Posterior Approach Aortic Root Enlargement in Redo Aortic Valve Prosthetic Replacement; Risk Factors

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Background: The aim of this study is to assess the outcome of aortic root enlargement by posterior approach in cases of redo aortic valve replacement and to report our experience regarding the postoperative mortality rates.

Methods: We reviewed perioperative outcomes among patients undergoing redo aortic valve replacement with aortic root enlargement at our institution between May 2008 and December 2011. Risk factors for operative death were evaluated by means of multivariable analysis. Total of 25 patients (13 males and 12 females) had repeated aortic valve replacement, mean age 36.64 ± 4.10. The causes for reoperation were prosthetic valve malfunction due to patient prosthesis mismatch causing high transvalvular pressure gradient, infective endocarditis and bioprosthetic valve degeneration. The size of explanted prostheses ranged between 19–21 mm while the size of the implanted prostheses ranged between 21–25 mm. Root enlargement was accomplished by Manougian technique in which a Dacron patch was used.

Results: The indications for redo surgery were prosthetic valve malfunction (18 patients), previous tissue valve degeneration (5 patients), infective endocarditis (2 patients). The overall hospital mortality was 8% (2 patients) due to low cardiac output state, the following were found to be the independent predictors for in-hospital mortality: preoperative New York Heart Association functional class IV, infective endocarditis and impaired left ventricular ejection fraction (LVEF) ≤50%.

Conclusion: Aortic root enlargement by posterior approach in cases of redo aortic valve replacement is still a challenging procedure that is associated with relatively high operative risk, endocarditis and preoperative cardiac function are the most important predictor for operative risk.

Abbreviations: AVR = aortic valve replacement. ARE = Aortic root enlargement. PPM = prosthesis–patient mismatch. PVM = prosthetic valve malfunction.

Key words: Aortic valve replacement, Reoperation, Aortic valve malfunction, Aortic root enlargement.

Improved survival after the first operation of artificial valve replacements has meant that more patients ultimately will require a redo operation at a certain time. Thus reoperations become an integral part of a cardiac surgeon’s practice, understanding the risk factors associated with redo surgery is helpful in improving the results of mortality and morbidity. Optimal planned reoperation strategy and proper timing of the surgery are of utmost importance [4].

Reoperative aortic valve surgery has traditionally been associated with significant mortality and morbidity [4]. Mechanical valves have a long record of excellent durability [2], but significant morbidity and sometimes mortality related to anticoagulant-related haemorrhage and other factors. Bioprosthetic aortic valves have more freedom from thromboembolism [11], but are subject to primary tissue failure and may therefore require rereplacement.

In redo aortic valve replacement the surgeon may face a challenging technical problem of a small annulus after explanting the previously implanted valve due to scarring, distortion or calcification. Replacement with a small prosthesis may result in prosthesis–patient mismatch with consequent left ventricular dysfunction. Moreover,
a small prosthesis in a narrow aortic annulus may not provide clinical or hemodynamic benefits to a large or physically active individual. Thus, an annulus-enlarging procedure such as that described by Manouguian and colleagues [5], Nicks and colleagues [16]. Or Konno and colleagues [1], is needed. We describe our experience of 25 patients in whom the Manouguian technique was used in redo aortic valve replacement.

Our aim is to report our experience in redo aortic valve cases that need aortic root enlargement aimed to minimize potential mismatch after valve replacement, and to assess the feasibility of posterior approach that is used in our institution in these cases as well as the risk associated with such procedure.

**Patients and Methods**

All the patients undergone surgery in kaser elaini and new kasr Elaini hospital and Nasser institute hospital between May 2008 and December 2011. Patients data were analyzed retrospectively from hospital records. Data included preoperative diagnosis, investigations, operative reports, postoperative course and follow-up. Patients included in this study were operated on by a total of 3 surgeons. The first operation was done in our hospital in 6 patients, while the remaining patients were referred from other institutions.

