Minimally Invasive Direct Access Balloon-Expandable Transcatheter Mitral Valve Replacement for Extensive Mitral Annular Calcification after Transcatheter Aortic Valve Replacement

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Abstract: Mitral annular calcification can pose a formidable surgical challenge in the setting of mitral valve replacement for mitral stenosis. Although there are reports of transapical valve-in-valve transcatheter mitral valve replacement in the setting of degenerated bioprosthetic mitral valve replacement, there is less experience with transcatheter mitral valve replacement for mitral annular calcification. This report describes a patient who previously received a transcatheter aortic valve replacement and then subsequently underwent a minimally invasive right thoracotomy for transcatheter mitral valve replacement with a successful result. We discuss technical pearls and operative considerations based on an extensive experience with minimally invasive valve surgery from a right mini-thoracotomy.

Key Words: Transcatheter valve replacement, Mitral annular calcification, Mitral valve replacement.

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Minimally invasive and transcatheter interventions for valvular heart disease are becoming more common. However, mitral annular calcification (MAC) poses a formidable challenge to surgical mitral valve replacement (MVR) for mitral stenosis (MS). Mitral annular calcification is a chronic, degenerative process influenced by age, female sex, atherosclerosis, and chronic kidney disease with complex calcium-phosphate metabolism.[1] There have been reports of using a transcatheter aortic valve prostheses implanted into the mitral position via either a transapical route or under direct vision.[2] Typically, when placed under direct vision, this has been performed via a conventional median sternotomy.[3] We report a case involving implantation of a balloon implantable SAPIEN 3 (Edwards Lifesciences, Irvine, CA USA) valve for severe MS with severe MAC. Although this procedure has been reported in a patient with a transcatheter aortic valve replacement (TAVR) already in place from a transseptal approach,[4] we report a minimally invasive right thoracotomy transcatheter mitral valve replacement (TMVR) after a previous TAVR.

Video clip is available online.

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Patient Profile

The patient is a 74-year-old woman with severe chronic obstructive pulmonary disease (FEV_1 = 1.02 L or 47% predicted, diffusing capacity for carbon monoxide = 44% predicted) on home oxygen, severe pulmonary hypertension (pulmonary artery systolic pressures in the 70–80s or 2/3's of systemic), asymptomatic severe unilateral carotid disease, extensive peripheral vascular disease with multiple ileofemoral revascularization interventions, and a history of aortic valve stenosis. One year earlier, she had undergone a bovine pericardial self-expandable (25-mm Portico Transcatheter Aortic Valve Implantation System, St. Jude Medical, St. Paul, MN USA, now Abbott Laboratories, Abbott Park, IL USA) TAVR through a transaortic route via upper ministernotomy at our institution. Six months later, her moderate MS progressed to severe MS (mitral valve area = 0.8 cm^2, mean gradient = 14 mm Hg) with Class IV NYHA symptoms. She underwent two percutaneous balloon mitral valvuloplasty interventions with an Inoye balloon over the course of 3 months with transient symptomatic relief. She now presented with persistent moderate to severe MS and new severe mitral regurgitation with NYHA Class IV symptoms. Preoperative imaging confirmed severe circumferential MAC, severe tricuspid regurgitation, left ventricular ejection fraction of 55%–60%, and normal right ventricular function. The Society of Thoracic Surgeons (STS) Predicted Risk of Mortality was 12%, and transapical implantation was not considered an option because of the high risk of left ventricular outflow tract obstruction (LVOTO) with a previous self-expandable TAVR in place and bulky anterior mitral valve leaflet and chordal disease (Fig. 1).

Operative Technique

The patient was placed in the supine position with the right arm over the head. Arterial cannulation was performed through the right axillary artery in the axilla due to severe peripheral vascular disease while venous cannulation was through the right femoral vein. A 5-cm incision over the right chest directed toward the 4th interspace as has been previously described in detail for minimally invasive valve surgery was performed.[5,6] Upon entering the chest, adhesiolysis was performed and the pericardium was opened over the phrenic nerve. Cardiopulmonary bypass was initiated, and the ascending aorta was cross-clamped using a flexible and retractable shaft cross-clamp (Cygnet, Vitalitec, Plymouth, MA USA). A single dose of modified antegrade del Nido cardioplegia was delivered. Carbon dioxide was infused into the operative field at 2 L/min. Venous drainage was augmented with vacuum assistance applying negative pressures of 30 to 70 mm Hg as needed to decompress the right heart. Next, a left lateral atriotomy through Waterston groove was performed providing full visualization of the mitral valve demonstrating a very thickened and calcified anterior leaflet. This was resected in its entirety along with the adjacent chords to reduce the risk of LVOTO (Fig. 2). The posterior leaflet and chords were preserved, and pledgeted sutures were placed on the ventricular side of the annulus in the anterolateral and posteromedial commissures and through the posterior leaflet of the mitral valve at the P1-P2 and P2-P3 junctions (Video, Supplemental Digital Content, http://links.lww.com/INNOV/A176).

