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Left Ventricular Torsion before and after Percutaneous Mitral Balloon Valvuloplasty

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ABSTRACT

Background: The valve disease is frequently caused by the rheumatic mitral stenosis in developing and developed countries alike and it is still a key issue. Although there is a significant decrease in rheumatic fever diffusion, its percentage is still about 12% of the native valvular heart disease.

Aim of Work: The key objective of this work was to assess the impact of percutaneous mitral balloon valvuloplasty (PMBV) on the LV torsion and this objective was achieved by using the two-dimensional speckle-tracking echocardiography.

Patients and Methods: The study used the prospective observational method and had been carried out in the Department of Cardiology, Al-Azhar University Hospitals. The treatment group consisted of 35 patients who were candidates for PMBV and the control group consisted of 20 matching patients in terms of gender and age but they were healthy. All the participants of study had been assessed using the conventional echocardiography and speckle-tracking echocardiography on the previous day and 3 months after the procedure.

Results: Using the parameters of the conventional echocardiography, we found that there were no significant differences between the treatment group and the control group in the LV ejection fraction (EF) and RV systolic function (TAPSE) before the PMBV. After applying the Speckle-tracking echocardiography, the results indicated that LV torsion decreased in the treatment group compared to the control group before the PMBV. After 24 hours and 3 months after the PMBV, the patients of treatment group had shown a statistically significant improvement in LV torsion.

Conclusion: The LV torsion in MS patients significantly improved immediately and in the short-run follow-up after the PMBV

Keywords: Rheumatic mitral stenosis, Echocardiography, Management.

INTRODUCTION AND RATIONALE

The valve disease is frequently caused by the rheumatic mitral stenosis in developing and developed countries alike and it is still a key issue. Although there was a significant decrease in rheumatic fever diffusion, its percentage is still about 12% of the native valvular heart disease [(1)].

One of the most important objectives of echocardiography is to evaluate the RHMS acuteness and such evaluation is conducted by measuring the mitral valve area (MVA) and choosing the right patients for the percutaneous mitral balloon valvuloplasty (PMBV) [(2)]. In addition, the MS management was dependent on the accuracy of evaluation of the echocardiography of the mitral value area (MVA) [(3)].

The method that achieved the highest level of reliability in the mitral valve area calculated compared to the Golin's Formula, which is invasively derived and considered by some as the golden standard for calculating the MVA, is the planimetry 2-dimensional MVA(MVA_{2D}) [(4)]. However, the advancement of technology including the advent of 3D transesophageal echocardiography (3DTEE) has achieved a higher degree of accuracy and feasibility as a method used to calculate the MVA in patients who are assessed for PBMV [(5)]. But the planimetry is required to be accurately conducted at leaflet tips in a well-oriented plane. Consequently, it is necessary to be conducted by expert operators. As a result, the key challenge of using this method is the hardness of obtaining such a plane [(6)].

In 1923, the Surgical Commissurotomy[(7)] was first introduced and in the 1940s, it was considered the typical treatment for patients with MS [(8)]. However, when the Inoue balloon catheter was introduced in 1984 [(9)], the percutaneous mitral balloon valvuloplasty (PMBV) had become the safest and most effective treatment for MS.[(10)] Then, it has been developed as the most favorite treatment method for patients who were symptomatically selected with rheumatic MS [(11)].

Then, when the preferred mitral valve anatomy became available, the balloon valvuloplasty has been chosen as the favorable procedure [(12)]. The mitral valve is considered suitable for the PBMV based on the results of echocardiography and the criteria which

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were most widely accepted for the pre-procedure selections according to the Wilkins score and Cormier score [13, 14].

PATIENTS & METHODS

The current study followed the observational cohort methodology and was carried out in the Department of Cardiology, Al-Azhar University Hospitals. The treatment group consisted of 35 patients who were candidates for PMBV and the control group consisted of 20 matching patients in terms of gender and age but they were healthy. All the participants of study had been assessed using the **2DE** and **2D STE** on the previous day and 3 months after the procedure.

