Case Report

Transcatheter, valve-in-valve transapical aortic and mitral valve implantation, in a high risk patient with aortic and mitral prosthetic valve stenoses

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ABSTRACT

Transcatheter valve implantation continues to grow worldwide and has been used principally for the nonsurgical management of native aortic valvular disease-as a potentially less invasive method of valve replacement in high-risk and inoperable patients with severe aortic valve stenosis. Given the burden of valvular heart disease in the general population and the increasing numbers of patients who have had previous valve operations, we are now seeing a growing number of high-risk patients presenting with prosthetic valve stenosis, who are not potential surgical candidates. For this high-risk subset transcatheter valve delivery may be the only option. Here, we present an inoperable patient with severe, prosthetic valve aortic and mitral stenosis who was successfully treated with a trans catheter based approach, with a valve-in-valve implantation procedure of both aortic and mitral valves.

Received: 04-09-14
Accepted: 04-02-15

Key words: Prosthetic valve aortic stenosis; prosthetic valve mitral stenosis; transcatheter aortic valve replacement; transcatheter

INTRODUCTION

Transcatheter valve implantation for severe aortic stenosis (TAVR) is now a well-established modality of therapy for inoperable as well as surgically-high risk patients. It is also growing to be an increasingly viable option for patients with prosthetic valve disease who are not acceptable surgical candidates for redo surgical aortic valve replacement. There may also be patients with multiple prosthetic valves who need re-operation for valve stenosis who carry an unacceptable surgical risk. Below, we present a unique case of a successful dual-simultaneous, aortic and mitral transapical valve implantation using the Edwards Sapien valve in- both the aortic and mitral positions, via a valve-in-valve technique, in a high-risk patient deemed to be an unacceptable risk for conventional redo- valve surgery.

CASE REPORT

An 81-year-old male presented with sudden onset of heart failure symptomatology (New York Heart Association [NYHA] class 4) for urgent cardiology evaluation. He had been deemed too high-risk for conventional surgery by two community cardiothoracic surgeons. Past medical history was significant for five vessel coronary artery bypass grafting (in conjunction with mitral and aortic valve replacement (AVR) with porcine bioprosthetic valves performed 7 years earlier at an outside institution), paroxysmal atrial fibrillation,

Access this article online
Website: www.annals.in
DOI: 10.4103/0971-9784.154493
Quick Response Code:

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prior MI and diabetes. Transesophageal echocardiogram revealed significant prosthetic valve disease. In the aortic position was a 25 mm Medtronic Mosaic tissue prosthesis with calcific and obstructed leaflets and elevated mean transvalvular gradient [Figure 1]. Mild aortic insufficiency was noted. Imaging of the mitral valve revealed a 31 mm Medtronic Mosaic prosthesis with calcific, obstructed and severely stenotic leaflets and a mean mitral gradient of 12–16 mmHg at a heart rate of 75 mmHg, with mild mitral regurgitation [Figures 2, 3, Videos 1 and 2]. Left ventricular (LV) function was relatively well preserved with an ejection fraction of 55%, however there was moderate to severe right ventricular (RV) enlargement and severe RV hypokinesis in conjunction with severe pulmonary hypertension [Video 3]. Cardiac catheterization revealed patent vein grafts, as well as a patent, left internal mammary graft to the left anterior descending artery. Right heart catheterization revealed right atrial mean pressure of 11, pulmonary capillary wedge pressure mean 20, cardiac index of 1.8–1.9 L/min/m^2. Pulmonary artery pressures were 63/30 mmHg with a mean of 44 mmHg. During this work-up period, the patient began to develop significant clinical deterioration with worsening fatigue, shortness of breath and pedal edema. He was deemed to be too high-risk for a conventional surgical approach. The STS risk calculation for either an isolated surgical AVR or isolated mitral valve replacement was 16.5% and 20% respectively in this patient. The risk for combined double valve surgical replacement is not calculable within the program, but would certainly be higher. Balloon dilatation alone for both stenotic valves was not an option given the potential for severe valve regurgitation (both mitral and aortic), which could be fatal. In addition, the rigid stents of both the new valves to be implanted are considered sufficient to dilate the stenotic leaflets. Given the relative urgency of the situation a percutaneous approach was thought to be most appropriate. Our transcutaneous aortic valve implant program uses the Edwards Sapien Transcatheter Heart Valve (THV, Irvine, CA), which has only been Food and Drug Administration approved for aortic valve use. It was decided to use the Sapien valve in the mitral position as an off-label/palliative/humanitarian indication in this situation. After the appropriate approvals the surgical plan was the transapical percutaneous approach and catheter delivery of both aortic and mitral valves over existing stenotic prosthetic valves, under general anesthesia with left femoral artery cut-down for cardiopulmonary bypass (CPB) back up if needed. The procedure was performed in the cath lab with a team that comprised cardiac

