

Aortic Root Enlargement in patients with small aortic annulus undergoing double valve replacement. A retrospective Comparative cohort study

Yasser Shaban Mubarak (✉ yassemubarak73@gmail.com)

Cardiothoracic surgery department <https://orcid.org/0000-0002-3068-1607>

Ahmed Abdel Rahman Abdeljawad

Cairo University Kasr Alainy Faculty of Medicine

Research article

Keywords: Aortic root enlargement, Manouguian procedure, Nick's procedure, Small aortic annulus, double valve replacement

Posted Date: December 23rd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-133500/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Version of Record: A version of this preprint was published at The Heart Surgery Forum on March 4th, 2021. See the published version at <https://doi.org/10.1532/hsf.3401>.

Abstract

Objectives

Small Aortic Annulus (AA) is big issue during Aortic Valve Replacement (AVR) necessitating replacement of inappropriate-sized prostheses especially during Double Valve Replacement (DVR). Despite that small aortic valve prostheses can lead to Prosthesis-Patient Mismatch (PPM), there remains reluctance to perform aortic root enlargement (ARE) procedures fearing from morbidity and mortality. We evaluate clinical and echocardiographic outcomes in patients with small AA undergoing DVR.

Methods

The study included 100 consecutive patients underwent DVR for combined rheumatic aortic and mitral valve diseases, between June 2016 and November 2020. Only (50) patients had ARE with DVR. ARE was performed using an autologous or bovine pericardium or Dacron patch by Nick's or Manouguian procedures. The estimated post-operative end-points were mortality, effective orifice areas (EOA), mean aortic pressure gradient and valve-related complications. The least post-operative follow-up period was 6 months.

Results

The study included 30 male and 70 female patients with mean age of 45 ± 10 years, body surface area (BSA) of 1.6 ± 0.50 m², aortic annulus diameter was 20 ± 0.4 mm, EOAI was 0.80 ± 0.50 cm²/m², and aortic mean gradient (PG) 80 ± 40 mm Hg. During follow-up period, there was a mild paravalvular leak (1%) with, (1%) heart block, and residual mean PG on prosthetic aortic valve with all cases of DVR alone.

Conclusion

Enlargement of aortic root by Nick's or Manouguian technique is safe and effective in patients with small aortic annulus undergoing double valve replacements.

Introduction

Rheumatic Heart Disease (RHD) is very common in developing countries. It affects mainly mitral and aortic valve. It causes annular fibrosis, may be lead to smaller AA. So, if smaller prosthesis is implanted, there may develop PPM, poor Left Ventricle (LV) mass regression, increases overload, and low survival rate. With undersized prosthetic valve, patient can't maintain normal activity; produce symptoms of aortic stenosis (AS) and PPM. Rahimtola first described the issue of PPM, if the EOA of prosthetic valve is very small in relation to patient's BSA [1–2]. Nicks and colleagues first proposed posterior root enlargement in 1970. The Nicks technique facilitated placement of a larger size aortic valve prosthesis by extending the

aortotomy posteriorly through aortic sinus across the aortic ring and inserting a patch to augment the annulus [3].

Severe PPM according to the valve's EOA indexed (EOAi) [$EOAi < 0.85 \text{ cm}^2/\text{m}^2$] is associated with worse hemodynamic and clinical outcome [4]. PPM is a predictor of mortality and it can be responsible for post-operative high transvalvular mean PG. ARE allows for larger prosthesis implantation, consequently avoiding PPM. Despite these potential benefits of ARE, it has not been widely performed by cardiac surgeons, fearing of an increased risk of mortality and morbidity [5–6–7].

Cardiac surgeons performing AVR, in case of small AA, should be familiar with techniques of ARE to allow insertion of appropriate-sized prostheses and to avoid PPM. When ARE is performed properly by an experienced cardiac surgeon, it is safe and reproducible [8]. So, nowadays surgeons prefer to do ARE to get rid of PPM and to obtain optimum hemodynamics [1–2].

