Bicuspid aortic valve disease and ascending aortic aneurysm: should an aortic root replacement be mandatory?

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Abstract

OBJECTIVES: The higher risk of adverse aortic events in patients with bicuspid aortic valve (BAV) disease and ascending aorta aneurysm is known, but the management of moderate aortic root dilatation in younger patients is a controversial issue. The aim of the study was to compare survival in patients with or without root replacement.

METHODS: We reviewed 166 consecutive patients with BAV disease and concomitant ascending aorta aneurysm (mean ascending aorta diameter: 51.4 ± 7.2 mm) undergoing cardiac surgery from 1994 to 2010. A total of 77 patients underwent Bentall procedure (90.9% male, mean age: 55.7 ± 12.7 years, Bentall group), whereas the remaining 89 patients underwent aortic valve replacement with supracoronary ascending aorta replacement (SAAR 71.9% male, mean age: 60.5 ± 11.2 years, SAAR group, P = 0.002). The preoperative mean diameter of the root was 44.0 ± 7.2 mm in the Bentall, and 38.5 ± 4.8 mm in the SAAR group (P < 0.0001).

RESULTS: In-hospital mortality was 2.6% in the Bentall, and 2.3% in the SAAR groups. Overall survival was 84 and 81% in the Bentall (median follow-up: 105 months) versus 89 and 88% in the SAAR (median follow-up: 73 months) groups at 10 and 15 years (P = 0.36), respectively. The mean cardiopulmonary bypass (CPB) time was 201 ± 56 min and 174 ± 58 min (P = 0.0016), the mean cross-clamp time 156 ± 42 min and 132 ± 38 min (P = 0.0008) in the Bentall and SAAR groups, respectively. Four sudden deaths have occurred in the Bentall group and in 2 in the SAAR group. Progressive dilatation of the aortic root in the SAAR group was not significant (postoperative mean diameter: 36.3 ± 4.4 mm). Neither subgroup of patients in the SAAR with preoperative moderate dilatation of aortic root had significant aortic dilatation at the mean follow-up of 73 ± 39 months (preoperative diameter: 43.5 ± 2.3 mm versus postoperative: 39.1 ± 4.2 mm). One patient in Bentall and 1 in the SAAR groups were reoperated for tubular graft infection.

CONCLUSIONS: In patients with BAV disease, ascending aortic aneurysm and moderate dilatation of the root, the significant reduction of CPB and cross-clamp times, the stability of the residual root at long term and the low risk of adverse aortic events associated with SAAR compared with the Bentall procedure have led us to consider the isolated aortic valve replacement with supracoronary aorta replacement an alternative strategy to the Bentall procedure, especially in high-risk and older patients.

Keywords: Bicuspid aortic valve • Aortic aneurysm • Aortic root dilatation

INTRODUCTION

The association between bicuspid aortic valve (BAV) disease and ascending aorta dilatation is well recognized [1], but the actual risk of acute aortic events is a controversial issue [2]. The incidence of BAV is 1–2% in the general population [3, 4] and the correlated pathology is often observed at an early age. The young age of patients and the higher risk of aortic dissection in the presence of ascending aorta dilatation [5] have led many authors in recent years to suggest an aggressive surgical approach through a composite root replacement even in the case of a mild-to-moderate aortic dilatation [6, 7].

Nevertheless, some studies seem to indicate a lower risk of aortic events in such cases, suggesting that the type of aortic valve dysfunction (stenosis versus insufficiency) could be helpful in predicting [8] an unfavourable progression of the aortic dilatation.

Unfortunately, most of the published reports are focused on the evaluation of the tubular segment of the ascending aorta and only few studies [9, 10] have specifically analysed the fate of the sinuses of Valsalva.

The data of these series, despite the limited number of patients and follow-up, support the hypothesis that further enlargement of
the non-replaced aortic root is uncommon, and that catastrophic aortic events occur rarely in the early and late follow-up [11].

Considering these evidences, the aim of this observational retrospective study was to compare long-term results in terms of mortality for cardiac death and occurrence of aortic pathological events between patients treated with separate valve combined with supracoronary ascending aorta replacement (SAAR) group and those who underwent composite root replacement (Bentall group). ‘Furthermore, any diameter change of the non-replaced aortic root was also evaluated in the first group’.