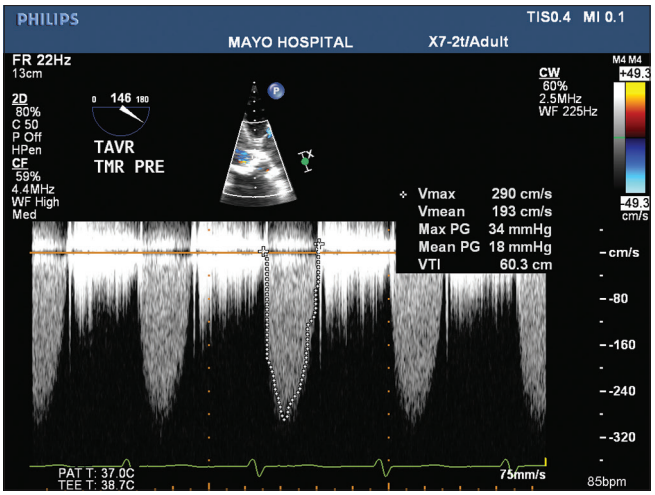

Figure 1: Severe calcific prosthetic aortic stenosis with elevated gradients

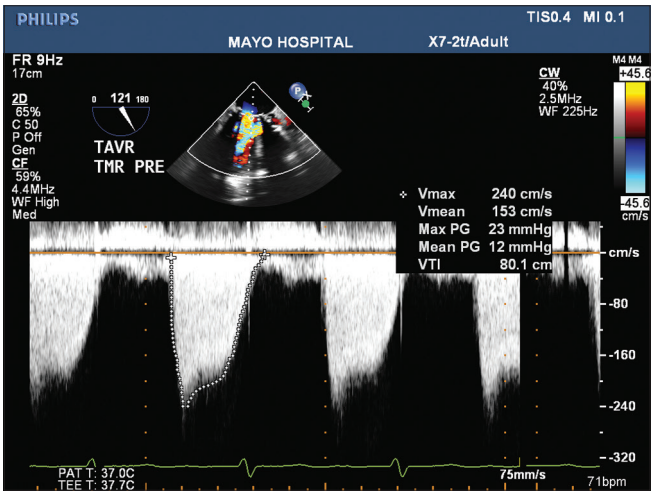

Figure 2: Continuous wave Doppler of mitral valve inflow illustrating severe prosthetic valve mitral stenosis

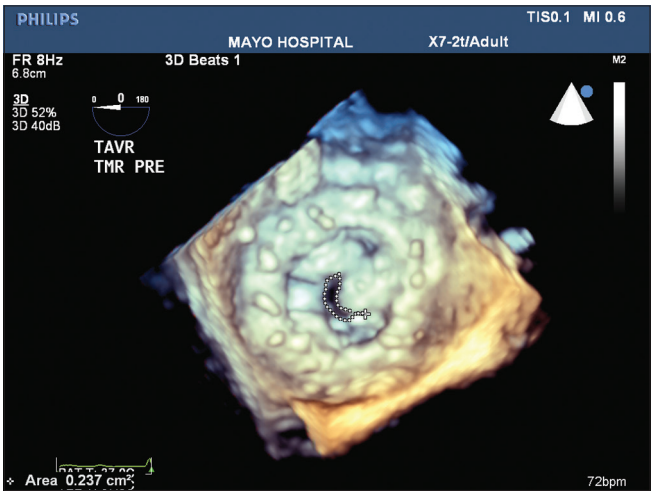

Figure 3: Three-dimensional view of prosthetic mitral valve showing stenotic mitral valve area

anesthesiology, cardiac surgery, perfusion back up and interventional cardiology. The transapical approach, via limited left anterior thoracotomy was chosen for valve replacement over transfemoral because of more anatomic and direct access to both mitral and aortic valves, in addition to the presence of significant peripheral vascular disease and calcification of the peripheral vessels and abdominal aorta.

