European Journal of Cardio-Thoracic Surgery 0 (2019) 1–7
doi:10.1093/ejcts/ezz065

ORIGINAL ARTICLE

Cite this article as: Chirichilli I, Irace F, Weltert L, Tsuda K, Scaffa R, Salica A *et al.* Morphological modification of the aortic annulus in tricuspid and bicuspid valves after aortic valve reimplantation: an electrocardiography-gated computed tomography study. Eur J Cardiothorac Surg 2019; doi:10.1093/ejcts/ezz065.

Morphological modification of the aortic annulus in tricuspid and bicuspid valves after aortic valve reimplantation: an electrocardiography-gated computed tomography study†

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Received 16 October 2018; received in revised form 2 February 2019; accepted 7 February 2019

Key question

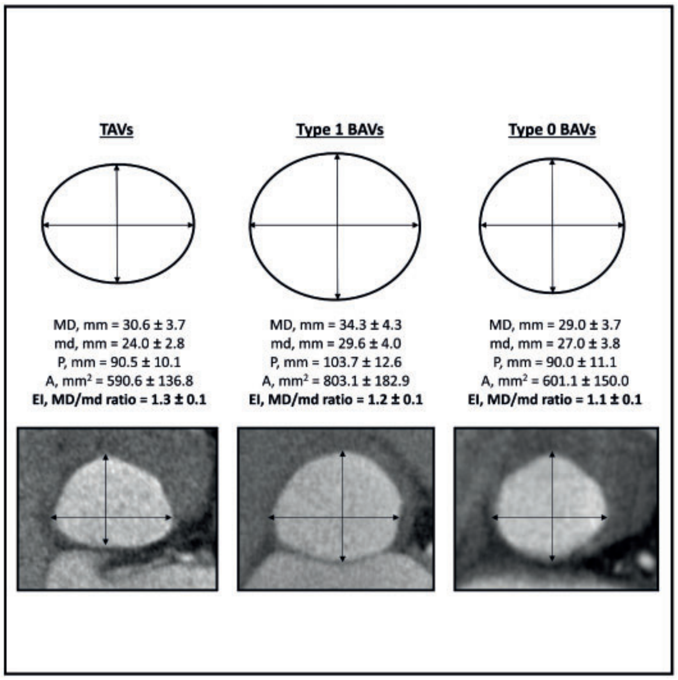
How does reimplantation of the aortic valve modify the morphology of the aortic annulus in the tricuspid aortic valve (TAV) and the bicuspid aortic valve (BAV)?

Key finding(s)

There is a possible gradual spectrum of circularity from TAVs to type I BAVs to type 0 BAVs.

Take-home message

Aortic valve reimplantation plays an active role in the shape and geometry of the aortic annulus with differing results with BAV and TAV.



Abstract

OBJECTIVES: Aortic valve-sparing operations have been shown to produce fewer valve-related complications than valve replacement. The aortic root is a morphological and functional unit in which the annulus plays an important role on dynamism, shape and geometry of the valve with different results in bicuspid aortic valves (BAVs) or tricuspid aortic valves (TAVs). The aim is to evaluate the differences in the size and shape of the aortic annulus between native BAVs and TAVs using ECG-gated computed tomography (CT) after a reimplantation procedure.

METHODS: We selected 35 patients scheduled for aortic valve reimplantation who underwent good-quality preoperative and postoperative ECG-gated contrast-enhanced CT scan of the aortic root. Twenty-three patients had TAV, 8 patients type 1 BAV and 4 patients type 0 BAV.

†Presented at the 32nd Annual Meeting of the European Association for Cardio-Thoracic Surgery, Milan, Italy, 18–20 October 2018.

Major diameter and minor diameter, perimeter (P) and area (A) were measured. The shape of the aortic annulus was considered 'circular' or 'elliptic' according to the Ellipticity Index. We also selected a subgroup of 18 patients (9 TAVs and 9 BAVs) to evaluate annular shape and size variations through the cardiac cycle and to study the expansibility both in the preoperative and in the postoperative phases.

