Bioprosthetic Valve Durability After Stentless Aortic Valve Replacement: The Effect of Implantation Technique

Siamak Mohammadi, MD, Dimitri Kalavrouziotis, MD, MSc, Pierre Voisine, MD, Eric Dumont, MD, Daniel Doyle, MD, Jean Perron, MD, and François Dagenais, MD

Division of Cardiac Surgery, Quebec Heart and Lung Institute, Quebec City, Quebec, Canada

Background. The Freestyle stentless bioprosthesis (FSB) (Medtronic Inc, Minneapolis, MN) is implanted using 2 techniques—subcoronary or aortic root replacement. Our objective was to determine whether the implantation technique had an impact on late reoperation for structural valve deterioration (SVD).

Methods. Between 1993 and 2013, 531 patients underwent aortic valve replacement (AVR) or aortic root reconstruction with an FSB. The implantation technique was subcoronary in 430 patients (group S) and root replacement in 101 patients (group R). Median follow-up was 10.8 years for group S patients and 10.1 years for group R patients. The follow-up was complete in all patients.

Results. Mean age was 68.2 years in group S and 65.2 in group R ($p = 0.001$). In-hospital mortality was 3.5% and 5.0% in group S and group R, respectively ($p = 0.56$). Late reoperation was required in 60 (14.5%) hospital survivors in group S and 8 (8.3%) hospital survivors in group R. There were 36 reoperations in group S and 3 in group R for SVD. Freedom from reoperation for SVD was 94.6% and 76.7% at 10 and 15 years, respectively, in group S, and 98.9% and 88.1% at 10 and 15 years, respectively, for group R ($p = 0.04$). The subcoronary technique was an independent risk factor for late reoperation for SVD ($p = 0.002$). Implantation technique was not independently associated with in-hospital and long-term mortality.

Conclusions. The Freestyle bioprosthesis implanted as a root replacement was associated with less reoperation for SVD over the long term compared with the subcoronary technique. However, the method of implantation has no influence on early and long-term survival.

(Ann Thorac Surg 2014;■:■–■)

During the past 2 decades, stentless aortic bioprostheses have been used for the replacement of diseased aortic valves [1, 2]. Two surgical techniques have been predominantly used for aortic valve replacement (AVR) or root replacement, or both, using the Freestyle stentless bioprosthesis (FSB) (Medtronic Inc, Minneapolis, MN)—a subcoronary implantation technique and a root replacement using a modified Bentall operation with reimplantation of the coronary ostia or root inclusion technique [3]. Because of the unique design features of the FSB, the mechanism and rate of structural valve deterioration (SVD) may differ compared with those observed for other aortic biological substitutes. Furthermore, mechanisms of failure may differ according to the implantation technique. A few studies have examined the association between the surgical implantation technique and the mid- and long-term durability of aortic autografts (Ross procedure) [4, 5], and homografts [6–9]. However, the effect of implantation technique on SVD among stentless aortic xenografts has not been extensively studied. Our objective was to determine the impact of the surgical implantation technique of the FSB on late reoperation for SVD in a large single-center experience.

Patients and Methods

Patient Population

Patient baseline and operative data were collected prospectively for all patients and stored in our computerized cardiac surgical database. Between January 1993 and July 2013, 531 patients aged 18 years and older who underwent primary elective AVR or aortic root reconstruction with an FSB, with (n = 174) or without (n = 357) concomitant coronary artery bypass grafting (CABG), were identified at our institution. The implantation technique was subcoronary in 430 patients (group S) and aortic root replacement in 101 patients (group R) using a modified Bentall (n = 95) or root inclusion technique (n = 6). Redo operations and patients with additional concomitant valve or aortic arch procedures, or both, were excluded from this study. The choice of implantation technique was based on patient anatomy, cause of aortic valve disease, and surgeon discretion. In group S patients, the prosthesis noncoronary sinus of Valsalva was preserved. Sizing was performed with the sizer provided by the manufacturer of the FSB. During the time of this study, 4,621 primary AVRs and 657 aortic root replacements with or without CABG were performed at our institution.

Accepted for publication Feb 17, 2014.

Address correspondence to Dr Mohammadi, Division of Cardiac Surgery, Quebec Heart and Lung Institute, 2725 Chemin Ste-Foy, Quebec City, Quebec, Canada, G1V 4G5; e-mail: siamak.mohammadi@fmed.ulaval.ca.

Published by Elsevier Inc

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2014.02.040

All patients were followed annually at our dedicated valve clinic. Transthoracic echocardiograms were obtained every 2 years to measure left ventricular ejection fraction, transvalvular aortic pressure gradients, presence and severity of aortic insufficiency (AI), and SVD. This study was reviewed and approved by our institutional review board and ethics committee.

