Minimally invasive papillary muscle sling placement during mitral valve repair in patients with functional mitral regurgitation

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Background: We evaluated the safety and feasibility of minimally invasive mitral valve repair with papillary muscle sling placement via a right anterior thoracotomy approach in patients with severe functional mitral regurgitation (MR).

Methods: We retrospectively reviewed all minimally invasive mitral valve repairs with papillary muscle sling placement in patients with severe functional MR performed at our institution between October 2011 and September 2012. The operative times, lengths of stay, postoperative complications, and mortality were analyzed.

Results: We identified a total of 19 consecutive patients. There were 12 men (63%); the mean age was 60 ± 13 years. The mean ± SD left ventricular ejection fraction was 23% ± 5.5%, and 4 (21%) of the patients underwent previous coronary artery bypass graft surgery. The median aortic cross-clamp and cardiopulmonary bypass times were 106 (interquartile range [IQR], 76-120) and 163 (IQR, 119-170) minutes, respectively. The median intensive care unit length of stay was 64 (IQR, 43-75) hours, and the median postoperative length of stay was 7 (IQR, 5-7.5) days. Postoperatively, 2 patients developed acute kidney injury. There were no reoperations for bleeding or any cerebrovascular accidents. The 30-day mortality was 0. A follow-up echocardiogram, obtained at a median of 3 (IQR, 1-7.5) months, demonstrated none to trivial MR in all patients.

Conclusions: Minimally invasive mitral repair with papillary muscle sling placement for severe functional MR is safe and effective in the short-term. Long-term data are needed to evaluate the effects on left ventricular remodeling and to assess the durability of the repair. (J Thorac Cardiovasc Surg 2014;147:496-9)

In patients with left ventricular systolic dysfunction and functional mitral regurgitation (MR), the surgical treatment of the mitral insufficiency is a challenging issue. Most of these individuals have a structurally normal mitral valve, but the valve is incompetent because left ventricular remodeling has disturbed the relationship between the subvalvular apparatus and the mitral valve leaflets. Therefore, more attention is given to correcting the papillary muscle displacement when these individuals undergo mitral valve repair. One of these approaches involves the placement of a sling around the papillary muscles. This technique has been previously reported as being performed via median sternotomy. We report our experience performing this technique using a minimally invasive approach via a right lateral thoracotomy.

METHODS

After obtaining approval from the Mount Sinai Medical Center (Miami Beach, Fla) Institutional Review Board, with patient consent waived, we retrospectively reviewed all heart operations performed at our institution between November 2011 and September 2012, to identify patients with functional MR who underwent mitral valve repair with papillary muscle sling placement using a minimally invasive approach.

All patients had their valvular lesions documented by diagnostic catheterization and echocardiography, and all operative reports and echocardiograms were reviewed. Intraoperative transesophageal echocardiography was performed to evaluate the mitral valve, and grading of the MR was done in accordance with the American Society of Echocardiography guidelines.[1] The MR was graded as severe (4+), moderate to severe (3+), moderate (2+), mild (1+), or trace/none (0). A postoperative transesophageal echocardiogram was obtained to evaluate the repair. The surgical technique time was analyzed on the basis of aortic cross-clamp and total cardiopulmonary bypass times. The outcome variables evaluated were 30-day mortality and postoperative complications, which were identified as follows: postoperative renal failure, bleeding requiring reoperation, cerebrovascular accident, prolonged ventilation (>24 hours), reintubation, deep wound infection, and atrial fibrillation. The definitions and variables selected were based on the Society of Thoracic Surgeons Database definitions. All patients were evaluated approximately 30 days postoperatively in the outpatient setting.

Surgical Technique

A femoral platform was used to establish cardiopulmonary bypass. A longitudinal 2- to 3-cm incision was made superior to the inguinal crease. The femoral artery was cannulated with a 16F to 18F arterial cannula (Edwards, Irvine, Calif) or a 15F to 19F arterial cannula (Bio-medicus; Medtronic, Minneapolis, Minn), and the femoral vein was cannulated with a 25F venous cannula (Bio-medicus, Medtronic). With the aid of transesophageal echocardiography, the venous cannula was placed in the superior vena cava. A 5- to 6-cm skin incision was made in the right fourth to fifth intercostal space lateral to the anterior axillary line. A soft tissue retractor and rib spreader were used to provide further exposure. The

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Abbreviations and Acronyms
IQR = interquartile range
MR = mitral regurgitation

