International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)
Journal Home page: www.iscientific.org/Journal.html
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The potential role of 2D- speckle tracking echocardiography in detecting cardiac dysfunction in multiple sclerosis

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Abstract

Studies of cardiovascular impairment in MS patients were the focus of much attention. However, the mechanisms of such dysfunction are not completely elucidated. To evaluate how patients' left and right ventricles work with relapsing-remitting MS and to correlate those functions with disease parameters. The case-control research included participation from fifty individuals diagnosed with multiple sclerosis as well as fifty healthy controls who were comparable to one another in terms of age and gender. Echocardiography, tissue Doppler, and two-dimensional speckle tracking were the methods that were used in order to evaluate the heart function of each and every person. The two-dimensional left ventricular ejection fraction, mitral annular plane systolic excursion, longitudinal tissue Doppler velocities, myocardial performance index, and global longitudinal strain were all significantly lower in patients with multiple sclerosis (MS) compared to controls. This indicates that there was a significant decrease in the left ventricular systolic function. A significantly decreased mitral input E/A ratio was also seen in individuals with multiple sclerosis, indicating a markedly diminished left ventricular diastolic performance, lower mitral annulus diastolic velocities, higher peak TR velocity, higher mitral E/E` ratio, and longer LV isovolumetric relaxation time, in contrast to the subjects who were healthy. There were many signs of poorer RV function in the patient group in comparison to the control group. These indicators included a decreased tricuspid annular plane systolic excursion, a reduced longitudinal systolic and diastolic velocity, an increased RV myocardial performance index, and raised pulmonary arterial systolic pressures. No clear connection could be found between the severity of the ailment or the length of time it had been present and the performance of the heart. MS patients had impaired biventricular cardiac function, compared to the healthy population, however there was no correlation between the intensity or length of the illness and this impairment.

Keywords: Multiple Sclerosis; Speckle tracking echocardiography; Tissue Doppler imaging, Cardiac dysautonomia; EDSS

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1. Introduction

Inflammation and demyelination of the CNS, either with or with no demyelination of the peripheral nervous system, characterize multiple sclerosis (MS), a chronic neurological condition. For middle-aged adults, it ranks high among the leading causes of neurological impairment. About 80% of MS patients experience episodes of neurological deficits followed by a period of recovery (relapsing-remitting MS), while 10%-15% exhibit a progressive course without remissions (primary progressive MS) [1]. One possible explanation for the greater mortality rate among MS patients compared to the general population is the higher prevalence of various comorbidities including cardiovascular (CV) disease. The detailed mechanisms of CV impairment in MS patients are not well-illustrated yet, but many factors are suggested to contribute to increased CV risk among MS populations; like the chronic inflammatory status, hyper-oxidative stress, impaired endothelial function, lack of physical exercise, and elevated cardiovascular risk factors in multiple sclerosis patients such as obesity, diabetes, dyslipidemia, and smoking [2].

In spite of the value of research in this area, cardiovascular function evaluation was rarely done in this group of patients. The majority of investigations focused only on the heart-harming effects of mitoxantrone. In addition, few studies that conducted in the past to evaluate heart function of individuals with multiple sclerosis (MS) exclusively used traditional two-dimensional echocardiography and tissue Doppler imaging. However, to the best of our knowledge, the relatively new speckle tracking technique, although rapid, simple, and valuable in early detection of subtle myocardial affection, was not previously used in this area, except in one

study [3]. Using a variety of echocardiography methods, including a 2D speckle tracking approach, this study set out to assess heart function in multiple sclerosis patients and establish a correlation between the assessed parameters and the severity and duration of the condition. For multiple sclerosis patients, this might be useful in identifying those at elevated risk of cardiovascular disease.

2. Methods

2.1. Study design and study population

In this case-control research, 100 participants were split evenly between 50 people with relapsing-remitting multiple sclerosis and 50 healthy individuals who were matched for age and sex. From January 2020 to October 2020, every single patient received care from the Neurology clinic at Beni-Suef University Hospital. Prior to inclusion in the trial, all individuals or their family were asked to provide written informed permission. All procedures followed the guidelines laid forth in the Declaration of Helsinki. The ethics committee of Beni-Suef University's Faculty of Medicine gave its stamp of approval to the project. Reference number FMBSUREC/05012020/Zaher is assigned to the committee.

