Transcatheter Mitral Valve-in-Valve Implantation in Patients With Degenerated Bioprostheses

Moritz Seiffert, MD,* Lenard Conradi, MD,* Stephan Baldus, MD,† Johannes Schirmer, MD,* Malgorzata Knap, MD,† Stefan Blankenberg, MD,† Hermann Reichenspurner, MD, PhD,* Hendrik Treede, MD*

Hamburg, Germany

Objectives  This study reports the results of a series of transapical mitral valve-in-valve implantations and aims to offer guidance on technical aspects of the procedure.

Background  Mitral valve reoperations due to failing bioprostheses are associated with high morbidity and mortality. Transcatheter techniques may evolve as complementary approaches to surgery in these high-risk patients.

Methods  Six patients (age 75 ± 15 years) received transapical implantation of a balloon-expandable pericardial heart valve into a degenerated bioprosthesis (range 27 to 31 mm) in mitral position at our institution. All patients were considered high risk for surgical valve replacement (logistic EuroSCORE: 33 ± 15%) after evaluation by an interdisciplinary heart team. Procedural and clinical outcomes were analyzed.

Results  Implantation was successful in all patients with reduction of mean transvalvular gradients from 11.3 ± 5.2 mm Hg to 5.5 ± 3.6 mm Hg (p = 0.016) and median regurgitation from grade 3.0 (interquartile range [IQR]: 2.7 to 3.1) to 0 (IQR: 0 to 1.0, p = 0.033) with trace paravalvular regurgitation remaining in 2 patients. Apical bleeding occurred in 2 patients requiring rethoracotomy in 1 and resuscitation in a second patient, the latter of whom died on postoperative day 6. In the remaining patients, median New York Heart Association functional class improved from 3.0 (IQR: 3.0 to 3.5) to 2.0 (IQR: 1.5 to 2.0, p = 0.048) over a median follow-up of 70 (IQR: 25.5 to 358) days.

Conclusions  With acceptable results in a high-risk population, transapical mitral valve-in-valve implantation can be considered as a complementary approach to reoperative mitral valve surgery in select patients.  (J Am Coll Cardiol Intv 2012;5:341–9) © 2012 by the American College of Cardiology Foundation

From the *Department of Cardiovascular Surgery, University Heart Center Hamburg, Hamburg, Germany; and the †Department of General and Interventional Cardiology, University Heart Center, Hamburg, Germany. The authors have reported that they have no relationships relevant to the contents of this paper to disclose. Drs. Seiffert and Conradi contributed equally to this work. Manuscript received September 7, 2011; revised manuscript received November 28, 2011, accepted December 8, 2011.
Due to favorable clinical results, bioprostheses have increasingly been chosen over mechanical valves even in younger patients undergoing surgical valve replacements. As outcomes improve, a growing need for reoperative valve replacements due to xenograft degeneration may be anticipated in the future. Mitral valve reoperations can be associated with a high mortality related to the patients’ clinical condition, significant comorbidities, and the complexity of the procedure itself (1–5).

After proof of principle (6), transcatheter valve-in-valve therapies have been evolving as promising complementary approaches to reoperative valve surgery in high-risk surgical patients, sparing them the need for complex reoperations associated with the use of extracorporeal circulation. Increasing experience with this novel approach has been collected for the aortic position, and first results seem appealing in a select patient group (7–11). At the same time, the technique has been refined and applied in mitral, tricuspid, and pulmonary positions, but experience is small when compared with aortic valve-in-valve implantation and limited to single case reports or small case series (10–18). Implantation after mitral valve repair and annuloplasty has also been reported (19). Different approaches to access the mitral valve have been advocated, including transseptal and transatrial techniques (11,20). Nevertheless, most experience has been gained using the transapical access (11,13). To contribute to the growing knowledge and understanding of this novel technique, we report a series of patients undergoing transapical mitral valve-in-valve implantation at our institution and attempt to offer insights into the technical challenges accompanying this procedure.