pericardium was opened over the phrenic nerve and tacked to the skin. By using transesophageal echocardiographic guidance, a retrograde coronary sinus catheter was inserted into the right atrium directly through the incision. One dose of antegrade cold blood cardioplegia was given to establish electromechanical arrest of the heart. Thereafter, retrograde cold blood cardioplegia was given throughout the procedure at 20-minute intervals. A left lateral atriotomy is performed through the Waterson groove to enter the left atrium. An atrial lift retractor and atrial exposure blade were used for visualization of the mitral valve. A specially designed papillary exposure device was used to visualize the infravalvular apparatus. We do not place the mitral annular sutures first because this impairs visualization. A long-shafted curved clamp was used to encircle all sets of papillary muscles. This procedure needs to be performed carefully to not penetrate the papillary muscles. In addition, the clamp needs to be as close to the base of the papillary muscles as possible. Different size clamps are required depending on the width of the muscles. This maneuver can be time-consuming for it to be performed properly. This will avoid the graft slipping superiorly and entrapping the chordae. A 4-mm polytetrafluoroethylene graft (Gore-Tex; W. L. Gore & Associates, Inc, Newark, Del) was then placed around the base of the papillary muscles (Figure 1). Care is taken to place the graft so that it has an anchoring muscle that will prevent upward migration. The edges of the sling are approximated as tightly as possible and tied with a 4-0 Prolene suture (Ethicon, Inc, Somerville, NJ) in a mattress manner and then a continuous over-and-over manner. This may require several sutures to apply the maximum tension to approximate the graft. At the completion, the papillary muscles are tightly approximated and juxtaposed. Thereafter, the mitral valve repair was performed. The size of the anterior leaflet was used to determine the size of the annuloplasty ring. We do not undersize the ring. The annuloplasty ring used was a profile three-dimensional ring (Medtronic). A 4-0 Prolene suture was used to close the left atrium. Carbon dioxide was infused into the operative field at 2 L/min throughout the entire procedure.

When concomitant tricuspid valve surgery was performed, the superior and inferior vena cavae were encircled with vessel loops. Before the right atrium was opened, the long femoral venous cannula was withdrawn into the inferior vena cava and then both cavae were snared with the vessel loops. The right atrium was then opened, and a sump suction was inserted into the superior vena cava to provide drainage. We did not use a separate venous cannula.

In patients with a history of coronary artery bypass surgery, moderate to deep hypothermia (24°C-26°C) and fibrillatory arrest were used. Cardioplegia was not delivered at all. Removal of air was performed via a vent placed through the atriotomy into the left ventricle and an aortic root vent.

In patients with a history of atrial arrhythmias, a concomitant modified left atrial ablation procedure was performed first after exposure of the left atrium and mitral valve. The intra-atrial ablation lines were created with a saline irrigated unipolar radiofrequency probe (Cardioblate; Medtronic). The ablation lines included isolation of the pulmonary veins, followed by a box lesion communicating the pulmonary veins. Additional lines were created around the left atrial appendage, and from the appendage to the left pulmonary veins. The last lesion set was from the left pulmonary veins to the mitral annulus (P2-P3 region). The left atrial appendage was ligated from within the left atrium with a double row, continuous suture line. We did not perform right atrial ablation in any of the patients.

With the heart empty, a ventricular pacing wire was placed. After discontinuing cardiopulmonary bypass and administering protamine, decannulation was performed. The purse string sutures were tied, and the femoral artery was reinforced using a 5-0 Prolene suture. A single chest tube was left in the pleural space. For pain relief, an On-Q pain relief system was inserted (I-Flow Corporation, Lake Forest, Calif). Two catheters were placed to continuously deliver 0.25% bupivacaine for 72 hours. The thoracotomy incision was closed in the routine manner.

Statistical Methods

Continuous variables are expressed as the mean ± SD or median and interquartile range (IQR, 25th-75th quartile), as appropriate. The statistical analyses were performed using SPSS, version 17 (SPSS Inc, Chicago, Ill).

RESULTS

We identified 19 consecutive patients, consisting of 12 (63%) men and 7 (37%) women, with a mean age of 60 ± 13 years. The mean ejection fraction was 23% ± 5.5%, with a mean mitral valve tenting height of 10 ± 2 mm. There were 4 (21%) patients with a history of coronary artery bypass graft surgery. In all patients, the MR was functional, with an ischemic cause in 9 (47%) and a nonischemic origin in 10 (53%). All patients were in New York Heart Association Functional class III to IV (Table 1). Of the 19 patients, 2 underwent concomitant tricuspid valve repair due to the presence of moderate to severe tricuspid regurgitation and 3 underwent a concomitant ablation procedure for atrial fibrillation.

The median aortic cross-clamp and cardiopulmonary bypass times were 106 (IQR, 76-120) and 163 (IQR, 119-170) minutes, respectively. On postoperative transesophageal echocardiogram, none of the patients had any discernible MR. The median number of units of packed red blood cells transfused was 1 (IQR, 0-2). The median intensive care unit length of stay was 64 (IQR, 43-75) hours. Postoperatively, 2 (10.5%) patients developed renal failure. None of the patients had a cerebrovascular accident, required reoperation for bleeding, or developed a deep wound infection. The median postoperative length of stay was 7 (IQR, 5-7.5) days (Table 2). There were no operative deaths, and at a median follow-up of 9.5 (IQR, 6.5-12) months, all patients were alive.

A follow-up echocardiogram, obtained at a median of 3 (IQR, 1-7.5) months, demonstrated none to trivial MR in all patients. The mean ejection fraction increased to 31% ± 17%, and the mitral valve tenting height was reduced to a mean of 5 ± 2 mm.

DISCUSSION

Functional, or secondary, mitral insufficiency in patients with reduced left ventricular systolic function is usually a result of annular dilatation and papillary muscle displacement, with the mitral leaflets being anatomically normal.[2] Whether to perform mitral valve surgery in patients with severe MR and advanced heart failure is controversial, with the published data showing equivocal results.[3-5] Thus, to our knowledge, the optimal approach to the management of individual patients with functional MR has not been