

Future of cardiac computed tomography

Carlo N De Cecco, U Joseph Schoepf

Carlo N De Cecco, U Joseph Schoepf, Division of Cardiovascular Imaging, Department of Radiology and Radiological Science, Medical University of South Carolina, Charleston, SC 29425, United States

U Joseph Schoepf, Division of Cardiology, Department of Medicine, Medical University of South Carolina, Charleston, SC 29425, United States

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Correspondence to: Carlo N De Cecco, MD, PhD, Division of Cardiovascular Imaging, Department of Radiology and Radiological Sciences, Medical University of South Carolina, 25 Courtenay Drive, MSC 226, Charleston, SC 29425, United States. dececco@musc.edu
Telephone: +1-843-8763185
Fax: +1-843-8763157

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Abstract

Coronary computed tomography angiography (CCTA)

has become an integral tool in the noninvasive diagnostic workup of patients with suspected coronary artery disease in both elective and emergency settings. Today, it represents a mature technique providing accurate, non-invasive morphological assessment of the coronary arteries and atherosclerotic plaque burden. Iterative reconstruction algorithms, low kV imaging, and single-heart beat acquisitions hold promise to further reduce dose requirements and improve the safety and robustness of the technique in several circumstances including imaging of heavily calcified vessels, patients with morbid obesity or irregular heart rates, and assessment in the emergency setting. However, it has become clear over recent years that cardiac radiologists need to take further steps towards the development and integration of functional imaging with morphological CCTA assessment to truly provide a comprehensive evaluation of the heart. Computed tomography myocardial perfusion imaging, including both dynamic and static dual-energy approaches, has demonstrated the ability to directly assess and quantify myocardial ischemia with simultaneous CCTA acquisition with a reasonable contrast medium volume and radiation dose delivered to the patient. In order to promote CCTA in the clinical and research environments, radiologists should prepare to embrace the change from morphological to functional imaging, furnishing all the necessary resources and information to referring clinicians.

Key words: Coronary computed tomography angiography; Coronary computed myocardial perfusion imaging; Functional imaging; Coronary artery disease; Dynamic imaging; Dual energy coronary computed

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Core tip: Coronary computed tomography angiography (CCTA) represents a mature technique providing accurate, non-invasive morphological assessment of the coronary arteries and atherosclerotic plaque burden. Computed tomography myocardial perfusion imaging, including both dynamic and static dual-energy approaches, has

demonstrated the ability to directly assess and quantify myocardial ischemia with simultaneous CCTA acquisition. In order to promote CCTA in the clinical and research environments, radiologists should prepare to embrace the change from morphological to functional imaging.

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In recent years, coronary computed tomography angiography (CCTA) has transitioned through the experimental and clinical validation stages to become an integral tool in the noninvasive diagnostic workup of patients with suspected coronary artery disease in both elective and emergency settings. Today, it represents a mature technique providing accurate, non-invasive morphological assessment of the coronary arteries and atherosclerotic plaque burden with a pooled sensitivity and specificity of 98% and 89%, respectively^[1]. Technical innovations are continuously improving diagnostic performance and decreasing the radiation dose and contrast medium volume necessary for this test. Iterative reconstruction algorithms, low kV imaging, and single-heart beat acquisitions hold promise to further reduce dose requirements and improve the safety and robustness of the technique in several circumstances including imaging of heavily calcified vessels, patients with morbid obesity or irregular heart rates, and assessment in the emergency setting. In parallel with the growth of CCTA, the cardiac radiologist has evolved from the role of a general thoracic radiologist with limited knowledge of cardiac pathophysiology to a specialist with vast expertise in cardiac disease and cutting edge imaging applications.

However, it has become clear over recent years that cardiac radiologists need to take further steps towards the development and integration of functional imaging with morphological CCTA assessment to truly provide a comprehensive evaluation of the heart. In fact, a growing body of evidence has shown that a purely anatomical evaluation of coronary stenosis does not adequately predict hemodynamic relevance and is thus suboptimal for guiding patient management, including the major FAME and COURAGE trials which validated the impact of functional tests in coronary revascularization^[2,3]. In response to this limitation, innovative computed tomography (CT) technology has allowed the derivation of functional data in addition to morphological assessment, providing comprehensive appraisal of both the anatomical and functional aspects of coronary heart disease with a single modality.

CT myocardial perfusion imaging, including both dynamic and static dual-energy approaches, has demonstrated the ability to directly assess and quantify myocardial ischemia with simultaneous CCTA

acquisition with a reasonable contrast medium volume and radiation dose delivered to the patient as long as the scanner technology is recent enough to meet such high technological requirements^[4]. The administration of a pharmacological stressor, including adenosine, regadenoson, dobutamine, or dipyridamole, to induce a hyperemic myocardium, could represent a potential challenge from a radiological point of view. However, as demonstrated in our department, a trained team composed of a radiologist, technologist, and nurse with the support of cardiologists or anesthesiologists can safely handle the administration of these drugs, especially in the case of regadenoson, a selective A2A receptor agonist with limited side effects and convenient administration.

