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Original Article

Effect of Percutaneous Transvenous Mitral Commissurotomy on Right Ventricular Function: A Quasi-Experimental Study

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Abstract

Objective: This study aimed to evaluate the changes in right ventricular (RV) function among patients undergoing percutaneous transvenous mitral commissurotomy (PTMC) for mitral stenosis (MS).

Methodology: A quasi-experimental study was conducted in the Department of Cardiology at Hayatabad Medical Complex, Peshawar, from April 2021 to October 2021. Initially, baseline transthoracic echocardiography (TTE) was performed, followed by PTMC for all patients. Post-procedure, patients were monitored in the Coronary Care Unit (CCU) for 24 hours. A follow-up TTE was conducted 24 hours post-PTMC to assess changes in RV function, specifically evaluating parameters such as RV systolic pressure (RVSP), right ventricular outflow tract fractional shortening (RVOT-FS), right ventricular Tei index (RV Tei index), RV wall thickness, and pulmonary artery systolic pressure.

Results: Significant changes were observed in RV parameters before and after 24 hours of PTMC. The mean change in RVSP was 5.70 ± 4.50 mmHg ($p < 0.001$). The mean change in RVOT-FS was -1.22 ± 3.02% ($p = 0.003$). The RV Tei index showed a mean change of 0.14 ± 0.015 ($p < 0.001$). The mean change in RV wall thickness was 0.10 ± 0.03 mm ($p < 0.001$). Additionally, pulmonary artery systolic pressure demonstrated a mean change of 17.09 ± 4.20 mmHg ($p < 0.001$).

Conclusion: The findings indicate that PTMC significantly improves right ventricular function in patients with mitral stenosis. These results underscore the importance of PTMC in the management of RV dysfunction associated with mitral stenosis.

Keywords: Atrial Fibrillation, Echocardiography, Mitral Stenosis, PTMC, Right Ventricle, Pulmonary Hypertension

INTRODUCTION

Rheumatic heart disease (RHD) is the most prevalent cause of mitral stenosis (MS) worldwide. MS leads to increased pressure in the left atrium (LA), reduced forward blood flow to the left ventricle (LV), and ultimately results in pulmonary hypertension and heart failure symptoms. Initially, patients with MS in normal heart rhythm can compensate for the impaired blood flow from the LA to the LV by enlarging the LA and augmenting LA contraction, thus preserving LA total emptying volume [1]. However, over time, persistent tachycardia and chronic pressure overload cause left atrial remodeling. This process triggers various histological changes in the LA, including hypertrophy, necrosis, apoptosis, and fibrosis, promoting the development of atrial fibrillation (AF) [2,3].

Symptoms of MS may manifest or worsen with any increase in heart rate, such as during exercise, and can be accompanied by episodes of rapid heartbeats. Additionally, they may be triggered by pregnancy or other physiological stressors, such as infections. In MS, the pressure buildup in the heart is subsequently redirected to the lungs, leading to fluid accumulation and shortness of breath [4].

Most MS cases result from rheumatic fever and subsequent RHD. Less common causes include calcification of the mitral valve leaflets and certain types of congenital heart disease. MS can also arise from a congenital cleft in the mitral valve. Notably, MS is the most prevalent valvular heart disease during pregnancy [5]. Other contributing factors include infective endocarditis, systemic lupus erythematosus, calcification of the mitral annulus, Whipple disease, endomyocardial fibroelastosis, Fabry disease, malignant carcinoid syndrome, and rheumatoid arthritis. Rare causes include Hurler's disease, Hunter's disease, and amyloidosis [6,7].

Right ventricular (RV) performance is crucial in determining clinical symptoms, pre-operative survival, exercise capacity, and postoperative outcomes in individuals with MS [8]. MS causes elevated left atrial pressure due to backflow, leading to increased pulmonary venous and arterial pressures, which in turn cause RV dysfunction. Additionally, RV dysfunction can result from the rheumatic process directly affecting the heart muscle.

The present study aims to determine the effect of PTMC on RV function before and after the procedure in patients with MS. Despite PTMC being regularly performed in our hospital, long-term follow-up is challenging as many patients do not return for scheduled visits. This leaves the impact of PTMC on survival due to changes in RV function unclear. Additionally, despite over two decades of PTMC practice, local studies on its effect on RV function are scarce. Thus, this study aims to assess the pre- and post-PTMC changes in RV function among patients with MS. This study will provide local statistics on the magnitude of changes in RV function after PTMC compared to baseline. The results will be published in local literature, contributing to the scientific knowledge and providing recommendations for future research.

