

Surgical Technique: Papillary Muscle Sling for Functional Mitral Regurgitation during Minimally Invasive Valve Surgery

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ABSTRACT

In patients with functional mitral regurgitation, the placement of a sling encircling both papillary muscles in conjunction with mitral annuloplasty appears to be a rational approach for surgical correction, because it addresses both the mitral valve and the deformities of the subvalvular mitral apparatus. Reports in the literature that describe the utilization of this technique are few, and mainly involve a median sternotomy approach. The purpose of this communication is to describe the technical details of performing this procedure via a minimally invasive approach.

INTRODUCTION

The functional, or secondary, mitral insufficiency noted in patients with left ventricular dysfunction is a result of mitral annular dilatation and displacement of the papillary muscles and chordal tethering, with the mitral leaflets being anatomically normal [Levine 2005]. The most common type of mitral valve repair performed for functional mitral regurgitation is an undersized mitral annuloplasty. In this technique, a small mitral annuloplasty ring is placed, which causes a reduction in the septolateral diameter of the mitral valve to increase the surface of coaptation [Bolling 1998]. The drawback with the undersized annuloplasty repair is the high rate of failure. Up to 28% of the patients who have undergone this procedure will develop at least moderate mitral regurgitation at 6 months postoperatively [McGee 2004]. The recurrence of mitral regurgitation in these individuals is most likely due to continued left ventricular remodeling, which causes further tethering of the papillary muscles [Hung 2004]. In an attempt to reduce the deleterious effects of this process, Hvass and colleagues developed a technique of placing a 4 mm Gore-Tex tube (W. L. Gore & Associates, Inc., Newark, DE, USA) around the trabecular base of both papillary muscles in

patients who were undergoing mitral annuloplasty for functional mitral regurgitation [Hvass 2003; Hvass 2010]. In all of their patients a median sternotomy approach was used. We recently reported our first case [Benjo 2012], and now describe how to perform this technique during minimally invasive mitral valve repair.

SURGICAL TECHNIQUE

The procedure begins with the utilization of femoral arterial and venous cannulation to establish cardiopulmonary bypass. A 2–3-cm longitudinal incision is made superior to the inguinal crease, and the femoral artery is cannulated with a 15–19-mm French arterial cannula (Bio-medicus, Medtronic, Minneapolis, MN, USA), and the femoral vein is cannulated with a 25 French venous cannula (Bio-medicus, Medtronic). With the aid of transesophageal echocardiography, the venous cannula is placed in the superior vena cava. This is important in order to obtain adequate venous drainage. A 5–6-cm skin incision is made in the right 4th to 5th intercostal space lateral to the anterior axillary line (Figure 1). A soft tissue retractor and rib spreader are placed to improve visualization. The pericardium is opened and tacked to the skin or pulled out through separate openings. With the use of transesophageal echocardiography guidance, a retrograde coronary sinus catheter is directly inserted into the right atrium through the incision. Cardiopulmonary bypass is initiated, and thereafter 1 dose of antegrade cold blood cardioplegia is given to establish electromechanical arrest of the heart. Retrograde cold blood cardioplegia is then given throughout the procedure at 20-min intervals. The mitral valve is accessed through a left lateral atriotomy, and a specially designed atrial lift retractor and atrial exposure blade are used for visualization of the mitral valve. The valve and the infravalvular apparatus are carefully assessed. If there is no evidence of leaflet pathology, one can proceed by the planned procedure. Annular sutures are initially placed for further exposure. A specially designed papillary and chordal exposure device facilitates visualization of these structures, and a curved long-shafted instrument is then used to encircle the papillary muscles. Care must be taken not to go through the muscles. The curved clamp must be placed around the muscles weaving between trabeculae. One must keep in mind that once the graft is in place,

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Figure 1. A 5-cm skin incision was made in the right 5th intercostal space at the anterior axillary line.

