



## Posterior Aortic Root Enlargement for Small Aortic Root: Early Results

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### Abstract

**Objective:** *To assess the safety and efficacy of aortic root enlargement for small aortic root to avoid patient prosthesis mismatch in patients undergoing aortic valve replacement.*

**Method:** *We reviewed early outcomes of 4/500 patients who received posterior enlargement of aortic annulus along with AVR from a period of January 2015 to December 2018. All were female patients. St Jude Medical regent valve (SJM) (St Jude Medical, St Paul, Minn) were implanted in 3 patients and Carpentiers-Edwards PERIMOUNT Magna Ease Bioprosthesis (Edwards Life sciences, Irvine, CA, USA) was implanted in one patient. Posterior root enlargement was done by modified manougian technique when the annulus was small for adequately sized valve as per BSA. Patients were followed up with serial echocardiography for a period of mean-17months.*

**Results:** *Root enlargement allowed us to implant at least 2 size larger prosthetic valve. There was no mortality. Clamp time was almost doubled. One patient had acute kidney injury in post-operative period. One patient had stuck valve after 3 months. Significant reductions in peak and mean gradients were achieved. Mean reductions in left ventricular dimensions were 12.75%.*

**Conclusion:** *Root enlargement done with modified manougian technique is safe and easily reproducible and very useful as a bail out procedure when surgeon encounter a small annulus. Our results favor the continuation of this procedure as it leads to both functional and anatomical improvements of left ventricle.*

**Keywords:** *small aortic root, patient prosthesis mismatch, posterior root enlargement.*

### Introduction

Small aortic root although uncommon but is challenging to manage. Posterior root enlargement can be safely performed whenever indicated<sup>[1,2,3]</sup>. The objective of our study is to retrospectively assess the safety and early results of root enlargement by modified manougian technique.

### Materials and Methods

From January 2015 to December 2018, 500 patients underwent aortic valve replacements. Only 4 patients underwent posterior aortic root enlargement. Three of these were planned and one done, as the patient's annulus was much smaller than reported on transthoracic echocardiography. We selected prosthesis based on patients age and

preference. Pre-operatively we calculated a minimum prosthetic aortic valve size based on a given patient's body surface area to prevent prosthesis mismatch as defined by an indexed effective orifice area of at least  $0.85\text{cm}^2/\text{m}^2$ . This method used to predict and define mismatch at the time of valve implantation has been previously validated<sup>[4]</sup>. When the annulus was smaller than the size adequate for a given patient posterior root enlargement was usually planned pre-operatively. To achieve this goal, we used published normal reference values of effective orifice area (EOA) for each valve type and size<sup>[5,6]</sup>. We assessed the clinical characteristics, early and midterm outcomes obtained by retrospective review.

#### **Clinical data**

All four patients were female with age ranging from 23 to 67 years (mean  $41.75 \pm 12.63$ ). Table 1 shows the clinical data of the patients. Three patients had body surface area (BSA)  $<1.7\text{m}^2$  and 1 patient had  $\text{BSA} > 1.7$  with body mass index of 40 (obese). Body weight ranged from 43 to 86 (mean  $61.75 \pm 18.5$ ). Three patients were in NYHA III and 1 was in NYHA IV. All had severe aortic stenosis, cause being BAV in 2 patients, congenital in 1 and rheumatic in 1. One patient had associated severe mitral stenosis necessitating double valve replacement and the patient with congenital aortic stenosis patient had subaortic membrane with severely thickened and deformed tricuspid aortic valve. All had normal ejection fraction with peak gradients of  $101.75 \pm 39.98$  (ranging from 100-140 mmHg). Annulus size was  $\leq 18\text{mm}$  in all the patients.

#### **Operative Data**

Operative data is detailed in table 2. Type and minimum size of prosthesis were already determined pre-operatively. Need for root enlargement was planned in 3 cases based on the above stated criteria and was decided on table in patient 4. All operations were performed under Cardiopulmonary bypass, moderate hypothermia, and cardioplegic arrest. Delnido blood

cardioplegia was used in all patients and was repeated at 60 mins. In all cases posterior root enlargement was done by modified manougian technique<sup>[7,8]</sup> in which the aortotomy was extended in the commissure between the left coronary cusp and noncoronary cusp after dissecting away the left atrial roof from the aortic wall. The incision was carried down to the mitral annulus and into the anterior mitral leaflet. Left atrial roof was opened in one patient only. The gap created was closed with an ovoid patch of bovine pericardium in 3 patients and a composite patch of dacron plus autologous pericardium in 1 patient respectively. 19mm St Jude Medical regent valve (SJM) (St Jude Medical, St Paul, Minn) were implanted in 3 patients and 21mm Carpentiers-Edwards PERIMOUNT Magna Ease Bioprosthesis (Edwards Life sciences, Irvine, CA, USA) was implanted in one patient. One patient additionally underwent mitral valve replacement and one had sub aortic membrane resection.

