Long-Term Clinical and Echocardiographic Outcome in Patients With Mitral Stenosis Treated With Percutaneous Transvenous Mitral Commissurotomy

Fumihiko Saeki, MD; Yuko Ishizaka, MD; Tsutomu Tamura, MD

Long-term follow-up after percutaneous transvenous mitral commissurotomy (PTMC) is limited. Ninety-four middle-aged (51±9 years) mitral stenosis patients who underwent successful PTMC were followed up with annual echocardiography for 6.1±1.4 years. PTMC success was defined as either mitral valve area (MVA) >1.5 cm² or a MVA of more than twice the pre-procedural value, together with no worsening of mitral regurgitation >grade 2+. Mitral valve replacement (MVR), worsening of congestive heart failure (CHF), and thromboembolism were sought for survival analysis. Restenosis was defined as loss of more than 50% of the initial procedural MVA gain. Functional limit of daily activities was assessed through a questionnaire. The study population was divided into group 1 (post-procedural MVA >2.0 cm²), group 2 (MVA >1.5 cm² and ≤2.0 cm²) and group 3 (MVA ≤1.5 cm²). The 6-year survival with freedom from MVR, CHF, thromboembolism, and combined events (MVR+CHF) was 92%, 95%, 91%, and 88%, respectively. No group 1 patient experienced MVR or CHF. Restenosis was predominant in group 3. Deterioration of daily activities during follow-up was not observed in group 1; however, it was significant in group 2 (p<0.05) and group 3 (p<0.001). These results demonstrated that patients who attained a large MVA (>2.0 cm²) immediately after PTMC maintained their procedural benefit with less clinical complication and with less limitation of daily activity. (Jpn Circ J 1999; 63: 597–604)

Key Words: Daily activity; Event-free survival; Functional limit; Percutaneous transvenous mitral commissurotomy; Restenosis

Percutaneous transvenous mitral commissurotomy (PTMC) has been established as a reasonable treatment of choice since its first introduction as a clinical application. In the majority of mitral stenosis (MS) patients, PTMC provides good immediate improvements of both cardiac hemodynamics and clinical sympotoms. However, there are few published reports concerning the long-term outcome of mitral valve area (MVA), clinical events and the functional limit of daily activities. Because most of the previous studies were retrospective, they provide limited information on post-procedural exacerbation. Moreover, few studies have been done in a single laboratory with a uniform technique.

We report the long-term results after successful PTMC using the single-balloon technique, performed and then evaluated in the same institution. The annual follow-up was focused on the MVA and clinical events.

Methods

Study Patients

From June 1987 to December 1990, 132 patients underwent PTMC in Mitsui Memorial Hospital. Achievement of either a MVA >1.5 cm² or a MVA of more than twice the pre-PTMC value was a requirement for procedural success. Another requirement was the absence of exacerbated mitral regurgitation (MR) of grade of 2+ or more by Sellers classification. Based on this criteria, 126 patients (95%) were judged to be successfully treated.

We followed up these patients with a scheduled annual interview and echocardiography. Seven patients who died of a non-cardiac cause were excluded. Exercise tolerance was evaluated through the answers to a questionnaire sent in August 1995, to which 117 patients (93%) responded. Of these, 94 patients (male/female: 23/71; age range: 37–66 years, mean±SD: 51±9 years) completed both the annual echocardiographic examination and the clinical interview. These were accepted as the study population.

Based on the MVA immediately after PTMC, the study population was divided into 3 subgroups: group 1 patients attained a satisfactory MVA (>2.0 cm²) immediately after PTMC; group 2 patients attained a fair commissurotomy result, but their MVA remained between >1.5 and ≤2.0 cm²; and group 3 patients had their MVA improved by PTMC to more than twice the pre-PTMC value, but their MVA remained ≤1.5 cm². Table 1 summarizes the baseline characteristics and pre-procedural hemodynamic parameters.