Methods

Demographic, intraoperative, and outcome data were collected retrospectively cohort comparative study on patients undergoing DVR with or without ARE at a multicenter institutions between July 2016 – November 2020. Those patients with pure or predominant aortic valve stenosis have been included in the study. One-hundred patients with small AA were performed DVR, only (50) patients were underwent ARE with DVR. The other (50) patients underwent DVR without ARE by less experienced junior surgeons. Mean age was 45 ± 10 years. Operative death and residual gradient on prosthetic aortic valve (AV) were evaluated. **Inclusion criteria:** Adult patients had RHD with small AA underwent DVR with or without ARE. **Exclusion criteria:** Patients were underwent Isolated AVR, DVR due to non-RHD, and associated procedure other than DVR. Also, Children, renal failure, redo, or emergency cases were not included.

A median sternotomy was performed, and cardiopulmonary bypass (CPB) with systemic cooling to $32 \text{ }^\circ\text{C}$ was routinely used. After the aorta is cross-clamped (ACC) and the heart is arrested by means of intermittent, antegrade cold blood cardioplegia directly delivered into coronary ostia. The decision to maximize aortic root was made after intra-operative assessment of AA. After excision of aortic leaflets and debridement of its annulus, it was sized. If it was not admitting appropriate-sized prosthesis suitable to age and BSA, [$EOAi \leq 0.85 \text{ cm}^2/\text{m}^2$] aortotomy incision is extended into the fibrous trigone between NCS and LCS [**Manouguian**]. Then, it may be extended somewhat more posteriorly than usual through the region of the native commissure above the midpoint of the anterior leaflet of the mitral valve. The depth of the incision into LA and mitral valve is determined by the amount of enlargement necessary but can extend for a distance of 4–8 mm. The incision into the roof of the left atrium is closed with pledgeted sutures.

Nick's maneuver enlarges the annulus by cutting into the nadir of NCS. This incision reconstructed using a tear drop shaped patch of autologous pericardium [Pericardial patch was harvested and fixed with glutaraldehyde] or bovine pericardium or Dacron patch. Patch was sutured with 4/0 polypropylene

starting at the nadir of annular enlargement incision and extending up to 2–3 cm above the plane of annulus.

We commonly used autologous pericardial patch, however the others patches were used according to availability. Also, we commonly used Nick's procedure as we are well trained and our experience to do it. My college had more experience on other techniques of ARE and recorded (5) case with Manouguian procedure. There was a single echocardiographer for this study and the echocardiograms were performed using a standard protocol.

After replacing the mitral valve, AA was resized and appropriate valve was chosen. We use a non-everting, horizontal mattress technique of 2/0 polyester were placed on annulus. Pledgeted sutures were placed in the plane of annulus where patch enlargement was performed with pledgets resting on outside of the patch. After replacing the valve patch, it was sutured to aortotomy margins using 4/0 polypropylene.

In cases of DVR without ARE, we had started to implant AV after MVR. So, AA gets the size of the valve that it deserves unrespect to BSA and EOAI. For better hemodynamic effect, we prefer to implant prosthetic AV in anteroposterior direction. We prefer to implant prosthetic mitral valve in anatomical position, so that struts of aortic valve do not impinge upon MV, which is already in position.

Figure (1,2,3)

The statistical analysis was performed using the SPSS software package (version 20.0; SPSS Inc., Chicago, IL, USA). The analyzed data were expressed as number (N), percentage (%), mean (M) and standard deviation (SD) or as proportions. P-value < 0.05 was considered statistically significant.

Results

Table (1), Table (2)

Post-operative Echocardiogram (TTE) before discharge showed acceptable mean gradients across aortic valve in all cases with ARE, however there are PMM with different levels on aortic valve in all cases without ARE.

Table (3)

The duration of ACC is slightly longer by approximately 10 min compared to routine DVR; it didn't make a significant difference in over-all management of patient. There is no incidence of intra-operative or post-operative bleeding, no excessive requirement of blood products. There was mild paravalvular leak in 1% and heart block in 1% in DVR without ARE.

Table (4)

The mean valve size was (21.5 ±1.6 mm) in only DVR group versus (23.2 ±2.3 mm) in DVR with ARE group (0.001 ≥ p value). With root enlargement one- two size bigger was replaced in 50 patients and PPM

was eliminated in all patients. Nick's was performed in (45) cases and Manouguian in (5) cases. Type of patches were used autologous pericardium in (35) cases, Dacron in (12) cases, and Bovine in (3) cases. There were no operative or in hospital mortality.

