'Frozen' Posterior Mitral Leaflet in Rheumatic Mitral Stenosis: Incidence and Impact on Outcome of Balloon Mitral Commissurotomy

Yoav Turgeman, Shaul Atar, Alexander Feldman, Mohamed Jabaren, Khaled Suleiman, Lev Bloch, Tiberio Rosenfeld

Department of Cardiology, Ha'Emek Medical Center, Afula, Israel

Background and aim of the study: **The incidence and clinical significance of immobile and 'frozen' posterior mitral leaflet (FPML) were evaluated in the pathophysiology and immediate outcome of patients with severe pliable mitral stenosis (MS) undergoing percutaneous balloon mitral commissurotomy (PBMC).**

Methods: **During the past four years, 30 'ideal' patients (mean age 46 ± 8 years) with Wilkins' score <8, bilateral commissural fusion and absence of commissural calcification underwent peri-procedural echocardiographic analysis. Anterior mitral leaflet (AML) mobility index (MI), chordae tendineae (CT) length, and mitral valve area (MVA) were evaluated.**

Results: **Pre-procedure FPML was noted in 28 patients (93%). All patients achieved MVA ≥1.5 cm². Post-procedure MVA in patients with bilateral commissural splitting was 1.9 ± 0.2 cm² versus 1.6 ± 0.1 cm² in patients with unilateral commissural splitting (p <0.05). CT lengths directed to the AML and PML were 15 ± 2 mm and 8 ± 2 mm, respectively (p <0.05). MI of the AML before and immediately after PBMC was 0.4 and 0.6, respectively (p <0.05). None of the patients with FPML showed improved mobility following successful PBMC.**

Conclusion: **FPML may be found in most patients with pliable MS. It is mainly a result of short, rigid and fused CT directed to the PML. A 'single-wing door' or a unicuspid valve may be used as a model for rheumatic pliable MS. It is suggested that pre-procedure leaflet morphology and functional assessment should focus on the AML.**

The Journal of Heart Valve Disease 2005;14:282-285

Each structural element of the mitral valve may be involved in the pathology and pathophysiology of rheumatic mitral stenosis (MS) (1,2). Therapeutic decision-making and prediction of both immediate and late procedural results is currently focused on the descriptive morphological characteristics of the mitral valve, as obtained by echocardiography and using a variety of scoring systems (3-5). However, the choice of therapeutic modality should be based on a combination of the descriptive and functional anatomy of the mitral valve.

Immobile and 'frozen' posterior mitral leaflet (FPML) is commonly noted on echocardiography in patients with rheumatic MS. The aim of the present study was to evaluate the incidence and clinical significance of FPML in patients with severe pliable MS, and its impact on the immediate outcome of percutaneous balloon mitral commissurotomy (PBMC).

Presented as a poster at the Second Biennial Meeting of the Society for Heart Valve Disease, 28th June-1st July 2003, Palais des Congrès, Paris, France

Address for correspondence:
Yoav Turgeman MD, Director of Invasive Cardiology, Department of Cardiology, Ha'Emek Medical Center, Afula 18101, Israel
e-mail: yoav_t@clalit.org.il

Clinical material and methods

Patients

A total of 131 PBMC procedures was performed by the present authors between January 1998 and January 2002. The optimal results were defined as: post-procedure mitral valve area (MVA) ≥1.5 cm² without major complications (death, angiographic mitral regurgitation grade >II/IV, tamponade or major embolic event) (6). A total of 92 patients (70%) had optimal results, whilst a sub-optimal PBMC result (MVA <1.5 cm²) was obtained in 35 patients (27%). The procedure failed in four patients (3%). Thirty 'ideal' patients were selected according to the following transthoracic echocardiography (TTE) criteria: Wilkins' score <8, bilateral commissural fusion, and absence of commissural calcification. Patients after previous balloon dilatation

or mitral valve surgery, or those with a clinically and echocardiographically non-ideally pliable valve (Wilkins' score ≥8, significant leaflet thickening or calcification and either partial or unilateral split commissures) were excluded from the study.

