Original article:

Evaluation of patient prosthetic aortic valve mismatch by Echocardiography

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Abstract:

Objective: Evaluation of Patient Prosthetic Mismatch (PPM) & factors causing PPM in patient & to study the adverse effects of patient prosthetic mismatch.

Methods: 33 Patients admitted for AVR (Prosthetic Mechanical valve ) for severe Aortic stenosis, preoperatively, in wards, on 7th day, post Operative & Six month post in operatively in OPD.

Results: - BSA, Age, gender & LV function of patient had no impact & prosthetic valve size found no difference in severity of PPM. In Mild PPM there was decrease in LV wall & septum thickness, which was not observed in severe PPM.

Conclusion: Severe PPM may result in slight increase in operative mortality and especially in setting of LV dysfunction. Severe PPM done not adversely effect short term survival. PPM may be avoided or its severity reduced with the use of preventable strategy at the time of surgery.

Introduction:

Our objectives were to evaluate of patient prosthetic Aortic valve mismatch (PPM) in Indian subjects and to determine the factors causing patient prosthetic Aortic valve mismatch (PPM) with to study adverse effects of patient prosthetic Aortic valve mismatch (PPM).

Material & methods:

The study was prospective study over two and half years. Patients undergoing aortic valve replacement (mechanical prosthetic valve) for aortic stenosis in MGM MEDICAL COLLEGE & HOSPITAL over two and half years are included in the study. This study was started after due approval from institutional ethics and scientific committee.


Inclusion Criteria:

As per ACC/ AHA guidelines - pure aortic stenosis (AVA < 1 cm², Mean gradient across aortic valve > 40 mmHg)

• Patients having severe aortic stenosis – symptomatic.
• Asymptomatic severe aortic stenosis undergoing CABG.

Exclusion Criteria:

• Moderate and severe aortic regurgitation.
• Double valve replacement / repair or triple valve replacement / repair surgery.
• Undergoing aortic bioprosthetic valve replacement.
• Age - younger than 18 years at the time of AVR.
Data was collected from patients admitted for aortic valve replacement (prosthetic mechanical valve) for severe aortic stenosis preoperatively in wards, on 7th day postoperatively in wards and in 6th month postoperatively in outpatient department.

Adult patients more than 18 years old suffering from severe aortic stenosis undergoing aortic valve replacement (prosthetic mechanical valve only) included in this study. Patients included were male and female, from rural as well as urban areas. Children were not included. Total 33 patients included in this study.

Total 33 patients underwent aortic valve replacement (prosthetic mechanical valve only). All patients included in the study.

Data was collected from admission to discharge and on follow up prospectively. Data was entered in the written proforma. A detailed history was taken and physical examination was done in all patients. Body surface area measured before surgery. Surgical profile was done before AVR. Aortic annulus, valve calcification, AVA by continuity equation, pressure gradients across aortic valve, LV dimension measured before surgery. Before surgery, EOA of prosthetic valve as given by manufacturer was indexed to BSA. If IEOA is less than 0.85 cm²/m², that means moderate PPM is expected. So took prosthetic valve of larger size, so that IEOA should be more than 0.85 cm²/m², that means mild PPM or no PPM which is accepted.

On 7th day and follow up 6 month IEOA calculated.

Echocardiography: 2D Echo test was done before surgery, 7th postoperative day and in sixth month of surgery.

All examinations were performed by a single dedicated and experienced echocardiographer. Echocardiography was carried out using GE VIVID S5 - machine.

In echocardiography laboratory, the EOA was derived from the continuity equation, using the area of the left ventricular outflow tract (LVOT) and the time-velocity integral (TVI) of the LVOT and the prosthesis, as follows: EOA = (LVOT area × LVOT TVI)/aortic prosthesis TVI. The mean gradient was measured by use of continuous-wave Doppler echocardiography and the simplified Bernoulli equation. The Doppler velocity profile for the LVOT TVI was obtained by positioning the pulsed-wave sample volume 0.5 to 1 cm below the sewing ring, in an apical three- or five-chamber view, so as to avoid the zone of flow convergence just below the aortic prosthesis. The sewing ring diameter was used for the LVOT diameter in all patients. IEOA was measured which is the EOA indexed to body surface area.

