowering treatment is warranted.
8. CTA has great potential for prognosis, but currently we do not have good outcome data in support of the use of this technology in routine disease management.
9. Until data are available regarding the natural history of coronary arterial atherosclerosis progression on CTA imaging, this modality cannot be recommended for assessment of the effectiveness of medical therapy.
9. Because of the prevalence of false-positive CTA results, practitioners should avoid scanning very low-risk patients.
10. There is a tendency to overcall stenosis severity with CTA in non-expert hands.
11. Stress radionuclide perfusion imaging in the evaluation of symptomatic patients with known CAD or with a high likelihood of CAD is likely to remain an initial test of choice. Data are currently available supporting the use of functional information from stress myocardial perfusion imaging (MPI) in guiding decisions regarding revascularization, and no such data exist at this time for CTA. Furthermore, these patients frequently have extensive coronary calcification, reducing the ability of CTA to rule out significant obstruction with high confidence. Despite this, the Achilles heel of nuclear stress testing is the patient with three-vessel or left main disease, in which CTA may be more sensitive.
12. CTA is particularly useful in symptomatic patients with a low pretest likelihood of CAD, or in whom the pain is unlikely to be cardiac in origin.
13. It is recommended to lower the heart rate for CTA to < 60 beats/minute, for example, through premedication with beta blockers. In general, CTA should include the administration of nitroglycerin immediately before the scan.
14. Technical limitations should be evaluated prior to considering CTA, *e.g.*, heart rate, body mass index (BMI), irregular rhythm, asthma, contrast allergy and renal insufficiency.
15. If CTA reveals stenosis between 50–70%, stress testing is the most appropriate next step before resorting to cardiac catheterization.
16. CTA may replace diagnostic catheterization in patients undergoing noncoronary cardiac surgery, *e.g.*, valve replacement or repair, cardiac tumor or repair of congenital heart disease.

C. The Role of Coronary CTA in Symptomatic Patients with Suspected CAD

Consensus

1. CTA is useful in ruling out the presence of significant coronary stenosis.
2. According to the National Cardiovascular Data Registry (NCDR) CATH-PCI, nearly 37% of cardiac catheterizations are normal and were generated from false-positive stress/stress perfusion tests. CTA is useful in the evaluation of symptomatic patients with equivocal or discordant results on a stress perfusion or wall motion study.
3. Many practitioners feel that any degree of stenosis due to calcified or noncalcified plaque on CTA should be treated aggressively with a statin and aspirin, although there are no data to support this. The goal of statin therapy in this setting, generally, is to decrease low-density lipoprotein (LDL) cholesterol to < 70 mg/dl.

D. The Role of CTA in Symptomatic Patients with Known CAD

Consensus

1. Patients with known CAD, *i.e.*, those with a very high pretest probability of having significant CAD and who are experiencing active chest pain, should be taken straight to the catheterization laboratory.
2. Patients with high pretest probability may not be the appropriate candidates for CTA because of a higher positive predictive value of stress MPI and other forms of stress functional testing.
5. CTA is not ready to replace diagnostic catheterization prior to CABG.
6. CTA may be useful in patients with known CAD to rule out progression of disease and presence of new disease in other vessel territories, though technical limitations exist in imaging patients with known CAD and prior angioplasty, stenting and/or CABG.

E. The Role of CTA in the Assessment of Acute Chest Pain in the Emergency Room (for Acute Coronary Syndrome)

Consensus

1. Only a small proportion of emergency room (ER) patients presenting with acute chest pain may be suitable for CTA evaluation due to many exclusionary criteria for the performance of CTA in the ER setting (*see the list of contraindications later in this section*).
2. Unless medically contraindicated, or a very high-quality scanner is available, *i.e.*, with the fastest temporal resolution, the patient should be given a beta blocker in the ER to achieve a heart rate between 45–60 beats per minute in order to acquire the highest possible image quality. The quality standard used in the ER should be even higher than what is used for routine outpatient imaging.
3. Patients who would be considered for stress MPI or echocardiography to determine the nature of their chest pain may be suitable candidates for cardiac CTA in the ER.
4. Any patient who would be sent straight to the catheterization laboratory or to whom a thrombolytic agent would be administered, *e.g.*, a patient with positive cardiac enzymes or acute electrocardiographic (ECG) changes, should not have their evaluation and treatment delayed by first performing a cardiac CTA.
5. It is preferable to wait until morning than to perform a suboptimal cardiac CTA study during the night with suboptimal imaging staff or patient preparation.
6. Although it is generally not recommended to perform “triple rule-out” on a routine basis, it is appropriate to open up the field of view, if clinically indicated, to rule out additional important diagnoses. However, the primary goal is still to achieve the highest-quality coronary CTA study.

Contraindications for CTA in the emergency room:

1. Atrial fibrillation (except in expert hands, and with careful adjustment of acquisition parameters, reconstruction window, ECG editing, higher radiation exposure due to ECG pulsing off, and knowing when *not* to scan);
2. Grade III renal failure (estimated glomerular filtration rate < 60);
3. History of stents and bypass grafts;
4. Hypotensive or shock state;
5. Allergy to iodinated contrast agents;
6. Uncooperative patient.

