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INVITED ARTICLE

Mitral balloon valvotomy, long-term results, its impact on severe pulmonary hypertension, severe tricuspid regurgitation, atrial fibrillation, left atrial size, left ventricular function

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Abstract Percutaneous mitral balloon valvotomy (MBV) was introduced in 1984 by Inoue who developed the procedure as a logical extension of surgical closed commissurotomy. Since then, MBV has emerged as the treatment of choice for severe pliable rheumatic mitral stenosis (MS). With increasing experience and better selection of patient, the immediate results of the procedure have improved and the rate of complications declined. When the reported complications of MBV are viewed in aggregate, complications occur at approximately the following rates: mortality (0–0.5%), cerebral accident (1–2%), mitral regurgitation (MR) requiring surgery (0.9–2%). These complication rates compare favorably to those reported after surgical commissurotomy. Several randomized trials reported similar hemodynamic results with MBV and surgical commissurotomy. Restenosis after MBV ranges from 4% to 70% depending on the patient selection, valve morphology, and duration of follow-up. Restenosis was encountered in 31% of the author's series at mean follow-up of 9 ± 5.2 years (range 1.5–19 years) and the 10, 15, and 19 years restenosis-free survival rates were (78 ± 2%) (52 ± 3%) and (26 ± 4%), respectively, and were significantly higher for patients with favorable mitral morphology (MES ⩽ 8) at 88 ± 2%, 67 ± 4% and 40 ± 6%, respectively ($P < 0.0001$). The 10, 15, and 19 years event-free survival rates were 88 ± 2%, 60 ± 4% and 28 ± 7%, respectively, and were significantly higher for patients with favorable mitral morphology 92 ± 2%, 70 ± 4% and 42 ± 7%, respectively ($P < 0.0001$). The effect of MBV on severe pulmonary hypertension, concomitant severe tricuspid regurgitation, left ventricular function, left atrial size, and atrial fibrillation is addressed in this review.

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1. Introduction

Mitral stenosis is a progressive disease that leads to heart failure and is finally fatal unless mechanical intervention enlarges the

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mitral valve orifice to permit adequate cardiac output at a tolerable left atrial pressure. Starting over 50 years ago a variety of surgical techniques were developed; first closed commissurotomy followed by open commissurotomy after the introduction of the cardiopulmonary bypass.[1,2] Mitral balloon valvotomy was introduced in 1984 by the Japanese surgeon Inoue, who developed the procedure as a logical extension of surgical closed commissurotomy.[3] Since then, MBV has emerged as the treatment of choice for severe pliable rheumatic mitral stenosis. The mechanism by which both procedures reduce stenosis is the same and involves mechanical dilatation of fused commissures.[4] Several randomized trials reported similar hemodynamic results with balloon valvotomy and surgical commissurotomy. However, periprocedural complications in surgical patients were somewhat higher.[5–8] Both forms of commissurotomy eliminate the risks common to prosthetic valves, which include primary valve failure, thromboembolism, and endocarditis. The purpose of this review is to summarize the immediate and long-term results up to 19 years of MBV, its complications, and elucidate the effect of MBV on severe pulmonary hypertension, concomitant severe tricuspid regurgitation, left ventricular function, left atrial size, and atrial fibrillation.

2. Techniques

The transseptal technique is the most common technique used to perform MBV. The technique consists of advancing a catheter over the wire across the interatrial septum after transseptal puncture, enlarging the opening and advancing one large balloon (Inoue balloon) or two smaller balloons (double-balloon technique) across the mitral orifice and inflating them within the orifice. Although acute and short-term outcomes differ little between these two techniques,[9,10] complications such as death, left ventricular perforation, and stroke appear to be less common with the Inoue balloon. The multiple advantages of the Inoue balloon, include low profile of the device, the elimination of the stiff guide wire (minimizing the risk of LV perforation), easy maneuverability, and the stepwise dilation (gradual increase of balloon size on sequential inflations).[11]