METHODOLOGY

Study Design: This quasi-experimental study was conducted to evaluate the effects of percutaneous transluminal mitral commissurotomy (PTMC) on right ventricular (RV) function in patients with mitral stenosis. The study spanned from April 2021 to October 2021.

Setting: The study was carried out in the Department of Cardiology at MTI-Hayatabad Medical Complex (HMC) in Peshawar, Pakistan.

Participants: The study population consisted of patients diagnosed with mitral stenosis (stage C or D) with a disease duration of at least one year. Eligible participants were aged between 20 and 60 years and included both male and female patients. Exclusion criteria were:

- Chronic renal failure, indicated by serum creatinine levels exceeding 1.2 mg/dL
- Chronic liver disease, diagnosed based on medical history and records
- History of coagulation disorders, documented in medical records

A total of 60 patients meeting the inclusion criteria were enrolled in the study through the outpatient department (OPD).

Variables: The primary outcome variables included changes in RV function parameters such as right ventricular systolic pressure (RVSP), right ventricular outflow tract fractional shortening (RVOT-FS), RV Tei

index, RV wall thickness, and pulmonary artery systolic pressure. These were measured using transthoracic echocardiography (TTE).

Data Sources/Measurement: Baseline TTE was performed for all participants to measure the initial RV function parameters. Following this, PTMC was conducted on all patients. Post-PTMC, patients were monitored in the Cardiac Care Unit (CCU) for 24 hours, and a follow-up TTE was conducted at the 24th-hour mark to assess changes in RV function. All TTE and PTMC procedures were performed by a single experienced cardiologist with a minimum of five years of experience to ensure consistency and reliability of the measurements.

Bias: To minimize bias and control for confounding factors, strict adherence to the exclusion criteria was maintained. Furthermore, all procedures were conducted by the same experienced cardiologist. Patient information, including name and age, was meticulously recorded in a pre-designed proforma.

Study Size: The study included a total of 60 patients, which was determined to be an adequate sample size to assess the primary outcomes of the study within the specified timeframe.

Quantitative Variables: The primary quantitative variables measured in this study included right ventricular systolic pressure (RVSP), right ventricular outflow tract fractional shortening (RVOT-FS), RV Tei index, RV wall thickness, and pulmonary artery systolic pressure. These parameters were assessed using transthoracic echocardiography (TTE) to evaluate changes in right ventricular function before and after percutaneous transluminal mitral commissurotomy (PTMC).

Statistical Methods: Data analysis was performed using SPSS version 26. Descriptive statistics were used to summarize the data. Mean and standard deviation (±SD) were calculated for quantitative variables. Frequencies and percentages were computed for qualitative variables. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations: The study was reviewed and approved by the Institutional Review Board (IRB) of Hayatabad Medical Complex, Peshawar, with approval number 615/HEC/B&PSC/2022. Written informed consent was obtained from all participants after explaining the study's objectives and potential benefits.

RESULTS

Participants: A total of 60 patients were included in this study. The participants were divided into two age groups: 40 patients (66.7%) were aged 20-40 years, and 20 patients (33.3%) were aged 41-60 years. The study cohort comprised 36 male patients (60%) and 24 female patients (40%). Comorbid conditions included hypertension in 12 patients (20%), diabetes mellitus in 11 patients (18.3%), and atrial fibrillation in 9 patients (15%). Additionally, 37 patients (61.7%) had stage C mitral stenosis, while 23 patients (38.3%) had stage D mitral stenosis.

Table 1: Changes in RV parameters pre- and post-PTMC

RV Parameters	Changes in RV Parameters	P-value
RVSP (mmHg)	5.7 ± 4.5	<0.001
RVOT-FS (%)	-1.2 ± 3	0.003
RV TEI Index	0.1 ± 0	<0.001
Wall Thickness (mm)	0.1 ± 0	<0.001
Pulmonary Artery Systolic Pressure (mmHg)	18 ± 4.2	<0.001

Descriptive Data: The mean age of the patients was 40.00 ± 10.68 years. The mean weight was 82.03 ± 8.38 kg, and the mean height was 5.6 ± 0.129 feet. The mean Body Mass Index (BMI) was calculated to be 29.00 ± 3.07 kg/m².

