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Potential for Rapid and Cost-Effective Cardiac Magnetic Resonance in the Developing (and Developed) World

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Cardiac magnetic resonance (CMR) is a comprehensive imaging modality that can be used to assess ventricular morphology, function, tissue characteristics, perfusion, flow, and scar. It offers a plethora of useful information for assessing both diagnosis and prognosis in patients with cardiomyopathies.[1] However, it is less utilized worldwide than other cardiac imaging modalities, primarily because of its lack of availability in less developed countries. Even in the developed world, it is less available beyond academic centers and high-volume practices.

The length of the examination (up to an hour) is another potential drawback for its use in underdeveloped countries. Several approaches have been taken in recent years to overcome this. A major engineering push in CMR technique development is to make the image acquisition faster, primarily through methods of faster image reconstruction.[2] Parallel imaging, which reconstructs images using data acquired from multiple surface coils, has been in use for over a decade, but the speedup factor for this is only 2- to 3-fold. Compressed sensing hastens reconstruction by using fewer lines of data, expanding upon CMR image data that are "compressible." Compressed sensing remains in development and sequences are not yet used clinically. Other novel approaches include CMR multitasking, which in theory enables the acquisition of multiple types of data without electrocardiographic triggering or breath holds in one 15-minute examination.[3] The issue with the latter 2 approaches is that they require the latest scanner models with updated and advanced software packages. These are generally not available in the developing world and thus these solutions are really aimed only at the developed world at present.

Abbreviated examinations have been piloted in the developing world. For example, an abbreviated examination for myocardial iron content using cine imaging and T2* imaging has been applied in Thailand,[4] but for a rather focused question only in iron overload states. There are other straightforward approaches to speeding up the examination for broader indications. One such approach is to give low doses of contrast before cine imaging.[5] Endocardial definition is often high enough after contrast to perform accurate measurement of left ventricular mass and volumes. This is one of the ways the investigators in the present study in this issue of the *Journal of the American Heart Association* (*JAHA*) enabled a short CMR examination to be applied in Peru.[6] Menacho and colleagues created a collaboration among investigators in 4 countries (United Kingdom, United States, Brazil, and Columbia). They developed a short (designed as 15 minutes) protocol for measurement of left ventricular volumes, function, and scar. After some training and mentoring, they applied it in 2 centers in Lima, Peru for 100 patients referred by local physicians. The protocol involved several localizing images followed by 2-, 3-, and 4-chamber and aortic valve cine acquisitions. Gadolinium contrast was then given and short-axis cine imaging was then performed as per the aforementioned study.[5] Finally, late gadolinium-enhanced imaging was done at the end of the protocol. Mean scan time was 18 ± 7 minutes. This abbreviated CMR protocol could in theory be implemented with appropriate training and supervision in almost any MR scanner facility around the world. This would represent a major advance in the general utility of CMR worldwide. The investigators should be congratulated on this proof-of-principle study.

The other important takeaway from the present study regards the clinical impact of the results of the studies. Within the first year after the CMR, the findings changed clinical management in 56% of the patients. A new diagnosis was made in 19%, medication was changed or added in 23%, and other actions taken such as surgery, angiography, biopsy, hospital admission, etc in 13%. This impact on clinical decision making is in the same range as prior published results of large registries[7] as well as pooled centers[8] and single centers.[9] The latter study by Abbasi et al[9] was specifically targeted at patients with heart failure with

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reduced ejection fraction. This showed significant impact in 65% with a new diagnosis in 30% and change in management in 52%. Together, these studies demonstrate the important diagnostic information provided by CMR in patients with cardiomyopathies.

Importantly, the present study demonstrates that similar information can be provided with an 18-minute examination using only cine and late gadolinium enhanced imaging. The latter 2 sets of pulse sequences provide the most important diagnostic and prognostic information available in cardiomyopathies and thus the tailored examination is particularly appropriate here. An obvious question remains, namely, what pulse sequences are left out that might make a clinical impact in a longer examination? Certainly T1 mapping is 1 such sequence. Native T1 mapping is particularly useful in making the diagnosis of amyloidosis (high native T1)[10] or Anderson-Fabry disease (low native T1)[11] without having to give gadolinium contrast. Furthermore, native T1 and postcontrast T1 can be used together to measure extracellular volume, and both native T1 and extracellular volume offer prognostic information in a number of cardiomyopathies.[12,13] However, these techniques require advanced software as well as require significant time to acquire data pre- and postcontrast and in multiple slices if desired. In addition, save for amyloidosis and Anderson-Fabry disease, native T1 in and of itself is not diagnostic of different cardiomyopathies because of significant overlap amongst them. Although native T1 and extracellular volume offer prognostic information, they do not alter therapy at the present time. This may change in the future as additional research is performed.

Perfusion imaging is also not part of this limited examination and thus stress testing cannot be included. Stress CMR has become an important part of the armamentarium of the cardiac imager as it has been shown to be more accurate than single photon emission computed tomography,[14] compares favorably to fractional flow reserve in the cath lab,[15] and offers excellent prognostic information.[16] In evaluation of cardiomyopathies, it could be an important technique to be able to exclude coronary artery disease as the underlying cause. However, recent studies suggest that late gadolinium enhanced imaging may be enough to make the diagnosis most of the time.[17] Thus, the limited examination suggested in the present study may be enough information to help differentiate underlying causes of cardiomyopathies.

To make this proof-of-principle study a reality in much of the developing world, much work is ahead to train imagers at sites with appropriate scanner technology. Only in this way will an abbreviated protocol for evaluation of cardiomyopathies be implemented. This is an exciting time for the potential of broadening the impact of CMR throughout the developing world.

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