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CASE REPORT
Valvular heart disease

Sequential transcatheter aortic and pulmonic valve replacement in bioprosthetic valve dysfunction: a case report

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Background Transcatheter valve replacement is a less invasive alternative to surgical valve replacement and has become increasingly popular. It is often the preferred approach for patients with high surgical risk. In patients with multiple prior sternotomies and multi-valvular failure, sequential transcatheter valve replacements may be a viable option.

Case summary We present the case of a 61-year-old-man with two prior sternotomies who underwent sequential transcatheter replacements of the aortic and pulmonic valves for symptomatic aortic and pulmonary stenosis. He was deemed high risk for a repeat sternotomy. The decision to perform sequential transcatheter aortic valve replacement (TAVR) and transcatheter pulmonic valve replacement (TPVR) a month apart was made. Patient underwent valve-in-valve TAVR in a stentless bioprosthetic valve with 29-mm Edwards Sapien 3 followed by TPVR with 26-mm Edwards Sapien 3. He tolerated both procedures well and was asymptomatic at 1-month follow up.

Discussion To our knowledge, this is the first reported successful case of sequential TAVR and TPVR with right ventricular outflow tract stenting in a patient with both aortic and pulmonic bioprosthetic valve dysfunction. Our case demonstrates that transcatheter approach to multi-valvular replacements may be a viable option for high-risk surgical patients.

Keywords TAVR • TPVR • Bioprosthetic valve dysfunction • Ross procedure • Case report • Valve-in-valve

ESC Curriculum 4.9 Multivalvular disease • 4.10 Prosthetic valves • 4.8 Pulmonary stenosis • 4.1 Aortic regurgitation • 9.1 Aortic disease

Learning points

- Sequential transcatheter valve replacements may be a viable option for high-risk surgical patients with both aortic and pulmonic bioprostheses dysfunction.
- The lack of stented frame and fluoroscopic markers makes valve-in-valve transcatheter aortic valve replacement in stentless bioprosthetic valves technically more challenging than in stented bioprostheses.

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Introduction

Transcatheter valve replacement has become a cornerstone in treatment of patients with valvular heart disease. Valve-in-valve (ViV) transcatheter aortic valve replacement (TAVR) is a viable, less invasive alternative to surgical replacement for the treatment of bioprosthetic aortic valve failure and provides excellent rates of freedom from all-cause mortality in high-risk surgical patients.[1] Similarly, transcatheter pulmonary valve replacement (TPVR) has emerged as an alternative to surgical replacement of right ventricle outflow tract and pulmonic valve in many patients, especially those with congenital heart disease.[2,3] We report a rare case of successful sequential transcatheter replacements of both aortic and pulmonic valves.

Timeline

1997	Ross procedure for aortic regurgitation and bicuspid aortic valve.
2007	Bentall procedure with freestyle aortic valve replacement with root repair and pulmonary valve replacement.
Day 0	Patient presented to urgent care with acute chest pain. He was found to have non-ST-elevation myocardial infarction and underwent left heart catheterization, which did not show significant obstructive coronary artery disease. Patient was discharged with diuretics and antibiotics for presumed congestive heart failure and pneumonia.
Day 14	Patient presented to urgent care with shortness of breath. Transesophageal echocardiogram showed severe aortic stenosis. Right heart catheterization showed moderate to severe pulmonary stenosis.
Day 39	Transcatheter aortic valve replacement with 29 mm Edwards Sapien 3.
Day 79	Transcatheter pulmonary valve replacement with 26 mm Edwards Sapien 3 within a 26–30 mm CP Stent.
Day 80	Discharged home on warfarin and aspirin.
Day 107	Initial office follow-up. Patient asymptomatic and exercising without difficulty.
Day 421	One-year follow-up. Patient continues to have excellent exercise capacity. Repeat Transthoracic echocardiogram showed left ventricular ejection fraction 60% with well seated aortic and pulmonary bioprostheses.