PTMC Technique

The transvenous transseptal approach with Inoue balloon was used in all subjects. The initial balloon size was measured just before each commissurotomy procedure; we selected 27.5–28.0 mm for male patients and 27.0–27.5 mm for female patients. The balloon size was increased stepwise by 0.5 mm consecutive dilatations until a MVA of more than 2.0 cm² was reached or MR increased significantly. Hemodynamic parameters, such as pulmonary capillary wedge pressure and left atrial pressure, were measured before and after PTMC. The severity of MR was graded using left ventriculography and Sellers classification.
Table 1  Baseline Characteristics of the Study Patients

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (n=32)</th>
<th>Group 2 (n=41)</th>
<th>Group 3 (n=21)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>50±8</td>
<td>50±10</td>
<td>53±10</td>
<td>NS</td>
</tr>
<tr>
<td>Male gender (%)</td>
<td>44</td>
<td>17</td>
<td>10</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Atrial fibrillation (%)</td>
<td>62</td>
<td>73</td>
<td>71</td>
<td>NS</td>
</tr>
<tr>
<td>NYHA functional class (4”)</td>
<td>2.3±0.6</td>
<td>2.3±0.5</td>
<td>2.8±0.5</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Wilkins echo score</td>
<td>6.6±1.3</td>
<td>7.1±1.5</td>
<td>9.0±1.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mitral regurgitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>28</td>
<td>31</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Grade 1</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>NS</td>
</tr>
<tr>
<td>Grade 2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>MVA (2DE) (cm²)</td>
<td>1.2±0.3</td>
<td>1.0±0.3</td>
<td>0.8±0.1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mean LA pressure (mmHg)</td>
<td>19±5</td>
<td>19±5</td>
<td>23±8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Balloon size used (mm)</td>
<td>28.0±1.0</td>
<td>28.0±1.0</td>
<td>27.5±0.8</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

NYHA, New York Heart Association; MVA, mitral valve area; 2DE, 2 dimensional echocardiography; LA, left atrium.

Table 2  Hemodynamic Characteristics Before (Pre) and Immediately After (Post) Precutaneous Transvenous Mitral Commissurotomy

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>MVA (2DE) (m²)</td>
<td>1.2±0.2</td>
<td>2.3±0.2**</td>
<td>1.0±02</td>
<td>1.8±0.1**</td>
</tr>
<tr>
<td>Mean LA pressure (mmHg)</td>
<td>19±6</td>
<td>12±4***</td>
<td>19±5</td>
<td>12±3**</td>
</tr>
<tr>
<td>NYHA functional class (4”)</td>
<td>2.3±0.6</td>
<td>1.1±0.3***</td>
<td>2.3±0.5</td>
<td>1.2±0.5**</td>
</tr>
<tr>
<td>MR grade</td>
<td>0.4±0.5</td>
<td>0.6±0.3</td>
<td>0.2±0.1</td>
<td></td>
</tr>
</tbody>
</table>

AMR, exacerbation of mitral regurgitation grade; Other abbreviations are the same as Table 1.
P value (*<0.0005, **<0.0001) shows the result of comparison of hemodynamic parameters in each subgroup between the Pre and Post measurements.

Echocardiographic Measurements

Measurement of the MVA was done using 2-dimensional echocardiography. The mitral orifice was visualized through the parasternal short axis view and its area was manually traced by planimetry. Measurement was repeated 5 times in different cardiac cycles and the mean value was used for analysis. Echocardiographic examination was scheduled annually in the follow-up period, regardless of the immediate PTMC results. We defined restenosis as the loss of more than 50% of the initial MVA gain immediately after PTMC. Echocardiographic severity of mitral valve disease was judged according to the Wilkins score system, which is based on the semiquantitative grading of leaflet thickening, mobility, calcification, and subvalvular involvement on a scale of 1 to 4.17

Clinical Follow-up

Patients were followed up after PTMC for 6.1±1.4 (range: 0.4–8.4) years. Most of them were followed up by cardiologists in the hospital, and their cardiac functional class and clinical events were evaluated. As for the patients who were followed up elsewhere, their clinical status and echocardiographic data were confirmed through correspondence with their attending physicians. Clinical events during follow-up were defined as either the experience of mitral valve replacement (MVR), worsening of congestive heart failure (CHF) requiring hospitalization, or onset of thromboembolism. The patients who underwent MVR were censored from later follow-up on the day of their operation.

Estimates of Daily Activities

The maximum limit of daily activity was evaluated using the scale reported previously.18 Patients were requested to answer 20 specific activities listed in the questionnaire, as either ‘capable’ or not. This self-assessment of daily activities was done retrospectively targeting 3 separate time-points; namely, just before PTMC, immediately after PTMC and their last follow-up. Estimated maximum limit of daily activities was expressed as the corresponding metabolic equivalents (METs) value.

