*Original Article*

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# Strategy to Avoid Patient Prosthesis Mismatch: Role of Aortic Root Enlargement in the Current Scenario

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**Abstract**

*Background:* The choice of valve with an Effective Orifice Area (EOA) and design material providing efficient hemodynamics is an important factor affecting the Quality of Life (QOL) in patients who are going through the aortic valve replacements. The aim of our study was to evaluate non–dyspenic life without any complications of heart failure with different types of available mechanical valve prosthesis irrespective of Body Surface Area (BSA) of patients. *Materials and Methods:* Our preventive strategy was to implant a larger prosthetic valve in aortic position by using suitable types of mechanical a prosthesis to avoid the patient's severe Prosthesis Mismatch (PPM). The decision to enlarge the aortic root was taken only when 17 mm sizer could not be easily placed through the aortic root. We reviewed the clinical outcomes and complications in 21 patients who underwent aortic valve replacements done by a single surgeon from January 2018 to May 2019. *Results:* The patient's age ranged from 13–57 years with male predominance (71.42%). Majority of our patients (80.16%) had NYHA class III symptoms at initial presentation while 19.04% had class IV symptoms. The preoperative echocardiography data were in the following range: aortic annulus diameter (17-24 mm), aortic valve areas (0.6-1.58 $cm^2$), peak and mean gradients (72–131 mmHg, 18-64 mmHg), Left ventricle mass index (LVMI= 68-176 $gm/m^2$). PPM was moderate in 71.425% of cases and severe in 19.04% of cases. The aortic root enlargements (Nunez Procedure) were done in 9.52% of cases. The postoperative and follow-up echocardiography data were in the following range: peak and mean gradients (13–31 mmHg, 9–16 mmHg), EOA (1.1–3.02 $cm^2$) Left ventricle mass index (LVMI= 26.4-114 $gm/m^2$). *Conclusion:* In our study, we found that with the availability of newer generations of mechanical aortic valves having thinner sewing rings and supra-annular position with better orifice areas reduce the incidence of PPM and avoid the complications of the aortic root enlargement without compromising the Quality of Life (QOL) of patients. LV regression showed a positive correlation with the reduction of the mean aortic gradient achieved by AVR. AVR caused significant LV regression in all patients irrespective of the presence of PPM.

**Keywords:** Aortic Stenosis; Patient prosthesis mismatch; Aortic valve replacement; Aortic root enlargement; Left ventricle mass index.

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## Introduction

Aortic stenosis is the third commonest cardiovascular disease and the commonest valvular heart disease in the developed world. In India, presently, it is the third commonest valvular heart disease after mitral stenosis and mitral in

competence. The term Prosthesis Patient Mismatch (PPM) was coined by Rahimtoola[1] in 1978. The ratio of EOA and BSA is called an indexed Effective Orifice Area (iEOA). By the current definition of PPM, Effective Orifice Area Ondexed (EOAI) $\leq$0.65 $cm^2/m^2$ is severe and 0.65–0.85$cm^2/m^2$ is moderate PPM. A potential problem in Aortic Valve Replacement (AVR) for patients with a small aortic annulus is PPM. The newer available mechanical prosthesis and their unique designs are conceived to increase effective orifice area and prevent PPM. Root enlargement procedures like Yamaguchi, Konno, and Manouguian may allow a prosthesis that is two sizes bigger than what the annuals would otherwise have accommodated (Figure 1). A supra-annular placement may allow a somewhat bigger valve to be seated. Oversizing of the valve is fraught with dangers of LV rupture, heart block, circumflex compression, LV outflow tract obstruction and pulmonary veins stenosis.

## Materials and Methods

Our preventive strategy was to implant a larger prosthetic valve in aortic position by using suitable types of the mechanical prosthesis to avoid severe patient's prosthesis mismatch. The decision to enlarge the aortic root was taken only when the 17-mm the sizer could not be easily placed through the aortic root. We reviewed the clinical outcomes and complications in 21 patients who underwent aortic valve replacements are done by a single surgeon (techniques of implantation of the valve after complete excision of the diseased aortic valve and were used 2-0 pledegetted ethibond everted sutures) from January 2018 through May 2019. The group excluded patients who underwent AVR with concomitant procedures.