RESULTS: Preoperative CT scans showed an elliptic shape of TAVs (Ellipticity Index 1.3 ± 0.1), a circular shape of type 0 BAVs (1.1 ± 0.1) and an intermediate behaviour of type 1 BAVs, suggesting a possible gradual spectrum of circularity from TAVs to type 1 BAVs to type 0 BAVs. Postoperative CT scans did not show any significant difference in annular shape among the 3 groups, which demonstated a similar roundness, obviating the preoperative differences. Analysing the expansibility of the aortic annulus during the cardiac cycle, we observed that it was completely absent in the preoperative phase in BAVs, while in the postoperative phase, both TAVs and BAVs showed a small but similar expansibility after the annular reduction.

CONCLUSIONS: There is a possible gradual spectrum in terms of shape, from native TAVs, to type 1 BAVS to type 0 BAVs. These differences are eliminated in the postoperative phase, suggesting an active role of the annuloplasty on the geometry of the aortic annulus. The preoperative analysis showed a complete inelasticity of BAVs, which was partly restored in the postoperative phase.

Keywords: Aortic annular shape • Bicuspid aortic valve • Tricuspid aortic valve • Aortic annular expansibility • Aortic valve reimplantation

INTRODUCTION

The effort to better understand and reproduce aortic valve-sparing operations is based on the demonstrated principle of fewer valve-related complications as compared to aortic valve replacement procedures [1]. Stability and reproducibility of aortic valve repair are improving, thanks to a fixed geometric annuloplasty [2–6]. In particular, the reimplantation procedure allows at the same time aortic root replacement and aortic annulus stabilization, guaranteeing stable and long-term results [7, 8]. Specific shape features of aortic annulus were identified both in bicuspid aortic valves (BAVs) and in tricuspid aortic valves (TAVs) by previous studies, even if they are still under debate [9–11]. The purpose of this study was to assess the effective modification in size and shape of the aortic annulus after the aortic valve reimplantation procedure. In particular, we focused on shape modifications and relative differences between native BAVs and TAVs.

MATERIALS AND METHODS

From October 2014 to July 2018, we selected 35 patients scheduled for aortic valve reimplantation at European Hospital of Rome, who underwent good-quality preoperative and postoperative ECG-gated contrast-enhanced computed tomography (CT) scan of the aortic root, performed with an adequate heart rate to minimize possible artefacts. The CT protocol included a ECG-retrospective contrast-enhanced CT scan of the entire thoracic aorta after injection of a bolus of 70–90 ml of iomeprol 400 mg I/dl (Iomeron 400, Bracco, Milan, Italy) at a flow rate of 5 ml/s, followed by a 30-ml saline flush, using a 64-slice CT scanner (Brilliance 64, Philips). CT data sets were reconstructed with a slice thickness of 1 mm (reconstruction increment 0.5 mm) every 10% steps of the R-R interval (from 0% to 90%) using a medium-smooth convolution algorithm, and an image matrix of 512×512 pixels. Dedicated multiplanar planes have been reconstructed applying the double oblique view in order to obtain an axial plane, perpendicular to the long axis of aortic root. The axial image passing through the aortic annulus was identified below the aortic valve at the level of the ventricular–aortic junction. We identified the aortic annulus by the plane passing through the nadir of the 3 cusps. Major diameter and minor diameter, perimeter (P) and area (A) in diastole were measured. The shape of the aortic annulus was considered 'circular' or 'elliptic' according to the Ellipticity Index (EI) defined as a major diameter/minor diameter ratio: a value $\geq$1.1 was considered 'elliptic'. Table 1 summarizes the preoperative data of these patients. The patients were predominantly men (n = 31; 89%), with a mean age of 51.1 ± 14 years (range 24–77 years). A TAV was present in 23 patients (66%) and a bicuspid valve was present in 12 patients (34%) (4 type-0 BAV and 8 type-1 BAV) according to the Sievers Classification [12]. Associated pathologies included: Marfan syndrome in 4 patients (11%), type A aortic dissection in 2 patients (6%) and aortic arch involvement in 2 patients (6%). Preoperative echocardiography findings showed a mean left ventricular ejection fraction of 60 ± 6%; none-to-mild aortic regurgitation ($\leq$2+) was evident in 29 patients (83%); and moderate-to-severe aortic regurgitation ($\geq$3+) in 6 patients (17%). The mean aortic root diameter was 49.8 ± 4.2 mm. Two patients had concomitant moderate mitral regurgitation, 1 coronary disease and 1 previous cardiac surgery.