2.2. Inclusion criteria

A diagnosis of relapsing- remitting multiple sclerosis (RRMS) was made for individuals who met the 2017 McDonald's criteria. At least one month after their previous relapse, patients were evaluated when they were in a state of remission. There was a wide age range, from 15 to 45.

2.3. Exclusion criteria

We did not include the following cases in our analysis.: MS patients on mitoxantrone which is known to have cardiotoxic side effects, patients with a history of any associated autoimmune disease, those having a history of cardiovascular illness, conditions affecting the kidneys, lungs, liver, or blood, or those diagnosed with diabetes mellitus, hypertension, dyslipidemia, pregnant patients and patients with poor acoustic windows.

2.4. Those that were chosen to participate went through the following

1. Recording medical history, including how long the condition has been present, the total number of relapses, and any disease-modifying medications (DMDs) used.
2. General and cardiological assessment: Measurements of the patient's height, weight, blood pressure, body mass index, surface area of the body, and symptoms of heart failure were taken from all patients and controls; such as lower limb swelling, high jugular vein pressure, and bilateral fine basal crepitations.
3. Neurological Evaluation: The Expanded Disability Status Scale (EDSS) was used for all patients to evaluate the disability of MS patients. The total score ranges from zero to 10 (death due to MS) [4].
4. Radiological assessment: In order to identify the location, magnitude, and quantity of MS plaques and to rule out other structural abnormalities, magnetic resonance imaging (MRI) was performed on brain and spinal cord in all patients who considered for the study.
5. Transthoracic echocardiography: Ultrasound (EPIQ 7, Philips Medical Systems) was used for the procedure on all patients and controls. In accordance with the echocardiography protocols, we measured strain, M-mode, and 2D tissue Doppler [5].

2.5. Conventional Echocardiography

Using the parasternal long-axis view, the left ventricle's internal dimensions were assessed. The left ventricle (LV) was measured end-systolic and end-diastolic volumetrically in the right and left apical chambers, respectively. After determining EDV and ESV, the following equation was used to determine LVEF: EF = [(EDV - ESV (/EDV)] x 100 (a modified version of Simpson's rule). According to the following formula: "Cube formula of LV mass = 0.8 x1.04x [(IVS+LVID+ PWT (3 -LVID3] + 0.6g", the mass of the left ventricle was also determined by taking linear measurements of its end-diastolic diameter and wall thickness. The Body Surface Area used as an index for all the observed diameters, volumes, and masses of the LVs. The M-mode positioned on medial mitral annulus and tricuspid annulus to capture systolic excursions of mitral annular plane (MAPSE) and tricuspid annular plane (TAPSE). The ideal positioning of the PW Doppler volume of sample across the tips of the mitral leaflets in the apical 4-chamber view was used to evaluate the diastolic function of the left ventricle. Subsequently, the mitral E/A ratio, mitral deceleration time, and E wave velocity were measured. In the apical 4-chamber view, the tricuspid leaflet tips were used to optimally align the CW Doppler sample volume, which allowed for the measurement of peak TR velocity as well. Next, the simplified Bernoulli formula was used to get the right ventricular systolic pressure (RVSP) from the peak TR jet velocity. This result was then coupled with the RA pressure. Both the PASP and the RVSP are identical when there is no gradient across the pulmonary valve or the RV outflow tract.

2.6. Tissue Doppler Imaging

Larger sample volume size, lower velocity scales, low filter, and low gain settings were used. TDI was performed with ECG gating, using mainly apical views, and our main modality was PW TDI. Peak longitudinal systolic and diastolic velocities (S`& E` velocities) were assessed online by pulsating the mitral and tricuspid annuli, then the online mitral E/E` ratio was calculated. Also, time intervals (ET, IVCT, IVRT) were measured by online pulsed tissue Doppler, then the myocardial performance index was calculated for both right and left ventricles, MPI= [(IVRT + IVCT)/ET]. NB: All the values of velocities and time intervals for the mitral annulus were measured as the average of the values of the medial and lateral mitral annuli.