## Results

The patient's age ranged from 13–57 years with male predominance (71.42%). The majority of our patients (80.16%) had NYHA class III symptoms at initial presentation while 19.04% had class IV symptoms (Figure 2,3). The preoperative echocardiography data were in the range-aortic annulus diameter (17–24 mm), aortic valve areas (0.6–1.58 $cm^2$), peak and mean gradients (72–131 mmHg, 18–64 mmHg), Left ventricle mass

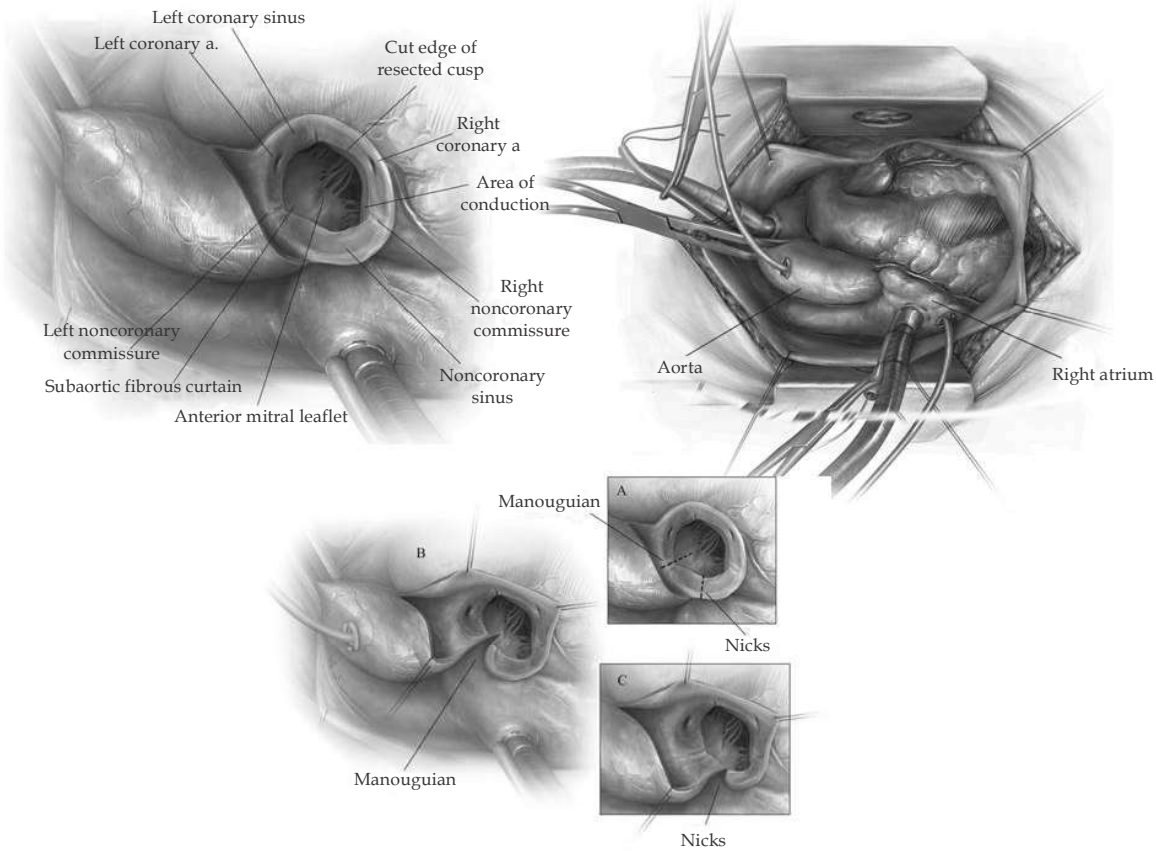


**Fig. 1:** Aortic Root Enlargement.

index (LVMI= 68–176 gm/m$^2$) (Figure 6). PPM was moderate in 71.425% of cases and severe in 19.04% of cases. The aortic root enlargements (Nunez Procedure) were done in 9.52% of cases. The range of cardiopulmonary bypass time and cross-clamp time in aortic root enlargement was 396–402 minutes and 302–350 minutes while in other patients it was in the range of 116–176 minutes and 95–157 minutes respectively (Fig. 4). The most common size of the mechanical prosthetic aortic valve was in the range of 17–19 mm (Fig. 7). The postoperative and follow-up echocardiography data were in the range-peak and mean gradients (13–31 mmhg, 9–16 mmHg), EOA (1.1–3.02 cm$^{2)}$ Left ventricle mass index (26.4–114 gm/m$^2$). By upsizing the aortic valve prosthesis after complete excision of the diseased valve and using a newer generation prosthetic valve we were able to reduce PPM from moderate to mild in 71.42% cases and severe to moderate in 9.52% cases (Fig. 5). The mortality was 9.52% of cases. On follow-up, the non-dyspenic life was achieved in 90.47% of cases (Fig. 8).