#### **Results**

In all the patients we could implant a 2 size greater valve because of root enlargement. Clamp time was almost double (mean 135 mins) as compared to routine AVR (60-70). In one case where ARE was planned on table, clamp time was significantly longer. There was no in-hospital mortality. One patient had acute kidney injury in the postoperative period, which resolved in 3 weeks. There was no significant bleed requiring re-exploration in the post operative period.

Follow up was 100% complete and ranged from 5 months - 38 months (mean 17 months). Functional class improved from NYHA III-IV to NYHA II-I. None of the patients had any acute events except one patient who underwent thrombolysis for stuck valve. Ejection fraction remained almost same. Mean reductions in Left ventricular end diastolic diameter were 12.75%. Significant reduction in peak and mean gradients were also achieved

**Table 1** (pre-operative data) n=4

PREOP	PATIENT 1	PATIENT 2	PATIENT 3	PATIENT 4
AGE(in years)	40	37	23	67
SEX	F	F	F	F
BSA	1.67M2	1.5M2	1.39M2	1.77M2
EOA	1.42CM2	1.27CM2	1.18CM2	1.5CM2
Aortic annulus	17	16	15	17
MIN VALVE SIZE	#19MM SJM regent	#17MM SJM regent	#17MM SJM regent	#21MM MAGNA EASE
DISEASE	BAV	RHEUMATIC	CONGENITAL	BAV
LESION	SEVERE AS MILD TR	SEVERE M.S MOD AR/AS	SEVERE AS SAM	SEVERE A.S
NYHA	III	III	II	III
CORONARIES	N	N	N	N
RHYTHM	SINUS	AF(CVR)	SINUS	SINUS

BSA-body surface area; EOA- effective orifice area; BAV-bicuspid aortic valve; NYHA-new york heart association; AS-aortic stenosis; SAM-sub aortic membrane

**Table 2** Operative data

	1	2	3	4
PROCEDURE	AVR+ARE	DVR+ARE	AVR+SAM RESECTION	AVR+ARE
ARE TECHNIQUE	MODIFIED MANOUGIAN	MODIFIED MANOUGIAN	MODIFIED MANOUGIAN	MODIFIED MANOUGIAN
GRAFT	BOVINE PERICARDIUM	BOVINE PERICARDIUM	BOVINE PERICARDIUM	COMPOSITE PATCH (PERICARDIUM+DACRON)
CLAMP TIME	106 MINS	145 MINS	125 MINS	162 MINS
VALVE	SJM 19MM (EOA 1.7CM2)	SJM 19MM (EOA 1.7CM2)	SJM 19 MM (EOA 1.7CM2)	21MM PERIMOUNT MAGNA EASE (EOA 1. CM2
REXPLORATION	NONE	NONE	NONE	NONE
OTHER COMPLICATIONS	NIL	NIL	NIL	ACUTE KIDNEY INJURY
HOSPITAL STAY	6 days	5 days	6 days	10 days

**Table 3**

ECHO	PT 1		PT 2		PT 3		PT 4	
	PRE OP	POST OP						
P.GR.	100	11	47	12	140	16	120	26
M.GR	62	5.4	33	7	74	9	72	17
LVED	40	32.6	40	38.6	39	34	50	42.5
% age reduction		20%		3.5%		13%		15%
LVES	22	21.3	22	21.5	16	15	33	26.6
%age reduction		4%		2%		7%		20%

Pre op and post op echo comparisons. P.GR-peak gradient; M.GR-mean gradient; LVED-left ventricular end diastolic diameter; LVES-left ventricular end systolic Diameter;

**Discussion**

The main goal of aortic valve replacement (AVR) for aortic stenosis is to alleviate the pressure overload on the left ventricle, thus allowing remodeling and regression of the ventricular mass. Patient Prosthetic Mismatch (PPM), was first described by Rahimtoola. It is present when the effective orifice area (EOA) of the prosthesis is

less than normal human valve. It is mainly encountered in patients undergoing surgery for aortic stenosis. Main hemodynamic consequence of PPM is increased trans-valvular gradients, delaying regression of left ventricular mass. Increased left ventricular mass is an independent predictor of survival as it carries a high risk of sudden cardiac death.<sup>[9]</sup>