2.7. 2D Speckle Tracking Echocardiography

A steady electrocardiogram (ECG) recording and sufficient grayscale picture were acquired to analyze the left ventricular global longitudinal strain using the three conventional apical views (apical 4-, apical 2-, and apical 3-chamber). The equipment automatically computed the aortic valve closure time based on the ECG gating after three consecutive cardiac cycles. Using the Cardiac Motion Quantification (CMQ) feature on the Q lab10 software, the saved pictures were analyzed offline. After the system automatically or semi-automatically located the area of interest from the ECG recordings, it calculated the end-systole. Both the endocardial and epicardial borders were monitored by the program. Afterwards, all segments'

longitudinal deformation characteristics were shown numerically and graphically. At last, the program developed a 17-section bull's-eye view of the maximum longitudinal systolic strain, along with an automated determination of the average worldwide longitudinal strain.

2.8. Intra- and Inter-Observer Variability

For analysis of the left ventricular global longitudinal strain, the three standard apical views (apical 4-, apical 2-, and apical 3- chamber) were obtained with a stable ECG recording and adequate grayscale image. Three consecutive heart cycles were recorded and aortic valve closure time was automatically calculated by the machine depending on the ECG gating. Using the Cardiac Motion Quantification (CMQ) feature on the Q lab10 software, the saved pictures were analyzed offline. After the system automatically or semi-automatically located the area of interest from the ECG recordings, it calculated the end-systole. Both the endocardial and epicardial borders were monitored by the program. Afterwards, all segments' longitudinal deformation characteristics were shown numerically and graphically. At last, the program developed a 17-section bull's-eye view of the maximum longitudinal systolic strain, along with an automated determination of the average worldwide longitudinal strain.

2.9. Statistical analysis

The present research's sample size was determined using G*Power version 3.1.9.2 software, which was based on a pilot study that came before it. A statistical power of 80% (1-β) required the participation of 100 individuals. There was a 5% chance of a type I mistake (α). We used IBM Statistics 20 (SPSS) to conduct our statistical study. Mean, standard deviation (SD), numerical values, and percentages were the ways in which the study's variables were represented. Random samples Quantitative factors comparing the MS and control groups were analyzed using a T-test. We compared the MS group to the control group on categorical factors using a chi-square test. To determine if there was a connection b/w quantitative variables, Pearson's correlation used. Statistical significance determined by p-values≤ 0.05 (2-sided).

3. Results and discussion

3.1. Results

Table 1 shows the characteristics of the two groups at their baseline. Age, sex, body mass index (BMI), blood sugar (BSA), systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and smoking were not significantly different between MS patients and controls. Table 2 displayed the neurological and radiological characteristics of the patient group. Patients with multiple sclerosis had markedly elevated mean values of left ventricular dimensions, volumes, and mass in comparison to the control group. They had markedly diminished left ventricular (LV) systolic function relative to control participants, shown by considerably lower left ventricular ejection fraction (LVEF), reduced mitral annular plane systolic excursion (MAPSE), decreased longitudinal systolic velocity (S`), elevated LV myocardial performance index, and diminished left ventricular global longitudinal strain (GLS), with P-values above 0.001 for all measures (Table 3). The patient group had also a significantly reduced LV diastolic filling, in contrast to the control group, confirmed by significantly lower E and higher A wave velocities, longer mitral DT, lower mitral E/a ratio, higher peak TR velocity, lower E' diastolic velocity, higher mitral E/E' ratio and longer LV isovolumetric relaxation time (P-value> 0.001, 0.001, >0.001, >0.001, 0.001,> 0.001, >0.001, >0.001, respectively) (Table 4). Meanwhile, right ventricular (RV) function was significantly reduced in the patient group, in comparison to the control group, as shown by significantly lower TAPSE, lower longitudinal tricuspid annular systolic and diastolic velocities, higher RV MPI, and higher PASP (P-value >0.001, >0.001, >0.001, >0.001, 0.001, respectively) (Table 5). In the present study, 44% (n=22) of our patients were on DMDs, while 56% (n=28) did not receive DMDs. No statistically significant difference was found between the two groups, regarding left ventricular systolic performance (LVEF, MAPSE, mitral S` velocity, LV MPI, and LV GLS), left ventricular diastolic filling (E/A ratio, mitral DT, mitral E` velocity, peak TR velocity and LV IVRT) or right ventricular function (TAPSE, tricuspid S` velocity, Tricuspid E` velocity, RV MPI, and PASP). No statistically significant correlation could be detected between cardiac function and either disease duration, EDSS score, the total number of relapses, or the MRI lesion load. Only the LV end-systolic diameter was significantly correlated with disease duration, EDSS score, and the total number of relapses (P-value=0.048, 0.003, 0.044, respectively), and the LV end-diastolic diameter was significantly correlated with EDSS score (p-value=0.010). Some echocardiographic measurements taken from one of our cases and its matched control were illustrated in figure (1) & (2). Interestingly, one of the included patients was a 30-year-old female patient with no history of any cardiovascular disease, with normal kidney and thyroid functions. She was diagnosed as multiple sclerosis 3 years ago, with EDSS score 5. She didn't receive DMDs for 2 years because she was seeking for pregnancy. She had moderate pericardial effusion, detected by echocardiography, as shown in figure (3), suggesting that MS might cause pericardial involvement, but this matter still needs further research.

