Papillary Muscle Sling: A New Functional Approach to Mitral Repair in Patients With Ischemic Left Ventricular Dysfunction and Functional Mitral Regurgitation

Ulrik Hvass, MD, Michel Tapia, MD, Frank Baron, MD, Bruno Pouzet, MD, and Abdel Shafy, MD

Cardiovascular Surgery, Bichat Hospital, Paris, France

Background. **In patients with ischemic left ventricular dysfunction (LVD) and functional mitral regurgitation (FMR), restoring a more normal alignment between mitral annulus and laterally displaced papillary muscles (PM) may be beneficial in terms of mitral repair and regional dynamics.**

Methods. **Ten patients, 29 to 78 years old, with an ejection fraction of 25% to 45%, pulmonary hypertension greater than 60, and New York Heart Association Class III–IV, had their PMs drawn together by a tightly encircling loop using a 4-mm Gore-Tex tube. Associated mitral annuloplasty rings were only moderately undersized. Efficiency was essentially evaluated on reversal of mitral tenting and control of FMR.**

Results. **Postoperative echocardioraphy revealed changes in "tenting effect" from 14 ± 2.8 mm to 4 ± 1.41 mm. Regurgitation is none to trivial in 9 patients, and mild in 1 patient. The posterior left ventricular wall between the PMs is shortened as a result of the surgical remodeling and may be beneficial on local dynamics.**

Conclusions. **Joining the PM side-by-side has an obvious immediate effect on mitral leaflet mobility by suppressing the tethering due to displacement of the PM. An eventual result on local ventricular dynamics needs confirmation.**

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Abnormal displacement of the papillary muscles (PM) leading to excessive tension on chordae has been demonstrated in patients with ischemic left ventricular dysfunction (LVD) and functional mitral regurgitation (FMR). The tethering, restricting mitral leaflet mobility, and resulting in mitral regurgitation suggests that correction of FMR should also focus on some form of intraventricular remodeling directed to relieve tension on chordae.

Based on these considerations we tested a new approach that consists in correcting, through the left atrium and the mitral orifice, the abnormal displacement of the PM using an intraventricular sling (Gore-Tex 4-mm tube; W.L. Gore Associates, Flagstaff, AZ) encircling the trabecular base of both PM. Tightening and securing this sling anchors the base of the PMs together.

Reestablishing a more normal annulus-to-papillary muscle alignment was expected to relieve the excess tethering on the mitral leaflets, and significantly restore leaflet mobility. A moderately undersized mitral annuloplasty ring, essentially correcting annular dilatation, would then complete the repair.

The intended procedure would thus comprise a double mitral ring: one inside the ventricle at the level of the PM, the other on the mitral annulus.

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Address reprint requests to Dr Hvass, Cardiovascular Surgery, Bichat Hospital, 46 rue Henri Huchard, Paris 75018, France; e-mail: ulrik.hvass@bch.ap-hop-paris.fr.

Patients and Methods

Patients

Since June 2000, 10 patients with sequel of inferior or lateral infarction and chronic ischemic mitral insufficiency have benefited from a double repair associating an intraventricular peri-papillary muscle sling completed by a classic intraatrial mitral annuloplasty ring. Ages were 29 to 78 years old, mean age was 55 years old. Ejection fraction on angiograms was between 25% and 45%. Left ventricular end-diastolic and end-systolic diameters were, respectively, 70 ± 0 mm and 54 ± 5.6 mm. All patients had a systolic pulmonary arterial pressure above 60 mm Hg. Mitral regurgitation was moderate to moderately severe, or 2 to 3 on a scale of 4. Medical therapy was maximal and the patients had experienced several hospital admissions for left ventricular failure. NYHA was III–IV. All patients had dilated left ventricles with obvious tenting of the mitral leaflets on preoperative transesophageal echocardiography, suggesting that the main mechanism of mitral regurgitation was due to PM displacement. Transgastric short-axis view allows an estimation of the augmented distance between the two PMs, 3.8 ± 0.6 cm compared with normal values of 2.5 ± 0.3 cm.

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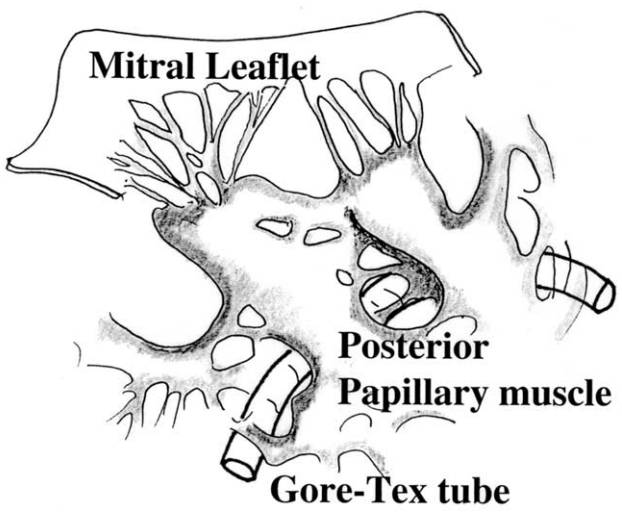

Fig 1. The Gore-Tex tube encircles the trabecular base of the posterior papillary muscle, then that of the anterior papillary muscle. The tube is then tightened and secured with sutures, creating a complete sling that brings both papillary muscles in close contact.

