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CASE REPORT

ADVANCED

DAVINCI CORNER

Successful Closure of Paravalvular Leak Using Computed Tomography Image Fusion and Planning With 3-Dimensional Printing

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ABSTRACT

The presence of moderate to severe paravalvular leak increases mortality. We present a case of giant paravalvular leak closure using the 3-dimensional printing model to assess the success of the device to be used for its closure, computed tomography was performed for planning and guiding the procedure by image fusion. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2022;4:36–41) © 2022 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 72-year-old man was admitted to our hospital (National Medical Center "November 20," Institute of Social Security and Services for State Workers, Mexico City, Mexico) in September 2020 for deterioration of New York Heart Association (NYHA) functional class III heart failure in the last 5 months. Presenting with dyspnea, orthopnea, and paroxysmal nocturnal dyspnea, the patient was in congestive heart failure without clinical improvement, despite receiving medical treatment indicated by clinical practice guidelines. On physical examination, he was afebrile, with a blood pressure of 110/55 mm Hg, a heart rate of 115 beats/min, a respiratory rate of 25 breaths/min, and oxygen saturation of 88% on room air. The jugular veins in his neck were engorged, and he had pulmonary auscultation with bilateral rales and right pleural effusion. His heart rhythm was irregular, with

LEARNING OBJECTIVES

- To evaluate the benefit of the 3-dimensional trial model in patients with mitral PVL to improve the success of the transcatheter closure procedure and reduce the complication rate.
- To consider the use of image fusion in percutaneous closure of PVL to facilitate leak crossover and decrease fluoroscopy time.

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a third sound, and he had a grade 3 holosystolic murmur in mitral focus.

PAST MEDICAL HISTORY

The patient's medical history was notable for type 2 diabetes mellitus Kidney Disease Improving Global Outcomes stage 3b chronic kidney disease, dyslipidemia, hyperuricemia, and valvular atrial fibrillation. In 2016, he presented with deterioration of NYHA functional class III heart failure and received a diagnosis of ischemic heart disease in addition to severe stenosis of the mitral and aortic valves and severe tricuspid regurgitation. He underwent coronary artery bypass grafting with Hemaduct drain (Cardinal Health) implantation from the internal mammary artery to the anterior descending artery and a reverse saphenous vein to the posterior descending artery, valve replacement with mechanical prostheses (29-mm for the mitral valve and 25-mm for the aortic valve), and tricuspid valve repair. Follow-up showed that the patient remained in NYHA functional class I heart failure.

DIFFERENTIAL DIAGNOSIS

The clinical history of the patient, the deterioration of functional class on minimal effort, and the findings of the physical examination are suggestive of congestive heart failure of valvular origin resulting from dysfunction of the mitral prosthesis secondary to prosthetic insufficiency or paravalvular leak (PVL). Another probable cause is ischemic heart disease despite the absence of angina.

INVESTIGATION

Laboratory investigations were notable for the following: hemoglobin, 12.7 g/dL; hematocrit, 38.8%; B-type natriuretic peptide (BNP), 2,450 pg/mL; plasma creatinine, 1.84 mg/dL; urea, 88 mg/dL; Modification of Diet in Renal Disease glomerular filtration rate, 38 mL/min/1.73 m^2, and the absence of hemolysis data. Transthoracic echocardiogram revealed a left ventricular ejection fraction of 49%, a dilated left ventricle, and a dilated left atrium; pulmonary artery systolic pressure was 60 mm Hg. Transesophageal echocardiography (TEE) confirmed mitral prosthesis dysfunction secondary to severe PVL in a lateral location and a transprosthetic gradient of 4 mm Hg with the aortic prosthesis functioning normally (**Figures 1 and 2,** Video 1). Cardiac computed tomography (CT) revealed a large mitral PVL with a diameter of 1.36 × 1.61 cm, an area of 2.47 cm^2, and an anterolateral location between 9 and 11 o'clock (**Figure 3**). The use of CT was beneficial in selecting the type and size of the ideal device for adequate closure of the PVL. A successful result was obtained with the use of Occlutech Paravalvular Leak Device (PLD) 18 × 10 mm (Occlutech GmbH) without presenting interaction with the operation of the prosthesis; no other test device was used (**Figures 4 to 6,** Video 2). The patient had a high fragility score (Society of Thoracic Surgeons score of 10%).