Case description

A 61-year-old man with significant cardiac history presented to urgent care with acute chest pain. He had history of Ross procedure at age 37 for aortic regurgitation (AR) and bicuspid valve. He subsequently underwent Bentall procedure with Medtronic Freestyle aortic valve replacement and root repair as well as pulmonary valve replacement at age 47 and had known moderate-severe pulmonic stenosis. On exam, patient was hypoxic to 93% on room air with a blood pressure of 100/47 mmHg and pulse of 72 bpm. He had rales in bilateral lung fields, a systolic murmur at the left and right upper sternal borders, and 2+ lower extremity edema. Patient was found to have elevated high-sensitivity troponin to 2.62 ng/mL (0.00–0.07), and his electrocardiogram showed sinus rhythm with new ST depressions in inferolateral leads. He was given aspirin, atorvastatin, metoprolol, and enoxaparin for NSTEMI. Left heart catheterization showed an anomalous left circumflex artery (LCx) arising from the right coronary cusp, non-obstructive coronary artery disease, and suggestion of severe AR on aortogram. Left ventricular end diastolic pressure was elevated to 35 mmHg, suggestive of diastolic dysfunction. Transthoracic echocardiogram (TTE) showed only mild paravalvular leak, preserved left ventricular (LV) size with ejection fraction of 65%, and stable moderate-severe pulmonary stenosis (PS). The patient improved with diuresis and was discharged on furosemide and antibiotics for congestive heart failure and presumed pneumonia.

However, he returned to urgent care 2 weeks later with worsening shortness of breath. Although prior TTE only showed mild aortic paravalvular leak, bioprosthetic AR can be difficult to detect by surface echocardiogram. Given the clinical suspicion for severe AR, a transesophageal echocardiogram (TEE) would be appropriate and highly sensitive for confirming the degree of AR. The TEE was performed to better evaluate the aortic bioprosthesis and showed severe eccentric AR. Right heart catheterization confirmed moderate-severe PS with mean gradient of 35–40 mmHg and peak gradient of 50mmHg, with pulmonary capillary wedge pressure of 29 mmHg. Given the new AR in addition to known PS causing symptomatic decompensated HF, replacement of both aortic and pulmonic valves was proposed. Surgical and transcatheter therapies were considered. The patient was deemed high risk by the heart team for a sternotomy considering his extensive history of prior surgeries. He was ultimately evaluated for TAVR with plan for TPVR if he remained symptomatic after TAVR. The TAVR was selected as the first procedure because the PS had been slowly progressive for several years while the aortic prosthetic dysfunction was new. The TAVR protocol CT demonstrated adequate iliofemoral conduits and appropriate aortic complex for TAVR. The TAVR CT also confirmed severe narrowing of the pulmonary homograft (*Figure 1*).

The patient underwent TAVR with 29-mm Edwards Sapien 3 (S3) Ultra valve via right femoral artery. The valve was deployed successfully with two additional mLs of contrast using rapid ventricular pacing and fluoroscopic guidance to confirm position. Given difficult visualization of the freestyle annulus, both TEE and the placement of multiple pigtails in the aortic sinuses were utilized to better define the annular plane. Despite this, the valve deployment ended up lower than planned (*Figure 2*); however, TEE confirmed well-positioned valve with no paravalvular leak. The TTE following the procedure showed well-functioning prosthesis with mean gradient of 4.3mmHg. The patient had an unremarkable post-op course and was discharged on aspirin and warfarin. Oral anticoagulation was started to decrease risk of clinical valve thrombosis following ViV TAVR.[4]

Three weeks later, the patient reported significantly improved symptoms but had ongoing dyspnea with moderate exertion. He was evaluated for TPVR for his severe PS. The TTE again showed a well-functioning aortic bioprosthesis and stable pulmonary valve stenosis with mean gradient of 42 mmHg and peak gradient of 68 mmHg. The patient underwent stenting of the stenosed pulmonary homograft followed by TPVR with 26-mm Edwards S3 Ultra valve. Initially, the stenosed proximal pulmonary artery (PA) was dilated with sequential balloons to 24 mm, with intermittent injection of the right coronary and anomalous LCx to ensure there was no hemodynamic compromise from compression (*Figure 3*). Next, given that there was a persistent gradient across the stenosed segment of the homograft, the pulmonary valve and proximal PA were stented with a 26–30 mm CP stent (*Figure 4*), which was post-dilated with a 24-mm True balloon as it remained constrained at the area of the ostial pulmonary artery. A bare metal stent was chosen over a covered stent to prioritize radial strength. Finally, a 26-mm S3 Ultra valve was deployed under rapid pacing, with placement of the S3 valve at the area of residual constraint in the ostial pulmonary artery (*Figure 5*). The S3 valve was then post-dilated with the

