Transcatheter Mitral Valve-in-valve Explant: Lessons Learned.

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Central Picture Legend
Mitral valve-in-valve CT images and explanted valves in an en-bloc technique

Central Message

Transcatheter mitral valve-in-valve explant is feasible and best performed in an en bloc manner with both valves removed at the same time.

Introduction:

Transcatheter mitral valve replacement (TMVR) in degenerated surgical valves (MViV) was approved by the Food and Drug Administration for high-risk patients in 2017. According to Mack et al, 3597 patients were treated with TMVR between 2014 and 2020. In 2019 alone, 1120 patients underwent TMVR with 78% of those as MViV. Based on a thorough search of the literature, only 1 report of valve-in-valve explant has been published.

We describe our technique and lessons learned from three MViV explants. This report was approved by our institutional review board with a waiver of consent (# 202312337, 12/14/2023).

Case 1

A 66-year-old male patient with Von Willebrand disease status post bioprosthetic mitral valve replacement with a 29 Epic valve (Abbott Cardiovascular Inc., St. Paul, MN) presented with shortness of breath due to structural valve deterioration (Table 1). After heart team discussion, the patient underwent transcatheter MViV replacement with 26 mm Sapien 3 valve (Edwards Lifesciences, Irvine, CA) +2 ml of inflation volume. A 26 mm valve was chosen due to concern for a left ventricular outflow tract (LVOT) obstruction with the use of a larger valve.
However, he continued to have symptoms with elevated gradients. After further investigation a patient–prosthetic mismatch (PPM) was suspected, and a surgical referral was made for surgical valve replacement. During surgery, we noted that the transcatheter valve was extremely difficult to mobilize from inside of the surgical valve. Once the surgical valve cuff was released, the transcatheter frame was found embedded into the myocardium. The frame was shaved off and both valves explanted en bloc.

**Case 2**

A 74-year-old male patient post mitral valve replacement with a 29-mm Epic valve (Abbott Cardiovascular Inc., St. Paul, MN) and coronary artery bypass grafting presented with shortness of breath and structural valve deterioration (Table 1). After heart team discussion, the patient underwent MViV with 29 mm Sapien 3 + 2ml above standard inflation volume (Edwards Lifesciences, Irvine, CA). His 1-year echocardiogram showed a gradient of 10 mmHg with recurrent symptoms. A thrombus on the valve was ruled out by computed tomography (CT) and a surgical referral made. PPM was suspected and a valve explant was recommended. Removal of the MViV with the same en bloc technique as in the previous case was performed. The frame was flared significantly out of the surgical valve such that separate removal of either valve alone was not possible (figure 1E).

**Case 3**

A 71-year-old male patient status post–mitral valve replacement presented with acute severe regurgitation and pulmonary edema from structural valve degeneration (Table 1). The Patient
underwent surgery with a 29 mm Sapien 3 valve (Edwards Lifesciences, Irvine, CA) with
nominal inflation volume inside a 33 mm Epic valve (Abbott Cardiovascular Inc. St. Paul, MN)
urgently. Two years later, patient developed recurrent bacterial endocarditis and surgical explant
was indicated. The valves were removed in the same en bloc technique as in the previous two
cases (Video attached). The transcatheter valve was slightly flaring outside of the surgical valve
(Figure 1F).

Discussion:
Transcatheter MViT procedures are being performed more frequently with equivalent 1-year
mortality as redo mitral valve replacement\(^1\). This will lead to more implants and the need for
explant once complications happen. We discuss above three cases of explanted MViT. Two
cases likely due to PPM and the third case due to persistent bacterial endocarditis. In the first
case the patient had a body surface area of 2.21 and a 26 Sapien valve inside a 29 Epic valve.
PPM was confirmed with a dobutamine stress echocardiogram. In the second case, a 29 Sapien
valve inside a 29 Epic valve had high gradients leading to readmission with congestive heart
failure. Valve thrombosis was ruled out as the valve gradients initially were lower (Table 1). Our
third patient developed MViT endocarditis with recurrent bacteremia despite antibiotic therapy,
and the decision was made to explant the valve.