ABBREVIATIONS AND ACRONYMS

CT = computed tomography

NYHA = New York Heart Association

PVL = paravalvular leak

TEE = transesophageal echocardiography

TAVR = transcatheter aortic valve replacement

MANAGEMENT

Image fusion using the Heart Navigator system (Philips Healthcare) facilitated location of the PVL (**Figure 7**). The PLD 18 × 10 mm system was implanted under fluoroscopic and echocardiographic surveillance on the first attempt. No other device was used, a successful result was obtained, and a second parallel guide was not used (**Figures 8 and 9,**

FIGURE 1 Initial Echocardiogram Showing Severe Paravalvular Leak

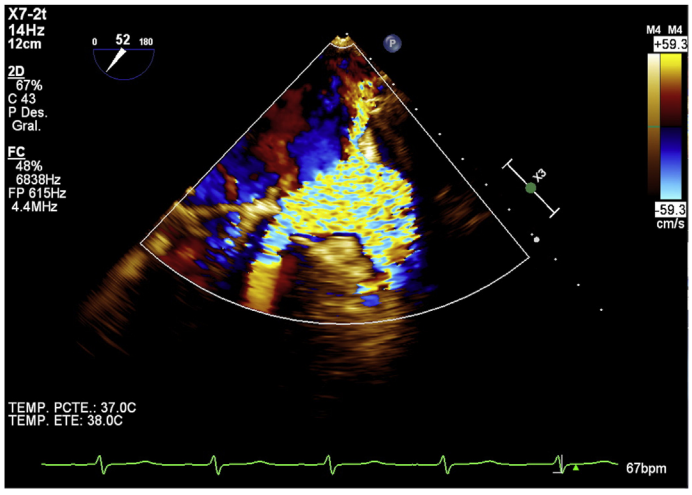

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FIGURE 2 Initial Echocardiogram Showing Gradient Medium 4 mm Hg

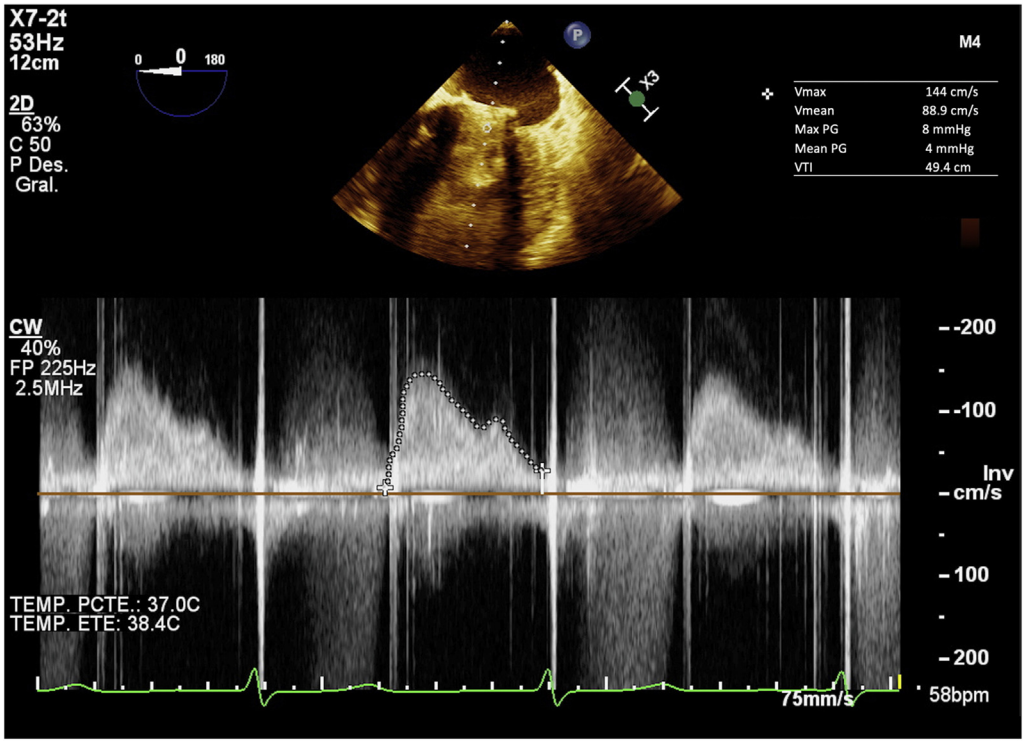
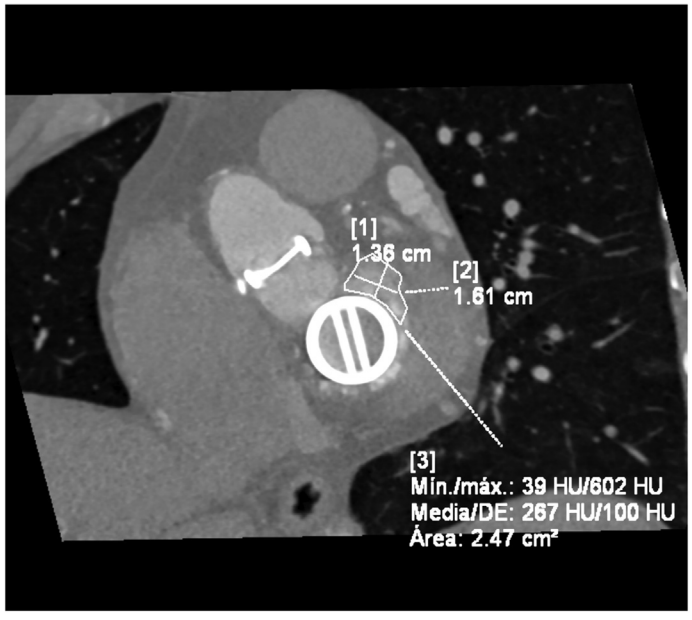


