Prediction of Left Ventricle Function from Pre-Operative Left Ventricle End-Systolic Dimension in Mitral Valve Replacement

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INTRODUCTION

Rheumatic Heart Disease (RHD) makes up about 20% burden of heart disease in the endemic population. It results from acute rheumatic fever as a result of infection by Group A Streptococci; M-protein cross-reacts with the cardiac myosin which causes T-cell–induced injury of heart valves [1]. Rheumatic fever occurs 2–3 weeks after infection by Group A streptococci and individuals present with rheumatic heart disease in their 20’s and 30’s [2]. According to an estimation, 50 to 80 million are suffering from Rheumatic heart disease worldwide [3]. The most common heart valve affected by rheumatic heart disease is the mitral valve followed by the aortic valve. Isolated mitral stenosis occurs in about 40% of patients with RHD and 60% of patients give a history of suffering from rheumatic fever [4, 5]. The common presentation is dyspnea precipitated by exercise, emotional stress, pregnancy, infection, sexual intercourse, and rapid atrial fibrillation. The echocardiographic findings of rheumatic heart disease include anterior leaflet thickening, chordal thickening, chordal fusion restricted leaflet motion, excessive leaflet motion, and leaflet prolapse [6, 7]. Mitral valve replacement is the preferred surgical option in case of RHD due to an
ongoing disease process which can lead to failure of mitral repair [4, 8]. Mitral valve replacement (MVR) can be done through standard sternotomy, lateral thoracotomy (minimally invasive) incisions, or small ports (robotic valve surgery [9]. The postoperative left ventricular systolic contractile function is a major determinant of the prognosis and recovery of patient after mitral valve replacement [10]. Ejection fraction in post-operative echocardiography can accurately tell the function of heart after mitral valve replacement. We normally use pre-operative ejection fraction as a predictor of post-operative ejection fraction. However, end-systolic dimension is less dependent on left ventricle loading condition than is pre-operative ejection fraction. It is therefore a better measure of postoperative left ventricular systolic function [11].

M E T H O D S
This is a retrospective study of 100 patients from April 2022 to October 2022. The study was conducted at National Institute of Cardiovascular Diseases, Karachi. It was an observational cross-sectional study. A randomized, non-probability sampling technique was utilized. Inclusion criteria included all ages, either gender, only mitral valve surgeries, and all patients which come under class 1 of American Heart Association guidelines for mitral valve replacement [12]. Exclusion criteria included double valve replacements, concomitant coronary artery bypass surgery, aortic valve replacements, moderate to high risk surgery on Euro score, redo operations, and all those who refused to participate in the study. All patients with missing pre-operative and post-operative LVESD and Ejection Fraction (EF) were excluded from the sample. All the pre-operative data of patient was taken with a special focus on echocardiography report and echocardiographic images. Pre-operative echocardiography was performed within 3 months of operative and post-operative echocardiography within 1 month after the valve replacement. The per-operative details of patients were noted and then post-operative echocardiograms and early recovery of patient. All post-operative echocardiograms were done by FCPS consultants. All patients having cardiopulmonary bypass times of >150 mins and aortic cross-clamp times > 100 minutes were excluded from the study to avoid the discrepancy in the results due to long cardiopulmonary bypass (CPB) and cross-clamp times. Informed verbal consent from patients was taken from all patients. All the data was taken from cardiac surgery department of NICVD. All the mitral valve surgeries were performed by experienced surgeons having more than 10 years post-fellowship experience in mitral valve replacements. The data was collected and analyzed via SPSS version 23 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp). Frequency calculated by standard methods. Mean ± standard deviation was obtained for quantitative variables like age (years), LVESD (mm), LVEDD (mm), PASP (mmHg), and EF (%). Frequencies and percentages were calculated for categorical variables like types of mitral valve disease and size of prosthetic mitral valves used for replacement. The non-parametric chi-square test is applied to the data. Statistical significance is kept at p<0.05.

R E S U L T S
A total of 100 patients were included; 70% of our sample consisted of females and 30% males. The mean age of our patients was 37 ± 10 years (minimum: 17 years and maximum: 68 years), LVESD of 34.7 ± 8.4 mm, LVEDD of 51.1 ± 9.1 mm, PASP of 44 ± 11 mmHg, and pre-operative ejection fraction of 55 ± 9 and 47 ± 12% (Table 1).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>37 ± 10</td>
</tr>
<tr>
<td>LVESD (mm)</td>
<td>34.7 ± 8.4</td>
</tr>
<tr>
<td>LVEDD (mm)</td>
<td>51.1 ± 9.1</td>
</tr>
<tr>
<td>PASP (mmHg)</td>
<td>44 ± 11</td>
</tr>
<tr>
<td>PRE-OP EF (%)</td>
<td>55 ± 9</td>
</tr>
<tr>
<td>POST-OP EF (%)</td>
<td>47 ± 12</td>
</tr>
</tbody>
</table>

Table 1: Patients Characteristics
All patients were suffering from Rheumatic heart disease of mitral valve. Other types of degenerative or ischemic mitral valve diseases were excluded from the sample. We divided the sample on basis of valvular pathology: 31% of patients had severe mitral regurgitation, 8% had severe mitral regurgitation and moderate mitral stenosis, 17% had severe mitral stenosis (Wilkin score more than 8, not candidates of PTMC), 31% had severe mitral stenosis and moderate mitral regurgitation, 3% had severe mitral stenosis and mild mitral regurgitation and 2% had severe mitral regurgitation and severe mitral stenosis (Figure 1).