Statistical Analysis

Values were expressed as mean±SD. Continuous variables were compared using a paired t-test. Comparison of numerical variable among subgroups was performed using one-way ANOVA test. Chi-square test or Fisher’s exact test were used for comparison of categorical variables. Cumulative event-free survival curves were determined by an actuarial method using Kaplan-Meier estimates. The probability of event-free survival was compared among subgroups using log-rank test. A p value of less than 0.05 was considered statistically significant. Analysis was performed using SAS statistical software (SAS Institute Inc, Cary, NC, USA).

Results

Immediate PTMC Results

The comparison of baseline patient characteristics, including pre-PTMC hemodynamic data, is shown in Table 1. Group 1 consisted of more male patients compared with groups 2 and 3. The pre-PTMC comparison revealed that group 3 patients had a significantly smaller MVA, higher Wilkins echo score, higher NYHA functional class and higher mean left atrial pressure. No significant difference was observed among the 3 subgroups concerning age, percentage of atrial fibrillation rhythm and pre-procedural MR severity.
Comparison of the maximum Inoue balloon diameter used during PTMC demonstrated that group 3 patients were treated with a less inflated balloon.

Hemodynamic data immediately after PTMC are shown in Table 2. In each subgroup, the increase in MVA, reduction of mean left atrial pressure, and improvement of the NYHA functional class were observed with statistical significance. Exacerbation of MR (ΔMR) immediately after PTMC was significant in group 1 (p<0.005) and group 2 (p<0.0001) patients.

**Event-Free Survival**

During our long-term follow-up, no cardiac death was observed. Fig 1 demonstrates the estimated actuarial event-free survival for the study population. Each curve corresponds to the survival with freedom from, respectively, MVR, CHF, thromboembolism, and from a combination of events (MVR + CHF). Estimated event-free survival rate at mean follow-up period (=6.1 years) was 92% for MVR, 95% for CHF, 88% for combined events (MVR + CHF), and 91% for thromboembolism. Fig 2 shows the result of combined event-free survival analyzed through the log-rank test. On 7 years follow-up, survival with freedom from combined (MVR + CHF) events was significantly low (p<0.05) in group 3 [0.65; 95% confidence intervals (CI) 0.44–0.87], compared with group 2 [0.80; CI 0.67–0.94]. Subgroup analysis based on the pre-procedural Wilkins echo score demonstrated that long-term survival with freedom from combined events (MVR + CHF) was low in the high score group (score >8), although this trend was not statistically significant (Fig 3).

Table 3 demonstrates the observed incidence of clinical events, valvular restenosis, and the status of anticoagulation therapy during follow-up. Group 3 patients experienced more MVR and restenosis; however, no significant difference among the subgroups was observed concerning the incidence of CHF and thromboembolism. Twelve patients (group 2/group 3 = 2/10) underwent MVR, and the average time period from PTMC to MVR was 4.8±2.1 (range: 0.4–7.9) years. The reason for MVR was either exacerbation of symptoms or restenosis. Dyspnea was manifest in 4 patients (group 2/group 3 = 1/3), and mitral valve restenosis was detected in 8 patients (group 2/group 3 = 1/7). Follow-up of these MVR patients revealed that their MVA significantly decreased from 1.4±0.1 cm² immediately after PTMC to 1.1±0.2 cm² just before MVR (p<0.001).

Exacerbation of CHF requiring hospitalization occurred in 5 patients (group 2/group 3 = 3/2), and the average time period from PTMC to the onset of CHF symptoms was 3.7±1.8 (range: 1.3–5.7) years. Three of these patients eventually underwent MVR. The period from the onset of CHF symptoms to MVR was not uniform.

Thromboembolism was observed in 10 patients (group 1/group 2/group 3 = 4/5/1). The affected organs were brain...
in 7, spinal cord in 1, extremity in 1 and colon in 1. Eight of them were in chronic atrial fibrillation, 1 patient was in paroxysmal atrial fibrillation, and the last patient experienced conversion from sinus rhythm to atrial fibrillation during follow-up. At the onset of thromboembolism, oral aspirin or ticlopidine had been given for 5 and 3 patients, respectively; however, none of these 10 patients had been given anticoagulant therapy with warfarin. The average time period from PTMC to the onset of thromboembolic event was 3.6±1.8 (range: 0.2–7.8) years.

