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Original Article

Assessment of the Early Period Impact of Percutaneous Mitral Balloon Valvuloplasty on Right Ventricular Functions in Patients with Isolated Clinically Significant Mitral Stenosis Using 2D Speckle Tracking Echocardiography

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Abstract

Objectives: In this study, the early impact of percutaneous mitral balloon valvuloplasty (PMBV) on right ventricular (RV) systolic function in patients with clinically significant mitral stenosis (MS) was investigated using two-dimensional speckle tracking echocardiography (2D-STE).

Methods: Twenty patients were included in the study. RV free wall longitudinal strain and strain rate measurements were performed on all patients 24 h before the procedure in addition to conventional echocardiographic examination. The same parameters were evaluated in the same patients after 24–48 h of the procedure.

Results: No significant change was observed in RV free wall apical, mid, basal longitudinal, global RV free wall strain and strain rate values after the procedure when pre-procedure and post-procedure 2D-STE values were compared.

Conclusion: In the present study, no significant change was detected in the early deformation parameters obtained from the RV free wall in MS patients who underwent PMBV.

Keywords: Mitral stenosis; percutaneous mitral balloon valvuloplasty; right ventricular strain.

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İzole Klinik Olarak Anlamlı Mitral Darlığı Olan Hastalarda Perkütan Mitral Balon Valvüloplastinin Sağ Ventrikül Fonksiyonları Üzerindeki Erken Dönem Etkisinin 2D Speckle Tracking Ekokardiyografi ile Değerlendirilmesi

Özet

Amaç: Bu çalışmada, klinik olarak anlamlı mitral darlığı (MD) olan hastalarda perkütan mitral balon valvüloplastinin (PMBV) sağ ventrikül (RV) sistolik fonksiyonu üzerindeki erken etkisi iki boyutlu benek izleme ekokardiyografisi (2D-STE) kullanılarak araştırılmıştır.

Gereç ve Yöntem: Yirmi hasta çalışmaya dahil edildi. Konvansiyonel ekokardiyografik incelemeye ek olarak tüm hastalardan işlemden 24 saat önce RV serbest duvar longitudinal strain ve strain rate ölçümleri yapıldı. Aynı parametreler işlemden 24–48 saat sonra aynı hastalarda değerlendirildi.

Bulgular: İşlem öncesi ve sonrası 2D-STE değerleri karşılaştırıldığında işlem sonrası RV serbest duvar apikal, mid, bazal longitudinal, global RV serbest duvar strain ve strain rate değerlerinde anlamlı bir değişiklik gözlenmedi.

Sonuç: Bu çalışmada, PMBV uygulanan MD hastalarında RV serbest duvarından elde edilen erken deformasyon parametrelerinde anlamlı bir değişiklik saptanmamıştır.

Anahtar sözcükler: Mitral darlık; perkutan mitral balon valvuloplasti; sağ ventriküler gerilme.

Introduction

In developing countries worldwide, rheumatic heart disease (RHD) is a significant reason of morbidity and mortality.[1] The most common RHD is rheumatic mitral stenosis (MS), which can cause the development of pulmonary hypertension.[2] Morphological alterations in the pulmonary bed due to long-term pulmonary hypertension can result in secondary right ventricular (RV) dilatation, overload, and failure.

RV dysfunction has a very important effect on symptom development and prognosis in patients with MS.[3] Strain and strain rate (SR) measurements are relatively new methods to assess RV function among many parameters. To assess RV function with strain and SR, tissue doppler imaging (TDI) is used.[4] This method has various limitations such as angle dependence. Two-dimensional speckle tracking echocardiography (2D-STE) measures myocardial movement and deformation without depending on the doppler signals. Due to the lack of angle dependency, more accurate strain and SR analysis can be performed with the 2D-STE method.

Very few studies have examined RV function immediately after percutaneous mitral balloon valvuloplasty (PMBV) in MS using 2D-STE.[5] The objective of this study was to assess the immediate effect of PMBV on RV function.

Materials and Methods

This study was conducted between 2011 and 2012. The study included 20 patients with clinically significant rheumatic MS. Written informed consent was received from all patients. This study was approved by the Kartal Koşuyolu High Specialization Training and Research Hospital Ethics Committee (number: 2024/02/771, date: 23/01/2024). This study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Clinically significant MS was determined according to the current ESC guideline definition and the indication for PMBV was decided according to the guideline (mitral valve area (MVA) <1.5 cm^2 and symptomatic patients) or high thromboembolic risk without atrial fibrillation rhythm (history of transient ischemic attack or cerebrovascular accident) or systolic pulmonary artery pressure (PAPs) >50 mmHg and absence of contraindication for PMBV.

The inclusion criteria:

1. Presence of clinically significant MS
2. Wilkins score <8.

The exclusion criteria:

Patients with,

1. Diabetes mellitus, hypertension
2. Coronary artery disease
3. Severe or moderate valvular heart disease other than MS (aortic regurgitation, aortic stenosis and mitral regurgitation)
4. Non-sinus rhythm
5. Severe lung disease
6. Congenital heart disease or cardiomyopathy
7. Unfavorable characteristics (clinical or anatomic) or contraindications for PMBV.