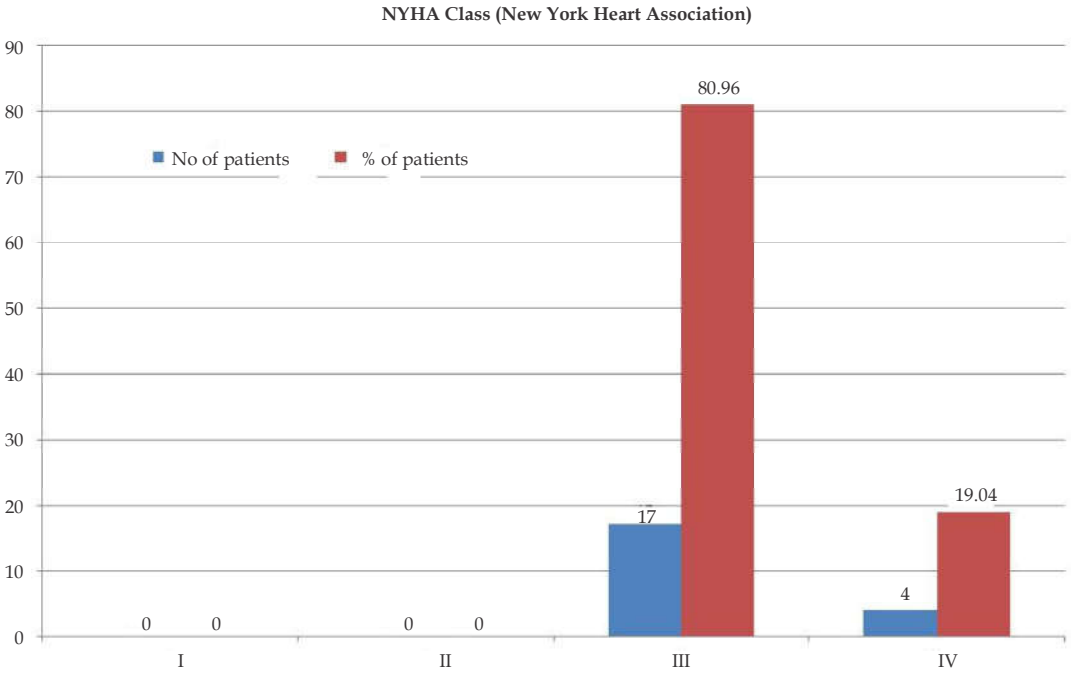


**Fig. 2:** NYHA Class of patients.

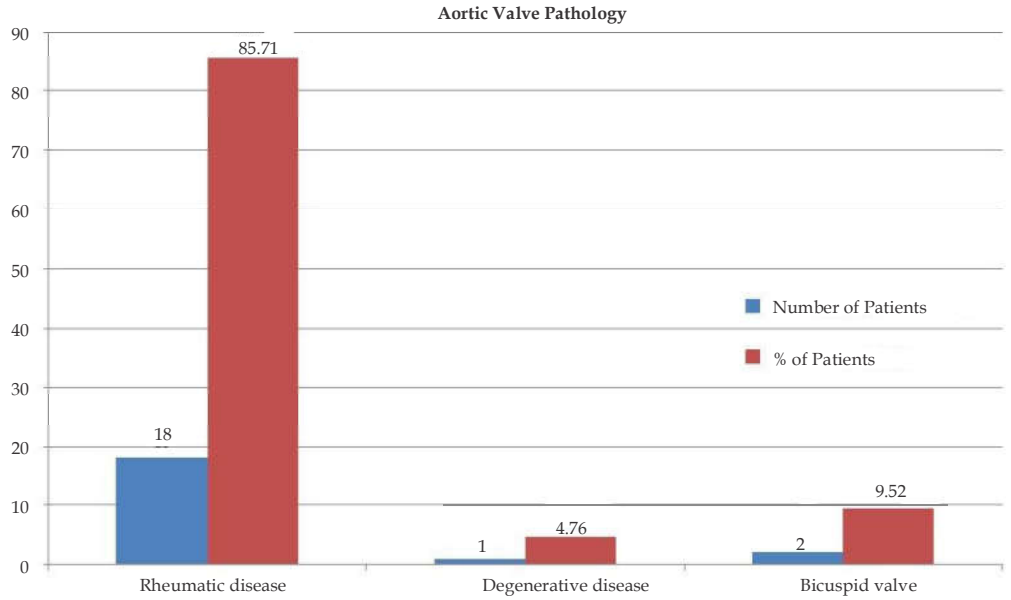


**Fig. 3:** Pathology of valve.

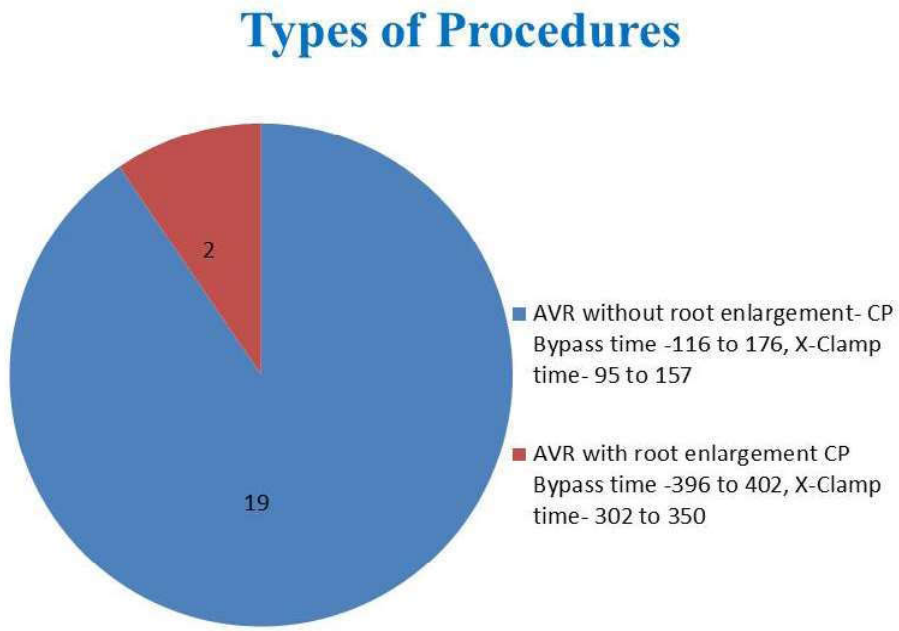


**Fig. 4:** Type of Procedure.

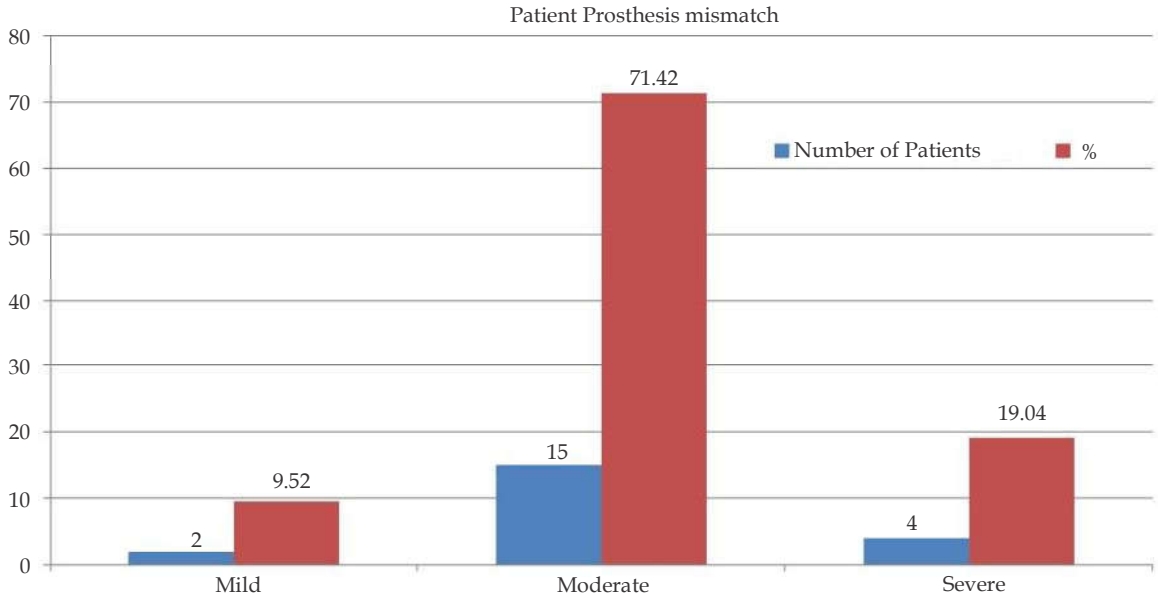


**Fig. 5:** PPM

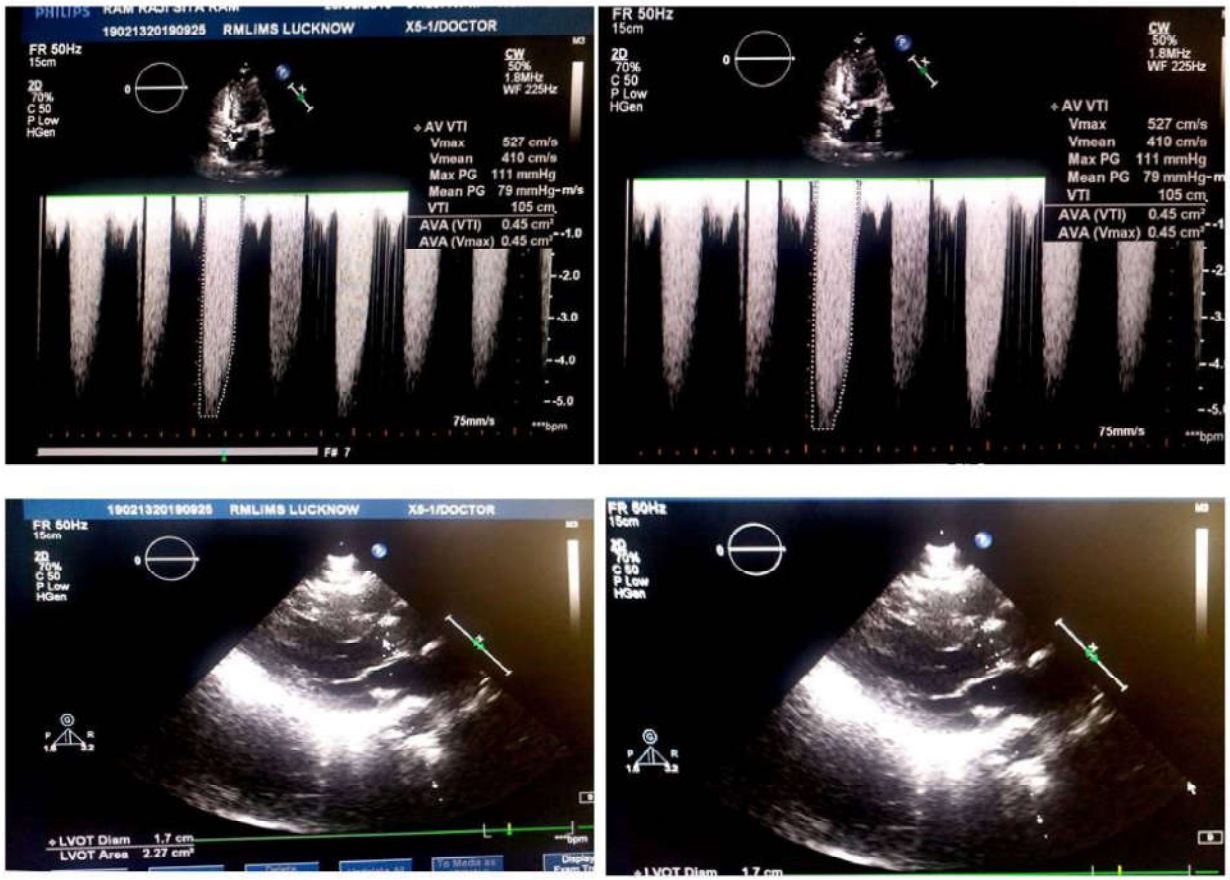


