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Clinical Investigation

The Impact of Bicuspid Aortic Valve Leaflet Fusion Morphology on the Ascending Aorta and on Outcomes of Aortic Valve Replacement

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Background: Patients with bicuspid aortic valves (BAVs) tend to develop dilation of the ascending aorta. The aim of this study was to analyze the impact of leaflet fusion pattern on aortic root diameter and outcomes in patients undergoing surgery for BAV vs tricuspid aortic valve (TAV) disease.

Methods: This is a retrospective review of 90 patients with aortic valve disease (mean [SD] age, 51.5 [8.2] years) who underwent aortic valve replacement for BAV (n = 60) and TAV (n = 30). Fusion of right-left (R/L) coronary cusps was identified in 45 patients, whereas the remaining 15 patients had right-noncoronary (R/N) cusp fusion. Aortic diameter was measured at 4 levels, and Z values were computed.

Results: There were no significant differences between the BAV and TAV groups for age, weight, aortic insufficiency grade, or size of implanted prostheses. However, a higher preoperative peak gradient at the aortic valve was significantly associated with R/L fusion (P = .02). Preoperative Z values of ascending aorta and sinotubular junction diameter were significantly higher in patients with R/N fusion than with the R/L (P < .001 and P = .04, respectively) and TAV (P < .001 and P < .05, respectively) subgroups. During the follow-up period (mean [SD], 2.7 [1.8] years), 3 patients underwent a redo procedure. At the last follow-up, the sizes of ascending aorta were similar among all 3 patient groups.

Conclusion: This study suggests that preoperative dilation of the ascending aorta is more common in patients with R/N fusion than in patients with R/L and TAV but is not significantly different between all groups in the early follow-up period. R/L fusion was associated with an increased risk of preoperative presence of aortic stenosis.

Keywords: Congenital heart disease; surgery; aortic valve; outcomes; bicuspid aortic valve

Introduction

Bicuspid aortic valve (BAV) is a common congenital valvular malformation found in 1% to 2% of the general population, and it is responsible for a significant proportion of aortic valve replacement (AVR) in adults.[1,2] Patients with BAV are at increased risk for aortic stenosis (AS) and aortic insufficiency (AI), which may require catheter or surgical intervention, such that up to one-third of patients undergoing aortic valve surgery in the United States has BAV.[3] Ascending aortopathy is a less-recognized association with BAV despite the fact that it can result in significant dilation of the ascending aorta at an earlier age than in patients with aortopathy from other etiologies.[4,5] Because aortic complications in patients with BAV are more frequent than in the general population (accounting for up to 15% of aortic dissections), identifying risk factors for aortic root dilation is an important endeavor.[6]

Currently, there is limited information regarding whether the type of leaflet morphology in BAV is associated with abnormalities of valve function and the aortic size in a young adult population.[5,7,8] The aim of this study was to analyze the impact of leaflet fusion pattern on aortopathy severity and the differences in aortic root diameter in patients

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undergoing AVR surgery for different morphologies of BAV vs tricuspid aortic valve (TAV) disease.

Patients and Methods

Study Participants

Approval from the Memorial Healthcare System institutional review board was obtained for this study, and the need for consent was waived. This article reports a retrospective review of 90 young adults with aortic valve disease (61 males and 29 females; mean [SD] age at surgery, 51.5 [8.2] years; median age, 54 years; age range, 31-60 years) who underwent AVR with or without concomitant aortic surgery with BAV (n = 60) and TAV (n = 30) during a 5-year period at Memorial Regional Hospital in Hollywood, Florida. After reviewing the preoperative echocardiograms of all patients, it was possible to identify the preoperative morphology of the BAV in all patients: the fusion of right-left (R/L) coronary cusps was identified in 45 patients (the R/L group), whereas the remaining 15 patients had right-noncoronary (R/N) cusp fusion (the R/N group).

Data on age at procedure, sex, original anatomic diagnosis, prior interventions, indications for AVR, cardiopulmonary bypass (CPB) and myocardial ischemic times, postoperative complications, and mortality were extracted from the medical record and surgical database. The results of the echocardiographic analysis of each semilunar valve, surgical or transcutaneous intervention, and long-term follow-up were abstracted from the cardiology database.

Surgical Technique

All procedures were carried out via a standard median sternotomy or partial upper sternotomy with CPB with ascending aorta cannulation. Cardiopulmonary bypass was established with either single atrial or bicaval cannulation, depending on the concomitant procedure. Moderate hypothermia (28-32 °C) was used in all cases. Myocardial protection was achieved using antegrade and retrograde cold blood cardioplegia, and additional topical cooling was achieved using ice.

