



Case Report

Simultaneous Transcatheter Mitral and Tricuspid Valve-in-Ring Implantations: Case Report

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A 60-year-old female patient with atrial fibrillation recurrent heart failure admission, following mitral and tricuspid ring annuloplasties, was found to have severe mitral and tricuspid regurgitation. We proceeded with successful simultaneous transcatheter mitral and tricuspid valve-in-ring implantations, as the patient was deemed inoperable due to prior chest radiation.

Case Description

The patient presented to our institution with abdominal distention and dyspnea on exertion. She had a history of mechanical aortic valve replacement, in 2015, using a 21-mm Advancing The Standard (ATS Medical, Minneapolis, MN) bileaflet valve, mitral valve repair using a complete 28-mm Carpentier-Edwards physio-ring, and tricuspid valve repair using a 32-mm incomplete Carpentier-Edwards classic annuloplasty ring (both Edwards Lifesciences, Irvine, CA), for radiation-induced severe aortic, mitral, and tricuspid regurgitations, respectively. Her symptoms recurred 1 year following the surgery, leading to repetitive admissions for cardiac ascites and flash pulmonary edema.

Transthoracic echocardiography (TTE) showed a left ventricular ejection fraction of 35%, moderate dilatation of the right ventricle with severe systolic dysfunction, and mild regurgitation across the mechanical aortic valve. Further TTE showed severe tethering of the mitral and tricuspid valves, with severe regurgitation and a pulmonary artery systolic pressure (PASP) of 69 mm Hg (Videos 1 and 2,  view videos online), which is a significantly elevated PASP given that severe right ventricular dysfunction and severe tricuspid regurgitation are 2 factors that could underestimate PASP.

The patient was deemed inoperable due to multiple comorbidities, severe right ventricular dysfunction, pulmonary hypertension, prior sternotomy, and chest radiation for breast cancer. Percutaneous edge-to-edge intervention was not an option, due to severe leaflet tethering. Consequently, the heart team opted for simultaneous mitral and tricuspid transcatheter valve-in-ring (TVIR) implantations. Although we could have followed a standard approach of initial mitral valve replacement and reassessment of tricuspid function, the structural failure of the tricuspid ring valve favored a simultaneous approach.

Procedural planning for accurate valve sizing was done using 2-dimensional and 3-dimensional (3D) transesophageal echocardiography (TEE) using the smartphone-based valve in valve (ViV) mitral application developed by Dr Vinayak Bapat, with a thorough assessment of the prior operative report (Supplemental Figs. S1 and S2). A preplanning computed tomography (CT) scan was not done on this patient, as the patient had an acute kidney injury on top of having chronic kidney disease. Good 3D TEE can give us the same information. The important issue in ViV and valve-in-ring (VIR) implantation planning is the detailed information of the type, design, and size of the surgical bioprosthesis/ring, in particular when considering the multiple valves on the market. The details of the bioprosthetic valves can be obtained from the following sources: (i) manufacturer specifications; (ii) inner-diameter measurement using CT; and (iii) the smartphone application designed by Bapat.

Under general anesthesia and TEE guidance, a transeptal puncture using an SL-1 catheter (Abbott Vascular, Abbott Park, IL), and a BRK-1 needle (Abbott Vascular) was performed in an infero-posterior location. An Agilis 8.5-F catheter (Abbott Vascular) was advanced into the left atrium and steered toward the mitral valve. The mitral valve was crossed with a pigtail, over which a small 2-Safari Wire (Boston Scientific, Marlborough, MA) was advanced. The septum was then dilated with 12- × 40-mm Z-Med balloon (B. Braun, Melsungen, Germany). An Edwards Sapien S3 26-mm + 1 cc (Edwards Lifesciences) was then successfully deployed under rapid pacing performed on the wire inside the complete mitral ring using the “push-push” technique, with no gradient and no

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See page 800 for disclosure information.

Novel Teaching Points

- In addition to patient anatomy, the ring's characteristics can affect procedural success in VIR implantation.
- Valve implantation into flexible and semi-rigid rings has a lower risk of complications.
- The procedural technique selection should aim to optimize alignment to prevent PVL and embolization.
- Tricuspid VIR implantation is even more challenging, as the ring is incomplete, rendering the risks greater.

residual regurgitation (Fig. 1, A and B; Videos 3 and 4,  view videos online).

We then moved our attention to the tricuspid ring. To allow a more coaxial deployment, an Amplatz Extra stiff wire (Boston Scientific) was positioned in the pulmonary artery,

and an Edwards Sapien S3 29 mm + 5 cc, which increases the valve size to up to 31 mm was successfully deployed inside the incomplete tricuspid ring in a coaxial manner, with a mild central and mild paravalvular leak (PVL) at the incomplete ring portion (Fig. 1, C and D; Videos 5 and 6,  view videos online). The valve was overinflated by 5 cc to expand the valve as much as possible for adequate anchoring and prevention of embolization. This step is especially important for VIR procedures, as the behavior of the incomplete rings is unpredictable.