MATERIALS AND METHODS

The institutional electronic database of the University Hospital of Udine was searched to identify all the patients who underwent cardiac surgery due to BAV disease associated with ascending aorta dilatation (defined as an enlargement of the tubular segment with a diameter of >45 mm) from 1994 to 2010. Patients undergoing surgical intervention after 2010 were excluded in order to reach a minimum follow-up of 3 years for all patients.

The surgical technique comprised either separate aortic valve or SAAR if the diameter root was <45 mm or if composite root replacement (Bentall procedure) it was >45 mm. The asymmetry of the Sinuses of Valsalva and the wall thickness were considered in the decision-making in some cases with borderline root diameter. Patients undergoing surgery for type A ascending aorta dissection were excluded from the study.

In most of the patients, intraoperative transoesophageal echocardiography (TOE) was used to better define the diameter of the root before cardiopulmonary bypass (CPB) and after the surgical intervention. The follow-up information was obtained by means of phone contact and cardiological database search. Echocardiographic reports were screened to acquire the aortic root diameters in the SAAR group. Aortic root dimensions were measured at the level of the sinuses of Valsalva at the end-diastole from paraesternal long-axis view (TOE) and from high long-axis view at 120–150° (TOE).

Furthermore, the SAAR group was divided in two subsets, in order to identify patients with higher risk of adverse events: patients with an aortic root diameter of ≤40 mm (Group A) and patients with a diameter of >40 mm (Group B).

The study was approved by the institutional review board.

Statistical analysis

A descriptive analysis was conducted on the study subjects. Mean and standard deviation, median and interquartile range (IQR) were reported for continuous variables, while absolute frequencies and percentages for categorical ones. Comparisons between study groups for continuous variables were performed using the Student t-test or rank-sum test, while the paired Student t-test was used to compare pre- and postoperative aortic root diameters. The choice between parametric and non-parametric tests was made according to the normality of the distribution, as checked using the skewness–kurtosis test. Categorical variables in the two groups were compared using the χ² test; the Fisher exact test was used when the expected frequency in at least one cell was ≤5.

Different survival analyses were performed, end-points being death for all causes (data not shown) and death for cardiovascular disease, this being identified according to clinical judgement. Patients lost to the follow-up were analysed as censored in both analyses, while patients deceased for causes other than cardiovascular were censored only in the last one. Kaplan–Meier curves were plotted and log-rank test was used to compare the study groups. A Cox proportional hazards regression model was used to take into account the effect of possible confounders, defined as those variables that can have a role on modifying the relationship between the exposure (type of procedure) and the outcome (death for cardiac causes) and did not result to be balanced in the two study groups at the descriptive analysis. Univariate analyses were performed to identify, among possible confounders, the variables to include in the final adjusted model. Since gender and New York Heart Association (NYHA) class did not reach a statistically significant difference at the univariate analysis, and when included in a multivariate model it did not modify the estimate for the main end-point nor gave a contribution to explain our data, they were left out and only age was included as a continuous variable. The aortic root diameter, representing the main criterion when the choice between Bentall and SAAR procedures is made, could be considered as a possible confounder or, more precisely, as a potential source of selection bias. However, we decided not to include it in the model, since our aim was to see whether the two groups of patients (clinically different and, due to these differences, undergoing different procedures) had comparable survival, that is, if it is correct to treat different patients in different ways in order to obtain similar results. The analyses were performed using the statistical packages Stata version 11.0 (StataCorp LP, College Station, TX, USA) for Windows package and SAS Enterprise Guide Version 4.3 (SAS Institute, Inc., Cary, NC, USA).

RESULTS

A total of 166 patients were available for analysis: 89 patients underwent aortic valve combined with the SAAR group and 77 patients underwent modified Bentall procedure (Bentall group).

Preoperative characteristics of both groups are summarized in Table 1.

The mean age was 60.5 ± 11.2 years in the SAAR group (range, 29–79 years) and 55.7 ± 12.7 years in the Bentall group (range, 26–79 years).

The two groups were balanced according to the patients’ comorbidities. However, patients included in the Bentall group were more frequently males (91 vs 72%, P < 0.01), younger (median age: 55.8 vs 60.3; P = 0.02) and more severely ill according to NYHA classification (II or IV NYHA class: 30 vs 11%, respectively; P < 0.01).

