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CASE REPORT

ADVANCED

CLINICAL CASE

Unearthing the Tunnel

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ABSTRACT

We present a unique case of a paravalvular leak through a periannular channel around a bioprosthetic mitral valve. The role of multimodality imaging, in addition to novel technology, helped uncover the complex course of the jet, including its origin and direction, which translated into excellent procedural success. (**Level of Difficulty: Advanced.**)
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HISTORY OF PRESENTATION

A 75-year-old man presented to the valve clinic (Columbia Structural Heart and Valve Center) with activity-limiting dyspnea on moderate exertion and poor functional capacity (New York Heart Association functional class II-III). Physical examination was pertinent for a systolic murmur (left lower sternal border). He was afebrile, with blood pressure of 128/80 mm Hg and a heart rate of 60 beats/min in an atrial paced rhythm. His lung examination was clear, and there was edema of his lower extremities. Results of laboratory investigations showed indirect hyperbilirubinemia and microscopic hematuria.

LEARNING OBJECTIVES

- To recognize the role of multimodality imaging in preprocedural planning of complex structural mitral interventions.
- To be aware of the role, utility, and benefits of advanced novel technology with 3D rendering and transillumination technique in the application of transcatheter mitral valve therapies.

PAST MEDICAL HISTORY

The patient had a past medical history of coronary artery bypass surgery and mitral valve repair with a 30-mm Carpentier-Edwards Physio ring in 2010. The patient underwent bone marrow transplantation in 2011 for immunoglobulin G lambda multiple myeloma. In 2012, the patient had osteomyelitis and methicillin-resistant *Staphylococcus aureus* mitral valve endocarditis, which were treated medically initially. He subsequently had symptomatic severe mitral regurgitation after 8 months that required redo mitral valve surgery with a 25-mm Mosaic bioprosthetic valve (Medtronic).

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

AVP II = Amplatzer Vascular Plug II

CT = computed tomography

PVL = paravalvular leak

TEE = transesophageal echocardiogram

2D = 2-dimensional

3D = 3-dimensional

DIFFERENTIAL DIAGNOSIS

The differential diagnosis included cardiomyopathy (ischemic vs valvular), mitral regurgitation (central vs paravalvular), perivalvular abscess, pulmonary hypertension, and primary lung disease.

INVESTIGATIONS

A transesophageal echocardiogram (TEE) was performed and showed a severe paravalvular leak (PVL) at the lateral commissure (**Figure 1A**). With 3-dimensional (3D) multiplanar reconstruction, the vena contracta area measured 27 to 31 mm^2, with maximum and minimum dimensions of 8.5 mm and 3.9 mm, respectively. Advanced 3D photorealistic and transillumination rendering (EPIQ systems, X8-2T probe, Philips Medical Systems) revealed the entry origin of the PVL, which was a channel tracking under the annulus of the surgical valve (**Figures 1B to 1F,** Video 1). The entrance to the channel was at the midposterior (P2) annulus, and blood filled the channel exiting at the lateral commissure. Left ventricular systolic function and cavity size were normal. The right ventricle was moderately dilated, with moderately reduced systolic function. Cardiac computed tomography (CT) was performed using volume acquisition that confirmed the presence of a subannular channel (**Figure 2**). There was no significant coronary artery disease or signs of active endocarditis. Right-sided heart catheterization showed mildly elevated right- and left-sided filling pressures with moderate postcapillary pulmonary hypertension (mean right atrial pressure, 22 mm Hg; right ventricular pressure, 7/11 mm Hg; mean pulmonary artery pressure, 48 mm Hg; and mean pulmonary capillary wedge pressure, 28 mm Hg).

MANAGEMENT

He was evaluated by the multidisciplinary heart team and was deemed at high risk for surgical intervention. The decision was made to proceed with percutaneous PVL closure. Cardiac CT images were used for assessing the channel course and confirming the TEE findings, in addition to sizing the defect (**Figures 3A to 3C**).

Two-dimensional (2D) and 3D TEE guidance was used to optimize transseptal puncture, and the PVL was crossed using an Agilis catheter. The wire path followed the course of the channel along the posterior annulus and entered the left ventricle at the P2 region of the annulus (**Figures 4A and 4B**). A 12-mm Amplatzer Vascular Plug II (AVP II, Abbott) closure device was positioned using fluoroscopic and TEE guidance, the distal cap and barrel of the device were markedly deformed within the narrow channel (Video 2). Following release of the proximal cap within the left atrium, extensive 2D and 3D imaging revealed multiple trivial PVL jets (**Figure 5,** Video 3). No intraprocedural complications were noted.