There were 25 patients included in this study. Patient age at reoperation ranged from 23 to 45 years. In all the patients included in the study this was the first redo for all of them, all the patients had previous prosthetic or Bioprosthetic aortic valve replacement. The indications for redo surgery were prosthetic valve malfunction in 18 with high pressure gradient across the valve, denoting patient prosthesis mismatch, previous tissue valve degeneration in 5 patients, and infective endocarditis in 2 patients. The average time interval to the redo operation was 6 years. There were 20 mechanical and 5 bioprosthetic valve explanted during the redo procedure with a mean size of 19.8±3.40mm (19–21 mm), while the mean size of the implanted prostheses was 23.2±2.3 mm (21–25 mm).

Four patients presented with an emergency case of stuck valve and cardiogenic shock were excluded, also 3 patients with previous mitral valve surgery were also excluded, as well as patients with redo aortic valve surgery needing other procedure as CABG, and cases needed straightforward Redo aortic valve replacement without annular enlargement.

**Surgical Technique**

Operative technique included median re- sternotomy with dissection of the adhesions, cardiopulmonary bypass with single stage right atrial cannulation, moderate hypothermia and multidose cold antegrade blood cardioplegia. A transverse aortotomy was made and after explanting the old valve, excessive fibrotic tissue was debrided. If the annulus did accommodate a 19-mm obturator or less, root widening was undertaken. The aortotomy incision was extended posteriorly across the area of aorto-mitral continuity into the anterior mitral leaflet. The aortotomy incision was extended along the commissure between the left coronary and the noncoronary sinuses, across the centre of the fibrous origin of the anterior mitral leaflet 1.5 to 2 cm short of its free margin.

A Dacron patch was then used in all the patients to enlarge the aortic annulus with continuous 4/0 Proline sutures. The aortic roots were enlarged by 4 to 6 mm. The appropriate valve sizes were used to measure the enlarged annulus. The new valve prosthesis was generally secured in place using pledged horizontal 2-0 Ethibond mattress sutures, in all the patients a mechanical prosthesis were inserted. In the region of the patch, the sutures are passed full thickness from outside the patch to inside. Preoperatively, we calculate a minimum prosthetic aortic valve size based on a given patient’s BSA to prevent prospective mismatch as defined by an indexed effective orifice area of at least 0.85 cm²/m². To achieve this goal, we use published normal reference values of effective orifice area (EOA) for each valve type and size. After valve insertion the Dacron patch was used to close the aortotomy with or without additional enlargement of the ascending aorta. The left atrium was dissected and opened in 17 cases the resulting atrial opening was closed by a separate patch.

Our primary outcome in this study was hospital mortality, which was defined as any postoperative death in the hospital. The significant predictors for in-hospital mortality are: preoperative New York Heart Association functional class IV, infective endocarditis and impaired left ventricular ejection fraction (LVEF) <50%. All patients routinely underwent echocardiography before discharge to evaluate valve function and pressure gradient across the valve.

**The statistical paragraph in material and methods:**

Data were statistically described in terms of mean ± standard deviation (± SD), or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student t test for independent samples.

For comparing categorical data, Chi square (c²) test was performed. Exact test was used instead when the expected frequency is less than 5, p values less than 0.05 was considered statistically significant. All statistical calculations were done using computer programs SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows.

**Results**

**Demographics**

There were 13 males (52%) and 12 females (48%), the age ranged between 23 and 45 with a mean age of 36.64 ± 4.10 years. No statistical significant was found in hospital mortality related to the sex or age of the hospital. (P: NS).
Table 1 display the preoperative demographic data, the functional class of the patients was mostly of FC III, 14 patients (56%). There were 3 patients (12%) presenting with FC II, and 8 patients (32%) with FC IV.

Table 2 shows echocardiographic findings of the patients. Twelve patients (48%) were found to have LVED more than 5.3 cm, and 10 patients (40%) were found to have LVESD more than 3.9 cm. Also only 8 patient (32%) having an EF% more than 50%. The two mortality cases found to have an EF of less than 50%.

**Intraoperative Data**

The main indications for surgical interference were prosthetic valve dysfunction 18 patients (72%), bioprosthetic dysfunction in 5 patients (20%), and infective endocarditis in 2 patients (8%). These pathology were confirmed intraoperatively as shown in table 3.