Moreover, the valve pathology distribution was different: stenotic valve disease was prevalent in the SAAR group (46 vs 21%, P < 0.01), regurgitant valve disease in the Bentall group (49 vs 20%, P < 0.01), while mixed steno-regurgitant valve disease was similar (34 vs 30%, P = 0.60) in the two groups.

Preoperative aortic root median size was 44.5 mm in Bentall group and 38 mm in SAAR the group (P < 0.01). Preoperative ascending aorta mean diameters were 53.5 ± 8.6 mm and 49.5 ± 4.9 mm in the Bentall group and SAAR group, respectively (P < 0.01) as reported in Table 2. Intraoperative data are given in Table 3.

The Bentall procedure was performed in 69 patients (89.6%) using composite graft conduit with mechanical prosthesis (Carboseal; CarboMedics Inc., Austin, TX, USA; CarbonArt, Sorin, Saluggia, Italy) and in 8 patients (10.4%) using a tubular graft (Intervascular Datascope, La Ciotat, France; Vascutek, Terumo-Vascutek, Renfrewshire, Scotland)
sutured to a bioprosthesis (Carpentier-Edwards, Edwards Lifescience, Irvine, CA, USA).

In the SAAR group, 36 patients (40.4%) underwent separate aortic valve replacement with a biological prosthesis (Carpentier-Edwards, Edwards Lifesciences; Sorin, SoriniBiomedica Cardio SpA, Saluggia, Italy) and 53 patients (59.6%) with a mechanical prosthesis (CarboMedics, CarboMedics, Inc., Austin, TX, USA; Sorin, Biomedica Cardio SpA; St Jude Medical, St Paul, MN, USA). A tubular cylinder conduit graft was used for SAAR (Intervascular Datascope, La Ciotat, France; Vascutek, Terumo-Vascutek, Renfrewshire, Scotland).

The graft was extended to replace partially the aortic arch in 2 patients of the Bentall group and in 2 patients in the SAAR group. Mean size diameter of the aortic valve prosthesis was 23.4 ± 1.7 mm in the SAAR group and 25.0 ± 2.4 mm in the Bentall group. Mean CPB and cross-clamp (CC) time were significantly shorter in SAAR group (162 vs 195 min, P < 0.01 and 123 vs 152 min, P < 0.01, respectively).

### Early and late outcomes

In-hospital mortality was 2.3% (2/89 patients) and 2.6% (2/77 patients) in SAAR and Bentall groups, respectively. In the SAAR group, 1 patient died for congestive heart failure and 1 for multi-organ failure, while in the Bentall group both patients died for cardiac insufficiency.

The median follow-up time was 73 months (IQR: 53–109) for the SAAR group and 105 months (IQR: 63–141) for the Bentall group. Survival probability at 5, 10 and 15 years was 93, 89 and 88%, respectively in the SAAR group and 87, 84 and 81% in the Bentall group. The causes of death are summarized in Table 4.

During the follow-up, there were 7 cardiac-related deaths (7.9%) (including 2 sudden deaths) and 4 non-cardiac deaths (4.5%) in the SAAR group, while 11 (14.3%) cardiac-related deaths (including 4 sudden deaths) and 5 (5.2%) non-cardiac deaths in the Bentall group.

The main aim of this study was to compare survival in the two study groups using cardiac death as the end-point. The survival analysis did not allow to appreciate any difference between the SAAR and Bentall groups (log-rank test P = 0.36). Indeed, the Kaplan–Meier curves clearly do not cross, showing a similar trend and a slightly better survival for the SAAR group (Fig. 1). When a multivariate Cox proportional hazards model was run, the hazard ratio (HR) was not statistically significant [HR: 1.1; 95% confidence interval (CI): 0.7–4.8; P = 0.22], even when the effect of age was taken into account (HR for age: 1.1; 95% CI: 1.0–1.1; P = 0.02).