Patients were divided into 3 PPM groups according to severity: severe, moderate, and mild or not hemodynamically significant. Continuous variables were reported as mean ± SD, and the groups were compared with GLM - ANOVA. Reported probability values are based on the overall comparisons. Mann - Whitney test was used. Categorical variables were reported as a percentage of the total, and the groups were compared with the Student “t” test. Statistical analysis was done using SPSS version 17.0 for windows (IBM, Chicago, Illionos).
Results:

Table 1: Baseline characteristics of the study population pre-operatively

<table>
<thead>
<tr>
<th>Variable</th>
<th>Severe PPM (n = 4)</th>
<th>Moderate PPM (n = 11)</th>
<th>Mild PPM (n = 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>40 ± 15</td>
<td>54 ± 12</td>
<td>47 ± 15</td>
</tr>
<tr>
<td>Male (%)</td>
<td>75</td>
<td>91</td>
<td>61</td>
</tr>
<tr>
<td>BSA (m²)</td>
<td>1.6 ± 0.2</td>
<td>1.7 ± 0.1</td>
<td>1.4 ± 0.1*</td>
</tr>
<tr>
<td>BMI</td>
<td>23 ± 7</td>
<td>25 ± 3</td>
<td>20 ± 3*</td>
</tr>
<tr>
<td>CAD (%)</td>
<td>25</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>25</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>25‡</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>COPD (%)</td>
<td>0</td>
<td>27‡</td>
<td>6</td>
</tr>
<tr>
<td>CKD (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NYHA Class III – IV (%)</td>
<td>50</td>
<td>45</td>
<td>39</td>
</tr>
<tr>
<td>LVEDD (cm)</td>
<td>5.7 ± 0.9</td>
<td>4.7 ± 0.4</td>
<td>4.7 ± 0.7*‡</td>
</tr>
<tr>
<td>LVESD (cm)</td>
<td>3.8 ± 0.6</td>
<td>2.9 ± 0.4</td>
<td>3.1 ± 0.6*‡</td>
</tr>
<tr>
<td>IVS (cm)</td>
<td>1.5 ± 0.3</td>
<td>1.4 ± 0.1</td>
<td>1.5 ± 0.3</td>
</tr>
<tr>
<td>LVPW (cm)</td>
<td>1.3 ± 0.0</td>
<td>1.3 ± 0.1</td>
<td>1.2 ± 0.1</td>
</tr>
<tr>
<td>Calcified Aortic Valve (%)</td>
<td>100</td>
<td>100</td>
<td>89</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>50 ± 9</td>
<td>61 ± 5†</td>
<td>57 ± 12</td>
</tr>
<tr>
<td>AVA (cm²)</td>
<td>0.50 ± 0.13</td>
<td>0.66 ± 0.08</td>
<td>0.64 ± 0.16*</td>
</tr>
<tr>
<td>MPAG (mmHg)</td>
<td>66 ± 25</td>
<td>59 ± 18</td>
<td>64 ± 16</td>
</tr>
<tr>
<td>Annulus Size (cm)</td>
<td>2.0 ± 0.1</td>
<td>2.0 ± 0.1</td>
<td>2.0 ± 0.1</td>
</tr>
<tr>
<td>AR Grade 2 (%)</td>
<td>100</td>
<td>64</td>
<td>56</td>
</tr>
</tbody>
</table>

* - significant difference (p<0.05) between mild and moderate PPM groups. ‡ - indicates significant differences (p<0.05) between severe and mild PPM groups. † - indicates significant differences (p<0.05) between severe and moderate PPM groups.
Table 2: Characteristics of the study population in 6 months Post operatively

