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CASE REPORT

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Transcatheter treatment of complex pulmonic and aortic valvular disease following failed Ross procedure

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Abstract

A 63-year-old man with congenital bicuspid aortic valve disease and complex surgical history (that includes a Ross procedure complicated by cardiac arrest requiring emergency coronary artery bypass graft surgery, multiple subsequent sternotomies to treat a failed pulmonic homograft and pseudoaneurysm repair of the left and right ventricular outflow tracts (LVOT/RVOT), bioprosthetic aortic valve replacement, and aortic valve endocarditis) presented with worsening heart failure symptoms secondary to bioprosthetic aortic valve failure and recurrent pulmonic valve stenosis successfully treated with transcatheter intervention.

KEYWORDS

bicuspid aortic valve, pulmonic stenosis, Ross procedure, TAVR

1 | INTRODUCTION

The Ross procedure is a surgical treatment that consists of using the native pulmonic valve of the patient to replace the diseased aortic valve with heterograft pulmonic valve replacement. The procedure is typically performed in younger patients but is often associated with long-term complications requiring recurrent intervention.

2 | CASE REPORT

2.1 | History of presentation

A 63-year-old man presents with one year of progressive heart failure symptoms (NYHA class III/IV). Clinical examination confirmed an IV/VI late peaking crescendo decrescendo murmur at the right upper sternal border.

2.2 | Past medical history

The patient underwent a Ross procedure in 2002 for congenital bicuspid aortic stenosis, which was complicated by postprocedure cardiac arrest due to left main coronary obstruction. This was treated with emergent coronary bypass surgery utilizing the left internal mammary artery (LIMA) to the left anterior descending (LAD) and saphenous vein graft (SVG) to the left circumflex (LCx) coronary artery. The patient was subsequently found to have an aortic paravalvular leak (PVL) with fistulization of the noncoronary cusp to the left ventricle and right coronary cusp to the right ventricle requiring redo sternotomy for correction. In 2013, he developed severe pulmonary homograft stenosis and a pseudoaneurysm of the LVOT necessitating repeat sternotomy with pulmonary homograft replacement and concomitant bioprosthetic aortic valve replacement. In 2014, the patient underwent another

sternotomy for patch repair of recurrent LVOT/RVOT pseudoaneurysm, which was complicated by aortic valve insufficiency requiring repeat aortic valve replacement with a 21 mm Edwards Magna Ease valve. His post-op course was complicated by recurrent episodes of endocarditis and development of an annular abscess resulting in multiple hospital admissions in 2014, 2015, and 2017 for intravenous antibiotic treatment.

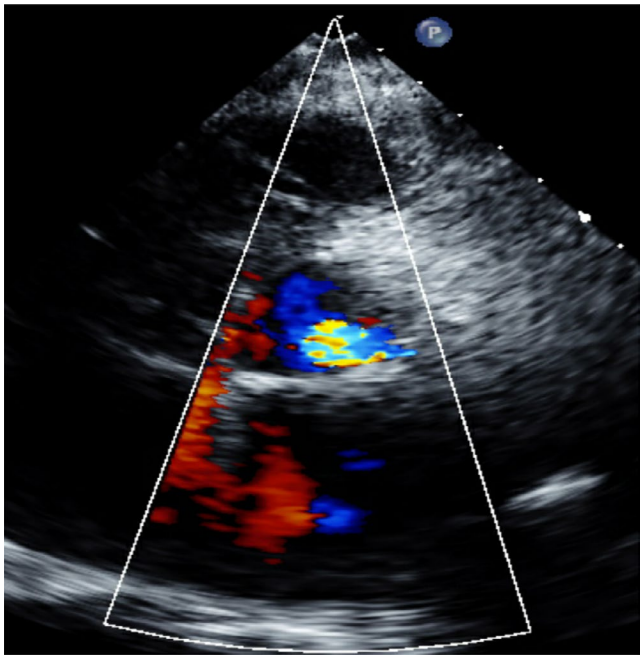

FIGURE 1 Initial transthoracic echocardiographic parasternal short-axis image demonstrating color Doppler of large jet of paravalvular aortic regurgitation