Moreover, we selected a subgroup of 18 patients (9 TAVs and 9 BAVs) who underwent good-quality preoperative and postoperative CT scan, both in systole and in diastole, to assess annular shape and size variations through the cardiac cycle, and evaluate its expansibility both in the preoperative and in the postoperative phases. In these 18 patients, image series were acquired at 30% and 70% of the cardiac cycle and were therefore considered 'systolic' or 'diastolic' sequences, respectively.

The surgical technique has been previously described; it has been standardized and did not undergo significant modifications during the study period [8, 13]. In brief, after the sinuses are excised and the coronary button detached, the valve is inspected for evaluation of leaflet quality. Once the valve is considered suitable to be spared, the root is accurately dissected down to the annulus. Dissection is conducted with particular care to go as deep as possible along the whole circumference of the annulus. Adding 5 mm to the annulus as measured using a Hegar dilator is used to choose the proper conduit size. Next, to adapt the graft to the specific patient's anatomy, the length of each commissure is reported onto the graft from the sinotubular junction down, ensuring that upon implantation, the top of the commissure will correspond to the level of the new sinotubular junction. Then a series of pledgeted sutures (usually between 6 and 9 sutures) are placed circumferentially and horizontally from inside out at the level of the aortic annulus. Care is taken to pass these sutures 1–2 mm below the annulus, avoiding any distortion or interfering with the normal movement of the leaflets. These sutures are then passed at the established level of the Valsalva graft and used to anchor it to the annulus. The commissures are then pulled inside

Table 1: Preoperative clinical data, echocardiographic and CT findings of all patients

Characteristics	Results
Number of patients	35
Age (years)	
Mean	51.1 ± 14
Range	24–77
Male sex, *n* (%)	31 (89)
Height (cm), mean ± SD	181.3 ± 9.3
Weight (kg), mean ± SD	85.9 ± 16.6
Body surface area (m^2), mean ± SD	2.05 ± 0.2
Bicuspid aortic valve, *n* (%)	12 (34)
Type 1	8 (67)
L-R	7 (87)
R-NC	1 (12)
Type 0	4 (33)
Tricuspid aortic valve, *n* (%)	23 (66)
Marfan syndrome, *n* (%)	4 (11)
Type A aortic dissection, *n* (%)	2 (6)
Previous cardiac surgery, *n* (%)	1 (3)
Aortic arch involvement, *n* (%)	2 (6)
Left ventricular ejection fraction (%), mean ± SD	60 ± 6
Aortic regurgitation, *n* (%)	
0	8 (23)
1+	13 (37)
2+	8 (23)
3+	3 (9)
4+	3 (9)
Eccentric jet of AR, *n* (%)	6 (17)
Left ventricle end-systolic volume (ml), mean ± SD	48 ± 21.5
Left ventricle end-diastolic volume (ml), mean ± SD	120.3 ± 42.3
Left ventricle end-systolic diameter (mm), mean ± SD	36.5 ± 5.5
Left ventricle end-diastolic diameter (mm), mean ± SD	53.5 ± 5.2
Mitral regurgitation >2+, *n* (%)	2 (6)
Aortic annulus (mm), mean ± SD	26.5 ± 3.3
Valsalva sinus (mm), mean ± SD	49.8 ± 4.2
Sinotubular junction (mm), mean ± SD	44.6 ± 6.7
Ascending aorta (mm)	46.8 ± 7.6
Mean EuroSCORE II (%), mean ± SD	2.3 ± 1.0

CT: computed tomography; SD: standard deviation.

