Review

Surgical Treatment for Ischemic Mitral Regurgitation: Strategy for a Tethered Valve

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Recently, ischemic mitral regurgitation (IMR) has been shown to be an individual risk factor for ischemic heart disease. The main mechanism of IMR is tethering of the leaflet secondary to left ventricular (LV) dilatation. In this situation, surgical treatment for IMR has been limited to ring annuloplasty with varying degrees of effectiveness. However, mid-term follow-up studies have shown that the results obtained with this approach are not satisfactory. Therefore, there has been a need to develop additional techniques to achieve more secure repair of IMR. The characteristics of the mitral leaflet configuration in IMR are apical displacement of the leaflets relative to the annulus, concavity of the leaflets, and a dilated annulus. Our basic strategy for a tethered mitral valve is rigid ring annuloplasty and inward correction of the outwardly displaced papillary muscle. For the latter correction, we employ the overlapping method or septal anterior ventricular exclusion (SAVE) procedure for LV volume reduction in cases of broad antero-septal infarction, or elevate the posterior papillary muscle by folding the LV wall at the root of the posterior papillary muscle via a small incision in the inferior wall in cases of infero-posterior infarction. An additional procedure is chordal cutting in combination with rigid ring annuloplasty and papillary muscle imbrication in combination with LV volume reduction. We have successfully combined these methods with the aid of detailed echocardiographic studies in individual patients. However, long-term follow-up will be necessary before this approach can be routinely adopted. (Ann Thorac Cardiovasc Surg 2005; 11: 288–92)

Key words: ischemic mitral regurgitation, tethering, surgical treatment

Introduction

Recently, attention is paid to ischemic mitral regurgitation (IMR) because it has become clear that IMR is an individual risk factor for ischemic heart disease.[1-5] Previously, the main cause of IMR was thought to be mitral valve prolapse due to dysfunction of the papillary muscle.[6,7] However, the current opinion is that, in most cases, the main cause of IMR is tethering of the leaflet secondary to left ventricular (LV) dilatation[8-14] and papillary muscle dysfunction attenuates IMR, as revealed by detailed echocardiographic studies.[15] In this situation, surgical treatment for IMR has been limited to annuloplasty using a rigid or flexible ring, with varying degrees of effectiveness.[16-19] However, Calafiore et al. have reported that ring annuloplasty is not effective in cases where tethering is strong,[20] and recently McGee et al. reported that the short- and mid-term outcomes of ring annuloplasty are not satisfactory.[21] This may be because this procedure cannot address the tethering itself. Therefore, there has been a need to develop additional techniques to achieve more secure repair of IMR. Here we describe our surgical strategy for treatment of mitral valve tethering.

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Characteristics of the mitral leaflet configuration in IMR

1: Apical displacement of the mitral leaflets relative to

the annulus[10-14)]
This is caused by outward dislocation of the papillary muscle secondary to LV dilatation. It must be noted that in the case of infero-posterior infarction, this phenomenon may occur without such severe LV dilatation.[22-25)]
2: Concavity of the leaflet[26)]
When there is heterogeneity of leaflet tethering, the tethering in the middle portion of the leaflet is stronger, resulting in concave deformation of the leaflet and narrowing of the coaptation zone.
3: Dilated annulus[25,27-31)]
Dilatation of the annulus secondary to LV dilatation also plays a role in IMR. In this setting, the annulus is deformed, making it rounder and losing its physiological saddle shape.[32-34)] The dilated distance of anterior and posterior annuli exacerbates the narrowed coaptation of the tethered valve.

Our strategy for a tethered mitral valve
Currently, no established method for IMR has been reported. In our institution, we combine the methods described below with the aid of detailed echocardiographic studies in individual patients.

Basic strategy
1: Ring annuloplasty
To increase the narrowed coaptation zone, this procedure is indispensable. If tethering is not so strong, this procedure alone achieves sufficient repair of IMR. To control the distance of the anterior and posterior annuli, we select a rigid ring.
2: Inward correction of the outwardly displaced papillary muscle
Considering the mechanism of IMR, the essential surgical aim must be inward correction of the displaced papillary muscle. For this purpose, we select the overlapping method[35,36)] or septal anterior ventricular exclusion (SAVE) procedure[37,38)] as the method of LV volume reduction in cases of broad antero-septal infarction accompanied by severe LV dilatation, or we elevate the posterior papillary muscle by folding the LV wall at the root of the posterior papillary muscle via a small incision in the inferior wall in cases of infero-posterior infarction (where the LV volume is often not increased to such an extent as to require reduction).[39)]

Additional procedures
1: Chordal cutting[40,41)]
When the shape of the leaflet is concave, this technique is effective in gaining an adequate coaptation zone, and therefore we use it in combination with rigid ring annuloplasty.
2: Papillary muscle imbrication in combination with LV volume reduction[42)]
When the distance of the anterior and posterior papillary muscles is too great for correction by LV volume reduction alone, we add this technique. It must be noted that this technique alone reduces LV volume.