We proceeded with implantation of a self-expandable bovine pericardial 26-mm SAPIEN 3 on a nitinol stent valve under direct vision. A dental mirror was used to visualize and confirm that the existing Portico TAVR would not be distorted after delivery of the SAPIEN 3 valve. The valve was reversed for implantation in the mitral position and crimped onto the Ascendra2 (Edwards Lifesciences, Irvine, CA USA) delivery device. The valve was positioned in an intra-annular position so that two-thirds of valve remained supra-annular on the atrial side. The balloon was inflated under direct vision and the valve deployed. The previously placed annulus-leaflet sutures were brought through the corresponding aspect of the valve and secured with a knot pusher (Figs. 3, 4).

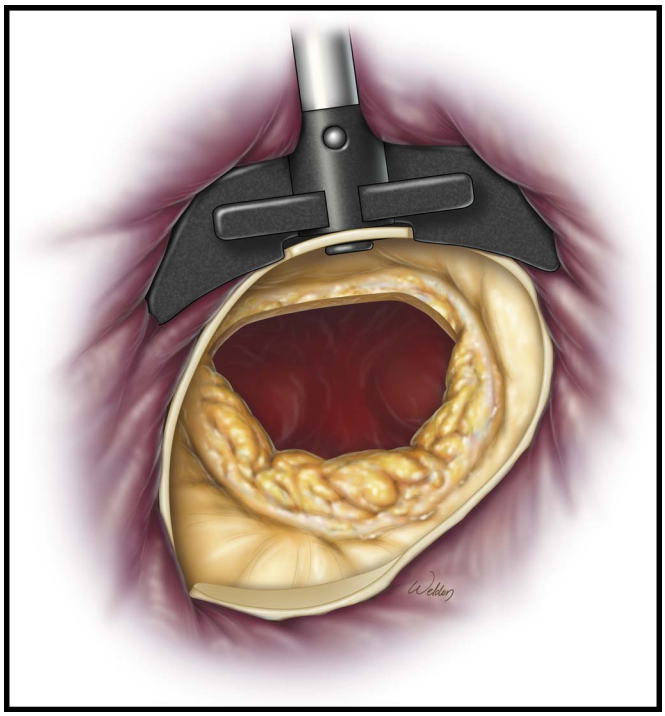

FIGURE 2. After MV leaflet resection with thickened mitral annular calcification.

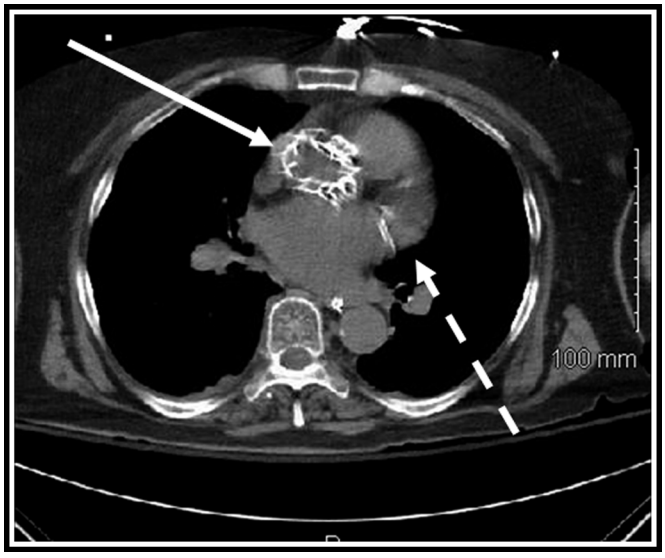

FIGURE 1. Preoperative computed tomography scan demonstrating previous self-expandable TAVR (solid arrow) and mitral annular calcification (dashed arrow).

