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Assessment of Left Ventricular Torsion by 2D Speckle Tracking Echocardiography in Diabetic Patients

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ABSTRACT

Background: Speckle tracking echocardiography (STE) is a novel, non-invasive technique for the evaluation of regional and global function of the left ventricle (LV). STE was suggested as an alternative method for evaluating LV torsion and deformation. We aimed to evaluate the LV torsion in diabetic patients using 2D STE. **Methods:** This single center, prospective study was carried out on 56 subjects recruited from Meoufia University Hospital. They were categorized into 2 groups; cases group (n=36) involved diabetic patients with preserved LV systolic function; EF ≥ 50% and control group (n=20) included age and sex matched individuals. All patients underwent general and local examination, conventional echocardiography and 2D STE. **Results:** The studied patients exhibited a significantly lower early diastolic myocardial wave velocity (E`) than the control group (P <0.05), and the ratio among early diastolic mitral inflow velocity and early diastolic myocardial velocity (E/e`) was significantly elevated in the trail patients contrast to in the control group (P <0.001). The control group exhibited a significantly higher apical rotation than the studied cases (P <0.001). Although the basal rotation of the patients under investigation was greater than that of the control group, it did not attain a statistically significant value (P >0.05). In summary, the torsion was significantly lower in the patients under study than in the control group (P <0.001). **Conclusions:** LV torsion by 2D STE was ignificantly lower in diabetic cases in contrast to controls so it should be measured in diabetic patients to detect early changes that correlate with LV dysfunction that can allow early detection and proper management.

Keywords: 2D Speckle Tracking Echocardiography; Diabetic; Left Ventricular; Torsion.

Introduction

For an extended period, it has been recognized that the heart undergoes a wringing (twisting) motion and rotation along its long axis. Various techniques have been employed by numerous investigators to quantify this twist motion and to attempt to elucidate its significance [1]. Radiopaque markers were embedded in the myocardium and their movements were observed through biplane cine angiography, as well as observations were made with sonomicrometry in animal hearts. Numerous of these methodologies are intrusive, rendering them inappropriate for the examination of human hearts [2].

A novel, non-invasive technique for the global and regional functional capacity evaluation in the left ventricular (LV) is speckle tracking echocardiography (STE). The STE provides the ability to monitor myocardial deformation in a manner that is independent of cardiac translation or insonation angle. Tagged cardiac magnetic resonance (cMR) was the sole method for angle-independent LV deformation assessment and rotation prior to the introduction of STE. Despite the fact that tagged cMR continues to be the standard method for evaluating LV deformation, its utilization is restrained

by its inherent high cost, low frame rate acquisition, complex data analysis and and time-consuming [3].

The use of STE as an alternative method for evaluating LV deformation and torsion was recently proposed. It has been methodically validated using color-coded tissue Doppler echocardiography, tagged cMR, and sonomicrometry. Its consistency and accuracy have been confirmed by numerous studies [4].

Numerous independent risk factors for the heart failure (HF) development in diabetics include an elevated body mass index (BMI) and an increased HbA1c. The risk of HF was reduced by 16% for every 1% decrease in HbA1c. A 12% elevation in the heart failure risk is associated with a 2.5 unit elevation in BMI. Insulin use, nephropathy, end-stage renal disease, proteinuria and retinopathy, albuminuria, and the diabetes duration are all independent risk factors for HF in diabetics. CHD and hypertension are the two most prevalent risk factors for the HF development in diabetics [5]. This trial was designed to assess LV torsion in diabetic patients through the use of 2D STE.

Patients and Methods

This prospective study was conducted at a single center and included 56 subjects who were recruited from Meoufia University Hospital between December 2022 and October 2023. The patients provided written consent that was informed. The ethics committee of Menoufia University Hospital allowed the trail to be conducted.

