Introducing *Radiology* Select: *Coronary Artery Disease*

Radiology Select

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Introduction

We are pleased to present volume three in the *Radiology* Select series, *Coronary Artery Disease*. This volume features 34 articles published in the journal from 2005 to 2011, focused on computed tomography (CT) and magnetic resonance (MR) imaging applications for the assessment of coronary artery disease (CAD). The field of noninvasive imaging of CAD by using CT and MR imaging has attracted great attention and made great progress. Technical developments in cardiac imaging often address the requirements for controlling motion from several sources, which is commonly challenging (1–3). Coronary plaques are at the core of the pathophysiology of CAD (4), leading to coronary artery stenosis that may result in myocardial ischemia detectable with the aid of perfusion imaging. Rupture of vulnerable coronary plaques may lead to coronary occlusions and emboli, which are the basis for myocardial infarctions that can be visualized on viability images obtained with delayed contrast agent–enhanced CT or MR imaging. The diagnostic accuracy of CT and MR imaging for the identification of flow-limiting coronary stenosis and the relationship between such stenosis and ischemia and infarction are pivotal in understanding the clinical effect of the imaging technology. The integrated assessment of coronary artery stenosis and the status of the myocardium distal to the stenosis by using a single imaging test is the "holy grail" of noninvasive cardiac imaging and still has not been fully accomplished by using CT or MR imaging.

Publications about CT of the heart have increased exponentially over the past several years (5). Many publications about cardiac MR imaging have been seen, with contributions from radiologists, physicists, and cardiologists (6). The articles for *Radiology* Select: *Coronary Artery Disease* were chosen to provide a comprehensive overview of CAD detection with CT and MR technologies and are structured as follows: reviews, technical developments, diagnostic accuracy and noncardiac findings, prognostic value, noninvasive coronary angiography, myocardial perfusion and viability imaging, and comprehensive diagnosis of CAD. We had to omit many excellent articles about CAD published in *Radiology* owing to space constraints and thematic selection of the various topics.

Reviews

Excellent introductions to the topics of CT and MR imaging of CAD were given by Bastarrika et al (7) and Finn et al (8), respectively, while Wu et al (9) presented all aspects of cardiovascular molecular imaging. Dewey (10) and Sakuma (11) recently reviewed the pros and cons of coronary CT and MR angiography.

Video
Online Education Edition and Tablet Edition of *Radiology* Select include a video with guest editors Marc Dewey, MD, PhD, Karen G. Ordovás, MD, MAS, and Albert de Roos, MD.

Technical Developments

Several breakthrough articles on technical developments in CAD imaging have been published in the journal (12–17). In cardiac MR imaging, automated quantification appeared to be a very relevant technical development in recent years (12,13). Automated quantification of cardiac function by means of MR imaging in the publication by van Geuns et al (12) was shown to correlate well with manual segmentation, with reduced interobserver variability. Heiberg et al (13) analyzed animal, phantom, and human data by using an automated approach that accounts for partial volume effects and showed this to be a less variable method for quantification of myocardial infarction at delayed-enhancement MR imaging. Whether very high field strengths improve coronary MR imaging or merely help achieve the same outcome as 1.5- and 3.0-T MR systems is still a matter of debate. Using qualitative as well as quantitative parameters for image quality assessment, van Elderen et al (14) showed the feasibility of selective coronary artery imaging at 7.0-T MR imaging in young healthy volunteers with potential improvements in image quality. Fast automated quantification of noncalcified coronary plaque by means of coronary CT angiography was presented by Dey et al (15) with good correlation in comparison to intravascular ultrasonography by demonstrating the feasibility of this noninvasive approach for estimating coronary plaque burden. Reducing radiation exposure of CT for CAD detection is an important clinical goal, and optimized electrocardiographic pulsing has been shown to allow this while preserving diagnostic accuracy (16). Owing to increasing computing power at reasonable prices, raw data–based iterative reconstruction is now feasible for radiation dose reduction in clinical practice. However, iterative reconstruction can also be used to decrease image noise and blooming from coronary calcification, which may lead to increased diagnostic accuracy if compared with filtered back projection, as shown by Renker et al (17).

Diagnostic Accuracy and Noncardiac Findings

The diagnostic accuracy of coronary CT angiography is greatly influenced by the pretest likelihood of CAD. As shown by Genders et al (18), the optimal diagnostic workup depends on the symptoms and risk factors of patients. The evidence-based assessment of cardiac CT is reviewed by Heffernan et al (19), who demonstrate how these findings can be implemented in clinical practice. The extent of coronary calcification also influences the accuracy of CT angiography for detecting significant stenosis, as described by Vavere et al (20). Kim et al (21) published a large study on noncardiac findings from cardiac CT in over 11 000 patients and found that the use of restricted instead of maximum fields of view resulted in 90% of the lung cancers being missed. This topic was also discussed in Controversy articles by Earls (22) and White (23). This issue is of potential impact for other fields of radiologic imaging, as well, and will continue to draw attention.