2.3 | Investigations

Transthoracic echocardiography (TTE) was significant for severe bioprosthetic aortic valve stenosis with moderate to severe paravalvular regurgitation (peak velocity 3.7 m/s, DVI 0.24, and acceleration time >100 ms with mean gradient 35 mm Hg) (Figure 1). Left ventricular ejection fraction was 46%. Additionally, pulmonic valve stenosis was identified with peak/mean gradient of 66/41 mm Hg and max velocity of 4.0 m/s. Angiography demonstrated occluded LIMA to LAD graft with the native LAD supplied by the native left main and total occlusion of the native LCx with patent SVG to the LCx. A right heart catheterization (RHC) was remarkable for severely elevated right ventricular systolic pressure of 102 mm Hg (Figure 2). Pulmonary artery pressure (PAP) was 32/15 mm Hg with mean PAP of 22 mm Hg.

2.4 | Management

Endovascular pulmonic valve replacement was undertaken by first performing serial balloon dilatation of the

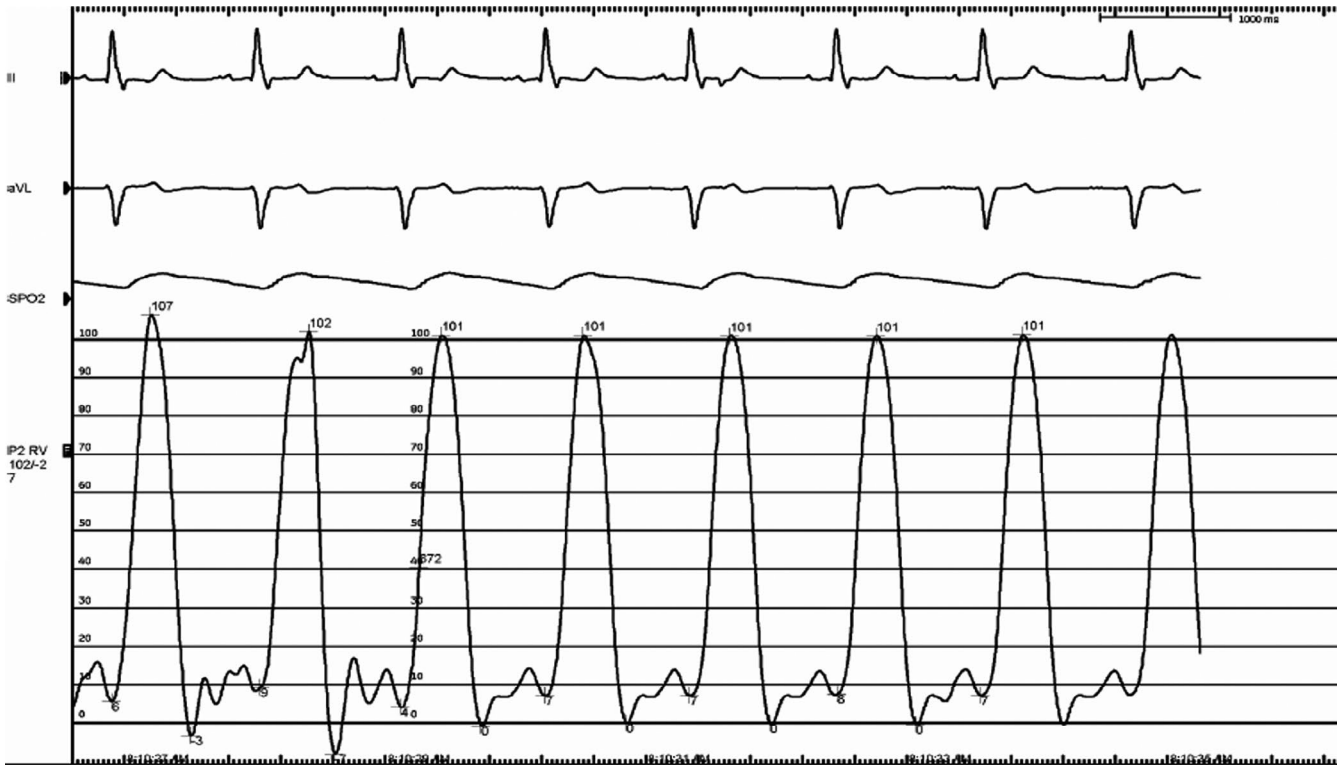

FIGURE 2 Right heart catheterization (RHC) with severely elevated right ventricular systolic pressure of 102 mm Hg

stenotic homograft using 16, 18, and 20 mm balloons. Because of the increased risk of coronary compression with transcatheter pulmonic valve interventions, patency of the SVG to LCx and left main coronary arteries was assessed during each balloon inflation using selective angiography. During inflation of the 20 mm balloon, there was partial angiographic compromise of the left main coronary artery, indicating that 18–19 mm would be the maximal safe diameter obtainable for transcatheter pulmonic valve implantation (Figure 3). Subsequent angiography demonstrated a small area of contained perforation of the homograft. As such, a