

## Role of Two Dimensional Speckle Tracking Echocardiography in Detection of Subclinical Left Ventricular Dysfunction in Patients with Systemic Lupus Erythematosus

Ahmed Roza<sup>(1)</sup>, Samy Nooh<sup>(2)</sup>, Yasser Omar<sup>(3)</sup>, Ahmed Elashkar<sup>(4)</sup> and Ahmed Abouel Azm<sup>(5)</sup>

Professor of Cardiology - Faculty of Medicine - Al-Azhar University, Egypt<sup>(1)</sup>

Assistant Professor of Cardiology - Faculty of Medicine - Al-Azhar University, Egypt<sup>(2)</sup>

Lecturer of Cardiology - Faculty of Medicine - Al-Azhar University, Egypt<sup>(3)</sup>

Lecturer of Internal Medicine - Faculty of Medicine - Al-Azhar University, Egypt<sup>(4)</sup>

M.B.B.CH- Faculty of Medicine - Cairo University, Egypt<sup>(5)</sup>

[ahmedsobhymohamedaboulazm@gmail.com](mailto:ahmedsobhymohamedaboulazm@gmail.com)

**Abstract: Introduction:** Patients with Systemic lupus erythematosus have increased prevalence of subclinical left ventricular dysfunction which may be a prognostic indicator of cardiac mortality and morbidity. Speckle tracking Echocardiography is a new echocardiographic technique that allows a precise evaluation of myocardial function. This method is accurate, reproducible, and angle independent, and it enables a complete assessment of regional and global function in three directions. **Aim of the work:** The objective of this study was to detect subclinical LV dysfunction in SLE patients without clinically evident cardiovascular (CV) disease using STE. **Material and methods:** The study was done in Echocardiography Unit, Cardiology department, at Al-Hussein and Bab EL-She ‘Riya University Hospitals – Al-Azhar University – Cairo – Egypt from October 2015 to November 2016. It included ninety patients, the patients were classified in to two groups: Group (A): 30 persons as a control subjects, Group (B1): 30 SLE patients with SLEAI less than 10, Group (B2): 30 SLE patients with SLEAI more than 10. The 2D STE assessment of LV longitudinal and circumferential strain and strain rate were done to all subjects. **Results:** In SLE group, left ventricular global longitudinal, circumferential strain and strain rate were significantly lower compared with the controls. **Conclusion:** In conclusion the relatively new STE can be used to diagnose subtle abnormalities in LV function in SLE patients which could not be detected by conventional TTE or TDI **Recommendations:** The STE technique should be combined with conventional echocardiography for follow up of ventricular function in SLE patients.

[Ahmed Roza, SamyNooh, Yasser Omar, Ahmed Elashkar and Ahmed Abouel Azm. **Role of Two Dimensional Speckle Tracking Echocardiography in Detection of Subclinical Left Ventricular Dysfunction in Patients with Systemic Lupus Erythematosus.** *Researcher* 2016;8(12):71-77]. ISSN 1553-9865 (print); ISSN 2163-8950 (online). <http://www.sciencepub.net/researcher>. 5. doi:[10.7537/marsrsj081216.05](https://doi.org/10.7537/marsrsj081216.05).

**Keywords:** systemic lupus erythematosus - ventricular function - speckle tracking echocardiography

### 1. Introduction

Systemic lupus erythematosus is a multi-organ autoimmune disease associated with high cardiovascular morbidity and mortality that primarily affects young women.<sup>1</sup>Patients with Systemic lupus erythematosus have increased prevalence of subclinical left ventricular dysfunction which may be a prognostic indicator of cardiac mortality and morbidity. In this regard the standard method for evaluating cardiac function used in clinical practice often lacks sensitivity to detect myocardial abnormalities in Systemic lupus erythematosus. <sup>2</sup>Tissue Doppler imaging is a non-invasive technique widely used to detect subtle, asymptomatic myocardial function abnormalities. Myocardial velocity indicates the rate at which particular point that the myocardium moves toward or away from the transducer. Speckle tracking echocardiography is a relatively new technique that provides accurate quantitative evaluation of regional and global LV function independent of the insonation angle and cardiac

translational movements. <sup>3</sup>The objective of this study was to detect subclinical LV dysfunction in SLE patients without clinically evident cardiovascular (CV) disease using STE.

