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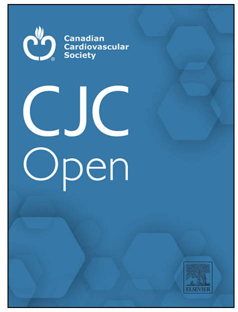

Simultaneous Transcatheter Mitral and Tricuspid Valve-in-Ring Implantations: Case Report

Jennifer Jdaidani, MD, Hadi Skouri, MD, Dounia Z. Iskandarani, MSc, Malek Nayfeh, MD, Elsa Hebbo, Omar Chaabo, MD, Walid Gharzeddine, MD, Fadi J. Sawaya, MD

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

Jennifer Jdaidani MD[1], Hadi Skouri MD[1], Dounia Z. Iskandarani MSc[1], Malek Nayfeh MD[2], Elsa Hebbo[2], Omar Chaabo MD[1], Walid Gharzeddine MD[1], Fadi J. Sawaya MD[1]

[1] American University of Beirut Medical Center, Division of Cardiology, Beirut, Lebanon

[3] American University of Beirut, Lebanon

Corresponding Author:

Fadi J. Sawaya MD, Assistant Professor of Medicine

Interventional and Structural Cardiologist

Director Structural Heart Program

American University of Beirut Medical Center

Cairo Street, Beirut, Lebanon

Phone number: +9613949137

Email: fjsawaya@gmail.com

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Abbreviations and Acronyms

CE: Carpentier-Edwards

TTE: Transthoracic Echocardiography

TVIR: Transcatheter Valve-In-Ring

2D: 2-Dimensional

3D: 3-Dimensional

TEE: Transesophageal Echocardiogram

VIR: Valve-In-Ring

PVL: Paravalvular Leak

CT: Computed Tomography

THV: Transcatheter Heart Valve

LVOT: Left Ventricular Outflow Tract

Case Description

A 60-year-old female patient with atrial fibrillation recurrent heart failure admission following mitral and tricuspid ring annuloplasties, 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.

The patient presented to our institution with abdominal distention and dyspnea on exertion. She has a history of mechanical aortic valve replacement in 2015 using a 21mm Advancing The Standard (ATS) bi-leaflet valve, mitral valve repair using a complete 28mm Carpentier-Edwards (CE) physio-ring, and tricuspid valve repair using a 32 mm incomplete CE classic annuloplasty ring, for radiation induced severe aortic, mitral, and tricuspid regurgitations respectively. Her symptoms recurred one 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 mmHg **(Supplemental Video S1 and S2)** which is a significantly elevated PASP given that severe RV dysfunction and severe TR are two factors that could underestimate PASP.

The patient was deemed inoperable due to multiple comorbidities, severe RV dysfunction, pulmonary hypertension, prior sternotomy, and chest radiation for breast cancer. Percutaneous edge to edge intervention was not an option due to severe leaflets tethering. Consequently, the heart team opted for simultaneous mitral and tricuspid transcatheter valve-in-ring (TVIR) implantations. While 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 (2D) and 3-dimensional (3D) transesophageal echocardiogram (TEE) while 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 Figure S1 and S2**). A preplanning CT scan was not done on this patient as the patient had an acute kidney injury on top of chronic kidney disease. A good 3D – TEE can give us the same information. The important issue in ViV and valve-in-ring planning is the detailed knowledge of the type, design, and size of the surgical bioprosthesis/ring, in particular when considering multiple valves on the market. The details of the bioprosthetic valves can be obtained from (1) manufacturers specification; or (2) inner diameter measurement using CT or (3) smartphone application designed by Bapat.