neoconduit within the homograft was created by implantation of an 18 x 28 mm Cheatham Platinum (CP)-covered stent. Due to the significant elastic recoil noted on fluoroscopy after CP stent deployment, a 10 x 29 mm Palmaz stent was hand-mounted onto the used CP stent balloon for deployment and was postdilated to 18 mm with a high-pressure balloon catheter (Figure 4). A 20 mm Edwards Sapien S3 valve was then deployed inside this neoconduit. Due to the rigidity and sizing of the neoconduit, the maximal expansion of the S3 valve is constrained, such that the outer diameter of the pulmonic neoconduit does not exceed 18–19 mm. Final pulmonary artery angiography showed no significant pulmonic regurgitation (Figure 5). Right ventricular pressure improved to 41/4 mm Hg (Figure 6).

Two weeks later, the patient underwent valve-in-valve (VIV) transcatheter aortic valve replacement (TAVR) utilizing a 23 mm Edwards Sapien Ultra valve under transesophgeal echocardiographic (TEE) guidance. The valve was deployed somewhat more ventricular than is typical in order to utilize the sealing of the valve skirt to close the large area of PVL involving the superior LVOT. Following valve deployment, additional balloon postdilatation was performed using a 22 mm True Dilatation Balloon (Bard) to deliberately fracture and enlarge the bioprosthetic surgical valve. This was meant to seal the large area of PVL and assure optimal transvalvular hemodynamics (Figure 7). The pressure gradient across the aortic valve

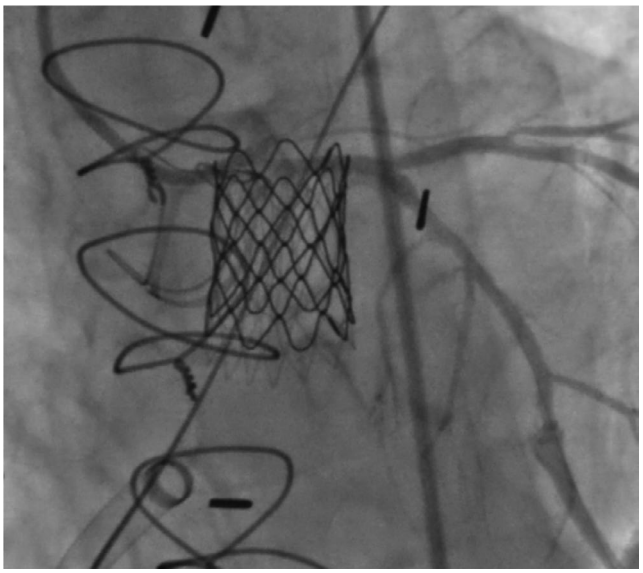

FIGURE 4 Angiographic image showing Palmaz stent inside of the CP stent to create the neoconduit. Angiography reveals widely patent left main coronary artery following neoconduit creation

