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Immediate and Short-Term Impacts of Successful Percutaneous Transvenous Mitral Commissurotomy on Right Ventricular Function

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ABSTRACT

Background: Mitral valve is the most frequent valve that is affected by rheumatic heart disease. Abnormalities of Right Ventricular Function (RVF) play an important role in the development of clinical symptoms and the overall prognosis of patients with Mitral Stenosis (MS). Previous studies have shown discordant findings regarding the effect of Percutaneous Transvenous Mitral Commissurotomy (PTMC) on RVF.
Objectives: This study aimed to evaluate the immediate and short-term impacts of PTMC on RVF using two-dimensional and tissue Doppler echocardiographic indices.
Methods: RVF was measured using transthoracic echocardiography indices (Tricuspid Annular Plane Systolic Excursion (TAPSE) and Peak Systolic Myocardial Velocity by DTI (RVSm)) in 75 patients with isolated severe MS presented to Rajaie Cardiovascular, Medical and Research Center between March 2016 and February 2019 before, after, and six months after PTMC.
Results: All procedures were done successfully. The echocardiographic mean Mitral Valve Area (MVA) increased significantly from 1.0 ± 0.2 to 1.4 ± 0.2 cm (P < 0.001) and the mitral valve mean gradient decreased significantly from 10.2 ± 5.3 to 6.3 ± 2.8 mmHg after successful PTMC (P < 0.001). Systolic Pulmonary Artery Pressure (SPAP) also decreased significantly from 44.7 ± 11.3 to 35.9 ± 8.4 mmHg after PTMC (P < 0.001) and to 35.1 ± 6.7 mmHg after the six-month follow-up (P < 0.001). RVSm was 11.3 ± 2.5 cm/s before PTMC, which did not change immediately after that, but decreased to 12.1 ± 1.9 cm/s after the six-month follow-up (P < 0.003). TAPSE was 19.5 ± 4.3 mm before PTMC, which significantly increased to 21.1 ± 3.2 mm six months after PTMC (P < 0.005).
Conclusion: This study suggested that successful PTMC could improve RVF and decrease pulmonary artery pressure.

1. Background

Mitral valve is the most frequent valve that is affected by rheumatic heart disease (1). In patients with mitral valve stenosis, right ventricular failure may develop either by the rheumatic process directly or through hemodynamic alterations resulting from pulmonary vascular changes (2). Abnormalities of Right Ventricular Function (RVF) play an important role in the development of clinical symptoms and the overall prognosis of patients with Mitral Stenosis (MS) (2-4). In the last two decades, Percutaneous Transluminal Mitral Commissurotomy (PTMC) has become the treatment of choice for patients with symptomatic rheumatic MS (3). Using this method, Mitral Valve Area (MVA) can be increased, which can improve the hemodynamic and clinical features of patients with MS (5). Previous studies have shown that MS could affect the left ventricular function. The effect of PTMC on the improvement of left ventricular function has been demonstrated through many studies, as well (6-10). Nonetheless, time course of the changes in the RVF following the relief of mitral obstruction in these patients has not been adequately studied although improvement of the right ventricular systolic and diastolic functions has been reported in some studies (11-16). Hence, the present study aims to assess the immediate effect of PTMC on RVF using two-dimensional and Doppler echocardiographic indices.

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2. Objectives

This study aims to evaluate the immediate and short-term impacts of PTMC on RVF.

3. Patients and Methods

3.1. Population

This observational study was conducted on 75 patients with severe MS referred to Rajaie Cardiovascular, Medical and Research Center between March 2016 and February 2019. Among the patients, 25 had atrial fibrillation, none had more than mild aortic stenosis or regurgitation or mitral regurgitation, and five had tricuspid regurgitation (moderate or more). Written informed consent forms were obtained from all patients.