Discussion

Patient's age and activity can be considered for calculating cardiac output demand; young people with active life style will require larger prostheses for a higher cardiac demand. Since implanting a small-sized valve can worsen outcome due to increased preload [2]. This study was undertaken to review our strategy and feasibility of ARE in patient underwent DVR to avoid PPM without increase in morbidity or mortality especially in young patients (age 45 ± 10).

In patients with a small AA, it is difficult to implant large valve prostheses. PPM is the immediate consequence of this situation [6]. We observed high variable pressure mean gradient across aortic prosthesis with DVR alone (postoperative PG 25.9 ± 5.8).

Rheumatic heart diseases usually affect left heart valves requirement DVR. Small AA is a big problem facing cardiac surgeons in AVR especially with DVR. Most of the patients also have tricuspid valve disease, atrial fibrillation and severe LV dysfunction, that add risk factors on hemodynamics if ARE did not performed. So, there is still debated whether implant small prosthesis or ARE to avoid increasing morbidity or mortality. [9]. In our study, preoperative risk factors were not obstacles to do ARE, however, these factors may be worse with PPM.

ARE techniques can be performed simply and modified without complexity to get benefit and avoid complications. So, that is an alternative to implantation of too small prosthesis, ARE may actually reduce mortality [10]. Our study used to perform Nick's procedure or its modification to implant larger prosthesis without increasing risk of technique even in junior surgeons.

There have been only a few studies on ARE during DVR. Some studies have only small number of patients of non-Rheumatic etiology and others are case reports. ARE during DVR is enlarging AA without increase in operative mortality; however it is at expense of prolonged CPB time [10]. That is encouraging us to collect data for comparison between two groups of DVR with/out ARE, and motivate cardiac surgeons to do ARE, if needed to avoid PPM. ARE itself does not increase operative risk. Surgeons should not be reluctant to enlarge the aortic root to permit implantation of adequately sized valve prostheses.

ARE requires some technical skills, and should not increase operative risk. So, it is possible to implant valve 1–2 sizes larger than the native annulus [4]. We observed in the study no incremental risk in mortality or adverse events after surgical ARE compared with AVR alone.

Most surgeons prefer to use a small aortic prosthesis instead of expanding the annulus. Yet the use of a small aortic prosthesis may be associated with obstruction of left ventricular output, resulting in a higher PG and PPM. Studies have demonstrated that mortality was higher in patients receiving a small aortic

prosthesis [11]. So, ARE is a safe procedure with expert surgeon and should be considered at the time of AVR even with DVR to avoid PPM.

Surgical ARE has not been widely performed by cardiac surgeons, because of concerns regarding the possible increased risk of early mortality and morbidity [4]. In our study, ARE seems to be safe and did not increase morbidity and mortality.

Conclusion

Aortic root enlargement can be safely done in patients undergoing double valve replacement with benefit of bigger size prosthesis without additional mortality and morbidity.

Abbreviations

aortic root enlargement, **DVR**: double valve replacement, **AV**: aortic valve, **AVR**: aortic valve replacement, **AA**: Aortic Annulus, **ACC**: Aortic Cross Clamp, **NCS**: Non Coronary Sinus, **LCS**: Left Coronary Sinus, **LV**: Left Ventricle, **RHD**: rheumatic heart disease, **PPM**: Prosthesis Patient Mismatch, **EOA/i**: Effective Orifice Area/ indexed, **RHD**: Rheumatic Heart Disease, **BSA**: Body Surface Area, **PG**: Pressure Gradient, **EF**: Ejection Fraction, **CPB**: Cardio Pulmonary Bypass, **Ao. /CC time**: Aortic Cross Clamp/ time, **MV**: Mechanical Ventilation, **HB**: Heart Block, **LCO**: Low Cardiac Output, **COPD**: Chronic Obstructive Pulmonary Disease, **CAD**: Coronary Artery Disease, **DM**: Diabetes Mellitus, **HTN**: Hypertension, **AF**: Atrial Fibrillation, **AS**: Aortic Stenosis, **TTE**: Trans Thoracic Echography.

Declarations

Ethics approval and consent to participate

Patient confirms that have read and understood the information about the research as provided in the participant information sheet inside his file.