F. The Role of CTA in the Assessment of Acute Chest Pain in the Emergency Room (“Triple Rule-Out” Protocol)

Consensus

1. The triple rule-out protocol is rarely needed for cardiac CTA in the ER.
2. Currently, it is neither technically suitable nor medically necessary to perform triple rule-out on a routine basis.
3. Optimal protocols for pulmonary embolism, coronary CTA and CTA for aortic dissection differ; a triple rule-out protocol would not be ideal for all three.
4. The consensus recommendation is to first risk-stratify the patient and then perform a specific CT protocol for a specific indication (*i.e.*, CT pulmonary angiogram with or without a CT venogram of lower extremities to rule out acute pulmonary embolism, thoracic and abdominal CTA to rule out acute dissection, and coronary CTA to rule out acute coronary syndrome).
5. The ultimate goal is to perform the highest-quality study for the specific indication, and to avoid a “shot-gun” approach that compromises quality.

G. The Role of CTA in Symptomatic Patients with Known Coronary Artery Disease (Post-Coronary Stenting)

Consensus

1. Not all patients with stents are evaluable by CTA.
2. The evaluability of a stent is very much dependent on the size of the patient and the internal diameter of the stent (> 3 mm stents are more often evaluable).
3. Larger patients exhibit lower image quality due to increases in image noise and reductions in arterial opacification. The general upper limit of the patient’s BMI should be 35–40 kg/m².
4. The positive predictive value of diagnosing in-stent restenosis using CTA is low. This may be improved by performing CTA on patients with a higher pretest likelihood based on their clinical symptoms.
5. Because they tend to be larger, left main stents are evaluable, but not common.

6. The minimum scanner requirement for evaluating coronary stents is \geq 64-slice multidetector-row computed tomography (MDCT).
 7. The presence of calcium in or around the stent can also negatively affect the evaluability of a coronary artery stent.
 8. If symptoms are classic for angina, cardiac catheterization, not CTA, is the appropriate test to perform.
5. Sometimes calcium is so dense that visually there is no need to proceed with the CTA, but this is scanner-dependent due to variation of artifact.
 6. It may be sufficient for clinical purposes to estimate the amount of coronary calcium from the coronary CTA itself, and not perform a separate, unenhanced scan.

H. The Role of CTA in Symptomatic Patients with Known Coronary Artery Disease (Post-CABG)

Consensus

1. The challenge of CTA in post-CABG patients is the evaluation of the native vessels.
2. Depending on the nature and location of the grafts, assessment can be very difficult due to artifacts from the metallic surgical clips.
3. Motion also plays an important role in making it difficult to assess the distal anastomosis of a bypass graft, especially if there are surgical clips at or adjacent to the anastomosis.
4. Functional assessment using stress MPI or echocardiography may be more useful in this group of patients in general, and should be used first rather than CTA, because the question of graft patency is not as important as the functional significance of the grafts and the native vessels.
5. Exceptions include: reoperation bypass mapping of the previous bypass grafts, the setting of aortic dissection, extremely difficult catheterization, or patients who are high-risk for catheterization, *e.g.*, patients with Marfan's syndrome, or who had strokes from previous catheterization due to severe aortic atherosclerotic disease.
6. If CTA is necessary, it is extremely desirable to have documentation of the prior operation before performing the CTA study.
7. It is inappropriate to perform CTA in an asymptomatic patient post-CABG.
8. There is no consensus on the scan range in the presence of internal mammary artery grafts. Some experts have suggested starting from the subclavian artery, and others from just above the aortic arch.

I. Should a Calcium Score Be Obtained before Performing CTA?

Consensus

1. Calcium scoring (CAC) is applied for risk stratification of asymptomatic patients.
2. CTA is for evaluation of chronic or acute chest pain, and does not absolutely need to be combined with CAC.
3. Some centers use CAC to determine if they should proceed with the CTA study, *e.g.*, they establish a cutoff at a score of 1000, above which they will not proceed with the CTA.
4. CAC scoring should be based upon a single scan, not an average of the results of two scans.

J. The Role of Contrast Agent Selection in CTA

Consensus

1. Contrast-induced nephropathy (CIN) is associated with poorer outcomes in patients with chronic renal dysfunction.
2. The major risk of CIN is preexisting renal dysfunction.
3. Most of the published studies on CIN involve intra-arterial use of contrast agents, most commonly in cardiac catheterization.
4. CIN is probably dose-dependent.
5. CIN does not seem to be dependent on iodine concentration.
6. Osmolality and iodine concentration are not necessarily directly related; *e.g.*, in the United States, the highest concentration approved for an iodinated contrast agent is 370 mgI/mL; iopamidol 370 is manufactured at that concentration, and yet has a relatively low osmolality.
7. When comparing high-osmolar to low-osmolar contrast agents, CIN may be related to osmolality.
8. Among low-osmolar contrast agents, including iso-osmolar agents, CIN rates may depend on the individual agent.
9. CIN may take 24 to 96 hours to manifest itself through a rise in the serum creatine level; monitoring of at-risk patients should be continued after scanning.
10. A delayed rash is a type IV hypersensitivity reaction to a drug (or contrast agent). It takes hours to days to manifest itself, resists treatment and may take weeks to resolve, similar to exposure to poison ivy. For patients who suffer such a delayed rash after CT scanning, the contrast agent may be the cause.
11. Urticaria (hives) is a type I hypersensitivity reaction that typically manifests itself immediately and resolves quickly, either with or without specific treatment. However, care should be taken to ensure that the patient does not suffer a more serious type I reaction such as throat edema, bronchospasm or shock.
12. As a direct effect, contrast media may cause vasodilation, leading to a decrease in blood pressure that may be associated with some pooling of contrast in major vessels. Data do not demonstrate a difference in heart rate response to iso-osmolar versus low-osmolar contrast agents.
14. The deep breath taken and held during contrast agent administration for coronary CTA could result in a Valsalva maneuver and delay entry of the contrast agent into the heart.
15. In general, the higher the iodine concentration, the better the quality of the CTA study due to improved vascular opacification.

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