All patients with severe MS (defined as planimetered MVA < 1.5 cm^2), New York Heart Association functional classes ≥ II and < IV, mitral regurgitation ≤ 2+, suitable valve morphology, and absence of concomitant cardiovascular diseases requiring surgical correction, candidates for PTMC, and patients with mitral regurgitation grade 2 or more, Left Ventricular Ejection Fraction (LVEF) < 50%, and previous aortic or mitral valve surgery were excluded from the study.

3.2. Echocardiographic Measurement

All patients were evaluated using transthoracic echocardiography followed by transesophageal echocardiography at the echocardiography unit of Rajaie Cardiovascular, Medical and Research Center before and 24 hours after PTMC. This was done using a Vivid 3 ultrasound imaging system (GE Healthcare, Milwaukee, WI) equipped with a 2.5-MHz transducer. All measurements were performed in accordance with the recommendations of the American Society of Echocardiography (17). MVA was measured by planimetry in all patients. The peak and mean mitral valve transannular pressure gradients and late filling velocities were measured using the Bernoulli principle from continuous wave Doppler recordings through the center of the mitral inflow. The Wilkins score was used to evaluate mitral leaflet mobility, valvar and subvalvular thickening, and calcification (18). MVA was determined again via planimetry 24 - 48 hours after mitral balloon dilatation. Measurements were taken in three beats in patients with normal sinus rhythm and in ten beats in those with atrial fibrillation, and the mean values were taken for analysis. Assessment of the left ventricle was performed using the Simpson method.

Systolic Pulmonary Artery Pressure (SPAP) was derived from the tricuspid regurgitant jet peak velocity using the modified Bernoulli equation (peak gradient = 4 V 2, where V was the maximal velocity of the tricuspid regurgitant jet using continuous-wave Doppler).

RVF was assessed by echocardiographic parameters according to the guidelines for echocardiographic assessment of the right heart in adults (19). Peak Systolic Myocardial Velocity measured by DTI (RVSm) (Figure 1) and Tricuspid Annular Plane Systolic Excursion (TAPSE) were determined by the difference in the displacement of the right ventricle base during systole and diastole (20) (Figure 2).

3.3. PTMC

All patients underwent PTMC by the antegrade transseptal approach using an Inoue balloon and a stepwise dilatation strategy (21). The nominal balloon diameter was decided according to the height of the patient (height [cm]/10 + 10 = balloon diameter]. Echocardiography was done at the end of the procedure to assess perforation and to look for an atrial left-to-right shunt using color flow Doppler. Optimal PTMC was defined as post PTMC MVA ≥ 1.5 cm or at least 25% increase in the valve area with no more than one grade increase in mitral regurgitation and no major complications.

All patients were followed for one year for any symptoms of RVF, including easy fatigability, exercise intolerance, raised Jugular Venous Pulsation (JVP), abdominal distension, hepatomegaly, and pedal edema.