**Methods**

**Patient population.** From December 2009 to July 2011, 6 patients were admitted to our institution with significant signs of valve dysfunction long term after bioprosthetic mitral valve replacement (MVR) (Table 1). Indication for valve replacement was based on current guidelines (21). All patients presented with severe comorbidities precluding them from surgical treatment as determined by an interdisciplinary heart team. Pre-operative transesophageal echocardiography was used to determine valve pathology and inner stent diameter. Coronary angiography was performed to rule out significant coronary artery disease requiring intervention.

**Transapical Valve-in-Valve Implantation**

Valve-in-valve implantation was performed in a specially equipped hybrid suite with a primed heart-lung machine available in the room in case of hemodynamic compromise. Procedures were performed under general anesthesia, as previously described (10). Briefly, after left lateral minithoracotomy in the fifth or sixth intercostal space, ventricular pacemaker leads were placed and purse-string sutures were applied to the apex. After apical puncture, soft and subsequent stiff guidewires were inserted transapically, advanced through the mitral prosthesis, and placed in the pulmonary vein. In 1 case of severe mitral stenosis and the inability to cross the calcified bioprosthesis with the transcatheter heart valve (THV), balloon valvuloplasty of the degenerated valve was performed. This step was not done in the remaining cases. Measurements of the inner stent diameter of the bioprostheses were obtained by transesophageal echocardiography, and a 23- or 26-mm THV was selected for implantation. Compared with transapical placement of a THV in the aortic position, the Edwards Sapien valve (Edwards Lifesciences, Irvine, California) was crimped in a reverse fashion onto the balloon catheter (Fig. 1). Subsequently, the THV was introduced through a transapically placed sheath, positioned, and then deployed into the degenerated mitral bioprosthesis under fluoroscopic and echocardiographic guidance (Fig. 2). Similar to Cheung et al. (14), the THV was placed to slightly overlap the stent of the degenerated bioprosthesis into the left atrium for sufficient anchoring. These steps were carried out under rapid ventricular pacing. Subsequently, valve performance was assessed by transesophageal echocardiography and fluoroscopy.

In 2 patients with concomitant intervention of the aortic valve, a THV was deployed antegrad into the degenerated bioprosthesis or the calcified aortic annulus (Patients #2 and #3) (Table 1, Fig. 3), as previously described (10). Implantations in the aortic position were performed before the mitral valve interventions to allow for better access to the aortic valve. After small angulation of the sheath and exchange of the introducer device, mitral valve-in-valve implantation was performed using the same access route, as described in the previous text.

**Echocardiographic assessment and clinical follow-up.** Transthoracic echocardiography was performed at baseline, before discharge, and at 30 days according to recent recommendations (22). The effective orifice area (EOA) was assessed using the continuity equation approach. The indexed EOA was calculated by indexing the EOA to the patient’s body surface area, computed using Dubois’ formula. According to the literature, patient–prosthesis mismatch was defined as an indexed EOA ≤1.2 cm²/m² (23). Clinical follow-up was performed at 30 days and 6 months, if applicable.
Transcatheter Mitral Valve-in-Valve Implantation

Baseline, pro-
phases were performed using GraphPad Prism version 5.02
Basel characteristics.

The study population was 100% female with a mean age of 74.7 ± 14.6 years (range: 52 to 88 years). All patients were highly symptomatic with a median New York Heart Association (NYHA) functional class of 3.0 (IQR: 3.0 to 3.5). Patients were admitted with severe dysfunction of the implanted bioprostheses 10.5 ± 4.1 years after surgical MVR. Five patients had stented bioprostheses size 27 mm in situ, whereas 1 patient had received a 31-mm valve. Overall, 5 patients primarily displayed signs of regurgitation of the previously implanted xenograft due to different etiologies, whereas 1 patient presented with prevailing stenosis and concomitant regurgitation. Risk score predicted a 30-day mortality of 33 ± 15% (logistic EuroSCORE) and 19 ± 11% (Society of Thoracic Surgeons predicted risk of mortality). Hemolytic anemia, most likely due to severe mitral regurgitation (MR), was seen in 1 patient.