Surgical Technique

Once the mitral valve has been exposed and analyzed as anatomically normal we placed the stitches on the mitral annulus preparing for the annuloplasty. Slight traction on these sutures allows a better exposure of the subvalvular apparatus. The position of the anterior PM usually seems normal, under the anterior mitral commissure. The posterior PM is usually out of the field and it may be necessary to place a textile under the heart to visualize it correctly and to gain adequate access. We then proceed by insinuating a blunt dissector through the stronger trabeculations at the base of the posterior papillary muscle attachment to the ventricular wall ensuring that the Gore-Tex tube, after being pulled through, will not slip out of position once released (Fig 1). Variations in PM anatomy, single or multiple, do not affect feasibility. We then take the same tube around the base of the anterior PM. The loop is progressively tightened until the two PMs are in close contact. The 4-mm Gore-Tex tube forms an intraventricular ring that is secured with strong sutures. Once tightened there is no residual gap between the bases of the two PM. No sutures are placed on the papillary muscles themselves. The procedure is completed by mitral annuloplasty and the necessary coronary bypass grafts.

Results

Positioning the intraventricular sling was possible in all patients. By approximating the two PM, tension on the mitral chordae is immediately unloaded, improving leaflet mobility and coaptation. Cross-clamping time was initially prolonged a mean 28 ± 3.5 minutes and has been reduced in the latest cases. Mitral annular dilatation, which is often an associated consequence of chronic mitral regurgitation, is then corrected using a moderately undersized Carpentier Physio Ring (Carpentier-Edwards, Irvine, CA), sizes 30 ± 2.8 mm. Coronary bypass grafts comprise 2 ± 1.41 grafts per patient. All patients survived. Follow-up is 3 to 24 months. Residual regurgitation is none to trivial in 9 patients, and no more than mild in 1 patient.

The tenting effect on the mitral leaflets is considerably attenuated, as revealed by comparing the preoperative and postoperative two-dimensional echocardiograms even though the PM displacements are probably not fully corrected, in particular the apical displacement. The tenting effect, measured as the distance between mitral annulus plane and leaflet coaptation, varies from a preoperative mean value of 14 ± 2.8 mm to a postoperative mean value of 4 ± 1.41 mm. Patients with the longer follow-up demonstrate no secondary displacement of the intraventricular sling. Preoperative and postoperative left ventricular end-diastolic diameters diminished from 70 ± 0 mm to 62.4 ± 3.5 mm. End-systolic left ventricular diameters changed from 54 ± 5.6 mm to 51.5 ± 4.9 mm, the latter diameter being influenced by postoperative paradoxical septum. Functional status improved from NYHA III–IV to NYHA I–II in all but 1 patient.

Comment

Mitral annuloplasty as the sole procedure [1] in patients with functional mitral regurgitation addresses only one of the components of mitral dysfunction. Although the early results are often satisfactory, there is a trend to consider that additional procedures [2–3] are necessary besides mitral ring to enhance ventricular performance and reduce the incidence of recurrent mitral regurgitation.

Considering that the components of the mitral apparatus belong to a single functional unit, this intraventricular remodeling of the posterior base of the left ventricle appears to be a rational approach for surgical correction that takes into account the deformities of the subvalvular mitral apparatus [4].

When tension is relieved from the mitral chordae, seriously under sizing the prosthetic mitral ring does not appear to be necessary. Restoring mitral leaflet mobility, already obvious in the operating room, is confirmed by regression of the tenting effect in all patients.

The expected advantages of this new technique are to make mitral repair more physiologic through restoring leaflet mobility and coaptation while avoiding the risk of mitral stenosis that can occur when seriously undersizing a mitral ring.

Long-term advantages can also be anticipated, such as a lower incidence of recurrent mitral regurgitation. Recurrent mitral regurgitation, following an initially successful mitral annuloplasty [5], may be related to continuing papillary muscle displacement that augments the tethering on the leaflets, deranging once more the ratio between mitral orifice and covering surface of the mitral leaflets. The PM sling, by anchoring the PM together, suppresses the possibility of further lateral papillary displacement that might prevent or at least delay the occurrence of these recurrent mitral leaks.

Another long-term advantage may comprise an effect on regional wall motion, related to the posterior plication of the left ventricle between the two PM, affecting the ratio between volume and mass.

Conclusions

Intraventricular remodeling by means of a sling encircling and anchoring both papillary muscles in a more normal "papillary muscle-to-mitral annulus" alignment, completed by mitral annuloplasty, seems an interesting approach in patients with chronic ischemic LVD and FMR. An eventual result on local ventricular dynamics and on preventing recurrent mitral regurgitation will need confirmation by randomized and long-term studies.

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Tom R. Karl, MD
The Annals *Internet Editor*
UCSF Children's Hospital
Pediatric Cardiac Surgical Unit
505 Parnassus Ave, Room S-549
San Francisco, CA 94143-0118
Phone: (415) 476-3501
Fax: (212) 202-3622
e-mail: karlt@surgery.ucsf.edu