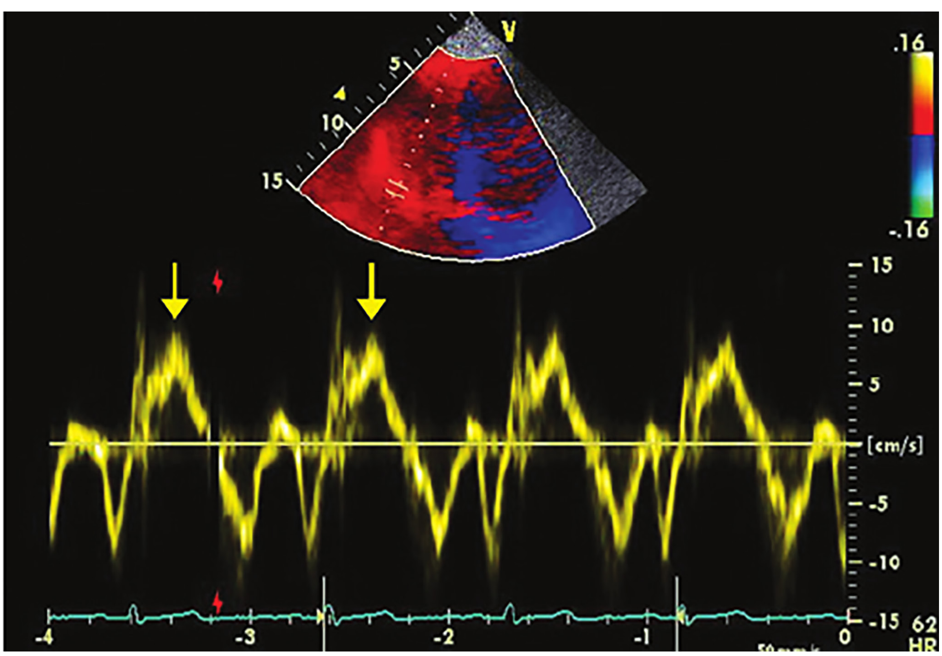

Figure 1. Measurement of the Lateral Tricuspid Annular Tissue Doppler Velocities

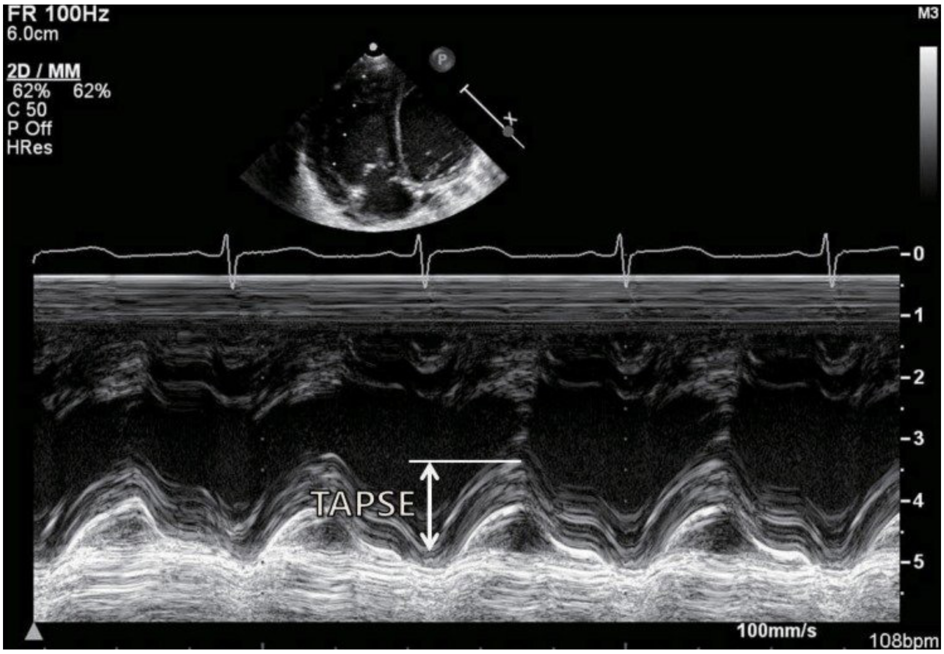

Figure 2. Measurement of Tricuspid Annular Plane Systolic Excursion

3.4. Statistical Analysis

All quantitative data have been expressed as mean ± SD. Statistical analysis was performed by using one-way Analysis of Variance (ANOVA) and its non-parametric equivalent, Kruskal-Wallis test. Independent sample t-test and chi-square test were also used. P-values less than 0.05 were considered to be statistically significant. SPSS, version 24.0 (SPSS, Inc., Chicago, IL) was used for statistical analysis.

4. Results

Baseline characteristics of the patients have been summarized in Table 1. Accordingly, 14.67% of the patients were male and 85.33% were female. The mean age of the patients was 47.4 ± 12.2 years. Among the patients, six (8%) showed the signs and symptoms of Congestive Heart Failure (CHF); i.e., pedal edema, dyspnea on exertion, exercise intolerance, and easy fatigability. However, only one patient had the signs and symptoms of CHF during the six-month follow-up after the successful PTMC.

