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Research Article

Functional Aortic Annulus Remodeling During Bicuspid Aortic Valve Repair: New Concept of Integrated Dual Annuloplasty and Symmetrical Root Enhancement

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Abstract

The Functional Aortic Annulus contains all structures from Ventricular Aortic Junction (VAJ), aortic root sinuses, subcommissural triangles to the Sino-Tubular Junction (STJ) The presented approach embraces two new **concepts:** Dual Annuloplasty and Symmetrical Root Enhancement. Dual annuloplasty consists of both internal and external rings; the internal geometric anuloplasty ring (HAART ™provides symmetrical configuration . The external annuloplasty provides systolic stabilization of the fibrous annulus. Symmetrical Root Enhancement Strategy (SYMREST) provides symmetrical, remodelling of aortic root.

Results: Aortic and annular dimensional metrics showed significant decrease in all patients (p=0,002). Regression model of Variances showed longitudinal time interaction between three time points: Annulus diameter: p=0,007, Aortic Root: p=0,02, Mean Gradient: p=0,005.

Conclusions: Dual annuloplasty combining external and internal annuloplasty supports the virtual basal ring and VAJ together with sinus remodelling, and enables complete FAA remodelling by stabilizing annulus components and enhancing positive aortic remodelling postoperatively.

Introduction

We illustrate the concept of Bicuspid Aortic Valve (BAV) repair in severe AV regurgitation with its fundamental element of Functional Aortic Annulus (FAA) remodeling by integrated internal and external annuloplasty thereby improving annular stabilization and symmetrical, 180° configuration of annulus and aortic root [1], (Figures 1,2). The clinical efficacy of this strategy has been demonstrated by serial longitudinal echocardiographic surveillance (1).

Patients

Figure 1: CT Reconstruction 1 year: Internal Ring (in the middle) And Replaced Noncoronary Sinus (on the left hand side)

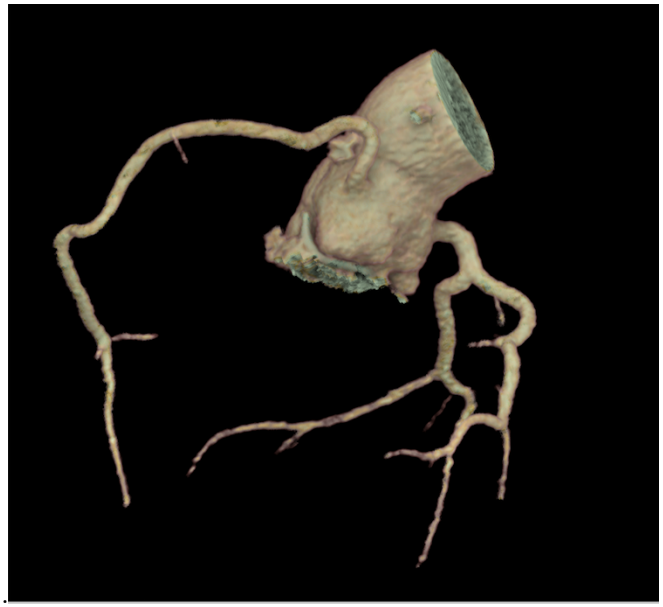

Fig 1b- CT reconstruction 1 year: Internal ring annuloplsty and fused sinuses (left anf right) with coronary arteries take off.

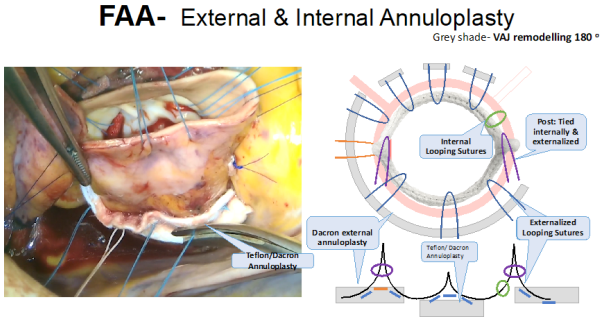

Figure 2: Dual Annuloplasty: Internal anatomical ring (Inside at centre) and Dacron prosthesis for external annuloplasty (Outside).

Ethical Statement

The study has been approved by Institutional EC. The Committee decided that a follow-up strategy was clinically required and not a medical experiment; thus, a the specific Committee's consent was not required (: KB-558/18). This trial has been accepted by EC for statuary grant with Wroclaw Medical University (Grant: ST.C050.18.027).

Between 2022 and 2024 a total of 29 consecutive patients (men, 91.8%, mean age 40 years [32; 48], underwent isolated repair of BAV Sievers type I by a single surgeon (MJ) executing exclusively an integrated approach of both internal anatomical and external ring stabilization in concert with a concomitant sinus symmetrical enhancement styrategy. Patients with root aneurysm counseled for Valve Sparing Root Replacement (VSRR) due to aortic root aneurysm coexisting with AR have been excluded. With no intra- and perioperative death and no mortality during the ongoing surveillance scheme up to date, no need for corrective operations was encountered during a mean follow-up at 28 months (SD +/- 17) . In all patients Transthoracic Echocardiography (TTE) was performed before, early post-repair surgery and at a minimum of 12 months [2]. With longitudinal continuous variables data sets available for the point in time analysis, we used the T-test (or Mann-Whitney U test) for numerical variables. For the trend analyses, we used a mixed-effects regression model for numerical variables.

