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EDITORIAL COMMENT

Perfusion Imaging Without Tunnel Vision*

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Myocardial perfusion imaging (MPI) with cardiac magnetic resonance (CMR) has proven to be an accurate modality for the detection of coronary artery disease, despite the long-standing limitation that only 2 to 4 2-dimensional slices through the heart could be imaged during each heartbeat at rest and during stress and while a contrast bolus passes through the heart. Nevertheless, such rather limited spatial coverage of the heart remains unsatisfactory and may have held back the clinical performance of CMR in the field of MPI. Acquiring a magnetic resonance image requires performing a set of spatial encoding steps, each of which takes a couple of milliseconds, for a total of approximately 200 ms or less per image in a CMR perfusion scan. In this issue of *iJACC*, Manka et al. (1) demonstrate the feasibility and performance of accelerated MPI. The technique used in the study (*k*-space and time sensitivity encoding) undersamples the images by exploiting spatiotemporal correlations within the data for the image reconstruction from sparsely sampled data. Twenty patients underwent MPI CMR using a 3.0-T whole-body CMR imager before diagnostic X-ray coronary angiography, and the investigators report high diagnostic accuracy. Although they chose to put the net 6-fold acceleration to use for obtaining higher spatial resolution on the order of 1 mm in plane for 3 short-axis slices, the same technique could enable complete coverage of the heart. This makes it feasible to shed the restricted view of the heart in myocardial perfusion studies by CMR, something akin to overcoming tunnel vision.

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The study raises the question of what spatial resolution will be adequate for an accurate detection of coronary artery disease. The glib answer would be that more is better, but higher spatial resolution means more limited coverage of the heart, and with the smaller voxel size, one has to accept a lower signal-to-noise ratio. Because the endocardial layer of the wall is most vulnerable to ischemia, it is necessary to have sufficient spatial resolution to resolve a transmural perfusion gradient (2); this has been an advantage of CMR versus nuclear imaging. But how far do we need to carry this, or is the spatial resolution used in a recent, large, multicenter study sufficient (3)? The answer remains to be determined. Manka et al. (1) present some results from an analysis of their studies in which the spatial resolution was reduced by post-processing, but arguably, they do not provide a conclusive answer yet. Rather, a larger, preferably multicenter study is needed to test performance at different spatial resolution settings in the clinical setting.

What are the limitations of the technical developments that led to the study by Manka et al. (1)? For one, any sort of acceleration of the image acquisition generally extracts a penalty in terms of signal-to-noise ratio. The investigators tested their new method on a magnetic resonance imaging scanner operating at 3-T, a field strength that is still rarely used for routine cardiac imaging in the clinical setting, but the higher field strength certainly compensated in part for any decrease in signal-to-noise ratio due to acceleration of the image acquisition (4). It also remains unknown how the techniques for accelerated imaging used by Manka et al. (1) compare with other noteworthy alternatives for more rapid CMR perfusion imaging. Several are under active development at CMR research centers, with one, highly constrained back

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projection (5), achieving the surprising feat of high acceleration and improved contrast-to-noise ratios. Remarkable developments in this area also include compressive sensing, a novel concept that has overturned the sampling requirement embodied in the 50-year-old Shannon-Nyquist theorem, which implied for magnetic resonance that images need to be acquired over a regularly spaced grid of points with a minimal distance between the sampling points to avoid aliasing (6). It has turned out that sparse pseudo-random subsets of spatial encodings can be sufficient for the reconstruction of an image, assuming that one has some a priori knowledge of how the image is best compressed. There may therefore be more than one good cure to tunnel vision in CMR perfusion imaging, and the next few years promise important advances in this area. How the benefits of these technical advances will be apportioned to optimize different aspects important to MPI remains to be seen, but Manka et al. (1) are among the very first to show that these advances are not just an ivory-tower concept, but robust enough for the CMR clinic and with substantial benefits for fast perfusion imaging.

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