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Tissue Doppler Imaging Findings Including Prominent S Wave in Patients With Mitral Valve Prolapse Syndrome

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Background: Mitral valve prolapse (MVP) is allied to a variety of echocardiographic and pathologic findings, not least courtesy of the advent of novel and stringent echocardiographic criteria. MVP enjoys definite and clear-cut characteristics and is, as such, a fertile ground for research. Tissue Doppler imaging (TDI) is a relatively new imaging technique, and there is currently a dearth of information on this modality in patients with MVP syndrome.

Objectives: We aimed to evaluate the findings of TDI in MVP syndrome.

Patients and Methods: Seventy-five patients with MVP syndrome and 50 normal individuals as the control group were evaluated. The general characteristics and echocardiographic findings, especially TDI results, were evaluated and compared between the two groups. Mitral annular TDI velocities (Sm, Em, and Am) were measured at the lateral corner of the MV in the apical four-chamber view of transthoracic echocardiography.

Results: Seventy-five patients (48 females) at a mean age of 26.5 ± 9.4 years and 50 individuals (32 females) at a mean age of 27.1 ± 8.3 years were enrolled in the study. As the important results of our study, Sm wave was much more prominent and much higher in the MVP group (P = 0.00); Em was lower (P = 0.00) and Am was slightly higher (P = 0.12). Furthermore, the E waves of MV inflow for the MVP and control groups were similar and E/Em was significantly higher in the MVP group (P = 0.00); taken together with a higher left atrial volume in this group, this finding revealed a relatively higher left ventricular end-diastolic pressure.

Conclusions: Sm wave in TDI is prominent and significantly high in MVP syndrome. Also, our study showed some degree of diastolic dysfunction in MVP patients.

Keywords: Mitral Valve Prolapse; Echocardiography; Elasticity Imaging Techniques; S wave

1. Background

Mitral valve prolapse (MVP) is defined echocardiographically as single or bi-leaflet prolapse of 2 mm or more, beyond the long-axis annular plane, with or without leaflet thickening (1, 2). MVP syndrome is a very common syndrome among cardiac valvular diseases and is seen in 2.4% of the general population, with its prevalence reaching 35% in patients with Marfan syndrome (1). More prevalent in females and may be associated with varying symptoms, MVP is a fairly heterogeneous disease given its natural course. This syndrome is associated with a genetic component which may cause histological abnormalities of the valvular tissue or geometric disparities between the left ventricle (LV) and the MV and is generally considered a benign condition. However, MVP may result in mitral regurgitation (MR), infectious endocarditis, sudden cardiac death, or cerebrovascular accidents. This syndrome is the most common etiology for MR and MV surgery in the United States of America (2, 3).

Most patients with this syndrome are asymptomatic and have a benign course; in more severe cases, however, the rupture of the chordae tendineae may occur and result in rapid deterioration of the patient's condition. The most common pathologic findings in this syndrome are myxomatous changes in the MV leaflets, which can lead to the fragmentation of the collagen fibrils and loose spongiosa degeneration. Defects in the endothelium may predispose the patient to infectious endocarditis (2, 3).

Most patients with MVP syndrome are asymptomatic; nevertheless, the symptoms (if they do occur) are usually divided in to three groups. One group exhibits autonomic dysfunction signs and symptoms, another group has MR symptoms, and finally the third group demonstrates complications such as cerebrovascular accidents, infectious endocarditis, and arrhythmias (1).

Implication for health policy/practice/research/medical education:
Mitral valve prolapse (MVP) is associated with a variety of echocardiographic and pathologic findings, especially thanks to new and strict echocardiographic criteria. MVP has definite and precise characteristics that are interesting for research. Moreover, tissue Doppler imaging (TDI) is a relatively new imaging technique, and there are limited data on this modality in patients with MVP syndrome. We sought to evaluate the findings of TDI in MVP syndrome. Sm wave in TDI is prominent and significantly high in MVP syndrome. Our findings showed that some degree of diastolic dysfunction is present in MVP patients.

Physical examination findings include low body mass index (BMI), straight-back syndrome, scoliosis, pectus excavatum, Marfan syndrome findings, and most importantly click-murmur in auscultation. Electrocardiographic (ECG) findings are non-specific and include ST-T changes, specifically in leads 2, 3, and aVF, in addition to a notch at the end of the QRS complex (2-5).

Tissue Doppler imaging (TDI) is one of the newest echocardiographic modalities and plays a significant role in the diagnosis of many cardiac diseases. Indeed, TDI is used to unmask and evaluate even the slightest systolic and diastolic dysfunction in patients with various cardiac diseases. Evaluation of myocardial velocity with TDI in systole and diastole is a marker of ventricular function in systole and diastole, respectively. TDI findings are not influenced significantly by the flow of blood, so they can assess systolic and diastolic functions simultaneously (5, 6).