FIGURE 3 Cardiac Computed Tomography Showing Size of Paravalvular Leak (1.36 × 1.61 cm) Anterolateral Location

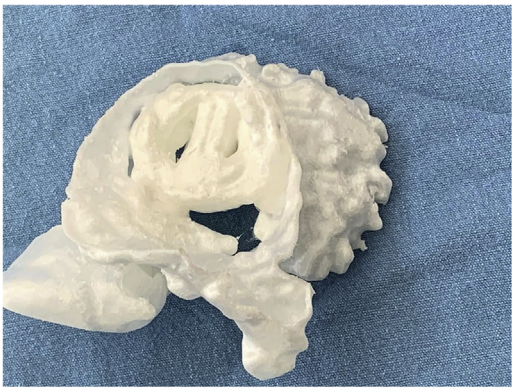


Video 3). The hemodynamic response and the degree of residual leak were evaluated by TEE, which showed only slight residual PVL and a mean transprosthetic gradient of 3 mm Hg (**Figures 10 and 11,** Video 4). The procedure was completed without complications.

DISCUSSION

PVL or paravalvular regurgitation is a serious complication and an underrecognized condition affecting 6% to 15% of surgical prosthetic valves, annuloplasty rings, and transcatheter aortic valve replacements (TAVRs). Moderate to severe PVL after surgery or TAVR is associated with increased mortality (1-3). The incidence of PVLs after surgical valve replacement varies in different studies, ranging from 7% to 17% in the mitral position (4). The 2020 joint American College of Cardiology and American Heart Association guideline for the management of patients with heart valve disease proposes percutaneous closure of PVLs with a grade of recommendation Class 2a and a Level of Evidence: B (5). Percutaneous

FIGURE 4 Paravalvular Leak Test Model Obtained by 3-Dimensional Printing

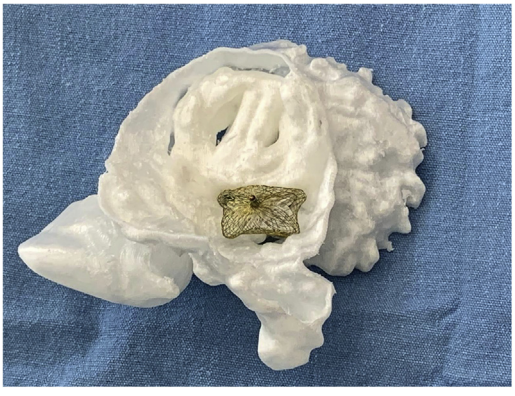


closure of PVLs has shown significant promise with reported success rates as high as 86% (2). Planning with cardiac CT scan facilitates selection of the size and type of device necessary for closure of the PLV. We can obtain 3-dimensional printing of a test model to predict the success of the device to be used in addition to performing image fusion with Heart Navigator to guide the procedure and obtain a satisfactory result (6). Studies show the feasibility of using 3-dimensional impression models before the procedure, thereby predicting a successful result (7).

