EDITORIAL COMMENT

CMR to Evaluate Bioprosthetic Aortic Stenosis?*

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With an aging population and the emergence of transcatheter valve replacement (1), the evaluation of bioprosthetic valve anatomy and function is of increasing importance. Traditional “tried and true” methods of assessing bioprosthetic valve dysfunction have relied on 2-dimensional echocardiographic techniques that evaluate leaflet morphology and mobility, as well as Doppler-based parameters that measure transprosthetic pressure gradients and flow (2). When such data are insufficient, or when there is discordance between clinical and echocardiographic measures of prosthetic valve function, a limited array of options currently exist for further assessment, including an invasive hemodynamic evaluation, fluoroscopy, and computed tomographic imaging (3). Additional noninvasive imaging methods that could quantify the anatomic and physiological severity of bioprosthetic valve dysfunction would offer a useful addition to the current diagnostic armamentarium.

Prosthetic valve dysfunction can include structural failure caused by progressive tissue degeneration, thromboembolic complications, or infections. Structural failure is the most common complication and results in valvular stenosis or regurgitation. When such lesions are suspected, various Doppler parameters can be used to determine valvular function, particularly in cases when the valve is not well visualized (i.e., mechanical valves and stented bioprosthetic valves).

Cardiac magnetic resonance (CMR) has been widely applied as an adjunct technique to echocardiography, invasive hemodynamics, and computed tomography for the assessment of native valve stenosis and regurgitation (4–12). CMR provides a multiparametric, quantitative view of the anatomic and physiological consequences of valve dysfunction, including transvalvular flow and velocities by phase-contrast (PC) imaging, ventricular size and function, and in some cases, direct valve planimetry. In this issue of iJACC, Maragiannis et al. (13) investigated the clinical application of CMR to evaluate bioprosthetic valve dysfunction.

Maragiannis et al. (13) studied 38 patients with bioprosthetic aortic valve replacement who underwent echocardiography and CMR studies. The CMR protocol consisted of planimetry of the anatomic orifice area (AOA) and PC imaging to calculate a novel CMR parameter: PC effective orifice area (EOA). Although planimetry is a useful anatomic assessment of aortic valve structure, it is dependent on optimal en face imaging planes with adequate temporal and spatial resolution for accuracy. In contrast, the effective orifice area (EOA), which is calculated as forward flow divided by the velocity time integral (VTI), offers a more robust technique to estimate valvular area, because it is less dependent on image quality and plane selection. However, EOA has not been previously assessed with CMR, in part because PC analysis by CMR provides measures of velocity at a particular plane and has a lower temporal resolution than Doppler-based measurements. To calculate an EOA based on PC, Maragiannis et al. (13) measured the peak velocity through the aortic valve and constructed VTI curves based on multiple data points (typically around 11) during the systolic ejection period. The PC-EOA was then calculated by dividing the calculated forward volume by the PC-based VTI (i.e., distance traveled). The PC-derived VTI was slightly smaller (bias

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of ~1.18 cm) than the Doppler-derived VTI, which is not unexpected given the underestimation of flow by CMR, caused by a stronger dependence on plane selection and a lower temporal resolution. However, PC-EOA compared favorably to EOA by Doppler echocardiography, and there was excellent agreement in clinical classification of aortic valve stenosis severity between CMR and echocardiography. The authors concluded that CMR-based techniques to define EOA may serve as an ancillary to more accessible echocardiographic techniques.

The use of a physiological measure of flow quantification represents a step forward from standard CMR planimetry, which is technically challenging and may suffer from signal void or partial volume effects. Nevertheless, several important limitations merit mention. Precise flow quantification by CMR requires a high temporal resolution to accurately estimate peak velocity. In addition, inherent limitations of PC imaging (including phase offset, suboptimal selection of velocity-encoding gradients during acquisition, inadequate data during atrial fibrillation, and reliance on image plane selection) can interfere with optimal quantification of PC-VTI. Motion-correction algorithms to keep the area of PC acquisition steady (such as T1 mapping or 4-dimensional flow) offer additional value as unique parameters not obtainable by echocardiography remains an area of active investigation (14,15).

Ultimately, with an aging population and a rapid adoption of transcatheter bioprosthetic valve technology, further investigation is necessary to define the group of patients in whom CMR (in addition to echocardiography) will be clinically helpful.

**REFERENCES**


Despite these limitations, the authors are to be commended for extending CMR techniques that have been established with native valve assessment to bioprosthetic valves. However, the question of when CMR might be useful in the management of patients with prosthetic valve dysfunction remains open for additional investigations. Are certain bioprosthetic valves (e.g., stentless valves) more amenable to PC-EOA than others? Are there particular subgroups of patients with suboptimal echocardiographic windows in whom CMR measures of valvular stenosis might offer more clinical insight versus echocardiography? Finally, whether other emerging CMR techniques (such as T1 mapping or 4-dimensional flow) offer additional value as unique parameters not obtainable by echocardiography remains an area of active investigation (14,15).

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