EDITORIAL COMMENT

CMR Imaging for Diastolic Hemodynamic Assessment

Fantasy or Reality?*

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Assessment of pericardial disease by cardiac magnetic resonance (CMR) is a well-established clinical application (1). For the diagnosis of constrictive pericarditis, CMR has focused on morphological features, specifically pericardial thickness (2,3) as well as distorted ventricular contours, dilated hepatic veins, and the inferior vena cava (IVC). Pericardial thickness >4 mm measured by CMR demonstrated 93% accuracy in diagnosing constriction (4), but pericardial thickness measurement is a crude tool with which to assess complex hemodynamics. Studies also have shown that almost 20% of patients with constriction have normal pericardial thickness on histological examination as well as on transesophageal echocardiography and computed tomography (5,6).

More recently, CMR has focused on imaging biomarkers of pericardial inflammation, through gadolinium enhancement (7-11) and fluid-sensitive sequences (10,12). In addition to providing evidence of pericardial pathology, these biomarkers may indicate a likelihood of clinical response to pharmacotherapy to decrease pericardial inflammation and even reverse constrictive processes (13).

However, pericardial thickening and inflammation do not necessarily predict hemodynamic sequelae. Patients may have thickened, enhancing, edematous pericardium in acute or recurrent pericarditis without constrictive physiology. Likewise, patients can have constrictive hemodynamics but modest (although rarely normal) findings on morphological assessment.

Constrictive pericarditis has hemodynamic features of respiratory variation in ventricular filling and increased interventricular dependence (14,15). Recent work in CMR has focused on demonstrating some of the features of constriction seen in echocardiography. CMR can demonstrate the abnormal septal “bounce” seen on echocardiography in 81% to 89% of patients with constriction on routine balanced steady-state free precession images (10,16). Newer free-breathing sequences allow assessment of respirophasic changes in septal motion (17). However, standard assessment for constriction by CMR does not provide real-time hemodynamic information. To improve the diagnostic accuracy of CMR for constrictive pericarditis, techniques allowing assessment of altered hemodynamics could be an important advance.

The contribution of the current study by Thavendiranathan et al. (18) in this issue of JACC is to use a real-time phase-contrast sequence to directly assess respirophasic alterations in ventricular filling. This has the advantage of simultaneously and directly measuring mitral and tricuspid valve inflow rather than inferring information from changes in septal position. This should be a more precise method to evaluate ventricular filling in patients with constriction, and initial results in a small subset of patients are promising.

Phase-contrast techniques (19) have a long history of use for flow quantification, and despite validation and reproducible results in many studies, clinical implementation has been limited (20). In part, this is because performing the examination...
requires meticulous attention to detail and manipulation of many variables by the technologist and because post-processing can be labor intensive, time-consuming, and inefficient.

With regard to the current work, there are theoretical and practical limitations to implementation. CMR frequently obtains lower peak velocities than echocardiography (21). The images acquired in this study are rather low in spatial resolution, presumably to maintain temporal resolution and signal-to-noise ratio. Because phase-contrast CMR determines a mean voxel velocity, this may underestimate peak velocity. Tachypneic and orthopneic patients may also have tracings that are difficult to interpret because of shallow diaphragmatic excursion, particularly, and the respiratory data are analyzed by visual inspection.

Although the new real-time phase-contrast sequence still has many of the same limitations as a classic phase-contrast sequence, it has some advantages because phase-contrast imaging has historically been limited by arrhythmia or reduced breathhold capacity. Real-time imaging has practical benefits because cardiac hemodynamics vary according to patients’ conditions; this is typically the case in constrictive pericarditis with respiratory variation. However, respiratory variation of mitral and tricuspid valve flow velocities is not specific to constrictive pericarditis. It can happen in patients with exaggerated respiratory efforts or in chronic obstructive pulmonary disease, obesity, or asthma. Echocardiography can distinguish them using superior vena cava velocity and mitral annulus velocity pattern. For CMR to be more specific, it would be important not to miss constriction due to respiration and increased early diastolic mitral annulus velocity. For CMR to be more sensitive, it would be important not to miss constriction due to lack of respiratory variation in mitral valve inflow velocities.

The ultimate question is whether this approach, which entails time-consuming post-processing and requires validation across different patients, scanners, and CMR vendors, will increase diagnostic accuracy for constrictive pericarditis. In fact, in this analysis, measuring pericardial thickness was 100% accurate in distinguishing patients with constriction from those without. Other standard assessments including diastolic septal bounce, respirophasic septal shift, and IVC plethora were confirmatory in most patients. The reality of clinical care is that echocardiography is very good at documenting constriction in most patients, and few patients are referred for CMR without having had an echocardiogram. Those with technically limited or nondiagnostic echocardiographic studies are likely to benefit most from CMR, but may be the most difficult to evaluate. The key, as the authors acknowledge, will be to show incremental improvement in diagnostic accuracy by combining this approach with the standard CMR examination in patients suspected not only of constrictive pericarditis, but also for other confounding conditions. When this can be accomplished routinely, the fantasy of CMR becoming a “one-stop shop” for evaluation of patients with heart failure will become a clinical reality.

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