**Restenosis**

The follow-up results on MVA after PTMC demonstrated marked difference among the 3 subgroups (Fig.4). In group 1 patients, the average MVA value was maintained at ≥2.1 cm² throughout the 7-year follow-up. In group 2 patients also, whose average MVA immediately after PTMC was 1.8 cm², the post-procedural MVA showed no change during the 7-year follow-up. Group 3 patients, whose MVA was 1.4 cm² immediately after PTMC, showed a gradual decline of the MVA value during follow-up. The decline reached a significant level (p<0.05) at 2 years follow-up. Eighteen patients (group 2/group 3 = 2/16) were judged to have had restenosis (Table 3). Its incidence was significantly higher (p<0.001) in group 3 (76%; 16/21) compared with group 1 (0%; 0/32) and group 2 (5%; 2/41).
This suggests that the follow-up results of MVA in the restenosis subgroup closely resembled those in group 3. The time period from PTMC to the detection of restenosis was 3.1±1.5 (range: 1–7) years. The decrease in the MVA in the restenosis subgroup exceeded 0.2 cm² and 0.3 cm² at 3 and 7 years follow-up, respectively. The decline reached significant level (p<0.005) at 7 years follow-up.

**Echo Score**
Mean echo score was 7.4 for the whole study population, 6.6 in group 1, 7.1 in group 2, and 9.0 in group 3 (Table 1). The high echo-score subgroup (echo score >8) consisted of 26 patients: 2 from group 1, 8 from group 2, and 16 from group 3 (Table 4). Among this high (>8) echo-score population, exacerbation of the MR grade was pronounced in those with a good or fair commissurotomy result (=group 1- or group 2-derived patients) compared with group 3-derived patients. However, no significant difference was demonstrated as with the incidence of clinical events. Restenosis was predominant in group 3-derived patients. The results of the followed up MVA are shown in Fig 5. In both subgroups, the post-procedural MVA showed no decline until 6 years follow-up.

**Estimates of Daily Activity**
PTMC provided immediate improvement in daily activities in each subgroup (Fig 6, Table 5). On post-procedural follow-up, the maximal limit of daily activity had declined in group 2 (p<0.05) and group 3 (p<0.001), whereas it had continued unchanged in group 1. The time point of the late post-procedural follow-up was almost the same among the 3 subgroups.

**Discussion**
PTMC has been established as a standard therapy for mitral valve stenosis. However, little is known concerning the long-term post-procedural outcome of the patients, especially with regard to restenosis and clinical events. Although former studies have tried to find prognostic factors in various follow-up periods, few studies have accomplished a prospective and repetitive follow-up for more than 5 years. Population size, patient age distribution, and commissurotomy technique (single or double balloon) should also be considered for the fair assessment of these results.

Through repeated instruction to our target patients, we accomplished a long-term (6.1 years in average) follow-up with minimal case drop-out. This follow-up design also facilitated collecting precise data on clinical events. Except for daily activity evaluation, our present study was performed in a prospective manner after performing a uniform single balloon commissurotomy technique.

**Immediate PTMC Success**
The immediate PTMC result can be influenced by various factors such as the patient's age, valvular morphology, commissurotomy technique adopted, or by the definition of success. Although previous studies have reported excellent immediate PTMC outcome, the comparison of each result should be done cautiously. A high rate of success (93.6% of patients achieved post-procedural MVA ≥1.5 cm² and MVA increase of at least 25%) was reported in a young patient population (age, 27±8 years) with a pliable mitral valve. On the other hand, a less successful rate (72.7%; 96/132) was observed in more aged population (age, 44±14 years) with a calcified valve. In the present study, the immediate PTMC success rate was 95% (126/132) in a middle-aged population. Inclusion of patients with a MVA ≤1.5 cm² (=group 3) might have caused an overestimation of the success rate. However, the high echocardiographic score (mean±SD, 7.4±1.6) of our population suggests that the stenotic change of their mitral valve was not mild, so our success rate still remains within the acceptable range (75.0%; 99/132), even if we exclude group 3 patients.

