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EDITORIAL COMMENT

Feature Tracking by CMR

A "Double Feature"?*

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There has been growing clinical interest in quantifying myocardial performance by assessing myocardial strain. The clinical adoption of strain imaging has recently been driven by advances in speckle-tracking echocardiography (STE) and its widespread availability. Recent STE studies have shown that assessment of left ventricular global longitudinal strain (LVGLS) can potentially elucidate subtle changes in myocardial function (1). In the burgeoning field of cardio-oncology, there is a particular interest in using GLS to assess early effects of chemotherapy-induced cardiotoxicity (2).

Cardiac magnetic resonance (CMR) is well established as a modality for measuring myocardial strain, dating back to the seminal description of myocardial tagging (MT) by Zerhouni et al. (3) in 1988. CMR strain assessment underwent significant evolution in the 1990 to 2000s, including the development of the spatial modulation of magnetization (SPAMM) technique, which is used in current CMR MT (4). SPAMM creates a grid of radiofrequency "tags" that move with the myocardium, enabling tracking of cardiac deformation. MT has been extensively validated, used in many clinical studies, and has served as the gold standard technique for validation of other strain measurement techniques including STE. A challenge with conventional MT is that it necessitates detection and tracking of the tag intersections to measure regional changes in deformation, which requires significant post-processing. More recent developments such as harmonic phase (HARP) (5), strain encoding (SENC) (6), and displacement encoding with stimulated echos (DENSE) (7,8) can assess strain with simplified post-processing pipelines. Although MT-based strain measurements are the most accurate techniques for measuring regional myocardial strain, the acquisition of additional images and the necessity of post-processing has limited the widespread use of CMR tagging in routine clinical practice. As such, the ability to quantify both left ventricular (LV) ejection fraction and strain from standard clinical steady-state free precession (SSFP) cine images, using a technique such as CMR feature tracking (CMR-FT), is an enticing "double feature."

Tracking of points or "features" across multiple images is based on pattern-matching techniques. A point is tracked by defining a small patch around the pixel in one frame and finding the most similar patch of pixels in the next image frame. In this way, motion can be tracked through successive frames. In ultrasound, "speckle" results from the interference pattern of subresolution scatterers in the myocardium, which provides the texture that can be tracked from frame to frame. Speckle tracking can be affected by a number of factors, including signal dropout, reverberation, clutter artifacts, through-plane motion, lateral resolution, and temporal resolution. As such, many modern ultrasound packages overcome these limitations by combining speckle tracking with tracking of other features in the image, including the mitral annular plane and myocardial-blood interface. CMR images do not have an equivalent of "speckle" because the apparent texture within the myocardium on CMR images is due to random noise and does not provide information for tracking. However, cine-SSFP pulse sequences have excellent blood-tissue contrast and delineation of endocardial features which can be tracked through the cardiac cycle in a means similar to that used to analyze echocardiographic images. CMR-FT has been available for approximately 6 years; however, most of the studies in normal subjects have been small, with limited intermodality comparisons to STE or other CMR strain techniques. An important step towards clinical adoption is characterizing the normal ranges and reproducibility of strain metrics by CMR-FT.

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In this issue of *iJACC*, Vo et al. (9) performed a systematic review and meta-analysis of the normal values reported for global strain metrics derived from CMR-FT and performed meta-regression to identify potential sources of variability between studies. The authors performed a similar analysis for assessment of strain by MT, DENSE, and SENC. The analysis of CMR-FT included 18 studies and a total of 659 healthy subjects. The majority of studies were performed using SSFP cine images obtained at 1.5-T, and all but 2 studies used analysis tools from the same vendor. The authors found significant heterogeneity in strain measurements between studies for LVGLS, LV global radial strain (GRS), and right ventricular global longitudinal strain (RVGLS), but this heterogeneity was not explained by technical factors such as field strength or analysis software vendor, or by physiological factors such as age and sex. In this analysis, LVGCS and LVGLS were more robust, with smaller 95% confidence intervals (CIs) on the pooled means and lower intra- and inter-reader variability for the individual studies as compared with LVGRS and RVGLS.

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As compared with other strain modalities, GLS as determined by CMR-FT was similar to that derived from SENC and STE, but higher than that reported for MT. LVGCS was similar to that from STE, but was systematically higher than values from SENC, MT, or DENSE. This bias could potentially be related to differences in the effects of through-plane motion on STE and CMR-FT as compared with tagging techniques. There was significant variation across all reported modalities for LVGRS, suggesting lack of robustness of this parameter.

This meta-analysis is well executed and comprehensive in its assessment of variability based on the defined covariates. Obviously, the study is subject to the usual limitations of all meta-analyses including lack of patient level data and covariates. Another limitation is that there was significant residual heterogeneity, as evidenced by lack of overlap of "normal" ranges of individual studies. This heterogeneity was not explained by the parameters assessed in meta-regression. It is possible that technical factors such as the temporal and spatial resolution of the SSFP cine images, which were not included in the meta-regression, but which are known to affect the quality and accuracy of FT techniques, could explain some of the heterogeneity between studies. An important caveat is that this meta-analysis provides an estimate of the pooled mean and 95% CI for the pooled mean, but cannot define the "normal range" for strain metrics, which would require patient-level data. For example, in Table 2, the 95% CI on the pooled mean LVGLS is (−19.3 to −20.1), whereas the 95% CI for the first study is (−16.9 to −19.1), which does not even overlap the 95% CI of the pooled mean. This would imply that >95% of the subjects in the first study have abnormal strain, which is likely incorrect.

The heterogeneity between studies in this meta-analysis is not unique to CMR-FT because similar lack of overlap between studies has been seen in STE meta-analyses and multivendor comparative studies (10,11). This variability has led to a substantial effort by the European Association of Cardiovascular Imaging and American Society of Echocardiography to work with vendors to standardize methodology for acquisition, analysis and reporting of STE strain results (12). A similar multivendor effort in the CMR-FT community led by the Society of Cardiovascular Magnetic Resonance would likely reduce variability and facilitate the development of vendor-independent normal values.

So, will CMR-FT become a replacement for myocardial-tagging by CMR? The feasibility of measuring strain by CMR-FT of cine SSFP images will likely lead to clinical adoption of such techniques at least for characterizing global strain metrics. CMR-FT techniques that use a hierarchical approach and only track a small number of points within the myocardium will likely be insufficient to reliably provide regional assessment of strain as compared to tagging-based approaches. However, for diseases associated with diffuse and homogenous abnormalities, CMR-FT could be CMR's answer to STE as a simple method for deriving global strain metrics and LVEF in 1 study, a sure "double feature."

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