2. Objectives

There is limited evidence of any controlled study evaluating the myocardial velocity pattern in MVP syndrome; accordingly, we aimed to assess TDI findings in MVP patients in the present study.

3. Patients and Methods

Seventy-five adult patients, including 48 females, and 50 individuals, including 32 females, were recruited in our study. Patients with related cardiac disorders [e.g. other valvular disease, cardiomyopathies, coronary artery disease, and left ventricular ejection fraction (LVEF) < 45%] and patients with diabetes, systemic hypertension, significant (moderate or severe) MR, and atrial fibrillation were excluded from the study. Patients receiving beta blockers and all other drugs with effect on LV diastolic and systolic function were also excluded. Written informed consent was obtained from all the patients, and the study was approved by our local Ethics Committee.

3.1. Mitral Valve Prolapse Criteria

MVP is an abnormal motion and displacement (> 2 mm) of one or both MV leaflets (morphologically normal in appearance or redundant and/or thickened) into the left atrium in systole. The echocardiographic diagnosis of MVP was based on the parasternal long-axis view. The diagnosis of MVP was made by mid-to-late systolic click and murmur at auscultation and also echocardiography (1-3). All the echocardiographic studies were performed with Vivid 3 GE (General Electric Healthcare Company, Milwaukee, WI, USA).

3.2. Tissue Doppler Imaging Velocities

Myocardial velocities were studied online using a standard TDI via the pulse wave Doppler technique. TDI was acquired during a breath-hold over three consecutive cardiac cycles by high-intensity, low-velocity myocardial signals at a high frame rate. The TDI of the mitral annulus was achieved from the apical four-chamber view. A sample volume (1.5 mm in size) was placed at the lateral part of the mitral annulus. The average of three end-expiratory cycles was assessed. The analysis was performed for MV inflow measurements, including peak early (E) and peak late (A) flow velocities, E/A ratio, and the deceleration time of early mitral flow velocity (DT- time interval of peak E-wave velocity to its extrapolation to the baseline), and for TDI systolic (Sm) and early (Em) and late diastolic velocities (Am) (5).

Left atrial volume was measured from the standard apical two and four-chamber views at the end of systole. Left atrial volume was calculated using the formula: LV volume = $0.85 \times (A1 \times A2)/L$ (A1 is left atrial area in the apical four-chamber view and A2 is left atrial area in the apical two-chamber view, and L is the shortest orthogonal left atrial dimension in the apical four-chamber or two-chamber views) (3).

3.3. Statistical Analysis

The continuous variables with a normal distribution are presented as mean ± standard deviation. The K-S test was used to assess the normal distribution of the continuous variables. The mean differences for the continuous data between the two groups were analyzed with the independent samples t-test. The chi-squared test or the Fisher exact test, if applicable, was employed to compare the categorical parameters. A P value ≤ 0.05 was considered statistically significant. All the statistical analyses were done using PASW Statistics 18 for Windows (SPSS Inc., Chicago, Illinois, USA).

4. Results

The MVP group comprised 75 patients (48 females) at a mean age of 26.5 ± 9.4 years and the control group consisted of 50 individuals (32 females) at a mean age of 27.1 ± 8.3 years. The MVP and control groups were matched for age and sex. The salient findings of the present study were as follows:

Sm wave was much more prominent and much higher in the MVP group ($P < 0.001$) (Figure 1). Also, Em was lower ($P < 0.001$) and Am was slightly higher in the MVP group ($P = 0.12$). Moreover, the E waves of MV inflow for the MVP and control groups were similar and E/Em was significantly higher in the MVP group ($P < 0.001$); taken together with a higher left atrial volume in this group, this finding revealed a relatively higher LV end-diastolic pressure and some degree of diastolic dysfunction in the MVP patients. The echocardiographic findings are shown in Table 1.

Also because of slightly higher A values in the MVP patients, E/A value was lower in the MVP patients. Am was higher in the MVP patients as well, thereby reducing Em/Am. Interestingly, deceleration time was significantly higher in the MVP group, which may be an indicator of diastolic dysfunction.

5. Discussion

Functional and structural changes in MVP syndrome have been vastly studied and, at least from a theoretical point of view, hint at dysfunction around the mitral annulus in the myocardium. Studies have shown that myocardial fibrin percentage is higher in MVP patients, which may be due to increased preload and/or inherited cardiomyopathy (1-3).

It has been previously suggested that some defects in the blood supply may play a role in MVP syndrome, and recent studies have shown decreased coronary blood supply and ischemic changes in patients with this syndrome. Be that as it may, there are studies whose findings do not chime in with these reports (6, 7).

TDI is a novel diagnostic modality that can unmask even the slightest systolic or diastolic dysfunctions (5). We sought to provide data on TDI findings in patients with MVP syndrome, and, interestingly, detected significantly prominent S waves in our MVP patients. We concluded that the mobility of the myocardium and leaflet displacement and movement were significantly higher in the MVP patients.

