

Coronary artery imaging with multidetector computed tomography: A call for an evidence-based, multidisciplinary approach

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Modern multidetector computed tomography systems are capable of a comprehensive assessment of the cardiovascular system, including noninvasive assessment of coronary anatomy. Multidetector computed tomography is expected to advance the role of noninvasive imaging for coronary artery disease, but clinical experience is still limited. Clinical guidelines are necessary to standardize scanner technology and appropriate clinical applications for coronary computed tomographic angiography. Further evaluation of this evolving technology will benefit from cooperation between different medical specialties, imaging scientists, and manufacturers of multidetector computed tomography systems, supporting multidisciplinary teams focused on the diagnosis and treatment of early and advanced stages of coronary artery disease. This cooperation will provide the necessary education, training, and guidelines for physicians and technologists assuring standard of care for their patients. (*Am Heart J* 2006;151:945-8.)

Promise and limitation of rapid technological developments

Multidetector computed tomography (MDCT) has witnessed a very rapid technological development over the last few years. The time between introduction of new MDCT scanner generations, with increasing number of detectors and faster tube rotation, has accelerated to a point that published data typically does not reflect the newest level of technology at the time of print. These developments have, in particular, advanced cardiovascular computed tomographic (CT) imaging. Modern MDCT imaging allows comprehensive assessment of cardiovascular anatomy and is used for an expanding range of clinical indications, including imaging of the aorta and pulmonary vasculature. Recent results increasingly demonstrate its value for noninva-

sive assessment of coronary anatomy, including luminal stenosis and atherosclerotic plaque.^{1,2}

Because of its less invasive nature, coronary CT angiography (CTA) is expected to accelerate novel diagnostic approaches that will eventually impact on the prevention and treatment of coronary artery disease (CAD), which remains the leading cause of mortality in industrialized societies.^{3,4} The development and evaluation of MDCT provides unique opportunities across multiple specialties including radiology, cardiovascular medicine, and cardiothoracic surgery. However, the eventual role of MDCT in clinical practice is unclear, and many questions remain regarding its appropriate use. Potential risks are related to the intravenous administration of iodinated contrast material and radiation exposure, which exceeds that of a diagnostic cardiac catheterization.^{5,6} In addition, inappropriate clinical application could lead to unnecessary treatment of low-risk populations and be associated with significant direct and indirect risks to patients. This is particularly important because the prevalence of false-positive or equivocal test result is not known in low- and medium-risk populations.⁷ Therefore, strict clinical selection of patients is necessary until this technology has undergone a rigorous scientific evaluation as the basis for broader clinical guidelines (Table I).^{8,9} The development of such standards, similar to those published for conventional coronary angiography¹⁰ and coronary calcium scoring with electron beam computed tomography,^{11,12} will eventually define an

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Table I. The need for standards and guidelines

Credentialing of imaging centers and physicians
Proper maintenance of the MDCT scanner
Protocol development for specific indications
Assuring control of patient radiation dose
Optimal use of intravenous contrast
Meaningful image evaluation and documentation
Transparent coding and billing
Exchange of information across proprietary software

evidenced-based role of CTA, in comparison with alternative diagnostic modalities, including noninvasive, functional assessment of ischemia (stress testing) and invasive assessment of coronary anatomy (conventional cardiac catheterization). Successful introduction of coronary CTA into clinical routine will likely be associated with changes of current practice patterns, characterized by cooperation between multiple specialties.

The need for an evidenced-based clinical approach

In current clinical practice, the appropriate selection of patients who will likely benefit from coronary assessment with CT is still challenging. The current literature about coronary CTA with MDCT mostly reflects single-center experiences of technical feasibility in relatively small patient populations with known or suspected CAD. The study groups are typically selected for good image quality, excluding patients with high or irregular heart rate and poorly visualized coronary segments secondary to dense calcification. Based on these preliminary studies, a wide range of potential clinical indications for coronary CTA has been suggested, ranging from identification and exclusion of significant luminal stenosis in symptomatic patients to the assessment of subclinical atherosclerosis in asymptomatic patients.

The clinical value has to be evaluated in the context of current standard practice. This can be exemplified by the identification of subclinical disease (for potential pharmacologic interventions aimed at disease prevention) and the identification of luminal stenosis (for potential percutaneous or surgical revascularization).

Published guidelines for disease prevention provide a structured approach to diagnostic assessment and subsequent behavioral, dietary, and pharmacologic interventions.^{13,14} The role of noninvasive imaging, in particular with carotid ultrasound (ie, carotid intima-media thickness) and CT calcium scoring, has been extensively examined but is not yet reflected in current guidelines.¹⁵ In comparison to carotid intima-media thickness and CT calcium scoring, the increased radiation exposure^{5,6} and potential side effects of intravenously administered iodinated contrast media make coronary CTA a less desirable screening test. In

addition, although a large body of literature demonstrates the prognostic value of calcium scoring beyond the assessment of traditional clinical risk factors,¹⁶ comparable results with CTA do not yet exist.

The role of coronary imaging in patients with documented or suspected coronary luminal stenosis is described in clinical guidelines for conventional x-ray coronary angiography published by the American College of Cardiology/American Heart Association.¹⁷ A review of these guidelines demonstrates that only selected patients, generally those with a high pretest probability of obstructive disease, are expected to benefit from evaluation of coronary anatomy. There are currently no data supporting different recommendations for coronary CTA. Moreover, patients with high probability of CAD are not likely to benefit from CTA because this would only confirm the need for invasive, diagnostic/therapeutic catheterization. It has therefore been suggested that CTA is more suitable for selected patients with relative contraindications to invasive angiography and patients with intermediate probability of disease, who are typically referred to noninvasive imaging such as nuclear stress imaging. However, although a large body of literature and clinical experience guides clinical management based on ischemia assessment,¹⁸ such experience does not yet exist for CTA.

