Myocardial Deformation Imaging by Feature-Tracking Cardiac Magnetic Resonance in Acute Myocardial Infarction

Do We Need It?

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Adverse left ventricular (LV) remodeling with persistent and worsening LV dysfunction after acute myocardial infarction (AMI) is strongly associated with long-term cardiovascular morbidity and mortality. Hence, identification of patients with low likelihood of LV contractile recovery despite successful reperfusion therapy represents an important issue in clinical cardiology, with significant implications for patient management. These considerations have stimulated research into new imaging biomarkers, which provide quantitative and objective estimation of post-AMI myocardial damage and potentially identify patients at short- and long-term clinical risk.1,2

See Article by Khan et al

In the past 2 decades, cardiac magnetic resonance (CMR) with late gadolinium enhancement (LGE) imaging has emerged as a powerful clinical tool in AMI, providing diagnostic and prognostic information, which are incremental and superior to those obtained using other imaging modalities.1–3 Numerous studies have demonstrated the usefulness of CMR viability indices in predicting functional improvement post AMI. It has been known for some time that the extent of segmental LGE, especially if measured after 7 days post MI, is a key determinant of recovery of myocardial wall thickening and global LV systolic function.1–3 Similarly, the presence of microvascular obstruction on early gadolinium enhancement or LGE imaging and the presence of intramyocardial hemorrhage on T2-weighted short-TI inversion recovery imaging have been linked to poor regional and global functional recovery.4,5

Myocardial deformation imaging techniques, which are able to discriminate between active and passive myocardial contraction in the longitudinal, circumferential, and radial direction, have also been demonstrated of value for the identification of myocardial viability.6 Historically, regional LV deformation in CMR has been evaluated using the tagging technique; however, myocardial tagging (in which virtual markers in the myocardium are obtained with magnetization saturation bands) requires complex and time-consuming data acquisition and postprocessing. The recently introduced feature-tracking CMR software system overcomes these challenges, allowing fast and accurate assessment of LV strain using basic cine CMR sequences, already acquired as part of the standard CMR examination, without any need for a specific encoding pulse.10 Hence, CMR feature tracking is potentially highly translatable into routine clinical practice. Several studies have assessed the accuracy and reproducibility of this new technique (using CMR tagging as reference standard), showing that feature-tracking CMR measurements of circumferential strain have the best agreement with CMR tagging measurements, and have demonstrated value in patients with AMI, chronic ischemic LV dysfunction, and nonischemic cardiomyopathies.7–15

In this issue of Circulation: Cardiovascular Imaging, Khan et al compared the accuracy of several CMR viability indices for the prediction of functional improvement and normalization of dysfunctional segments after AMI in a cohort of patients enrolled in the Complete Versus Lesion-Only Primary PCI CMR substudy.16 Baseline and follow-up CMR scans were performed in 164 AMI patients after a median interval of 2.9 days and 9 months from the index event, respectively. Out of the 2624 myocardial segments, segmental dysfunction, defined as wall motion score ≥2, was observed in 32% of myocardial segments at acute CMR and in 19% myocardial segments at follow-up CMR; 62% dysfunctional segments at baseline showed segmental improvement (defined as wall motion score decrease of ≥1) at follow-up CMR, of which almost half showed complete normalization (defined as return of wall motion score to 1). The accuracy of the following CMR viability indices in predicting segmental functional recovery was then assessed: (1) segmental extent of LGE (SEE); (2) myocardial salvage index; (3) segmental microvascular obstruction; (4) segmental intramyocardial hemorrhage; (5) feature tracking–derived segmental peak endocardial circumferential strain (Ecc). The predictive accuracy of SEE for segmental improvement and normalization was high (area under the curve = 0.840 and area under the curve = 0.887, respectively), with similar or superior predictive value when compared with the other CMR viability indices taken into account. In particular, segmental peak endocardial circumferential Ecc provided similar predictive value (area under the curve = 0.834) for the likelihood of segmental functional improvement and lower predictive value (area under the curve = 0.836) for the likelihood of segmental functional normalization compared with SEE. It is, however,
worth noting that segmental recovery occurred in a nonnegligible proportion (33%) of segments having SEE >75% at baseline CMR, which is in keeping with previous findings by other investigators, and that 179 out of 495 dysfunctional myocardial segments at follow-up CMR scan had normal contractility at baseline CMR. Other important finding was that myocardial salvage index and intramyocardial hemorrhage were not analyzable in ≤23% of segments because of poor T2-weighted short-T1 inversion recovery images.

Overall, the present study provides several important clues to the clinical cardiologist regarding the utility, feasibility, and pitfalls of comprehensive CMR imaging early after AMI. First, it confirms that the myocardial hyperenhancement observed by LGE imaging early after AMI (<7 days) does not exclusively reflect irreversible myocardial damage but also involves ischemic but viable myocardium within the area at risk, consequently leading to a significant overestimation of infarct size. Indeed, this concept explains the relatively large number of dysfunctional myocardial segments which recovered contractility despite having SEE >75% at baseline CMR, as well as the close relationship observed between SEE and segmental myocardial salvage index (r=-0.89) and the lack of additive prognostic value of segmental myocardial salvage index. Second, it corroborates that the acquisition of T2-weighted short-T1 inversion recovery images strongly relies on the presence of regular heart rhythm and patient’s ability to adequate breath-holding (2 prerequisites not easily met in patients with recent AMI); as recognized by the authors themselves, newer tissue characterization (T1 and T2 mapping) techniques may perform better, in terms of both clinical feasibility and predictive accuracy. Third, it sheds some light on the clinical utility of myocardial deformation imaging by feature-tracking CMR in the setting of AMI. Although not incrementally useful, this technique performs well compared with LGE imaging and seems to represent its best alternative, particularly for the prediction of segmental functional improvement; it may therefore be useful when dealing with patients having contraindications to gadolinium-based contrast agents, when CMR scan time is an issue and when LGE images are of nondiagnostic quality. However, some interesting questions remain unanswered by the present study. First, would the assessment of both subepicardial Ecc and subendocardial Ecc provide superior information compared with subendocardial Ecc alone? Subendocardial and subepicardial layers are differently affected by AMI, and it is conceivable that their specific strains have different ability to predict segmental contractile recovery. Small historical studies using CMR tagging have indeed raised the hypothesis that the preservation of myocardial fibers in the subepicardial region is specifically linked to the late improvement in regional and global LV function after MI. Second, may deformation imaging be useful in predicting the worsening of contractility of initially normal segments? This paradoxical phenomenon is likely related to the severe dysfunction of adjacent segments and to the presence of adjacent large scar subjected to negative remodeling and could be predicted by imaging modalities assessing the deformation rather than the structural properties of the myocardium.

In conclusion, the present work is the largest reported series of the use of feature-tracking CMR in AMI population and importantly is the first to use data derived from a multicenter trial in this area; the authors are to be congratulated for this. However, their results cannot be considered definitively conclusive on the incremental utility of feature-tracking CMR in AMI. Further studies, investigating the deformation properties of apparently normal myocardial segments and taking into account the behavior also of the subepicardial myocardium, are needed to fully elucidate the added value of this relatively new technique in this clinical setting.

Disclosures

None.

References


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