3. Echocardiographic evaluation

Echocardiography is the mainstay of the noninvasive evaluation of mitral stenosis. The transthoracic echocardiography provides an evaluation of the valvular apparatus, mitral valve area (MVA), left atria dimension, and associated valve lesions. Doppler echo provides hemodynamic evaluation including mean mitral gradient, MVA, assessment of concomitant tricuspid regurgitation (TR) and estimation of pulmonary artery pressure. The morphologic evaluation of the mitral valve is semiquantilated using echocardiographic score (echo score). The scoring system evaluates leaflet thickening, mobility, calcification, and subvalvular involvement on a scale of 0–4, as described by Wilkins et al.[12] The mitral valve morphology is considered favorable if the mitral echocardiographic score (MES) is $\leqslant$8. Transesophageal (TEE) echo should be performed before MBV for patients with atrial fibrillation or prior history of systemic embolism or very obese patient where the left atrium was not properly visualized. We do not recommend TEE as a routine procedure before MBV.[13]

4. Results

4.1. Immediate hemodynamic results

The left atrial pressure, mean mitral gradient, and pulmonary artery systolic pressure decreased significantly after MBV with a corresponding increase in MVA. In the National Heart, Lung Blood Institute Balloon Valvotomy Registry of 736 patients,[14] the MVA by echocardiographic assessment was 1.09 $\pm$ 0.29 cm^2 before the procedure and increased to 1.8 $\pm$ 0.15 cm^2 after the procedure. In the author's series, 547 consecutive patients[13] the echocardiographic MVA was 0.92 $\pm$ 0.17 cm^2 before the procedure, and increased to 1.95 $\pm$ 0.29 cm^2 after the procedure. A significant inverse relationship was found between the echo score and post-procedure MVA where mitral valve morphology was found to be a strong predictor of post-procedure mitral opening.[12,15] However, good results could also be obtained in cases with relatively high echo score.

4.2. Complications of balloon mitral valvotomy

In general, MBV is a safe procedure with high success rate, particularly if the patients chosen have optimal valve morphology as determined by echo score. When the reported rates of complications of MBV are viewed in aggregate, complications appear to occur at approximately the following rates: mortality (0–0.5%), cerebrovascular accident (CVA) (0.5–2%), cardiac tamponade (0.7–1%), mitral regurgitation requiring surgery (0.9–2%), mitral regurgitation of some degree (15%), and atrial septal defect detected by color Doppler (20–23%) which, however, closes or decreases in size in most patients.[11,16,17]

4.3. Long-term follow-up and predictors of restenosis and event-free survival

4.3.1. Mitral restenosis

The restenosis rate after MBV has been reported as 39% at 7 years[18] and was lower (31%) at 19 years in our younger population (mean age 31.5 $\pm$ 11 years)[19] and was 20% in subgroup of patients with MES $\leqslant$ 8. The actuarial freedom from restenosis rates for this population were 78 $\pm$ 2% at 10 years, 52 $\pm$ 3% at 15 years, and 26 $\pm$ 5% at 19 years and were significantly higher for patients with optimal morphology echo score $\leqslant$ 8, namely 88 $\pm$ 2% at 10 years, 67 $\pm$ 4% at 15 years, 40 $\pm$ 6% at 19 years (Fig. 1) . The predictors of being free from restenosis were a low echo score ($P < 0.0001$) and post-procedure MVA $\geqslant$ 2.0 cm^2.[19–21]

4.3.2. Event-free survival

Iung et al. reported an event-free survival (survival with freedom from redo MBV, MVR, cardiac death, NYHA functional class III or IV) rate of 61% at 10 years in 528 patients with successful PMBV (mean age, 49 years).[21] Palacios et al. (879 patients with successful MBV mean age, 55 years) reported a rate of 38% at 12 years for patients with echo score $\leqslant$8 and 22% for patients with echo score $>$8.[22] Event-free survival rates at 10, 15, and 19 years were 88%, 60%, and 28%, respectively, in our relatively younger patients and were significantly