Impact of patient–prosthesis mismatch after transcatheter aortic valve-in-valve implantation in degenerated bioprostheses

Moritz Seiffert, MD,[a] Lenard Conradi, MD,[a] Stephan Baldus, MD,[b] Malgorzata Knap, MD,[b] Johannes Schirmer, MD,[a] Olaf Franzen, MD,[b] Dietmar Koschyk, MD,[b] Thomas Meinertz, MD,[b] Hermann Reichenspurner, MD, PhD,[a] and Hendrik Treede, MD[a]

Objective: Transcatheter valve-in-valve implantation is evolving as an alternative to reoperative valve replacement in high-risk patients with degenerated bioprostheses. Nevertheless, hemodynamic performance is limited by the previously implanted xenograft. We report our experience with patient–prosthesis mismatch (PPM) after valve-in-valve implantation in the aortic position.

Methods: Eleven patients (aged 79.3 ± 6.1 years) received transapical implantation of a balloon-expandable pericardial heart valve into a degenerated bioprosthesis (size, 23.9 ± 1.6 mm; range, 21–27 mm) in the aortic position. All patients were considered high risk for surgical valve replacement (logistic European System for Cardiac Operative Risk Evaluation, 31.8% ± 24.1%). Severe PPM was defined as an indexed effective orifice area less than 0.65 cm^2/m^2, determined by discharge echocardiography.

Results: Severe PPM was evident in 5 patients (group 1) and absent in 6 patients (group 2). Mean transvalvular gradients decreased from 29.2 ± 15.4 mm Hg before implantation to 21.2 ± 9.7 mm Hg at discharge (group 1) and from 28.2 ± 9.0 mm Hg before implantation to 15.2 ± 6.5 mm Hg at discharge (group 2). Indexed effective orifice area increased from 0.5 ± 0.1 cm^2/m^2 to 0.6 ± 0.1 cm^2/m^2 and from 0.6 ± 0.3 cm^2/m^2 to 0.8 ± 0.3 cm^2/m^2. Aortic regurgitation decreased from grade 2.0 ± 1.1 to 0.4 ± 0.5 overall. No differences in New York Heart Association class improvement or survival during follow-up were observed. One patient required reoperation for symptomatic PPM 426 days after implantation.

Conclusions: Valve-in-valve implantation can be performed in high-risk surgical patients to avoid reoperation. However, PPM frequently occurs, making adequate patient selection crucial. Small bioprostheses (<23 mm) should be avoided. Implantation into 23-mm xenografts can be recommended only for patients with a body surface area less than 1.8 m^2. Larger prostheses seem to carry a lower risk for PPM. Although no delay in clinical improvement was seen at short-term, 1 PPM-related surgical intervention raises concern regarding long-term performance. (J Thorac Cardiovasc Surg 2012;143:617-24)

Transcatheter valve therapies have been evolving as promising alternatives to conventional surgery in high-risk patients. Transcatheter valve-in-valve implantation can spare elderly patients reoperative valve replacement for degenerated bioprostheses. First experiences with this novel approach have been published and seem appealing in the light of the high risk associated with conventional redo surgery in these frail patients.[1-4] At the same time, concerns have been raised regarding valve-in-valve function and the suitability of a variety of market-approved bioprostheses for the accommodation of 2 or 3 sizes of transcatheter heart valves (THVs) not specifically designed for valve-in-valve implantation. Hemodynamic performance of the valve-in-valve construct inevitably is limited by annular geometry defined through the previously implanted xenograft and its rigid stent.

Several cases of residual stenoses, increased transvalvular gradients, and low effective orifice areas (EOAs) have been described after valve-in-valve procedures,[5] making patient–prosthesis mismatch (PPM) a concern.[6] PPM has been extensively investigated as a potential problem after surgical valve replacement and is considered as an EOA of the valve prosthesis that is physiologically too small in relation to the patient's body surface area (BSA).[7] The rationale is that a smaller EOA will result in higher transvalvular gradients. The indexed EOA (iEOA) is the only parameter found to consistently correlate with postoperative gradients. PPM is generally defined as iEOA 0.85 cm^2/m^2 or less (moderate) or iEOA 0.65 cm^2/m^2 or less (severe).[8] Although there has been much controversy regarding the influence of moderate PPM, there has been considerable

From the Departments of Cardiovascular Surgery[a] and General and Interventional Cardiology,[b] University Heart Center Hamburg, Germany.

Disclosures: Dr Franzen received lecture fees from Edwards Lifesciences. All other authors have nothing to disclose with regard to commercial support.

M.S. and L.C. contributed equally to this work.

Read at the 91st Annual Meeting of The American Association for Thoracic Surgery, Philadelphia, Pennsylvania, May 7–11, 2011.

Received for publication May 7, 2011; revisions received July 15, 2011; accepted for publication Nov 7, 2011; available ahead of print Dec 12, 2011.

Address for reprints: Moritz Seiffert, MD, Department of Cardiovascular Surgery, University Heart Center Hamburg, Martinistrasse 52, 20246 Hamburg, Germany (E-mail: m.seiffert@uke.de).