Echocardiographic mean MVA was 1.0 ± 0.2 cm² in the transthoracic echocardiography carried out before PTMC, which increased to 1.4 ± 0.2 cm2 after PTMC, and the difference was statistically significant (P < 0.001). In addition, mitral valve mean gradient was 10.2 ± 5.3 mmHg that decreased significantly to 6.3 ± 2.8 mmHg after the successful PTMC (P < 0.001).

Echocardiographic indices were measured six months after the successful PTMC (Table 2). Left atrial diameter was 4.3 ± 0.5 cm before PTMC, which decreased to 4.2 ± 0.6 cm immediately after PTMC and to 4.1 ± 1.2 cm after six months, and both were statistically insignificant (P = 0.272). Moreover, LVEF significantly increased from 50.2 ± 4.5% to 52.7 ± 3.0% six months after PTMC (P <

Table 1. Baseline Characteristics of the Patients

Characteristics	Number (Percentage)
Age	47.4 ± 12.2
Male	11 (14.67%)
Female	64 (85.33%)
MVA before PTMC	1.0 ± 0.2
MVA after PTMC	1.4 ± 0.2
LVEF	50.9 ± 4.8
Atrial fibrillation	25 (33.3%)
Functional class (NYHA)	
Class I	13 (17.3%)
Class II	56 (74.7%)
Class III	6 (6%)
Class IV	0 (0%)
Wilkins score	
8	20 (26.7%)
9	45 (60%)
10	10 (13.3%)

Abbreviations: VA, mitral valve area; PTMC, percutaneous transvenous mitral commissurotomy; LVEF, left ventricular ejection fraction

Table 2. Echocardiographic Variables before and Six Months after PTMC

Variable	Before PTMC	Immediately after PTMC	P-value	Six Months after PTMC	P-value
LA diameter	4.3 ± 0.5	4.2 ± 0.6	NS	4.1 ± 1.2	NS
MVA	1.0 ± 0.2	1.4 ± 0.2	< 0.001	1.4 ± 0.2	< 0.001
MV gradient	10.2 ± 5.3	6.5 ± 3.3	< 0.001	6.6 ± 4.1	< 0.001
Systolic pulmonary artery pressure	44.7 ± 11.3	35.9 ± 8.4	< 0.001	35.1 ± 6.7	< 0.001
LVEF	50.2 ± 4.5	50 ± 3.8	NS	52.7 ± 3.0	< 0.001
RV sm	11.3 ± 2.5	11.5 ± 2.1	NS	12.1 ± 1.9	0.003
Tricuspid annular plane systolic excursion	19.5 ± 4.3	19.7 ± 3.8	NS	21.1 ± 3.2	0.005

Abbreviations: MVA, mitral valve area; PTMC, percutaneous transvenous mitral commissurotomy; LVEF, left ventricular ejection fraction; RVSm, peak systolic myocardial velocity measured by DTI

0.001). Besides, SPAP decreased significantly from 44.7 ± 11.3 to 35.9 ± 8.4 mmHg after PTMC (P < 0.001). A further decrease was also observed in SPAP at the six-month follow-up (35.1 ± 6.7 mmHg).

Before PTMC, seven patients (9.3%) were found to have right ventricular failure by transthoracic echocardiography. RVSm was 11.3 ± 2.5 cm/s before PTMC, which did not change immediately after that, but decreased to 12.1 ± 1.9 cm/s after six months (P < 0.003).

TAPSE was 19.5 ± 4.3 mm before PTMC, which significantly increased to 21.1 ± 3.2 mm at the six-month follow-up after PTMC (P < 0.005) (Table 2).

