A papillary-ventricular complex repair technique for functional mitral regurgitation

Ichiro Hayashi*, Hirofumi Kasahara, Keiko Abe and Norimasa Haijima

Department of Cardiovascular Surgery, National Hospital Organization Saitama National Hospital, Wako City, Saitama, Japan

* Corresponding author. Department of Cardiovascular Surgery, National Hospital Organization Saitama National Hospital, 1-2 Suwa, Wako City, Saitama 351-0102, Japan. Tel: +81-48-4621101; fax: +81-48-4641138; e-mail: hyshhime@me.point.ne.jp (I. Hayashi).

Received 27 June 2013; received in revised form 31 July 2013; accepted 13 August 2013

Abstract

The objective of this study was to describe a simple and reproducible papillary-ventricular complex technique for repairing functional mitral regurgitation. To avoid a recurrence of mitral regurgitation subsequent to left ventricular remodeling, we performed papillary muscle plication and papillary muscle and head approximation in combination with relocation of the papillary muscle heads to correct any anterior and or posterior mitral leaflet discrepancy and to preserve the papillary-ventricular complex. Preliminary results in 7 patients showed an encouraging functional improvement following surgery. Future long-term controlled studies in a greater number of patients are required to further assess this novel technique.

Keywords: Mitral regurgitation • Mitral valve repair • Myocardial infarction

INTRODUCTION

The standard approach for treating functional mitral regurgitation (FMR) is the undersized mitral ring annuloplasty [1]. This technique remains controversial, because recent studies have demonstrated that mitral regurgitation can persist or recur in association with continued left ventricular (LV) remodeling [2]. Mechanistic studies have determined that FMR is caused by displacement of the papillary muscles and tethering of the mitral valve leaflets after LV remodeling. Therefore, the correction should focus on the papillary-ventricular complex. Several procedures have been developed to correct papillary-ventricular complex displacement [3–5], but no procedure has been established as the gold standard. To restore the physiological function of the papillary muscles to their physiological position, we developed a simple and reproducible approach that involved papillary muscle plication and simultaneous papillary muscle and head approximation.

MATERIAL AND METHODS

This procedure was performed through a trans-septal or left interatrial groove incision during cardiac arrest. First, posteromedial papillary muscle head approximation of the anterior and posterior mitral valve leaflets was performed. A 2-0 Nespolene U-shaped stitch reinforced by Teflon pledget was passed in a clockwise direction through the posteromedial papillary muscle head of the anterior leaflet and then through the head of the posterior leaflet. One or two suture bites were made on the posterolateral myocardium between these papillary muscles. At the anterolateral commissure, the anterolateral papillary muscle heads of the posterior and anterior leaflets were sutured and tied concurrently, after which reinforcement was applied with another Teflon patch (Fig. 1 and Supplementary Video 1). The optimal papillary muscle distance should return to physiological position about 15 mm [6]. We also added traction sutures to both papillary muscle heads for muscle tip relocation (Supplementary Video 2). The final position is determined as the point at which leaflet coaptation occurs in the plane of the mitral annulus and the LV saline infusion test revealed disappearance of mitral regurgitation [7]. Mitral annuloplasty was performed using either a Carpentier-Edwards physior ring (Edward Life Science, Irving, CA, USA) or a Saddle Rigid ring (St Jude Medical Minneapolis, MN, USA) to prevent future dilatation. Ring size was determined according to the surface of the anterior leaflet (28 mm in 1 case, 30 mm in 3, 32 mm in 2 and 34 mm in 1), and coronary artery bypass grafting was performed if needed. We used this approach to treat 7 consecutive patients with FMR who were scheduled to undergo modified papillary muscle plication. The indication for surgery was heart failure, Class III or IV as defined by the New York Heart Association (NYHA). Mitral regurgitation was moderate to severe in all cases (Table 1).

RESULTS

All patients survived the surgery without any serious complications, and postoperative mitral regurgitation was either minimal or entirely absent. All patients improved to NYHA functional Class I or II (Table 1). One patient with LV tachycardia identified before surgery was readmitted to the hospital 4 months after, and he came off this follow-up group. In all other 6 patients, mitral...
Figure 1: (A) A 2-0 Nespolene U-shaped stitch reinforced with a Teflon pledget is passed through the posteromedial papillary muscle head of the anterior leaflet and through the head of the posterior leaflet (1). One or two (2 and 3) suture bites are then made on the posterolateral myocardium between the two papillary muscles. Next, the anterolateral papillary muscle head of the anterior leaflet and the head of the posterior leaflet are sutured (4). The sutures are then reinforced with another Teflon patch and tied. AML: anterior mitral leaflet; PML: posterior mitral leaflet; ALPM: anterolateral papillary muscle; PMPM: posteromedial papillary muscle. (B) Schematic representation of relocation sutures between anterior and posterior papillary muscle heads and posterior mitral annulus buttressed with Teflon pledgets.
valvular function has remained stable during the short-term (range 3–12 months) follow-up with no-to-mild mitral valve regurgitation. This technique is considered to be safe and effective. However, long-term follow-up on a greater number of patients is necessary to verify our findings.