Study Outcomes

Early outcomes including in-hospital mortality and postoperative morbidity were compared among group S and group R patients. Long-term all-cause mortality was assessed using provincial vital statistics provided by the Quebec Statistical Institute. Freedom from reoperation because of SVD was determined in accordance with the American Association for Thoracic Surgery and the Society of Thoracic Surgeons Committee for Standardizing Prosthetic Heart Valve Morbidity [10]. Follow-up was complete for all patients.

Statistical Analysis

Results are expressed as mean ± standard deviation (SD) or median (interquartile range), as appropriate, for continuous variables, and percentages for categorical variables. Continuous and dichotomous variables were analyzed using the Student's t test or χ^2 test, respectively. Logistic regression analysis was performed to determine the multivariate predictors of early mortality. The Kaplan-Meier technique and log-rank statistics were used for longitudinal data. A Cox multivariate proportional hazards regression model was fit to assess the predictors of reoperation and late mortality. Variables were presented to the model if a univariate association with the outcome of interest was present at $p < 0.20$. Implantation technique (subcoronary versus root replacement) was forced into the final models to assess its effect. The selection of variables with interaction terms was performed using a forward approach. Akaike's information criterion and Schwarz's Bayesian criterion were used to compare candidate models. The same approach was used to add interaction terms into the models. For the Cox models, the Martingale residuals were used to examine the functional form of the continuous variables and to confirm that no transformation was necessary. The adequacy of the proportional hazards assumption was checked by the graphic representation of the logarithm cumulative hazard rates versus time, whereas the continuous variables were stratified into 4 disjointed strata. Next, an artificially time-dependent covariate was added to the model to test the proportionality assumption. Associations were considered significant if the 2-sided $p < 0.05$. The data were analyzed using the statistical package program SAS, version 9.1.3 (SAS Institute Inc, Cary, NC).

Results

Baseline Characteristics

The indication for AVR with an FSB and the clinical as well as operative characteristics of the patient population are shown in Table 1. Mean age was slightly higher in group S (68.2 ± 8.2 years) compared with group R (65.2 ± 8.5) ($p = 0.001$). Group S patients were significantly more likely to be women and have diabetes compared with group R patients. The aortic valve lesion was predominantly aortic stenosis (AS) in both groups, although group R patients had a greater prevalence of AI either in isolation or concomitant with AS. The duration of cardiopulmonary bypass was, on average, 9 minutes longer in group R patients ($p = 0.03$), although aortic clamp times were similar.

Early Outcomes

In-hospital mortality was 3.5% (n = 15) for group S patients and 5.0% (n = 5) for group R patients ($p = 0.56$). The overall incidence of postoperative adverse events according to implantation technique was similar among the 2 groups, although there was a higher risk of new-onset postoperative atrial fibrillation among group R patients (38.6% versus 24.2%; $p = 0.004$) (Table 2). On predischarge transthoracic echocardiography, there was a significantly higher incidence of patient-prosthesis mismatch (PPM) among group S patients, which was defined as an indexed effective orifice area ≤ 0.75 cm^2/m^2 (Table 2).

On multivariate logistic regression, implantation technique was not associated with in-hospital mortality after risk adjustment ($p = 0.61$) (Table 3).

Late Outcomes

Among the 511 patients who survived to hospital discharge, longitudinal follow-up data until the end of July 2013 were available for 100% of patients. The mean and median durations of follow-up were 10.4 ± 4.4 years and 10.8 years, respectively, (interquartile range, 7.3–13.5 years; maximum 20.3 years) for group S and 9.8 ± 3.8 years and 10.1 years, respectively, (interquartile range, 7.4–12.5 years; maximum 19.8 years) for group R patients ($p = 0.2$).

SURVIVAL. There were 240 late all-cause deaths during follow-up in group S and 41 in group R. The unadjusted 5-, 10-, and 15-year survival rates among group S patients were 86.5%, 64.2%, and 37.9%, respectively, and were not significantly different from those observed among group R patients (88.5%, 68.2%, and 52.3%, respectively) (log-rank $p = 0.21$) (Fig 1A). The unadjusted 5-, 10-, and 15-year survival rates among patients younger than 60 years did not show any significant difference between group S patients and group R (Fig 1B). Survival estimates showed a mean survival of 12.7 ± 0.3 years for group S patients and 14.2 ± 0.7 years for group R patients ($p = 0.15$).

Several variables emerged as independent predictors of late mortality among patients who underwent FSB implantation: chronic obstructive pulmonary disease (adjusted hazard ratio [HR], 1.6; 95% confidence interval [CI], 1.2–2.0; $p = 0.0007$), reoperation for all causes during the first hospitalization (HR, 1.5; 95% CI, 1.1–2.0; $p = 0.005$), mechanical ventilation >48 hours (HR, 2.5; 95% CI, 1.4–3.1; $p = 0.0005$), and older age (HR, 1.1;