### 2. Material and methods:

The study was done in Echocardiography Unit, Cardiology department, at Al-Hussein and Bab EL-She ‘Riya University Hospitals – Al-Azhar University – Cairo – Egypt from October 2015 to November 2016. It included ninety patients, the patients were classified in to two groups: Group (A): 30 persons as a control subjects, Group (B1): 30 SLE patients with SLEDAI less than 10, Group (B2):30 SLE patients with SLEDAI more than 10. Patients were selected according to the following criteria: In this study, we included all SLE patients on corticosteroid therapy, Exclusion criteria were Hypertensive patients (Systemic hypertension was defined as a systolic blood pressure greater than or equal to 140 mmHg and/or a diastolic pressure greater than or equal to 90

mmHg and/or the use of anti-hypertensive medication, Diabetic patients (Diabetes mellitus was defined as presence of hyperglycemia due to defective insulin secretion, defective insulin action or both according to American diabetes association diagnosis and classification of diabetes mellitus 2012), Smoker: (Smokers were defined as those with a current or recent history of smoking of burning tobacco encased in cigarettes, pipes, and cigars within the past 1 year, History of ischemic heart disease (UA, MI, PTCA, CABG.....etc.), Left ventricular ejection fraction  $\leq$  52%, Regional wall motion abnormalities, Congestive heart failure, Significant valvular heart disease, Cardiomyopathies, Congenital heart disease, Technically poor acoustic window for transthoracic echocardiography and Refusal to perform TTE examination.

Informed verbal consent, full history taking were taken from all patients included in the study. Full clinical examination, resting standard 12-leads electrocardiogram, Plain chest X-ray and laboratory tests were carried out on every patient included in the study.

#### **Echocardiography**

All patients were examined in the left lateral decubitus position, according to standard techniques with a commercially available ultrasound transducer and equipment (X5-1 adult probe, A Philips IE 33 phased array system equipped). The images were digitally stored for off-line analysis (Q LAB version 9.0).

#### **Transthoracic echocardiography and tissue Doppler imaging**

The following measurements were taken: Left atrial volume using biplane disk summation technique in apical 2 & apical 4 views. Left ventricular ejection fraction (LVEF) was obtained by the biplane Simpson's method. Trans-mitral pulsed wave Doppler velocities were recorded from the apical four-chamber (4-CH) view.<sup>4</sup> Early (E) and late (A) wave peak velocities, E/A ratio, E deceleration time (E-DT) were measured. By placing the Doppler sample volume midway between the mitral inflow and aortic outflow tract, trans-mitral and trans-aortic Doppler flows were recorded simultaneously. The ejection time (ET), isovolumic contraction time (ICT) and isovolumic relaxation time (IVRT) was measured. The myocardial systolic (S), early diastolic ( $\dot{E}$ ), and late diastolic ( $\dot{A}$ ) peak velocities were obtained at the lateral and septal corners of the mitral annulus in the 4-chamber (4-CH) view by pulsed wave tissue Doppler keeping the angle between the beam and the wall motion direction  $<15^\circ$ . The E/mean E (E/Em) ratio was subsequently calculated. TR systolic jet velocity (m/sec): Peak modal velocity during systole at leading edge of spectral waveform was obtained. All the above

measures were recorded as the average of three consecutive cycles.<sup>5</sup>

#### **Speckle tracking echocardiography (STE)**

In blinded post-processing, longitudinal and circumferential deformation had been assessed by speckle tracking, being measured the peak segmental longitudinal systolic strain (SLSS) from the apical 4-chambers, 2-chambers and long axis views and peak segmental circumferential systolic strain (SCSS) from short axis basal, mid and apical and strain rate (Sr) for the 18 segment LV model, with high frame rates ( $> 60$  frames/s) using commercial imaging analysis software (Philips IE 33 software). Advanced measures of LV diastolic function were obtained by 2D speckle tracking SR analysis. This imaging technique allows for the assessment of LV myocardial deformation by tracking natural acoustic markers (speckles) in a frame-to-frame basis within the cardiac cycle. The speckles are visible in the standard gray-scale 2D images and are equally distributed within the myocardium. Strain rate during isovolumic relaxation period ( $SR_{IVR}$ ), strain rate during early diastole ( $SRe$ ) and strain rate during late ( $SRA$ ) diastole were measured.<sup>6</sup>

#### **Statistical analysis of data:**

The collected data were revised, organized, tabulated and statistically analyzed using statistical package for social sciences (SPSS) version 22.0 for windows. Data are presented as the Mean  $\pm$  standard deviation (SD), frequency, and percentage. Categorical variables were compared using the chi-square ( $\chi^2$ ) and Fisher's exact tests (if required). Continuous variables were compared by the Student t test (two-tailed) and one - way ANOVA test for parametric data. Mann -Whitney U and Kruskal - Wallis tests for nonparametric data. Pearson and spearman correlation was used to study the correlation between the studied variables. The level of significance was accepted if the P value  $< 0.05$ .

