David valve-sparing aortic root replacement: Equivalent mid-term outcome for different valve types with or without connective tissue disorder

John-Peder Escobar Kvitting, MD, PhD,[a] Fabian A. Kari, MD,[a] Michael P. Fischbein, MD, PhD,[a] David H. Liang, MD, PhD,[b] Anne-Sophie Beraud, MD,[b] Elizabeth H. Stephens, MD, PhD,[a] R. Scott Mitchell, MD,[a] and D. Craig Miller, MD[a]

Objective: Although implicitly accepted by many that the durability of valve-sparing aortic root replacement in patients with bicuspid aortic valve disease and connective tissue disorders will be inferior, this hypothesis has not been rigorously investigated.

Methods: From 1993 to 2009, 233 patients (27% bicuspid aortic valve, 40% Marfan syndrome) underwent Tirone David valve-sparing aortic root replacement. Follow-up averaged 4.7 ± 3.3 years (1102 patient-years). Freedom from adverse outcomes was determined using log-rank calculations.

Results: Survival at 5 and 10 years was 98.7% ± 0.7% and 93.5% ± 5.1%, respectively. Freedom from reoperation (all causes) on the aortic root was 92.2% ± 3.6% at 10 years; 3 reoperations were aortic valve replacement owing to structural valve deterioration. Freedom from structural valve deterioration at 10 years was 96.1% ± 2.1%. No significant differences were found in survival ($P = .805$, $P = .793$, respectively), reoperation ($P = .179$, $P = .973$, respectively), structural valve deterioration ($P = .639$, $P = .982$, respectively), or any other functional or clinical endpoints when patients were stratified by valve type (tricuspid aortic valve vs bicuspid aortic valve) or associated connective tissue disorder. At the latest echocardiographic follow-up (95% complete), 202 patients (94.8%) had none or trace aortic regurgitation, 10 (4.7%) mild, 0 had moderate to severe, and 1 (0.5%) had severe aortic regurgitation. Freedom from greater than 2+ aortic regurgitation at 10 years was 95.3% ± 2.5%. Six patients sustained acute type B aortic dissection (freedom at 10 years, 90.4% ± 5.0%).

Conclusions: Tirone David reimplantation valve-sparing aortic root replacement in carefully selected young patients was associated with excellent clinical and echocardiographic outcome in patients with either a tricuspid aortic valve or bicuspid aortic valve. No demonstrable adverse influence was found for Marfan syndrome or connective tissue disorder on durability, clinical outcome, or echocardiographic results. (J Thorac Cardiovasc Surg 2013;145:117-27)

ACD

Supplemental material is available online.

The surgical management of aortic valve regurgitation and aortic root pathology has evolved during the past 3 decades.[1] The standard of care using composite valve grafts (CVG) with a mechanical or bioprosthetic valve has several important—but different—inherent limitations (eg, indefinite need for anticoagulation versus limited durability, respectively). Based on the premise that preserving the patient's native aortic valve would be associated with a substantially lower incidence of all valve-related complications, several surgical techniques have been described and are generically termed ''valve-sparing aortic root replacement'' (V-SARR).[2,3]

V-SARR has been proposed as a reasonable treatment alternative for patients with connective tissue disorders (CTDs) such as Marfan syndrome (MFS) and bicuspid aortic valve (BAV) disease. However, several groups have observed high reoperation rates in both patients with MFS and BAV and raised concern about the use of V-SARR in such patients.[4-8] Thus, the widespread use of V-SARR in patients with BAV or CTD remains controversial, especially when a reproducible and durable alternative exists such as CVG with a mechanical valve.[9,10] Furthermore, the reoperation risks remain undetermined whether reoperation after V-SARR should become necessary, but the reoperation mortality rate after other

From the Department of Cardiovascular and Thoracic Surgery,[a] and Division of Cardiovascular Medicine,[b] Stanford University School of Medicine, Stanford, Calif.

This work was supported by the US-Norway Fulbright Foundation, the Swedish Heart-Lung Foundation, and the Swedish Society for Medical Research (to Dr Kvitting).

Disclosures: Authors have nothing to disclose with regard to commercial support.

Read at the 92nd Annual Meeting of The American Association for Thoracic Surgery, San Francisco, California, April 28-May 2, 2012.

Received for publication April 23, 2012; revisions received Aug 13, 2012; accepted for publication Sept 12, 2012; available ahead of print Oct 19, 2012.

Address for reprints: D. Craig Miller, MD, Department of Cardiovascular and Thoracic Surgery, Falk Cardiovascular Research Center, Stanford University School of Medicine, Stanford, CA 94305-5247 (E-mail: dcm@stanford.edu).

0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2012.09.013

Abbreviations and Acronyms

BAV = bicuspid aortic valve
CTD = connective tissue disorder
CVG = composite valve graft
MFS = Marfan syndrome
V-SARR = valve-sparing aortic root replacement
TAV = tricuspid aortic valve
TTE = transthoracic echocardiogram

types of aortic root replacement procedures has been reported to exceed 11%.[11]

Hence, we compared the midterm survival, risk of reoperation, incidence of structural valve deterioration, and degree of residual aortic regurgitation (AR) in patients with either a tricuspid aortic valve (TAV) or BAV with or without CTD using the Tirone David reimplantation technique of V-SARR.