The total bypass time was more than 120 min in 4 patients (16%) and less than 120 min in only 21 patients (84%). While the cross clamp time was more than 90 min in 8 patients (32%) and less than 90 min in 17 patients (68%). 4 patients needed a longer time on bypass in order to control bleeding.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Number of patients (%) n=25</th>
<th>Deaths (%) n=2</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (y)±SD</td>
<td>36.64 ± 4.10</td>
<td>1(7.70)</td>
<td>0.549</td>
</tr>
<tr>
<td>Male (%)</td>
<td>13(52.00)</td>
<td>1(7.70)</td>
<td>0.549</td>
</tr>
<tr>
<td>NYHA class (%)</td>
<td>1(40.00)</td>
<td>0(0.00)</td>
<td>0.317</td>
</tr>
<tr>
<td>1</td>
<td>3(12.00)</td>
<td>0(0.00)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>14(56.00)</td>
<td>1(7.14)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>8(32.00)</td>
<td>1(12.50)</td>
<td>0.026*</td>
</tr>
<tr>
<td>Diabetic patients (%)</td>
<td>8(32.00)</td>
<td>0(0.00)</td>
<td>0.072</td>
</tr>
</tbody>
</table>

**Table 1: Demographic data**

*Chi-square test p<0.05*

<table>
<thead>
<tr>
<th>Echocardiography</th>
<th>Number of patients (%) n=25</th>
<th>Deaths (%) n=2</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVED≤ 5.30 cm</td>
<td>13(52.00)</td>
<td>0(0.00)</td>
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<tr>
<td>LVED&gt; 5.30 cm</td>
<td>12(48.00)</td>
<td>2(16.67)</td>
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<tr>
<td>LVES ≤ 3.9 cm</td>
<td>15(60.00)</td>
<td>0(0.00)</td>
<td></td>
</tr>
<tr>
<td>LVES &gt; 3.9 cm</td>
<td>10(40.00)</td>
<td>2(20.00)</td>
<td>0.317</td>
</tr>
<tr>
<td>EF%≤ 50%</td>
<td>17(68.00)</td>
<td>2(11.76)</td>
<td></td>
</tr>
<tr>
<td>EF% &gt;50%</td>
<td>8(32.00)</td>
<td>0(0.00)</td>
<td>0.072</td>
</tr>
</tbody>
</table>

**Table 2: Preoperative echocardiography.**

<table>
<thead>
<tr>
<th>Indications</th>
<th>Number of patients (%) n=25</th>
<th>Deaths (%) n=2</th>
<th>P value</th>
</tr>
</thead>
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<tr>
<td>Prosthetic endocarditis</td>
<td>2(8.00)</td>
<td>1(50.00)</td>
<td></td>
</tr>
<tr>
<td>Bioprosthetic failure</td>
<td>5(20.00)</td>
<td>0(0.00)</td>
<td></td>
</tr>
<tr>
<td>PVM</td>
<td>15(60.00)</td>
<td>1(10.00)</td>
<td>0.118</td>
</tr>
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**Table 3: Indications for surgery**
The total number of explanted valves were 20 mechanical and 5 bioprosthetic valves, after root enlargement all the patients received mechanical valves with 1 or 2 larger size with an mean size of 23.2±2.3. The mean size before root enlargement was 19.8±1.50, while the mean size after root enlargement was 23.2±2.3.

Postoperative echocardiography revealed well functioning aortic prosthesis with an mean peak pressure gradient a cross the new prosthetic valve of 19.2±1.50mmhg, only 4 cases showed trivial mitral regurgitation which was not detected in the preoperative echocardiography.

### Outcomes

The total number of hospital mortality was 2 cases (8%), the main causes of death low cardiac output status, the patients died postoperatively in the ICU. Exploration was undertaken in the 3 cases due to bleeding with proper control of bleeding.

### Predictors of Hospital Mortality

The independent predictors of mortality were determined by multivariable logistic regression analysis and included increasing NYHA class, infective endocarditis, and preoperative EF%.