Table 2: Operative data

Variables	Results
Graft diameter—overall (mm), mean ± SD	30.8 ± 1.5
32, *n* (%)	19 (54)
30, *n* (%)	11 (31)
28, *n* (%)	5 (14)
Graft diameter—TAVs (mm), mean ± SD	30.4 ± 1.5
32, *n* (%)	9 (39)
30, *n* (%)	10 (43)
28, *n* (%)	4 (17)
Graft diameter—BAVs (mm), mean ± SD	31.5 ± 1.2
32, *n* (%)	10 (83)
30, *n* (%)	1 (8)
28, *n* (%)	1 (8)
Combined operations, *n* (%)	6 (17)
Coronary bypass graft	1 (3)
Mitral valve repair	3 (9)
Aortic arch intervention	2 (6)
Leaflet plication	17 (49)
Mean cardiopulmonary bypass time (min), mean ± SD	122.8 ± 18.8
Mean aortic cross-clamp time (min), mean ± SD	105.2 ± 14.3
Number of sub-valvular annular stitches	
BAV patients	12
Mean number of stitches	8.1
SD	±0.9
Range	7–10
TAV patients	23
Mean number of stitches	6.3
SD	±0.9
Range	6–9

BAV: bicuspid aortic valve; SD: standard deviation; TAV: tricuspid aortic valve.

the graft and fixed at the new sinotubular junction. The valve remnants are then sutured to the graft using 3 continuous 4/0 prolene sutures. Coronary ostia are sutured onto the corresponding sinus. Suture of the graft to the distal aorta completes the procedure. The technique works equally well in cases of bicuspid valve where the graft will naturally expand into a 2-sinus configuration. The Valsalva graft characteristics have also been described in detail in several previous publications [13, 14].

Table 2 describes the operative data. Six patients received a combined procedure (3 mitral valve repair, 1 coronary bypass graft and 2 aortic arch intervention). The mean graft conduit size was 30.8 ± 1.4 mm. Seventeen patients (49%) had adjunct aortic cusp plication. In BAV patients, the mean number of used stitches for the annuloplasty was 8.1 ± 0.9 (range 7–10); in TAV patients, the mean number was 6.3 ± 0.9 (range 6–9).

The study received ethical approval by the local committee.

Statistical analysis

All data were entered into the Hospital Clinic File System (Clinic Data Pro 4., System Line, Empoli, Italy) at the time of surgery, images of CT scans were processed from the PACS System (Carestream Health Inc., Rochester, NY, USA) into comma-separated values and then entered into a dedicated Microsoft Excel 2016 Datasheet. All statistical analyses were then carried out on SPSS 22 (IBM, Armonk, NY, USA) running on Windows 10 Machine (Microsoft Inc. Redmond, WA, USA).

Descriptive statistics are indicated as absolute numbers and percentages for discrete variables, and as mean and standard deviation for continuous variables. Where appropriate, minimum and maximum limits are expressed too.

Comparison of continuous measure was done via appropriate test, either paired measure *t*-test (for repeated measurements in the same subject before and after operation), the Mann–Whitney test or the Kruskal–Wallis test after evaluation of type of distribution of the population of values. *P*-values less than 0.05 indicated statistical significance.

The complete series of results are tabulated while the most relevant are also discussed in detail in the text, with *P*-values indicated contextually.