<table>
<thead>
<tr>
<th>Variable</th>
<th>Severe PPM (n – 3)</th>
<th>Moderate PPM (n – 11)</th>
<th>Mild PPM (n – 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEDD (cm)</td>
<td>5.1 ± 0.9</td>
<td>4.5 ± 0.5</td>
<td>4.2 ± 0.5†</td>
</tr>
<tr>
<td>LVESD (cm)</td>
<td>3.5 ± 0.6</td>
<td>2.9 ± 0.4</td>
<td>2.7 ± 0.5*‡</td>
</tr>
<tr>
<td>IVS (cm)</td>
<td>1.5 ± 0.1</td>
<td>1.2 ± 0.1</td>
<td>1.2 ± 0.2*‡</td>
</tr>
<tr>
<td>LVPW (cm)</td>
<td>1.3 ± 0.0</td>
<td>1.1 ± 0.1</td>
<td>1.1 ± 0.1*‡</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>57 ± 6</td>
<td>60 ± 6</td>
<td>59 ± 7</td>
</tr>
<tr>
<td>IEOA (cm²)</td>
<td>0.6 ± 0.0</td>
<td>0.76 ± 0.00</td>
<td>0.9 ± 0.0*‡</td>
</tr>
<tr>
<td>MPAG (mmHg)</td>
<td>41 ± 15</td>
<td>23 ± 9†</td>
<td>18 ± 4*‡</td>
</tr>
</tbody>
</table>

* - significant difference (p<0.05) between mild and moderate PPM groups. ‡ - indicates significant differences (p<0.05) between severe and mild PPM groups. † - indicates significant differences (p<0.05) between severe and moderate PPM groups.

Discussion:
Among the 33 patients, 9 were women (27%). The mean age was 49 (range 25-70) years. Mean body surface area was 1.56 (1.19 - 2.04) m², and mean left ventricular EF was 57.6%. 12% developed severe PPM (IEOA ≤ 0.65cm²/m²), 33% moderate PPM (IEOA >0.65cm²/m², ≤ 0.85 cm²/m) and 55% mild PPM (IEOA >0.85cm²/m²). No Prior cardiac surgery had been performed in any patient. Concomitant CABG was performed in 7 (21%) patients and no concomitant aortic root enlargement was done. All the patients reported improvement in symptom class after aortic valve replacement. In our study BSA and age of the patient had no impact on severity of PPM and prosthetic valve size found no difference in severity of PPM. There was no relation between annulus size and severity of PPM. Gender had no impact on severity of PPM. In our study LV function had no impact on PPM severity. In mild PPM group there was significant reduction in wall thickness and improvement in LV dimensions on 7th day as well as 6 months postoperatively. In moderate PPM, there was significant reduction in thickness of IVS and LV posterior wall at 6 months. In severe PPM group there was significant improvement in LVEDD and LVESD at 6 months of surgery, but no regression of left ventricular wall and septal thickness. One patient in severe PPM group developed cerebrovascular accident postoperatively and died in hospital, one patient of severe PPM group developed complete heart block and required permanent pacemaker implantation. One patient of mild PPM group died 9 months post AVR mostly due to sudden cardiac death at home.

Conclusion:
Data about PPM in Indian population is scarce to the best of our knowledge. The current study is the tries to analyse PPM in Indian patients undergoing AVR. Most patients undergoing prosthetic AVR will ‘technically’ have some degree of PPM. Although it is possible that severe PPM may result in a slight increase in operative mortality, and especially in the setting of pre-existing impaired ventricular function, it is seen in our study, even when severe does not
adversely affect short term survival. As opposed to other risk factors, PPM may be avoided or its severity may be reduced with the use of a preventive strategy at the time of operation.

**Abbreviations & Acronyms:**

PPM: Patient Prosthetic Mismatch.
AVR: Aortic valve replacement.
LV: Left ventricles.
BSA: Body surface Area.
CABG: Coronary Artery Bypass Surgery.
LVOT: Left ventricular Outflow Tract.
TVI: Time Velocity Integral
EOA: Effective Orifice Area.
IEOA: Indexed Effective Orifice Area.

**Recommendations:**

1. PPM is preventable. Before surgery, EOA of prosthetic valve as given by manufacturer should be indexed to BSA. If IEOA is less than 0.85 cm²/m², that means moderate PPM is expected. So take prosthetic valve of larger size, so that IEOA should be more than 0.85 cm²/m².
2. For defining PPM severity, IEOA at 6 month or more should be calculated.
3. EOA by continuity equation (and then IEOA) should be calculated for defining severity of PPM not gradient across aortic valve, as gradient can be affected by hyperdynamic circulation.
4. There should be close follow up in patients with severe and moderate PPM.
5. Symptomatic (angina, syncope, dyspnea) severe PPM patients should be considered for reo-peration, it would be very important to insert a prosthesis that will provide a larger indexed EOA or aortic root enlargement.

**References**