ACD

METHODS

Patients

A Tirone David-I, Tirone David-V, or Tirone David-V-Stanford modification V-SARR was performed in 233 patients at Stanford from July 1993 to December 2009 (total number at Stanford now > 300) with the follow-up window closing in June 2010. One patient undergoing root repeat replacement after a previous Yacoub remodeling procedure for acute aortic dissection was excluded. A total of 170 patients (73%) had a TAV and 63 (27%) a BAV. The mean age was 36 ± 13 years (range, 11-68) for the TAV group and 43 ± 12 years (range, 19-64) for the BAV group; 115 (67%) and 50 (80%) were male patients in the TAV and BAV groups, respectively. No patient required an emergency procedure for acute type A aortic dissection. Additional demographic variables according to valve type are listed in Table 1. The distribution of patients by valve type over time is illustrated in Figure 1, *A*. The age distribution of the TAV and BAV patients and BAV subtypes according to Sievers' classification[12] are shown in Figure 1, *B* and *C,* respectively. The patients in the TAV group were significantly younger, taller, and slimmer than in the BAV group (Table 1). While the TAV group had larger aortic root dimensions, the BAV group had larger ascending aortic diameters.

Operative Procedure

Early in the experience, the original V-SARR reimplantation technique described by David and Feindel (Tirone David-I) was used in 26 patients.[3] Thereafter, 19 patients received a Tirone David-V procedure. The Tirone David-V-Stanford modification V-SARR technique has been used exclusively since December 2002 in 188 patients.[13]

Total or partial transverse arch replacement was performed when necessary using the "Peninsula technique," with a single sigmoid-shaped suture line from the ligamentum to the innominate artery using selective antegrade cerebral perfusion (usually a 6-8 mm arterial perfusion graft sewn to the innominate artery; a distribution of cannulation sites is given in Table 2) and moderate hypothermic circulatory arrest (bladder 25°C-27°C).[14] Concomitant arch replacement was performed more frequently in patients with a BAV because their aneurysmal pathologic features often included the arch[15] (Figure 1, *D*).

Coronary artery reimplantation as full-thickness Carrel "button" anastomoses was done whenever possible. One patient with an anomalous, intramural coronary artery had his left main coronary artery reconstructed using an arterial (superficial femoral) autograft. Six patients required a Kay-Zubiate right coronary reconstruction (2-3–cm greater saphenous vein interposition graft) because of technical complications. The distribution and type of aortic valve repairs used in the TAV and BAV group and concomitant procedures are listed in Table 2.

Valve Repair

Aortic valve cusp repair was performed in 63 of the TAV patients (37%). Cusp repair consisted of shortening the free margin at the nodulus of Arantius in all 63 TAV patients without formal cusp plication sutures. Among the BAV patients, 42 required cusp-free margin shortening (67%) using 1 or more sutures to correct prolapse and cusp redundancy. A total of 68 sutures were placed, resulting in an average of about 1.4 sutures (range, 1-4) per patient. Seven of these sutures were centrally placed at the nodulus of Arantius, and the remaining 61 sutures were placed further toward the commissures along the cusp-free margin. In addition, a small triangular resection of the raphé was performed in 7 BAV patients, along with cusp-free margin shortening. Creation of commissural neosuspensory cords using 5-0 Gore-Tex sutures was done in 3 BAV patients to replace ruptured "truncal" commissural suspensory chords.

Endpoints

The primary endpoints were all-cause overall mortality; reoperation on the aortic root for any cause; structural valve deterioration (SVD); and freedom from greater than 2+ AR.

Follow-up

Postoperative valve-related adverse events were compiled and analyzed according to the American Association for Thoracic Surgery–Society of Thoracic Surgeons–European Association Cardio-Thoracic Surgery Guidelines for Reporting Morbidity and Mortality after Cardiac Valvular Operations.[16] The patients were followed up clinically on a regular basis; current follow-up data were obtained by interviewing the patients and their physicians by telephone. The mean ± standard deviation follow-up was 4.7 ± 3.3 years; the maximum follow-up was 15.1 years (median, 4.2 years; interquartile range, 2.3-6.6 years; cumulative, 1102 patient-years). At 5 years of follow-up, 88 patients remained at risk, but only 18 patients were at risk at 10 years; for those with MFS or other CTD, the corresponding numbers were 46 and 7. SVD was categorized according to the valve-reporting guidelines.[16]

Echocardiography

Transthoracic echocardiograms (TTEs) were performed periodically (usually once annually) postoperatively. We obtained late TTE images in 213 of 224 patients (233 minus 4 deaths and 5 who underwent late AVR), equating to 95% late echocardiographic follow-up completeness. The average period of late TTE was 3.9 ± 3.3 years postoperatively (median, 3.4 years; interquartile range, 1.24-5.8 years; maximum, 13.4 years).

AR was graded as either none or trivial (grade 0), mild (grade 1+), moderate (grade 2+), moderate to severe (grade 3+), severe (grade 4+) according to color flow mapping and continuous wave and pulsed wave Doppler by 2 expert echocardiographers (D.H.L. and A.-S.B.), who specifically focused on the vena contracta width and AR timing and mechanism.

Statistical Analysis

Continuous variables are expressed as the mean ± 1 standard deviation or median and interquartile range. The Mann-Whitney rank sum test was used to compare the 2-group continuous variables. Categorical data were tabulated in 2×n tables, and 2-group comparisons were made using the chi-square test or Fisher's exact probability test. The Kaplan-Meier method was used to calculate the nonadjusted actuarial survival and freedom from adverse events; a statistical comparison of event rates was determined using log-rank calculations. For perspective, age-, gender-, and race-matched survival estimates for the US population were calculated. To identify the