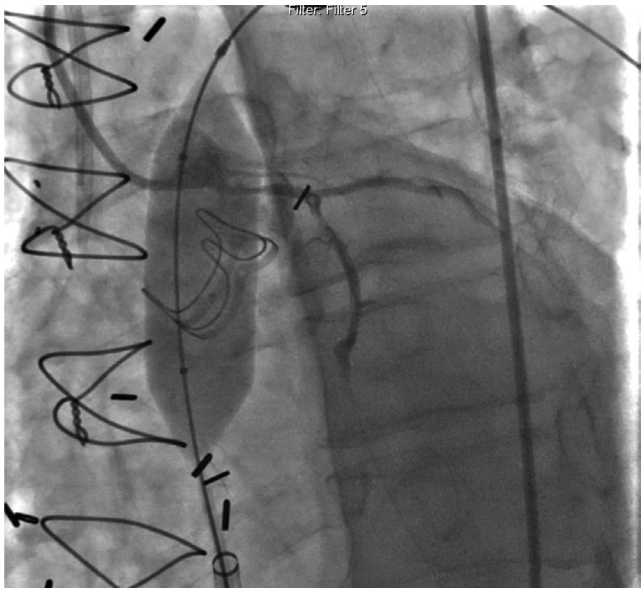

FIGURE 3 Angiographic image performed during 20 mm balloon inflation showing partial angiographic compromise of the left main coronary artery

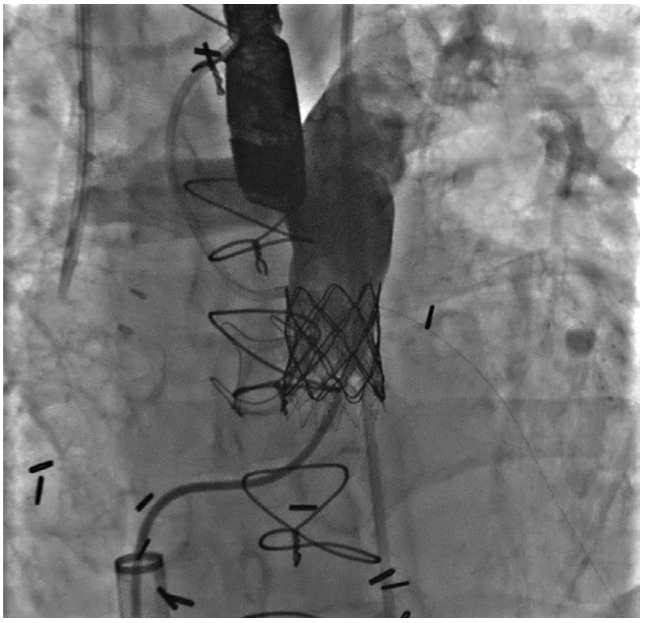

FIGURE 5 Final pulmonary angiography following transcatheter valve implantation revealing no significant pulmonic regurgitation

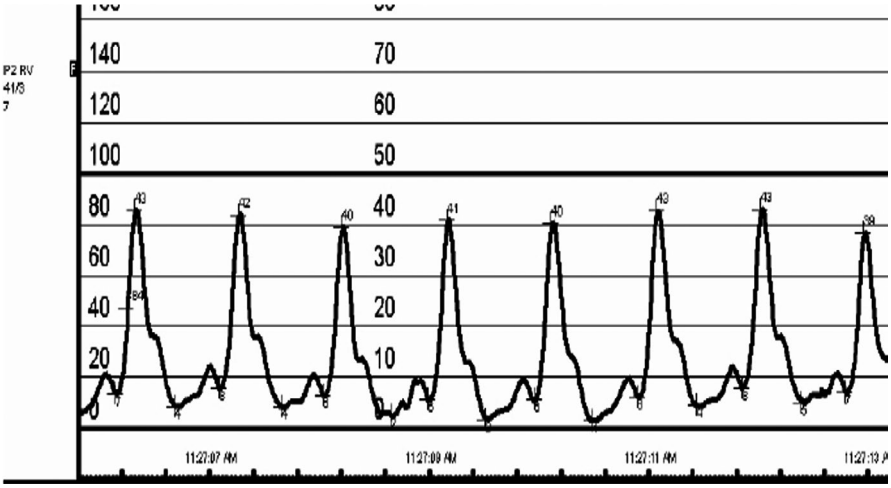

FIGURE 6 Right ventricular pressure tracing obtained at the conclusion of the transcatheter pulmonic valve implantation procedure