In addition, unique to this procedure was the necessity for trans-atrial septal puncture (not a routine part of transcatheter aortic valve replacement [TAVR]). The key indication for this was to obtain a "road map" of left atrial anatomy via contrast dye (left atrial angiogram) to be able to visualize appropriate percutaneous valve seating and positioning for implant, valve-in-valve. Furthermore, as is the nature of percutaneous valve replacement, there is no option of re-seating the newly implanted Sapien valve or adjusting its position once implanted, so meticulous planning needs to be done prior to valve deployment as any adjustments postdeployment are impossible. Using alternate vein femoral venous access, a transatrial septal puncture catheter was inserted and using fluoroscopic and transesophageal echocardiographic guidance with radiofrequency ablation, a transseptal puncture was made from the right atrium to the left atrium and a catheter passed into the left atrium. A "pigtail" catheter was then inserted through this catheter and a left ventriculogram was performed to get the best coplanar view for the transcatheter mitral procedure that would follow the aortic valve implant. A 23 mm Sapien valve was chosen for the aortic implant and a 29 mm Sapien valve was chosen for the prosthetic mitral valve following extensive imaging studies of the stenotic valves as is the protocol for TAVR, in conjunction with detailed transesophageal echocardiography (TEE) and computed tomography guided valve annular measurements. Following thoracotomy and exposure of the LV apex, heparinization was performed to maintain an ACT >250 s throughout the procedure, as is the standard protocol for TAVR. Had full CPB support been required, additional heparin would have been administered to the patient. Following needle puncture of the LV apex a 5 French introducer was positioned in the LV apex. Subsequently, an extra-stiff Amplatz-manufacturer boston scientific, USA wire was inserted through the stenotic aortic prosthetic valve. Under fluoroscopic guidance, the aortic valve transcatheter delivery system was placed through the aortic valve, appropriately positioned with fluoroscopic guidance, and then with a respiratory hold and rapid ventricular pacing at 160 bpm (to keep the arterial blood pressure at 50 mmHg, with temporary cessation of cardiac output) the Sapien 23-mm transcatheter aortic valve was balloon inflated and positioned in appropriate position [Figure 4]. Once this was completed, the rapid pacing was discontinued, ventilation resumed, delivery system retracted, and subsequently over an exchange catheter, the Amplatz wire was pulled back. With TEE the transcatheter aortic valve was imaged and this demonstrated excellent transcatheter aortic valve function with no significant perivalvular leak and a mean gradient between 3 and 9 mmHg across

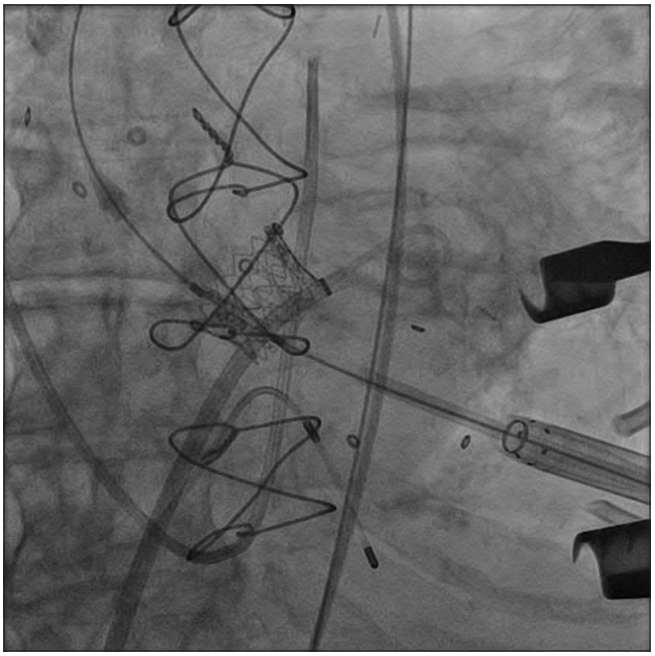

Figure 4: Fluoroscopic view of deployed transcatheter 23 mm Edwards valve within stenotic aortic tissue valve with delivery sheath in left ventricular cavity and Amplatz wire through deployed valve