RESULTS

Preoperative aortic annulus shape

Preoperative CT scans showed a trend towards a larger aortic annulus in BAVs than in TAVs, in terms of perimeter (P) (99.1 ± 10.1 vs 90.5 ± 10.1 mm; mean difference +9%, *P*-value 0.39) and area (A) (735.7 ± 190.3 vs 590.6 ± 136.8 mm^2; mean difference +24%, *P*-value 0.14), although differences did not reach statistical

Table 3: Preoperative diastolic measurements of the aortic annulus: TAVs versus type 1 BAVs versus type 0 BAVs analysis

Parameters (*n* = 35)	TAVs (*n* = 23), mean ± SD	Type 1 BAVs (*n* = 8), mean ± SD	Type 0 BAVs (*n* = 4), mean ± SD	*P*-value
MD (mm)	30.5 ± 3.7	34.2 ± 4.3	29.05 ± 3.7	0.04
md (mm)	23.9 ± 2.8	29.5 ± 3.9	27.03 ± 3.7	<0.01
Perimeter (mm)	90.5 ± 10.1	103.6 ± 12.5	89.9 ± 11.1	0.02
Area (mm^2)	590.6 ± 136.8	803.09 ± 182.8	601.1 ± 149.9	0.01
EI (EI—MD/md ratio)	1.3 ± 0.1	1.2 ± 0.1	1.1 ± 0.1	<0.01

BAV: bicuspid aortic valve; EI: Ellipticity Index; MD: major diameter; md: minor diameter; SD: standard deviation; TAV: tricuspid aortic valve.

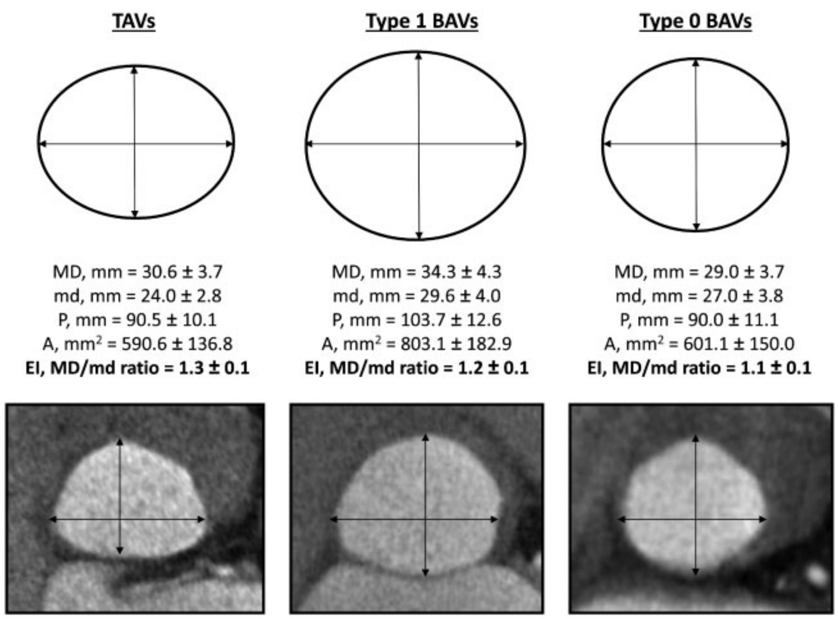


Figure 1: Preoperative diastolic measurements of aortic annulus: TAVs versus type 1 BAVs versus type 0 BAVs. BAV: bicuspid aortic valves; EI: Ellipticity Index; MD: major diameter; md: minor diameters; TAV: tricuspid aortic valves.

significance. TAVs were characterized by an elliptical shape as compared to the more circular shape of the overall BAVs (EI 1.3 ± 0.1 vs 1.1 ± 0.1; mean difference -12%, $P < 0.01$), with a significant difference in the minor diameter (23.9 ± 2.8 vs 28.7 ± 3.4; mean difference +20%, $P < 0.01$).

When analysing the subgroups of type 0 BAVs and type 1 BAV, and comparing them to the TAVs, CT scan data showed that the shape of type 0 BAVs was perfectly circular (1.1 ± 0.1), while type 1 BAVs lay in an intermediate spectrum with a more circular annulus compared to TAVs, but not perfectly round as type 0 BAVs (1.2 ± 0.1, $P < 0.01$), suggesting a possible gradual range of circularity from TAVs, to type 1 BAVs to type 0 BAVs (Table 3).

Figure 1 shows the gradual trend towards circularity, both in a representative scheme and in CT scan images.