### Discussion

Reoperative valvular surgery is often performed in higher-risk patients rather than those undergoing primary procedures and is more technically demanding. Reoperative aortic valve surgery after previous AVR has therefore been associated with increased morbidity and mortality compared with that seen with primary procedures. Although some series have reported that prior CABG is not a significant risk factor for mortality during subsequent AVR[18], the incremental risk of aortic valvular reoperation caused specifically by prior aortic valve surgery has been difficult to quantify.

The main challenging problem in redo cases is the smaller annular size following explanation of the previous implanted prosthesis due to associated fibrous tissue and pannus that many cause an obstructive effect to the left ventricular out flow, and prevent the insertion of the proper size of the new prosthesis. Although some physicians continue to debate the clinical effect of aortic valve prosthesis size on outcome, interest in prosthetic hemodynamics persists. Indeed, superior hemodynamic performance is the very basis of many arguments in favor of the use of stentless xenografts and the Ross pulmonary autograft operation[3].
In patients with a small aortic annulus, the decision to insert a small prosthesis or to enlarge the annulus is controversial. [10]. The contra-indications for aortic root enlargement include relative mitral incompetence that does not require immediate valve replacement and calcified aortic-mitral septum and AML.

Other authors dispute the relevance of PPM in the current era, reporting little or no relationship between valve orifice size and outcome. It has been further suggested that PPM is, in practice, quite uncommon [4]. These arguments are complicated by various definitions of PPM ranging from an indexed orifice area of less than 0.6 cm²/m², [9], to less than 0.85 cm²/m², as well as dispute over the more appropriate measure of orifice area (geometric or effective). Foster and colleagues [9], found no correlation between aortic transvalvular gradients and clinical status during long-term follow-up of patients with a body surface area of 1.6 m² who had received 17-mm or 19-mm Bjork-Shiley valves.

Regardless of academic argument, the practicing surgeon has a number of options available when confronted with the small aortic root and a circumstance in which he wishes to implant a valve larger than the annulus readily accepts [2]. Among those options is posterior aortic root enlargement. Many surgeons are reluctant to perform ARE with a concern that this procedure will increase operative morbidity and mortality. Surgeons should not be reluctant to enlarge the aortic root to permit implantation of adequately sized valve prostheses [8].

Manouguian and colleagues [22], reported their surgical experience of patch enlargement of a narrow aortic valve annulus by posterior incision. In the techniques described by Nicks and colleagues [16], the incision is continued downwards into the noncoronary sinus, dividing the aortic annulus and extending only as far as the origin of the AML. This enlarges mainly the supravalvular area and the aortic leaflet is usually widened by only a few millimetres. In our series, the indication was a narrow aortic root in redo aortic valve replacement. It is important that the incision is directed precisely towards the centre of the fibrous origin of the AML to avoid distortion due to patch enlargement. The Use of a pericardial patch is associated with the risk of kinking of the root, aneurysmal dilatation, and rupture; hence a Dacron patch is preferred whenever possible.

Sommers and colleagues [21], reported that the degree of enlargement of the aortic annulus is determined by extension of the aortic incision into the AML maximally to its appositional portion. The AML is the ideal site for extension of the aortic root incision because there is continuity between the postero-lateral part of the aortic root and the anterior leaflet of the mitral valve. The AML is functionally passive and no impairment of mitral valve function results from the patch enlargement technique. Moreover, the AML consists of collagenous fibres and is quite strong and resistant. Patch repair of the anterior leaflet of the mitral valve is thus possible without much technical difficulty.

There is no permanent impairment of mitral function when the extension of the aortic incision into the AML is limited to approximately 1 cm because the initial portion of the AML is not actively involved in the valve action [7].

In the current series reoperative surgery was associated with a significantly increased risk of mortality (8%). Other studies showed higher incidence, this difference may be due to the increased prevalence of other risk factors in patients undergoing reoperations [17]. For instance, patients presenting with active endocarditis underwent urgent or emergency operations more often in the redo AVR and Bentall-after-AVR groups than in the group undergoing primary AVR. Timing of the operation is important because non-elective operation was also reported to be a predictor of death by Akins and associates [10].