A hockey stick aortotomy with subsequent removal of the native aortic valve and debridement of the native annulus and aortic root was performed. After sizing the annulus with an industry-labeled sizer, the prosthesis was carefully chosen. In 3 patients, when an effective orifice area index greater than 0.85 cm^2/m^2 could not be achieved because of a small annulus, a Manougian (n = 1) or Nicks (n = 2) procedure was performed to avoid any prosthesis-patient mismatch. Either continuous or interrupted sutures were used for the proximal anastomosis, depending on surgeon preference. After decannulation, the valve function and mean pressure gradients were obtained using multiplane transesophageal echocardiography from a deep transgastric view.

Indications for AVR included predominantly AS (n = 35 [39%]), predominantly AI (n = 28 [31%]), and combined AI and AS (n = 17 [19%]). Ten valve replacements (11%) were carried out because of endocarditis. Isolated AVR was performed in 71 (79%) patients. Nineteen patients (21%) underwent aortic root reconstruction (Bentall procedure). Twenty-two patients (24%) underwent the following additional concomitant cardiac procedures during the valve implantation: coronary artery bypass grafts (n = 12), mitral valve replacement or repair (n = 9), and subaortic membrane resection (n = 1). In addition, 3 patients had a Maze procedure, and 1 patient had a pacemaker insertion.

Bioprosthetic bovine pericardial-stented Carpentier-Edwards PERIMOUNT Magna prostheses (Edwards Lifesciences) were implanted in 80 patients (89%). Mechanical valve prostheses were used in 10 patients (11%), with a St Jude Medical Regent (St Jude Medical) bileaflet mechanical prosthesis in 6 patients and St Jude Medical Masters Series (rotatable) mechanical valves in 4 patients who underwent a Bentall procedure. A biologic conduit for the Bentall procedure, constructed using 26 or 30 mm of sinus of Valsalva Gelweave-coated vascular graft (Terumo Aortic) and a 3- to 5-mm smaller bioprosthetic Magna valve sewn into the sinus of the Valsalva base, was inserted in 15 patients. Replacement of the ascending aorta and Bentall procedure was decided upon according to current guidelines that state that ascending aortic replacement should be considered when the ascending aorta measures larger than 4.5 cm if

Abbreviations and Acronyms

AI	aortic insufficiency
AS	aortic stenosis
AVR	aortic valve replacement
BAV	bicuspid aortic valve
CPB	cardiopulmonary bypass
R/L	right-light
R/N	right-noncoronary
TAV	tricuspid aortic valve

undergoing a concomitant procedure such as AVR.[9] All patients in this study who underwent a Bentall procedure had an ascending aorta that measured greater than 5.0 cm. The mean (SD) CPB and cross-clamp times were 119 (68) minutes (range, 61-446 minutes) and 92 (46) minutes (range, 47-311 minutes), respectively. The mean (SD) size of implanted prostheses was 23.5 (2.5) mm (range, 19-31 minutes).

Echocardiographic Data and Measurements

We reviewed hospital records, clinic records, surgical records, and echocardiographic data for patient demographic information, aortic valve morphology, AS and degree thereof, AI and severity thereof, ascending aortic dimensions, and the presence or absence of aortic coarctation. The most recent echocardiogram, or one preceding surgical or catheter intervention, was considered for overall incidence of associated lesions. When a patient had endocarditis, a study at least 1 year before the episode of endocarditis was reviewed to properly identify cusp anatomy. Cusp fusion was determined by review of echocardiographic images by a single observer. Bicuspid aortic valves were identified via echocardiography or magnetic resonance imaging. Aortic diameter was measured at 4 levels, and Z values were computed. A BAV was defined as the presence of 2 cusps and commissures, with or without fusion in either structure. Bicuspid aortic valve phenotypes were defined and classified using established criteria by Sievers et al[5] or by Kang et al.[10] According to Sievers' classification, type 0 (anterior-posterior) and type I (left and right coronary cusps) were combined to form the R/L group, and type 0 (lateral) and type I (right and noncoronary cusps) were combined to form the R/N group.[5] According to Kang's classification, types 1 and 2 were combined to form the R/L group (fusion of right-left coronary cusps), and types 3 and 5 to form the R/N group (fusion of right-noncoronary cusps).[10]

Aortic stenosis was evaluated by Doppler echocardiography using standard techniques of interrogation, and peak and mean pressure gradients were calculated by a modified Bernoulli equation. Peak Doppler velocity of more than 2 m/s across the aortic valve was considered abnormal, less than 3.5 m/s velocity was considered mild, and greater than 3.5 m/s was considered moderate or higher. These velocities correspond to peak instantaneous gradients of 16 mm Hg for mild stenosis and greater than 50 mm Hg for moderate or greater stenosis. Aortic insufficiency was evaluated using established criteria,[11] including the regurgitant jet width relative to annular diameter ratio, pressure halftime, the presence of abnormal diastolic retrograde flow in the descending thoracic aorta, and left ventricular diastolic dimension. Aortic insufficiency was categorized as none (0), trivial (1+), mild (2+), moderate (3+), or severe (4+).