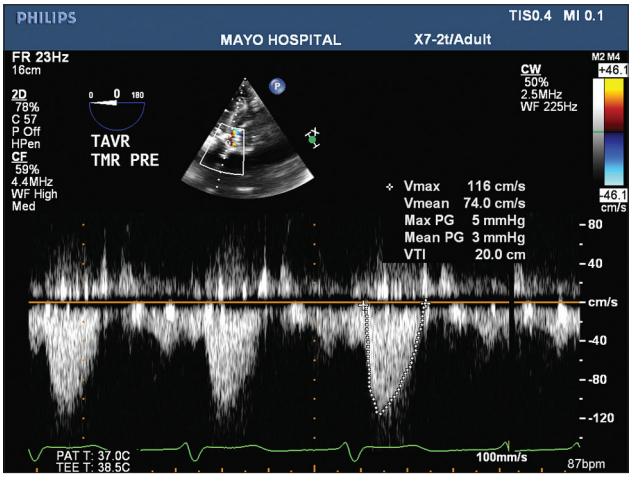

Figure 5: Postimage illustrating newly implanted valve in aortic position with low mean gradient

the new valve [Figure 5]. Using the same sheath but changing the angle towards the mitral annulus, a wire was advanced across the stenotic bioprosthetic mitral valve, over which an Extra-stiff Amplatz- manufacturer boston scientific, USA wire passed into the left atrium, leaving the floppy portion of the wire in the right superior pulmonary vein so that the stiff portion of the wire was traversing the bioprosthetic stenotic valve. Next the 29 mm Sapien THV was loaded and positioned appropriately (mounted on the delivery system 180 degrees opposite to the delivery orientation of a transapical aortic valve) onto the delivery system, placed across the mitral valve, after respiratory hold and rapid ventricular pacing at 160 BPM to prevent regurgitant LV ejection and prosthesis malpositioning during delivery, the valve was balloon inflated into place [Figure 6]. In both situations, ventilation was immediately resumed after cessation of rapid pacing, as is the routine in TAVR. TEE exam confirmed the function of the 29 mm Sapien aortic valve placed in the mitral position to be excellent, with a 3–5 mm gradient at a horizontal rule (HR) of 65, [Figure 7]. LV function was shown to be markedly improved, with the two newly implanted THV's with low gradients as mentioned above, in the setting of normal hemodynamics, with minimal paravalvular leaks [Figure 8 and Videos 4-7].

Unlike conventional valve replacement surgery with expected postoperative Intensive Care Unit (ICU) ventilation, the approach with percutaneous valve replacement is more towards rapid extubation. Anesthetic goals here included maintenance of hemodynamic stability in a patient with severe mitral and aortic stenosis with significant RV dysfunction and pulmonary hypertension. After placement of invasive arterial and central venous monitoring (via 9F sheath and pulmonary artery catheter) anesthesia was carefully induced with low dose opiate and etomidate. The key hemodynamic goals at anesthetic induction were maintenance of sinus rhythm, avoidance of systemic hypotension and preservation of cardiac output with inotropes if necessary-given the severe mitral and aortic stenosis, posing a significant threat for cardiac arrest at anesthetic induction. A TEE probe was inserted following uneventful anesthetic induction. Given his severe pulmonary hypertension, RV protective measures were instituted with intravenous milrinone and epinephrine infusions along with inhaled nitric oxide delivered at 40 PPM - immediately following anesthetic induction.

