Cardiac Magnetic Resonance for Paravalvular Leaks in Post-Transcatheter Aortic Valve Replacement

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A 80-year-old man with known coronary artery disease presented with progressively worsening shortness of breath over the past few weeks. On transthoracic echocardiography (TTE) examination he was found to have severe aortic stenosis with an aortic valve area of 0.8 cm². Maximum aortic valve velocity was 4.25 m/s, peak gradient was 72.2 mm Hg with a mean gradient of 43.0 mm Hg, and mild aortic valve insufficiency was noted. He was deemed a surgical candidate and was randomly assigned to transcatheter aortic valve replacement (TAVR) as part of the Placement of Aortic Transcatheter Valve Trial II trial. An Edwards Sapien 29-mm XT bioprosthesis valve was placed through left-sided transfemoral access uneventfully. Within a day of the procedure, the patient reported worsening dyspnea. A postprocedural TTE revealed mild anterior and posterior paravalvular leak (PVL) by color Doppler (Figure 1 and Movie I in the online-only Data Supplement). Given the clinical and imaging findings, a higher-grade PVL was suspected, prompting further evaluation with cardiac magnetic resonance (CMR) imaging.

CMR 3-chamber view visualized the bioprosthesis, with phase contrast imaging identifying posterior PVL (Figure 2A and 2C and Movie II in the online-only Data Supplement). The anterior PVL was not well seen, likely because of the eccentricity of the jet and off-axis location. Short-axis CMR views are inappropriate for the evaluation of PVL because of significant artifact attributed to the metallic frame of the bioprosthetic valve. Paravalvular leak regurgitant fraction by flow quantification was 34% (grade 2, moderate; Figure 2E). The PVL was thought to be contributing to the patient’s symptoms, and a decision was taken to proceed with valve-in-valve TAVR.

Through right transfemoral access, a second Edwards Sapien 29-mm XT valve was deployed. Repeat CMR showed decrease of the posterior paravalvular PVL noted on the 3-chamber view (Figure 2B and 2D and Movie II in the online-only Data Supplement). CMR flow quantification showed significant reduction of PVL regurgitant fraction to 13.2% (grade 1, or mild; Figure 2F). By discharge, the patient’s symptoms had improved, and a predischarge TTE showed an aortic valve area of 2.43 cm² with a maximum aortic velocity of 2.10 m/s, a peak gradient of 17.6 mm Hg with a mean gradient of 8.5 mm Hg, and only mild PVL.

Discussion

TAVR is accepted as standard of care for patients with inoperable severe aortic stenosis. It provides an alternative therapy to patients who are at high risk for surgical aortic valve replacement because of their associated comorbid conditions. One common complication of TAVR is PVL, which occurs because of incomplete sealing of the aortic annulus by the bioprosthesis. PVL has significant impact on both short- and long-term prognosis, with a higher incidence in TAVR compared with surgical aortic valve replacement. Imaging artifacts caused by shielding and reverberation of the bioprosthesis, as well as the location and complex shape of the PVL defect, limit identification and quantification of PVL. The aortic annulus is more often oval in shape, whereas the prosthetic device is circular in design. This geometric-prosthesis mismatch is often accentuated by the variable shape of the aortic annulus during the course of cardiac cycle.

CMR phase contrast or velocity-encoded mapping is accurate in quantifying total aortic regurgitation, the sum of valvular aortic regurgitation and PVL. Because of the phenomenon of intravoxel spin dephasing, a regurgitant jet causes signal change, either a bright or dark signal, depending on the direction of flow measurement, which allows for easy visualization. Given the 2-dimensional nature of phase-contrast imaging, eccentric regurgitant jets may not be seen, such as in this case. However, one major advantage of CMR in the characterization of PVL is the ability to quantify regurgitant flow regardless of whether a regurgitant jet has been visual identified: on the basis of the forward and reversal flows, regurgitant volumes and flow are determined.

The physiologically variable shape of the PVL defect limits accurate quantitative evaluation through TTE. CMR RV or regurgitant fraction quantification is not limited by the variable change of the orifice during the cardiac cycle. TTE evaluation is semiquantitative and with a degree of subjectivity. CMR approach is more quantitative and has low interobserver variability. TTE should be the first modality of choice to investigate after TAVR PVL. However, when clinical presentation and TTE results are incongruent, CMR should be considered for further evaluation of PVL, especially when a therapeutic intervention is under consideration.
Disclosures

Drs Lerakis and Babaliaros are consultants to Edwards Lifesciences. The other authors report no conflicts.

References


Figure 1. Post-transcatheter aortic valve replacement transthoracic echocardiogram showing paravalvular defect and leak. A, B-mode parasternal long axis view showing 29-mm Sapien valve in the aortic position (yellow arrows). B, Color Doppler shows posteriorly located mild paravalvular leak (red arrow). C, Off-axis parasternal long axis view demonstrating the mild anterior paravalvular leak (pink arrow). Identifying this jet required tilting the probe anteriorly. D, B-mode parasternal short-axis view with the 29-mm Sapien valve in the aortic position (yellow arrows). E, Color Doppler shows mild anterior paravalvular leak (pink arrow).

Figure 2. Before and after valve-in-valve cardiac magnetic resonance (CMR) imaging with 3-chamber views and phase contrast imaging and regurgitant flows. A and B, CMR 3-chamber view showing posterior paravalvular leak (red arrow). Note the location of bioprosthetic device (yellow arrows). C and D, 3-chamber view phase contrast (PC) image shows posterior paravalvular leak (PVL; red arrow). Note that because of the partial metallic nature of the prosthetic device, metallic artifacts are seen on PC (chevron). E and F, CMR flow quantification across the aortic valve reveals significant paravalvular regurgitant fraction of 34% (grade 2, moderate). Forward flow across the aortic valve was 84.05; reversal flow was 28.80. CMR flow quantification across the aortic valve reveals reduced paravalvular regurgitant fraction of 13.2% (grade 1, mild). Forward flow across the aortic valve was 93.98; reversal flow was 12.49.
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**Movie Legend**

**Movie 1.** Parasternal Long (Panels A and B) and Short Axis (Panels C and D) views post-transcatheter aortic valve replacement, with (B and D) and without (A and C) color Doppler. The red arrow indicates the site of the posterior paravalvular leak in (panel C). The pink arrow indicates the anterior paravalvular leak (panel A and D), visible on off-axis view (Panel A). Best viewed with Windows Media Player.

**Movie 2.** 3-Chamber cine (Panels A and B) and phase contract (Panels C and D) cardiac magnetic resonance (CMR) pre (A and C) and post-valve-in-valve (B and D). The red arrow indicates the site of the posterior paravalvular leak. Best viewed with Windows Media Player.