Under general anesthesia and TEE guidance, a trans-septal puncture using SL-1 catheter and BRK-1 needle was performed in an infero-posterior location. An Agilis catheter 8.5 F was advanced into the left atrium and steered towards the mitral valve. The mitral valve was crossed with a pigtail, over which a small Safari wire was advanced. The septum was then dilated with 12 x 40 mm Z-Med balloon. An Edwards Sapien S3 26mm + 1 cc 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 residual regurgitation **(Figure 1 A and B) (Supplemental Video S3 and S4).**

We then moved our attention to the tricuspid ring. To allow a more coaxial deployment, an Amplatz Extra stiff wire was positioned in the pulmonary artery, and an Edwards Sapien S3 29mm + 5ccs which increases the valve size to up to 31mm 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 **(Figure 1 C and D) (Supplemental Video S5 and S6).** The valve was overinflated with 5cc to expand the valve as much as possible for adequate anchoring and prevention of embolization. This is especially important for VIR as the behavior of the incomplete rings is unpredictable.

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

Follow-up Computed Tomography (CT) done two 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 (Figure 2)**.**

Discussion

TVIR implantation has increased over the years with mitral valve cases being more frequently performed, albeit with less technical success than transcatheter valve-in-valve. Moreover, the data regarding tricuspid valve-in-ring remains limited. Procedural planning is essential for successful outcomes and complication prevention. It consists of appropriate transcatheter heart valve (THV) selection by evaluating 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: PVL in the open aspect of the ring (4). 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, 4). 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 it is the most used technique to increase the effective skirt height by bi-commissural dimension, it can cause apical perforation. The "Poulez" technique can be used as an alternative. It consists of lateral deflection correction using a U-stitch for a short mitral valve landing zone (2). Tricuspid valve anchoring presents a higher risk of PVL, specifically through the open portion of the ring, since the most used tricuspid rings are incomplete near the AV node to prevent conduction blocks (3). It is common to find oval-shaped tricuspid rings as well, that are 3D and asymmetric due to the non-planar annulus of the tricuspid valve, further increasing the risk of PVL. In our case, we were fortunate to only encounter a mild leak from the open portion of the ring, with a mild central regurgitation jet most likely caused by the over-expansion of the S3 valve with 5 extra ccs. When considered significant, the paravalvular leak can be closed by percutaneous vascular plugs during or after the procedure with careful consideration of the gap size (3). Moreover, since 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 TMVR. 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 (1). When pre-procedural CT analysis shows critical neo-LVOT and surgery is not feasible, prevention by preparatory septal ablation, or “kissing balloons” technique to re-orient the THV, or Reverse “LAMPOON” should be attempted (1). The “kissing balloons” technique involves two balloons. The perfusion balloon is advanced retrogradely 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 to maintain LVOT patency, identify the landing zone and aid in orientation of the transcatheter valve.

To concise, this case highlights the following points:

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

Conclusion

Off-label simultaneous mitral and tricuspid TVIR 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.

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Disclosures:

Dr. Sawaya is a TAVR proctor for Edwards Lifesciences, Medtronic, Abbot Vascular, and Boston Scientific.

All remaining authors have nothing relevant to disclose.

Consent

Patient consent for publication has been obtained by the authors. **References**

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Table 1: Ring or Band Considerations for Procedural Planning

RING / BAND	SUITABLE	UNSUITABLE
TYPE	Complete	Incomplete
SHAPE	Circular	Non-circular
SYMMETRY	Symmetrical	Unsymmetrical
SIZE	Less than 34 mm	More than 34 mm
RADIO-OPACITY	Good	Invisible
FLEXIBILITY	Flexible or Semi-Rigid	Rigid
ANCHORING ABILITY	Secure	Unsecure

Figure Captions

Figure 1:

A) Baseline mitral and tricuspid rings on fluoroscopy and mechanical aortic valve

B) Mitral VIR deployment on fluoroscopy

C) Tricuspid VIR deployment on fluoroscopy

D) Mitral and tricuspid VIR after implantation on fluoroscopy

Figure 2: Follow up Computed Tomography Mitral and tricuspid VIR successfully deployed.