Echocardiographic assessment

All patients underwent TTE before, during, and 24 h after the PBMC procedure. For pre-procedure TTE, the Wilkins' score, commissural calcification, site of fusion (bilateral or unilateral), leaflet mobility and chordae tendineae length (mm) directed to both leaflets, were determined (3,7). Chordae tendineae length was measured as the mean distance (in mm) between the tip of the papillary muscle and the ventricular aspect of both leaflets during early systole, using modified views (8). In order to assess leaflet motion and to measure the mobility index (MI), the mitral leaflets were imaged in the parasternal long-axis view during maximal doming of the anterior mitral leaflet (AML) in early diastole (4). As shown in Figure 1, the extent of doming of the AML was quantified by drawing a line from the junction of the posterior wall of the aortic root to the tip of the AML. From this line, a perpendicular was drawn to the leading edge of the maximal dome of the AML, and leaflet motion was expressed as the slope between these two lines (4). The MI was graded as mild (≥0.45), moderate (0.26-0.44) and severe (<0.25) impairment (4). The MVA (in cm^2) and mean transvalvular diastolic gradient (in mmHg) were calculated using planimetry and Doppler echocardiography, respectively.

PBMC technique

All patients underwent PBMC by the trans-septal antegrade approach, using the Inoue balloon catheter (Toray Industries Inc., Tokyo, Japan) and the step-wise dilatation technique (9). Balloon diameter size was determined according to the patient's height (10). Immediately after dilation, the planimetric valve area, transvalvular gradients, post-dilatation commissural morphology (unilateral or bilateral splitting) and periprocedural complications were monitored continuously using TTE.

Statistical analysis

Values of MVA (cm^2), transvalvular gradient (mmHg) and chordae tendineae length (mm) were reported as mean ± SD. Student's *t*-test was used to compare continuous variables, and a chi-square test for comparing categorical variables. A p-value <0.05 was considered to be statistically significant.

Results

A total of 101 'non-ideal' patients was excluded; hence, data were analyzed from 30 'ideal' patients (26 women, four men; mean age 46 ± 8 years) who underwent successful PBMC.

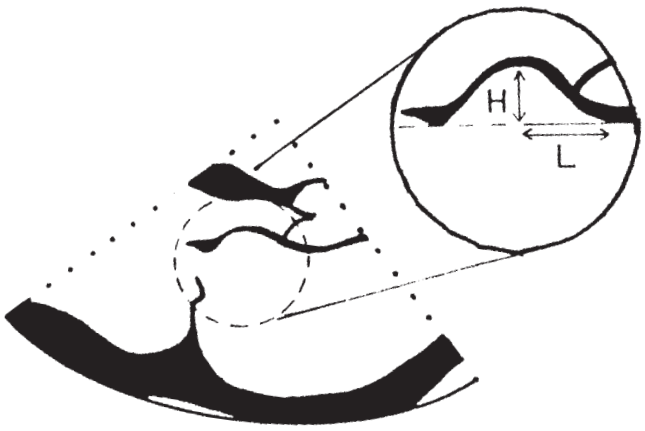

Figure 1: Calculation of the mobility index of the anterior mitral leaflet. Maximal doming of the anterior leaflet was quantified in the parasternal, long-axis, two-dimensional echocardiographic view. The height (H) of doming was divided by length (L) to express the slope of leaflet motion. (Reproduced from Reference (4), with permission).

Incidence and impact of FPML

Pre-procedure FPML was identified in 28 patients (93%), while only very mild posterior displacement of the PML in early diastole was noted in two patients. There was no improvement in PML mobility following PBMC in any of the 30 patients, regardless of the post-procedure commissural status.

Chordae tendineae length and morphology

The mean chordae tendineae length directed to the AML was 15 ± 2 mm, while that directed to the PML was 8 ± 2 mm ($p < 0.05$). Dense subvalvular fibrosis, shortening and fusion of the chordae tendineae was detected only in those directed to the PML.