Similar to our data regarding S wave and Em and Am, Zampoulakis (8) (2006) showed that whereas mean S was significantly higher at rest in MVP patients, it was higher after exercise in healthy subjects. The authors also reported that although mean AM was higher at rest, this was not seen after exercise, and E' at rest was higher in the control group. They concluded that in MVP syndrome, while there was increased mobility of the myocardium at rest in comparison with healthy subjects, no sufficient increase was observed in exercise and physical activity in mobility and contractility, which might be due to insufficient blood supply, as was mentioned before. Also similar to our findings, again, they suggested that some degree of diastolic dysfunction might be present in MVP patients. It is deserving of note that S waves in our study were much more prominent than those in the said study (8).

Some other studies have reported results about systolic and diastolic dysfunction in MVP patients. For example, Boudoulas (9) and Zuppiroli (10) suggested that disarray in the MV structure was the cause of LV dysfunction in

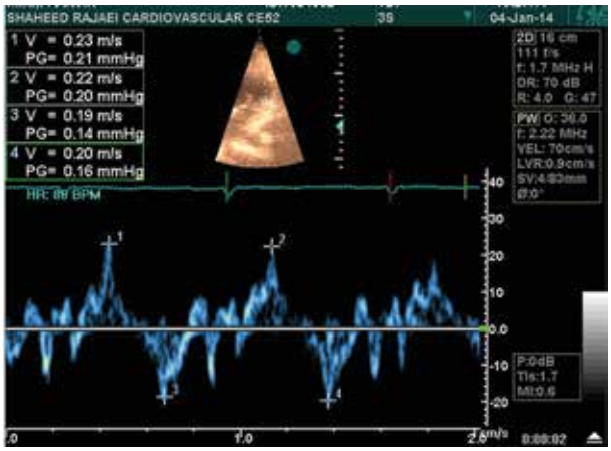

Figure 1. Prominent S wave in the Tissue Doppler Imaging of the Patients With Mitral Valve Prolapse

Table1. Tissue Doppler Imaging Findings in the Mitral Valve Prolapse and Control Groups [a, b]

Variable	Patients, (n = 75)	Control, (n = 50)	P value
Age, y	26.5 ± 9.4	27.1 ± 8.3	0.72
Sex (F/M)	48/27	32/18	0.09
LVEF	58.5 ± 4.6	58.8 ± 4.9	0.73
LA Volume, cm^3	45.12 ± 11.32	34.86 ± 10.67	< 0.001
S, cm/s	23.11 ± 3.42	11.15 ± 2.85	< 0.001
Em , cm/s	12.41 ± 3.67	16.55 ± 3.15	< 0.001
Am , cm/s	9.06 ± 3.49	8.12 ± 2.75	0.12
E , cm/s	84.30 ± 16.50	84.68 ± 11.70	0.89
A , cm/s	60.43 ± 23.4	55.33 ± 16.22	0.19
Deceleration time of E wave, ms	190.60 ± 31.00	173.89 ± 23.19	< 0.001
E/A ratio	1.44 ± 0.31	1.52 ± 0.41	0.23
E/Em ratio	6.77 ± 3.67	5.11 ± 1.55	< 0.001

[a] Mean ± SD

[b] Abbreviations: A, peak late diastolic flow velocity; Am, early diastolic velocity of the lateral portion of the mitral valve annulus by tissue Doppler imaging; E, peak early diastolic flow velocity; Em, early diastolic velocity of the lateral portion of the mitral valve annulus by tissue Doppler imaging; LA, left atrium; LVEF, left ventricular ejection fraction; Sm, systolic velocity of the lateral portion of the mitral valve annulus by tissue Doppler imaging

these patients, which could cause defects in the blood supply to the basal wall of the LV and could eventually lead to local ischemia and regional wall motion abnormalities. Wu (11) and Tentolouris (12) also posited that insufficiency in the blood supply to the myocardium adjacent to the mitral annulus was responsible for ventricular dysfunction.

Finally, in our study, higher E/E' in the MVP group, in tandem with a higher left atrial volume and deceleration time, revealed a relatively higher LV end-diastolic pressure and some degree of diastolic dysfunction. Nonetheless, our hot result was the highly prominent S wave in the MVP patients.

S wave in TDI imaging is very prominent and is significantly high in MVP syndrome. Our findings showed some degree of diastolic dysfunction in the MVP patients. For better evaluation of this issue, further studies with larger patient populations are strongly advised.

Limitations: We considered some exclusion criteria to make our study groups more homogenous; nevertheless, this may limit the generalizability of the findings. A relatively restricted sample size, especially in the control group, is another limitation of this study.

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Authors' Contributions

Dr. Alizadehasl provided the study idea, examined the patients, and participated in the writing of the paper Dr. Azarfarin analyzed the study data, wrote the paper, and submitted it to the journal.

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