Exclusion criteria were coronary artery disease patients (excluded by history of angina, ECG changes and echocardiography), significant valvular lesions, systemic hypertension, arrhythmias as atrial fibrillation, extrasystoles,..etc, poor transthoracic echogenic window, myocardial diseases " HCM, DCM and infiltrative diseases", pericardial diseases, and history of thyroid diseases ,chronic kidney disease, or chronic liver disease.

Grouping:

The trail participants were separted to two groups: the cases group (n=36) consisted of diabetic preserved LV systolic function patients (EF ≥ 50%) and the control group (n=20) involved matched individuals in sex and age.

All patients underwent a exhaustive medical history taking including age, gender, duration of diabetes and medications either oral hypoglycemic drugs, insulin or both combined, a through clinical examination involving general examination including blood pressure, pulse, neck veins, lower limb edema, etc, and local examination by auscultation of the heart to detect abnormal heart sounds, murmurs or additional sounds to help exclude valvular heart disease or HF.

12- leads ECG was performed to exclude patients with ECG changes consistent with ischemic heart disease, LV hypertrophy, atrial fibrillation or significant arrhythmias. Echocardiography was performed using a General Electric Vivid E9 machine. A harmonic M5S variable-frequency (1.7 - 4 MHz) phased-array transducer was installed in Healthcare (GE Vingmed, Norway). As advised by the American Echocardiography Society, the patients were placed in the left lateral position and is attached to a single-lead ECG device [6].

A conventional echocardiogram:

In addition to the short axis and parasternal long views, 2D echocardiography was performed at the apical window. The E/A ratio, the late diastolic wave velocity (A), and the early diastolic wave peak velocity (E wave) over the mitral valve were all measured using Doppler imaging. More specifically, pulsed and continuous wave Doppler were implemented. An 1.5-mm sample volume was

positioned at the lateral mitral of the mitral annulus in the apical 4-chamber view for color Doppler and Doppler tissue imaging. Based on the analysis, the E wave and the E/e' ratio were detected. M-Mode was employed to detect the following: aortic root diameter, EF, LA, FS, diameter, LVEDD, LVESD, IVSD, and LVPWd.

STE in two dimensions:

It was utilized to assess LV rotation and torsion by acquiring specific short-axis planes with internal landmarks. The apical plane was developed as far distal as possible to the papillary muscles, while the basal plane was developed at the mitral valve leaflets level, prohibiting the mitral annulus. This was implemented to guarantee that the LV cross section was as circular as probable [7]. Speckle-tracking imaging analysis was done utilizing the software available (Echo PAC BT 12, GE-Vingmed; Norway).After manually tracing the LV endocardial border, the software produced a second, larger, concentric tracing at the epicardium to ensure that the entire LV myocardium was accounted for. The software subsequently processed speckle-tracking on a frame-by-frame basis to convert each LV view into six equal segments.The average rotation at aortic valve closure was determined by measuring the basal and apical rotations based on the LV average rotations from the six segments. Positive values were implemented to symbolize the apical rotation, while negative values were implemented to symbolize the basal rotation. The LV twist is equivalent to the apical rotation minus the basal rotation. Twist and rotation are represented by degrees [8].

The LV outflow tract was underwent pulsed wave Doppler tracing to ascertain the aortic valve closure and opening timing, which is indicative of systole.

Statistical analysis:

The statistical analysis was controlled utilizing SPSS v28 (IBM Inc., Chicago, IL, USA). The two groups were contrast utilizing the unpaired Student's t-test. The quantitative variables were presented as the mean, standard deviation (SD), and range. The qualitative variables, which were expressed as frequency and percentage (%), were analyzed utilizing the Chi-square test. Statistical significance was defined as a two-tailed P value of 0.05 or less.

Results

No significant difference was detected among the studied groups regarding sex and age. (P value greater than 0.05). the duration of diabetes in the studied patients ranged from 1 year to 20 years.Regarding antidiabetic drugs, 19 patients were on oral antidiabetic drugs, 15 patients were on insulin therapy and 2 patients received combined oral antidiabetic and insulin therapies (**Table 1)**.