We also found that worsening NYHA class was a significant predictor of hospital mortality, as did Jamieson and coworkers [12]. Reoperations may therefore involve greater risk not just because of increased technical difficulties but also because such patients often present urgently with endocarditis, congestive heart failure, or shock or with renal failure related to sepsis. These conclusions were also reached by Poter and colleagues, who recently analyzed their institutional experience with reoperative aortic valve surgery and concluded that mortality was related to endocarditis, advanced NYHA symptom class, peripheral vascular disease, impaired LV function, and male sex but not to reoperation itself [14].

These findings are consonant with those of other authors. Sommers [8], observed a statistically insignificant trend toward a higher mortality rate among patients undergoing ARE (7.1% vs 3.5%), however, subsequent studies by Potter and colleagues [13], reported mortality rates among patients undergoing AVR with ARE that were actually lower than those observed among patients undergoing isolated AVR. In none of these studies did multivariate analysis identify ARE as a risk factor for operative death.

In their series, Sergey documented an aggressive practice of annular enlargement of 20% in patients undergoing primary operations, 36% in patients undergoing redo AVR, and 6% in patients undergoing Bentall procedures after prior AVR. The mean size of valve implanted at reoperation was identical in patients undergoing primary AVR versus redo AVR, whereas those undergoing Bentall procedures received valves with larger sizes. It is likely that without the greater prevalence of annular enlargement during redo AVR, the mean size of prostheses reimplanted would have been significantly lower. The requirement for annular enlargement was associated, however, with a significant increase in hospital mortality. Whether an increased operative risk caused by annular enlargement is counterbalanced by improved late survival related to a larger prosthesis and improved hemodynamics remains controversial and cannot be addressed by our current study [4].

The concept of PPM was formally introduced into the literature by Rahimtoola in 1978. In theory, PPM exists to some degree whenever the effective orifice area of the prosthetic valve is less than that of the normal valve. [6]. In practice, this is
the case, to a greater or lesser extent, with almost all prosthetic options. Indeed, this was the rationale put forward by Nicks and colleagues in their original article on the subject of ARE. The disagreement on the subject concerns the clinical effect of PPM. Some authors argue that PPM rarely occurs, and others argue that even if it is present, it is of no clinical significance[23].

It should also be noted that arguments concerning PPM are complicated by disagreement over its definition. Those who define PPM as an indexed effective orifice area (iEOA) of less than 0.60 cm²/m report it to be a rare occurrence, whereas others who define it as an iEOA of less than 0.85 cm²/m² [19] report more occurrence rate. Even more confusion is engendered by the various uses of effective orifice area and geometric orifice area for each of the very large number of valvular prostheses in clinical use. In an effort to account for this, a sophisticated analysis performed by investigators at the Cleveland Clinic using multivariable propensity scores and multivariable hazard function analyses with bootstrap resampling defined PPM in no less than 4 different manners, including manufacturers’ labeled valve size, manufacturers’ stated internal orifice area, indexed internal orifice area, and disease score as an expression of variant of internal orifice area from the expected value. [20]. Regardless, it is intuitive that an operation performed to relieve valvular stenosis should leave the patient with the least possible residual obstruction to flow. It is also clear that transvalvular gradients increase exponentially as the iEOA decreases to less than 0.8 to 0.9 cm²/m². [15].

Limitation of the study

The most important limitation of the study was the small number of patients and failure to provide long-term follow-up. We encourage prospective operative strategies to minimize predictable mismatch, as well as a renewed interest in aortic root enlargement in redo patients with relatively small aortic roots. Also the primary end point of our study was to document overall time related survival, but secondary endpoints as reoperation, bleeding, and stroke incidence, neurologic deficit lasting more than 24 hours need to be more investigated.

Conclusion

Aortic root enlargement by posterior approach in cases of redo aortic valve replacement is still a challenging procedures that can be done with an acceptable outcome and acceptable operative risk.

References

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