### **3. Results**

#### **Clinical, demographic and laboratory Characteristics (table 1):**

A total of 60 female SLE patients and 30 normal subject as control group were included in the study. Patients had a significantly higher ESR ( $p < 0.0001$ ), HsCRP ( $p = 0.0001$ ), total serum cholesterol ( $p = 0.006$ ) and serum triglycerides ( $p = 0.0001$ ) compared to the control. Patients had a significantly lower hemoglobin ( $p < 0.0001$ ) compared to the control. There was no statistically significant difference between the two groups as regard WBCs ( $p$  value 0.9), platelet ( $p$  value 0.37), AST ( $p$  value 0.73), ALT ( $p$  value 0.5), Albumin ( $p$  value 0.42) and serum creatinine ( $p$  value 0.3).. In the present study, there

were no significant differences between the two groups as regards age and sex by inclusion criteria.

**Table (1): Comparison between the two groups as regard laboratory data**

	Control group (A)	Patient group (B)	P value
AGE	31.40±7.74	32.43± 8.18	0.567
BMI	27.60±4.26	26.43±2.25	0.092
Hb (gm/dl)	13.28±1.39	10.22±1.31	<0.0001
WBCs (x10 <sup>3</sup> /mm <sup>3</sup> )	7.17±1.9	7.1±3.44	0.9
Platelet (x10 <sup>3</sup> /mm <sup>3</sup> )	236.27±99.06	212.72±126.07	0.37
HsCRP(mg/dl)	.53±.22	.954±.54	0.0001
ESR (mm/h)	17.9±5.18	64.08±31.56	<.0001
AST(IU/L)	18.69±4.95	18.3±5.14	0.73
ALT (IU/L)	16.13±4.29	15.46±4.52	0.5
Albumin(g/dl)	3.88±.72	3.77±.516	0.42
Cholesterol (mg/dl)	171.27±19.39	205.12±64.16	0.006
Triglyceride(mg/dl)	104.77±20.28	158.95±68.51	0.0001
Creatinine (mg/dl)	.88±.21	.94±.28	0.3

ESR: erythrocyte sedimentation rate; Hs CRP: high sensitivity C-reactive protein; Hb: hemoglobin; WBC: white blood cells; AST: aspartate transaminase; ALT: alanine transaminase. Results are presented as means or as median (Interquartile range). P value>0.05= insignificant, P <0.05= significant, P< 0.001= highly significant.

#### Conventional echocardiography and Doppler tissue imaging (table 2).

E/A ratio was lower in SLE patients (group B) than in the control group (group A). Regarding the DTI, the septal and Lateral E' peak velocities demonstrated a stepwise decrease from group A

(control) to group B1 (SLE with SLEDAI less than 10) to group B2 (SLE with SLEDAI more than 10), while an opposite stepwise increase was shown in E/Em ratio that increased from group A (control) to group B1 (SLE with SLEDAI less than 10) to group B2 (SLE with SLEDAI more than 10).

**Table (2): Comparison between the two groups according to results of Echocardiographic.**

Variable	Control group (A)	Patient group (B)	P value
EF	68.07±3.7	66.77±3.03	.78
LA volume	25±5.36	24.6±5.3	.74
TV velocity (m/s)	23.8±1.94	23.75±2.23	.92
E(m/s)	.90±.14	.71±.10	.001
A(m/s)	.64±.14	.84±.12	.001
E/A ratio	1.42±.11	.86±.10	.001
Septal E' (m/s)	.10±.05	.10±.02	.423
Septal A' (m/s)	.27±.37	.08±.02	.001
Lateral E' (m/s)	.13±.02	.11±.02	.001
Lateral A' (m/s)	.09±.01	.08±.02	.024
Em(m/s)	.12±.03	.11±.02	.018
E/Em	6.89±.99	7.89±2.19	.004

A: late diastolic filling; Am: mitral annulus late diastolic velocity; E: early diastolic filling; EF%: ejection fraction; Em: mitral annulus early diastolic velocity; LA: left atrium; TV: tricuspid valve P value>0.05= insignificant, P <0.05= significant, P< 0.001= highly significant.