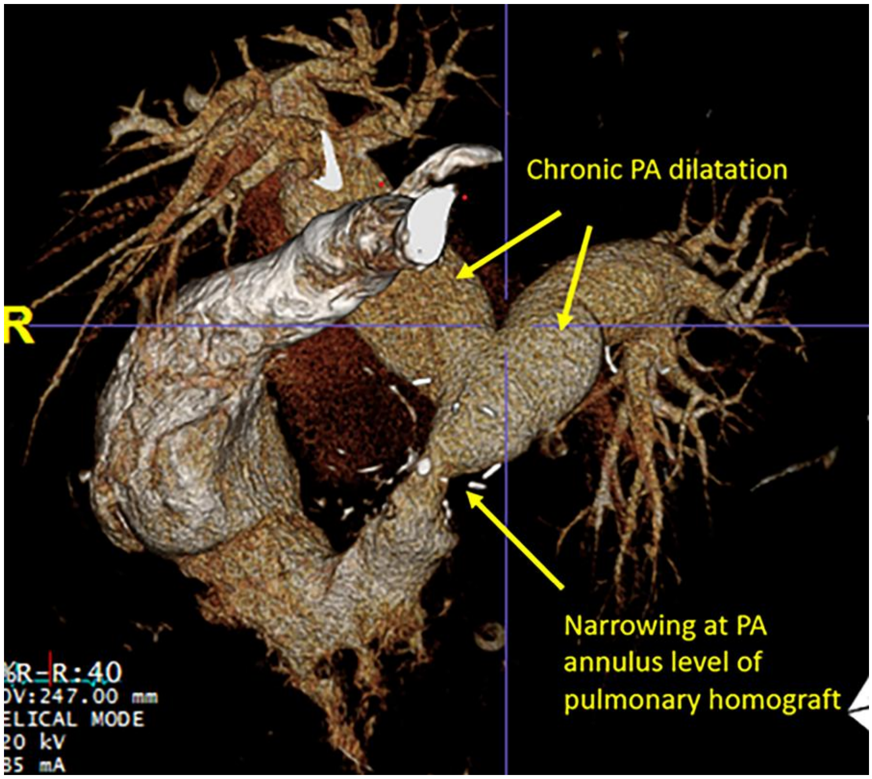


Figure 1 CTA showing narrowed pulmonary homograft.

