A simple approach to mitral valve repair: Posterior leaflet height adjustment using a partial fold of the free edge

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Objectives: Multiple techniques have been used to repair degenerative mitral valve prolapse with leaflet elongation, without creating systolic anterior motion. We describe a simple, reproducible, measured technique to guide repair.

Methods: From January 2010 to July 2012, 171 patients underwent mitral valve repair; 128 (75%) with Carpentier type II prolapse. For 48 patients (37.5%), the resected posterior leaflet free edge was partially folded to restore the normal 2:1 ratio of the A2 and P2. All patients underwent complete ring annuloplasty sized to the height of A2.

Results: The preoperative A2/P2 ratio was 1.5 ± 0.5. After repair, the A2/P2 ratio was 1.9 ± 0.3 and 2.0 ± 0.3 in the no fold and partial fold groups, respectively ($P = .57$). The ring sizes were larger in the partial fold group ($P < .001$) because the A2 height was larger ($P = .001$). No obstructive systolic anterior motion was present. Of the 171 patients, 91.4% had grade 4+ preoperative mitral regurgitation, with no 3 or 4+ mitral regurgitation during follow-up. At the last follow-up visit, grade 2+ mitral regurgitation was observed in 5% of the patients. No 30-day mortalities or reoperations occurred.

Conclusions: Partial fold of the posterior leaflet free edge is a simple technique to restore the normal 2:1 ratio of A2/P2 with a ring size determined by the A2 height. Using just the A2 height, mitral surgeons can reproducibly repair the posterior leaflet prolapse, choose the appropriate ring size, and avoid more complex leaflet reconstruction or judgment of the neochord length. (J Thorac Cardiovasc Surg 2014;148:2780-6)

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Degenerative mitral valve (MV) disease, especially Barlow disease, is characterized, not only by chord elongation and/or rupture leading to prolapse, but also by elongation of the leaflets with increased height (‘‘tall leaflets’’).[1-3] This excess tissue can complicate MV repair for type II disease, because it can contribute to asymmetric closure at the point of coaptation and could be a contributing cause of systolic anterior motion (SAM).[2,4] The elongated posterior leaflet can be managed by resection and reconstruction (sliding-plasty) or, more recently described, by completely folding the posterior leaflet over.[5-7] However, these techniques have been used without direct measurement, instead relying on the experience and judgment of the surgeon, which varies widely.[8-10] No general agreement has been reached, even among the most experienced surgeons, regarding when the leaflet is ‘‘too tall’’ and needs intervention or what the height should be after sliding-plasty or foldoplasty; thus, most surgeons are confused about when these techniques should be used. Also, no consensus has been reached regarding the ring types (complete or incomplete, rigid or flexible) and sizing.[11] The repair rates have been low in low-volume centers and in the hands of surgeons with little valve experience, likely owing to the complexity of the pathologic features in type II disease.[8,9,11]

To gain more precise information about the leaflet height and variability, we began to directly measure the leaflet segments before, during, and after repair.[3] We then developed a new precise approach to reconstruct the posterior leaflet and reestablish the normal ratio of 2:1 between the anterior leaflet height (A2) and posterior leaflet height (reconstructed P2). We always used a complete ring in the present study, and the ring size was chosen according to the height of A2. We advocate this technique in patients with type II disease with a ratio of anterior leaflet height to posterior leaflet height of >2:1. The objective of the present report was to describe the findings and measurements, the technique of posterior leaflet adjustment using partial foldoplasty (PF), and our early outcomes.

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Abbreviations and Acronyms

LA = left atrial
LV = left ventricular
NF = no fold
PF = partial foldoplasty
SAM = systolic anterior motion

METHODS

The data for our project was obtained from the Cardiovascular Research Database in the Clinical Trial Unit of the Bluhm Cardiovascular Institute at Northwestern Memorial Hospital. The institutional review board at Northwestern University approved the database (project no. STU00012288). The subjects refusing participation in the project were not included in the present analysis.

From January 2010 to July 2012, 128 patients who had undergone MV repair by 1 surgeon and had had Carpentier type II prolapse were included in the present study. We compared 2 groups according to the surgical technique used: (1) PF (n = 48; 37.5%) and (2) no fold (NF; n = 80; 62.5%). The patient characteristics and associated surgical procedures are summarized in Table 1. The MV leaflet measurements were made directly by the surgeon using a custom calipers (Table 2), as previously described.[3] After the free edge was resected and adjusted to the desired level, it was measured again. The measurements were recorded and entered in custom fields in the Cardiovascular Research Database. No sliding-plasties and no artificial chords were used.