Exclusion criteria

- Atrial fibrillation.
- Ischemic heart diseases.
- Diabetes mellitus.
- Hypertension.
- Mitral regurgitation (MR) grade > 2/4.
- Left bundle branch block on the electrocardiogram.
- Pericardial disease.
- Chronic obstructive pulmonary disease.

All medications were stopped 24 h before the echocardiographic examination.

Echocardiography assessment:

In accordance with the recommendations of the American Society of Echocardiography, the dimension and functions of Left ventricular (LV) and LA diameter were measured [15].

In random order and blinded by the 2D findings, the recorded images were analyzed on a workstation by relying on the dedicated software(QLab 10, iE33 Philips). Then, using the average gain and luminosity, the acquisition was performed and adjusted offline to obtain the best detection of borders.

The calculation of the average measurements of the five consecutive cardiac cycles is performed for each variable and the determination of LV dimensions and LV fractional shortening was carried out using the modified biplane method of Simpson in apical two- and four-chamber views. The calculation of LV fractional shortening was performed by dividing the difference between the LV end-diastolic diameter (LVEDD) and the LV end-systolic diameter (LVESD) by the LVEDD.

At the level of mitral valve, the planimetry was used in the PSAX view to estimate the mitral valve area (MVA) and according to the formula of Bernoulli, the proper ventricular systolic pressure (RVSP) was estimated based on the tricuspid regurgitation.

Speckle-tracking echocardiography:

Using a high frame rate (at least 50 frames) with the digital routine grayscale B-mode for STE, the scanning of the basal and apical short axis planes was performed after the standard clinical echocardiographic examination. The levels of proper short axis were determined at the level of the mitral valve for the basal level images and at the level of the LV cavity alone without visible papillary muscles for the apical level images.

The cardiac cycle with the best quality of digital imaging was chosen and at the end of systole, the **LV endocardium** was traced as motion has been automatically traced all over the cardiac cycle by the software. From the apical view, a negative angular value was assigned to the clockwise rotation and a positive angular value was assigned to the counter-clockwise rotation [15]. The maximum difference between the apical rotation and basal rotation refers to the highest LV torsion [16].

In order to measure the torsion, the short-axis images are acquired at the level of mitral valve leaflets from the LV base and from the LV apex by relying on the parasternal or subcostal windows at end-expiration. The smallest attainable cavity above the papillary muscle attachment level refers to the apical cut [16].

RESULTS

This study is observational cohort study, conducted in Cardiology Department, Al-Azhar University Hospitals.

Sample size was 55 patients. Thirty-five Patients (Group A) were candidate for PMBV enrolled into the study group and 20 patients (Group B) (matched in age and sex but healthy people) as a control group.

There was female predominance in patients' group and control group. Out of 55 patients, 41 candidates (74.5%) were females. 27 female (49%) were in group (A) while 14 female (25.5%) were in group (B).

According to age, there was no statistically significant difference between patient group and control group. Age ranged from 23-45 years in patient's group (Group A) and from 18-44 years in the control group (Group B).

Baseline conventional echocardiographic parameters showed that there was no significant difference between the patient group and the control group as LV ejection fraction (EF) and RV systolic function (TAPSE) **pre PMBV.** However, the patient group showed larger left atrium (LA) antero-posterior diameter compared to the control group **(p<0.001) pre PMBV**.

Speckle-tracking echocardiography revealed that there was a statistically differences between patient group and control group as patients had lower LV

apical rotation, basal rotation as well as lower LV torsion than control group (Table 1).

