Intra-Atrial Placement of a Mitral Prosthesis in Patients with Severe Mitral Annular Calcification

Christos G. Mihos¹, Orlando Santana¹, Julio Peguero², Joseph Lamelas³

¹Columbia University Division of Cardiology, Mount Sinai Heart Institute, ²Division of Internal Medicine, Mount Sinai Medical Center, ³Division of Cardiac Surgery, Mount Sinai Heart Institute, Miami Beach, Florida, USA

Background and aim of the study: The safety and durability of intra-atrial placement of mitral valve prostheses in patients with severe mitral annular calcification (MAC) were evaluated.

Methods: A retrospective analysis was conducted of all patients with severe MAC who underwent intra-atrial placement of a mitral valve prosthesis between September 2008 and August 2011, by placement of an 8 mm Dacron graft sutured circumferentially around the sewing cuff. Both, intraoperative and postoperative echocardiography were performed to evaluate the adequacy of prosthesis placement and to assess the presence of mitral regurgitation (MR).

Results: A total of six patients (three males, three females; mean age 78 ± 9.7 years) was identified. The median EuroSCORE risk calculation was 14.5 (IQR 13-18), and three patients had a history of previous cardiac surgery. Three operations were performed via a minimally invasive approach. Three patients underwent concomitant coronary artery bypass graft surgery; one of these patients also underwent aortic valve replacement. All prostheses were placed successfully and no paravalvular leaks were observed postoperatively. There was one in-hospital mortality. The median aortic cross-clamp time was 176 min (IQR 156-190 min) and the median cardiopulmonary bypass time 178 min (IQR 156-218 min). The median preoperative versus postoperative MR grade was 3 (IQR 3-4) versus 0 (IQR 0-0). Follow up echocardiography was performed on two patients on postoperative days 20 and 70, respectively, but there was no evidence of MR. The median total length of hospital of stay was 11 days (IQR 4-19 days).

Conclusion: In patients requiring mitral valve replacement in which severe annular calcification prohibits standard valve surgery, the intra-atrial placement of a mitral valve prosthesis is a feasible option.

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retrospectively to identify those patients who underwent intra-atrial placement of a mitral valve prosthesis.

In all patients, valvular lesions were documented by diagnostic catheterization and echocardiography, and all operative reports and echocardiograms were reviewed. The European System for Cardiac Operative Risk Evaluation score (EuroSCORE) was calculated for each patient. Intra-operative transesophageal echocardiography (TEE) was performed to evaluate the mitral valve, and grading of the MR was made in accordance with the American Society of Echocardiography guidelines (6). The MR was graded as severe (4+), moderate-to-severe (3+), moderate (2+), mild (1+), or trace/none (0). Postoperative TEE was performed to evaluate the prosthesis placement, and any remaining MR was again graded. The surgical technique time was analyzed on the basis of the aortic cross-clamp and total cardiopulmonary bypass (CPB) times.

Surgical technique

The patient was placed in a supine position and underwent anesthetic induction and intubation with a single-lumen endotracheal tube. Intraoperative TEE was performed to evaluate the mitral valve and to grade the severity of the MR. In minimally invasive patients, a femoral platform was utilized to establish CPB. The femoral artery was cannulated with a 16-18 Fr arterial cannula (Edwards Lifesciences, Irvine, CA, USA), and the left femoral vein with a 25 Fr venous cannula (Bio-medicus; Medtronic, Minneapolis, MN, USA). With the aid of TEE, the venous cannula was placed in the superior vena cava. If significant peripheral vascular disease had been present, then axillary artery cannulation would have been performed.

Conventional sternotomy was utilized in three patients; in one case this was converted to a sternotomy from a minimally invasive approach. The remaining patients underwent a minimally invasive approach via a 5- to 6-cm skin incision made in the right 4th-5th intercostal space at the anterior axillary line. In these cases, the patient’s right arm was positioned down and slightly off the bed. Additionally, a roll was placed behind the right scapula to elevate the patient’s right side. With TEE guidance, a retrograde coronary sinus catheter was inserted directly through the incision. One dose of antegrade cold blood cardioplegia was administered to establish an electromechanical arrest of the heart. Thereafter, retrograde cold blood cardioplegia was applied throughout the procedure at 20- to 25-min intervals. In patients with a history of previous heart surgery, moderate-to-deep hypothermia (24-26°C) and fibrillatory arrest was used; no cardioplegia was delivered to these patients. The removal of air was achieved through a vent placed via the atriotomy through the mitral valve, and into the left ventricle.