Insignificant difference was showed among the studied groups regarding left atrial diameter and aortic root diameter (P >0.05). By studying LV dimensions and systolic function we detect that there were no significant difference among the studied groups regarding LVIDd, LVIDS, EF and FS (P >0.05) (**Table 2)**.

We found that the studied groups did not demonstrate any statistically significant difference in late diastolic wave velocity (A wave), E wave, or E/A ratio (P >0.05) when comparing mitral inflow waves. In contrast, the early diastolic myocardial wave velocity (E`) was significantly lower in the studied cases than in the control group when we compared myocardial velocity using Doppler tissue imaging (P <0.05). Ultimately, the control group showed a significantly lower early diastolic mitral inflow velocity ratio to early diastolic myocardial velocity (E/e) than the cases under investigation (P <0.001) (**Table 3)**.

Apical rotation was significantly lower in the studied patients contrast to in the control group (P <0.001), whereas basal rotation was elevated in the studied cases contrast to in the control group but did not reach significant value (P >0.05). Finally, the torsion was significantly higher in the control group than in the studied cases (P <0.001) (**Table 4)**.

Table 1: Comparison of age and sex in the studied groups

		Control group (n=20)	Cases group (n=36)	P value
Age (years)	**Mean ± SD**	45.2 ± 9.5	49.53 ± 9.26	0.103
Sex	**Male**	13 (65%)	21 (58.33%)	0.625
	Female	7 (35%)	15 (41.67%)	

**: significant as P value ≤0.05.*

Table 2: Comparison of conventional echocardiographic parameters in the studied groups

	Control group (n=20)	Cases group (n=36)	P Value
Ao (cm)	2.81 ± 0.45	2.82 ± 0.37	0.878
LA (cm)	3.7 ± 0.34	3.63 ± 0.55	0.594
IVSD (cm)	0.85 ± 0.13	0.89 ± 0.12	0.229
LVPWd (cm)	0.83 ± 0.11	0.88 ± 0.14	0.186
LVIDd (cm)	4.99 ± 0.34	4.93 ± 0.45	0.592
LVIDS (cm)	3.34 ± 0.27	3.36 ± 0.33	0.856
EF (%)	61.85 ± 3.47	60.14 ± 3.74	0.098
FS (%)	33.1 ± 2.47	32.14 ± 2.8	0.205

o: Aortic root diameter, LA: Left atrium diameter, IVSD: Interventricular septal end diastole, LVPWd: Left ventricular posterior wall end diastole, LVIDd: Left ventricular internal diameter in diastole, LVIDS: Left ventricular internal diameter in systole, EF: Ejection fraction, FS: Fractional shortening.

Table 3 :Comparison of parameters of LV diastolic function in the studied groups

		Control group (n=20)	Cases group (n=36)	P value
E (m/s)	**Mean ± SD**	0.73 ± 0.17	0.66 ± 0.15	0.101
A (m/s)	**Mean ± SD**	0.72 ± 0.16	0.67 ± 0.16	0.311
E/A ratio	**Mean ± SD**	1.05 ± 0.22	1.02 ± 0.32	0.701
E` (cm/sec)	**Mean ± SD**	0.09 ± 0.02	0.08 ± 0.02	**0.025***
E/e'	**Mean ± SD**	6.68 ± 1.28	9.36 ± 2.2	**<0.001***

**: significant as P value ≤0.05.*: statistically highly significant as P value < 0.001. E: early diastolic wave velocity, A: late diastolic wave velocity, E`: early diastolic myocardial wave velocity.*

Table 4: Comparison of apical rotation, basal rotation and torsion in the studied groups

		Controlgroup (n=20)	Cases group(n=36)	P value
Apical (◦)	**Mean ± SD**	13.19 ± 2.06	8.19 ± 3.5	**<0.001***
Basal (◦)	**Mean ± SD**	-4.54 ± 1.46	-4.21 ± 3	0.645
Torsion (◦)	**Mean ± SD**	17 ± 2.48	10.93 ± 2.35	**<0.001***