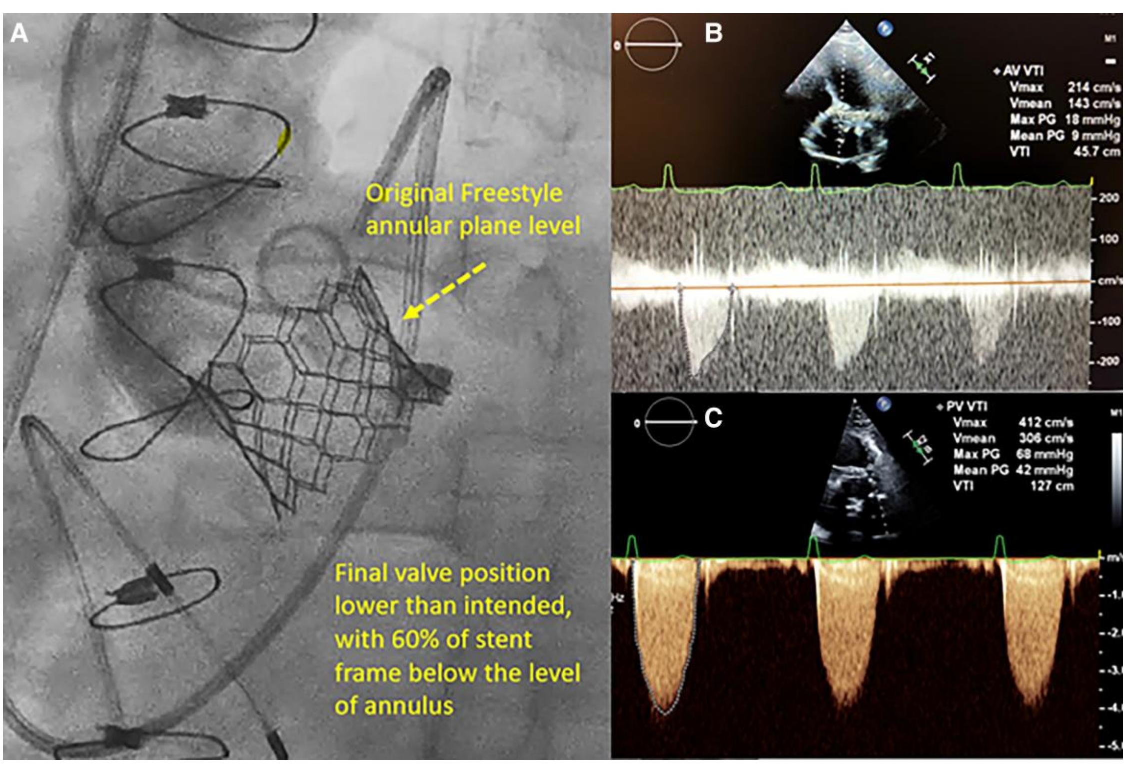


Figure 2 *(A)* Transcatheter aortic valve replacement (TAVR): 29 mm S3 + 2 in 29-mm freestyle valve. *(B)* Mean gradient after TAVR. *(C)* Residual PV gradient after TAVR.

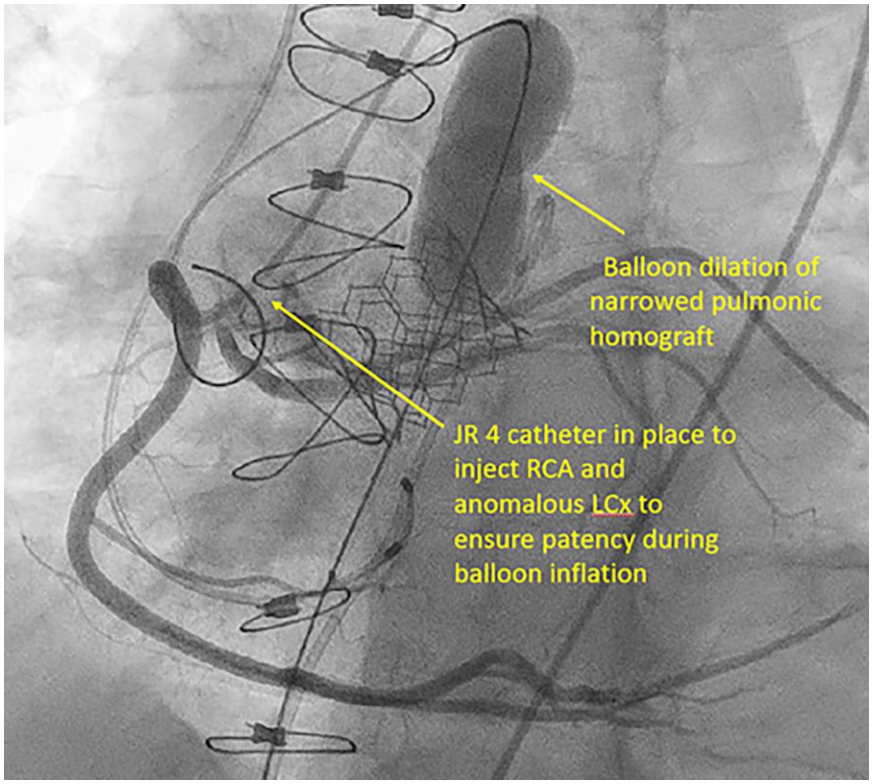


Figure 3 Transcatheter aortic valve replacement: initial balloon angioplasty.