**Fig. 6:** Preoperqative Echocardiography.

**Fig. 7:** Type of prosthesis used at aortic position.

| Serial No. | Valves at aortic Position (Mechanical Prosthetic) | N= Number of patients | PG (mmHg) | MG (mmHg) | EOA (cm2) | LVMI (gm/m2) |
|---|---|---|---|---|---|---|
| 1 | TTK Chitra valve size | | | | | |
| | 17 mm | 02 | 27–31 | 14–16 | 1.1–1.2 | 00 |
| | 19 mm | 05 | 24–26 | 12–15 | 1.2–1.4 | 58–114 |
| | 21 mm | 04 | 20–24 | 11–14 | 1.6–1.9 | 42–62.3 |
| | 23 mm | 02 | 13–16 | 09–11 | 2.0–2.2 | 24.2–26.6 |
| 2. | St Jude master series | | | | | |
| | 17 mm | 01 | 22 | 10 | 1.3 | 63.5 |
| | 19 mm | 05 | 16–22 | 09–13 | 1.4–1.5 | 44.7–54.2 |
| 3. | Medtronic valve | | | | | |
| | 18 | 01 | 23 | 11 | 1.98 | 40.3 |
| | 22 | 01 | 14 | 09 | 3.02 | 26.4 |

PG = Peak Gradient, MG= Mean Gradient, EOA= Effective Orifice Area, LVMI= Left Ventricle Mass Index

**Complications**

| | |
|---|---|
| Prolonged ventilation (>24 hours) | 01 (4.76%) |
| Neurological events | 00 |
| Respiratory failure | 01 (4.76%) |
| Valve related events | 00 |
| Mortality | 02 (9.52%) |