Table 2: Stratification by gender

RV Parameters	Changes in RV Parameters	P-value
Male		
RVSP (mmHg)	5.9 ± 4.6	<0.001
RVOT-FS (%)	-1.1 ± 3.1	0.041
RV TEI Index	0.1 ± 0	<0.001
Wall Thickness (mm)	0.1 ± 0	<0.001
Pulmonary Artery Systolic Pressure (mmHg)	18.3 ± 4	<0.001
Female		
RVSP (mmHg)	5.4 ± 4.4	<0.001
RVOT-FS (%)	-1.4 ± 3	0.028
RV TEI Index	0.1 ± 0	<0.001
Wall Thickness (mm)	0.1 ± 0	<0.001
Pulmonary Artery Systolic Pressure (mmHg)	17.6 ± 4.5	<0.001

Outcome Data: Baseline transthoracic echocardiography (TTE) measurements revealed that the mean right ventricular systolic pressure (RVSP) was 61.48 ± 4.60 mmHg, the mean right ventricular outflow tract fractional shortening (RVOT-FS) was

34.70 ± 2.40%, the mean RV Tei index was 0.45 ± 0.015, the mean RV wall thickness was 6.14 ± 0.024 mm, and the mean pulmonary artery systolic pressure was 47.31 ± 3.90 mmHg. Follow-up TTE measurements, taken 24 hours post-percutaneous transluminal mitral commissurotomy (PTMC), indicated significant changes with a mean RVSP of 55.78 ± 2.37 mmHg, a mean RVOT-FS of 35.92 ± 2.18%, a mean RV Tei index of 0.31 ± 0.00, a mean RV wall thickness of 6.04 ± 0.01 mm, and a mean pulmonary artery systolic pressure of 29.32 ± 1.33 mmHg.

Main Results: The changes in right ventricular (RV) function parameters before and after PTMC were statistically significant, with the following results:

Table 3: Stratification by history of hypertension

RV Parameters	Changes in RV Parameters	P-value
Hypertensive		
RVSP (mmHg)	4.6 ± 4.7	0.006
RVOT-FS (%)	-2.6 ± 1.9	0.001
RV TEI Index	0.1 ± 0	<0.001
Wall Thickness (mm)	0.1 ± 0	<0.001
Pulmonary Artery Systolic Pressure (mmHg)	18.4 ± 2.8	<0.001
Non-hypertensive		
RVSP (mmHg)	6 ± 4.5	<0.001
RVOT-FS (%)	-0.9 ± 3.2	0.058
RV TEI Index	0.1 ± 0	<0.001
Wall Thickness (mm)	0.1 ± 0	<0.001
Pulmonary Artery Systolic Pressure (mmHg)	17.9 ± 4.5	<0.001

Table 4: Stratification by atrial fibrillation at presentation

RV Parameters	Changes in RV Parameters	P-value
With Atrial Fibrillation at Presentation		
RVSP (mmHg)	7.6 ± 5.1	0.002
RVOT-FS (%)	-2.4 ± 1.7	0.003
RV TEI Index	0.1 ± 0	<0.001
Wall Thickness (mm)	0.1 ± 0	<0.001
Pulmonary Artery Systolic Pressure (mmHg)	19.2 ± 1.9	<0.001
Without Atrial Fibrillation at Presentation		
RVSP (mmHg)	5.4 ± 4.4	<0.001
RVOT-FS (%)	-1 ± 3.2	0.026
RV TEI Index	0.1 ± 0	<0.001
Wall Thickness (mm)	0.1 ± 0	<0.001
Pulmonary Artery Systolic Pressure (mmHg)	17.8 ± 4.5	<0.001

DISCUSSION

The current study involving 60 patients who underwent percutaneous transluminal mitral commissurotomy (PTMC) demonstrated significant improvements in several key cardiovascular parameters. There was a substantial decrease in the mean right ventricular systolic pressure (RVSP), with a P value of <0.001, indicating strong statistical significance. Additionally, the mean right ventricular outflow tract fractional shortening (RVOT-FS) significantly increased (p = 0.003). The mean right ventricular Tei index also showed a marked decrease (P <0.001). Importantly, the study noted a significant decline in the mean baseline pulmonary artery systolic pressure, which decreased from 47.31 ± 3.90 mmHg to 29.32 ± 1.33 mmHg post-PTMC (p <0.001).