5. Discussion

Abnormalities of RVF play an important role in the development of clinical symptoms and the overall prognosis of patients with MS (2, 4). RVF can be evaluated by many echocardiographic methods. In the present study, TAPSE and RVSm were used to assess RVF in patients with MS before and after successful PTMC and at the six-month follow-up.

Systolic long-axis velocity measurement of the lateral tricuspid annulus allows a reliable assessment of Right Ventricular Ejection Fraction (RVEF) in clinical practice (22). A study by Wahl et al. indicated that RVSm was the best predictor of RVEF in comparison to other echocardiographic methods (22). In the current study, RVSm did not change immediately after PTMC, which was consistent with the findings of the previous studies. Santosh kumar et al. reported no change in the right ventricular peak systolic myocardial velocity immediately after PTMC (23). Drighil et al. also showed no change in RVSm immediately after PTMC (21). However, contradictory results were obtained in some other studies. For instance, Setty et al. indicated a significant change in RVSm immediately after PTMC (24). The present study results demonstrated a significant reduction in RVSm at the six-month follow-up after the successful PTMC. This could be the result of the positive right ventricular remodeling after the successful PTMC.

In the current study, TAPSE increased from 19.5 ± 4.3 mm before PTMC to 19.7 ± 3.8 mm after that, but the difference was not statistically significant. This finding was comparable to that of a previous study performed by Drighil et al., which revealed no increase in TAPSE immediately after the successful PTMC (21). Bensaid et al. also noticed an insignificant increase in TAPSE after PTMC. In contrast, a study by Sowdagar et al. showed a significant increase in TAPSE after PTMC (25). Santosh kumar et al. also observed a significant increase in TAPSE after successful PTMC (23). In the present study, TAPSE increased significantly to 21.1 ± 3.2 mm after six months (P < 0.005). This finding suggested the gradual improvement of RVF after PTMC.

The current study results revealed a significant decrease in SPAP from 44.7 ± 11.3 to 35.9 ± 8.4 mmHg after PTMC (P < 0.001). A further decrease in SPAP was also seen at the six-month follow-up (35.1 ± 6.7 mmHg). These findings were comparable to those of the previous study conducted by Sriram et al. (26), which showed that successful PTMC could lead to a significant decrease in pulmonary artery pressure.

The present study results indicated a significant increase in the left ventricular function (measured by biplane Simpson method) from 50.2 ± 4.5 to 52.7 ± 3.0, which was statistically significant (P < 0.001). Similar results were also obtained by GN Rajesh et al. (27).

The current study results showed the significant improvement of RVF (assessed by TASPE and RVSm). A previous study by Sowdagar et al. (25) demonstrated that decreased RVSm and TAPSE could be associated with poor prognosis. Hence, increase in these indices after PTMC could be related to improvement of prognosis. Yet, this finding is required to be confirmed in further studies. The present study results also showed that successful PTMC could improve the function of the left ventricle and decrease the pulmonary artery pressure. Obviously, further studies with larger sample sizes could help confirm these findings.

5.1. Limitations

This study was single-center with limited number of patients. In addition, a long-term follow-up could not be provided.

5.2. Conclusion

Successful PTMC could improve the functions of both ventricles and decrease the pulmonary artery pressure.

5.3. Ethical Approval

IR.IUMS.FMD.REC.1398.502

5.4. Clinical Trial Registration Code

This was a descriptive study and the patients who underwent PTMC with physical examination and transthoracic echocardiography were followed up.

5.5. Informed Consent

The study protocol was approved by the Institutional Review Board and Ethics Committee and all participants provided written informed consent forms. All patients had understood the information and had the chance to ask questions.

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Authors' Contribution

Study concept and design: H.M., A.A., and H.R.S. Analysis and interpretation of data: S.R., H.M., and Z.M. Drafting of the manuscript: S.R. and Z.M. Critical revision of the manuscript for important intellectual content: A.A. and H.R.S. Statistical analysis: S.R. and Z.M.

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The authors have no financial interests related to the material in the manuscript.

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