3.2. Discussion

There is strong evidence suggesting cardiovascular dysfunction with multiple sclerosis affected individuals. Nevertheless, the exact ways in which this malfunction occurs remain a mystery [6]. Heart valve systolic and diastolic function were shown to be considerably impaired in MS patients, according to our researchs, in contrast to the matched healthy controls, confirmed by significantly lower LVEF (P-value > 0.001), lower 2D LV global longitudinal strain (P-value > 0.001), lower mitral E` velocity (P-value > 0.001), longer LV isovolumetric relaxation time (p-value > 0.001). Additionally, our patients had a significantly reduced RV function, in comparison to control group, confirmed by significantly lower TAPSE (P-value > 0.001) and significantly higher RV myocardial performance index (P-value> 0.001). Neither the left nor right ventricular function nor severity of disease found to be statistically correlated with one another. However, there was a positive correlation b/w end-systolic diameter of left ventricle and disability score, total number of relapses, and duration of disease (P-value = 0.048, 0.003, and 0.044, respectively), and b/w end-diastolic diameter of left ventricle and EDSS score (P-value = 0.010).

We found that Mincu R. I. et al. used a combination of traditional echocardiography, tissue Doppler, speckle

tracking, and 3D echocardiography to assess heart function in multiple sclerosis patients. Left ventricular systolic and diastolic functions were found to be significantly impaired in MS patients compared to controls. This was supported by significantly lower 2D LVEF (P-value > 0.001), lower LV GLS (P-value > 0.001), 3D LVEF (P-value > 0.001), lower mitral E' velocity (P-value = 0.010), and longer LV IVRT (P-value > 0.001). Results showing considerably decreased TAPSE (P-value > 0.001), greater RV MPI (P-value > 0.001), and RV strain (P-value > 0.001) showed that RV function was severely diminished in MS patients compared to controls. Cardiac dysfunction was not associated with the severity or length of illness, according to authors. Furthermore, with respect to all echocardiographic characteristics, there was no statistically significant difference between the MS patients who underwent DMDs and those who did not. Their MS patients' observed cardiac dysfunction prompted them to speculate that an intrinsic myocyte pathology may be to blame [3]. Also, Ferit Akgul et al. assessed MS patients' heart function using the tissue Doppler and the traditional echocardiography. Patient group was shown to have considerably deteriorated left ventricular functions (systolic and diastolic) when compared to control group. This was supported by substantially shorter left ventricular intraventricular resynchronization time (IVRT) (P=0.001), and significantly longer left ventricular myocardial perfusion index (MPI) (P=0.04). In addition, they did not discover any evidence that LV dysfunction was associated with the severity or length of the illness. Myocardial dysfunction may be caused by autoimmunity, according to their suggestion [7]. In addition, Olindo et al. used radioactive angiocardiography to measure EF in the left and right ventricles. The researchers observed that, as compared to healthy persons, MS patients had a significantly lower RV EF (P-value= 0.02) and LV EF (P-value < 0.0001). In 25% of MS patients, they found pathological affection for the right ventricle EF (7.5%), left ventricle EF (10%), or both (7.5%). Ventricular EF was also unrelated to demographic variables such as age, sex, illness duration, disease history, EDSS, or prior therapy. As cardiac autonomic dysregulation is common in multiple sclerosis patients, they hypothesized that the reported affection of EF may be related to this disorder [8]. Additionally, Ziaber J et al. found a significant decrease in cardiac output and LVEF in supine position in MS patients having higher EDSS scores, as compared to those having lower EDSS scores and controls (P-value >0.01). These findings were intensified in the standing position in MS patients with higher EDSS scores. In contrast to our results, this study reported a significant correlation between cardiac impairment and EDSS score. The authors found that