Interventional CMR: Great Promise, but a Long Road Ahead

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Performing interventions in a cardiac magnetic resonance (CMR) environment can be viewed as somewhat of a Herculean task. However, the soft tissue contrast afforded by CMR, and the excellent image quality have attracted many into this developing field. There are a number of laboratories actively working on novel cardiovascular procedures; many have been performed in large animals, but some in patients with congenital heart disease as well (1). The pediatric interventionalists have selectively focused on interventional cardiac magnetic resonance (iCMR) to avoid radiation risk. These investigators should be applauded as it takes substantial commitment and significant resources. Such an endeavor requires specialized equipment including magnetic resonance (MR)-compatible catheters, which not only complicates but raises the expense of the procedure.

The equipment manufacturers have long recognized the potential in this arena. An original design over a decade ago was a “double donut” construct wherein the operator approached the patient in the space flanked by two 0.5-T magnets. However, a low field strength and suboptimal image quality restricted this approach. Another strategy referred to as “XMR” comprised an angiographic suite adjacent to the CMR platform wherein an on-a-track patient table could be moved rapidly between the two imaging modalities. However, this approach still required the use of X-ray as part of the procedure. A third approach has developed shorter and wider bore CMR magnets that facilitate interventional procedures by increasing the access to the patient as well as the size of the patient that can be imaged. The interventionalist is closer to the patient while the procedure is being performed. Yet another approach, nearing implementation, allows a 1.5-T magnet to be rotated into the field in an operating or angiographic suite for a combined imaging and interventional procedure. These advances raise the level of anticipation and expectation for exciting developments in this field.

The initial forays into iCMR were made with the development of catheters for ex vivo imaging atherosclerotic plaques. In vivo studies proved more difficult due to the limited field of view afforded by the catheters, and the motion within the vessel degraded the image acquisition. As such, the attention turned to larger vessels and catheters that could be tracked within the vasculature. CMR techniques were developed to assist during the treatment of aortic aneurysms and coarctation. Small studies have already demonstrated the feasibility of iron-laden stem cell injections into the left ventricles in animal models of myocardial infarction during an iCMR examination with exquisite image quality (2). Electrophysiologists are now guiding catheters in the CMR environment, demonstrating the ability to make electrical measurements and catheter maps in experimental and clinical set up (3).

This rapidly advancing and fascinating field is the subject of a number of articles in this month’s iJACC. Schmitt et al. (4) present intriguing primary data of measurements of systolic and diastolic function in the CMR environment. These complex measurements were validated first in a porcine model and then in a small set of patients with a single ventricle. End-systolic measures of contractility or pressure-volume relationships were made by combining...
invasive pressure measures using conductance catheter with cine CMR derived volume measurements. End-diastolic compliance measures were obtained with volume perturbations by velocity encoded blood flow CMR measures in the aorta and pulmonary artery; good agreement was observed between CMR and invasive measures. Thus, a comprehensive assessment of ventricular systolic and diastolic function, similar to invasive measurements, was demonstrated by CMR. It is these kinds of studies that help move iCMR closer to clinical reality as measurements that previously could only be made in the catheterization laboratory. Another manuscript from the group of Robert Lederman at the National Heart, Lung, and Blood Institute (5) has exquisitely summarized the history of development of the field and defined the important clinical targets for past, present, and future. They have emphasized the need for further technological development in this field. They reveal that commercial manufacturers have been slow to develop MR-compatible devices hence the slower maturation of the field.

The last decade has brought slow but steady progress in the field of iCMR. It is essential that the number of laboratories and investigators involved in research in the field continue to grow. With growing interest and technological advances, it is expected that there may be a more enthusiastic response from industry toward development of CMR-compatible equipment. The currently available equipment cannot support widespread application of iCMR procedures in patients. It is a still a field of great promise, but there lies a long road ahead.

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