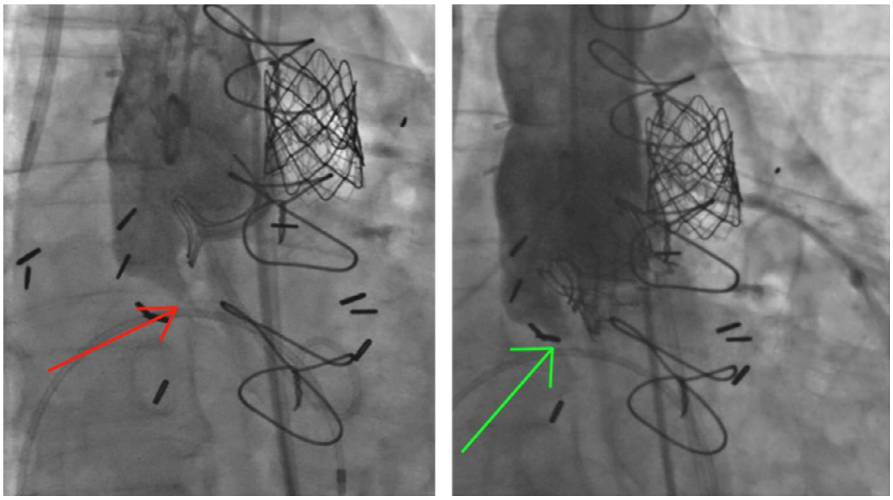

FIGURE 7 Aortic root angiography performed pre- and post-TAVR. (A) arrows highlight significant source of perivalvular regurgitation. (B) showing final angiography with resolution of perivalvular leak after Sapien 3 Ultra implantation followed by bioprosthetic valve fracturing using a 22 mm True Dilatation balloon (Bard)

resolved after TAVR implantation (Figure 8). Final TEE imaging revealed near-total resolution of both PVL and aortic stenosis (Figure 9).

3 | DISCUSSION

Although the patient met class I indications for surgical aortic and pulmonic valve replacement, we opted for an endovascular approach to address both valvular pathologies given his high risk for surgical complications. We prioritized pulmonic valve intervention given that right ventricular dysfunction is typically more recalcitrant to reversal than left ventricular dysfunction. This is due to limited medical therapy and concern for compromised left-sided output due to inadequate preload from right ventricular dysfunction.

Ideal transcatheter pulmonic intervention involves implanting a valve large enough to eliminate the hemodynamic stress placed on the right ventricle, while simultaneously avoiding catastrophic rupture of the stenotic pulmonic conduit and/or coronary artery compression. In this case, we were unable to obtain surgical records confirming the original pulmonic conduit size. Thus, we performed serial balloon dilatation to determine the maximal feasible neoconduit size. Because of the risk of coronary compression, it is critical to perform coronary angiography during each balloon inflation to avoid coronary compression. Therefore, the maximal allowable size of the neoconduit is limited by the largest diameter balloon that does not lead to coronary compression.

In this case, balloon dilatation leads to a small contained perforation of the surgical pulmonic conduit, and a CP-covered stent was deployed to remedy this. Although the CP stent sealed the perforation, it did not have adequate structural radial strength to resist elastic recoil in the highly stenosed pulmonic homograft. Therefore, the addition of the Palmaz stent was necessary to add additional structural integrity to the neoconduit. With adequate scaffolding in place, the Edwards valve could then be deployed.