0022-5223/$36.00

doi:10.1016/j.jtcvs.2011.11.004

Abbreviations and Acronyms

AR = aortic regurgitation
AVR = aortic valve replacement
BSA = body surface area
EOA = effective orifice area
iEOA = indexed effective orifice area
NYHA = New York Heart Association
PPM = patient–prosthesis mismatch
THV = transcatheter heart valve

evidence that severe PPM has a negative impact on patient outcome.[9]

By implanting 1 valve within another instead of replacing it and the lack of oversizing, valve-in-valve procedures seem predestined for the occurrence of PPM. This problem has been investigated in vitro. Although implantation of a 23-mm THV into a stented 23-mm bioprosthesis reduced transprosthetic pressure gradients and improved EOA similar to surgical aortic valve replacement (AVR), implantation into smaller valves insufficiently relieved the stenosis.[10] Furthermore, the rigidity of the bioprosthesis stent can constrain oversized valve-in-valve implantation and prevent full expansion, leading to leaflet distortion and subsequent transvalvular aortic regurgitation (AR).

Systematic investigation of PPM after valve-in-valve implantation has not been performed. The current study retrospectively analyzed the data of valve-in-valve implantations performed at University Heart Center Hamburg to address this issue and attempts to offer guidance to prevent this potential problem.

MATERIALS AND METHODS

Patient Population

From August 2008 to March 2011, 11 patients were admitted to the University Heart Center Hamburg with significant signs of valve dysfunction (stenosis, regurgitation, mixed disease) long-term after bioprosthetic AVR. Indication for valve replacement was based on current guidelines.[11] All patients presented with severe comorbidities precluding them from surgical treatment as determined by an interdisciplinary heart team. Preoperative transesophageal echocardiography was used to determine valve pathology and inner stent diameter; computed tomography scans of the aortic arch and femoral vessels were used to assess vascular status. The transapical approach was chosen for the straight and short access to the site of valve implantation in all patients.

Transcatheter Valve-in-Valve Implantation

Transcatheter valve-in-valve implantation was performed in a specially equipped hybrid suite under general anesthesia, as previously described.[3] Briefly, after left lateral minithoracotomy and ventricular pacemaker-lead placement, pursestring sutures were applied and a transapical guidewire was inserted. Subsequently, the crimped Edwards SAPIEN THV (Edwards Lifesciences LLC, Irving, Calif) was introduced through a sheath and deployed into the degenerated xenograft prosthesis antegrade in the aortic position without prior balloon valvuloplasty of the degenerated prosthesis. These steps were carried out under rapid ventricular pacing and fluoroscopic control. Subsequently, valve performance was assessed by transesophageal echocardiography and fluoroscopy. A 23-mm balloon-expandable valve was used in 10 patients, and a 26-mm device was used in 1 patient.

Echocardiographic Assessment and Follow-up

Transthoracic echocardiography was performed at baseline and before discharge.[12] The EOA was assessed using the continuity equation approach. The iEOA was calculated by dividing the EOA with the patient's BSA, computed using the Dubois formula (BSA [m^2] = 0.007184 · weight [kg]$^{0.425}$ · height [cm]$^{0.725}$). According to the literature, severe PPM was defined as iEOA 0.65 cm^2/m^2 or less.[8] Patients with severe PPM after valve-in-valve implantation were included in group 1. Patients without echocardiographic evidence of severe mismatch were included in group 2. Follow-up was performed at 30 days, 6 months, and 1 year, if applicable, collecting data regarding functional status (New York Heart Association [NYHA] class), echocardiographic valve function, and mortality.

Statistical Methods

Continuous variables are expressed as mean ± standard deviation, and categoric variables are expressed as proportions (%). The mean values of continuous variables were compared using the Student *t* test generating 2-tailed *P* values. Categoric variables were compared using the Fisher exact test. Cumulative probability of survival was estimated using the Kaplan–Meier method and compared between groups using the log-rank test. All statistical analyses were performed using GraphPad Prism version 5.02 (GraphPad Software, Inc, La Jolla, Calif).

RESULTS

The study population was predominantly male with a mean age of 79.1 ± 6.3 years (range, 70–88 years; Table 1). Patients were admitted with severe degeneration of the implanted bioprostheses 12.6 ± 6.2 years after surgical AVR. Ten patients had stented bioprostheses sizes 21 to 25 mm in situ, and 1 patient had a stentless 27-mm valve (Table 2). Overall, 4 patients (36%) primarily displayed signs of stenosis of the previously implanted xenograft, and 4 patients (36%) presented with regurgitation, mostly due to prolapse of a single cusp. Three patients (27%) showed a mixed disease. Baseline characteristics including echocardiographic measurements and comorbidities are presented in Table 1. After transcatheter aortic valve-in-valve implantation, 5 patients had an iEOA 0.65 cm^2/m^2 or less (severe PPM, group 1), 5 patients had an iEOA less than 0.85 cm^2/m^2 but greater than 0.65 cm^2/m^2 (moderate PPM, group 2), and 1 patient had an iEOA greater than 0.85 cm^2/m^2 (no PPM, group 2), as determined by echocardiography at discharge. No statistically significant differences in baseline parameters were observed between both groups, although there was a trend toward a higher risk profile in group 1.

In both groups, the iEOA improved only slightly after valve-in-valve implantation, missing statistical significance (group 1, 0.50 ± 0.13 to 0.58 ± 0.06 cm^2/m^2; group 2, 0.62 ± 0.27 to 0.83 ± 0.28 cm^2/m^2; Figure 1, *A*). A significant reduction in mean aortic valve gradient from 28.2 ± 9.0 mm Hg at baseline to 15.2 ± 6.5 mm Hg at discharge was observed in group 2 ($P = .02$), whereas only a mild decrease