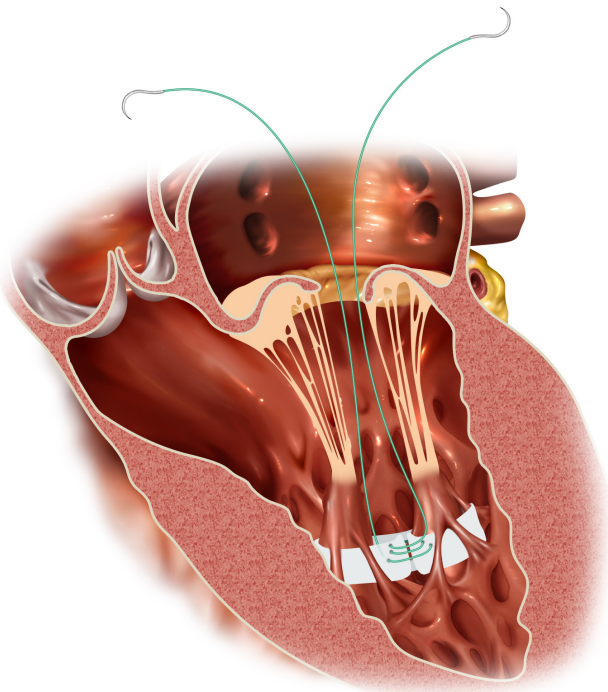


Figure 2. Placement of a 4-mm Gore-Tex tube around the papillary muscles. The papillary muscles are drawn together, correcting their lateral and downward displacement.

it should not slip superiorly and encircle the chordae. Once the papillary muscles are encircled, an 8-mm red rubber catheter is placed around them. It is usually easier to start with encircling the right papillary muscles, pull the red rubber catheter, then proceed in a similar fashion with the left papillary muscles. Once the red rubber is completely around the base of the papillary muscles, a 4-mm Gore-Tex graft is then sutured to the tip of the red rubber. The red rubber and graft are carefully pulled circumferentially in order to avoid tearing through the papillary muscles. The red rubber should not be pulled out toward the incision. Once the sling is completely around the base, it is approximated with a 4-0 Prolene (Ethicon, Inc, Somerville, NJ, USA) suture; initially, in a mattress fashion and then in continuous over-and-over fashion. The graft should be approximated tightly (Figure 2). At the completion of the approximation, one should not be able to place a Yankauer suction catheter between the papillary muscles. If a space remains, additional Prolene sutures are placed to further approximate the graft and papillary muscles. Thereafter, the mitral valve repair is performed with a rigid annuloplasty ring and implanted with the aid of a knot tyer. The size of the anterior leaflet is used to determine the size of the annuloplasty ring. A saline test of the valve is performed, and it is common to see a small leak in the P2-P3 cleft or the appearance of leaflet distortion in this area. Postoperative transesophageal echocardiography usually demonstrates excellent coaptation with no evidence of regurgitation. A 4-0 Prolene suture is used to close the left atrium. Carbon dioxide is infused into the operative field during the entire procedure.

Removal of air from the heart is performed with a venting needle in the ascending aorta. After discontinuation of cardiopulmonary bypass and administration of protamine, decannulation is performed. A single chest tube is left in the pleural space unless the patient is taking clopidogrel, in which case an additional Blake chest tube is placed in the pericardial space. For pain relief, an On-Q pain relief system is inserted (I-Flow Corporation, Lake Forest, CA, USA). The thoracotomy incision is closed in the routine fashion.

DISCUSSION

Since the main culprits in the development of functional mitral regurgitation are the changes in left ventricular geometry that lead to alteration of the ventricular-valvular anatomy, addressing only the valve through repair techniques often does not suffice. Although the optimal surgical approach for functional mitral regurgitation remains controversial, it would seem that the addition of a papillary muscle sling to the standard mitral annuloplasty would be beneficial, because this addresses both the annular deformities and the papillary muscle displacement. Hvass and colleagues have demonstrated that on the valvular level, a papillary muscle sling improves mitral leaflet mobility and may prevent the recurrence of mitral regurgitation, whereas on the ventricular level, it acutely changes the shape and the volume of the left ventricle, and on follow-up the left ventricular diameter decreases, the ejection fraction increases, and the sphericity index improves [Hvass 2010].

The addition of a papillary muscle sling to the standard mitral annuloplasty is safe and feasible when performing minimally invasive valve surgery. The patients we select for this procedure are those with severe, functional mitral regurgitation who have an ejection fraction of 40%. In those patients with ischemic mitral regurgitation and coronary artery lesions amenable to angioplasty, we utilize a hybrid approach of performing the percutaneous intervention followed by the minimally invasive valve surgery [Santana 2012].

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