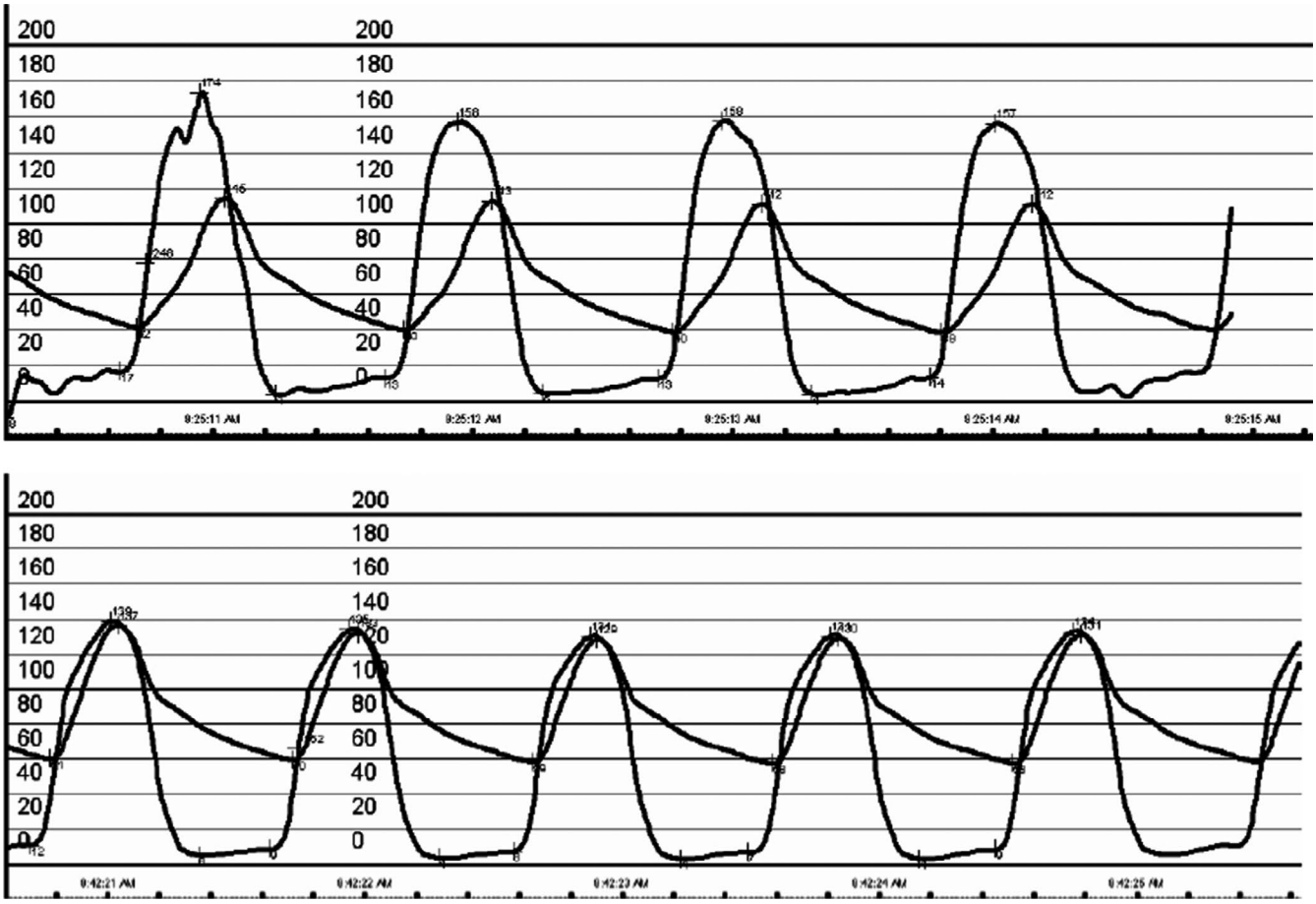

FIGURE 8 Hemodynamic tracings obtained pre- and post-TAVR. The peak-to-peak gradient across the aortic valve went from 45 to 1 mm Hg, and the systemic diastolic pressure increased from 20 to 60 mm Hg following transcatheter aortic valve-in-valve implantation followed by bioprosthetic valve fracturing