Prognostic Value

A large single-center study by Dedic et al (24) in over 400 patients showed that coronary CT angiography is a strong predictor of future adverse events that has incremental value over clinical predictors, stress testing, and coronary calcium scores. In a Spanish multicenter study of over 1700 patients, Bodi et al (25) analyzed different MR imaging variables for the prediction of hard cardiac events. In the multivariable analysis, only stress-induced wall-motion abnormalities and myocardial perfusion defects were predictive of major adverse cardiac events. Lim et al (26) analyzed 3000 asymptomatic individuals with coronary CT angiography and found, after adjustment for confounding factors, that metabolic syndrome was significantly associated with coronary artery stenosis, multivessel involvement, and mixed plaque. The performance of coronary CT angiography in asymptomatic subjects is controversial, but new indications for coronary CT angiography may become accepted with further evidence for the appropriateness. Lee and coworkers (27) examined patients with an anomalous right coronary artery that had an interarterial course above or below the level of the pulmonary valve and showed that a high interarterial course was associated with higher prevalence of angina and major adverse cardiac events.

Noninvasive Coronary Angiography

Further reduction in the effective dose of coronary CT angiography is a major goal for further acceptance of the technique in routine clinical practice. Using prospectively triggered axial acquisitions, Earls et al (28) showed improved image quality and the feasibility of greatly reducing effective dose, as compared with those achievable with retrospectively gated acquisitions. Effective β blockade is another important measure to improve image quality and reduce radiation dose by means of heart rate reduction, as reviewed by Mahabadi et al (29). Coronary MR angiography is less dependent on heart rate than CT, and Sakuma et al (30) explored how the technique could be used to achieve study times of less than 30 minutes by using whole-heart MR sequences that resulted in moderate to good accuracy at 1.5 T. Further reductions of imaging time without losses in diagnostic accuracy could be achieved with the addition of 32-channel coils (31). Lin et al (32) showed that coronary distensibility measurements with MR imaging are not only reproducible but may also become a reliable marker of cardiovascular aging. Coronary MR angiography may be used to assess vascular structure in conjunction with vascular function for better characterizing the disease process.

Myocardial Perfusion and Viability Imaging

Because morphologic assessment of luminal coronary artery narrowing as seen with coronary CT angiography, which—similar to conventional coronary angiography—is a poor predictor of myocardial ischemia, additional perfusion imaging may be necessary to determine if a patient might benefit from revascularization therapies. Approximately 50% of patients with obstructive CAD have normal myocardial perfusion; this indicates that only half of stenotic coronary arteries may be hemodynamically significant. Accordingly, it is potentially beneficial to explore the use of cardiac CT or MR for combined anatomic and stress perfusion imaging in patients with CAD (33). Gebker et al (34) confirmed the high per-patient sensitivity and moderate specificity of MR perfusion imaging in a single-center study of about 100 patients. Since coronary CT angiography itself is rather nonspecific for ischemia-related coronary stenosis, the addition of myocardial CT perfusion imaging is promising. In 35 patients, Rocha-Filho et al (35) indicated the incremental value of dual-source CT adenosine-mediated stress myocardial perfusion imaging over coronary CT angiography alone.

Coronary CT angiography combined with myocardial CT perfusion imaging appears to mirror the MR imaging paradigm, which has been established as the reference standard for estimating myocardial perfusion and viability (33). An excellent overview of the past, present, and future of delayed contrast enhancement for myocardial viability imaging with MR imaging is given by Ordovás and Higgins (36). It is important to recognize the serial changes in the size of the area of delayed enhancement in the infarcted region in the acute setting of myocardial infarction. Ibrahim et al (37) showed that the area of delayed enhancement decreases significantly in size between days 1 and 7 after reperfusion of acute myocardial infarction. The size of the enhanced infarct at 7 days best represented the final infarct size at follow-up. Nassenstein et al (38) explored the visualization of small myocardial lesions at late gadolinium enhancement after microembolization. That study revealed that improving spatial resolution is a key factor for better characterization of microinfarcts by using delayed enhancement MR imaging. Carlsson et al (39) recently showed in an animal study that both MR imaging and CT are sensitive enough to depict microinfarcts. Improved characterization of myocardial fibrosis and the periinfarct border on images obtained with late gadolinium enhancement may become important for predicting arrhythmias and sudden death. Accurate estimation of the area at risk for myocardial infarction is important for therapy planning. T2-weighted MR imaging has been advocated for estimating the size of the myocardial area at risk. O'Regan et al (40) used T2*-weighted MR imaging to define hemorrhage after reperfusion in the area at risk. They showed that myocardial hemorrhage leads to underestimation of the area at risk seen on T2-weigthed MR images when using signal intensity threshold criteria.

Comprehensive Diagnosis of CAD

Comprehensive assessment of CAD with a single imaging test would be an important advancement. Foo et al (41) showed that it is feasible to integrate coronary MR angiography after myocardial perfusion in the waiting time before delayed-enhancement sequences for viability imaging without involving additional imaging time. It is not unlikely that CT will catch up to MR imaging for comprehensive imaging of CAD due to the high accuracy of coronary CT angiography and the promising results in myocardial CT perfusion imaging, as shown by Bamberg et al (42).

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