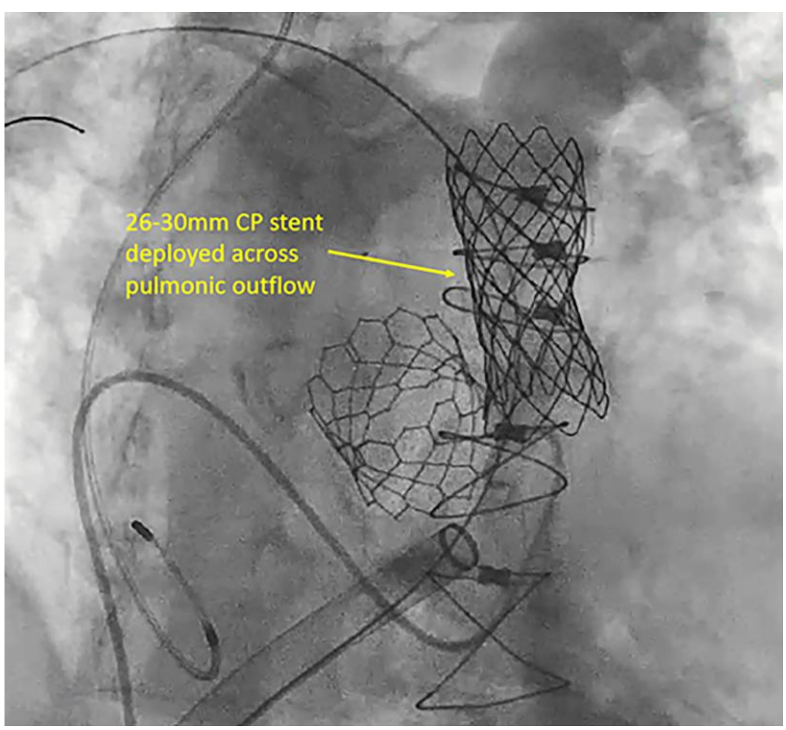


Figure 4 Transcatheter aortic valve replacement: 26–30 mm CP stent. Post-stent deployment.

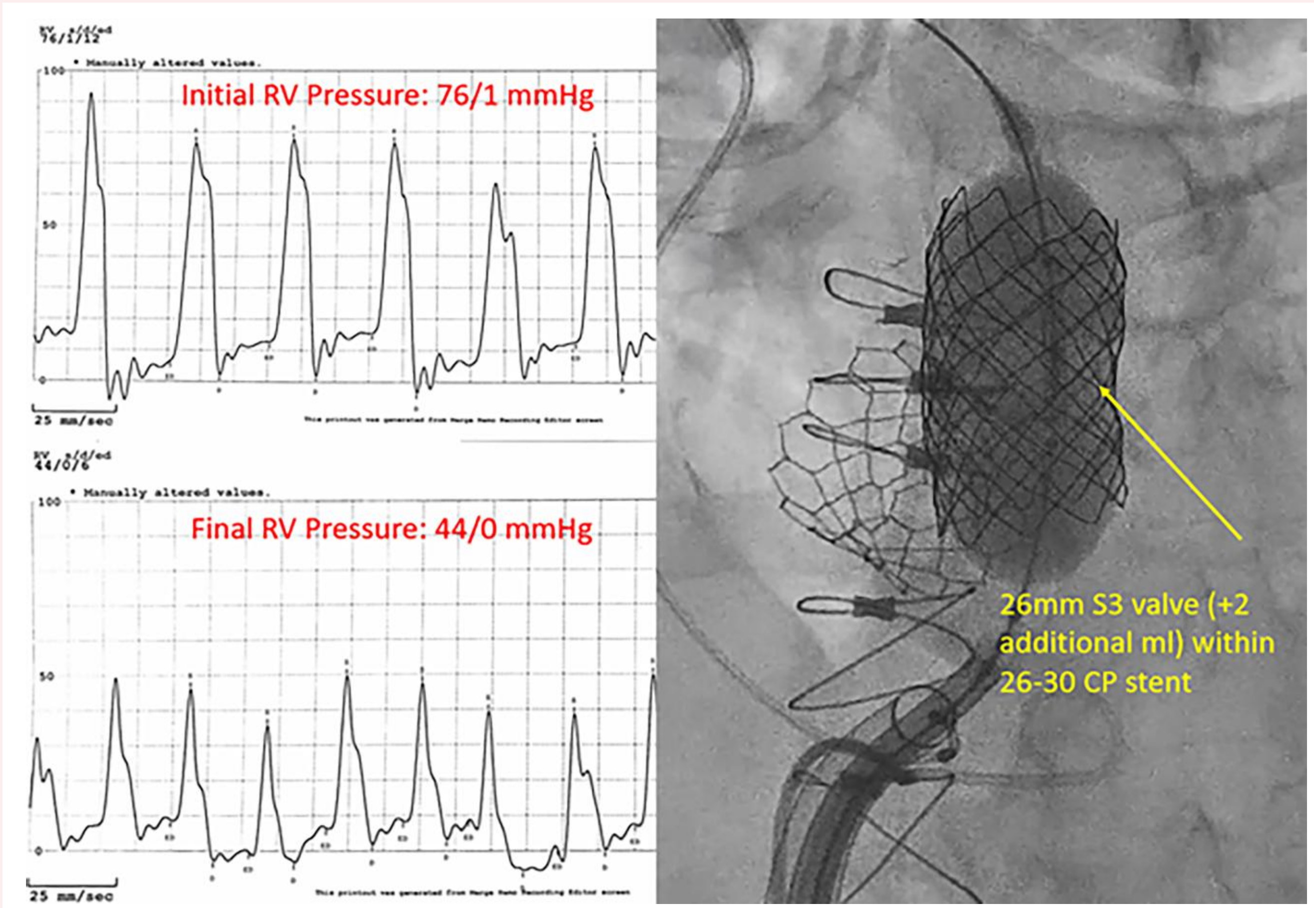


Figure 5 Transcatheter aortic valve replacement: deployment of 26 mm S3 + 2 valve within 26–30 mm CP stent. Initial and final right ventricular invasive pressure waveforms.