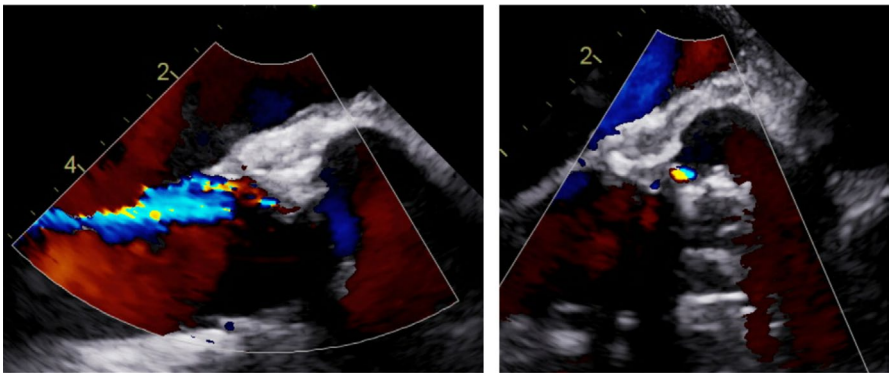

FIGURE 9 Transesophageal echocardiographic images using color Doppler performed pre- and post-TAVR showing near-total resolution of significant perivalvular leak

Another important consideration with transcatheter pulmonic valve implantation is the choice of valve and the associated risk for endocarditis. There have been variable reports of endocarditis after Melody and Sapien valve implants, with more reports in the literature of the former. Less data exist for the Sapien valve; however, the COMPASSION study reported 97.1% freedom from endocarditis at 3 years[1] and Hascoet et al. reported no cases of endocarditis in a series of 47 patients who received a Sapien valve in the pulmonic position.[2] The potential lower risk of endocarditis with the Sapien valve was one of the factors we considered when deciding what valve to implant in this patient.

The aortic valve intervention presented the challenge of treating bioprosthetic valve stenosis with concomitant moderate to severe PVL. After valve deployment, postdilation bioprosthetic valve fracture (BVF) and enlargement of the surgical valve lead to sealing of the PVL and improvement in overall hemodynamics. Given the young age of the patient, we prioritized treatment

of PVL at the LVOT level by placing a Sapien Ultra valve slightly more ventricular than would be typical, followed by BVF. This strategy avoided placement of a vascular plug, which can increase the risk of complications with future TAVR in TAVR procedures. Vascular plugs may deform during valve expansion leading to ostial right coronary artery (RCA) obstruction or migration.

3.1 | *Follow-up*

At one-month follow-up, the patient reported symptomatic improvement. At 3 months, he was exercising more than 20 min per day at the gym and reported walking up several flights of stairs without difficulty. His heart failure symptoms resolved, and diuretic therapy was discontinued.

4 | CONCLUSIONS

This case highlights the utility of transcatheter techniques in addressing multivalvular pathology including pulmonary valve-in-valve intervention in patients with symptomatic pulmonary valve stenosis and TAVR for severe aortic stenosis who are not ideal surgical candidates. Techniques for safe and optimal valve implantation and achieving optimal hemodynamics are outlined along with implications for future intervention.

ACKNOWLEDGMENTS

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CONFLICT OF INTEREST

Dr. Stinis has served as a consultant and proctor for Edwards Lifesciences.

AUTHOR CONTRIBUTIONS

MA drafted the manuscript. RS made edits to the manuscript and helped in drafting the manuscript. CS made edits to the manuscript, helped in drafting the manuscript, and performed the procedure.

ETHICAL APPROVAL

The content of this manuscript has not been previously published, and all data and figures have been presented in accordance with the ethics policy of the journal.

CONSENT

The patient was personally contacted by the corresponding author and gave consent in both verbal and written format for the use of personal health information in accordance with the patient consent policy of the journal.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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