Aortic measurements were performed in parasternal long-axis views using 2-dimensional imaging, inner edge to inner edge, at maximum excursion. The aortic root diameter was measured at the sinuses of Valsalva, and the ascending aortic diameter was recorded as the largest diameter distal to the sinotubular junction. Aortic dimensions were compared with published data and expressed as Z scores relative to body surface area (calculated according to the formula of Haycock et al[12]). For the purposes of this study, mild/moderate aortic dilation was defined as a Z score above the mean for a body surface area of more than 3 but less than 6, and severe dilation as a Z score greater than 6. Patients were included in the study if they had dilation of the aortic root, measured at the level of the sinuses of Valsalva, the sinotubular junction, and/or the ascending aorta.

Statistical Analysis

Data were analyzed using the SPSS version 22.0 software (SPSS, Inc). $P < .05$ was considered statistically significant. Continuous variables were expressed as mean (SD) or as median and range, and categorical variables as numbers and percentages. The independent sample *t* test was used for comparative analysis between 2 groups for normally distributed data, the results of which were confirmed by the Kolmogorov–Smirnov test. A Fisher exact test was used for comparative analysis between independent groups for categorical variables. Variables for the 3 cohorts were compared using 1-way analysis of variance. Kaplan-Meier curves for actuarial survival and freedom from any type of intervention on the aortic valve were created. The log-rank test was used to estimate the statistical difference between the 2 groups of patients.

Early mortality was defined as death during initial hospitalization or within 30 days of the procedure. Any deaths later than that were defined as late mortality.

Results

There were 2 early deaths (2.2%) and 3 late deaths (3.3%) out of 90 patients. The early deaths occurred in TAV (n = 1) and BAV (n = 1) groups, and the late deaths occurred in BAV (n = 2) and TAV (n = 1) groups. The 5-year survival rate was 94.4%. Six patients required extracorporeal membrane oxygenation or intra-aortic balloon pumping for postoperative low cardiac output (TAV, n = 3 vs BAV, n = 3; $P = .40$), all of which were successfully weaned from extracorporeal membrane oxygenation. Additional morbidity included reexploration for bleeding in 5 patients (TAV, n = 2 and BAV, n = 3) and complete heart block that required permanent pacemaker insertion in 2 patients (both from the BAV group). Overall, freedom from postoperative morbidity at 7 years was 83% for the TAV group and 87% for the BAV group ($P = .75$).

The demographic and preoperative patient characteristics are displayed in Table I.[13] There were no significant differences between the BAV and TAV groups with respect to age, weight, height, grade of AI, size of implanted prostheses, and presence of concomitant Bentall procedure. Longer CPB time (mean [SD]: TAV, 142 [84] min vs BAV, 107 [56] min; $P = .04$) and cross-clamp time (mean [SD]: TAV, 113 [61] min vs BAV, 81 [33] min; $P = .01$) as well as high percentages of any concomitant heart procedures except Bentall procedure (TAV, 47% vs BAV, 10%; $P < .001$), were significantly more common in the TAV group (Table I). Conversely, a higher peak preoperative gradient on the aortic valve was significantly associated with the BAV group (mean [SD]: BAV, 62 [38] mm Hg vs TAV, 41.5 [40.5] mm Hg; $P = .03$). Preoperative aortic measurements (diameter at 4 levels and Z value) of patients in BAV and TAV groups before AVR are shown in Table II.

In the subanalysis for all 3 groups, the preoperative peak gradient on aortic valves was significantly higher in patients in the R/L group than in the TAV group (mean [SD]: R/L, 63.5 [33.5] mm Hg vs TAV, 41.5 [40.5] mm Hg; $P = .02$) but was not significantly different than in the R/N group (R/N, mean [SD], 58.3 [50.6] mm Hg; $P = .72$). The CPB and cross-clamp times were significantly longer for patients in the TAV group than for those in the R/L group ($P < .05$ and $P = .02$, respectively). Conversely, the CPB time was not significantly different between patients in the TAV and R/N groups (R/N, mean [SD], 111 [45] min; $P = .11$). Finally, there was no significant difference in preoperative and intraoperative measurements between the R/L and R/N subgroups (Table I).

