

Coronary MRA: Applications, Needs, and what about CTA?

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Introduction

Heart disease is the leading cause of death in the United States, with coronary artery disease (CAD) the major underlying pathology[1]. Chest discomfort is the most common symptom of CAD. However, many people with symptoms of chest discomfort do not have obstructive CAD. It has been estimated that symptoms of chest pain bring 7 million people to the emergency room every year[2, 3]. It is critical to diagnose the presence of CAD accurately in these patients, so that potentially life-saving treatments can be initiated. Conversely, it is important to rule out CAD quickly and accurately in those presenting with chest discomfort in order to avoid additional, perhaps even harmful, testing and treatment, and inaccurate labeling of a patient with a diagnosis of heart disease. Beyond detecting anatomical coronary stenoses, knowing the downstream effects on coronary flow, myocardial ischemia/infarction, and ventricular function can provide further guidance for patient treatment. Finally, there is a strong need to detect coronary atherosclerosis prior to clinical symptoms and monitor its response to preventive therapies.

Noninvasive stress testing for CAD

Currently, the initial noninvasive diagnostic pathway to detect CAD is typically a stress test. Exercise testing with or without imaging (either myocardial perfusion or echocardiographic) is preferred in patients who can exercise. From 1993 to 2001, the proportion of imaging stress tests have increased nearly three fold so that imaging was used in ~80% of all stress tests. This trend has continued such that in 2005 Medicare data, 91.5% of all stress tests involved imaging and myocardial perfusion studies were estimated to account for nearly 2% of the annual Medicare budget[4]. However, the diagnostic accuracy of stress testing, even with imaging, is approximately 80% in most series, leading to a significant proportion (~30%) of invasive x-ray coronary angiography in patients ultimately found to have no obstructive CAD.

Noninvasive coronary angiography

Both MR and CT coronary angiography have been developed as noninvasive alternatives to standard x-ray coronary angiography. The goal has been to improve on the diagnostic performance of stress testing and thus avoid the need for invasive testing. As coronary MRA studies will be covered in more detail by the subsequent speakers, the focus here will be an update on recent CT angiography studies. The primary technique in current use is 64-slice multi-detector CT (MDCT). Here, 64 slices of data are acquired simultaneously as the scanner rotates, covering the entire heart in under 20 seconds. This yields a 4D "whole-heart" volumetric data set with isotropic resolution on the order of 0.5mm x 0.5mm x 0.5 mm. The scan is timed with arterial passage of iodinated contrast (given IV) and nitroglycerin is given orally to dilate the coronaries. The temporal resolution is typically 150-200ms, so beta-blockers are given to lower the heart rate in order to maximize the duration of diastole (when the heart is not contracting).

There are two recent multi-center studies of 64-slice MDCT (CORE-64 and ACCURACY), comparing CTA to the "gold standard" x-ray coronary angiography.

CORE-64 found a sensitivity of 85%, specificity of 90% and a negative predictive value of 83% in 291 patients[5]. They also reported radiation exposure 15-16 mSv. They concluded that CCTA is not accurate enough in patients with chest pain to replace x-ray coronary angiography. ACCURACY [6] had several advantages over the CORE-64 trial in that it evaluated all patients and all coronary segments, not excluding patients with high coronary calcium scores or coronary segments below a certain size. Furthermore, it studied patients without known CAD, so the prevalence of CAD in this population (25%) was more consistent with a low-to-intermediate-risk population compared to CORE-64 (prevalence of 56%). The major findings in the 230 patients were high sensitivity and NPV (94-95% and 99%, respectively, for both >50% and >70% stenosis analyses) and good specificity (83% for both analyses). However, in this more typical patient population, the PPV was low: 64% and 48%, respectively, for >50% and >70% stenosis analysis. Thus, while the study provides a high NPV using a more real-world evaluation of CCTA, the low PPV numbers raise the concern that a substantial portion of these false-positive patients will be referred on for unnecessary invasive testing.

MDCT technology continues to advance, with the development of dual-source scanners to improve temporal resolution and 256- and 320-slice scanners to allow coverage in 1-2 heartbeats.[7] Also, axial scanning protocols, instead of helical, are now feasible and reduce radiation exposure.[8] Coronary calcium remains a significant cause of indeterminate or false positive CTA studies. Coronary MRA takes longer and typically has a lower spatial resolution than CTA, but performs better with calcified lesions[9], has better temporal resolution, does not involve radiation, and does not require IV contrast. Larger multi-center trials of coronary MRA are needed.

Comprehensive cardiac imaging

Detecting anatomic stenoses alone does not appear adequate to determine which patients will benefit the most from coronary revascularization vs. medical therapy. The recent FAME study showed that even relying on invasive x-ray angiography was not as predictive as relying on downstream hemodynamic effects[10]. Patients who were treated based on the impaired coronary flow had fewer heart attacks than those treated based on the angiogram alone. Cardiac MRI is well established to assess myocardial perfusion, ischemia, and infarction, which may further enhance the diagnostic accuracy and treatment guidance[11].

Subclinical disease

A major goal of cardiovascular imaging is a noninvasive test to identify patients with subclinical disease who are at high risk for future clinical events. Coronary MRA sequences that null the signal from flowing blood have been able to show increased coronary wall thickness in patients with early disease and risk factors[12]. Additionally, coronary functional responses, namely increases in coronary diameter and flow in response to stimuli, have been shown to be impaired in patients with subclinical disease or risk factors[13]. Finally, late gadolinium enhancement of the coronaries has been shown, though the etiology and clinical significance are not well understood[14]. All of these techniques offer methods to better characterize early coronary atherosclerosis. Furthermore, as a noninvasive/non-radiation test, serial coronary evaluation to monitor improvement with therapy is feasible.

Conclusion

In summary, a highly accurate noninvasive coronary angiogram is needed. While the use of coronary CTA has become more widespread, recent results from multi-center

trials are suboptimal and coronary MRA has several inherent advantages. Multi-center trials of the most recent coronary MRA techniques are warranted, with an emphasis on also showing improved outcomes[15]. Included in these evaluations are strategies that combine downstream information about the myocardium to improve diagnostic accuracy and treatment guidance. Finally, a number of MRI techniques exist for studying the coronary wall and vasodilator function. Broader dissemination of the recent developments in coronary MRA to clinical scanners will help with further evaluation and validation as an alternative to CTA in many patients.

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