Concomitant aortic valve disease was present in 2 patients. In 1, the 23-mm Carpentier-Edwards porcine valve in the aortic position featured calcified leaflets accounting for a moderate stenosis (EOA: 1.1 cm², mean transprosthetic gradient: 18 mm Hg, Patient #2). In the other, severe calcific stenosis of the native aortic valve was identified (EOA: 0.9 cm², Patient #3).

Due to their severe comorbidities, 2 younger patients were also considered suitable for transcatheter valve-in-valve implantation: One patient suffered from severe destructive rheumatoid arthritis with continuous immunosuppression and pronounced circular calcification of the mitral annulus (Patient #5). Multiple valve surgeries due to endocarditis had been performed on another patient who had suffered from septic encephalopathy and chronic renal failure (Patient #4). Detailed patient data and comorbidities are listed in Table 1; mitral valve characteristics are listed in Table 2.

Procedural outcomes. Transcatheter mitral valve-in-valve implantation was performed successfully without the use of extracorporeal circulation in all patients. Mitral valve inner

Data management and statistical methods. Baseline, procedural, and follow-up data were prospectively entered into a database and retrospectively analyzed. Continuous variables are expressed as mean ± SD if normally distributed or median plus interquartile range (IQR) if skewed or ordinal. Categorical variables are expressed as frequencies and proportions (%). The differences in mean values of continuous variables before and after the intervention were compared using the paired Student t test or the Wilcoxon matched-pairs signed rank test for ordinal values, generating 2-tailed p values. Statistical significance was assumed at p < 0.05. All statistical analyses were performed using GraphPad Prism version 5.02 (GraphPad Software Inc., La Jolla, California).

Ethics. All patients were fully informed about the valve-in-valve procedure and signed written consent forms.

Results

Baseline characteristics. The study population was 100% female with a mean age of 74.7 ± 14.6 years (range: 52 to 88 years). All patients were highly symptomatic with a median New York Heart Association (NYHA) functional class of 3.0 (IQR: 3.0 to 3.5). Patients were admitted with severe dysfunction of the implanted bioprostheses 10.5 ± 4.1 years after surgical MVR. Five patients had stented bioprostheses size 27 mm in situ, whereas 1 patient had received a 31-mm valve. Overall, 5 patients primarily displayed signs of regurgitation of the previously implanted xenograft due to different etiologies, whereas 1 patient presented with prevailing stenosis and concomitant regurgitation. Risk score predicted a 30-day mortality of 33 ± 15% (logistic EuroSCORE) and 19 ± 11% (Society of Thoracic Surgeons predicted risk of mortality). Hemolytic anemia, most likely due to severe mitral regurgitation (MR), was seen in 1 patient.

Concomitant aortic valve disease was present in 2 patients. In 1, the 23-mm Carpentier-Edwards porcine valve in the aortic position featured calcified leaflets accounting for a moderate stenosis (EOA: 1.1 cm², mean transprosthetic gradient: 18 mm Hg, Patient #2). In the other, severe calcific stenosis of the native aortic valve was identified (EOA: 0.9 cm², Patient #3).

Due to their severe comorbidities, 2 younger patients were also considered suitable for transcatheter valve-in-valve implantation: One patient suffered from severe destructive rheumatoid arthritis with continuous immunosuppression and pronounced circular calcification of the mitral annulus (Patient #5). Multiple valve surgeries due to endocarditis had been performed on another patient who had suffered from septic encephalopathy and chronic renal failure (Patient #4). Detailed patient data and comorbidities are listed in Table 1; mitral valve characteristics are listed in Table 2.