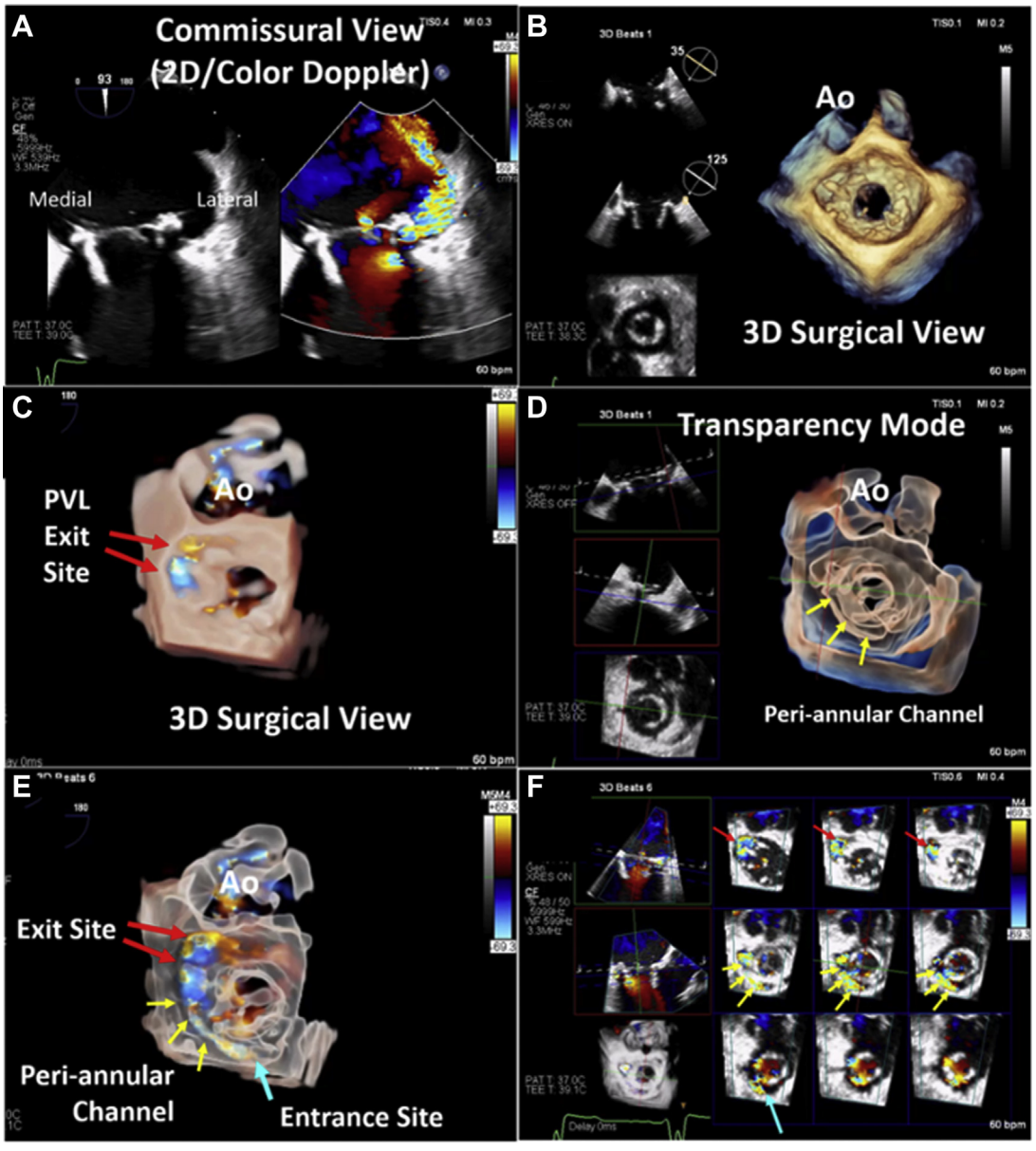
DISCUSSION

PVL is a rare but serious complication after surgical valve replacement and can lead to heart failure and/or hemolytic anemia.[1,2] It occurs in 7% to 17% of mitral valve replacements. Surgical reintervention for PVLs is associated with a high risk of morbidity and mortality; therefore, percutaneous treatment of PVLs has become first-line therapy for most symptomatic patients.[3]

In this case, our patient's heart failure symptoms were attributed to the significant mitral prosthetic PVL. The use of advanced TEE imaging software with a photorealism 3D-rendering technique and transillumination images with transparency enhanced the echocardiographic visualization of the complex geometry of the periannular channel, which could have been a sequela of his previous endocarditis.[4,5] In addition, placing the virtual light source above and around the mitral annulus, and the use of transillumination rendering, assisted in highlighting the exit and entrance of the periannular channel.[6]