Table (1): Speckle-tracking echocardiography , Apical rotation, basal rotation and torsion pre PMBV and control

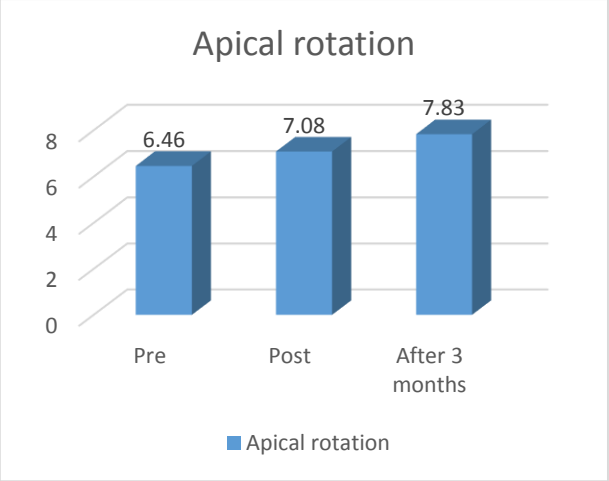
Parameters		Mean ± SD	*P*
Apical rotation (º)	Patient	6.463 ± 0.42	< **0.001**
	Control	8.745 ± 0.36	
Basal rotation (º)	Patient	-5.166 ± 0.20	< **0.001**
	Control	-6.175 ± 0.21	
Torsion (º)	Patient	11.63 ± 0.46	< **0.001**
	Control	14.92 ± 0.44	

Immediate & short-term follow-up results of BMV in patient group showed that patient sample had successful BMV procedures with significant increase in MV area one day and 3 months after **PMBV** by planimetry (P<0.001). There was also significant drop in mean pressure gradient across the mitral valve pre and post **PMBV** (p<0.001)**.**

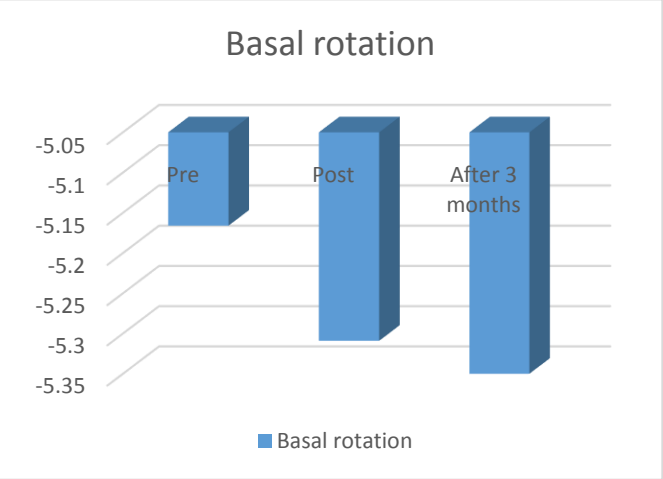
There was a significant drop in RVSP among patient group one day & 3 months post PMBV (p = 0.001). There was a statistically significant decrease in LA diastolic dimensions one day and after 3 months of PMBV comparing to baseline measurement (p<0.001).

As regard LV; the patients had statistically significant increase in LVEF immediately after one day and 3 months after **PMBV** compared to baseline management (p<0.001).

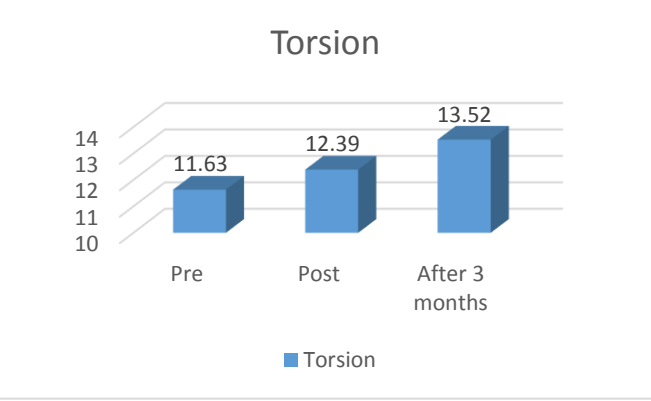
***Regarding Speckle tracking echocardiography**, there was a statistically significant improvement in LV apical rotation, basal rotation as well as LV torsion immediately post and after 3 months of PMBV comparing to pre **PMBV**. However comparing basal rotation immediately post and 3 months after **PMBV**, there was no significant statistical difference.