Assessment of MVA might be biased by the measurement method adopted. In cases with normal sinus rhythm, the MVA value estimated by the pressure half-time method correlates well with that obtained from catheterization. However, in cases with hemodynamic change, MR or atrial fibrillation, the pressure half-time method is less reliable. We adopted 2-dimensional MVA measurement because 69% of our study population were in atrial fibrillation at entry, and because hemodynamic fluctuation seemed inevitable during the long-term follow-up.

**Late Events After PTMC**
In the post-PTMC follow-up, cardiac death and MVR are the most serious clinical events. However, the incidence of MVR during follow-up is difficult to compare among studies because there exists no definite guideline indicating MVR for post-PTMC patients. Moreover, most of the MVR candidates experience precedent hospitalization due to exacerbated CHF. Therefore, survival analysis of combined events including cardiac death, MVR and CHF together would be more practical and reliable rather than evaluating these events separately.

The relation between pre-PTMC valvular morphology and late outcome has been noted by previous
stroke. Palacios et al clearly demonstrated that a low echo-score is associated with good intermediate-term event-free survival. They followed up 327 post-PTMC patients for 20±12 (6–49) months and found that survival with freedom from cardiac death, MVR, or combined events (cardiac death, MVR, and NYHA class III or IV) was significantly excellent in patients with a low echo-score (<8). Through the 32±8 months follow-up of 328 post-PTMC patients, Jung et al reported their analytic results on predictors for prognosis. In their study, survival with freedom from mitral operations was 84% (CI 78–90%), and survival with freedom from combined events (death, mitral operations, and NYHA class III or IV) was 76% (CI 70–82%). Our results of event-free survival was superior to both those studies on MVR (94% at 5 years, 90% at 7 years follow-up) and on combined (MVR+CHF) events (93% at 5 years, 86% at 7 years follow-up). This difference might be partly explained by the relatively mild mitral valve involvement of the present study population. Those with a high (>8) Wilkins echo score comprised 28% of our study population, whereas it was 84% in the other 2 studies. The timing of the recommendation for MVR should also be considered in the analysis. Our policy was to recommend MVR when patients were judged restenotic or when they were hospitalized due to exacerbated CHF. However, the period from recommendation to acceptance of MVR was diverse on a case by case basis. Because no definite criteria for indicating MVR exists for post-PTMC patients, comparison between studies of the event-free survival should be done cautiously.

Jung et al analyzed 15 parameters of both the pre- and post-PTMC stage, and found 4 independent predictors for good late functional outcome: namely, echocardiographic score, NYHA functional class and cardiac index before PTMC, and MVA immediately after PTMC. Through a much longer period of follow-up, we also confirmed that the MVA immediately after PTMC is an important predictor for cardiac events (Fig 2). From our observation, the incidence of MVR seemed to increase after 5 years follow-up. Out of 12 patients who eventually underwent MVR, 6 patients (50%) were operated on after more than 5 years post-PTMC follow-up. Extended observation on post-PTMC patients might be necessary to establish predictors for cardiac events.

In our study population, the incidence of CHF among the 3 subgroups showed no significant difference (Table 3). Palacios et al also reported the equal incidence of CHF (NYHA class III or IV) between high (>8) and low (≤8) echo-score subgroups. These results might be explained by the biased treatment of CHF patients. Because the attending physician already knew the baseline information, patients with poor left ventricular function might have been more vigorously treated. Another explanation might be that patients with a suboptimal PTMC result and a high incidence of restenosis were censored in the early stage of follow-up due to elective MVR before overt CHF exacerbation.

Stroke has been pointed out as a major complication in mitral stenosis patients, even after PTMC. However, no long-term results on the event rate of post-PTMC thromboembolism are available for comparison. Through the 13.7 years follow-up of patients who underwent open mitral commissurotomy (OMC), Herrera et al reported a thromboembolic event rate of 9.7% (15/159). This result could not be simply compared with that from the PTMC patients, because some of their population underwent a combined operation other than OMC, such as mitral annuloplasty, splitting of the papillary muscle, and removal of thrombus in the left atrial cavity. The event rate for thromboembolism in the present study population was 11% (10/94). Nine of these 10 patients (90%) with thromboembolism had a MVA >1.5 cm² immediately after PTMC (group 1 or group 2) (Table 3). Together with their history of medication, a high risk of thromboembolism is suggested, even after successful PTMC and with continued antiplatelet therapy. Anticoagulation therapy with warfarin of post-PTMC patients appears to be essential, and it should be confirmed through another prospective study.