Procedural outcomes. Transcatheter mitral valve-in-valve implantation was performed successfully without the use of extracorporeal circulation in all patients. Mitral valve inner

Table 1. Baseline Clinical Parameters

<table>
<thead>
<tr>
<th>Patient #</th>
<th>Age (yrs)</th>
<th>Log ES</th>
<th>STS-PROM</th>
<th>NYHA Functional Class</th>
<th>Comorbidities</th>
<th>Previous Sternotomies</th>
<th>Creatinine (mg/dl)</th>
<th>PAP (mm Hg)</th>
<th>TR Grade</th>
<th>EF</th>
<th>Additional Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>88</td>
<td>48.2%</td>
<td>26.8%</td>
<td>3</td>
<td>AF, previous stroke, gastrointestinal bleeding, and breast cancer</td>
<td>1: MVR</td>
<td>1.6</td>
<td>44</td>
<td>2</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>83</td>
<td>22.3%</td>
<td>NA*</td>
<td>4</td>
<td>Previous AVR with dysfunction, CAD, persistent anemia due to recurrent gastrointestinal bleeding, colon dysplasia, pacemaker implantation, AF</td>
<td>1: AVR, MVR</td>
<td>1.3</td>
<td>55</td>
<td>3</td>
<td>60%</td>
<td>Aortic valve-in-valve</td>
</tr>
<tr>
<td>3</td>
<td>86</td>
<td>40.3%</td>
<td>NA*</td>
<td>3</td>
<td>Decompensated HF, aortic stenosis, AF, previous stroke, cerebrovascular disease, CAD, CABG, and PCI</td>
<td>1: MVR, CABG</td>
<td>0.7</td>
<td>48</td>
<td>1</td>
<td>55%</td>
<td>TAVI</td>
</tr>
<tr>
<td>4</td>
<td>62</td>
<td>48.7%</td>
<td>29.4%</td>
<td>3</td>
<td>Decompensated HF, previous redo AVR and TVR for endocarditis with septic encephalopathy, intracranial bleeding, chronic hemodialysis for renal failure, AF, previous stroke, previous gastrointestinal bleeding, CAD</td>
<td>1: AVR, MVR, TVR</td>
<td>5.1</td>
<td>45</td>
<td>2</td>
<td>55%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>52</td>
<td>11.1%</td>
<td>9.7%</td>
<td>3</td>
<td>Severe destructive rheumatoid arthritis and circular calcification of the mitral annulus, IDDM</td>
<td>1: AVR, MVR</td>
<td>0.7</td>
<td>83</td>
<td>3</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>75</td>
<td>26.6%</td>
<td>9.2%</td>
<td>3</td>
<td>Hemolytic anemia, von Willebrand’s disease, CAD, previous breast cancer</td>
<td>1: MVR</td>
<td>1.7</td>
<td>65</td>
<td>1–2</td>
<td>55%</td>
<td></td>
</tr>
</tbody>
</table>

*STS-PROM not available for combined aortic and mitral valve procedures.

AF = atrial fibrillation; AVR = aortic valve replacement; CABG = coronary artery bypass grafting; CAD = coronary artery disease; EF = left ventricular ejection fraction; HF = heart failure; IDDM = insulin dependent diabetes mellitus; log ES = logistic European system for cardiac operative risk evaluation (EuroSCORE); MVR = mitral valve replacement; NYHA = New York Heart Association; PAP = systolic pulmonary artery pressure; PCI = percutaneous coronary intervention; STS PROM = Society of Thoracic Surgeons predicted risk of mortality; TAVI = transcatheter aortic valve implantation; TR = tricuspid regurgitation; TVR = transcathedral valve replacement.
Stent diameters were measured as 23.0 ± 1.3 mm. Subsequently, 23- and 26-mm Edwards Sapien valves were used in 3 patients each. Two of the 6 patients received additional procedures: One patient underwent concomitant transcatheter aortic valve implantation (TAVI) through the same transapical access for a calcific aortic valve stenosis. A second patient received a transcatheter valve-in-valve implantation into a dysfunctional bioprosthesis in the aortic position (Fig. 3). Including these additional procedures, operating time was 100.2 ± 20.4 min. Median fluoroscopy time was 428 (IQR: 264 to 977) s with 20.0 (IQR: 9.5 to 218.0) ml of contrast agent used. In patients with isolated mitral valve-in-valve implantation, 0 to 20 ml of contrast dye were infused.