Case presentations
Case 1 (broad anterior infarction)[43)]
The concomitant operation is the left atrial Maze operation.

LV volume reduction was performed by the overlapping method.

In this case, although the degree of tethering was relatively small, the coaptation zone was markedly narrowed because of the concave shape. Four strut chordae of the anterior leaflet were cut, and then annuloplasty using a 30-mm Carpentier-Edwards rigid ring (Edwards Lifesciences, USA) was performed. After the operation, echocardiography showed a convex shape, an adequate coaptation zone, and absence of IMR (Fig. 1).
Case 2 (broad anterior and inferior infarction)[39)]
The concomitant operation is CABG (lt.ITA-LAD · Ao-RCA).

LV volume reduction was also performed by the overlapping method.

In this case, two large posterior papillary muscles were present and both were strongly displaced by the presence of inferior infarction. Therefore, we imbricated the anterior one anteriorly and elevated the posterior one by folding the inferior wall. This eliminated most of the valve tethering when viewed through the left atriotomy before performing annuloplasty using a 28-mm Carpentier-Edwards rigid ring. After the operation, echocardiography showed an adequate coaptation zone and absence of tethering and IMR (Fig. 2).

Discussion

Detailed clinical studies using echocardiography, and also several experimental studies, conducted over the last few years have proved that the main mechanism responsible for IMR is outward displacement of the papillary muscle and consequent tethering of the mitral valve leaflets.[1-5,8-15)]
This means that IMR is not a disease of the valve, but of the LV myocardium, therefore, the surgical methods used

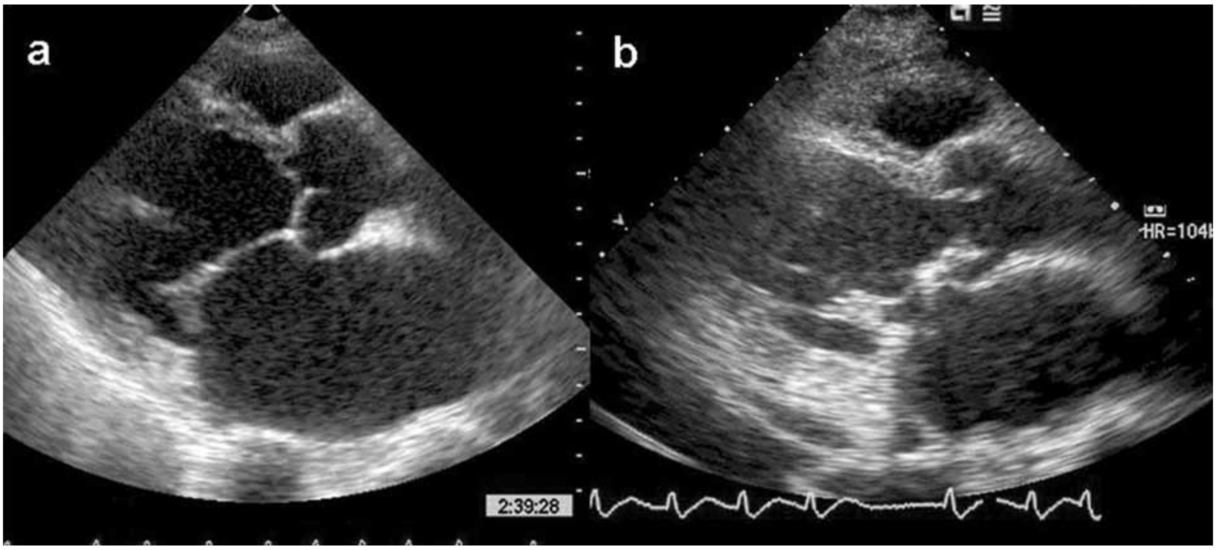

Fig. 1.
a. Case 1 before surgery.
The leaflets are apparently tethered towards the apex. The anterior leaflet shows concave deformity. Doppler mode demonstrates severe MR.
b. Case 1 after surgery.
MR and tethering of the leaflets have disappeared, and the leaflet is now the correct convex shape.