Patients with R/L fusion were more likely to have AS than were those in the TAV group (R/L, 51% vs TAV, 27%; $P < .05$), but the presence of AS was not significantly different between either R/L and R/N subgroups (R/N, 38%; $P = .56$) or between patients with R/N and TAV ($P = .50$). The size of the ascending aorta was significantly larger in patients with R/N fusion than in the TAV group (mean [SD]: R/N, 46.5 [7.6] mm vs TAV, 37.7 [10.1] mm; $P = .002$) and in the R/L subgroup (R/L, mean [SD], 38.5 [9.5] mm; $P = .003$). Neverthe-

TABLE I. Preoperative and Intraoperative Characteristics of Patients With Aortic Valve Replacement

Characteristic	R/L (n = 45)	R/N (n = 15)	TAV (n = 30)	*P* value[a]
Age, mean (SD), y	52.8 (7.6)	50.5 (8.2)	50.0 (9.1)	.30
Weight, mean (SD), kg	86.9 (18.7)	83.3 (22.9)	94.5 (22.6)	.17
Height, mean (SD), cm	170.5 (10.7)	170.8 (11.8)	175.1 (8.4)	.14
Peak gradient on aortic valve, mean (SD), mm Hg	63.5 (33.5)[b]	58.3 (50.6)	41.5 (40.5)[b]	.07
Grade of AI, mean (SD)	1.5 (1.0)	1.9 (1.0)	1.8 (1.2)	.38
Size of implanted prosthesis, mean (SD), mm	23.4 (2.4)	23.8 (2.1)	23.5 (2.8)	.88
CPB time, mean (SD), min	106 (59)[b]	111 (45)	142 (84)[b]	.07
Cross-clamp time, mean (SD), min	82 (34)[b]	80 (30)[c]	113 (61)[b,c]	.01
Concomitant Bentall procedure, No. (%)	7 (16)	5 (33)	7 (23)	.31
Concomitant any cardiac procedures except Bentall procedure, No. (%)	4 (9)[b]	2 (13)[c]	14 (47)[b,c]	.001

AI, aortic insufficiency; CPB, cardiopulmonary bypass; R/L, right-left; R/N, right-noncoronary; TAV, tricuspid aortic valve.

[a] $P < .05$ is considered statistically significant.
[b] Significant difference ($P < .05$) between R/L and TAV groups.
[c] Significant difference ($P < .05$) between R/N and TAV groups.
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TABLE II. Preoperative Aortic Measurements in Patients With Aortic Valve Replacement

	BAV (n = 60)	TAV (n = 30)	*P* value[a]
Aortic diameter, mean (SD), mm			
Aortic annulus	24.8 (3.8)	24.3 (4.4)	.60
Sinus of Valsalva	34.6 (6.1)	34.1 (8.1)	.77
Sinotubular junction	30.6 (6.4)	30.6 (9.2)	.98
Ascending aorta	40.4 (5.7)	37.7 (5.3)	.22
Z value			
Aortic annulus	1.6 (1.4)	1.1 (1.6)	.18
Sinus of Valsalva	1.9 (1.6)	1.4 (2.2)	.26
Sinotubular junction	2.5 (1.7)	2.1 (2.4)	.40
Ascending aorta	5.2 (2.6)	4.2 (2.7)	.08

BAV, bicuspid aortic valve; TAV, tricuspid aortic valve.

[a] $P < .05$ is considered statistically significant.

less, there were no significant preoperative differences in the levels of aortic annulus, sinotubular junction, or sinus of Valsalva among all 3 groups (Fig. 1).

The Z values of the ascending aorta and sinotubular junction diameters were significantly higher in patients with R/N fusion (mean [SD], 7.0 [1.6] and 3.4 [1.9], respectively) than in the R/L (mean [SD], 4.6 [2.5] and 2.2 [1.6]; $P < .001$ and $P = .04$, respectively) and TAV (mean [SD], 4.2 [2.7] and 2.1 [2.4]; $P < .001$ and $P = .05$, respectively) groups, whereas the Z values of sinus of Valsalva or aortic annulus junction diameters were similar among all groups (Fig. 2).[13] In addition, there were no significant differences in Z values at all 4 levels between TAV and R/L fusion subgroups.