When explanting a valve-in-valve, the surgeon has two options. First, the transcatheter valve can
be removed separately, followed by the surgical valve. A second options is removing both valves
simultaneously “en bloc”. For a transcatheter valve-in-valve in the aortic position, removing the
transcatheter valve first allows for better visualization of the surgical valve. The transcatheter frame is easily accessible, and its presence hinders access to the surgical valve. A strategy for transcatheter valve removal separately followed by surgical valve removal is feasible in the aortic position. In the mitral position, the transcatheter frame is not directly seen, as it is mostly inside the left ventricular (LV) cavity, but the surgical cuff is adequately visualized and accessed. Flaring of the transcatheter mitral valve into the ventricle is inevitable in the situations of a larger transcatheter valve compared to the surgical prostheses. This flaring helps prevent valve migration but makes separate removal of the transcatheter valve challenging. Also, flaring could push the frame into the ventricular wall and surrounding structure, as in our first case and the case described by Sukioka et al. In their report, the transcatheter mitral valve was attached to the aortic valve leaflets through the LVOT and required shaving it off the leaflets and subsequent aortic valve replacement. The inability to visualize the transcatheter valve frame through an atriotomy makes removal of the transcatheter valve separately a blind procedure that could lead to damage to surrounding structures. Releasing the surgical valve cuff first allows for retracting both prostheses into the atrium gradually and releasing areas of contact under direct vision as shown in our video. Alternatively, the frame can be visualized directly through the aortic valve accessed by an aortotomy if needed, as described in the case by Sukioka et al.

In our case series we found that certain characteristics can predict a more difficult explant, including the larger the size of the transcatheter valve compared to the surgical valve, use of more inflation volume during the TMVR, and a smaller neo-LVOT area. A large transcatheter valve and the use of more inflation volume both lead to valve flaring into the LV cavity as shown
in Figure 1 (D, E). A smaller LVOT and LV cavity may lead to the transcatheter valve frame attaching to surrounding structures as described in Case 1.

In the future, more percutaneous mitral valve will be implanted, some with apical attachments and some with larger profiles. Different explant techniques will be required for each system. The focus of percutaneous valve design is related to valve stability, LVOT obstruction and durability. These are important issues; however, ease of explant should also be considered, especially when this technology is utilized for low-risk patients with longer longevity. As surgeons describing and sharing these techniques is important because use of TMVR will increase. This is the first case series describing MViV surgical explant. As it is only a three-patient series, more data and experience are needed to confirm generalizability of our findings.

**Conclusion:**

Mitral valve-in-valve explant is technically feasible. We recommend en bloc removal of both valves as the safest method of valve explant.


**Figure 1:**

A: CT scan with surgical mitral prostheses in place. B & C: Transcatheter valve with proximity to the aortic valve and posterior LV wall. D: Implant of a 29 Sapien valve in a 29 Epic valve with flaring into the LV cavity (arrow) outside the surgical frame, E: A 29 Sapien valve inside a 29 Epic valve + 2 mL inflation volume; arrows shows the flaring outside the surgical frame. F: A 29 Sapien valve inside a 33 Epic valve with normal inflation; minimal flaring is noted compared to E.

**Video:**

Case 3 explant of 29 Sapien valve with normal inflation volume in a 33 Epic valve. We show the en bloc explant technique of valve removal.

