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EDITORIAL COMMENT

Is One Better Than Two?

T_1 Mapping in Myocarditis*

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"Everything should be made as simple as possible, but not simpler"—Einstein's razor (1)

Acute myocarditis is an important differential diagnosis for patients presenting with chest pain and/or dyspnea, not only because of its relatively common incidence (2), but also because of risks of arrhythmia, sudden cardiac death, and future cardiomyopathy. Although endomyocardial biopsy is advocated in patients with deteriorating cardiac function (3), until recently, the diagnosis was often made on clinical grounds, largely because of the lack of a reliable noninvasive test. Over the last decade, cardiac magnetic resonance (CMR) imaging has sought to fill this diagnostic void. T_1-weighted (T_1W-CMR) imaging following gadolinium contrast administration can identify myocardial hyperemia through elevated early relative enhancement (ERE), and regional necrosis may be identified by late gadolinium enhancement (LGE). In addition, increased signal on T_2-weighted imaging (T_2W-CMR) can demonstrate myocardial edema. The presence of any 2 of myocardial edema, elevated ERE, or LGE on CMR is by consensus deemed to support a diagnosis of myocarditis in the appropriate clinical setting (the "Lake Louise criteria") (4), and offers improved diagnostic accuracy over any 1 of these CMR features in isolation. However, the improved diagnostic accuracy of multisequential CMR over a single-sequence approach comes at the cost of increased scan time, additional post-processing, and requirement for intravenous contrast. It is in this context that the findings reported in this issue of *iJACC* are of particular relevance.

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Ferreira et al. (5) used CMR to evaluate 50 patients with clinically suspected myocarditis and compared the findings with 45 controls. They assessed LGE and conventional dark-blood T_2W-CMR, and in addition, employed the novel techniques of native T_1 mapping and bright-blood T_2W-CMR, the latter of which has some technical advantages over dark-blood T_2W-CMR and has been shown to correlate with acute myocardial edema (6). They aimed to establish whether these methods would improve diagnostic accuracy beyond that of current sequences. All CMR findings were significantly different in patients compared with the control group, with T_1 mapping (using a diagnostic cutoff of ≥990 ms) and the presence of LGE having the highest sensitivity (90% and 74%, respectively), specificity (91% and 97%), and diagnostic accuracy (91% and 83%). The combination of LGE and T_1 mapping did not improve the diagnostic performance of LGE alone, but was superior to the combined results of T_2W-CMR techniques with LGE. The authors conclude that native T_1 mapping in isolation can detect myocarditis with a high diagnostic accuracy and is superior to T_2W-CMR.

Ferreira et al. (5) are to be commended on studying novel CMR techniques in a condition that is often difficult to diagnose with reasonable certainty, both clinically and with currently applied CMR sequences. Noncontrast T_1 mapping performed well in this study, and may be of particular relevance in patients unable to receive gadolinium-based contrast.

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Significant overlap would be expected between native T_1 mapping and LGE, which are both heavily T_1 dependent, as reflected in regional assessment of T_1 times. In patients with myocarditis, native T_1 times were longer than those of control patients in areas of myocardium with and also without LGE. Interestingly, even in areas that appear normal with LGE and T_2W-CMR imaging, the T_1 time was lengthened compared with controls, suggesting that these regions may be involved on a microscopic level. The mechanism for prolongation of pre-contrast T_1 time in acute myocarditis is unclear; however, it seems plausible that this reflects an increase in both intracellular and extracellular water content, consistent with previous studies showing a correlation in other causes of myocardial edema (6,7), and may possibly be related to potential T_2 effects in the T_1 mapping sequence (8).

The diagnostic accuracy of 91% of native T_1 mapping demonstrated by Ferreira et al. (5) compares favorably with that demonstrated in previous CMR myocarditis studies using the Lake Louise criteria, which had a diagnostic accuracy of 85% in 1 single-center study and 78% in pooled studies (4). It would be tempting to assert that 1 single measure of native myocardial T_1 time might be superior to any other currently advocated single measure or combination of CMR measures used to diagnose myocarditis. From a clinical perspective, 1 single, reliable CMR measure to diagnose myocarditis would offer considerable advantages with respect to simplicity and speed of acquisition, with no need for contrast administration. However, Ferreira et al. (5) demonstrate prudence on this matter when discussing their findings, and with good reason. The authors could not directly compare the diagnostic accuracy of native T_1 mapping with the consensus recommendation for CMR assessment of acute myocarditis because of the omission of ERE from their protocol. The performance of T_1W-CMR pre- and post-contrast evaluation was not performed because of an already lengthy CMR examination; however, a direct comparison between native T_1 mapping with the Lake Louise CMR criteria would be a more clinically applicable assessment. Myocardial T_2 mapping is another noncontrast quantitative technique for assessment of water content that also circumvents the need for reference skeletal muscle. This may perform better than either of the T_2W sequences assessed in this study; however, as yet, there are no comparative data of T_1 and T_2 mapping in this patient population. Another limitation is the lack of histopathology to support the diagnosis of myocarditis, a limitation shared by many papers evaluating the diagnostic utility of CMR. Although the drawbacks of endomyocardial biopsy are well documented in terms of sampling error, interpretation, and small risk of complications, it can still provide compelling diagnostic information that cannot be obtained noninvasively, which is especially important if steroid-responsive conditions such as giant cell myocarditis are considered. Furthermore, when offered a CMR approach to the diagnosis of myocarditis validated only against clinical criteria and not histology, a non-CMR physician might rightly question what CMR can offer *in a diagnostic sense* above standard clinical assessment. Finally, the findings of Ferreira et al. (5) will need to be confirmed by additional CMR studies from independent groups, and the utility of T_1 mapping should be evaluated not only in its ability to discern patients with acute myocarditis from healthy controls, but more importantly, against patients with other forms of cardiac disease with a similar presentation, such as new-onset cardiomyopathy. This latter group of patients is especially problematic using a T_1 mapping–based approach, given the documented efficacy of both native (9) and post-contrast T_1 mapping (10,11) in identification of diffuse myocardial fibrosis, which is a hallmark of cardiomyopathy.

Before the advent of CMR in the assessment of myocarditis, many patients were unable to be confidently diagnosed without myocardial biopsy. More recently, we have been able to greatly enhance our noninvasive diagnostic certainty with tissue characterization made possible by CMR; however, the range and combinations of CMR sequences and the supporting data can be baffling to the non-CMR physician. It is an appealing notion that in the future 1 single CMR sequence with high diagnostic accuracy might overcome much of the uncertainty and confusion that stems from the current multisequential approach. To this end, the work of Ferreira et al. (5) has made a significant contribution; however, much more work is required in our quest for diagnostic certainty in the CMR diagnosis of acute myocarditis.

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