**DISCUSSION**

FMR is a dynamic process in which LV remodelling leads to papillary muscle displacement and mitral annulus dilatation, which, in turn, decreases the size of the coapation zone. The surgical strategy should also correct LV posterolateral wall dilatation and prevent apical displacement of the tips of both papillary muscles to maintain a sufficient coapation zone. Nair et al. [3] described an approach for LV volume reduction that involved realignment of the papillary muscles without ventriculectomy. Papillary muscles could be used as a dynamic anchor to counter and prevent excessive dilatation of the LV. The resultant approximation of the papillary muscles would decrease LV circumferential diameter. This method of LV volume reduction can be accomplished through a left atrial or trans-septal incision without sacrificing the myocardium. Ishikawa et al. [5] reported on a papillary muscle sandwich plasty technique, which fixes the bases of the chordae tendineae of the anterior and posterior leaflets. This technique is effective in preventing the pseudoprolapase of anterior leaflet resulting from the anterior leaflet overriding the posterior leaflet as Sabet et al. described [8] in future LV remodelling. Our novel technique is able to decrease LV circumferential diameter and also increase the size of the coaptation zone, which may prevent subsequent FMR and LV remodelling. We also added traction sutures to both papillary muscle heads for muscle tip relocation. This combination procedure may be effective in preventing apical displacement of the tips of both papillary muscles. One patient with LV tachycardia identified was re-admitted to the hospital. The combination of this approach with antiarrhythmic surgery, such as cardioverter-defibrillator implantation, may be necessary to improve the outcomes of patients with severe ischaemic cardiomyopathy. Because of the unique anatomical pattern associated with FMR, it is possible to use this single technique to correct regurgitation. This technique may be helpful in preventing the recurrence of mitral valve regurgitation after protracted LV remodelling.

**SUPPLEMENTARY MATERIAL**

Supplementary material (Videos 1 and 2) is available at **EJCTS** online.

**Video 1:** A U-shaped stitch is passed through the PMPM head of the AML and through the head of the PML. Two suture bites are then made on the posterolateral myocardium between the two papillary muscles. Next, the ALPM head of the PML and the head of the AML are sutured. AML: anterior mitral leaflet; PML: posterior mitral leaflet; ALPM: anterolateral papillary muscle; PMPM: posteromedial papillary muscle.

**Video 2:** Persistent mild mitral regurgitation after papillary-ventricular complex repair had completely disappeared after re-location of papillary muscle heads.

**Conflict of interest:** none declared.

**REFERENCES**


---

**Table 1:** Early change in left ventricular function and mitral valve geometry

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF (%)</td>
<td>45.7 ± 14</td>
<td>43.0 ± 13</td>
<td>0.623</td>
</tr>
<tr>
<td>LVDD (mm)</td>
<td>65.3 ± 4.3</td>
<td>55.6 ± 6.0</td>
<td>0.015</td>
</tr>
<tr>
<td>LVDS (mm)</td>
<td>49.4 ± 5.9</td>
<td>44.4 ± 9.3</td>
<td>0.195</td>
</tr>
<tr>
<td>MV coaptation depth (mm)</td>
<td>10 ± 2.2</td>
<td>2.7 ± 0.8</td>
<td>0.0002</td>
</tr>
<tr>
<td>Papillary muscle distance (mm)</td>
<td>29 ± 4.8</td>
<td>17 ± 2.0</td>
<td>0.001</td>
</tr>
<tr>
<td>MR grade</td>
<td>3.4 ± 0.5</td>
<td>1.6 ± 0.5</td>
<td></td>
</tr>
<tr>
<td>NYHA Class</td>
<td>3.3 ± 0.5</td>
<td>1.4 ± 0.5</td>
<td></td>
</tr>
</tbody>
</table>

EF: ejection fraction; LVDD: left ventricular dimension diastolic; LVDS: left ventricular dimension systolic; MV: mitral valve; MR: mitral regurgitation; NYHA: New York Heart Association.