Collection of Data

All patients' baseline clinical and demographic parameters were recorded.

Echocardiographic Examination

The echocardiographic examination of the patients planned for PMBV was done within 24 h before and 24–48 h after the procedure. The TTE recordings of the patients were obtained with a standard ultrasound device (Vivid 7 GE Vingmed, Horten, Norway) using a 2.5 MHz phased probe and standard harmonic imaging. The standard apical image was acquired from the left lateral position in three consecutive cycles following the recommendations of the American Society of Echocardiography. MVA was measured by planimetry and pressure half -time. The maximum and mean mitral valve transannular valve gradients were measured from CW Doppler recordings from the mitral valve. The tricuspid annular systolic motion (TAPSE) was quantified in the apical four-chamber image. An M-mode cursor was positioned on the side of the lateral tricuspid annulus and the peak systolic displacement was calculated. Pulmonary artery systolic pressures were measured using the Modified Bernoulli equation by the CW Doppler method. The isovolumic acceleration time (IVA) was calculated by placing the PW cursor on the side of the lateral tricuspid annulus by TDI and dividing the isovolumic maximum systolic wave velocity by the acceleration time.

Strain – Strain Rate Echocardiography Measurements

For RV longitudinal strain and SR measurements in tissue velocity imaging mode, images were acquired from the apical four-chamber views with patient breath-hold in expiration, and moving images were recorded at a rate of 160–220 frames/s, including at least three cycles in each image. All the data acquired were digitally recorded for offline analysis. The images were further analyzed using 2D strain software (Echo PAC). Once the proper cardiac cycle was chosen, manually the endocardial border in the axis image was scanned. When sufficient scanning could not be done, the proper analysis was done by changing the width of the sector or by scanning the endocardial border once again. The lateral RV wall was divided into three segments, namely basal, mid, and apical and systolic strain and peak systolic SR were recorded individually for each segment. RV lateral free wall measurements of global strain and SR were also registered.

Procedure

Using an antegrade transseptal approach, the PMBV procedure was carried out with transthoracic echocardiography (TTE) guidance through the Inoue balloon technique. Nominal balloon diameter was determined according to the patient's height. (Maximum balloon size (mm) = (Height [cm]/10) + 10). A post-procedure MVA >1.5 cm^2 or >1 cm^2/m^2 and absence of moderate or severe mitral regurgitation was considered to be a successful PMBV.

Statistical Analysis

The data of the study were analyzed using Statistical Package for Social Sciences 21 (SPSS Inc., Chicago, IL, USA). Continuous

Table 1. Conventional echocardiographic data pre- and post-PMBV

Variable	Pre-PMBV	Post-PMBV	p
MVA planimetric (cm^2)	1.10±0.34	1.63±0.34	<0.0001
MVA-pressure half-time (cm^2)	1.13±0.16	1.70±0.33	<0.0001
Maximum gradient (mmHg)	25.08±9.26	14.08±5.93	<0.0001
Mean gradient (mmHg)	13.71±5.76	6.63±2.94	<0.0001
PAPs (mmHg)	45.57±15.58	33.35±11.10	<0.001
IVA	1.90±0.57	1.81±0.89	0.656
TAPSE (cm)	2.45±0.28	2.39±1.19	0.834

PMBV: Percutaneous mitral balloon valvuloplasty; MVA: Mitral valve area; PAPs: Systolic pulmonary arterial pressure; IVA: Isovolumic acceleration; TAPSE: Tricuspid annular plane systolic Excursion.

Table 2. The comparison of 2D speckle tracking echocardiographic data pre- and post-PMBV

Variable	Pre-PMBV	Post-PMBV	p
RVFW apical, strain (%)	-23.30±12.75	-28.38±8.66	0.088
RVFW mid-strain (%)	-25.28±11.54	-31.95±8.37	0.20
RVFW basal strain (%)	-29.31±6.95	-30.55±18.67	0.794
Global RVFW strain (%)	-26.70±5.43	-27.72±15.40	0.765
Global RVFW SR	-1.67±0.92	-2.06±1.04	0.133

PMBV: Percutaneous mitral balloon valvuloplasty; RVFW: Right ventricular free wall; SR: Strain rate.

variables were expressed as mean±standard deviation. Shapiro–Wilk test and graphic analyses were used to test for normality. For comparison of the data before and after the procedure, the paired-samples t-test was used. P<0.05 was considered statistically significant. For statistical analysis, SPSS version 15.0 package computer program was used.

Results

Twenty patients were included in the study (17 female and three male). The mean age of the patients was 34.33±8.5 years. None of the patients had any complications related to the procedure. The conventional echocardiographic data are presented in Table 1 and 2D-STE results are presented in Table 2.