In the subanalysis between patients with preoperative AS and AI, AI is associated with diffuse, significant enlargement at all 4 levels (both diameter and Z score; see Table III). Importantly, the Z score of the ascending aorta in patients with AS also is enlarged (AS subgroup, mean [SD], 3.8 [2.2]); however, it was significantly lower than Z score of ascending aorta with patients with AI (AI subgroup, mean [SD], 6.4 [2.7]; $P < .001$). In the subanalysis between patients with a Bentall procedure (n = 19) and those with a non-Bentall procedure (n = 71), the Bentall procedure was associated with diffuse, significant enlargement of the aorta (at all 4 levels, both diameter and Z score). Importantly, the size of the ascending aorta is significantly larger in patients with Bentall procedure (Bentall: mean [SD], 54.6 [5.0] mm; vs non-Bentall: mean [SD], 35.4 [16.1] mm; $P < .001$). Furthermore, the diameter of implanted prostheses is significantly larger in the Bentall subgroup of patients (Bentall: mean [SD], 25.2 [2.3] mm vs non-Bentall: mean [SD], 23.1 [2.3] mm; $P = .002$).

Follow-up data were available for all patients. The mean (SD) follow-up was 2.7 (1.8) years (range, 2 months-7 years; total, 248 patient-years). During the follow-up period, 3 patients underwent a redo intervention (1 from each group) at a mean (SD) interval of 2.8 (1.9) years (median, 2 years; range, 1.5-5 years). Overall freedom from aortic valve redo procedure at 7 years was 97% and was not significantly different between the groups. At the last follow-up, according to echocardiograms, the sizes of ascending aorta were similar between all groups (mean [SD]: BAV, 30.5 [5.9] mm vs TAV, 31.8 [5.3] mm; $P = .50$) and among the 3 subgroups (mean [SD]: TAV vs R/L, 29.8 [6.1] mm vs R/N, 33.2 [4.3] mm; $P = .59$). Moreover, there were no significant differences in the levels of aortic annulus, sinotubular junction, or sinus of Valsalva among the 3 groups (the diameters and Z values) at last follow-up. Finally, there were no significant differences in the ascending aorta diameter and Z score between Bentall and non-Bentall patients at last follow-up ($P = .64$).

Discussion

Bicuspid aortic valve disease is a common congenital valve disorder that affects 1% to 2% of the population. The condition may be associated with significant valvular dysfunction and can lead to AS or AI at an early age. It also places patients at increased risk for infective