Methods

The technique has been illustrated by tutorial MMCTS [1]. The Hemispheric Anatomical Annuloplasty Ring –HAART ™ [3] -internal annuloplasty ring - is sized based on the length of the free edge of the non-fused sinus and the intercommissural distance; the method has been validated clinically [2]. Aortic root dissection is limited to easily accessible areas that allow for suture externalization and for coronaries to remain untouched while still achieving complete annuloplasty. After both commissural sutures of internal ring are placed, the ring is passed below the valve and released from the holder. Subsequently, transannular horizontal mattress sutures are placed to loop the ring and they brought outside the aorta in subvalvular fasion (Figure 2). Those looping sutures previously brought outside the aorta are passed through trimmed Dacron or PTFE prosthesis and then tied (Figure 2). Felt stripes supports the external knots of the looping sutures and provides a secondary external stabilization of the ring —a so-called "belt on the outside". After tying down the remaining fused leaflet looping sutures attention is moved to the root. In order to achieve root symmetry -symmetric root enhancement/enlargement strategy or SYMREST is performed (Figure 3). It is based on sinus replacement with a properly sized Dacron prosthesis sutured directly to the annular tissue [1]. The formula of sizing to replace sinus is the same as for the internal ring, resulting in integrated approach.

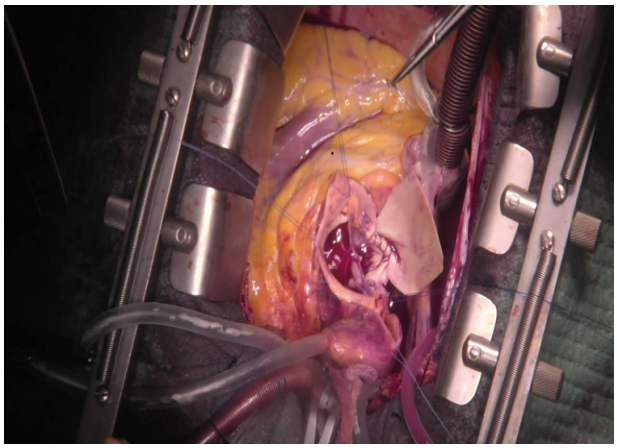

Figure 3: Perioperative: SYMREST- Symmetrical Root Enhancement Strategy- Noncoronary Sinus Of Valsalva Replacement with length of 48mm corresponding to the free edge length of non-fused leaflet and annulolasty ring diameter (25mm) .

Outcome & Discussion

Results

Long term, longitudinal echocardiographic assessment at a mean of 16 months (SD +/-7) of follow-up is shown in the Table 1.

TTE	Before	Early	Follow-up	P : f-up vs baseline
Aortic annulus	29 (27; 32)	23 (22; 23)	23 (22; 25)	**0.007**
Aortic root,	43 (38; 50)	38 (36; 39)	37 (34; 43)	**0.02**
STJ,	41 (32; 45)	34 (28; 35)	38 (35; 39)	**ns**
AA	46 (39; 50)	33 (32; 39)	36 (32; 40)	**ns**
EDD	61,5 (56; 67)	52 (48; 54)	51 (47; 54)	**0.002**
ESD	46 (36; 50)	36 (36; 37)	34 (28; 37)	**ns**
EF %	55 (53; 61)	55 (53; 60)	60 (60; 63)	ns
Max gradient	23 (8; 26)	16 (12; 26)	14 (8; 19)	**0.03**
Mean gradient,	15 (4; 20)	10 (7; 15)	8 (4; 10)	**0.005**
AR none	0	26	22	
AR mild	1	6	7	
AR moderate	3	0	0	
AR severe	29	0	0	

Table 1: Echocardiographic longitudinal data.

Median for comparison (interquartile range); P- values <0.05 were required for statistically significant differences. AR, aortic regurgitation; EF, ejection fraction; VAJ, ventriculo-aortic junction; EDD, end-diastolic dimension, ESD, end-systolic dimension.

Comments

Progressive annular dilatation caused by annulo-aortic ectasia may negatively impact on stability of BAV repair, which may apply to every element of the entire functional aortic annulus. Therefore, efforts are made to improve stability after repair. The presented technique of BAV repair with significant attention to VAJ remodeling by use of both external and internal geometric remodeling can achieve better stabilization. VAJ remodeling and symmetrical reorientation during BAV reimplantation has been previously recognized [4]. Hence, two ring repair strategy, applied separately for the VAJ and STJ level has proven promising and showed satisfactory results in different settings [5,6]. The concept of combining the benefits of two distinct techniques of aortic annuloplasty is a novel strategy and deserves further prospective evaluation.

The internal geometric ring provides FAA symmetrical remodelling and commissural symmetrical of 180° reorientation, while the external annuloplasty provides secondary stabilization of the ring and the weakest and unsupported fibrous portion of the annulu. Moreover, no additional time for suturing is required. Bolstering stability of internal annuloplasty during ring implantation by externalized sutures looping the ring into subvalvular position may mitigate the risk of dehiscence or migration towards LVOT. Incorporating symmetrical root enhancement (SYMREST) provides symmetricity of not only the annulus but also the aortic root, e.g. the entire FAA [7] Post-surgical TTE findings confirm lasting dual stabilization with remodelling of the entire functional aortic annulus and normalization of both transvalvular flow velocity and gradient as the basis for reverse LV remodelling over time.

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