The native aortic root diameters were stable at echocardiographic follow-up (73 ± 39 months) in the SAAR group. Moreover, the mean diameters were significantly smaller than preoperatively (36.3 ± 4.4 mm vs 38.5 ± 4.8 mm, P < 0.01). Regarding the two subsets of patients in the SAAR group (Group A ≤40 mm vs Group B >40 mm), the mean root diameters resulted unchanged at the follow-up in SAAR group A (35.7 ± 3.3 mm vs 35.0 ± 4.0 mm postoperative, P = 0.07) vice versa a significant reduction of the mean aortic root diameter was recorded in SAAR group B (43.5 ± 2.3 mm preoperative vs 39.1 ± 4.2 mm postoperative, P < 0.01). Data are given in Table 5.

In the SAAR group, 8 patients with preoperative aortic root exceeding size of 45 mm showed a reduction of the root diameter, which remained stable during the entire follow-up.

A sensitivity analysis was performed both including and excluding 4 patients who underwent non-coronary sinus replacement, but the results were comparable.

A late reoperation due to infection of the tubular prosthesis was observed in 1 patient in the SAAR group, who required an ascending aorta replacement, and in 1 patient in the Bentall group who underwent the composite graft replacement with a new valved biological conduit.

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### Table 1: Preoperative demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>SAAR group (n = 89)</th>
<th>Bentall group (n = 77)</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>60.5 ± 11.2</td>
<td>55.7 ± 12.7</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>60.3 (54.5–69.2)</td>
<td>55.8 (47.1–66.5)</td>
<td></td>
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<tr>
<td>Male sex</td>
<td>64 (71.9)</td>
<td>70 (90.9)</td>
<td>0.002</td>
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<td>Hypertension</td>
<td>52 (58.4)</td>
<td>45 (58.4)</td>
<td>1.00</td>
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<td>Smoking</td>
<td>21 (23.6)</td>
<td>16 (20.8)</td>
<td>0.66</td>
</tr>
<tr>
<td>Obesity</td>
<td>10 (11.2)</td>
<td>3 (3.9)</td>
<td>0.09</td>
</tr>
<tr>
<td>Dislipidaemia</td>
<td>26 (29.2)</td>
<td>16 (20.8)</td>
<td>0.21</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>9 (10.1)</td>
<td>4 (5.2)</td>
<td>0.26</td>
</tr>
<tr>
<td>PFO</td>
<td>-</td>
<td>3 (3.9)</td>
<td>0.10</td>
</tr>
<tr>
<td>Aortic coarctation</td>
<td>1 (1.1)</td>
<td>1 (1.3)</td>
<td>1.00</td>
</tr>
<tr>
<td>LV ejection fraction &lt;40%</td>
<td>5 (5.6)</td>
<td>4 (5.2)</td>
<td>1.00</td>
</tr>
<tr>
<td>NYHA class III or IV</td>
<td>10 (11.4)</td>
<td>23 (29.9)</td>
<td>0.003</td>
</tr>
<tr>
<td>Reoperation (%)</td>
<td>1 (1.1)</td>
<td>1 (1.3)</td>
<td>1.00</td>
</tr>
<tr>
<td>Endocarditis (%)</td>
<td>2 (2.3)</td>
<td>3 (3.9)</td>
<td>0.66</td>
</tr>
</tbody>
</table>

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### Table 2: Preoperative echocardiographic findings

<table>
<thead>
<tr>
<th>Variable</th>
<th>SAAR group (n = 89)</th>
<th>Bentall group (n = 77)</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stenotic valve pathology</td>
<td>41 (46.1)</td>
<td>16 (20.8)</td>
<td>0.001</td>
</tr>
<tr>
<td>Insufficiency valve pathology</td>
<td>18 (20.2)</td>
<td>38 (49.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mixed valve pathology</td>
<td>30 (33.7)</td>
<td>23 (29.9)</td>
<td>0.60</td>
</tr>
<tr>
<td>Aortic root diameter (mm)</td>
<td>38.5 ± 4.8</td>
<td>44.0 ± 7.2</td>
<td></td>
</tr>
<tr>
<td>Group A (&lt;40 mm)</td>
<td>35.7 ± 3.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B (&gt;40 mm)</td>
<td>43.5 ± 2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascending aorta diameter (mm)</td>
<td>49.5 ± 4.9</td>
<td>53.5 ± 8.6</td>
<td>0.0016</td>
</tr>
<tr>
<td>Group A (&lt;40 mm)</td>
<td>48.3 ± 4.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B (&gt;40 mm)</td>
<td>47 (45–51)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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*Rank-sum test.  
1The χ² test.  
1Fisher’s exact test.  
1Mean ± standard deviation; median (interquartile range).  
PFO: patent foramen ovale; LV: left ventricle; LVIF: left ventricular ejection fraction.
In the Bentall group, during the follow-up 1 patient developed an infection of the tubular graft, with postoperative late aortic dissection requiring intensive and prolonged antibiotic therapy.