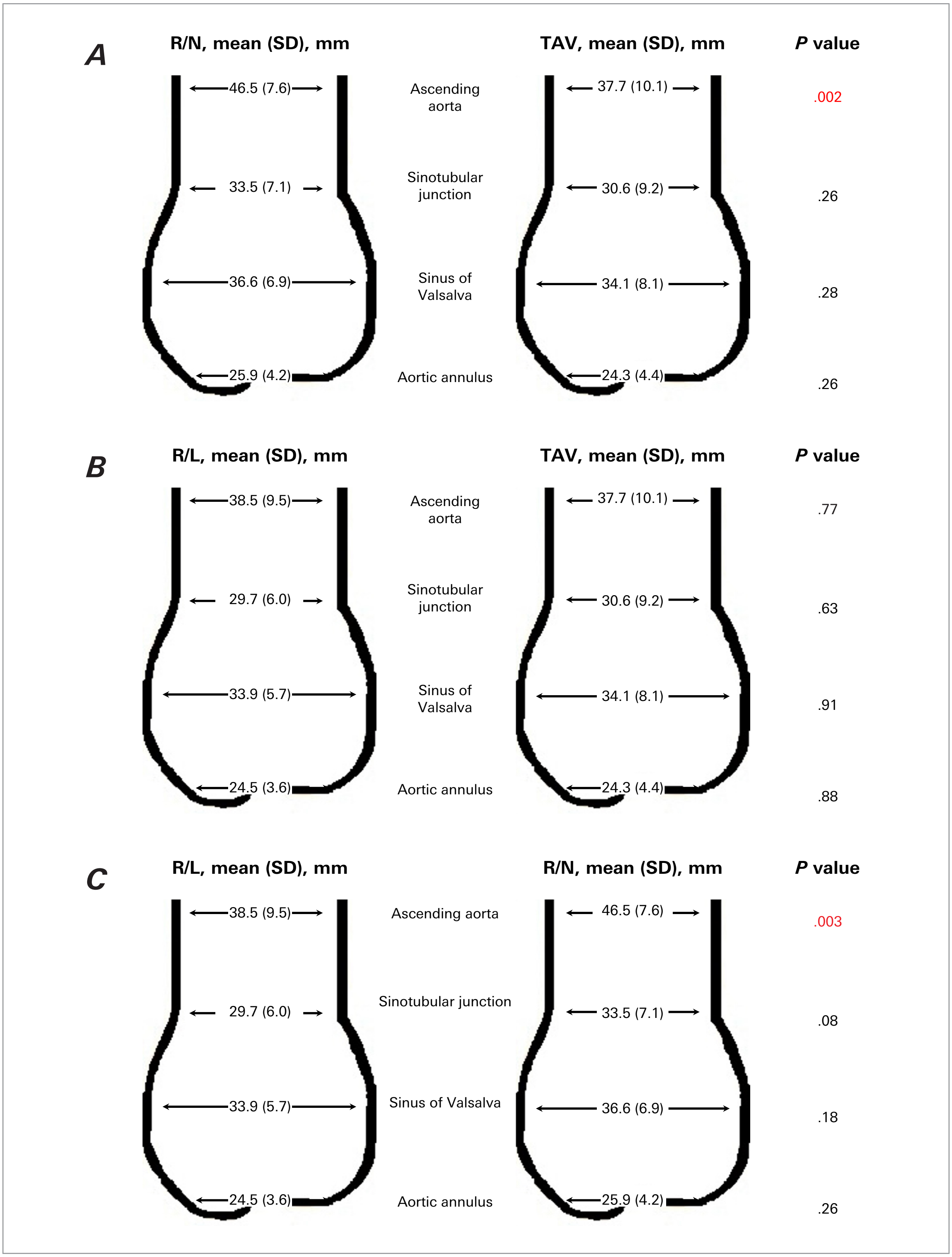

Fig. 1 Comparison of preoperative (pre–aortic valve replacement) aortic size (diameter) at 4 levels between 3 subgroups of patients: **A)** (R/N vs TAV, **B)** R/L vs TAV, and **C)** R/L vs R/N. $P < .05$ was considered statistically significant.

R/L, right-left; R/N, right-noncoronary; TAV, tricuspid aortic valve.

