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EDITORIAL COMMENT

Multimodality Imaging Is Key for a Successful Paravalvular Leak Repair*

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Paravalvular leak (PVL) is a complication following surgical or percutaneous valve replacement, more frequently seen in the mitral than aortic position.

Presenting symptoms are usually related to development of heart failure or hemolytic anemia. Although in symptomatic patients PVL intervention has been associated with improved event-free survival compared to conservative management, surgical intervention (PVL repair or valve replacement) has been associated with a high rate of morbidity, mortality and suboptimal results, especially in those who have undergone multiple prior cardiac operations and have significant comorbidities (1). In recent years, percutaneous PVL closure has emerged as a viable, less invasive alternative to surgical treatment, being particularly attractive for high-risk patients with multiple comorbidities. When performed in experienced centers, the rate of procedural success approaches 90% (2). In practice, however, there is a significant learning curve to perform successful percutaneous PVL repair due to the complex nature of the procedure. The procedure also requires close collaboration between imaging specialists, surgeons, and interventionalists (3). Advanced cardiac imaging is an integral part of the evaluation and guidance of percutaneous PVL repair.

In this issue of *JACC: Case Reports*, Espinoza Rueda et al (4) describes the clinical case of a 72-year-old man who was hospitalized with congestive heart failure and a new grade III holosystolic murmur at the apex 4 years following coronary artery bypass grafting with concomitant aortic and mitral valve replacement due to severe stenosis of both valves and tricuspid valve annuloplasty. Transesophageal echocardiography (TEE) revealed severe mitral PVL. Cardiac computed tomography (CT) confirmed the PVL defect location and size, and was used to obtain a 3-dimensional (3D) printed model to simulate PVL closure. The percutaneous PVL repair was performed successfully, with implantation of an Occlutech paravalvular leak device. The procedure was guided by the EchoNavigator system comprising of real-time fusion of echocardiography and fluoroscopic imaging. At the end of the procedure, there was minimal residual PVL and the patient experienced no complications.

This case shows the role of multimodality imaging to firstly define the location, shape and extent of the PVL; and secondly, to plan and guide the percutaneous PVL repair procedure.

A multimodality imaging approach is pivotal in the preprocedural planning of PVL closure to overcome the limitations of different imaging techniques, to properly identify prosthetic valvular dysfunction mechanism, to quantify the severity of the prosthetic valvular defect, and to anatomically define the PVL to appropriately plan the therapeutic intervention.

Echocardiography is the first-line imaging tool for evaluation of PVL. Although 2D echocardiography can provide approximation of the position, severity, and path of paravalvular regurgitation, 3D imaging enables a comprehensive assessment of the anatomical location, shape, and circumferential extent of the PVL, which provides important detail in planning and guiding the percutaneous repair (5,6). The

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echocardiographic grading of PVL severity has yet to be well standardized and remains a limitation (7).

In the present case, PVL severity estimation with transthoracic echocardiography was mainly based upon qualitative parameters. Cardiac CT provides important complementary detail in PVL evaluation. It provides high accuracy for determining the presence, size, and shape of the PVL, and identifies surrounding calcifications (8,9). Although its usefulness in assessing PVL anatomical features is key, cardiac CT is less sensitive for the assessment of regurgitation severity. Conversely, cardiac magnetic resonance imaging has been shown to have incremental utility over echocardiography by providing both anatomical features and quantification of the severity of the PVL. Cardiac magnetic resonance imaging quantification of paravalvular regurgitation can be performed by planimetry of the anatomic regurgitant orifice area, and also through phase-contrast velocity mapping analysis (7,10).

One of the challenges of percutaneous PVL closure is understanding the complex PVL shape in order to choose the appropriate device and the size of the device. In the case presented, the utility of an ex vivo 3D-printed model to simulate the PVL closure has been shown; this modeling step was useful in ensuring minimal interference of the device with prosthetic valve leaflet function. Although growing evidence supports the use of cardiac 3D-printed models in several clinical applications (preoperative planning, intervention simulation, intraoperative simulation, etc), the main limitation of this technology is the high cost inherent to the equipment and software needed to start a 3D-printing facility (11). However, cost-effective analysis has shown the feasibility of manufacturing low-cost 3D-printed cardiac models fulfilling the highest clinical and technical requirements (12). Ongoing efforts to develop new affordable materials and 3D printing technologies could increase accessibility of this tool across institutions and improve patients' quality of care. Finally, the use of echocardiographic-fluoroscopy fusion imaging, through the real-time overlay of 2D, 3D, or color Doppler images onto the fluoroscopic image enhances procedural guidance by localization of the PVL defect allowing more efficient PVL device closure (12,13).

This case shows the utility of multimodality imaging in supporting successful percutaneous repair of mitral bioprosthetic PVL. The integration of advanced cardiac imaging modalities including 3D printing can overcome limitations of individual techniques and guide complex and challenging procedures.

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