Graph 1: Speckle-tracking echocardiography , Apical rotation ,pre PMBV and control



Graph (2:) Speckle-tracking echocardiography , basal rotation , pre PMBV and control



Graph (3): Speckle-tracking echocardiography , torsion , pre PMBV and control

DISCUSSION

In developed countries, a descending direction of MS prevalence has been noticed whereas it is a key issue of public health in developing countries. Previously, a small number of studies found that the LV systolic dysfunction is common and makes real contributions to developing symptoms in patients having MS [17].

In addition, there are many studies which have attempted to establish a relationship between MS acuteness and the subclinical affection of LV function [18] and showed that the development of RV systolic dysfunction takes before the clinical symptoms [19].

This study attempted to evaluate the subclinical rheumatic MS influence on the LV systolic function at the global and regional level. In addition, it tried to assess the PMBV influence on such function using the speckle tracking technique.

In the current study, the number of patients who satisfied the criteria of our study was 35 and 20 who were healthy and matching in age and sex used as a control group. We found that the patients with MS had a significantly lower apical rotation, basal rotation and LV torsion compared to the control group.

A comparison of the LV strain was conducted before and after the PMBV by **Sengupta *et al.* [20],** they found that 14% of patients suffered from LV dysfunction and 12% of them suffered from atrial fibrillation. However, in the current study, we excluded patients suffering from comorbidities which might have an influence on the LV systolic function at the global or regional level in addition to patients suffering from LVEF impairment so as to correctly study the influence of MS on the subclinical affection of the LV systolic function.

In the current study, the majority of participants were females [77.1% (27 patients)] and males accounted for 22.9% (8 patients). Such percentage may show that the most known reason for the mitral stenosis is the rheumatic heart disease and such disease is highly prevalent among females [21].

Using the traditional echocardiographic parameters at the baseline (i.e. before the BMV), we found no statistically significant differences between control group and treatment group in terms of the LV systolic function (LVEF) and RV systolic function (TAPSE). However, we noticed that the LA diameter was 52.06 ± 4.99 vs 32.65 ± 3.18 ($p < 0.001$). The elevated transmitral mean PG (17.06 ± 3.90 vs 3.2 ± 0.69, $p < 0.001$) and RVSP (58.03 ± 11.43 vs 24.8 ± 2.86, $P < 0.001$) were larger for the treatment group compared to the control group. In addition, the key determinants of the LV systolic dysfunction were the LA size and transmitral pressure gradient [22].

Using the two-dimensional strain deformation to assess the LV systolic function, we identified early abnormalities in MS patients who were apparently suffering from the normal standard systolic function [23].

However, after using the speckle tracking echocardiography, we found that there is a statistically significant difference between the treatment group and control group as the patients of treatment group had low LV apical rotation (6.463 ± 0.42 vs 8.745 ± 0.36, $p<0.001$), low basal rotation (-5.166 ± 0.20 vs -6.175 ± 0.21, $p<0.001$) and low LV torsion (11.63 ± 0.46 vs 14.92 ± 0.44, $p<0.001$) compared to the control group. Furthermore, the results of study indicated a significant decrease in the values of LV basal, apical rotation and LV torsion for the treatment group compared to the control group. In turn, this indicates a possible underlying myocardial factor in which the rheumatic endocarditis and scarring have extended from the segments of mitral annulus to the segments of surrounding LV.

The analysis at the regional level showed that MS patients experienced a significant decrease in the LV apical, basal rotation and torsion compared to the control group of healthy people. Although those patients had normal LV systolic function, this result is consistent with the results of studies of **Bilen *et al.* [24]** and **Sengupta *et al***.[25].

