Contrast Agents for Coronary MRA

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The use of extracellular magnetic resonance (MR) contrast agents is increasing dramatically in all types of body magnetic resonance angiography (MRA) applications (1). A similar trend is developing for coronary MRA. This chapter provides a brief introduction to the topic. The ultimate role of contrast agents for coronary MRA is yet unknown. Thus we opted to keep this chapter rather brief and refer mostly to the peer-reviewed literature on this subject (2).

Most coronary artery MRA images have proton-density-weighted contrast as a direct consequence of the wait interval introduced by the cardiac synchronization. Therefore the signal from stagnant blood, blood clot, or plaque can recover completely and appear as an integral part of the coronary artery (appearing isointense), especially when signal-to-noise ratio (SNR) and resolution are not adequate (3). Contrast agents or preparation pulses (MTC or T2prep) would be very helpful to avoid this problem, and are both being investigated. It is known that coronary artery lumens appear thinner on contrast-enhanced MR images when compared to pre-contrast-enhanced images. This seems to suggest that without contrast the vessel wall and the blood cannot always be distinguished. It may also explain why certain types of coronary lesions are missed with coronary MRA (4,5). Black-blood imaging offers a totally different but complementary approach to this problem (6).

Contrast agents for MRA will cause a dramatic T1 shortening in blood and can yield high-quality breathhold MRA. Using a blood pool agent which remains in the blood for a longer period of time than an extracellular agent facilitates the acquisition of images. Wielopolsi et al. (3), Lorenz et al. (2), and especially Johansson et al. (7) provide excellent further discussions of these topics. We refer the reader to these articles. Lorenz et al. (2) reviewed various methods that have been proposed to improve signal-to-noise and contrast-to-noise ratios in MR coronary imaging with an emphasis on the role of T1-shortening contrast agents, both extracellular and intravascular.

The Use of Contrast Agents for Coronary MRA

Limited work on the use of extracellular and intravascular contrast agents with the first-generation techniques has been done (8–12). Promising early work with the second-generation techniques has also been performed in animals and humans (13–18). The use of contrast agents with the third-generation coronary MRA techniques appears promising and is discussed in more detail (19–22).

The Use of Contrast Agents with Third-Generation Techniques

MR contrast agents will probably have the most effect on third-generation coronary MRA techniques because they are very similar to the dynamic contrast-enhanced MRA techniques used for thoracic and body MRA today. These techniques can be used to image native coronary artery (11) and coronary artery bypass grafts (CABG) (23–25). In order to EKG-trigger these MRA pulse sequences for native coronary vessel imaging, one needs to use faster acquisitions rates, k-space data segmentation, data interpolation, and other technical tricks.

The initial experience with extracellular MR contrast agents seemed to indicate that very high doses would be needed for first-generation techniques (8,11). With bolus arrival timing to catch the first pass of the gadolinium contrast agent further image quality improvement have been obtained (improved signal-to-noise and contrast-to-noise ratios) for both second- and third-generation techniques (11,26). With the new experimental MR blood pool agents, however, even greater image improvements are being obtained (13–15,19,27). Sequential breathhold acquisitions, as short as 5–10 seconds, can be obtained, with relatively high-resolution, to image thin 3-D slabs. With several repeated short breathholds this allows patient-friendly high-resolution coverage of
large portions of the cardiac and coronary anatomy. It offers the advantage of 3-D acquisitions (with the opportunity for subsequent postprocessing and no misregistration) while taking advantage of the MR contrast agents.

The Future

The combination of MR contrast agents with coronary MRA techniques will most likely allow coronary MRA to outperform any other noninvasive coronary imaging technique on all fronts, including spatial resolution and 3-D volume coverage, as indicated by early results in animals (28) and humans.

As stated by Lorenz et al. (2), although much progress has been made in recent years in techniques for imaging the coronary arteries, ultimate clinical success remains unproved. Success will depend on synergistic developments in MR acquisition techniques, respiratory compensation methods, post-processing techniques, and contrast agents to develop a workable solution for reliable coronary imaging across a wide range of patients. Research is actively being performed to further evaluate this potential use of MR contrast agents (29,30).

References