The patient remained hemodynamically stable throughout under general endotracheal anesthesia with a light opiate, no benzodiazepine, low dose volatile anesthetic technique (tailored to rapid ICU extubation,) monitored with Swan-Ganz catheter and TEE, supported by epinephrine, milrinone and vasopressin infusions along with inhaled nitric oxide for RV support as mentioned above. Once hemostasis was achieved, the thoracotomy incision was closed, and patient taken to the ICU in stable condition. He was extubated in <24 h and was discharged from the hospital 6 days postprocedure. He continues to do well with markedly improved functional status (NYHA class 1) and acceptable prosthetic valve gradients.

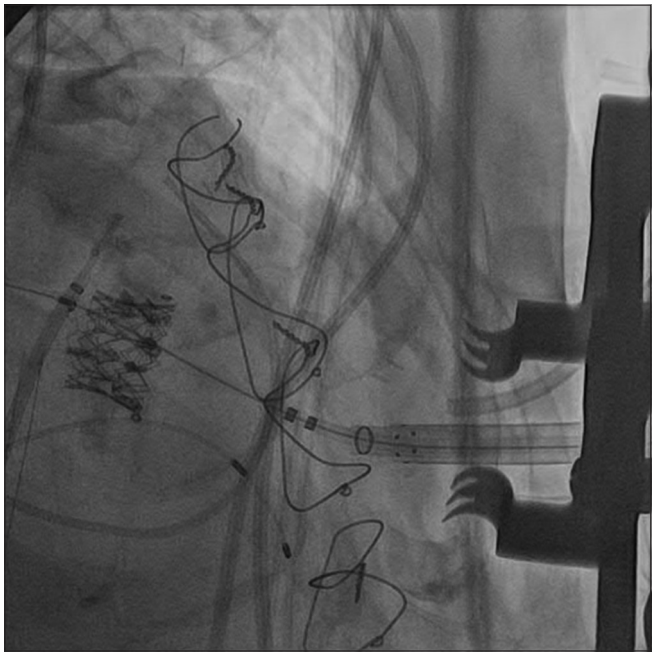

Figure 6: Fluoroscopic view of deployed transcatheter 29 mm Edwards valve within stenotic mitral tissue valve with delivery sheath in left ventricular cavity and Amplatz wire through deployed valve

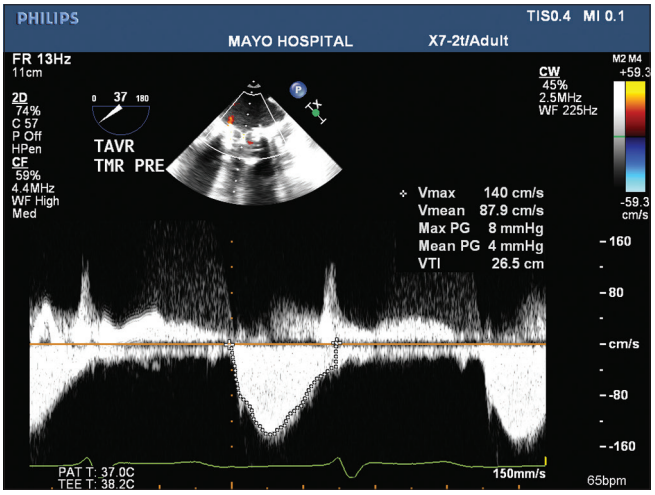

Figure 7: Continuous wave Doppler of mitral inflow illustrating low gradient in newly implanted mitral valve-in-valve