Postoperative modifications of the aortic annulus after the aortic valve reimplantation procedure

Postoperative CT scans did not show any significant difference in the annular shape between TAVs and overall BAVs (EI 1.1 ± 0.1 vs 1.1 ± 0.04; mean difference -0.5%, *P*-value 0.76), suggesting a similar roundness of the 2 postoperative groups, which obviated the preoperative differences.

Nevertheless, the aortic annulus of overall BAVs preserved their larger dimensions compared to TAVs, even if reduced by the aortic valve reimplantation (P 90.7 ± 7.3 vs 84.5 ± 7.1 mm; mean difference +7%, *P*-value 0.02. A 632.3 ± 123.6 vs 535.3 ± 97.5 mm^2; mean difference +18%, *P*-value 0.01) (Table 4).

Preoperative to postoperative variations in the aortic annulus after the aortic valve reimplantation procedure

Comparing preoperative CT scans with the postoperative ones, we observed a mean area reduction of 9% in TAVs and 14% in overall BAVs, with the difference between the 2 reductions not proving significant (*P*-value 0.14). The EI was reduced by 12% in TAVs and only 5% in BAVs, mostly due to type 1 BAVs ($P < 0.01$) (Table 5).

Postoperative expansibility of the aortic annulus during the cardiac cycle

The annular area expansibility, between systolic and diastolic sequences, assessed by postoperative CT scans of all patients, was only 1% (*P*-value 0.15) (Table 6).

Table 4: Postoperative diastolic measurements of the aortic annulus: TAVs versus overall BAVs analysis

Parameters (*n* = 35)	TAVs (*n* = 23), mean ± SD	BAVs (*n* = 12), mean ± SD	Mean difference (%)	*P*-value
MD (mm)	27.4 ± 2.4	29.7 ± 3	+2.2 (+8)	0.02
md (mm)	25.3 ± 2.3	27.6 ± 2.8	+2.2 (+9)	0.01
Perimeter (mm)	84.5 ± 7.1	90.7 ± 7.3	+6.1 (+7)	0.02
Area (mm^2)	535.3 ± 97.5	632.3 ± 123.6	+96.9 (+18)	0.01
EI (EI—MD/md ratio)	1.1 ± 0.1	1.1 ± 0.04	-0.006 (-0.5)	0.76

BAV: bicuspid aortic valve; EI: Ellipticity Index; MD: major diameter; md: minor diameter; SD: standard deviation; TAV: tricuspid aortic valve.

Table 5: Preoperative to postoperative variations in diastolic parameters

Preoperative to postoperative variations in diastolic parameters (*n* = 35)	TAV (%) (*n* = 23)	BAV (%) (*n* = 12)	*P*-value
MD (mm)	-3.1 (-10)	-2.8 (-9)	0.69
md (mm)	+1.4 (+6)	-1.1 (-4)	0.01
Perimeter (mm)	-5.9 (-6.5)	-8.4 (-8)	0.35
Area (mm^2)	-55.2 (-9)	-103.4 (-14)	0.14
EI (EI—MD/md ratio)	-0.14 (-12)	-0.05 (-5)	<0.01

BAV: bicuspid aortic valve; EI: Ellipticity Index; MD: major diameter; md: minor diameter; TAV: tricuspid aortic valve.

Table 6: Postoperative variations in aortic annulus expansibility during the cardiac cycle: overall patient analysis

Postoperative parameters (*n* = 18)	Diastole (*n* = 18), mean ± SD	Systole (*n* = 18), mean ± SD	Mean variation (%)	*P*-value
MD (mm)	29.0 ± 2.7	28.9 ± 2.5	-0.1 (0.2)	0.81
md (mm)	27.0 ± 2.4	27.4 ± 2.1	+0.4 (+2)	0.12
Perimeter (mm)	88.8 ± 7.4	89.5 ± 7.1	+0.7 (+1)	0.35
Area (mm^2)	596.4 ± 107.6	605.6 ± 96.6	+9.1 (+1)	0.15
EI (EI—MD/md ratio)	1.1 ± 0.1	1.0 ± 0.04	-0.02 (-2)	0.02

BAV: bicuspid aortic valve; EI: Ellipticity Index; MD: major diameter; md: minor diameter; SD: standard deviation; TAV: tricuspid aortic valve.