Because of the unusual course of the PVL and the varying size of the channel, we chose an AVP II device with a "cap" that would sit over the exit site within the left atrium and a barrel that would fill the periannular channel. Advanced TEE imaging in conjunction with cardiac CT allowed for robust preprocedural planning and a successful procedural result.[7]

FIGURE 1 **Preprocedural Transesophageal Echocardiogram**

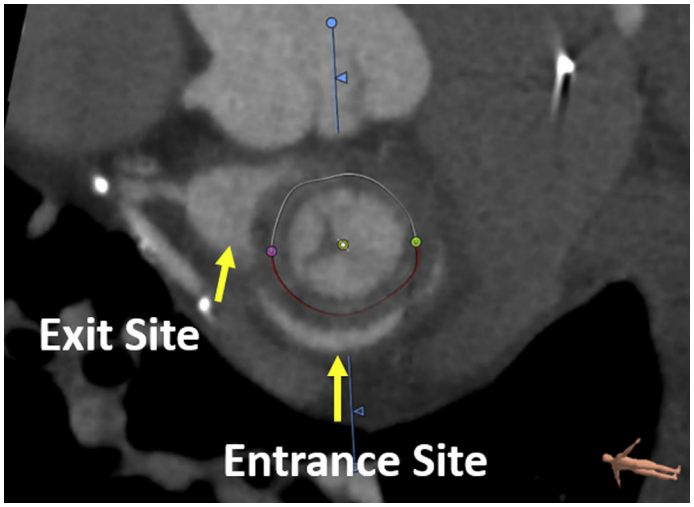


(A) Baseline 2-dimensional (2D) and color Doppler transesophageal echocardiogram in the commissural view demonstrating the paravalvular leak (PVL). **(B to E)** Baseline 3-dimensional (3D) transesophageal echocardiogram rendering in en face view showing the jet entrance **(blue arrow),** the periannular channel **(yellow arrows),** and the jet exit site **(red arrows). (F)** Paravalvular jet demonstration in en face view using multislice automated cropping **(arrows as in B to E)**. Ao = aorta.

FOLLOW-UP

Transthoracic echocardiography before discharge showed a well-positioned vascular plug with trace paravalvular regurgitation. Cardiac CT showed a well-positioned vascular plug with no prosthetic entanglement or complication (Figures 6A and 6B). At 1-month follow-up, the patient remained well,

FIGURE 2 Preprocedural Cardiac Computed Tomography



Cardiac computed tomography in the short axis at the level of the mitral annulus showing the entrance and exit point of the paravalvular leak jet across the channel.

with resolution of his symptoms. Laboratory findings showed new hematuria immediately after the procedure that improved over the following 3 weeks.