The mitral regurgitation (MR) degree was classified as follows: 0 (none or trivial), 1+ (mild), 2+ (moderate), 3+ (moderate-to-severe), or 4+ (severe). Intraoperative transesophageal echocardiography was used in all operations, and a predischarge echocardiogram was obtained for all patients. All patients were prospectively followed up by a dedicated valve nurse. The MR information is listed in Table 3. The follow-up data were 100% complete, and postdischarge echocardiograms were obtained for 80% of patients at 0.8 ± 0.6 year after surgery. The maximum follow-up period was 2.7 years.

Surgical Techniques

The procedure in the NF group consisted of resection of the prolapsed segment in 81%. In this group, the remaining posterior leaflet was approximately one half the height of A2 and therefore did not need the PF technique, and the edges of the resection were closed in 2 layers. The reconstructed segment was measured and termed the "reconstructed posterior leaflet height," and a ring size (median, 32 mm) was chosen according to the A2 height (24.9 ± 3.5 mm).

Technique of Posterior Leaflet Height Adjustment Using PF

A trapezoid resection of the flail or prolapsing segment (Figure 1, *A*) was performed, preserving the normal length chords on either side of the resection (Figure 1, *B*). The posterior annulus was plicated. The desired height of the posterior leaflet was one half the height of A2. A 5-0 Ethibond (Ethicon, Somerville, NJ) suture was placed from the left atrial (LA) to left ventricular (LV) aspect of the medial leaflet, typically 4 to 5 mm less than the desired height, from the LV to LA side of the leaflet at the chord attached to the free edge, thereby partially folding the free edge (Figure 1, *C*). The suture was then taken from the LA to LV side of the free edge of the lateral leaflet and back from the LV to LA side below the desired height (Figure 1, *C*). Tension on the suture causes both sides to fold over, creating a new free edge at the desired height (Figure 1, *D*). A second suture is placed at the free edge, through adjacent chordae, and both sutures are sewn down to the annulus and tied, taking care to smooth out raised areas of leaflet tissue (Figure 2, *A* and *B*). If indentations remain between the P1 and P2 remnant and the P2 and P3 remnant, they are routinely closed (Figure 2, *C* and *D*), and the completed repair is symmetric and properly proportioned to the height of A2. A complete remodeling ring is chosen according to the height of A2 (Figure 3). In some cases, only 1 side of the resection will be elongated. This is easily managed by PF of the side that is too long and passing the suture from the ventricular to atrial side of the opposing leaflet segment that is already at the desired height. Chord transfer was used in 9 (13%) of the NF and 8 (17%) of PF patients, with an edge-to-edge approximation in 7 (9%) of the NF and 3 (6%) of the PF patients. Of these, procedures, 7 were central (5 in the NF and 2 in the

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TABLE 1. Patient characteristics stratified by group

Characteristic	Overall (n = 128)	NF group (n = 80)	PF (n = 48)	*P* value
Age (y)	60.2 ± 12.5	62.1 ± 13.7	56.9 ± 9.5	.022
Female sex	49 (38)	30 (38)	19 (40)	.81
NYHA functional class I or II	115 (92)	72 (91)	43 (93)	.64
LVEF (%)	62.0 (58.0, 65.0)	61.0 (60.0, 65.0)	62.0 (55.0, 65.0)	.83
Mitral valve leaflet				.93
Posterior only	100 (84)	59 (83)	41 (85)	
Bileaflet	14 (12)	9 (13)	5 (10)	
Anterior only	5 (4)	3 (4)	2 (4)	
Chordal/leaflet transfer	18 (14)	10 (13)	8 (17)	.48
Edge to edge repair (Alfieri)	10 (8)	7 (9)	3 (6)	.61
Median ring size	32 (32.0, 36.0)	32.0 (30.0, 34.0)	34.0 (32.0, 37.0)	<.001
Tricuspid valve surgery	6 (5)	4 (5)	2 (4)	.83
Atrial fibrillation ablation surgery	25 (20)	15 (19)	10 (21)	.77
Coronary artery bypass	15 (12)	12 (15)	3 (6)	.14
Aortic valve surgery	2 (2)	1 (1)	1 (2)	.68
Crossclamp time (min)	67.0 (58.5, 74.5)	67.0 (58.5, 75.0)	67.5 (59.0, 74.5)	.78
Perfusion time (min)	76.0 (68.5, 92.5)	75.5 (68.0, 94.0)	77.0 (70.0, 88.0)	.99
30-d/in-hospital mortality	0 (0)	0 (0)	0 (0)	
All-cause long-term mortality	1 (1)	0 (0)	2 (4)	.07

Data presented as mean ± standard deviation, n (%), or median (quartile 1, quartile 3). *NF*, No fold; *PF*, partial foldoplasty; *NYHA*, New York Heart Association; *LVEF*, left ventricular ejection fraction.