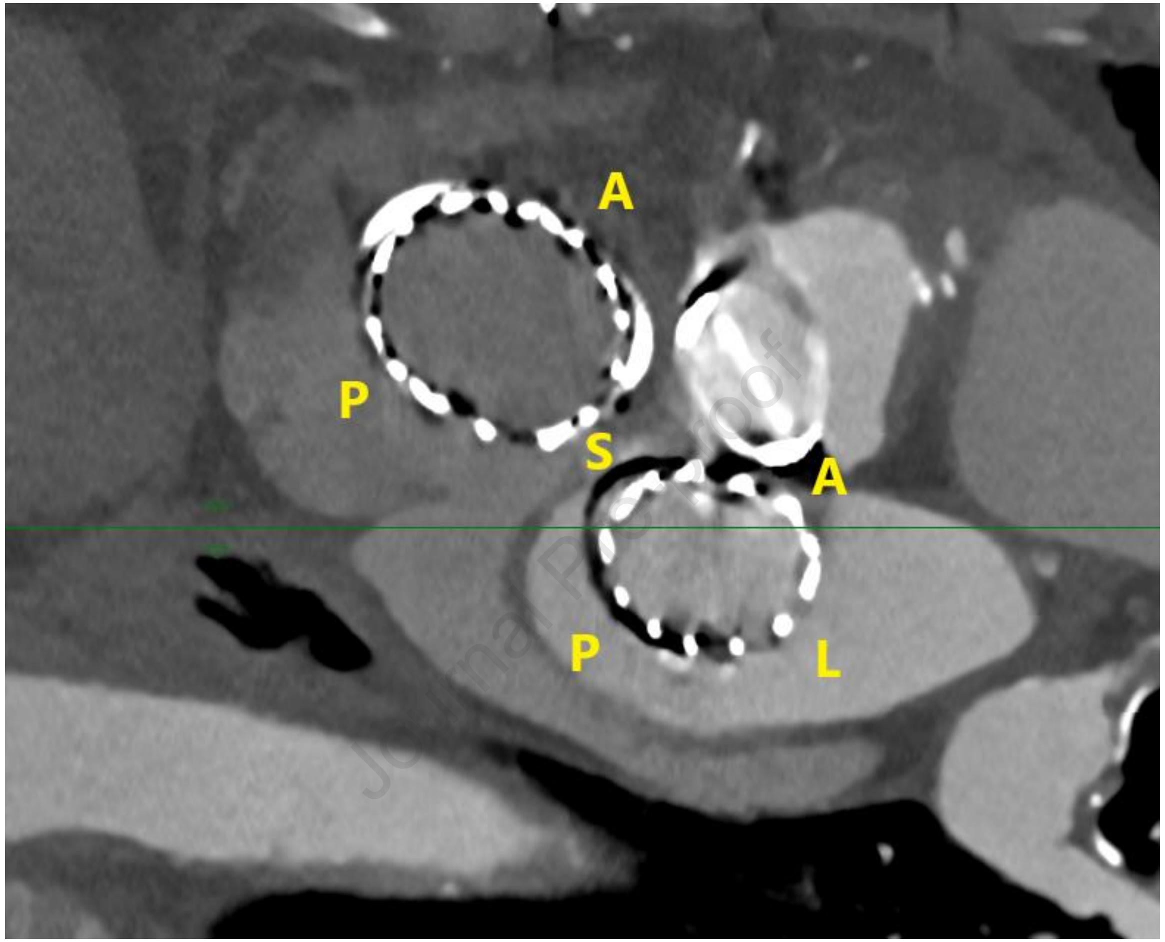

Figure 2

Follow up Computed Tomography

Mitral and tricuspid VIR successfully deployed.