By comparing the variations in the preoperative annular area between TAVs and overall BAVs, we observed that, unlike TAVs, the expansibility was completely absent in BAVs, suggesting a possible loss of elasticity, potentially due to the larger size preoperatively (A: mean variation TAVs +5% vs BAVs −0.3%, *P*-value 0.25). However, the difference in expansibility did not reach statistical significance. Instead, in the postoperative phase, both TAVs and BAVs show a small but similar expansibility of the aortic annulus after the annular reduction (A: mean variation TAVs +3% vs BAVs +2%, *P*-value 0.99).

DISCUSSION

This study documents the role of aortic valve reimplantation procedures on shape, dynamism and geometry of the aortic annulus, with different results in case of BAVs or TAVs.

In TAVs, preoperative CT scans have shown an elliptical shape that was forced into a circular shape after the aortic valve reimplantation procedure, as demonstrated by the postoperative CT scans, indicating that the aortic annuloplasty with the Dacron graft had probably an active reshaping role on the annular geometry, without causing aortic cusp distortion.

Rankin *et al.* have already assessed a similar concept. In fact, by using a refined model of hemispheric aortic valve leaflets nested within a cylindric aorta, mathematical studies and CT angiography analysis, they demonstrated, for the first time in awake humans, that the normal human TAV had an elliptical structure [9].

Based on this principle, they created a device designed to permanently restore the physiological annular geometry during aortic valve repair into a fixed structure (HAART 300—Biostable Science & Engineering, Inc., Austin, TX, USA). The device is based on the concept that the permanent restoration of the normal annular shape will facilitate the quality of aortic valve repair in mid- and long-term follow-up [15].

By observing the preoperative data, we found that BAVs have a mean larger annular size, in terms of area and perimeter, as compared to TAVs. This preprocedural anatomical finding might probably explain not only the greater mean area reduction of

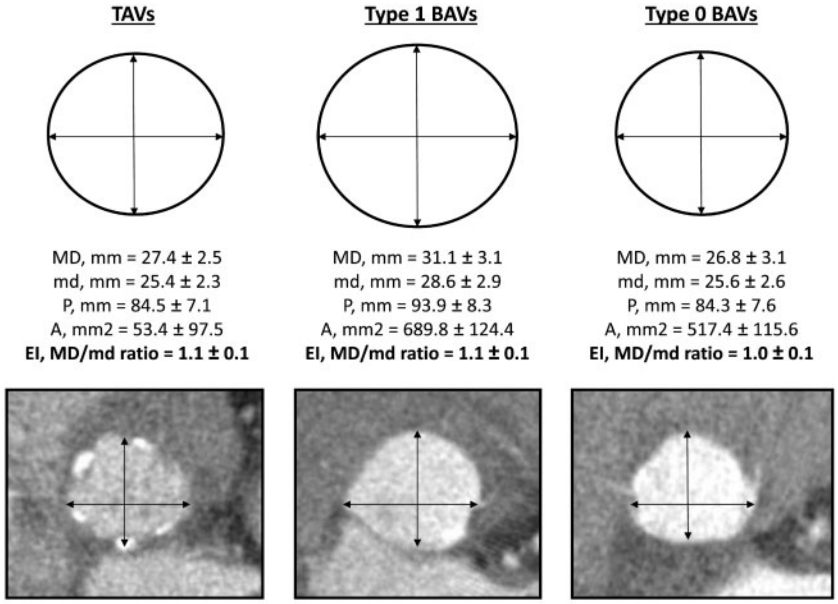


Figure 2: Postoperative diastolic measurements of aortic annulus: TAVs versus type 1 BAVs versus type 0 BAVs. BAV: bicuspid aortic valves; EI: Ellipticity Index; MD: major diameter; md: minor diameters; TAV: tricuspid aortic valves.

