

EDITORIAL COMMENT

Straining to Justify Strain Measurement*

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*When thus the heart is in a vein
Of tender thought, the simplest strain
Can touch it with peculiar power.*

—Sir Thomas Moore (1)

A broad array of cardiac imaging research and technique development has been deployed in the quest to define the earliest myocardial changes of cardiomyopathy so that earlier detection may afford more timely institution of therapy and improved outcomes. Recognition that high-resolution measures of myocardial deformation can be abnormal before global contractile dysfunction has further fueled development of techniques such as speckle tracking, myocardial tagging, displacement-encoded

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imaging, and vector velocity imaging. Nonetheless, one must strain to find clinicians who rely on any of these techniques for routine management decisions despite more than 20 years of technical refinement since the first myocardial tagging methods were described by Zerhouni et al. (2) and Axel and Dougherty (3). Rather, these approaches remain on the fringe of care, limited to the realm of interesting techniques seeking clinical relevance.

In an era when imaging lies squarely in the crosshairs of cost containment and health care reform, the reasons for this failure of strain measurement to gain any meaningful clinical use must be examined. Is it inconsistency in data acquisition? Does the burden of time-consuming post-processing limit practical applicability? Have we not met the threshold of evidence

required to demonstrate that detection of subclinical strain abnormalities leads to tangible improvements in outcomes? Or does contemporary heart failure practice cling too fervently to traditional hemodynamic, structural, and functional measures to incorporate new approaches? In light of more than 5.7 million Americans with heart failure who face a 20% 1-year mortality rate, improvements in methods of early diagnosis and treatment are clearly still needed.

In this issue of *JACC*, Hor et al. (4) present a new technique for measuring peak systolic circumferential strain (ϵ_{cc}) from routinely acquired cardiac magnetic resonance (CMR) cine images. The application of feature-tracking algorithms, designed originally for echocardiographic image analysis, to CMR cine images is a novel approach with potential advantages over existing methods. Such a technique would eliminate the need for additional time-consuming scans designed specifically for strain measurement such as tagging, displacement encoding, and phase-velocity imaging. Additionally, the described method of CMR feature tracking is rapid and automated. Their technique showed good agreement with strain measurement using tagged cine, a separate acquisition technique not routinely performed but historically the standard for CMR-based strain analysis that has been validated against sonomicrometry. Reproducibility among observers was also good, although data on the same observers' analyses of tagged cine data would have been useful for comparison. When applied to cine images from healthy controls and patients with Duchenne muscular dystrophy (DMD), the resulting strain measurements discriminated among groups with progressive myocardial disease. A most useful finding was that feature tracking–derived ϵ_{cc} in DMD patients showed abnormalities even in the setting of preserved systolic function, offering hope for earlier detection of inevitable cardiomyopathy in these patients.

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Although the authors claim that circumferential, longitudinal, and radial tissue velocity; displacement; strain; and strain rate could all be computed by feature tracking, only ϵ_{cc} averaged over a single midventricular slice was reported. The accuracy and reliability of regional measures of strain in multiple directions, and their applicability to diastolic strain measurement, remain unknown. The mix of acquisition techniques, including 3-T versus 1.5-T and breath-holding versus free-breathing, leaves some uncertainty as to applicability for a given acquisition mode. Covariate analysis by field strength and cine sequence would help address this before clinical implementation.

The endocardial feature tracking approach was not without limitations. Tagging-based ϵ_{cc} measurement discriminated between younger and older DMD patients, yet feature tracking-based ϵ_{cc} could not detect this difference. One would expect the difference to be real as DMD-associated cardiomyopathy advances with age. There was also a slight underestimation of ϵ_{cc} by feature tracking versus tagged cine analysis, and the difference between techniques increased as one progressed through patient groups with more advanced cardiomyopathy. This divergence warrants further investigation, even if the greatest utility for strain measurement in this population may be in earlier detection when left ventricular ejection fraction is normal.

A potential explanation for reduced sensitivity and slightly lower strain values is that the feature tracking algorithm tracks the deformation of only the endocardial border, not the epicardium, potentially losing transmural information captured in tag

grids that span the entire thickness of the ventricular wall. Mechanistically, this fits with the pathology of DMD-associated cardiomyopathy, which is characterized by epicardial injury by ex vivo histopathology and demonstrable in vivo with late postgadolinium imaging (Fig. 1).