Post-dilatation commissural status

Patients were allocated to two groups according to their post-PBMC commissural morphology: 12 patients (40%) had bilateral commissural splitting (BCS), and 18 (60%) had unilateral commissural splitting (ULCS). Patients with post-procedure BCS had a larger mean MVA and lower mean transvalvular gradient than those with post-procedure ULCS (1.9 ± 0.2 cm^2 versus 1.6 ± 0.1 cm^2 and 4 mmHg versus 8 mmHg, respectively; $p < 0.05$). The mean post-procedure MI of the AML was higher in the BCS group than in the ULCS group (0.7 versus 0.5, $p < 0.05$) (Table I).

J Heart Valve Dis
Vol. 14. No. 3
May 2005

Table I: Transthoracic echocardiography results according to post-percutaneous balloon mitral commissurotomy commissural status.

Parameter	Commissural splitting	
	Bilateral (n = 12)	Unilateral (n = 18)
MVA (cm^2)*	1.9 ± 0.2	1.6 ± 0.1+
MTG B/A (mmHg)	16/4	15/8+
AML-MI (B/A)	0.4/0.7	0.4/0.5+

*Values are mean ± SD.
AML: Anterior mitral leaflet; B/A: Before/after PBMC; MTG: Mean transvalvular gradient; MI: Mobility index; MVA: Mitral valve area.
+p <0.05.

Discussion

The results of this retrospective study showed that an immobile or 'frozen' PML is an abnormal pre-procedure morphological finding in almost all patients with pliable mitral stenosis. The immobility of the posterior leaflet persists after successful balloon dilatation, but was not affected by balloon-induced commissural splitting, and did not affect procedural success. Bilateral commissural splitting and an increase in AML mobility index - regardless of the presence or absence of a 'frozen' PML - were mainly responsible for the increase in mitral valve area after PBMC. It is suggested that commissural fusion does not affect the mobility of the PML, which is most probably principally affected by the anatomical mode of insertion and attachment of the fused chordae tendineae to the PML.

However, as has been reported with surgical commissurotomy in patients who achieve a final orifice area that is much closer to that of a normal valve, some posterior leaflets may acquire a degree of mobility. It can be assumed that with PBMC - however large the final orifice may be - rheumatic commissural fusion is not completely resolved. Although the present patients had 'ideal', pliable, non-calcific MS, 60% of them had unilateral splitting in the absence of any commissural calcification. Thus, the present findings were in accordance with a previous in-vitro study conducted by Ribeiro et al., who indicated that overall commissural splitting occurred preferentially in calcified commissures (81%) as opposed to only 56% in non-calcified commissures (11). Moreover, with the stepwise dilatation Inoue technique, no further dilatations were made once a reasonable MVA had been achieved, even in the presence of unilateral splitting, mainly to avoid periprocedural complications such as high-grade mitral regurgitation.

Posterior mitral leaflet structure and its chordae tendineae

Although the surface area of both mitral leaflets is identical, they differ in the length of attachment to the mitral annulus and the mode of insertion of chordae tendineae directed to each leaflet's ventricular surface area. The posterior mitral (mural) leaflet is more narrow, has two clefts that create three scallops, and has a longer attachment to the annulus compared to the anterior (aortic) leaflet. Whereas most of the chordae tendineae directed to the AML are inserted to its marginal zone, those directed to the PML from its margin back to the annulus attach to both its rough and clear ventricular zones (12).

Previous studies

The present results comply with previous clinical observations relating to mitral valve conservation surgery. Commerford et al. (13) analyzed 654 patients who underwent closed mitral valvotomy (the surgical equivalent of PBMC) operated on during a 12-year period, and concluded that a mobile anterior mitral leaflet is a prerequisite for a non-restrictive valve motion after closed commissurotomy. Green et al. (14) showed that successful mitral ring annuloplasty (regardless of the type of ring) results in a 'frozen' and immobile posterior leaflet. This observation fully supports the concept that a rheumatic pliable valve is almost a single-leaflet functioning valve, similar to the mitral apparatus obtained after successful mitral ring annuloplasty. In a recently published editorial, relating to the septolateral cinching technique, Frater commented that a rheumatic FPML is not corrected by commissurotomy, and that the posterior mitral leaflet stays immobile well after the stenosis has been corrected (15).