Selective applications of CTA may include assessing patients in whom stress imaging has been inconclusive, the evaluation of patients with chest pain in the Emergency Department, triage of symptomatic patients to bypass surgery or percutaneous coronary intervention, the preoperative assessment of patients who are undergoing noncoronary cardiac surgery, patients with valvular disease or acute aortic dissection limiting feasibility of conventional angiography, bypass graft evaluation including assessing the location of internal mammary grafts before reoperation, identification of coronary anomalies, and others.

For these evolving indications, the risk and benefit of coronary CTA for an individual patient should be carefully assessed by the referring physician involved in the clinical care and the cardiovascular imaging specialist supervising the examination. This assessment should be based on an understanding of the clinical need as well as the strengths and limitations of coronary CTA in comparison with invasive angiography and noninvasive stress imaging. The potential consequences of the CT test results on further clinical diagnostic and therapeutic management should also be considered because a positive or equivocal (eg, secondary to dense calcification, high or irregular heart rate) CT result will likely require additional testing. Computed tomographic angiography or a combination of CTA with, for example, stress testing should only be considered if the likelihood to subsequently avoid more invasive tests is high or if other tests are not feasible.

In summary, there is currently no outcome data to support a “screening” approach or non-physician-directed evaluation with coronary CTA. Therefore, aggressive commercialization including direct consumer advertising should be carefully avoided. On the other hand, it is likely that the less invasive nature of coronary CTA will shift the risk/benefit balance and eventually lead to the expansion of the clinical indications for coronary CTA, complementing imaging with conventional angiography and stress imaging. There is a need for large studies evaluating the clinical impact and cost-effectiveness of coronary CTA in comparison with cardiac catheterization and stress imaging. Eventually, clinical recommendations will be based on growing experience and evidence from such controlled clinical studies.

The need for a multidisciplinary approach

Multidetector computed tomography technology is continuing to evolve with rapid half-life, as 16-slice CT is superseded by 40- and 64-slice scanners and 128- and 264-detector systems, multiple tubes, dual energy, flat panel technology, and more sophisticated post processing systems are developed.² Simultaneous developments occur in the areas of electron beam computed tomography, magnetic resonance imaging, and nuclear imaging (positron emission tomography). Multidetector computed tomography may eventually become part of other acquisition strategies as advances in imaging technology continue and technologies combine.

To integrate the rapid technical development and evolving clinical applications, the evaluation of coronary CTA will benefit from cooperation between clinicians from multiple medical specialties and imaging physicists. Guidance by clinicians involved in direct patient care and treatment is crucial for clinically meaningful applications. Cooperation with imaging physicists will allow the development of scanner technology addressing remaining limitations for clinical use, including radiation dose, motion artifact, and blooming artifact secondary to dense calcification and metallic material (eg, coronary stents). In the face of changing scanner technology, it is also important to constantly adjust technical aspects of the imaging protocol to specific clinical indications, balancing the need for optimal anatomic and functional detail on the one hand and concern about contrast agent load and radiation dose^{5,6} on the other. Linking clinical and technical advances, dedicated clinical cardiovascular imaging specialists will direct the acquisition and interpretation of clinical studies and lead the scientific development of MDCT.

As reflected in recent clinical consensus statements from the American Colleges of Cardiology and Radiology, cardiovascular imaging specialists with

different specialty backgrounds should obtain competence from additional training and experience in tomographic imaging. This should include an understanding of basic physics, normal and abnormal cardiovascular anatomy, and extracardiac findings, which are frequently identified with cardiovascular CT and a more integral part of the study than in echocardiographic and magnetic resonance imaging examinations.^{8,9,19}

Multidisciplinary teams of specialists from radiology, cardiovascular medicine, and cardiothoracic surgery are best suited to lead the clinical and scientific evaluation of noninvasive coronary imaging with coronary CTA. This will include not only conventional applications in comparison with angiography but also new paradigms of atherosclerosis, including the assessment of subclinical CAD.²⁰⁻²³ Interdisciplinary cooperation will likely also affect current practice patterns. A typical CT practice involves the technologist-driven acquisition of large numbers of CT scans and the physician-directed evaluation of the images. In contrast, a conventional angiography laboratory is characterized by a smaller number of examinations, which are performed by a physician who is directly involved in clinical decision making. Modern CTA practices may require a combination of both, a more customized examination with more cooperation between referring clinician and reading physician than in traditional CT practices, but less involvement in clinical decisions than in conventional angiography laboratories. In this context, clinical guidelines will have to address the issue of self-referral. A careful scientific and clinical evaluation will eventually lead to new practice models and modification of organizational structure. It will also impact on current models of training and may lead to the “morphing of cardiovascular specialists.”²⁴

Conclusion

Modern MDCT systems are capable of a comprehensive assessment of the cardiovascular system, including noninvasive assessment of coronary anatomy.

Multidetector computed tomography is expected to advance the role of noninvasive imaging for CAD, but the eventual clinical role of MDCT is still unclear. Computed tomographic angiography or a combination of CTA with ischemia assessment (stress testing) should be considered if the likelihood to avoid more invasive tests is high or if other tests are not feasible.

Eventually, guidelines are necessary to standardize scanner technology and appropriate clinical applications for coronary CTA. Further evaluation and validation of this evolving technology will benefit from cooperation between different medical specialties, imaging scientists, and manufacturers of MDCT systems, supporting multidisciplinary teams focused on the diagnosis and treatment of early and advanced stages of CAD. Such a

collaborative environment of discovery will provide the necessary education, training, and guidelines for physicians and technologists and assure standard of care for their patients.

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