The mitral valve was accessed through Waterson’s groove, then through the atrial septum and into the left atrium. A specially designed atrial lift retractor and atrial exposure blade were utilized, which allowed for an easy visualization of the valve apparatus and revealed severe calcification of the annulus. In those patients undergoing a median sternotomy, a standard atriotomy approach was utilized. The anterior leaflet of the mitral valve was then resected, while the posterior leaflet was left intact. A Dacron graft of 8 mm diameter was then sutured circumferentially around the sewing cuff of the prosthetic valve with a 5-0 Prolene suture, using a continuous suture line. Thereafter, 4-0 Prolene pledged sutures were placed circumferentially in the atrial wall above the mitral annulus and then through the newly constructed sewing cuff. The valve with the newly constructed sewing cuff was then seated in a supra-annular position onto the atrial wall. Of note, one patient required the use of an inverted 23 mm Mosaic porcine aortic valve as the replacement prosthesis due to the severely calcified annulus and leaflets that limited the size of the prosthetic valve which could be utilized.

After weaning from CPB, intraoperative TEE was performed to evaluate the adequacy of the prosthesis placement and to assess for paravalvular leak or valve dehiscence (Fig. 1).

Results

A total of six patients (three males, three females; mean age 78 ± 9.7 years) was identified. The median EuroSCORE risk calculation was 14.5 (IQR 13-18).
All patients were in NYHA functional class III or IV. Three patients had undergone previous heart surgery; all of these had a history of aortic valve replacement (AVR), while one had also received coronary artery bypass graft (CABG) surgery and another replacement of the ascending aorta. Three patients were found to have clinically significant coronary artery disease on preoperative cardiac catheterization and underwent concomitant CABG surgery (two patients double-vessel, one patient single-vessel), one of whom also had an AVR. Four operations were performed via a minimally invasive approach; in one case (#6) this required conversion to a conventional median sternotomy for a single-vessel bypass to the obtuse marginal branch of the left circumflex coronary artery, after intraoperative TEE had revealed an infero-lateral wall hypokinesis (Table I).

Surgically placed valves included a Medtronic Hancock II porcine mitral valve in four patients (two 25 mm, two 27 mm), a 25 mm Medtronic Mosaic porcine mitral valve in one patient, and a 23 mm Medtronic Mosaic aortic valve in one patient. All prostheses were placed successfully, and no paravalvular leaks were observed postoperatively. One in-hospital mortality occurred due to complications from cardiogenic shock. The median aortic cross-clamp time was 176 min (IQR 156-190 min), and the median CPB time was 178 min (IQR 156-218 min). These times were similar as fibrillatory arrest was used in three patients. The median preoperative versus postoperative MR grade was 3 (IQR 3-4) versus 0 (IQR 0-0). A hemodynamic evaluation of the bioprosthetic valves revealed no evidence of patient-prosthesis mismatch. One patient (case #2) developed

### Table I: Patient characteristics.

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Gender</th>
<th>Age (years)</th>
<th>History</th>
<th>Surgery</th>
<th>EuroSCORE</th>
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<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>88</td>
<td>Severe aortic stenosis</td>
<td>Bioprosthetic AVR Two-vessel CABG</td>
<td>12.8</td>
</tr>
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<td>2</td>
<td>M</td>
<td>81</td>
<td>Bioprosthetic AVR</td>
<td>Reoperation Minimally invasive</td>
<td>15.3</td>
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<tr>
<td>3</td>
<td>F</td>
<td>74</td>
<td>AVR with replacement of ascending aorta</td>
<td>Reoperation Minimally invasive</td>
<td>13.6</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>84</td>
<td>CABG, bioprosthetic AVR</td>
<td>Reoperation Minimally invasive</td>
<td>40.9</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>61</td>
<td>Very severe mitral annular calcification</td>
<td>Two-vessel CABG</td>
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</tr>
<tr>
<td>6</td>
<td>F</td>
<td>83</td>
<td>Severe pulmonary</td>
<td>Minimally invasive hypertension with conversion to sternotomy and single-vessel CABG</td>
<td>18.5</td>
</tr>
</tbody>
</table>

AVR: Aortic valve replacement; CABG: Coronary artery bypass graft.