Postprocedural TTE revealed a mean trans-mitral and trans-tricuspid gradient of 4 mm Hg, trivial mitral prosthesis regurgitation, mild tricuspid regurgitation, and a significant decrease in PASP to 33 mm Hg. The patient had significant functional and symptomatic improvement and was discharged on double therapy with aspirin and warfarin 3 days following the procedure with a New York Heart Association class of II and normalized kidney function.

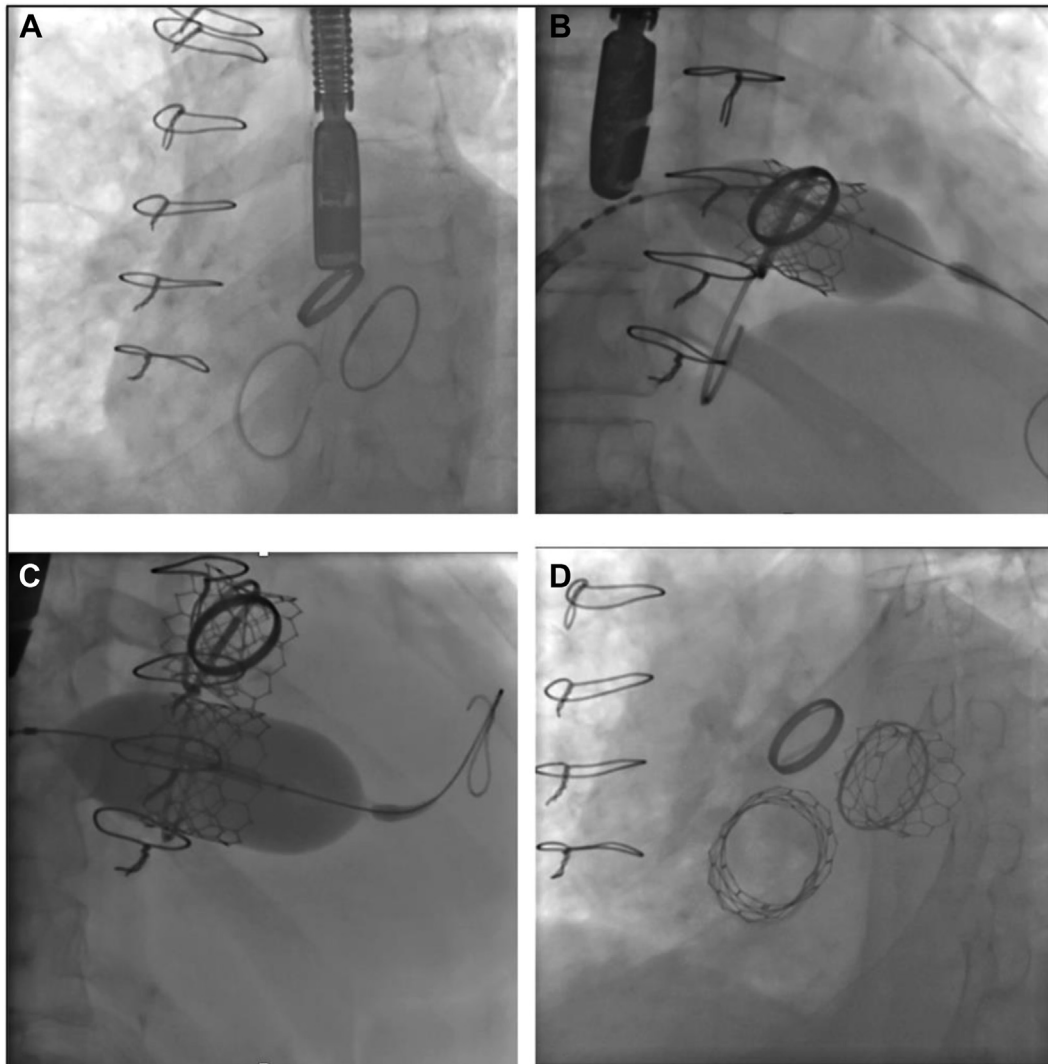


Figure 1. (A) Baseline mitral and tricuspid rings on fluoroscopy and mechanical aortic valve. (B) Mitral valve-in-ring (VIR) deployment on fluoroscopy. (C) Tricuspid VIR deployment on fluoroscopy. (D) Mitral and tricuspid VIR after implantation on fluoroscopy.