Abnormal strain has been shown to precede systolic dysfunction in pre-clinical models of DMD-associated cardiomyopathy (5). Although diastolic strain data were not presented in this work, one could envision that the proposed feature-tracking approach would offer a more robust calculation of diastolic strain using standard cine data versus techniques such as tagging and displacement encoding, which may not be capable of measuring strain across the entire cardiac cycle due to T1 relaxation. However, the authors do point out that this is less problematic at 3-T due to the inherently longer tissue T1 values.

Assuming that we now have a technique for routine, reproducible, and relatively painless myocardial strain measurement, what further evidence is needed to justify clinical use? Software advances that provide features such as visually appealing strain maps in place of manual comparison of segmental strain data would be a welcome and critical step before there can be wider adoption of strain measurement. Clinical trials have already shown that, using global left ventricular ejection fraction by echocardiography to guide initiation of therapy, treatment of DMD patients with angiotensin-converting enzyme inhibitors limits initiation and progression of cardiomyopathy (6). Prospective studies randomizing patients to therapeutic decision making with or without strain measurement

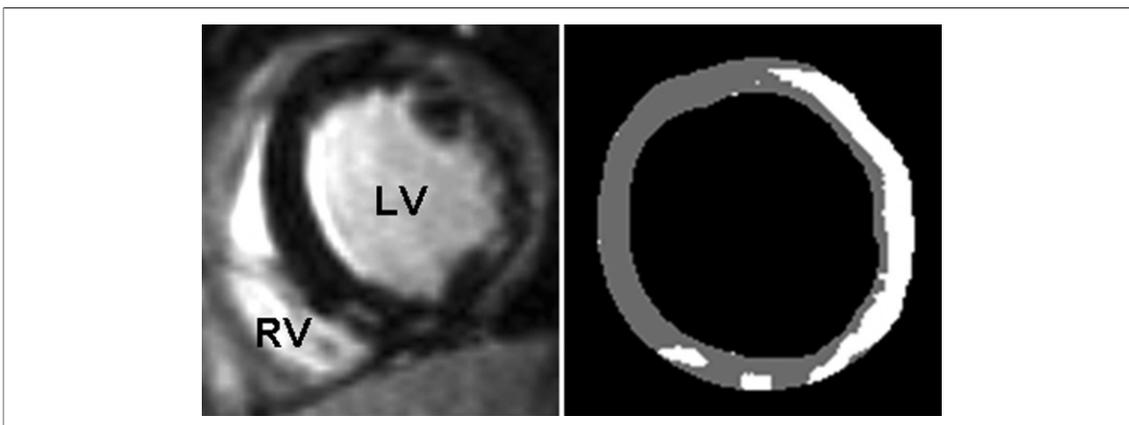


Figure 1. Late Post-Gadolinium Imaging of Dystrophin-Associated Cardiomyopathy

The typical late gadolinium enhancement pattern seen in dystrophin-associated cardiomyopathy (left) involves the lateral epicardium, similar to myocarditis. Applying thresholding to display pixels with signal intensity 2 SDs above the mean of nonenhancing myocardium is shown (right). LV = left ventricle; RV = right ventricle.

may be required (7). Extension of studies such as this to include patient outcomes and appropriate multivariate analysis to demonstrate the cost-effectiveness and added value of strain measurement to existing clinical, structural, and functional measurements will also be essential. The high morbidity and mortality in patients with heart failure give clinicians little time for techniques that reveal subtleties without proven impact on outcomes. Conversely, those that afford more accurate diagnosis and precision in assigning prognosis hold the promise of earlier institution of appropriate treatment to reduce death and disability. This would seem to be

particularly true in the management of patients with cardiomyopathies, in which early institution of therapies such as angiotensin-converting enzyme inhibitors and beta-blockers before end-stage heart failure has set in has repeatedly proven beneficial across the etiologic spectrum. This work has made a small but important step forward in realizing a clinical role for myocardial strain measurement in the evaluation of cardiomyopathy.

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