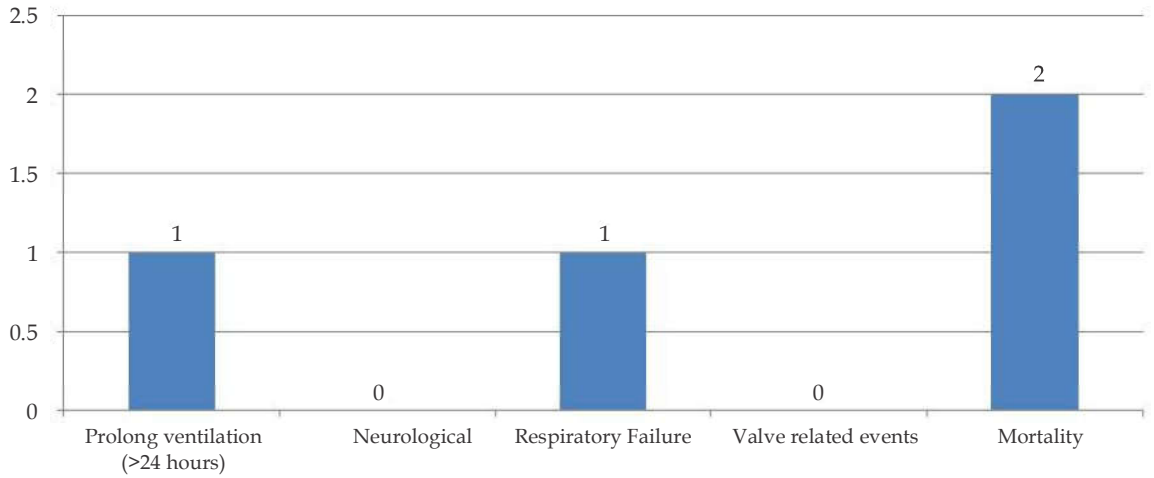


**Fig. 8:** Complications after procedure.

## Discussion

The aortic valve replacements in patients with small aortic root now depend on believers and nonbelievers of cardiac surgeons. Most of them have several reasons other than that of the scientific evidence in consideration of the Patient's Prosthesis Mismatch (PPM). The society of the Thoracic Surgeons database shows that up to two-thirds of the patients undergoing AVR seem to be affected by PPM. Body Surface Area (BSA) is a surrogate for the expected cardiac output which would be passing through this valve. Studies have shown that the metabolically active tissues are more important than adipose tissue, and hence, the obese people have a lesser chance of developing PPM as they have a higher BSA but less metabolically active tissue. Abid et al.[2] did a retrospective observational study in 91 patients who underwent AVR for severe aortic stenosis. They concluded that the incidence of PPM was found to be comparable to literature. There is a positive correlation between left ventricular regression and indexed EOA of the prosthetic valve. Left ventricular regression was significantly higher in patients with an indexed EOA of more than 0.75. Takaseya et al.[3] studied in 11 women aged 70 years or older who underwent AVR with a 17-mm Regent prosthesis (St Jude Medical, St Paul, MN). Preoperative echocardiography showed a mean indexed EOA of 0.33 +/− 0.14 $cm^2/m^2$ and a LVMI of 175 +/− 63 $g/m^2$. A significant increase in the mean indexed EOA (0.87 +/− 0.10 $cm^2/m^2$) and regression of LVMI were found (114 +/− 46 $cm^2/m^2$) on postoperative echocardiography. They concluded that AVR in elderly patients with small aortic roots (less than 19 mm) using a 17-mm Regent prosthesis showed satisfactory clinical and hemodynamic results without any mortality. Srivastava et al.[4] described that their preventative strategy was to implant a larger prosthetic valve by aortic root enlargement using the Nunez procedure in 17 patients. The decision to enlarge the aortic root was taken when the 19-mm sizer could not be easily placed through the aortic root. Postoperative reductions in peak and mean pressure gradients across aortic valve were 12.8–16.5 and 10.2–12.6 mm Hg, respectively and were able to eliminate PPM in 5 patients and reduce severe PPM to moderate in 11 patients. They concluded that aortic root enlargement is a safe procedure. Therefore, cardiac surgeons should not hesitate to enlarge the aortic root with an autologous pericardial patch to permit implantation of the adequate size of the aortic valve prosthesis, with minimal additional aortic cross-clamp time and no added cost. Johannes M Albes et al.[5] did mechanical AVR for combined stenosis and regurgitation was performed in 47 patients with standard CarboMedics