**DISCUSSION**

The frequent association between BAV and ascending aorta dilatation (30–70%) [12] is well known, as well as the involvement of the aortic root and sinuses of Valsalva is associated with faster growth of the aorta and higher rate of aortic events [13, 14].

Current guidelines (American College of Cardiology/American Heart Association 2010, European Society of Cardiology/European Association of Cardio-Thoracic Surgery 2014) suggest to replace the ascending aorta in the presence of a diameter of 45 mm or more if associated with BAV disease [15, 16]. Nevertheless, the general surgical posture appears to be more aggressive towards a more frequent replacement of less dilated segments, especially in younger patients [17, 18].

Some authors have considered a diameter exceeding 40 mm for surgical aortic replacement [6], others a diameter of ≤40 mm [7]. Recently, some studies [2] seem to indicate a non-significant progressive dilatation of the ascending segment after aortic valve replacement with low risk of aortic events. If the evolution of the ascending tract is well documented, the risk of progressive dilatation of the sinuses of Valsalva is less clear, being the specific studies inconclusive due to their small sample size and short follow-up [9, 10].

The Bentall procedure represents the preferable surgical approach because of the complete replacement of pathological aortic root and good long-term results have been reported so far with such a technique. However, although the operative risk is low.

In the Bentall group, during the follow-up 1 patient developed an infection of the tubular graft, with postoperative late aortic dissection requiring intensive and prolonged antibiotic therapy.
in centres with large experience [19, 20], data from The Society of Thoracic Surgeon indicate that the coronary ostia reimplantation may represent a potential risk for complications such as kinking, stretching, twisting of coronary arteries or false aneurysm formation and unexpected bleeding from the coronary ostia [21].

The results of our study show that no progressive enlargement of the sinuses of Valsalva is recorded at the long-term follow-up (38.5 ± 4.8 mm preoperative vs 36.3 ± 4.4 mm postoperative). Moreover, the results show a significant reduction of the mean aortic root diameter was observed in SAAR group B also when the preoperative diameter was >40 mm (43.5 ± 2.3 mm preoperative vs 39.1 ± 4.2 mm postoperative).

No root ruptures nor dissections occurred in the SAAR group and only 1 patient underwent reoperation for tubular graft infection. On the other hand, one late dissection was observed in the Bentall group.

Recent studies have demonstrated by four-dimensional flow MR imaging that an abnormal helical flow associated with an eccentric systolic flow jet can be seen in the proximal ascending aorta of patients with BAV, also in those with normal aortic dimension [22]. Accordingly, such a flow pattern seems not to be secondary to a dilated aorta but possibly implicated in the pathogenesis of aneurysm formation, being the eccentric flow jets the main cause of differential wall shear stress and consequent morphological changes [23].

Furthermore, Roberts et al. [8] reported that the most of patients with stenotic BAV had no loss or only minimal loss of medial elastic fibres, whereas the patients with pure aortic regurgitation had ~50% chance of having significant loss of medial elastic fibres with a higher risk of rupture or dissection.

These findings suggest that the haemodynamic pattern documented in the sinuses of Valsalva could have a primary implication in the aneurysm evolution and only in a limited cohort of BAV the structural alterations of the wall are determinant for its initial pathogenesis.

In the SAAR group, the BAV replacement with a stented prosthesis could remove the cause of abnormal eccentric systolic helical flow leading to a normal flow with reduction of haemodynamic stress on the wall and a lower risk of aortic events. Moreover, the remodelling of sinotubular junction as a consequence of the supracoronary aorta replacement with a tube graft would influence the reverse remodelling of the aortic root with reduction of its diameter, which remains stable at the long-term follow-up.