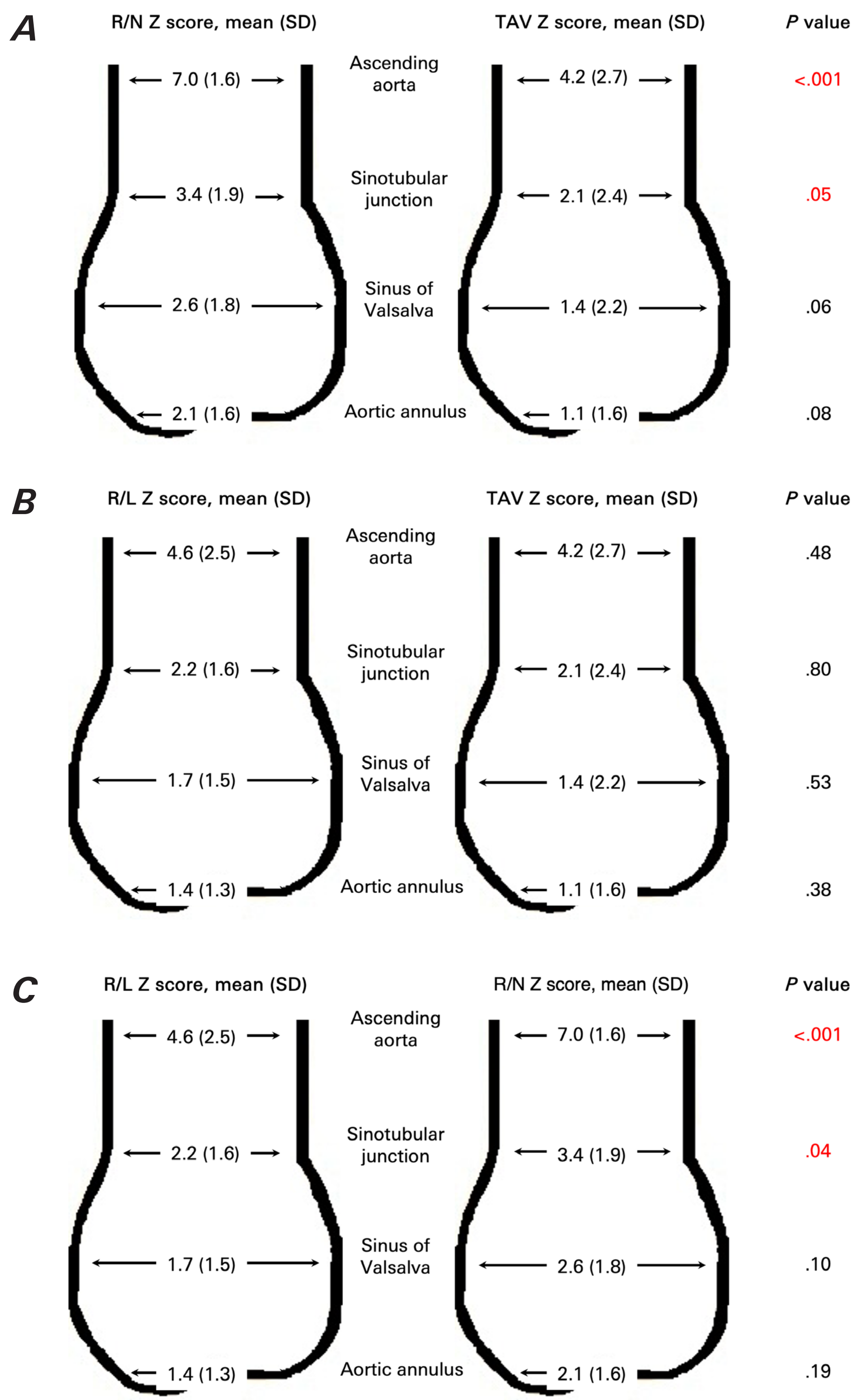

Fig. 2 Comparison of preoperative (pre–aortic valve replacement) aortic Z scores at 4 levels between 3 subgroups of patients: **A)** R/N vs TAV, **B)** R/L vs TAV, and **C)** R/L vs R/N. $P < .05$ was considered statistically significant.

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R/L, right-left; R/N, right-noncoronary; TAV, tricuspid aortic valve.

TABLE III. Preoperative Aortic Measurements in Patients With AS and AI

	AS (n = 28)	AI (n = 35)	*P* value[a]
Aortic diameter, mean (SD), mm			
Aortic annulus	22.7 (2.9)	27.2 (4.3)	<.001
Sinus of Valsalva	31.5 (4.2)	39.3 (7.9)	<.001
Sinotubular junction	27.2 (4.1)	36.2 (9.2)	<.001
Ascending aorta	35.5 (7.8)	46.2 (10.9)	<.001
Z value			
Aortic annulus	0.7 (1.1)	2.4 (1.6)	<.001
Sinus of Valsalva	1.0 (1.1)	2.9 (2.1)	<.001
Sinotubular junction	1.5 (1.2)	3.7 (2.3)	<.001
Ascending aorta	3.8 (2.2)	6.4 (2.7)	<.001

AI, aortic insufficiency; AS, aortic stenosis.

[a] $P < .05$ is considered statistically significant.

endocarditis. In addition, BAV has been associated with aortic wall abnormalities, including coarctation of the aorta, supravalvular AS, and ascending aortic dilatation and aneurysm formation. All of these disorders can have serious clinical consequences, such as potential aortic dissection and rupture.

The contribution of BAV leaflet anatomy to the associated aortic wall dilatation has attracted considerable interest more recently, but the association remains unclear, and contradictory data exist. One such example is the speculation that certain BAV phenotypes are associated with a higher risk of dissection and thus predispose patients to aortic root dilatation and aortic regurgitation, but this remains to be shown.[14,15]

The relative distribution of morphologically distinct cusp fusion patterns in BAV (ie, R/L and R/N) observed in this study is similar to those demonstrated in earlier reports.[8,16] Previous series have described that 70% to 75% of patients with BAV have fused R/L coronary cusps, whereas R/N cusp fusion is less prominent and found in only 20% of patients with BAV. The series in this study revealed the prevalence of R/L fusion to be very similar (R/L, 75% vs R/N, 25%). Regarding the geometry of the outflow tract, patients with BAV have consistently demonstrated larger annulus and left ventricular outflow tract dimensions than do patients with TAV, regardless of the presence of an aneurysm or ectasia.[14,15,17] The relationship between leaflet morphology and aortic features has not been so consistent. Jackson et al[15] found no relationship between BAV leaflet morphology and the frequency of aneurysm or ectasia, which stands in contrast to earlier reports where BAV R/L or R/N configuration was reported to be more frequently associated with dilatation of the aorta.[14]