In clinical settings where appropriate CT technology is not available or stress perfusion acquisitions cannot be easily performed, other options are available for the assessment of cardiac function^[5]. CT-based fractional flow reserve (FFR) allows the assessment of flow-limiting stenosis directly from CCTA datasets, without the use of stress agents, additional image acquisitions or contrast medium injections. However, CT-based FFR calculations require the use of dedicated third party off-site post-processing software, significantly increasing the cost and reporting time. In-house dedicated software is under development which could drastically increase the clinical availability and utilization of this technique. Other less advanced solutions in the diagnosis of significant coronary stenosis, including the lesion length/minimal luminal diameter or corrected coronary attenuation (CCO) can be directly calculated from the CCTA dataset without the need for any dedicated software and with sufficient efficacy^[6].

What role, then, should we expect CCTA to play in the standard clinical cardiovascular workup? As CT technology continues to increase the potential for functional assessment in CCTA, we believe the future of cardiac CT is bright.

The volume of CCTA examinations has increased exponentially over the last decade as the technique grew from a niche method performed in the research environment to a routinely used diagnostic test offered in most diagnostic imaging centers. As old scanners are replaced with more advanced versions, an increasing number of hospitals and private diagnostic centers will offer CCTA and it stands to reason that clinician demand will increase. In addition, the aforementioned technological improvements will bring CT-based functional analysis to clinical practice, echoing the rise of morphological CCTA assessment.

In order to promote CCTA in the clinical and research environments, radiologists should prepare to embrace the change from morphological to functional imaging, furnishing all the necessary resources and information to referring clinicians. We are confident in the continued development of this well-established but rapidly growing field and that any challenges to come will continue to promote the role of comprehensively trained cardiac

radiologists aware of their pivotal role in cardiac disease management.

REFERENCES

- 1 **De Cecco CN**, Meinel FG, Chiamida SA, Costello P, Bamberg F, Schoepf UJ. Coronary artery computed tomography scanning. *Circulation* 2014; **129**: 1341-1345 [PMID: 24664217 DOI: 10.1161/CIRCULATIONAHA.113.002835]
- 2 **Pijls NH**, Fearon WF, Tonino PA, Siebert U, Ikeno F, Bornschein B, van't Veer M, Klauss V, Manoharan G, Engström T, Oldroyd KG, Ver Lee PN, McCarthy PA, De Bruyne B. Fractional flow reserve versus angiography for guiding percutaneous coronary intervention in patients with multivessel coronary artery disease: 2-year follow-up of the FAME (Fractional Flow Reserve Versus Angiography for Multivessel Evaluation) study. *J Am Coll Cardiol* 2010; **56**: 177-184 [PMID: 20537493 DOI: 10.1016/j.jacc.2010.04.012]
- 3 **Shaw LJ**, Berman DS, Maron DJ, Mancini GB, Hayes SW, Hartigan PM, Weintraub WS, O'Rourke RA, Dada M, Spertus JA, Chaitman BR, Friedman J, Slomka P, Heller GV, Germano G, Gosselin G, Berger P, Kostuk WJ, Schwartz RG, Knudtson M, Veledar E, Bates ER, McCallister B, Teo KK, Boden WE. Optimal medical therapy with or without percutaneous coronary intervention to reduce ischemic burden: results from the Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation (COURAGE) trial nuclear substudy. *Circulation* 2008; **117**: 1283-1291 [PMID: 18268144 DOI: 10.1161/CIRCULATIONAHA.107.743963]
- 4 **Cannaò PM**, Schoepf UJ, Muscogiuri G, Wichmann JL, Fuller SR, Secchi F, Varga-Szemes A, De Cecco CN. Technical prerequisites and imaging protocols for dynamic and dual energy myocardial perfusion imaging. *Eur J Radiol* 2015; **84**: 2401-2410 [PMID: 25779223 DOI: 10.1016/j.ejrad.2015.02.010]
- 5 **De Cecco CN**, Varga-Szemes A, Meinel FG, Renker M, Schoepf UJ. Beyond stenosis detection: computed tomography approaches for determining the functional relevance of coronary artery disease. *Radiol Clin North Am* 2015; **53**: 317-334 [PMID: 25726997 DOI: 10.1016/j.rcl.2014.11.009]
- 6 **Wang R**, Renker M, Schoepf UJ, Wichmann JL, Fuller SR, Rier JD, Bayer RR, Steinberg DH, De Cecco CN, Baumann S. Diagnostic value of quantitative stenosis predictors with coronary CT angiography compared to invasive fractional flow reserve. *Eur J Radiol* 2015; **84**: 1509-1515 [PMID: 26022519 DOI: 10.1016/j.ejrad.2015.05.010]

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