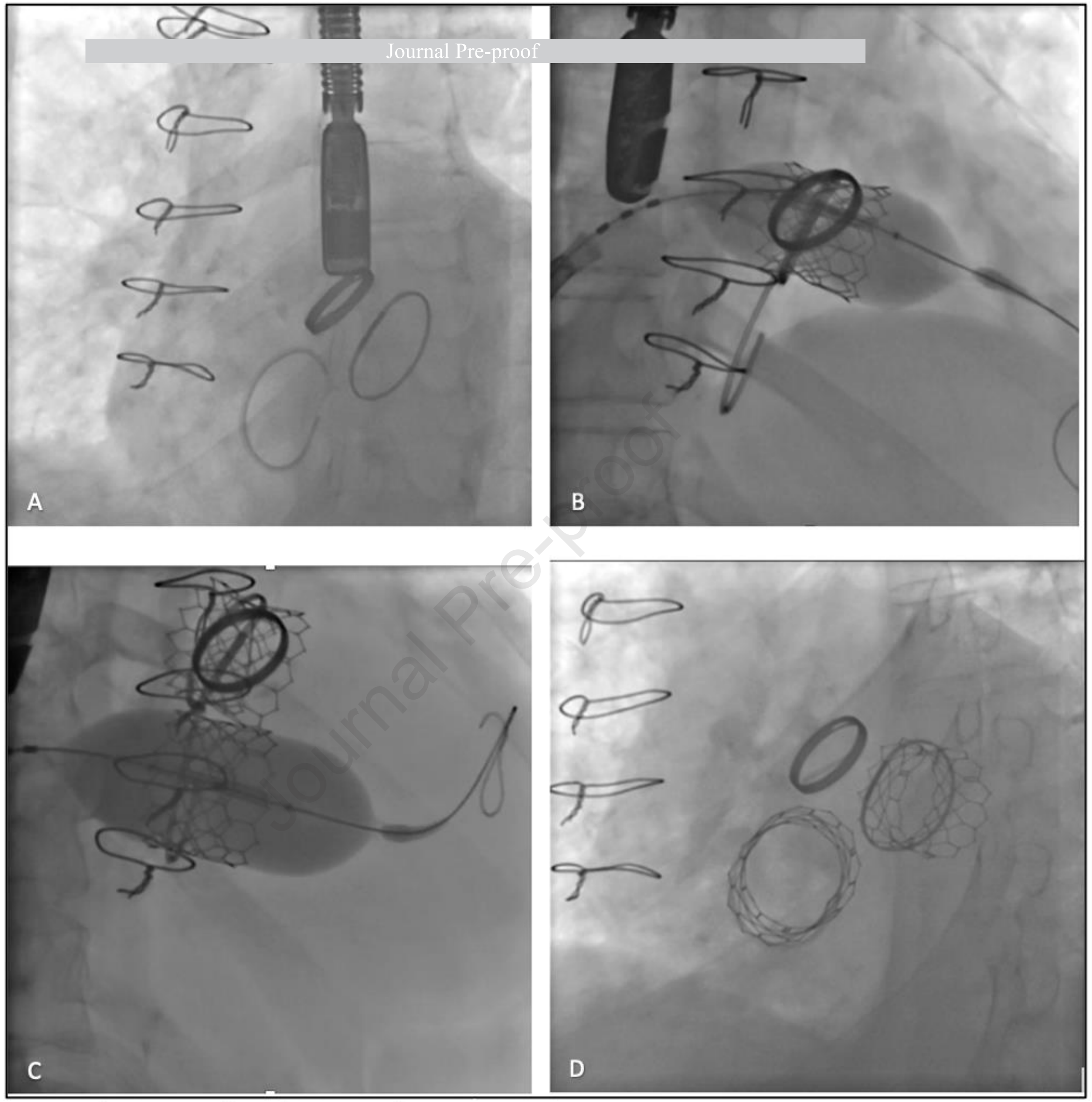

Figure 1:

A. Baseline mitral and tricuspid rings on fluoroscopy
B. Mitral VIR deployment on fluoroscopy
C. Tricuspid VIR deployment on fluoroscopy
D. Mitral and tricuspid VIR after implantation on fluoroscopy