In conclusion, a FPML may be found in most patients with severe pliable mitral stenosis, and is mainly the result of short, rigid and fused chordae tendineae directed to the PML. A 'single-wing door' or a unicuspid valve may be used as a model for rheumatic pliable mitral stenosis. It is suggested that finding an immobile and 'frozen' posterior mitral leaflet should not affect pre-PBMC assessment and the prediction of procedural success. The therapeutic approach should be mainly based on pre-procedure assessment of the anterior mitral leaflet structure and function and on commissural morphology.

References

1. Schoen EJ. Surgical pathology of removal natural and prosthetic valves. Hum Pathol 1987;18:558-567
2. Schoen EJ, Sutton MJ. Contemporary pathologic consideration in valvular heart disease. In: Virmani R, Atkinson JB, Fengolio JJ (ed.), Cardiovascular Pathology. WB Saunders, Philadelphia, 1991:334-353
3. Wilkins GT, Gillam LD, Weyman AE, et al. Percutaneous balloon dilatation of the mitral valve: An analysis of echocardiographic variables related to outcome and the mechanism of dilatation. Br Heart J 1988;60:299-308
4. Reid CL, Chandraratna AN, Kawanishi DT, Kotlewski AK, Rahimtoola SH. Influence of mitral valve morphology on the double-balloon catheter balloon valvuloplasty in patients with mitral stenosis. Circulation 1989;80:515-524
5. Iung B, Cormier B, Ducimetiere P, et al. Immediate results of percutaneous mitral commissurotomy. Circulation 1996;94:2124-2130
6. Vahanian A, Acar J. Mitral valvuloplasty: the French experience. In: Topol EJ (ed.), Textbook of Interventional Cardiology. 1st edn. WB Saunders, Philadelphia, 1994:1206-1225
7. Fatkin D, Roy P, Morgan JJ, Feneley MP. Percutaneous balloon mitral valvotomy with the Inoue single balloon catheter: Commissural morphology as a determinant of outcome. J Am Coll Cardiol 1993;21:390-397
8. Babburi H, Oommen R, Brofferio A, Ilercil A, Frater R, Shirani J. Functional anatomy of the normal mitral apparatus: A transthoracic, two-dimensional echocardiographic study. J Heart Valve Dis 2003;12:180-185
9. Inoue K, Hung JS. Percutaneous transvenous mitral commissurotomy (PTMC): The far-east experience. In: Topol EJ (ed.), Textbook of Interventional Cardiology. 1st edn.: WB Saunders, Philadelphia, 1990:887-899
10. Inoue K, Chen CR, Hung JS. Percutaneous transvenous mitral commissurotomy guided and assessed by echocardiography. In: Cikes I (ed.), Echocardiography in Cardiac Interventions. 1st edn. Kluwer Academic Publishers, 1989:67-76
11. Ribeiro PA, Zaibag ML, Rajendran V, et al. Mechanism of mitral valve area increase by in vitro single and double balloon mitral valvotomy. Am J Cardiol 1988;62:264-269
12. Turgeman Y, Atar S, Rosenfeld T. The subvalvular apparatus in rheumatic mitral stenosis. Methods of assessment and therapeutic implications. Chest 2003;124:1929-1936
13. Commerford PJ, Hastie T, Beck W. Closed mitral valvotomy: Actuarial analysis of results in 654 patients over 12 years and analysis of preoperative predictors of long-term survival. Ann Thorac Surg 1982;33:473-479
14. Green GR, Dagum P, Glasson JR, et al. Restricted posterior leaflet motion after mitral ring annuloplasty. Ann Thorac Surg 1999;68:2100-2106
15. Frater RWM. Septolateral cinching. J Heart Valve Dis 2002;11:1