FOLLOW-UP

The patient was discharged 48 hours after the procedure. The outpatient evaluation at 15 days showed clinical improvement and no cardiovascular symptoms.

FIGURE 5 Atrial View



The test model shows the total occlusion of the leak with the device.

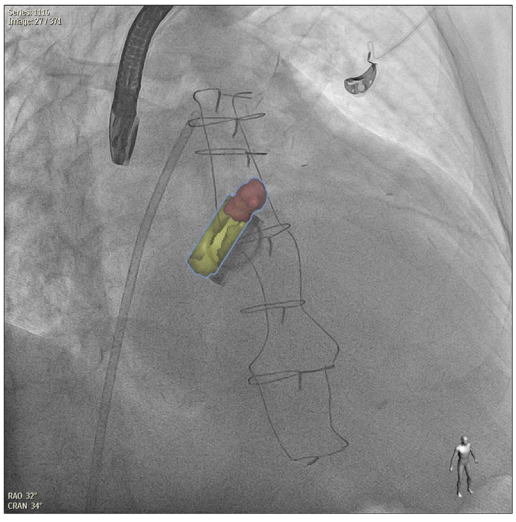
FIGURE 6 Ventricular View

The test model shows the total occlusion of the leak with the device.

CONCLUSIONS

Transcatheter closure of PVL provides a favorable prognosis for the patient. The success of the procedure increases when it is performed after proper planning. Our challenging case considers the use of several imaging tools—cardiac CT, TEE,

FIGURE 7 Image Fusion



The procedure was guided by image fusion, easily crossing the leak.

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FIGURE 8 Safety Test Before Releasing the Device

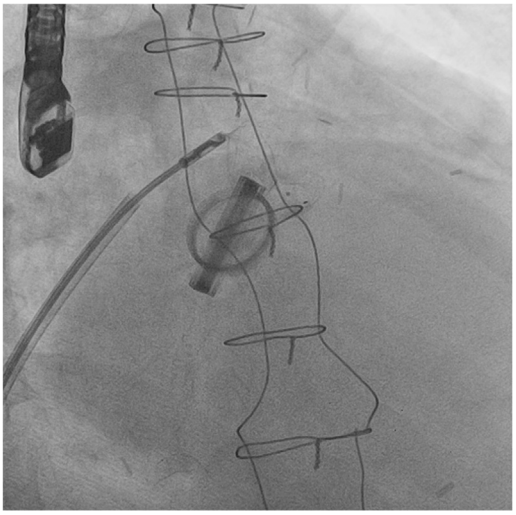
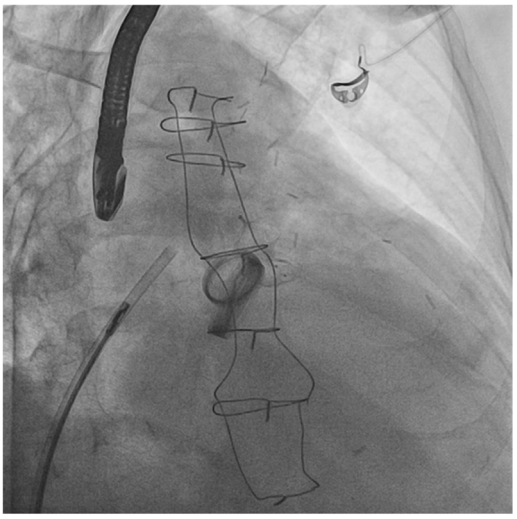


FIGURE 9 Implantation and Successful Release of the PLD System



3-dimensional printing, and image fusion with Heart Navigator—to obtain satisfactory results.