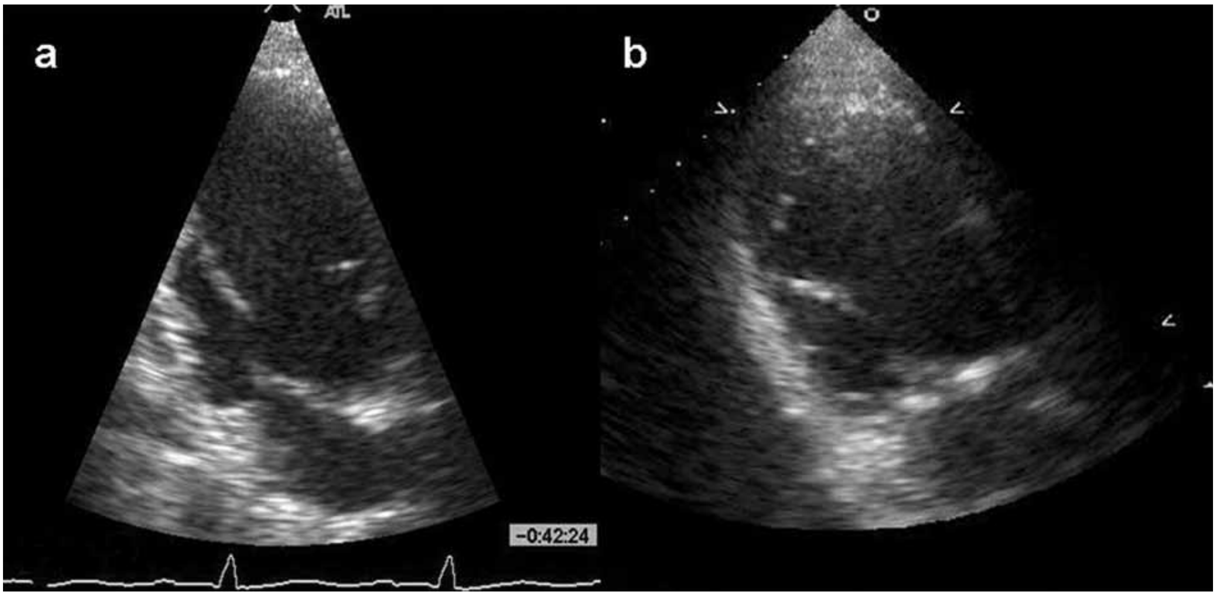

Fig. 2.
a. Case 2 before surgery.
The leaflets are apparently tethered towards the apex. The anterior leaflet shows slight concave deformity. Doppler mode demonstrates severe MR.
b. Case 2 after surgery.
MR and tethering of the leaflets have disappeared. However, concave deformity of the leaflet still remains.

previously for valvular MR are not effective except for ring annuloplasty.[16-19] However, recently a mid-term follow-up study showed that the outcome of ring annuloplasty was not satisfactory.[21] Recently, several promising experimental trials have been reported. Tibayan et al. have reported that septal-lateral annular cinching i.e. reduction of the distance of the anterior and posterior annuli diminishes the severity of IMR,[44] thus supporting our policy of selecting a rigid ring for annuloplasty. Messas et al. have reported a chordal cutting procedure,[40,41] and we have successfully adopted this method combined with rigid ring annuloplasty (case 1). Clinically, Hvass et al. have reported the use of a papillary muscle sling[45] and Menicanti et al. have reported papillary muscle imbrication.[42] These two methods share the same concept that reduction of the increased distance of the anterior and posterior papillary muscles diminishes the degree of tethering, with different approaches from the left atrium (LA) or the LV. We have also successfully adopted papillary muscle imbrication combined with LV volume reduction (case 2), and we consider that this method is indicated for cases of severe LV dilatation after broad anterior infarction.

Finally, a description of our original method is given below.[39] To relocate the posterior papillary muscle inwardly, we fold the inferior LV wall at the root of the dislocated posterior papillary muscle. In combination with rigid ring annuloplasty, this method effectively diminishes IMR (case 2). We think that this approach is an essential one for reduction of tethering. However, its limitation is that the free wall of the LV at the root of the dislocated papillary muscle must be infarcted transmurally. Therefore, this method is good for cases of infero-posterior infarction, but not for severe LV dilatation after broad anterior infarction.

At present, irrespective of the method selected for treatment of IMR, the long-term results are unpredictable. Many factors can affect the outcome, including whether or not LV remodeling has been completed at the time of surgery, or whether it will continue after surgery. In any event, surgical therapy for IMR is still at the starting line, and long-term follow-up of many cases will be mandatory in order to establish the most suitable method.

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