S3 balloon with excellent results. Angiography demonstrated no pulmonary regurgitation, and right ventricular pressure improved from 75/10 mmHg to 44/2 mmHg with a mean gradient of 8 mmHg on TTE. Patient tolerated the procedure well and was discharged home the following day on warfarin and aspirin along with his home medications including metoprolol, furosemide, and atorvastatin.

At 1 month follow-up after TPVR, TTE revealed normally functioning, well-seated bioprosthetic valves in aortic and pulmonic positions with no significant aortic or pulmonic paravalvular regurgitation. The mean gradient for TPVR was 12 mmHg and for TAVR was 11 mmHg. The LV systolic function was preserved with EF 65%. Patient reported marked improvement of heart failure symptoms and return of normal exercise tolerance. He completed cardiac rehabilitation and continued to report persistent exercise tolerance a year later. Repeat TTE at that time revealed preserved ejection fraction of 60% and well-seated bioprosthetic aortic valve with mean/peak gradient of 12/20 mmHg as well as well-seated bioprosthetic pulmonary valve with mean/peak gradient 11/23 mmHg.

Discussion

The TAVRs and TPVRs have become increasingly popular as a minimally invasive, safe alternative to surgical replacement.[3,5,6] However, to our knowledge, this the first reported case of successful sequential transcatheter replacements of aortic and pulmonic valves.

Our case also highlights the technical challenges of positioning ViV TAVR. While stentless aortic bioprostheses have risen in popularity as they offer superior hemodynamics compared to their stented counterparts, they lack a stented frame and fluoroscopic markers, which hinder visualization of TAVR positioning.[7] There are also fewer guidelines for sizing. In a study by Duncan *et al.* observing nearly 1600 failing surgical aortic valves, stentless ViV TAVR had higher prevalence of initial device malpositioning, requirement of a second transcatheter device, coronary obstruction, and paravalvular leak compared with stented ViV-TAVR.[8]

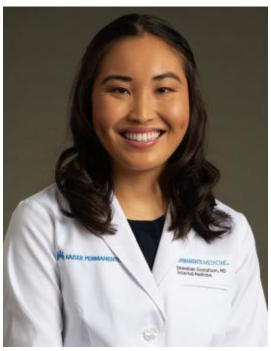
In addition, our case presents a rare case of pulmonary homograft failure. Carr-White *et al.* found that in a group of 144 patients who underwent Ross procedure, freedom from pulmonary homograft stenosis at 7 years was 79.7% and from reoperation, 96.7%. Risk of stenosis and reoperation is greatest in the first post-operative year.[9] Our patient presented with symptomatic pulmonary stenosis 14 years after pulmonary homograft placement and required reoperation. A third sternotomy in our patient would have carried a high risk for complications. Thus, sequential TAVR and TPVR provided a minimally invasive solution for correcting his aortic and pulmonic bioprostheses failure.

In the American Society of Thoracic Surgeons database of 623 039 patients undergoing surgery between 1993 and 2007, 11% had replacement or repair of more than one valve.[10] There is currently no standardized management strategy for these patients. As the trend towards minimally invasive procedures continues to grow, transcatheter therapies will likely play a key role in the management of multi-valvular heart disease.

Conclusion

We present—to our knowledge—the first successful case of sequential transcatheter replacements of aortic and pulmonic valves. The transcatheter approach for valve replacement can be a viable option in high-risk patients who are deemed surgically inoperable. This case also highlights the challenges of ViV TAVR in stentless aortic bioprostheses as well as potential long-term complications of multi-valve replacements in congenital heart disease. Further studies and case reports are needed to assess the long-term prognosis of sequential transcatheter valve replacements.

Lead author biography



Shanshan Gustafson is an internal medicine resident at Kaiser Permanente Mid-Atlantic States in Maryland, USA. She has special interests in valvular heart disease and heart failure.

Supplementary material

Supplementary material is available at *European Heart Journal—Case Reports*.

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None.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

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Data availability

The data underlying this article are available in the article and in its online supplementary material.

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