BAVs observed in the postoperative phase (14% vs 9%) but also the lack of expansibility already present preoperatively (-0.3% vs 5%), suggesting a possible loss of active elasticity.

Furthermore, we found that BAVs had an unexpected behaviour: in type 0 BAVs: the preoperative CT scans revealed a circular shape of the aortic annulus which was preserved even after the aortic reimplantation as demonstrated by the postoperative CT scans. Surprisedly, type 1 BAVs revealed an intermediate behaviour between TAVs and type 0 BAVs, with a native elliptic shape, less pronounced as compared to TAVs. Thus, in the postoperative phase, both TAVs and all types of BAVs had a circular shape reversing the preoperative differences (postoperative EI: TAVs = 1.1 vs BAVs 1.1, with a preoperative to postoperative EI variation of about 12% in TAVs and about 5% in overall BAVs, mostly due to type 1 BAVs).

The native shape of the BAVs is still a matter of debate. Rankin *et al*. [10] described the usual annular anatomy of BAVs as elliptical, with the sinus-to-sinus diameter being larger. Based on the same principle of TAVs, they created a novel bicuspid annuloplasty ring (HAART 200-Biostable Science & Engineering, Inc., Austin, TX, USA) with a circular base geometry to obtain an annular reduction and reshaping to a symmetric circular geometry that could facilitate leaflet repair and cusp coaptation.

On the contrary, Philip *et al*. [11] demonstrated that patients with severe aortic stenosis due to BAV had an aortic annulus significantly less elliptical (EI 1.2 ± 0.1 vs 1.3 ± 0.1, $P < 0.01$) and more circular (39% vs 4%, $P < 0.01$) compared to the TAV annulus, confuting the traditional exclusion criterion of BAV for transcatheter aortic valve replacement due to the asymmetric anatomy of the BAV annulus. Our possible explanation to this incongruity of data is the type of BAV: type 1 BAVs have a native intermediate behaviour between TAVs (elliptical shape) and type 0 BAVs (circular shape), suggesting that the presence of a complete or incomplete raphe and the spatial position of cusps might influence the difference in annular shape between the 2 subgroups of BAVs. This aspect might be explained by a possible gradual spectrum of circularity from TAVs, to type 1 BAVs to type 0 BAVs (Fig. 1).

Nonetheless, after aortic valve reimplantation, all valve types assume a circular form, suggesting the active role of the annuloplasty by the Dacron graft (Fig. 2). In fact, the annuloplasty seems to restore a symmetric geometry of the aortic annulus regardless of the native morphology, assuring the expected reduction in aortic annulus size. Overall, the annuloplasty did not influence the normal functioning of the valve, even though a cusp plication was more frequently necessary to compensate for a cusp prolapse induced by the reduction in root diameter.

The subgroup of 18 patients underwent pre- and postoperative ECG-gated CT scan, both in systolic and in diastolic sequences, which allowed variations in annular expansibility during the cardiac cycle to be evaluated. The preoperative analysis showed, unlike TAVs, a complete inelasticity of BAVs, which was then partly restored in the postoperative phase after the aortic annular reduction, becoming comparable to expansibility of TAVs.

Limitations

Due to the small size of the patient subgroups used, variations in annular expansibility should be considered with caution. These data need to be confirmed by a larger number of patients to evaluate a possible spectrum of ellipticity between BAVs and TAVs.

CONCLUSIONS

This study confirms the expected reduction in aortic annulus size following the reimplantation procedure. The annulus in TAVs was forced from a native elliptical to a circular shape. It was preserved in type 0 BAV where it maintained an almost perfect circular shape. Type 1 BAVs seem to lie in a spectrum between the previous ones, also becoming circular after the reimplantation.

The preoperative annular expansibility was completely absent in BAVs. In the postoperative phase it was small and similar to TAVs.

Conflict of interest: none declared.

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