orthostatic hypotonia was not observed in the majority of their MS patients. So, they concluded that the reported myocardial dysfunction in MS patients can be attributed, not only to autonomic nervous system dysfunction but also to secondary myocardial injury in the course of MS [9]. The mechanisms of cardiac dysfunction in MS patients are not completely understood until now. Most accepted mechanism is cardiac autonomic dysfunction which is well approved in multiple sclerosis [10]. A neurological injury that can destruct cardiac autonomic centers could also affect cardiac structure by development of early calcification, subendocardial micro infarcts, and formation of the contraction bands. Those changes might be due to excessive exposure to catecholamines. Additionally, there is also strong evidence of mitochondrial dysfunction in MS patients, leading to disturbance of myelin production and affection of the cardiac function [11]. In MS patients, the autoimmune central demyelination may be accompanied by autoimmune myocarditis leading to impairment in myocardial function. As regards the reported diastolic dysfunction in our patients, it might be attributed to the ventricular relaxation impairment which is seen in the early phase of the ventricular systolic dysfunction [12]. The modest sample size and cross-sectional design of the present investigation may explain why we did not find a statistically significant relationship between cardiac dysfunction and illness duration or severity. In addition, sympathetic over activity, a possible explanation of the observed heart dysfunction in MS patients, has not been extensively studied throughout the illness course. Myocardial dysfunction may also be associated with site of demyelinating lesions on magnetic resonance imaging (MRI), rather than the severity or length of the illness. A rise in sympathetic trunk output may be caused by hypothalamic lesions or by lesions affecting the medulla's vasomotor centers [13]. Finally, because we assumed that the use of DMDs might affect our echocardiographic findings in MS patients, we compared the cardiac function between patients who received disease modifying drugs and those who did not. We couldn’t detect a statistically significant difference between both groups, but we could not compare the impact of different lines of treatment on cardiac function due to the small sample size of our patient.Unlike our results, Ferit Akgul et al. reported preserved RV systolic and diastolic performance in MS patients, as compared to the control group. Surprisingly, Strotmann et al. found preserved left ventricle function in MS patients treated with mitoxantrone, compared to those who did not receive it [14]. Similar findings were reported by Spindler M et al. who showed that all parameters of LV diastolic performance were not different between MS patients on mitoxantrone and those who did not receive the mitoxantrone [15]. Similar findings were reported by Spindler M et al. who showed that all parameters of LV diastolic performance were not different between MS patients on mitoxantrone and those who did not receive mitoxantrone [16]. Being first research of its kind to examine heart function in the Egyptian MS patients was a strength of ours. To assess heart function in multiple sclerosis patients, we used speckle tracking method. Before the traditional echocardiography or tissue Doppler imaging can identify the subclinical cardiac deformities, this method plays an essential role in their detection.

4. Limitations

First, we looked at how patients on DMDs and those who didn't fared in terms of cardiovascular function. Unfortunately, our study's limited sample size prevented us from comparing how various DMDs affected cardiac function. Secondly, we were unable to connect the cardiac dysfunction in MS patients with the parameters of dysautonomia since no clinical or neurophysiological study of autonomic function in MS patients was conducted. Lastly, we failed to evaluate the relationship between the location of MRI lesions and cardiovascular performance in multiple sclerosis patients, which might play a significant role in causing autonomic dysfunction in this disease. Finally, the research did not evaluate LA function.

