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EDITOR'S PAGE

Whither Catheter-Based Intravascular Magnetic Resonance Imaging of Atherosclerosis?

Christopher M. Kramer, MD,* Jagat Narula, MD, PhD†

A great deal of hype and excitement accompanied the advent of catheter-based magnetic resonance imaging (MRI) of the vessel wall at the end of the 1990s. Initial studies were performed in the vessels ex vivo that demonstrated excellent correlation with histological characteristics of the imaged plaques (1–3). A problem arose that once the catheter was inserted in an artery, motion degraded the image quality. The imaging volume accessible to the receiver coil on the end of the catheter was limited in scope and prohibited a large enough field-of-view for imaging the entire vessel wall. In addition, image acquisition required several minutes. All of the above limitations precluded application in the clinical setting at that time. Although some inroads were then made to in vivo imaging in human iliac arteries, and the results compared favorably to intravascular ultrasound, the MRI characterization was limited to calcified and noncalcified plaques (4). The accuracy for identification of lipid and fibrous components of plaque was modest at best. As imaging from the surface of the body improved, the impetus to use an invasive device to image plaque appeared to wane. Surface imaging has allowed excellent characterization of plaque morphology in the aorta (5), carotid arteries (6), and peripheral vasculature (7). However, because surface MRI does not offer the spatial resolution to adequately characterize plaque in the coronary arteries, interest in catheter-based approaches has re-emerged.

In this issue of *iJACC*, Sathyanarayana et al. (8) present the advances in catheter-based imaging with MRI; the major improvements include greater speed of acquisition and higher spatial resolution. Images were acquired at several frames per second or near real-time, and the spatial resolution approached 300 μ adjustable down to 80 μ. At this resolution, one is almost at the level that imaging of the fibrous cap may become feasible in human coronary arteries. Proof of principle has been provided in ex vivo human iliac arteries as well as in vivo in a rabbit model of atherosclerosis. Imaging distance from the coil was as large as a 4 mm radius. One of the underlying reasons for these advances is the move to higher field strengths, in this case 3.0-T, which allowed a 4-fold increase in signal to noise ratio. Theoretically, even higher field strengths, such as 7.0-T, could be used; these are coming into clinical fruition and are in the initial stages of testing for cardiovascular applications.

The real application here is in the coronary arteries, as surface imaging by MRI of the vascular wall in other beds has come a long way with specialized surface coils and high-resolution black blood imaging techniques. It is not likely that we will be able to approach the necessary spatial resolution for coronary arteries anytime soon without intravascular imaging. So, in the coronary arteries, will MRI offer more information than the available intravascular techniques? The answer is probably yes and no. Intravascular MRI will have a better resolution and characterization capability than the ultrasound, but 1-10 μ optical coherence tomography-verified cap morphology and measurement of thickness cannot be bettered. Unlike electrophysiology and noncardiac applications, there has been little interaction between coronary interventionalists and MRI experts. There are only a handful of laboratories around the world that are working on that interface. The critical

From the *University of Virginia Health System, Charlottesville, Virginia; and the †University of California, Irvine, California. Dr. Kramer is supported by NIH R01 HL075792.

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mass of research in this arena will need to increase to be able to push the field further. In addition, availability of MRI-compatible catheters and devices would need to improve to push the field forward.

So, where are we headed with this form of imaging? Is it a precursor to the real deal and a procedure that will become clinically feasible within the next decade, or are we heading down a blind path with no end? The answer probably lies somewhere in-between. The technological advances that have allowed these observations occurred in a highly specialized center with exceedingly sophisticated MRI know-how and technological capabilities. A new technique will need to compete with other intravascular technologies. In the end though, the candle must be worth the wick. We have not proven that characterizing coronary atherosclerosis in vivo will make a difference in therapies or patient outcome. We know from a number of studies in coronaries and other vascular beds that the thickness and intact state of the fibrous cap and presence of hemorrhage within the plaque can predict subsequent events. We do not know that identifying these components and treating them earlier would make a difference in patient outcome. Until we do, this will be an area of conjecture and debate. And, even if we demonstrated the importance of plaque characterization, we do not as of yet have specific intervention strategy except the statin and stent shotgun. What the current presentation represents is another success story in the field of imaging and a step forward to be able to understand progression of atherosclerosis in vivo in humans. It is our sincere hope that it will help develop superior management strategies for the conquest of an elusive malady.

REFERENCES

1. Correia LCL, Atalar E, Kelemen MD, et al. Intravascular magnetic resonance imaging of aortic atherosclerotic plaque composition. Arterioscler Thromb Vasc Biol 1997;17:3626–32.
2. Rogers WJ, Prichard JW, Hu YL, et al. Characterization of signal properties in atherosclerotic plaque components by intravascular MRI. Arterioscler Thromb Vasc Biol 2000;20:1824–30.
3. Schneiderman J, Wilensky RL, Weiss A, et al. Diagnosis of thin-cap fibroatheromas by a self-contained intravascular magnetic resonance imaging probe in ex vivo human aortas and in situ coronary arteries. J Am Coll Cardiol 2005;45:1961–9.
4. Larose E, Yeghiazarians Y, Libby P, et al. Characterization of human atherosclerotic plaques by intravascular magnetic resonance imaging. Circulation 2005;112:2324–31.
5. Kramer CM, Cerilli LA, Hagspiel K, et al. Magnetic resonance imaging identifies the fibrous cap in atherosclerotic abdominal aortic aneurysm. Circulation 2004;109:1016–21.
6. Yuan C, Mitsumori LM, Ferguson MS, et al. In vivo accuracy of multispectral magnetic resonance imaging for identifying lipid-rich necrotic cores and intraplaque hemorrhage in advanced human carotid plaques. Circulation 2001;104:2051–6.
7. Li F, McDermott MM, Li D, et al. The association of lesion eccentricity with plaque morphology and components in the superficial femoral artery: a high-spatial-resolution, multi-contrast weighted CMR study. J Cardiovasc Magn Reson 2010;12:37.
8. Sathyanarayana S, Schär M, Kraitchman DL, Bottomley PA. Towards real-time intravascular endoscopic magnetic resonance imaging. J Am Coll Cardiol Img 2010;3:1158–65.