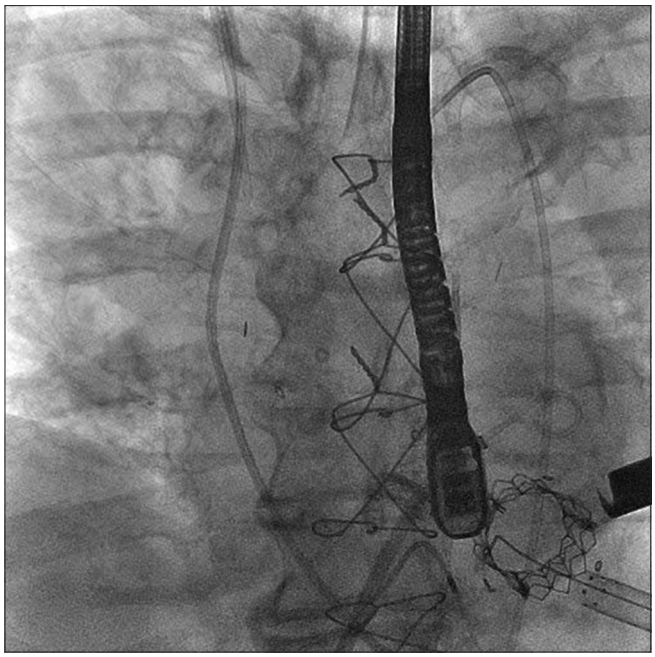

Figure 8: Fluoroscopic view of deployed "valve in valve" mitral and aortic valves in position with transesophageal echocardiography probe, pulmonary artery catheter previous sternotomy wires and valve delivery sheath in left ventricular apex

DISCUSSION

The concept of valve-in-valve percutaneous surgery is relatively new, although the percutaneous treatment of aortic valve disease is now well-established. After uncertain beginnings with published animal studies over 20 years ago,[1,2] the first percutaneous valves were implanted in the pulmonary[3] and aortic positions[4] in 2002. Since then, supported by data from the PARTNER trial[5] TAVR has been performed worldwide with encouraging results. In recent years, TAVR has not just been used in high-risk patients but also increasingly in redo-valve situations and in high-risk surgically inoperable patients with prosthetic valve disease. Data is beginning to accumulate attesting to the feasibility of using a transcatheter heart valve as a "valve-in-valve" device for both the aortic and mitral valves despite it being primarily designed as a valve for the aortic position.[6-9] Anchoring of the percutaneous aortic valve to the mitral annulus is aided by the mitral valve prosthetic sewing ring. In our patient both Sapien, valves were successfully deployed as valve-in valve deployments with no technical complications and excellent postprocedural flow characteristics. Of note-neither of the two deployments was preceded by balloon aortic valvuloplasty (BAV) of the existing prosthetic stenotic valve, as is the usual practice with native valves prior to transcatheter valve deployment. In degenerating prosthetic valves, BAV can cause embolization of the bulky and friable leaflets, predisposing to severe valvular regurgitation.[10] In this case, what is unique is the fact that both prosthetic diseased valves required valve-in-valve implantation, which was successfully accomplished via the transapical route with no complications or morbidity, without the needs for CPB. More data relating to short term, as well as long term outcomes and durability of valve-in-valve implantation, will be required before this method of therapy is recommended as standard of care in high-risk patients such as ours. Given the increasing numbers of patients worldwide undergoing TAVR once can expect repeat TAVR procedures with valve-in-valve implantation to treat prosthetic valve complications to only increase in the future-and these offer an attractive alternative to open sternotomy and CPB.[11]

Long-term valve outcomes following TAVR are still not clearly defined, what is clear, however, is that transcatheter heart valves are associated with a higher incidence of mild and moderate regurgitation compared with surgically implanted valves.[12-15] Precise grading of paravalvular regurgitation in the TAVR setting has lacked uniform standards. Recently, the Valve Academic Research Consortium proposed standardized endpoint definitions for TAVR grading of paravalvular regurgitation as part of their consensus report.[16] For both central and paravalvular AR, leaks are classified as mild, moderate and severe, incorporating standard Doppler criteria such as jet location, width, density, deceleration rate as well as circumferential extent of paraprosthetic regurgitation (<10% to >20%), and regurgitant volume/fraction. In our patient the Doppler features of the newly implanted aortic valve revealed no central or perivalvular leak, with a mean gradient of 9 mmHg at a heart rate of 87 bpm. The mitral valve-in-valve demonstrated a mean gradient of 4 mmHg at HR 65 bpm with trivial central and perivalvular leak.

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Cite this article as: Ramakrishna H, DeValeria PA, Sweeney JP, Mookaram F. Transcatheter, valve-in-valve transapical aortic and mitral valve implantation, in a high risk patient with aortic and mitral prosthetic valve stenoses. Ann Card Anaesth 2015;18:246-51.

Source of Support: Nil, **Conflict of Interest:** None declared.