In the SAAR group, a favourable fate of the root was observed for any type of valve dysfunction (stenosis versus insufficiency versus mixed pathology) and a worse evolution of sinuses of the Valsalva was not recorded also in case of pure aortic insufficiency. However, these latter results could be influenced by limited cohort, selection of patients and timing of surgery. Indeed, the conservative approach was chosen only in cases in whom no or mild aortic root dilatation was observed.

The overall survival of patients in the SAAR group at 5, 10 and 15 years was 93.3, 88.8 and 87.6%, respectively and was comparable with that of patients in the Bentall group (87.0, 84.4 and 80.5%, respectively). When a survival analysis was performed, using cardiac death as the end-point, no difference was observed between the study groups both at the crude and age-adjusted analysis (P = 0.36 and P = 0.22, respectively), even though an apparently better survival for the SAAR groups could be graphically appreciated. Nevertheless, the Kaplan–Meier curves show to be quite sparse, this preventing strong conclusions in long-term survival. However, our results are similar to those reported by Park et al. [6], where 10-year survival of the SAAR group was better when compared with other published series of patients showing a better survival after composite root replacement [24].

Although the rate of cardiac and non-cardiac deaths, of reoperation and of sudden deaths (patients in SAAR group, 4 patients in the Bentall group) was similar in both groups, CPB and CC times remain significantly longer in the Bentall group (P = 0.0016 and P = 0.0008, respectively), with a median difference of ~30 min for both variables. These findings should be taken into account when associated cardiac procedures could increase the surgical risk.

Two patients (1 in the SAAR group and 1 in the Bentall group) underwent reoperation for infection of the tubular prosthesis. The patient in the SAAR group underwent replacement of tubular graft whereas the patient in the Bentall group needed replacement of the root and ascending aorta with a valved bioconduit (Shelhigh conduit, Shelhigh, Inc., Millburn, NJ, USA). This kind of reoperation is technically more challenging, and carries higher operative risk [25] in patients with Bentall procedure. Therefore, a less aggressive approach in the management of the sinuses of Valsalva and coronary ostia could represent a favourable condition to significantly decrease the reoperative risk in such cases.

**Limitations**

The principal limitations of this study are the relatively small sample size, and the limited number of patients at the long-term follow-up that reduce the statistical power of our analysis, preventing from finding possible weak associations. In addition, the echocardiographic examination could not always represent the best method to study the sinuses of Valsalva in the postoperative course of such procedures (obesity, bad echo window). The computed tomography scan or magnetic resonance imaging could be used to better define the real diameters of the root. Another limitation is the retrospective nature of the study that hampers a time balance of the groups for unmeasured and unknown potential confounders. Finally, we are not able to draw any conclusion about the correlation between aortic wall alterations, type of BAV disease and outcomes of our study population, since the cohorts were small and insufficient data were retrieved in the database.

**CONCLUSIONS**

The study shows that in patients with BAV disease, ascending aorta aneurysm and moderate root dilatation of the isolated aortic valve
replacement combined with supracoronary aorta replacement presents similar results to Bentall procedure. Moreover, our data show a stability of the residual root and a low risk of adverse aortic events at the long-term follow-up. The significant reduction of CPB and CC time represents variable to be considered in case of more complex cardiac surgery in high-risk patients.

Nevertheless, patient-tailored approach must be always considered taking into account the morphological characteristic of the aortic root, particularly the asymmetric dilatation of sinuses of Valsalva and the wall thickness; the BAV morphology together with annulus or sinotubular junction dimension having been demonstrated all of them to be significant determinant at long-term outcome.

Conflict of interest: none declared.

REFERENCES


APPENDIX. CONFERENCE DISCUSSION

Dr L. Menicanti (Milan, Italy): Dr Vendramin, I would like to ask you two things. The first thing is that we know that the association between bicuspid aortic valve disease and the ascending aorta is determined by haemodynamics and by genetics. According to the experience you have accumulated in the past, what is your strategy now to deal with this problem that we always have when we have a moderate dilatation of the aortic root?

Dr Vendramin: I think that the answer is not unique in the sense that maybe you have to really individualize the best strategy for every patient. So the phenotypic heterogeneity of the valve in ascending aortic disease can justify a two-part consideration: so genetics and haemodynamics, and we have to consider two major elements: the type of dysfunction, first of all, and the morphology of the root in the young patient.