Restenosis After PTMC

Mitral valve morphology before PTMC has been shown as a good predictor of immediate PTMC success. However, for long-term post-procedural outcome, little has been clarified. Former studies listed the pre-PTMC Wilkins echocardiographic score as a reliable good predictor for restenosis. As this echocardiographic score strongly correlates with mitral valvar deformity, the score also depends on patient’s age. According to recent studies, the incidence of restenosis has been reported to be 2–21%. Studies that reported a low restenosis rate (2–6%) were targeting a young (<40 years) population with pliable valves. Such studies also reported results from a relatively short follow-up period (<12 months). In contrast, Desideri et al reported a much higher restenosis rate of 21% during the 19 months follow-up of their population (mean age: 52 years). Our study population is similar to that of Desideri et al in mean age and valvular morphology, so our restenosis rate of 19% during the follow-up period of 6.1 years on average seems reasonable. Our results suggest that those with a large post-procedural MVA are less susceptible to restenosis (Table 3, Fig 4).

Even with a high (>8) echo score before the procedure, some patients could attain >1.5 cm² MVA immediately after PTMC (Table 4). These patients (group 1- and group 2-derived) experienced significantly less restenosis, which implies the importance of a large MVA for the prevention of restenosis.

We also observed that half of the MVR patients had preceding restenosis, which suggests that annual echocardiography for MVA surveillance may be useful for detection of MVR candidates. Our results on restenosis may serve as a reference, because the PTMC technique was uniform and the follow-up period covered more than 5 years with little case drop-out.

Follow-up of Daily Activity

In spite of the difference of MVA achieved, the daily activities in each subgroup were markedly improved immediately after PTMC. However, deterioration of daily activity in both group 2 and group 3 patients during follow-up suggests an association between the prognosis of daily activity and the MVA attained immediately after PTMC.

The favorable long-term outcome of exercise tolerance observed in group 1 patients may justify seeking the maximum commissurotomy effect even with the expense of ≥1 increase of MR.

Study Limitation

Our study population was small in number and their mean age rather high compared with those reported previ-
Long-Term Follow-Up After PTMC

ous. Because few young mitral stenosis patients are newly diagnosed now in Japan, our observation covers a limited age group. However, our echocardiographic follow-up on the study population revealed no significant complication of age-related valvular heart disease, such as aortic valve degeneration. A considerable proportion of the patients eventually underwent MVR and were censored during the 6-year follow-up. This study design might have underestimated the post-procedural MVA decline, especially in group 3 or high echo-score patients. A high incidence of restenosis in such a subgroup might be a more reliable index for demonstrating the limits of the therapeutic efficacy of PTMC.

The estimation of daily activities was based on subjective answers to a questionnaire, not on a quantitative exercise tolerance test. Because the answer was given at the latest follow-up, the estimates of pre- and immediately post-PTMC daily activity were retrospective. However, a quantitative study on exercise tolerance can be time consuming and intolerable for some patients due to their cardiac symptoms and the results from such tests can be easily influenced by the pharmaceutical therapy. Follow-up for exercise tolerance in the long-term with an identical therapeutic background would not be practical even in a limited population.

Conclusion

Our long-term follow-up of MVA after PTMC clearly demonstrated that a good immediate commissurotomy result is maintained for at least 5 to 7 years in middle-aged MS patients. Those with a suboptimal commissurotomy result tend to have restenosis and clinical events in such a subgroup might be a more reliable index for demonstrating the limits of the therapeutic efficacy of PTMC.

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References

22. Block PC, Palacios IF, Block EH, Tuzcu EM, Griffin B: Late (two-year) follow-up after percutaneous balloon mitral valvotomy. Am J Cardiol 1992; 69: 51A–52A
30. Tuzcu EM, Block PC, Griffin BP, Newell JB, Palacios IF: Immediate and long-term outcome of percutaneous mitral valvotomy in patients
65 years and older. *Circulation* 1992; **85**: 963–971