### Table II: Operative data.

<table>
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<tr>
<th>Parameter</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>Mitral prosthesis size (mm)</td>
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<td>27</td>
<td>25</td>
<td>27</td>
<td>25</td>
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<td>Aortic cross-clamp time (min)</td>
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<td>FA</td>
<td>FA</td>
<td>FA</td>
<td>FA</td>
<td>FA</td>
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<tr>
<td>CPB time (min)</td>
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<td>235</td>
<td>158</td>
<td>141</td>
<td>155</td>
<td>198</td>
<td>225</td>
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<tr>
<td>Preop. MR grade</td>
<td></td>
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<td>4</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Postop. MR grade</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Hospital length of stay (days)</td>
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<td>29</td>
<td>20</td>
<td>6</td>
<td>16</td>
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<td>No</td>
<td>No</td>
<td>No</td>
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<td>Yes</td>
</tr>
</tbody>
</table>

CPB: Cardiopulmonary bypass; FA: Fibrillatory arrest; MR: Mitral regurgitation.
acute renal failure postoperatively and required surgical re-exploration for a retained hemothorax. The median total hospital length of stay was 11 days (IQR 4-19 days), and all surviving patients were discharged in NYHA functional class I (Table II). Two patients (case #1, preoperative MR grade = 3; case #2, preoperative MR grade = 4) underwent follow up echocardiography on postoperative days 20 and 70, respectively, with no evidence of MR or mitral stenosis.

Discussion
Among the patients in the present series, calcification was so extensive at the mitral annulus that the likelihood of performing a successful standard mitral valve replacement was low, and carried a substantial operative risk. Bioprosthetic valves were utilized due to the risk of mechanical valve leaflet interference with the underlying native calcified leaflets, and the valve prosthesis was sized according to the intra-annular dimension following the resection of as much calcified native leaflet tissue as possible. The primary objective of the study was to allow the valve struts of the prosthesis to lie within the native valve, which limited the size of the bioprosthetic valve used.

By placing the 8 mm Dacron graft as an intact tube and suturing it to the sewing ring of the bioprosthetic valve, a very large and compliant neo-sewing ring was essentially created. This approach curbed the risk of a peri-prosthetic leak or valve dehiscence and also decreased the operative time, thus reducing the surgical risk. In the three reoperations among the present patients, a minimally invasive approach via a left mini-thoracotomy was utilized, with adequate exposure of the surgical field obtained in all operations. A significant improvement in MR grade from moderate-to-severe (3+) preoperatively to trace/none (0) postoperatively was observed, highlighting the durability of the prosthesis placement.

The present case series of six patients undergoing intra-atrial placement of a mitral prosthesis in the setting of severe MAC has updated the initial case report of this technique (7). A similar procedure to that described here was reported by Nataf et al. (8) in 36 patients with either extensive MAC (n = 21) or infective endocarditis (n = 15). In these patients, the circumference of the sewing ring was enlarged by placing a 1.5 cm-wide Dacron collar around the mitral prosthesis, which was implanted with a running 3-0 suture at 0.5-1.5 cm above the mitral valve, between the free edge of the Dacron collar and the left atrial wall. When the mitral annulus was partially affected, the collar was attached to the atrial wall that was calcified, and the remainder of the prosthetic circumference was implanted to the mitral annulus. One technique-related operative death occurred due to hemorrhaging from a left atrial tear, and four reoperations were required due to periprosthetic leaks. The remaining data on this and similar approaches have been limited to case reports (9-13).

Study limitations
The primary limitation of the present study was its retrospective, single-center nature, which limited its generalizability. In addition, the sample size was small and the patient group heterogeneous. Nonetheless, the results obtained were most robust when viewed as an observational study of a consecutive series of mitral valve replacements utilizing an intra-atrial mitral valve prosthesis. The hypothesis is that this approach is feasible for patients in whom severe annular calcification prevents conventional valve replacement.

In conclusion, among patients with severe mitral annular calcification requiring mitral valve replacement, the intra-atrial placement of a mitral valve prosthesis is feasible, and provides advantages of reducing the operative time and surgical risks associated with a standard mitral valve replacement. Furthermore, the intra-atrial implantation of a mitral prosthesis may be safely performed via a minimally invasive approach, particularly in patients who have undergone a prior median sternotomy.

References