We have some histological news from the literature. There is a nice paper by Roberts who shows 100% no structural alteration of the wall in the stenotic bi-cuspid valve, compared with 50% alteration of the wall in pure aortic insufficiency. In my opinion it's a great result because it suggests how to do it in some cases.

If you have a young patient with stenotic valve disease and moderate aortic dilatation of the root, maybe you can be conservative and so replace the valve, because you change the haemodynamic pathogenesis of this kind of dilatation. And so you eliminate the eccentric posterior flow of the bicuspid valve and reduce the risk of aortic events.

On the other hand, if you have pure aortic insufficiency in the young patient and you decide to preserve the valve, you may have to do something to the root, a Yacoub, a Tirone David, whatever you prefer, but you have to reinforce the root. I think this is really important. In this case maybe the genetic pattern could play a stronger role.

And so I am more convinced that if you have a stenotic pathology or a mixed pathology, you can be more conservative, also for long-term follow-up.
In search of the right study design for bicuspid aortopathy treatment

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Keywords: Bicuspid aortic valve • Aortic aneurysm • Aortic root dilatation

The unanswered questions in the field of surgical treatment of bicuspid aortic valve (BAV)-associated aortopathy [1] periodically come in the limelight of the cardiac surgical literature. One of those questions is in the title of the paper by Vendramin et al. [2], published in this issue of the EJCTS: ‘should aortic root replacement be mandatory in the treatment of BAV disease and ascending aortic aneurysm?’.

In 2000, Sundt et al. [3] addressed this question in a retrospective series of BAV patients undergoing separate valve and aorta (n = 27) or composite aortic root (n = 18) replacement. The cut-off diameter to replace an aorta with BAV disease was 40 mm in that experience, but the criteria to choose between either technique were not specified. Observing no aortic complications in a mean follow-up of 5 years, they concluded that separate valve and graft replacement is a safe option, ‘at least in selected cases’ (i.e. when coronary ostia displacement is not significant or when concomitant procedures have to be performed).

In 2011, Park et al. [4] published a larger series, of 153 patients, in which the BAV had been replaced along with the ascending aorta but leaving the native root in place: again the choice of the procedure was by the operating surgeon and not by strict diameter criteria. No patient receiving separate replacement required reoperation for aortic root dilatation in a median follow-up time of 3.3 years.

On the other hand, in 2007 Etz et al. reported a hospital mortality of 2.9%, no aortic reoperation over a mean follow-up of 5.9 years and survival similar to the age-matched general population, in a series of Bentall operations [5]. In that series indications included dysfunctional BAV with ascending dilatation exceeding 40–45 mm.

All the above-mentioned studies share the same retrospective nature and its inherent limitations. First of all, the undefined or inconsistent criteria for the choice of the procedure (separate versus composite replacement) make it impossible to draw a general conclusion on whether one should be more or less aggressive in the treatment of the bicuspid aortic root. Even in Vendramin’s study, where the criteria were indeed disclosed (i.e. separate replacement if the root was <45 mm, otherwise Bentall) the outcomes of the two different procedures were actually evaluated in remarkably different patient profiles. Patients receiving Bentall operation were more often male and had more than twice the prevalence of aortic regurgitation compared with the other group and significantly greater aortic diameters not only at the root level, but also at the ascending level, notwithstanding their significantly younger age. Recently, we have observed that the anatomic-clinical form of BAV aortopathy characterized by these features, namely the ‘root phenotype’, accounting for ~20% of aortic dilatations with BAV [6], is associated with faster growth of the ascending aorta over time [7]. Lately, evidences are accumulating that the root phenotype may be a marker of earlier-onset, more severe and more progressive aortopathy [7, 8]; thus, in their experience Vendramin et al. have likely performed the more radical procedure in the group in which the worst pathology was concentrated. This could confirm a hypothesis that as long as the root phenotype is excluded, BAV aortopathy is safely and effectively treated by supracoronary replacement [3, 7].

The Bentall procedure is a low-risk operation in patients who present at a relatively young age with very few comorbidities if any. However, there is no doubt that separate valve and ascending replacement implies shorter operative times, no risk related to coronary ostia manipulation and—an argument that might be particularly relevant in a young patient population, with a longer