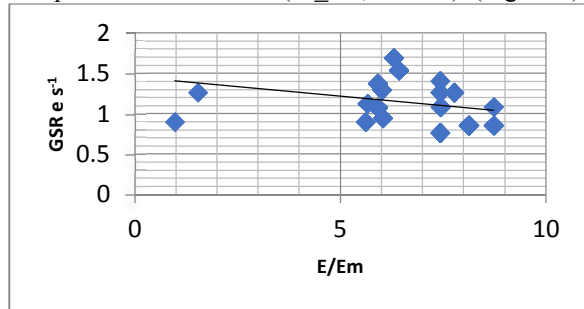
#### 2D-speckle tracking imaging

Comparing the three groups as regards longitudinal Figure (2) and circumferential peak systolic strain Figure (3) demonstrated a significant stepwise decrease of the global LV strain from group A (control) to group B1 (SLE with SLEDAI less than 10) to group B2 (SLE with SLEDAI more than 10). Furthermore, the global peak systolic strain rate (SRs

s<sup>-1</sup>) was significantly decreased in group B2 (SLE with SLEDAI more than 10) when compared to group A (control) and group B1 (SLE with SLEDAI less than 10).

The global early diastolic strain rate (SRE s<sup>-1</sup>) showed a significant stepwise reduction from group A (control) to group B1 (SLE with SLEDAI less than 10) to group B2 (SLE with SLEDAI more than 10).

On the other hand, the global late diastolic strain rate  $\text{SRa s}^{-1}$  was significantly increased in both group B1 (SLE with SLEDAI less than 10) and group B2 (SLE with SLEDAI more than 10) when compared to group A (control). Among the SLE patients, a significant negative correlation was evident between E/Em ratio and parameter of  $\text{SRe s}^{-1}$  ( $r = -0.2, P = 0.04$ ). (Figure 1)



**Figure (1): Relationship of E/Em ratio in SLE patients to global peak early diastolic strain rate  $\text{GSRe s}^{-1}$**

#### 4. Discussion

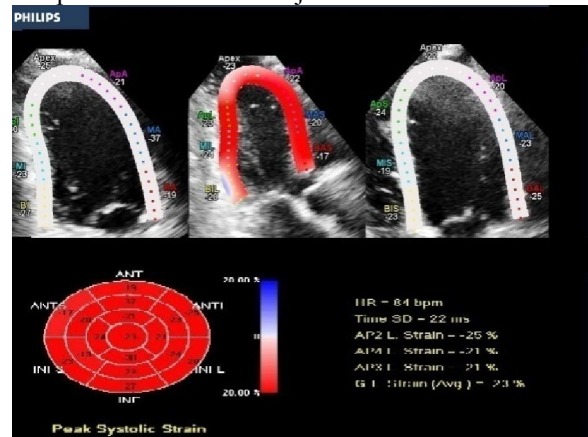
##### Assessment of LV Systolic Function:

Tissue Doppler echocardiography (TDI) is sensitive technique for the quantitative assessment of subclinical myocardial dysfunction.<sup>7</sup> However, local myocardial velocities obtained by TDI have the disadvantage of being influenced by heart movement and tethering to adjacent segments, which makes speckle tracking (STE) more suitable for diagnosing impaired segmental longitudinal mechanics.<sup>8</sup> STE is a new echocardiographic technique that allows a precise evaluation of myocardial function. This method is accurate, reproducible, and angle independent, and it enables a complete assessment of regional and global function in three directions.<sup>9</sup> Subclinical impairment of the LV has been demonstrated by STE in the setting of many disorders including hypertension, diabetes mellitus, atrial fibrillation and heart failure with preserved ejection fraction.<sup>10</sup> Most previous SLE studies were based on TDI and demonstrated normal LV systolic function; they assessed longitudinal strain at a limited region of left ventricle like four or two Segments.<sup>11</sup>

The study found that the peak global systolic longitudinal (GSLs) and circumferential (GSCS) strain and peak global systolic strain rate (GSRs  $\text{s}^{-1}$ ) of the LV using 2D speckle tracking is significantly lower in SLE group than control group and lower in patients with active SLE than patient with non-active SLE (p value) which may denote subclinical impairment of left ventricular systolic function.