Valve function. In the mitral position, mean transvalvular gradients improved from 11.3 ± 5.2 mm Hg to 5.5 ± 3.6 mm Hg (p = 0.016) after implantation, and the EOA remained unchanged (2.4 ± 0.6 cm² vs. 2.3 ± 0.2 cm²). When adjusted to body surface areas, indexed EOAs were 1.4 ± 0.1 cm²/m² after implantation. Patient–prosthesis mismatch, as defined by an indexed EOA ≤1.2 cm²/m², did not occur in any patients after transcatheter valve-in-valve implantation. Median MR was reduced from grade 3.0 (2.7 to 3.1) to 0 (IQR: 0 to 1.0, p = 0.033), with only 2 patients experiencing trace MR after implantation.

In the aortic position, concomitant TAVI extended the EOA from 0.9 to 1.5 cm² (Patient #3). Additional valve-in-valve implantation only marginally improved the EOA from 1.1 to 1.2 cm² with a reduction in mean transvalvular gradients from 18 to 8 mm Hg (Patient #2).

Clinical outcomes. Two patients suffered from apical bleeding late in the periprocedural course: One patient required surgical rethoracotomy on postoperative day 4 due to hemothorax and experienced an uneventful recovery thereafter (Patient #2). After a primarily uneventful course, a second patient suffered from acute hemodynamic compromise on day 6 requiring cardiopulmonary resuscitation (Patient #1). The patient subsequently died, and autopsy identified hemorrhagic shock due to acute bleeding from the apical wound as the cause of death.
Overall length of stay in-hospital was 9.6 ± 3.6 days with 1.5 ± 0.5 days in the intensive care unit. Although 3 of the 6 patients presented with concomitant renal dysfunction, no signs of acute kidney injury became obvious in the 5 patients discharged from our hospital. Overall, serum creatinine was 1.2 ± 0.5 mg/dl at baseline and 1.3 ± 0.8 mg/dl at discharge. Amount of packed red blood cells transfused in the early course after the procedure was 3.6 ± 1.7 U per patient. There were no adverse neurological events or arrhythmias necessitating pacemaker implantation in any of these patients. No clinical signs of hemolytic anemia were present in any of the patients following the procedure.

**Clinical follow-up.** At a median follow-up of 70 (IQR: 25.5 to 358) days, 5 patients were alive without the occurrence of any valve-related adverse events. Heart failure improved from median NYHA functional class 3.0 (IQR: 3.0 to 3.5) to 2.0 (IQR: 1.5 to 2.0, p = 0.048) at the last visit, and all patients were in good clinical condition. Echocardiographic follow-up demonstrated proper mitral valve-in-valve function. No signs of structural valve deterioration were noted at this early stage.

One patient was readmitted with gastrointestinal bleeding in the light of anticoagulation and sepsis 2 months after the procedure. No signs of endocarditis were found, and the patient could be discharged after resolution of symptoms under medical treatment.