There are several theories of relationship between BAV and aortic root dilation.[2] In the authors' opinion, the hemodynamics theory deserves special attention. Recent studies using 4-dimensional flow magnetic resonance imaging have provided more insight into the different hemodynamic burden on the aortic wall caused by flow disturbances.[2,18,19] In TAV, the flow is directed along the curvature of the aorta. In BAV, the flow angle is disturbed, resulting in a different pattern of increased wall shear stress that is dependent on the orientation of the cusps. In BAV with fusion of the R/L cusps, the flow is directed anteriorly and toward the right, which increases the wall shear stress in this region and results in aortic root dilatation. In BAV with fusion of the R/N cusps, the flow is directed higher into the ascending aorta toward the posterior aortic wall, resulting in ascending aorta dilation.[2,18,19] In support of this theory, the current study found that the preoperative size of the ascending aorta (diameter) was significantly larger in patients with R/N fusion than in patients in the TAV group and those in the R/L subgroup.

Previous studies have demonstrated that aortic elastic properties change in patients with BAV.[20] This was further evaluated by Schaefer et al,[14] who showed that the aortic root in an R/L fusion phenotype had a larger dimension and an increased wall stiffness than that with an R/N fusion phenotype. It was therefore speculated that differences in shear forces and pressure distribution within the aortic root had a direct effect on aortic root morphology. These findings support the idea of hemodynamics playing a major part in the pathogenesis of BAV-related aortic dilatation.[15,21] However, based on a similar classification and similar measurements, Jackson et al[15] could not confirm these findings in their study, which is concordant with the findings of Cecconi et al.[22] In contrast, the present study shows that although patients with R/N fusion had a significantly larger preoperative ascending aorta diameter, all other dimensions (sinus of Valsalva, sinotubular junction, and aortic annulus) were similar in the R/N and R/L fusion patient subgroups.

Before AVR, the preoperative ascending aortic dilatation rate in patients with BAV described in the present study was comparable to previously reported rates.[2,23,24] Detaint et al[23] showed a dilation rate of the sinus of Valsalva and ascending aorta of 0.21 mm/year and 0.42 mm/year, respectively. In the control group of patients with TAV, these dilation rates were significantly lower (0.09 mm/y and 0.20 mm/y, respectively).[23] In contrast, postoperative follow-up ascending aortic dilation rates were not significantly different between patients with BAV and TAV.[23] Abdulkareem et al[25] reported that all aortic root dimensions remained stable in patients with BAV and TAV after AVR. Moreover, Charitos et al[26] compared aortic dilation rates in patients with BAV and in patients with TAV and observed no significant difference directly postoperatively, although patients with BAV did have slightly larger ascending aortic dimensions than did those with TAV. No significant differences were found in this study between the 2 groups (and also among all 3 subgroups) in the dilation of the aortic root and ascending aorta at last follow-up. These findings would confirm the role of hemodynamics/flow direction theory in the dilation rate of the aortic root and ascending aorta when once the dysfunctional aortic valve has been replaced, the aortic dilation rate and risk of adverse aortic events at follow-up would be similar between BAV and TAV.[2,18]

In the current study, it was determined that there was a comparably low risk of adverse aortic events 7 years after AVR in young adult patients with BAV vs TAV and concomitant mild to moderate dilation of the ascending aorta. There was no difference in the prevalences of proximal aortic surgery between the study groups with low hospital morbidity and mortality, low rate of redo procedure and aortic events, and survival at a mean (SD) follow-up period of 2.7 (1.8) years.

This study has several limitations. First, this study was a nonrandomized, observational, retrospective review. Second, only a relatively small cohort of patients was enrolled. To strengthen these findings, larger studies at this institution or a multi-institutional study will need to be performed in the future. The most important limitation to note is the time period during which this study took place. A longer follow-up time may be required to verify the outcomes of all 4 aortic measurements, and the findings presented herein may be different from those that result from a different time period of evaluation. More participants and a longer follow-up time may also help identify the risk factors of ascending aorta dilation. Finally, the number of patients in the TAV group was markedly lower than the number in the BAV group, as one would expect in this population. Increasing the number of patients in the TAV group might change the findings from this study.

In conclusion, the authors suggest from this study that aortic valve morphology may be a determinant of aortic dilation in patients with BAV. It was found that preoperative dilation of the ascending aorta is more common in patients with R/N fusion, whereas there was no significant difference in R/L fusion between patients with BAVs and TAVs with respect to aortic dilation. Fusion of the R/L leaflets was associated with an increased likelihood of the presence of AS compared with R/N fusion and TAV. Finally, the presence of AI is similar in patients with R/N and TAV morphologies, and the degree of ascending aorta dilation at early follow-up is not significantly different between the groups.

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