Table 1. Ring / band considerations for procedural planning

RING / BAND	Suitable	Unsuitable
Type	Complete	Incomplete
Shape	Circular	Noncircular
Symmetry	Symmetrical	Unsymmetrical
Size, mm	< 34	> 34
Radio-opacity	Good	Invisible
Flexibility	Flexible or semi-rigid	Rigid
Anchoring ability	Secure	Unsecure

A follow-up CT scan 2 weeks later revealed well-seated circularized mitral and tricuspid valves, with no leaflet thickening or thrombus formation, showing nicely the relation of the mitral and tricuspid valves to the aortic valve and septum (Supplemental Fig. S3).

Discussion

TVIR implantation has increased over the years, with mitral valve implantation being performed more frequently, albeit with less technical success than that for transcatheter ViV implantation. Moreover, the data regarding tricuspid VIR implantation remains limited. Procedural planning is essential for successful outcomes and complication prevention. Such planning consists of appropriate transcatheter heart valve selection, via evaluation of patient anatomy and ring characteristics using vendor data, operative reports, TEE, ViV mitral application, and cardiac CT (Table 1). Optimal sizing of the valve is especially important to prevent the most common complication of VIR implantation, that is, PVL in the open aspect of the ring.¹ Flexible and semi-rigid rings can best circularize around the implanted valve with the least risk of PVL, especially when using an oversized valve for better seating. However, the rigid rings present a higher risk of PVL, valve deformity, and valve embolization.^{1,2} During VIR deployment, proper alignment is key to preventing PVL and embolization. In the presented case, coaxiality was achieved using the “push-push” technique, which consists of pushing on the wire and catheter upon valve deployment. Although this technique is the one most used to increase the effective skirt height by bicommissural dimension, it can cause apical perforation. The **POULEZ** (for **P**reparation of **U**-Stitch to **C**orrect **L**ateral **D**eflection for **E**ndovascular **M**itral **R**eplacement in **S**hort **L**anding **Z**one) technique can be used as an alternative. This technique consists of lateral deflection correction using a U-stitch for a short mitral valve landing zone.³ Tricuspid valve anchoring presents a higher risk of PVL, specifically through the open portion of the ring, as the most used tricuspid rings are incomplete near the atrioventricular node, to prevent conduction blocks.⁴ Oval-shaped tricuspid rings also are commonly found that are 3D and asymmetric due to the nonplanar annulus of the tricuspid valve, further increasing the risk of PVL. In our case, we were fortunate to encounter only a mild leak from the open portion of the ring, with a mild central regurgitation jet most likely caused by the overexpansion of the S3 valve by 5 extra cc. When it is considered to be significant, a PVL can be closed by percutaneous vascular plugs during or

after the procedure, with careful consideration of the gap size.⁴ Moreover, as left ventricular outflow tract (LVOT) obstruction is the number-one predictor of morbidity and mortality, it is one of the most feared complications in mitral transcatheter mitral valve replacement. The risk increases with deeper (more ventricular) VIR implantation, higher flare in the left ventricle, less obtuse aorto-mitral annular angle, and larger septal bulge.² When pre-procedural CT analysis shows critical neo-LVOT, and surgery is not feasible, prevention by preparatory septal ablation, or the “kissing balloons” technique to reorient the transcatheter heart valve, or the “reverse LAMPOON” technique (for **L**aceration of the **A**nterior **M**itral **L**efflet to **P**revent **L**eft **V**entricular **O**utflow **T**ract **O**bstruction) should be attempted.² The “kissing balloons” technique involves 2 balloons. The perfusion balloon is advanced in retrograde fashion into the LVOT and inflated under rapid pacing, prior to inflation of a transcatheter valve in the mitral position. The perfusion balloon maintains the patency of the LVOT and permits flow while positioning and deploying the mitral prosthesis. In addition, simultaneous inflation with the mitral valve prosthesis prevents over-flaring of the mitral prosthesis, which may contribute to the mechanical LVOT obstruction. This technique allows maintenance of LVOT patency and identification of the landing zone, and aids in orientation of the transcatheter valve.

Conclusion

Off-label simultaneous mitral and tricuspid TVIR procedures are possible safe alternatives for redo surgeries in the treatment of recurrent mitral and tricuspid regurgitations, when properly planned. Further investigations are needed to determine the efficacy and safety of these procedures with their long-term outcomes.

Ethics Statement

The paper reported is adherent to the ethical guidelines.

Patient Consent

Patient consent for publication was obtained by the authors.

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Disclosure

F.J.S. is a transcatheter aortic valve replacement proctor for Edwards Lifesciences, Medtronic, Abbot Vascular, and Boston Scientific. The other authors have no conflicts of interest to disclose.

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Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at <https://www.cjopen.ca/> and at <https://doi.org/10.1016/j.cjco.2023.03.013>.