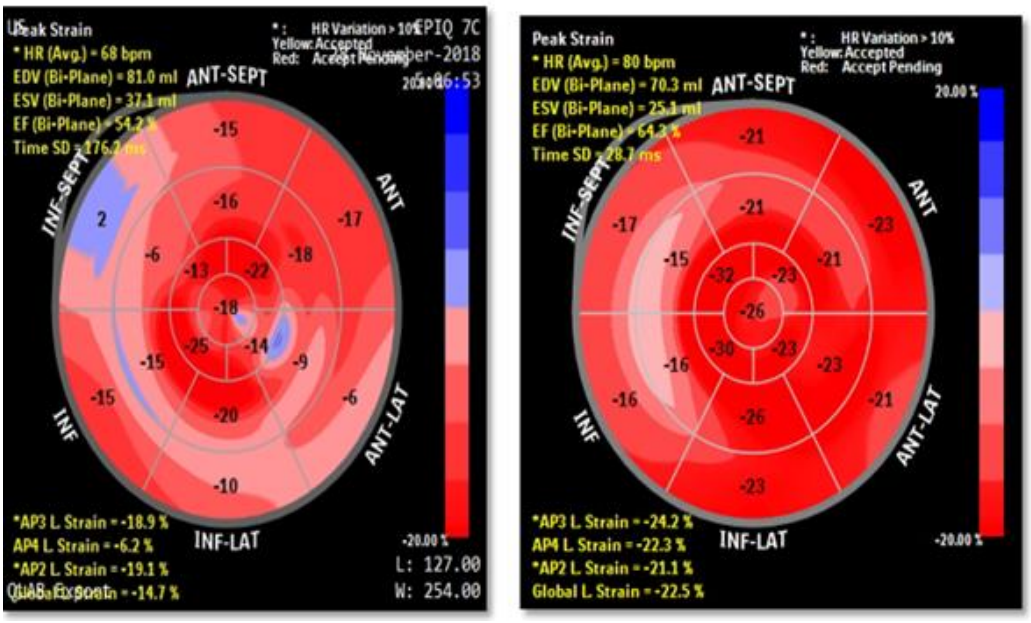

Figure (1): Eye mapping of the 17-segment model with automatic calculation of the LV GLS of a 38-year-old female patient with MS (on the left), and an age- & sex-matched control (on the right).

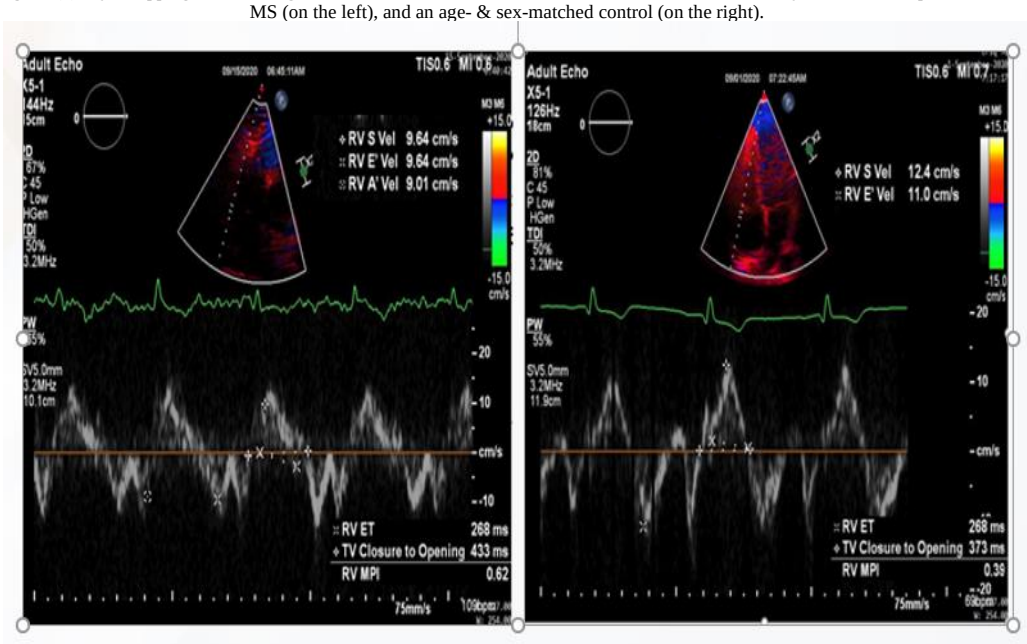

Figure (2): Right ventricular tissue Doppler imaging of a 38-year-old female patient with MS (on the left) and an age- and sex-matched control (on the right) with the patient showing lower S` & E` velocities and higher RV MPI (9.6 m/s, 9.6 m/s, 0.6, respectively).