Since its inception in 1984 by Inoue et al., PTMC has emerged as a safe and efficient therapy for mitral stenosis (MS), particularly for patients with favorable anatomical conditions. Over the past two decades, many cardiac centers have routinely conducted PTMC procedures [9]. However, there remains a paucity of data concerning PTMC's impact on right ventricular (RV) function. In one study, the mean pre-PTMC RVSP was significantly higher at 62.31 ± 10.91 mmHg compared to post-PTMC readings at 24 hours (57.51 ± 19.67 mmHg) and 6 months (46.49 ± 17.8 mmHg) [1].

Another study observed immediate improvements post-PTMC, including an increase in mitral valve area from a baseline of 0.71 ± 0.15 cm^2 to 1.84 ± 0.17 cm^2, a rise in RVOT-FS from 33.94% ± 7.55% to 37.33% ± 7.67%, and a significant reduction in systolic pulmonary artery pressure from 48.93 ± 13.08 mmHg to 29.56 ± 7.71 mmHg [10]. The RV Tei index also decreased from 0.47 ± 0.12 to 0.32 ± 0.11.

Additionally, echocardiograms conducted before PTMC revealed a mean mitral valve area of 0.9 cm^2 ± 0.24 cm^2, while those performed 24 hours after PTMC exhibited significant changes such as a mean left atrial diameter of 4.68 ± 13.1 cm, mean mitral valve area of 2.67 ± 0.71 cm^2, mean mitral valve gradient of 5.42 ± 4.6 mmHg, and mean RVSP of 43 ± 18.41 mmHg . These findings align with the current study's observations, which demonstrate significant changes in RV parameters before and after PTMC.

The existing literature indicates that MS predominantly affects younger individuals, with most symptomatic MS patients showing signs before reaching the age of 30 [11,12]. Our research findings are consistent with these studies. In contrast, in Western countries, MS tends to affect an older demographic, as shown by data from PTMC series in

developed nations [13,14]. Additionally, reports indicate that the progression of MS symptoms related to rheumatism in these areas is notably rapid. An earlier study indicated that more than 85% of patients were in functional Class III/IV at the time of diagnosis, highlighting the severity and advanced stage of the disease. The age distribution and higher prevalence among females observed in our patient group were consistent with results from similar studies conducted in developing nations [10,15,16].

PTMC has quickly become the preferred method for treating MS in patients with pliable valves. Research has demonstrated that PTMC outcomes in adults are on par with open commissurotomy and better than closed commissurotomy [17,18]. Employing a straightforward balloon sizing method based on height within the stepwise Inoue balloon approach during PTMC has been linked to impressive short-term and long-term success rates, coupled with a minimal risk of severe mitral regurgitation [19].

A significant number of patients with MS commonly exhibit initial respiratory symptoms, typically associated with chronic alterations in pulmonary circulation due to increased pulmonary venous pressure and reflex pulmonary artery constriction. The presence of water, proteins, and proteoglycans in the interstitial spaces of the lungs contributes to the clinical symptoms of MS. These changes can be detected through pulmonary function tests, which may reveal modifications in residual volume caused by elevated left atrial pressure. Recent research suggests that a successful PTMC procedure can result in immediate enhancements in both cardiac and pulmonary function, leading to an overall improvement in the clinical condition of MS patients [20,21].

Our study has certain limitations. The sample size was relatively small, and we were unable to conduct long-term follow-ups due to time constraints. Therefore, future studies with larger sample sizes and extended follow-up periods are recommended to further investigate these findings.

CONCLUSION

This study highlights the substantial impact of PTMC on post-procedure changes in right ventricular function in patients undergoing percutaneous mitral valve commissurotomy for mitral stenosis. Regular assessments in all cases of severe mitral stenosis to evaluate the effects on right ventricular function are advisable. The notable improvements observed after PTMC suggest that offering this procedure earlier to patients with severely compromised quality of life due to severe mitral stenosis could be beneficial.

AUTHORS' CONTRIBUTION

MAW, SKUR, ZAFG, and US: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. MAW, SKUR, ZAFG, and US: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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