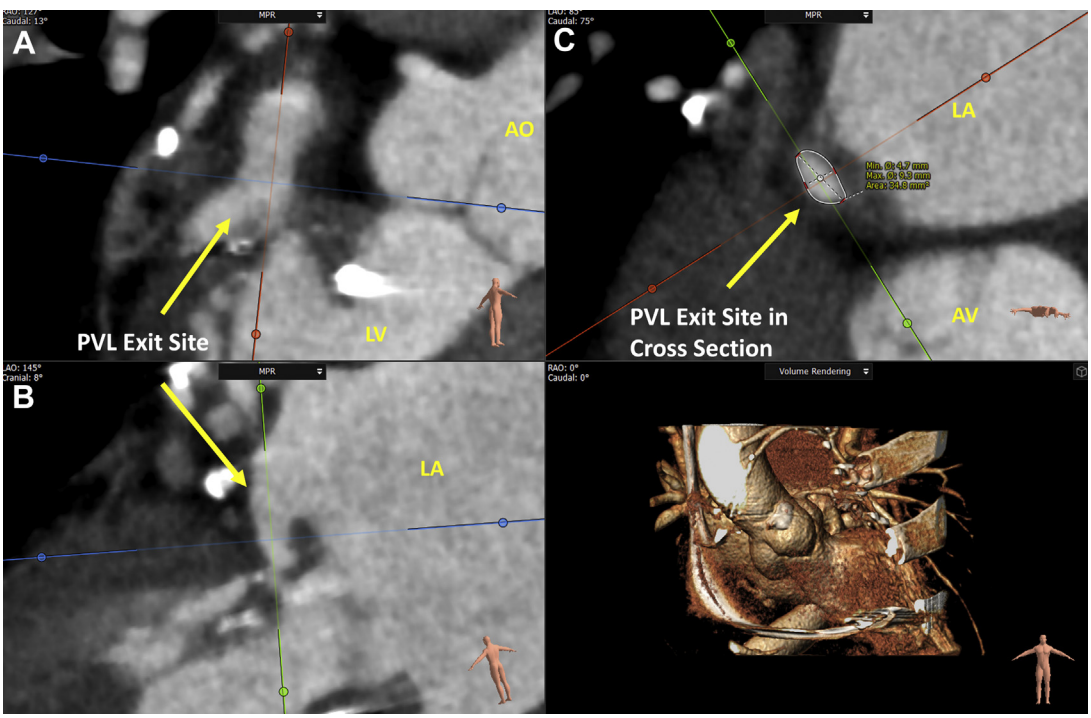
CONCLUSIONS

In this complex, high-risk patient with mitral PVL, the role of multimodality imaging was key to the success of complex structural interventions. The enhancement of image quality with novel technology, such as transillumination rendering, improved our ability to diagnose the condition, localize lesions, and guide structural interventions.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

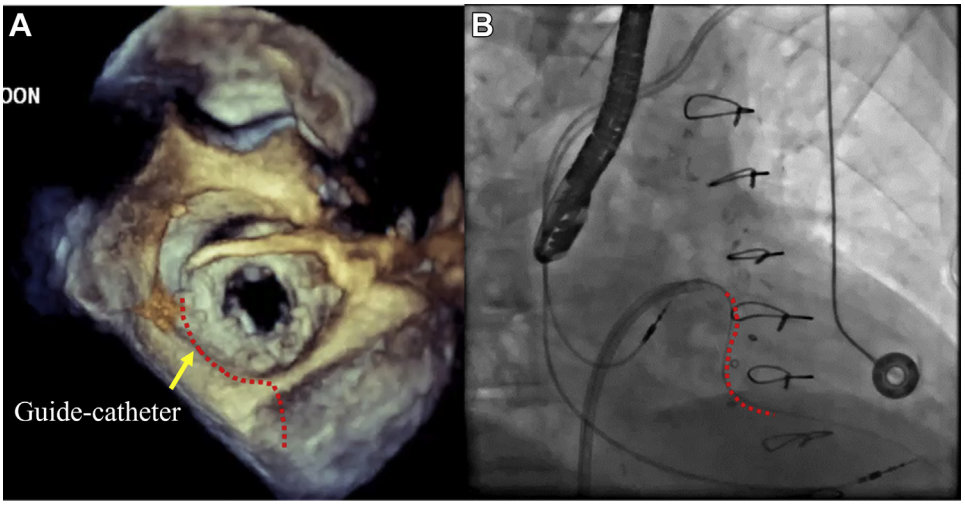
Dr Nemshah has received an educational scholarship from King Fahad Medical City through the Saudi Arabian Cultural Mission in Washington, DC. Dr George has received consulting fees from W.L. Gore & Associates, Vdyne, Cardiomech, Mitremedical, and Atricure. Dr Nazif has received consulting fees for or honoraria from Edwards Lifesciences, Medtronic, Venus Medtech, and Boston Scientific. Dr Vahl has received institutional funding to Columbia University Irving

FIGURE 3 Sizing of the Paravalvular Leak Defect by Cardiac Computed Tomography



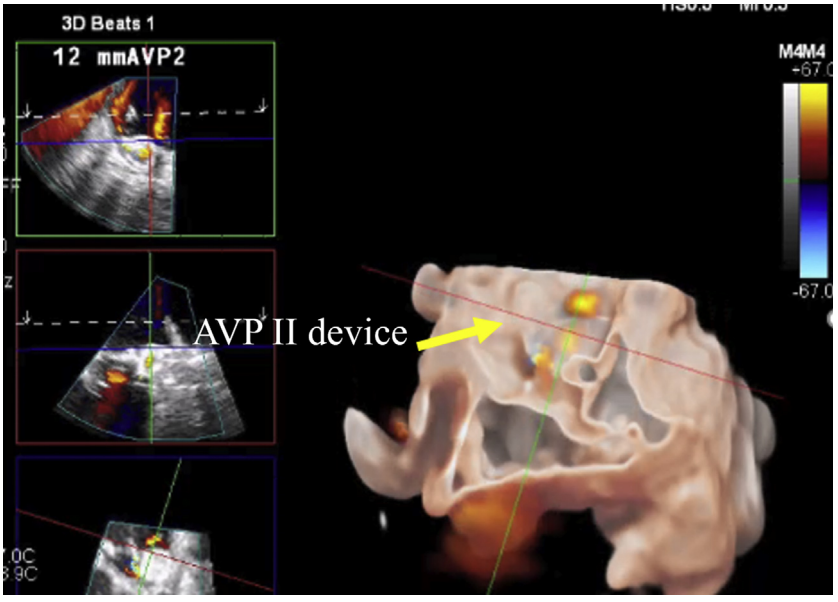
Preprocedural cardiac computed tomography with multiplanar reconstruction and analysis of the periannular channel at the junction with the left atrium. The crosshairs show the paravalvular leak channel in the **(A and B)** long axis and **(C)** short axis. **(C)** Cross-sectional image of the paravalvular leak channel with measurement (9.3 × 4.7 mm). A 12-mm Amplatzer Vascular Plug II (Abbott) device was selected for the procedure. AO = aorta; AV = aortic valve; LA = left atrium; LV = Left ventricle; Max = maximum; Min = minimum.