**Table 1:**

CABG (coronary artery bypass grafting), MViV (mitral valve-in-valve), TMVR (transcatheter mitral valve replacement), SMVR (surgical mitral valve replacement), CKD (chronic kidney disease), LVOT (left ventricular outflow tract), RAO (right anterior oblique), CRA (cranial), PPM (patient–prosthetic mismatch), mmHg (millimeter mercury), BSA (body surface area), MVmg (mitral valve mean gradient), CTA (computed tomography angiography), a-fib (atrial fibrillation), Epic Valve (Abbott Cardiovascular Inc. St. Paul, MN), ON-X valve (Artivion, Kennesaw, GA)
<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age at first surgery</strong></td>
<td>56</td>
<td>66</td>
<td>60</td>
</tr>
<tr>
<td><strong>First surgical Valve</strong></td>
<td>29 Epic Valve</td>
<td>29 Epic Valve</td>
<td>33 Epic Valve</td>
</tr>
<tr>
<td><strong>Associated procedure</strong></td>
<td>None</td>
<td>CABG × 2</td>
<td>None</td>
</tr>
<tr>
<td><strong>Mode of surgical valve failure</strong></td>
<td>Severe regurgitation</td>
<td>Severe stenosis</td>
<td>Severe regurgitation</td>
</tr>
<tr>
<td><strong>Mean valve gradient</strong></td>
<td>5 mmHg</td>
<td>12 mmHg</td>
<td>3 mmHg</td>
</tr>
<tr>
<td><strong>Time to MVIV therapy (years)</strong></td>
<td>10</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td><strong>Heart team decision re TMVR vs SMVR</strong></td>
<td>Von Willebrand disease; redo sternotomy TMVR was advised.</td>
<td>Redo sternotomy, patent grafts, advanced age (74 years); CKD TMVR was advised.</td>
<td>Acute regurgitation, pulmonary edema, decompensation heart failure; redo sternotomy advanced age (71 years); TMVR was advised.</td>
</tr>
<tr>
<td><strong>Transcatheter valve</strong></td>
<td>26 Sapien + 2 mL</td>
<td>29 Sapien + 2 mL</td>
<td>29 Sapien</td>
</tr>
<tr>
<td><strong>NeoLVOT area projected (mm²)</strong></td>
<td>201</td>
<td>588</td>
<td>430</td>
</tr>
<tr>
<td><strong>LVOT gradient post implant (mmHg)</strong></td>
<td>4</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td><strong>Mitral valve gradient (mmHg)</strong></td>
<td>10–12</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>At 30 days post-op</td>
<td>At 30 days post-op</td>
<td>At 30 days post-op</td>
</tr>
<tr>
<td><strong>BSA (m²)</strong></td>
<td>2.21</td>
<td>2.06</td>
<td>1.83</td>
</tr>
<tr>
<td><strong>Decision to explant</strong></td>
<td>Symptomatic gradient at rest 10 mmHg</td>
<td>At 1 year gradient increased to 10 mmHg</td>
<td>Endocarditis with recurrent bacteremia on antibiotic therapy</td>
</tr>
<tr>
<td><strong>Time to Mitral Valve-in-Valve explant (years)</strong></td>
<td>1</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Reason for explant</td>
<td>PPM</td>
<td>PPM</td>
<td>Endocarditis</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------</td>
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<td>-----------------------</td>
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<tr>
<td>Second surgical valve</td>
<td>ON-X mechanical 27/29 valve</td>
<td>33 Epic Plus</td>
<td>33 Epic Plus</td>
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<tr>
<td>Post-op gradient</td>
<td>5 mmHg</td>
<td>4 mmHg</td>
<td>4 mmHg</td>
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<tr>
<td>Postoperative complications</td>
<td>None</td>
<td>Acute kidney injury with return to normal</td>
<td>None</td>
</tr>
<tr>
<td>Last follow-up since explant</td>
<td>3 years</td>
<td>3 months</td>
<td>3 months</td>
</tr>
</tbody>
</table>
A. RSA
Surgical Mitral Valve

B. Aortic Valve

C. Posterior LV Wall

D. Flaring into LV

E. 29 Sapien Valve in 29 Epic

F. 29 Sapien Valve in 33 Epic