**: significant as P value ≤0.05. *: statistically highly significant as P value < 0.001*

Discussion

The novel non-invasive technique known as STE is used to evaluate both the global and localized function of the LV. With STE, one can monitor myocardial deformation without regard to the insonation angle or cardiac translation. Prior to the development of STE, cMR was the only method for assessing LV deformation and rotation that was independent of angle [9]. The application of tagged cMR is still the gold standard for evaluating LV deformation; however, its high cost, intrinsic low frame rate acquisition , and laborious and intricate data processing have limited its use. Color-coded tissue Doppler echocardiography, tagged cMR, and sonomicrometry have all been employed to conduct a systematic confirmation of STE. This technique was recently introduced as an alternative procedure for quantifying LV torsion and deformation. Numerous investigations have confirmed its precision and consistency [10].

To determine the initial diabetes mellitus effects on the LV systolic function, we examined the diabetes mellitus impact on LV torsion. We detect that the torsion and apical rotation values of the patients under trail were significantly lower than those of the controls in our trial ($P < 0.001$ for both). Nevertheless, the basal rotation values were lower in the studied cases than in the controls, although they did not reach a statistically significant level ($P > 0.05$).

This went with harmony with the findings that myocardial stiffness and LV remodeling can explain the change in LV torsion values in diabetic patients [11-15].

Our trial revealed no significant statistical differences in left atrial dimension and LV ejection fraction among the diabetic and control groups.

In agreement with us The diabetic group and the control group did not exhibit any significant differences in LA and EF values, as determined by Yang et al.[16] Additionally, they stated that the LV ejection fraction is consistently employed to assess contractile function in both healthy individuals and those with cardiac disease.

In an effort to ascertain an explanation, Lee et al.[17] proposed that diabetes mellitus may have a negligible impact on echocardiographic parameters, whereas microvascular reduction is the more significant factor. The potential explanations for these findings are as follows: mild diabetes does not result in a significant change in cardiac structure, and conventional echocardiographic parameters are unable to accurately depict early systolic dysfunction in T2DM cases.

The LV diastolic function parameters in our trial demonstrated that (E) was significantly lowered in the evaluated patients contrast to in the control group ($P <0.05$), while (E/e) was significantly elevated in the evaluated patients contrast to in the control group ($P <0.001$). In terms of E wave, A wave, and E/A ratio, there was no significant difference among the studied groups ($P >0.05$).

The reduction in LV wall compliance, which is a result of interstitial fibrosis , microvascular disease myocardial and lipid deposition is the cause of the LV diastolic function deterioration identified in DM [18].

Santos et al [19] also demonstrated that the pulmonary capillary wedge pressure and left atrial pressure are elevated when the LV diastolic function is lowered, as the LV wall becomes stiff and the compliance is lowerd. In order to detect the LV diastolic function, the e/a ratio is a parameter that is not sufficiently influenced by hemodynamics. Nevertheless, the E/e ratio is a more sensitive parameter for calculating the variations in diastolic function and is indicative of the changes in LV filling pressure.

As per Palazzuoli et al. [18], a reduction in LV wall compliance is the result of interstitial fibrosis, microvascular disease and myocardial lipid deposition in DM. This, in turn, results in an elevation in an elevated E/e` ratio and LV filling pressure.

This trail had certain limitations as the studied sample was small, the effect of BMI and obesity were not excluded in this trail and obesity is independent risk factor in evolving HF in diabetic patients so enrollment of BMI in the trail would make it more accurate to correlate among LV torsion and diabetes, and The patients were not followed up to ascertain the impact of diabetes duration or the improvement of LV torsion with improved diabetes control. Therefore, increasing sample size for proper and more accurate assessment of the studied topic is recommended .

Conclusions

LV torsion by 2D STE was significantly reduced in diabetic patients than in controls so it should be measured in diabetic patients to detect early changes that correlate with LV dysfunction that can allow early detection and proper management.

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