The study has got the formal approval and permission from Minia cardiothoracic surgery department

[Cardiothoracic surgery department section council was 5/2016 and approved NO. 277-5 / 2016] before to start the study. The study conformed to the principles of "Declaration of Helsinki" and the investigator followed the appropriate safeguards regarding the rights and welfare of the human participants that have been included in the performed study.

Consent for publication

It was obtained written consent from patients.

Availability of data and material

It is available from recording files and data at cardiothoracic surgery departments and cardiology clinics for follow up.

YM analyzed and interpreted the patient data. **AA** performed cases of Manouguian with DVR cases. **YS** performed most of ARE with Nicks technique. **YS** was writing the manuscript. **AA** have drafted the work or substantively revised it. **All** read and approved the final manuscript

Competing interest

None to declare

Funding: None

References

- 1- Ahsan M, Rahman L, Shariful A, Arifur M.** Case Report: Aortic Root Enlargement In Case of Double Valve Replacement. *KYAMC Journal.*2020; 11(2): 108-10.
- 2- Maheshwari A, Gupta R, Saha D, Naqvi SEH, Minhas HS, Geelani MA.** Konno Procedure for Managing Small Aortic Root during Aortic Valve Replacement Surgery: An Experience of 12 Cases. *W J Cardiovasc Surg.* 2020; 10: 24-31.
- 3-Grubb KJ.** Aortic Root Enlargement during Aortic Valve Replacement: Nicks and Manouguian Techniques. *Operative Techniques in Thorac Cardiovasc Surg.* 2016; 20: 206-18
- 4- Rocha RV, Manlhiot C, Feindel CM, Yau TM, Mueller B, David TE, et al.** Surgical Enlargement of the Aortic Root Does Not Increase the Operative Risk of Aortic Valve Replacement. *Circulation.* 2018; 137:1585–94.
- 5- Sa´ MPBO, Carvalho MMB, Filho DC, Cavalcanti LRP, Diniz RGS, Rayol SC, et al.** Impact of surgical aortic root enlargement on the outcomes of aortic valve replacement: a meta-analysis of 13174 patients. *Interact CardioVasc Thorac Surg.* 2019; doi:10.1093/icvts/ivy364.
- 6-Timala RB.** How I do it" Aortic Valve Replacement in case of Double Valve Replacement. *NHJ.* 2010; 7(1):50-53.
- 7-Fuster RG, Argudo JA, Albarova OG, Sos FH, Lo´pez SC, Codon˜er MB, et al.** Patient-prosthesis mismatch in aortic valve replacement: really tolerable? *Euro J Cardiothorac Surg.* 2005; 27: 441–49.
- 8-Feindel CM.** Aortic Root Enlargement in the Adult. doi:10.1053/j.optechstcvs.2006.03.002 .
- 9-Muppiri VK, Ali SN, Venkat KR, Rama KL.** Aortic root enlargement in patients undergoing double valve replacement for rheumatic etiology–preliminary results. *Indian J Thorac Cardiovasc Surg.* 2011; 27(4):161–64.

10-Sundt TM. Patch Enlargement of the Aortic Annulus using the Manouguian Technique.
doi:10.1053/j.optechstcvs.2006.03.003.

11-Wang B, Yang H, Wu S, Cao G, Yang H. Obesity and the risk of late mortality after aortic valve replacement with small prosthesis. *J Cardiothorac Surg.* 2013; 8: 174 - 75.

Tables

Table (1):- Demographic data, pre-operative risk factors.

Variable	DVR alone (N=50)	DVR with ARE (N=50)	
Age	Mean 42±6	Mean 45±10	
Gender	65% female	70% female	
BSA	1.6±0.5 m ²	1.8±0.6m ² [average 1.37 m ²]	
NYHA class			
I	5.9%	4.1%	
II	19.8%	15.9%	
III	60.4%	68.5%	
VI	13.9%	11.5%	
AF	20%	30%	
Bicuspid aortic valve	1%	2.5%	
PVD	No	No	
COPD	No	No	
LCO	No	No	
HTN	No	0.5%	
DM	No	2.5%	
s/p MI or CAD	No	No	
Smoking	5%	10%	
Stroke and TIAs	No	No	
Aortic lesion			
Stenosis	18.4%	34%	P-value ≤0.0001
Insufficiency	10.8%	3.7%	0.0002
Mixed	70%	61.6%	0.0069

Table (2):- Pressure gradient and EF.