**Discussion**

Reoperative mitral valve replacement can be associated with considerable mortality in elderly patients with comorbidities. Reported 30-day mortality rates ranged from 5.8% to 15.1% and 11.5% to 14.3% if combined with reoperative aortic valve surgery (1–5). Recent guidelines (21) recommend mitral valve surgery in patients with chronic severe MR and symptoms in the absence of severe left ventricular dysfunction (Class: I, Level of Evidence: B). Because of the operative risk and promising short- and mid-term results with TAVI (24,25), valve-in-valve procedures have been applied in these high-risk patients. However, due to the lack of durability data and the excellent long-term results achieved with conventional valve surgery, these novel approaches still demand special consideration of patient selection criteria. Particularly elderly patients with a significant-risk profile and indications for complex reoperations may benefit from these techniques. All patients described in this case series had an indication for reoperative valve surgery according to recent guidelines (21) but were considered high risk for conventional surgery by an interdisciplinary heart team consisting of cardiologists and cardiac surgeons. Severe comorbidities, such as destructive rheumatoid arthritis, bleeding disorders, and circular calcification of the mitral annulus did not necessarily find reflection in the employed risk-stratification tools, empha-
sizing the need for thorough interdisciplinary patient evaluation. Thus, 2 younger patients also underwent transcatheter mitral valve-in-valve implantation since conventional surgery was considered extremely high risk in these 2 patients.

As advocated by most other groups (11,12,14), we used the transapical approach with successful implantation in all patients. Transapical access is easy to set up and offers a straight and short route to the mitral plane allowing for coaxial alignment of the transcatheter within the degenerated bioprosthesis (Fig. 4). Additionally, this approach offered the opportunity to simultaneously access the aortic valve in 2 of the 6 patients (Fig. 3). Nevertheless, we experienced significant bleeding from the apical cannulation site in the first 2 patients, 1 of whom expired in hemorrhagic shock. Ventricular tissue may be very fragile in this select patient cohort, and implantation in mitral position may be

<table>
<thead>
<tr>
<th>Table 2. Mitral Valve Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient #</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

The valves and their manufacturers are as follows: CE porcine (Carpentier-Edwards Porcine mitral valve, Edwards Lifesciences, Irvine, California); Sapien and Sapien XT (Edwards Lifesciences); Medtronic Hancock II mitral valve and Medtronic Mosaic mitral valve (Medtronic, Minneapolis, Minnesota); SJM biocor (St. Jude Medical biocor mitral valve, St. Jude Medical, St. Paul, Minnesota).

EOA = effective orifice area; ID = inner stent diameter according to manufacturers’ specifications; measured ID = inner stent diameter according to intraprocedural transesophageal echocardiographic measurements; MR = mitral regurgitation; MS = mitral stenosis; MV = mitral valve; MVR = mitral valve replacement; NA = not available; PV = perivalvular; THV = transcatheter heart valve; TV = transvalvular; VG = mean transvalvular gradient.

Figure 3. Transcatheter Double Valve-in-Valve Implantation
Degenerated bioprostheses in the aortic and mitral positions (A) required implantation of 23-mm Edwards Sapien valves (Edwards Lifesciences) into a 23-mm Carpentier-Edwards aortic and a 27-mm mitral prosthesis (Edwards Lifesciences) (B and C). Echocardiography displaying valve function before (D) and after (E) mitral valve-in-valve implantation; Patient #2.
associated with more manipulation of the transapically inserted sheath, emphasizing the need for careful application of the purse-string sutures and meticulous control of bleeding after sheath removal. This is also reflected in the transfusion requirements of the reported case series. The transseptal and transatrial routes seem technically more demanding and may be reserved for patients not suitable for the transapical approach.

Careful echocardiographic measurements of the inner stent diameter are helpful for correct sizing of the THV since the inner diameter of the degenerated bioprostheses may deviate from the manufacturer’s specifications. Calcified or torn tissue leaflets and pannus may impose alterations on inner stent geometry as is being suggested by the differences in the obtained baseline echocardiographic measurements and manufacturer’s specifications in our experience (Table 2). Oversizing—as usually performed in native valves—is impeded due to the rigid xenograft stent, and valve underexpansion may contribute to increased gradients and regurgitation through leaflet distortion and early valve failure. Of particular note, the inner stent diameter differs distinctly from the labeled valve size, which usually represents the outer stent diameter. A chart providing these dimensions for a variety of mitral bioprostheses is included in the Online Appendix.