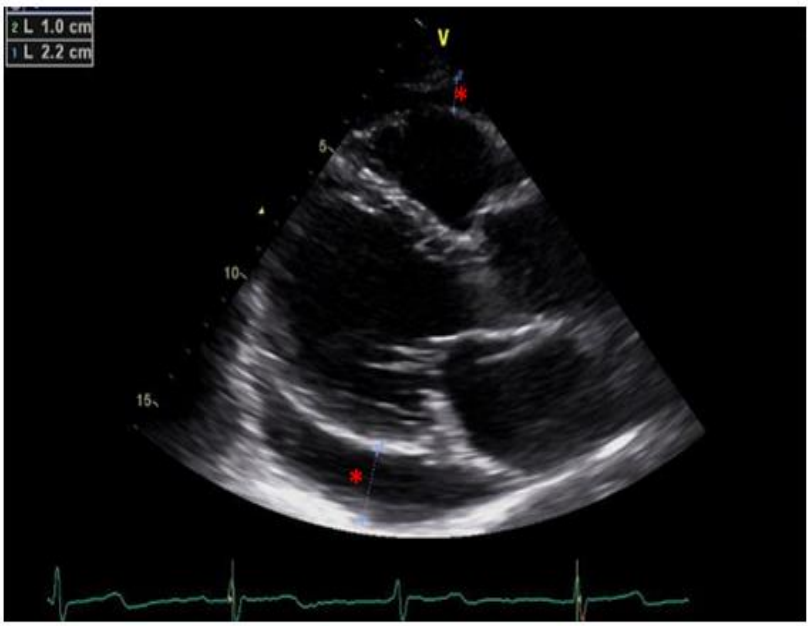

Figure (3): A case of pericardial effusion, detected in a female patient with multiple sclerosis.

Table (1): Commonalities between MS patients and healthy controls

		Patients (n=50)	Controls (n=50)	P-value
Age in years [mean (SD)]		32(8.47)	29(7.51)	0.107
Sex	Males [n(%)]	18 (36%)	16 (32%)	0.6
	Females [n(%)]	32 (64%)	34 (68%)	
BMI (kg/m2) [mean (SD)]		26.5(6.16)	26(4.17)	0.723
BSA (m2) [mean (SD)]		1.7(0.1)	1.7(0.2)	0.71
SBP (mmhg) [mean (SD)]		118(8.97)	116(6.66)	0.227
DBP (mmhg) [mean (SD)]		76(7.5)	74.22(6.5)	0.202
HR (beats/min) [mean (SD)]		84(13.26)	82.7(9.37)	0.55
Smoking	Smokers [n(%)]	8 (16%)	8 (16%)	1
	Non smokers [n(%)]	42 (84%)	42 (84%)	

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Table (2): Radiological and neurological features of multiple sclerosis patients

		Patients (n=50)
Disease duration in years [mean (SD)]		4.29(3.61)
EDSS [mean (SD)]		3.25(1.47)
Total number of relapses [mean (SD)]		3.38(3.61)
MRI lesion load [mean (SD)]		9.72(6.66)
DMDs	No DMDs [n(%)]	28 (56%)
	Interferon beta [n(%)]	18 (36%)
	Fingolimod [n(%)]	1 (2%)
	Cyclophosphamide [n(%)]	1 (2%)
	Azathioprine [n(%)]	1 (2%)
	Rituxmab [n(%)]	1(2%)

Table (3): Assessment of left ventricular dimensions and systolic performance with echocardiography in individuals with multiple sclerosis compared to control participants.