Variable	DVR alone.	DVR with ARE
Preop. mean PG (mmHg)	75±3.5	85 ± 0.5
Postop. mean PG (mmHg)	25.9 ± 5.8	15 ± 2.3
EF (%) Postop.	45 ± 4.7	55 ± 5.9

Table (3):- Postoperative data

Variable	DVR alone	DVR with ARE
CPB time (minutes)	117±43	133±49
ACC time (minutes)	92±35	105±39
Postop. LCO	No	4%
Bleeding and re-exploration	No	No
Blood product requirement	2±1.5	3±2.3
Duration of MV (hr.)	12 ± 6	18 ± 6.4
Infection		
SSWI	1.5%	3%
Pneumonia	No	0.5%
Heart Block (HB)	1%	No
Paravalvular Leak (PVL)	1%	No
ICU Stay (days)	3 ± 1.8	4 ± 2.3
Total Hospital Stay (days)	10 ± 5.1	12 ± 7.2

Table (4):- size of prosthetic valves

Variable	AVR alone	AVR with ARE
Prosthetic aortic valve	19 – 21	21 – 23 - 25
Prosthetic mitral valve	25- 27	27 – 29

Figures



Figure 1

Nick's procedure by incision of non-coronary cusp

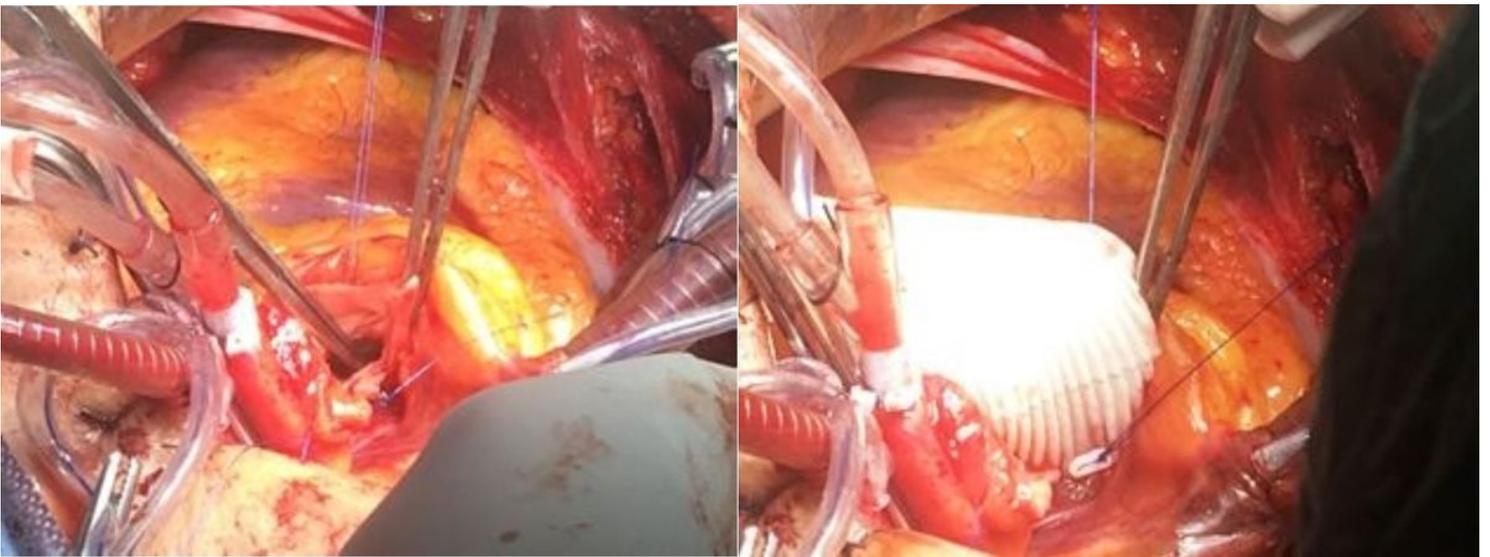


Figure 2

Patch suture started at angle of incision



Figure 3

Complete patch suture and suture for valve taken