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FIGURE 10 Final Echocardiogram Showing Slight Residual Leak

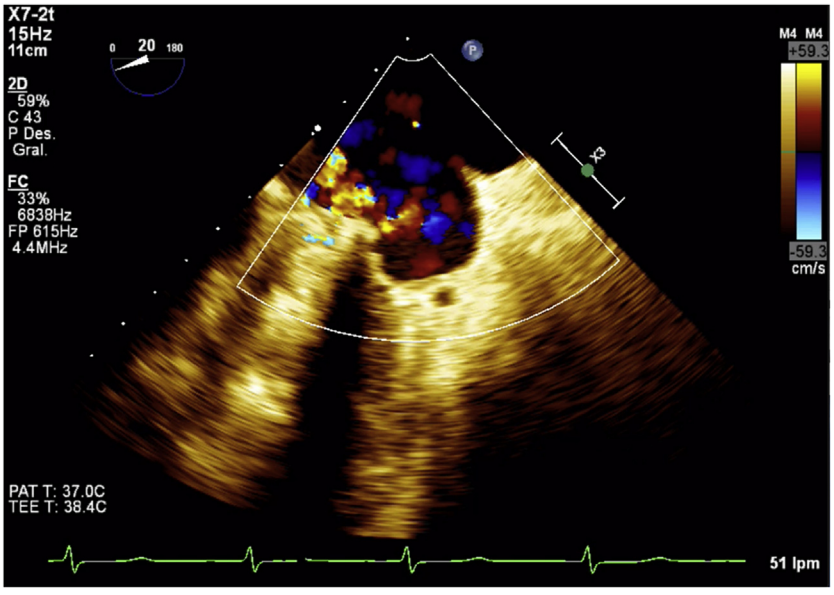
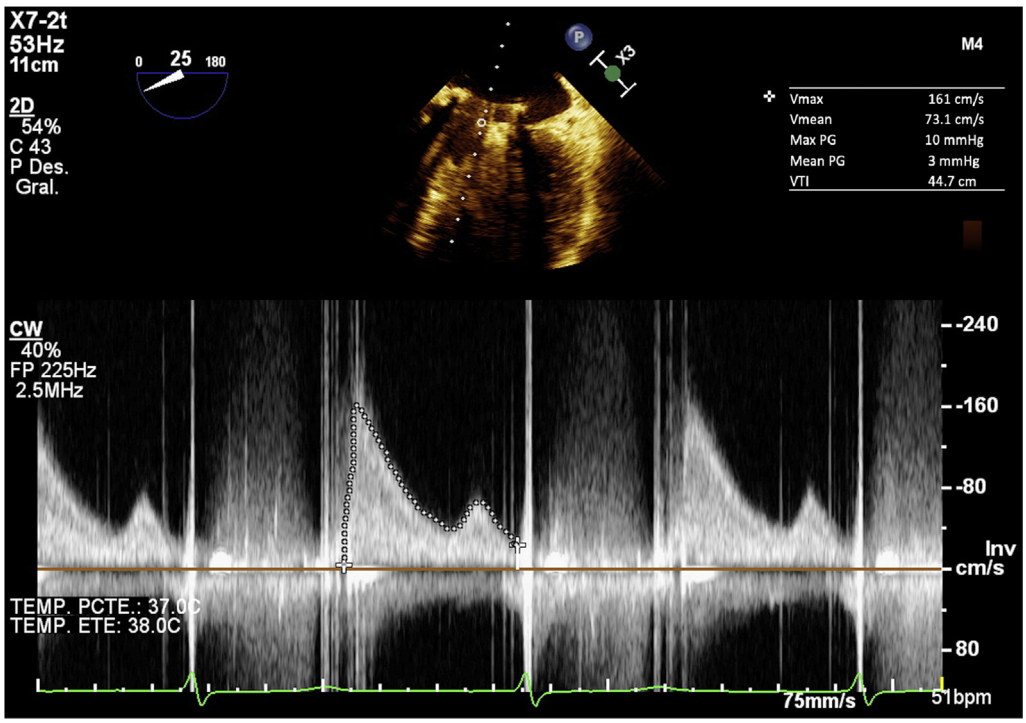


FIGURE 11 **Final Echocardiogram Showing Mean Gradient of 3 mm Hg**



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KEY WORDS 3-dimensional imaging, 3-dimensional printing, computed tomography, mitral valve, valve repair

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