Our patients who enrolled in the study had successful BMV with significant increase in the planimetry-measured MVA (0.96 ± 0.14 vs 1.97 ± 0.17, $p < 0.001$) as well as significant drop in the mean PG across the mitral valve (17.06 ± 3.90 vs 6.37 ± 1.06, $p < 0.001$)) and pulmonary artery systolic pressure (58.03 ± 11.43 vs 42.60 ± 7.68, $p < 0.001$). Furthermore, the LA dimensions statistically and significantly decreased after the PMBV (52.06 ± 4.99 vs 43.49 ± 2.29, $p < 0.001$). This finding is consistent with **Adavane et al**. [26] who found an immediate reduction in the volume of LA after the BMV in patients suffering from sinus rhythm. This immediate decrease in the volume of LA is most properly

explained by LA decompression and emptying through the release of the mitral valve obstruction by the PMBV.

In addition, the results of our study showed that the LV ejection fraction has slightly improved (58.29 ± 2.11 vs 60.60 ± 2.17, p < 0.001). **Mohan *et al.*** [27] found a similar observation and the most accurate cause of such immediate improvement is still unknown. However, the possible explanations might be the improved atrial contribution to LV filling and the improvement in the myocardial contractility [28, 29].

Through the STE, we found that the LV apical rotation pre vs post PMBV (6.46 ± 0.42 vs 7.08 ± 0.27, p < 0.001), post vs 3 months after PMBV (7.08 ± 0.27 vs 7.83 ± 0.18, p < 0.001), basal rotation pre vs post PMBV (-5.166 ± 0.20 vs -5.309 ± 0.22, p = 0.001). Besides, LV torsion pre vs post (11.63 ± 0.46 vs 12.39 ± 0.34, p = 0.001) and post vs PMBV (12.39 ± 0.34 vs 13.52 ± 0.23, p = 0.002) all immediately post and after 3 months of PMBV compared to pre **PMBV** had statistically and significantly improved.

The results of **Sengupta *et al.*** [30] indicated that the LV GLS significantly improved after PMBV compared to the baseline measurements before PMBV. As a result, this indicates that there is an underlying hemodynamic factor caused by the improved LV inflow through relieving the obstruction by the MS.

Nevertheless, the current study found that the LV basal rotation has statistically and insignificantly differed between the post and 3 months after PMBV (-5.309 ± 0.22 vs -5.35 ± 1.93, p = 0.312).

The significant reduction in the values of the LV basal and apical segmental strain compared to the control group indicated that there is a possible underlying myocardial factor in which the rheumatic endocarditis and scarring have extended from mitral annulus segment to the surrounding LV segment [22]. The results of study showed that such myocardial factor could be the key reason for the fact that the basal LV segmental rotation did not completely improve after the PMBV. In addition, it could contribute to the significant influence of the preload decrease in MS patients on GCS and GLS [22, 31].

Further, the findings of a study showed that the PBMV caused an immediate relief of the LV inflow obstruction and the improvement of the hemodynamics was related to the significant increases in the GLS and GCS within 24-28 hours and three-month post BMV. **Dray *et al*.** [32] reported that the STE-based longitudinal strain in a young girl underwent BMV had improved.

The results of our study found that the RVSP acuteness, as evaluated by the 2-D echocardiography as compared to pre PMBV(pre vs post PMBV 58.03 ± 11.43 vs 42.60 ± 7.68, p < 0.001)(post vs 3 months after PMBV 42.60 ± 7.68 vs 36.00 ± 6.03, p = 0.001) significantly improved immediately and three months after PMBV. Our findings are consistent with those of **Sengupta** [33] and **Kumar *et al.*** [34].

CONCLUSION

- The current study is the first attempt where the LV torsion was examined in patients with significant MS and in short term follow-up after successful BMV.
- The LV torsion had significantly improved in MS patients immediately and in short-term follow up after BMV.
- The study suggested that the decrease in the LV diastolic filling rather than the irreversible myocardial structural abnormality had prevalently contributed to reducing the LV mechanical performance in MS patients.
- Finally, our findings proved the dynamic and load-dependent features of the highest systolic LV torsion and the contribution to such features to the well-established relationship of Frank-Starling.

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