Blais and colleagues concluded that PPM is a strong and independent predictor of short-term mortality among patients undergoing AVR, and its impact is related both to its degree of severity and the status of left ventricular function. In contrast to other risk factors, PPM is an avoidable risk factor.<sup>[10]</sup>

The impact of PPM with Small St Jude valves on 388 patients was examined by Mohty et.al<sup>[11]</sup>. They demonstrated higher long-term mortality (hazard ratio 2.18) in patients with small prosthesis and severe mismatch. They concluded that preventive strategies like ARE should be considered in patients with high risk of PPM.

Pibarot et.al<sup>[12]</sup> identified indexed effective orifice area (indexed EOA) as the only parameter that has been found to consistently correlate with postoperative gradients. They graded the severity of PPM based on indexed EOA as: mild when indexed EOA  $>0.85\text{cm}^2/\text{m}^2$ , moderate  $0.85\text{--}0.65\text{cm}^2/\text{m}^2$ , severe  $<0.65\text{cm}^2/\text{m}^2$ .

Using these values they devised a strategy to calculate the minimum EOA of the valve to be implanted. We used the same strategy and when the minimum sized valve could not be implanted we enlarged the aortic annulus.

PPM has now been recognized by the American Society of Thoracic Surgeons and it has been identified as a non-structural dysfunction. Patch enlargement of annulus when  $i\text{EOA}<0.65\text{cm}^2/\text{m}^2$  is a class I indication and class IIb indication when  $<0.85\text{cm}^2/\text{m}^2$ .<sup>[13]</sup>

Patients with impaired LV function preoperatively represent a 'critical population' in whom even moderate PPM must be avoided. Ruel and colleagues found that patients with PPM and LV dysfunction experienced not only decreased late survival, but also a lower freedom from heart failure symptoms and a diminished LV mass regression<sup>[14]</sup>.

Sakamoto and colleagues concluded from their study of 181 patients out of which 24 patients ( $<65$  years) who received ARE +AVR, that enlargement of the small aortic annulus in patients less than 65 years of age seems to be the method

of choice to PPM but it is not necessary in patients more than 65 years of age with a relatively small body size who receive a bioprosthetic valve.<sup>[15]</sup>

Surgeons world over are reluctant to perform root enlargement because of increase in operative time and reports of increased incidence of morbidity and mortality but various studies have demonstrated the safety and efficacy of root enlargement.

Castro et al.<sup>[16]</sup> did ARE in 114 out of 657 patients (17%) mostly female, with a low-mortality rate (0.9%) and additional 20 min cross clamp time. Incidence of PPM decreased to 2.5% from 17%.

Rocha RV and colleagues when compared the in-hospital mortality of their patients of AVR+ARE (n=1854) to AVR (n=7039) they did not find a significant increase.(odds ratio, 1.03; 95% confidence interval, 0.75-1.41;  $P=0.85$ ).they also concluded that addition of root enlargement did not increase the post-operative morbidity although we had one patient with acute kidney injury.<sup>[17]</sup>

ARE can be also safely done in patients undergoing mitral along with aortic valve replacement as demonstrated by Zhong and colleagues<sup>[18]</sup>. 78 of their patients had ARE along with double valve replacement with good outcomes.

Stefano Urso and colleagues<sup>[19]</sup>, analysed 22 best evidence papers out of 400 on the impact of PPM, they concluded that the condition of severe PPM should be always avoided, while the presence of moderate mismatch could be tolerated in patients with normal ejection fraction without any impact on overall survival. However our strategy is to avoid even moderate PPM.

### Conclusion

Summarizing our study, root enlargement was done with modified manougian technique safely and effectively. This is safe and easily reproducible is very useful as a bail out procedure when surgeon encounter a small annulus. Our results favor the continuation of this procedure as it leads to both functional and anatomical improvements of left ventricle.

**Limitation of Study**

Our study included a small subset of patients therefore results of this cannot be extrapolated to larger and more heterogenous population

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**Conflicts of Interest:** None

**Abbreviations**

ARE- Aortic Root Enlargement

AVR-Aortic Valve Replacement

PPM-Patient Prosthesis Mismatch

IEOA- Indexed Effective Orifice Area

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