Figure 1: Types of Mitral Valve Diseases
A total of 100 patients were included; 70% of our sample consisted of females and 30% males. The mean age of our patients was 37 ± 10 years (minimum: 17 years and maximum: 68 years), LVESD of 34.7 ± 8.4 mm, LVEDD of 51.1 ± 9.1 mm, PASP of 44 ± 11 mmHg, and pre-operative ejection fraction of 55 ± 9 and 47 ± 12% (Table 1).

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Figure 2: Sizes of Mitral Valve Replacement

The data set of patients was divided to check for significance level. The LVESD was broadly divided into > 38 mm and less than 38 mm. It was found that patients whose left ventricular end-systolic dimension was greater than 38 mm had a drop in their post-operative Ejection Fraction after mitral valve replacement (p = 0.003)(Table 2).

<table>
<thead>
<tr>
<th>LVESD</th>
<th>Preserved Post-Op LV Function</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;38 mm</td>
<td>55 (35.38) [10.88] 6 (25.62) [15.03]</td>
<td>0.003</td>
</tr>
<tr>
<td>&gt;38 mm</td>
<td>3 (22.62) [17.02] 36 (16.38) [23.5]</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Relationship between LVESD and preserved postoperative LVEF

Ejection fraction of patients was also divided into short sets to increase accuracy level. Patients with a pre-operative Ejection Fraction of less than 55% suffered from post-operative LV dysfunction and patients with a pre-operative ejection fraction of more than 55% suffered less from LV dysfunction after mitral valve replacement (p = 0.02)(Table 3). However, if we intend to find a more reliable parameter to predict post-mitral valve replacement, we can deduce that LVESD is a more sensitive parameter as p value of 0.003 < 0.02.

<table>
<thead>
<tr>
<th>Pre-Op EF</th>
<th>Preserved Post-Op LV Function</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;55%</td>
<td>11 (16.25) [1.7] 14 (8.75) [1.15]</td>
<td>0.02</td>
</tr>
<tr>
<td>&gt;55%</td>
<td>54 (48.75) [0.57] 21 (26.25) [1.05]</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Relationship between pre-operative EF and preserved postoperative LVEF

Age of the patient, LVEDD, and PASP played no direct role in determination of post-operative LV function in mitral valve patients(Table 4).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Preserved Post-Op LV Function</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>36.58 40.55</td>
<td>0.8</td>
</tr>
<tr>
<td>LVEDD</td>
<td>47.63 59.72</td>
<td>0.7</td>
</tr>
<tr>
<td>PASP</td>
<td>65 29</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Table 4: Relationship of age, LVEDD, and PASP with preserved postoperative LVEF

**DISCUSSION**

Ejection Fraction post-operatively is a predictor of all-cause mortality [13]. A higher ejection fraction is associated with a better prognosis [14,15]. Our results have shown that LVESD is a definitive parameter to predict post-operative LV function in mitral valve patients. The research also proved the role of pre-operative Ejection fraction in predicting post-operative Ejection Fraction. However, in comparison to pre-operative LVESD, pre-op EF has an inferior predictability value for post-operative LV function after mitral valve replacements. Wang et al., studied the role of pre-operative LVESD and EF in determining postoperative EF in CABG patients. They included a sample of 939 patients. They concluded that smaller LVESD and lower ejection fraction have a greater potential for postoperative improvement in ejection fraction and outcomes [16]. In retrospective research by Tribouilloy et al., studied the additive value of LVESD to EF and collected a sample of 335 patients to predict the association between these pre-operative parameters and postoperative left ventricular dysfunction after mitral valve repair surgery done for severe mitral regurgitation. They concluded that pre-operative EF > 64% and LVESD < 37 mm incurred a lower postoperative risk of LV dysfunction [17]. Quintana et al., studied the sample of 1705 patients suffering from severe mitral regurgitation but preserved left ventricular function and discussed that a normal pre-operative EF is a misleading criterion to predict postoperative left ventricular dysfunction and found that it is not uncommon for patients having a preserved pre-operative EF to suffer from LV dysfunction after the surgery [18]. Wu et al., studied the combined association between high inferior vena cava diameter and LVESD in the causation of major adverse cardiovascular events and overall mortality in patients undergoing hemodialysis. They concluded that high LVESD is directly linked to higher all-cause mortality and major adverse cardiovascular adverse events [19]. Starling et al., in their study divided the sample into 3 groups: one with normal contractile function, 2nd with impaired contractile function but preserved ejection fraction, and 3rd with impaired contractile function. The LV function was assessed after the mitral valve surgery and found that left ventricular elastance is a better predictor to determine post-operative LV function than LVEF [20]. These studies add an additive value to our research and testify to the global applicability of our results on patients of rheumatic mitral valve disease undergoing mitral valve replacements.

**CONCLUSIONS**

Left ventricular end-systolic dimension (LVESD) is a reliable parameter to predict post-operative left ventricular ejection function. It can be regarded as a more
sensitive pre-operative criterion as compared to pre-operative ejection fraction to plan the post-operative management of the patient. Patients expected to have a more drop in left ventricular function post-mitral valve replacement can be planned meticulously with a multi-team approach to reduce the morbidity and mortality of the patients.

**Conflicts of Interest**
The authors declare no conflict of interest.

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**REFERENCES**