Conventional Echocardiographic Parameters

The data of conventional echocardiographic examinations before and after PMBV are presented in Table 1. PMBV resulted in a significant increase in MVA and a significant reduction in maximum mitral valve gradient, minimum mitral valve gradient, and PAPs. There were no significant changes in TAPSE and IVA.

2D Speckle Tracking Echocardiographic Parameters

Pre-procedural and post-procedural RV longitudinal 2D-STE values are presented in Table 2. No significant difference was found in RV free wall apical, mid, and basal strain values after the procedure. No significant change was observed in global RV free wall strain and SR values.

Discussion

In this single-center study of 20 patients, we found that in patients who underwent PMBV, there was no significant change in the RV conventional parameters (TAPSE and IVA) and deformation parameters determined by the STE, except for the increase in valve area and improvement in pulmonary artery pressure in the early post-procedural period. The major finding of this study is that RV deformation parameters are not predictive of the early procedural success of PMBV.

RV function is known to be significantly reduced in patients with MS.[6] The severity of RV failure is related to clinical symptoms, effort capacity, prognosis, and survival. Two important theories have been proposed to explain RV failure.[7,8] The first theory is that increased left atrial pressure affects the pulmonary artery pressure, which in turn causes secondary RV overload, dilatation, and failure. The second theory is that rheumatic involvement has a direct impact on the RV muscle tissue, leading to fibrosis, thickening, calcification, and myocyte necrosis.[9,10] Regardless of the mechanism, RV dysfunction affects the prognosis in patients with MS.[3]

In patients with MS, right ventriculography, radionuclide angiography, and magnetic resonance imaging were used to assess baseline RV function. Due to decreased spatial resolution, artifact accumulation, and cost problems of these imaging methods, echocardiographic evaluation of MS patients is more important. Strain and SR studies based on TDI and M-mode are currently available. However, the angle dependency of these methods limits their usefulness.[11–13] A relatively new method, 2D-STE is an angle-independent speckle tracking principle. The 2D-STE method was used in the studies by Ozdemir et al.,[14] Kumar et al.,[15] and Roushedy et al.,[16] and it was found that the RV global strain and regional strain obtained from the interventricular septum were significantly less than the control group, but the RV free wall strain was similar to the control group. No significant change was found in the basal, mid, and apical RV free wall longitudinal strain values in the early period

after PMBV in studies by Kumar et al.[15] and Roushdy et al.[16] In our study, the results were found to be similar to the results of Kumar et al.[15] and Roushdy et al.[16] No significant change was found in the basal, mid, and apical RV free wall longitudinal strain values in the early period after PMBV in our study. In the study of Sakkuru et al.,[17] an increase was detected in TAPSE and basal RV lateral free wall strain values in the early period after PMBV, but no statistically significant change was found in mid and apical lateral free wall strain values. In the present study, however, no significant improvement was detected in TAPSE and basal RV free wall strain values. In our study, strain, SR, and TAPSE values of the patients were within the normal range before the PMBV procedure according to the American Society of Echocardiography (ASE) guideline. In contrast to the MVA and PAPs values, which demonstrated an immediate improvement following the procedure, the absence of change in TAPSE, strain, and SR values can be attributed to the normal baseline values of the patients before the PMBV procedure.

Our results show similarities with the results of previous studies in the literature. Some studies have demonstrated a significant reduction in RV global longitudinal strain and RV septal strain values in patients with MS. In contrast, the free wall of the RV was not influenced, or in some studies, only a reduction in basal RV free wall strain values and no change in apical and mid-RV free wall strain values were observed. We evaluated the RV from the free wall in our study. We did not perform global and septal RV strain analysis. This difference between RV septal and RV lateral free wall strain values might suggest that the rheumatic endocardial injury extended from the mitral annulus to the peripheral left ventricular segments and consequently left ventricular septum was influenced, which in turn caused a decrease in RV septal strain values. Furthermore, despite an observed increase in RV global longitudinal strain and RV septal strain and no change in RV free wall strain values in the early period after PMBV in previous studies, it is possible that this is associated with the increased left ventricular filling and left ventricular contractility that occurs after PMBV. According to Kumar et al.,[15] the septum was found to be influenced even in the setting of moderate pulmonary hypertension, while RV lateral free wall strain values were affected in the presence of severe pulmonary hypertension. In the current study, 15 out of 20 patients showed PAPs > 40 mmHG. The absence of deformation parameter changes in the early period might suggest an ongoing compressive load in the early period. Due to its thin wall and compliant structure, the RV responds early to pre-afterload changes. For this reason, further studies involving patients with severe dysfunctional RV and severe pulmonary hypertension with a longer duration of follow-up might be needed to contribute to the literature.

Conclusion

No significant difference was observed in the early deformation parameters obtained from the RV wall in MS patients who underwent PMBV and the early deformation parameters of RV did not predict the success rate of the PMBV procedure.

Disclosures

Ethics Committee Approval: The study was approved by the Kartal Koşuyolu High Specialization Training and Research Hospital Ethics Committee (no: 2024/02/771, date: 23/01/2024).

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