FIGURE 4 **Intraprocedural Imaging**



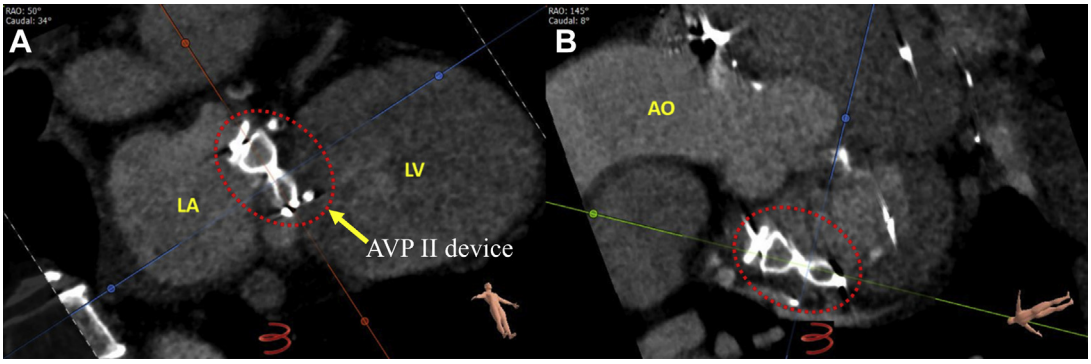
(A) Intraprocedural 3-dimensional transesophageal echocardiogram in the surgeon's view showing the guide catheter across the channel. The **red dotted line** shows the course of the wire as it travels through the channel. **(B)** Fluoroscopy showing the wire traveling through the periannular channel.

FIGURE 5 **Postprocedural 3-Dimensional Transesophageal Echocardiogram**



Postprocedure 3-dimensional photorealism rendering Amplatzer Vascular Plug II (AVP II, Abbott) device **(yellow arrow)** and the residual trace paravalvular leak jets.

FIGURE 6 Postprocedural Cardiac Computed Tomography



Follow-up cardiac computed tomography showing the Amplatzer Vascular Plug II (AVP II, Abbott) device **(red dotted circle)** in **(A)** the 2-chamber view and **(B)** the short-axis view at the level of the mitral prosthetic sewing ring. Abbreviations as in Figure 3.

Medical Center from Boston Scientific, Edwards Lifesciences, JenaValve, Medtronic, and Siemens Healthineers; and has received consulting fees from Abbott Vascular, Boston Scientific, and Siemens Healthineers. Dr Kodali has served as a consultant for and received honoraria from Admedus, Meril Lifesciences, JenaValve, and Abbott Vascular; has reported membership on the scientific advisory boards and equity in Dura Biotech, MicroInterventional Devices, Thubrikar Aortic Valve Inc, Supira, and Admedus; and has received institutional funding to Columbia University and/or the Cardiovascular Research Foundation from Edwards Lifesciences, Medtronic, Abbott Vascular, Boston Scientific, and JenaValve. Dr. Hahn has received speaker fees from Abbott Structural, Edwards Lifesciences, and Philips Healthcare; has received institutional consulting contracts with Abbott Structural, Boston Scientific, Edwards Lifesciences, and W.L. Gore & Associates; has received equity in Navigate; and is the Chief Scientific Officer for the Echocardiography Core Laboratory at the Cardiovascular Research Foundation for multiple industry-sponsored trials, for which she receives no direct industry compensation. Dr Khalique has received consulting fees from Abbott Structural and Boston Scientific; and has received Speakers Bureau fees from Edwards Lifesciences. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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KEY WORDS channel, echocardiography, mitral regurgitation, paravalvular leak, percutaneous closure, 3D

APPENDIX For supplemental videos, please see the online version of this paper.