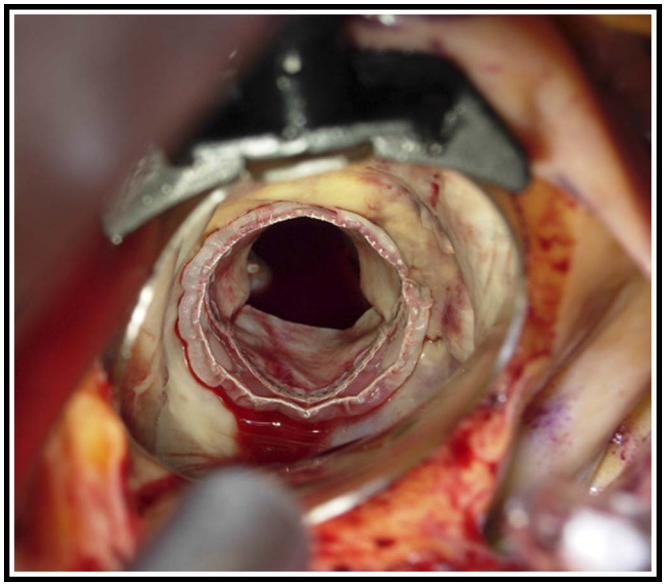

FIGURE 3. Intraoperative view through minimally invasive approach of the SAPIEN 3 valve seated in the mitral position.

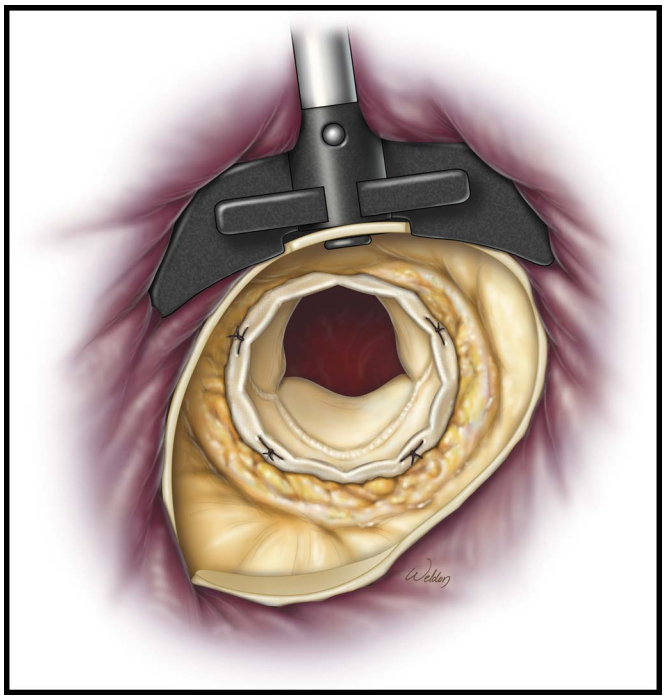

FIGURE 4. Intraoperative view through minimally invasive approach of the SAPIEN 3 valve seated in the mitral position.

After closure of the left atriotomy, a concomitant tricuspid valve repair was performed. The femoral venous cannula was withdrawn into the inferior vena cava and snared as previously described.[7] A right atriotomy was performed and a sump suction was immediately placed into the SVC then snared. Through the right atriotomy, a semirigid 26-mm band (TriAd, Medtronic. Dublin, Ireland) was implanted. Postprocedure transesophageal echocardiography demonstrated a well-seated mitral valve prosthesis with no paravalvular leak and trivial central MR as expected from the bioprosthesis. There were no signs of LVOTO and the previous TAVR seemed to be functioning well. The patient was separated from cardiopulmonary bypass uneventfully and transferred to the intensive care unit. The patient was managed with low-dose milrinone infusion and inhaled prostacyclin, transitioned to phosphodiesterase-5 inhibitor treatment with sildenafil and extubated on the second postoperative day. After a dual chamber permanent pacemaker was placed, the patient was discharged to a skilled nursing facility on postoperative day 9 on aspirin and clopidogrel. Follow-up echocardiogram at 6 weeks demonstrated preserved LV ejection fraction of 45% to 50%, a mild decrease in RV function, and normal functioning transcatheter mitral and aortic prostheses. The mean aortic valve gradient was 13 mm Hg, mean mitral valve gradient was 6 mm Hg, and there was mild tricuspid regurgitation. At 2-month follow-up, she felt well and reported NYHA II symptoms.

DISCUSSION

Extensive MAC presents a formidable challenge during MVR. The need for extensive debridement of the annulus to seat the prosthesis can increase the risk of left circumflex artery injury and atrioventricular disruption. Several techniques have been used including partial or en bloc decalcification, alternative atrial to ventricular suture placement around the calcium bar, and patch reinforcement of the annulus. Each of these approaches has its advantages and disadvantages with its technical complexity posing a challenge even to experienced mitral valve surgeons. Nevertheless, those techniques that still leave the calcium in situ increase the risk of malposition of the valve prosthesis and significant perivalvular leak. The approach to MAC for MVR requires a highly thoughtful and individualized approach balancing these considerations without clear surgical consensus. In severe cases, direct anastomosis of the prosthesis to the left atrium[8] and even a left atrium to left ventricle valved conduit[9] have been described.