prostheses and two types of diameter enhanced St. Jude Medical prostheses and compared these valves with standard bileaflet prostheses in vivo. They concluded that in patients with a small aortic annulus, who require a 21-mm valve, diameter-enhanced prostheses provide lower transvalvular gradients than conventional valves. However, in the intermediate clinical course, appropriate left ventricular remodeling occurred in all patients independent of the size and the type of the valve. Bottio et al.[6] analyzed the in vitro hydrodynamics of 5 currently available bileaflet mechanical prostheses that fitted a 21-mm diameter valve holder of a Sheffield pulse duplicator. Assuming that the 21-mm valve holder in which all the tested prostheses were accommodated is comparable with a defined aortic valve size. This hydrodynamic evaluation model allowed us to compare the efficiency of currently available valve prostheses, and among these, the SJM Regent and the Sorin Bicarbon Slimline exhibited the best performances. Pibarot et al.[7] used indices to predict mismatch were valve size, indexed internal geometric area and projected indexed EOA calculated at the time of operation, and results were compared with indexed EOA and mean gradients measured by Doppler echocardiography after the operation in 396 patients. They concluded that the projected indexed EOA calculated at the time of operation accurately predicts mismatch as well as resting and exercise postoperative gradients, whereas valve size and indexed internal geometric area cannot be used for this purpose. Okamura et al.[8] investigated the outcomes of isolated AVR performed with a 17-mm mechanical prosthesis in patients with aortic stenosis. They found that 23 patients with aortic stenosis underwent isolated aortic valve replacement with a 17-mm St. Jude Medical Regent prosthesis. Preoperative echocardiography yielded a mean aortic valve area of 0.36 +/− 0.10 $cm^2/m^2$, a mean left ventricular-aortic pressure gradient of 68.4 +/− 25.3 mmHg and a mean LVMI of 200 +/− 69 $g/m^2$. Echocardiography at 14.0 +/− 10.0 months after AVR showed a significant increase in the mean EOA index (0.95 +/− 0.24 $cm^2/m^2$), decrease in the mean left ventricular-aortic pressure gradient (17.4 +/− 8.2 mm Hg), and the decrease in the mean LVMI (124 +/− 37 $cm^2/m^2$). PPM (effective orifice area index < 0.85 $cm^2/m^2$) was present in 8 patients at discharge. In these patients as well as in those patients without PPM, the left ventricular mass index decreased significantly during follow-up. They concluded that AVR with a 17-mm Regent prosthesis seems to provide adequate clinical and hemodynamic results in patients with the small aortic annulus. Significant left ventricular mass regression was achieved during follow-up irrespective of the effective orifice area index at the time of discharge. Mohty et al.[9] designed a study to evaluate the effect of the valve of PPM on late survival after aortic valve replacement and to determine if this effect is modulated by patient age, body mass index, and preoperative left ventricular function. The indexed valve EOA was estimated in 2,576 patients having survived AVR and was used to define PPM as not clinically significant if it was >0.85 $cm^2/m^2$, as moderate if >0.65 and < or =0.85 $cm^2/m^2$, and severe if < or =0.65 $cm^2/m^2$. They found that moderate PPM is linked with an increase in late mortality in patients with LV dysfunction, but with normal prognosis in those with preserved LV function. Eric Jamieson et al.[10] did a study to determine the predictors of mortality after AVR and the influence of PPM on survival. Contemporary mechanical prostheses and bioprostheses were implanted in 3,343 patients with AVR. Their conclusion was that PPM doesn't predict overall standard unadjusted mortality to 15 years after AVR, regardless of the category of the EOA index. Pibarot et al.[11] updated the concept of aortic PPM to review the present knowledge with regard to its impact on hemodynamic status, functional capacity, morbidity, and mortality and they proposed a simple approach for prevention and clinical management of PPM because it can be largely avoided if certain simple factors are taken into consideration before the operation.

In the review of above literature, we found in our study that by upsizing the aortic valve prosthesis by complete excision of the diseased valve and using a newer generation prosthetic valve were able to reduce PPM from moderate to mild in 71.42% cases and severe to moderate in 9.52% of cases. The mortality was in 9.52% of cases. On follow-up, the non-dyspenic life of patients was in 90.47% of cases. Quality of life is dependent on the profession and the age of patients. Age, gender, or BSA did not influence the occurrence of PPM. LV regression showed a positive correlation with the reduction of the mean aortic gradient achieved by AVR. AVR caused significant LV regression in all patients irrespective of the presence of PPM. The clinical implication of LV regression considering EOA 1.1 $cm^2$ is the limit of PPM in our study.

## Conclusions

In our study, we found that with the availability of newer generations of mechanical aortic valves

having thinner sewing rings and supra-annular a position with better orifice areas were reduced the incidence of PPM. It also helped avoid the complications of aortic root enlargement without compromising the quality of life of patients. We also found that the Surgeon's skill and experience are very important in decision making in aortic valve surgery and aortic root enlargement is rarely necessary.

### *Declarations*

*Author's contributions:* All the authors have contributed to the article.

*Source of data and materials:* The data is taken retrospectively from hospital records.

*Financial support and sponsorship:* No financial support or sponsorship has been obtained.

*Conflict of Interest:* None

This paper was presented in 39th annual cardiothoracic surgery symposium October 9-13 San Diego, California, USA.

### *Limitation of the study*

1. The sample size was small.
2. The duration of the study was short.

### *Source of photo*

1. An operative technique in thoracic and cardiovascular surgery Autumn 2015 Volume 20, Issue 3, Pages 206–218 Aortic Root Enlargement During Aortic Valve Replacement: Nicks and Manouguian Techniques.
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