	Patients (n=50) mean (SD)	Controls (n=50) mean (SD)	P-value
LVEDD indexed (cm/m2)	2.68(0.399)	2.35(0.27)	<0.001*
LVESD indexed (cm/m2)	1.78(0.32)	1.48(0.17)	<0.001*
LVEDV indexed (ml/m2)	63.5(12.7)	48.6(8.95)	<0.001*
LVESV indexed (ml/m2)	26.8(6.38)	16.3(3.56)	<0.001*
LV mass indexed (gm/m2)	86.5(16.7)	43.5(9.26)	<0.001*
LV EF by Simpsons (%)	55.86(3.36)	66(3.54)	<0.001*
MAPSE (mm)	10.5(1.38)	19.5(2)	<0.001*
Mitral S` velocity (cm/sec)	6.9(1.23)	10.3(1.98)	<0.001*
LV MPI	0.57(0.05)	0.33(0.06)	<0.001*
LV GLS (%)	-17.67(1.4)	-22.5(1.16)	<0.001*

Table (4): Assessment of left ventricular diastolic performance with echocardiography in individuals with multiple sclerosis compared to control participants.

	Patients (n=50) mean (SD)	Controls (n=50) mean (SD)	P-value
Mitral E velocity (cm/sec)	65.9(8.57)	83.75(11.79)	<0.001*
Mitral A velocity (cm/sec)	57.3(8.78)	50.9(10.38)	0.001*
Mitral E/A ratio	1.14(0.16)	1.6(0.299)	<0.001*
Mitral DT (milisec)	189(9.53)	155.6 (23.33)	<0.001*
Peak TR velocity (m/sec)	2.5(0.2)	1.9(0.3)	0.001*
Mitral E` velocity (cm/sec)	9.6(1.48)	14.3(2.78)	<0.001*
Mitral E/E` ratio	6.8(1.22)	6(1)	<0.001*
LV IVRT (milisec)	93.9(10.96)	47.5(7.19)	<0.001*

Table (5): Right ventricular function, assessed by echocardiography, of patients with multiple sclerosis and control subjects.

	Patients (n=50) mean (SD)	Controls (n=50) mean (SD)	P-value
TAPSE (mm)	17.64(2.09)	27.8(3.28)	<0.001*
Tricuspid S` velocity (cm/sec)	10(0.97)	14.7(2.17)	<0.001*
Tricuspid E` velocity (cm/sec)	10(2)	16(3.95)	<0.001*
RV MPI	0.57(0.06)	0.32(0.06)	<0.001*
SPAP (mmHg)	32.18(3.68)	17.72(12.87)	0.001*

5. Conclusions

Compared to healthy persons, MS patients had markedly diminished biventricular systolic and diastolic performances. Except for a positive correlation between left ventricular end-systolic dimension and disease duration, EDSS and the number of relapses, and left ventricular end-diastolic dimension and the EDSS score, there was no significant correlation between cardiac affection and disease duration or disability status. When comparing the LV and RV functioning of MS patients who received disease-modifying medications to those who did not, no statistically significant change was seen.

❖ *Declarations*

Participant consent and ethical clearance: Everyone who took part in this research, or a member of their family, had to sign an informed consent form. All procedures followed the guidelines laid forth in the Declaration of Helsinki. The local ethics committee at Beni-Suef University's Faculty of Medicine gave its support to the project. Reference number FMBSUREC/05012020/Zaher is assigned to the committee.

Consent for publication: Not Applicable.

Availability of data and material: Upon a reasonable request and with the consent of the Faculty of Medicine, Beni-Suef University, Egypt, the datasets used and/or analyzed throughout the present investigation are accessible to the corresponding author.

Competing interests: Nothing biases the writers.

Funding: This study was not supported financially by the authors.

Authors' contributions: HB reviewed the whole text and was involved in the study's design. MA assisted with data collecting and analysis as well as paper drafting. In addition to assisting with article draughts, MH was involved in research design. In addition to assisting with article draughts, EE was involved in research design. Each author has reviewed and given their final approval to the text, and they have all agreed to take full responsibility for the work and see that any issues with its accuracy or integrity are thoroughly examined and handled.

Acknowledgements: Not applicable.

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