Although these tools exist in the surgical armamentarium, novel additional techniques and technologies hold promise in higher-risk patients. Of all isolated MV surgeries in the STS Database, 8% are performed in patients with a mortality risk of more than 8% and only 4% in patients with a risk of more than 12% with more than 80% of these patients requiring MV replacement.[10] With our expanding TAVR experience for calcific aortic stenosis, there has been an innovation imperative to develop transcatheter interventions for the mitral position. Although there are a number of devices in various stages of development for mitral regurgitation,[11] there are far fewer options for MS especially with MAC. There has been experience with the transapical approach for valve-in-valve replacement after degenerated bioprosthetic MVR.[12] However, there has been less experience with deployment under direct vision, and even this has been through a median sternotomy.[3]

Certain aspects of this case highlight technical considerations pertinent to a hybrid direct access approach to MVR. First, implantation of the valve prosthesis with a transvenous transseptal approach has been successfully described.[13] In the TMVR in MAC Global Registry[14] of 64 patients, balloon-expandable TMVR was performed through a transapical (44%), transseptal (41%), and transatrial (16%) method for MAC. Technical success was achieved in 72% of cases with 17% needing a second valve and 9% developing LVOTO. The overall 30-day mortality was 30% for this cohort with a mean STS risk score of 14. It should be noted that procedural success was highest and mortality lowest with the transatrial approach, demonstrating its superiority. Although there are reports of simultaneous TAVR and TMVR, there is no mention in the registry of minimally invasive TMVR with a TAVR in place.

Intuitively a balloon-expandable transcatheter valve with a smaller profile poses less risk of LVOTO than a self-expandable transcatheter valve and even less so with a lower profile surgical AVR in place. Among self-expanding TAVR devices, the Portico maintains a lower overall profile than the CoreValve or Evolut R (Medtronic, Inc, Dublin, Ireland) devices. This likely worked to our advantage in this case. The circumferential MAC, as opposed to isolated posterolateral MAC, likely provided additional support to allow for the prosthesis to be anchored within the MV annulus. Adding annular and leaflet pledgeted mattress sutures through the skirt of the TAVR potentially decreases the risk of paravalvular leak. Alternative techniques would include felt strip reinforcement of the annulus as well as direct insertion of Amplatzer (Abbott Laboratories, Abbott Park, IL USA) devices in deep crevices if necessary.

The feasibility of the minimally invasive TMVR also provides for concomitant procedures to be performed. In our case, a

tricuspid valve annuloplasty was placed to address the tricuspid regurgitation. The two separate atriotomy incisions provided better visualization of both valves than a single transseptal incision when working through a right mini-thoracotomy. Concomitant atrial fibrillation could also be addressed through a Maze procedure, and the left atrial appendage may be ligated simultaneously without adding significant complexity in selected patients. Although there is an understandable tendency to a "less is more" approach in complex patients, there is an equally valid approach in experienced hands "that complete is better" when it comes to multiple valve disease. The patient's best opportunity for maximal symptomatic improvement is likely to be complete correction of valvular pathology or "complete revalvularization."

For successful minimally invasive valve surgery, cannulation strategy must be flexible. In more than 2600 cases[15] of minimally invasive valve surgeries, more than 90% of cases could be successfully managed through the femoral approach but in 9% of cases central cannulation via the axillary artery was used as due to extensive peripheral vascular disease. In our case, because the arm was positioned over the head, axillary cannulation was only feasible in the axilla itself. Typically and preferably, a longitudinal incision is used over the groin to access both vessels to reduce the risk of wound seromas.[13]

Our case is unique by describing a transcatheter MVR (TMVR) using a minimally invasive right thoracotomy in the setting of a previous self-expandable TAVR. This case also highlights that in the setting of concomitant aortic stenosis and mitral valve disease (regurgitation or stenosis), consideration may be given to minimally invasive surgical double-valve intervention that demonstrates a mortality of less than 4% in our experience.[4] The addition of TMVR provides surgeons with an alternative replacement option to extensive MV procedures and its associated risks. Although cost considerations for TMVR may limit its widespread use, in the appropriate clinical setting, it can provide a suitable alternative. The ongoing MITRAL (Mitral Implantation of TRAnscatheter vaLves) clinical trial (NCT02370511) Investigational Device Exemption trial will further define this intervention's role in this challenging clinical problem.

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