The optimal imaging modality to evaluate the aortic or mitral annulus geometry and THV size still remains to be determined. Several studies have compared transesophageal and transthoracic echocardiography with multislice computed tomography (26,27), with the latter technique taking the elliptic shape of the aortic annulus into consideration, therefore yielding larger annular measurements. The development of second-generation THV aiming at anatomical orientation may promote 3-dimensional reconstruction using multislice computed tomography or echocardiography. At this point, information from multiple imaging modalities and manufacturer’s specifications should be incorporated into THV size choice.

The benefit of balloon valvuloplasty before valve-in-valve implantation is unclear, but its downsides are well known. Therefore, we used this technique only in 1 patient in whom passage of the extensively calcified xenograft with the THV was not feasible before valvuloplasty. No valvuloplasty was performed in the remaining patients, and we did not encounter any problems with regard to incomplete stent expansion in these procedures. Similar to aortic valve-in-valve procedures, implantation was performed with a slight atrial overlap of the THV over the stent of the degenerated bioprosthesis, allowing for sufficient anchoring and valve expansion (Fig. 1) (11).

Valve function improved with a decrease of regurgitation, mean transvalvular gradients, and unchanged EOA. A mean transvalvular gradient of 5.5 mm Hg persisted, accounting for a mild stenosis. This may have been due to implantation into smaller bioprostheses labeled 27 mm in 5 of 6 patients and is in agreement with previously published
data (11). Higher degrees of stenosis in small-size bioprostheses and the subsequent problem of patient–prosthesis mismatch did not occur in our experience, as opposed to aortic valve-in-valve implantation (28). MR, the leading pathology in 5 of 6 patients, was sufficiently reduced, with only trace regurgitation remaining in 2 patients. Regarding the 2 patients with double valve procedures, improvement in valve function was only marginal after concomitant valve-in-valve implantation in the aortic position. In both patients, mitral valve pathology qualified for the leading indication. A later intervention in case of progressive aortic valve disease may have been impeded by the previous mitral valve-in-valve procedure. Therefore, both valves were treated at the same time, even though stenosis was only moderate in 1 patient. Additionally, transvalvular aortic gradients may have been underestimated at baseline due to mitral valve pathology.

Depending on the amount of radio-opaque markers within the bioprostheses (Fig. 2 vs. Fig. 3), use of contrast dye can be reduced or even omitted to conserve renal function. In addition, transesophageal echocardiography may be helpful in guiding implantation in patients with largely radiolucent prostheses. Despite comparatively large volumes of contrast agent used in combined procedures, no acute kidney injury was observed in these patients. Length of stay in the hospital of almost 10 days seems long in the light of a transcatheter approach but may reflect the high-risk patient population described in this case series. During short-term follow-up, no valve-related adverse events or structural deterioration was noted, and clinical improvement with regard to symptoms and NYHA functional class was seen immediately. However, no exercise testing was performed to objectify these results. Furthermore, systematic analyses of long-term data in a larger patient population have to be performed to thoroughly evaluate this novel approach.

Conclusions

Reoperative mitral valve replacements are associated with an elevated operative risk, especially in elderly patients with multiple comorbidities. Sparing these patients the burden of a complex on-pump surgery requiring repeat sternotomy is an important advantage of a catheter-based approach. This series of 6 high-risk patients who successfully underwent mitral valve-in-valve implantation supports the notion that this procedure may serve as a complementary approach to reoperative mitral valve replacement in high-risk patients.

Reprint requests and correspondence: Dr. Moritz Seiffert, Department of Cardiovascular Surgery, University Heart Center Hamburg, Martinistrasse 52, 20246 Hamburg, Germany. E-mail: m.seiffert@uke.de.

REFERENCES


Key Words: mitral regurgitation ■ mitral stenosis ■ reoperation ■ transapical ■ valve surgery.

APPENDIX

For a listing of the mitral bioprostheses dimensions according to manufacturers’ specifications, please see the online version of this article.