This finding is concordant with the result of<sup>12</sup> that evaluated subclinical left ventricular dysfunction in asymptomatic SLE patients assessed by TDI echocardiography, in their study 67 asymptotically

patients with normal LVEF and 45 age-matched healthy volunteers, They found LV strain and strain rates were significantly lower in SLE patients compared with control subjects.



**Figure (2): 2D STE for calculation of LV Peak Segmental longitudinal strain at apical 2, 3 and 4 chamber view.**

Also, the results of this study reach agreement with the result of<sup>13</sup> which evaluated 50 SLE patients compared with 25 healthy subjects recruited as a control group. GSLs, GSCS, GSRs  $\text{s}^{-1}$  were significantly lower in the SLE vs. control group. And concordant with the result of<sup>14</sup> that evaluated Left ventricular systolic function in SLE adults assessed by 3D speckle tracking echocardiography, in their study 50 patients with SLE and 50 control subjects in the same range of age were prospectively evaluated. In SLE group, left ventricular global longitudinal strain (LVGLS), left ventricular global circumferential strain (LVGCS), left ventricular radial strain (LVRS-basal) were significantly lower compared with the controls. Further, in this study we found that elevated SLEDAI score, resulted in significantly lower values for LV longitudinal function strain and strain rate.<sup>14</sup>

##### Assessment of LV Diastolic Function:

Recent studies evaluating LV diastolic function used the ratio of early mitral diastolic velocity to early diastolic velocity (E/Em ratio).<sup>5</sup>

In patients with normal LV EF, Diastolic Dysfunction is defined as  $>50\%$  positive of the following parameter (Average E/Em  $> 14$ , Septal E' velocity  $< 7$  cm/s or Lateral E' velocity  $< 10$  cm/s, TR velocity  $> 2.8$  m/s and LA volume index  $> 34$  ml/m<sup>2</sup>).<sup>5</sup> Although it is a clinically useful method to assess LV diastolic function, the measurement of Em has a number of limitations which can affect its accuracy.

Firstly, this approach is an approximation of LV global function, assuming that a single or multiple site(s) represent global LV relaxation. However, it is known that even in patients without segmental dysfunction, LV regional differences exist and

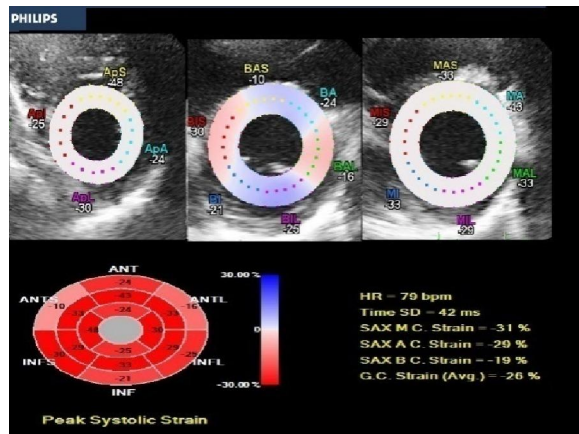


significant LV diastolic dyssynchrony has been described to be often present.<sup>5</sup>

Another important limitation of this approach is the potential effect of LA pressure. Since Em occurs during the early phase of LV filling, not only LV relaxation, but also LA pressure has an important impact on its value (Nagueh et al., 2016). Conversely, global LV diastolic strain rate might overcome all the above mentioned limitations. This measurement reflects in fact the performance of all LV segments, it is load independent and accounts for the initial LV size.<sup>15</sup>

The study found that the peak global early (SRe s-1) and late (SRa s-1) diastolic strain rate of the LV using 2D speckle tracking is significantly lower in SLE group than control group and the peak global early (SRe s-1) was lower in patients with active SLE than patient with non-active SLE (p value) which may denote subclinical impairment of left ventricular diastolic function.

This finding is concordant with the result of<sup>12</sup> that evaluated subclinical left ventricular dysfunction in asymptomatic SLE patients assessed by TDI echocardiography, in their study 67 asymptomatic SLE patients with normal LVEF and 45 age-matched healthy volunteers, They found LV global early (SRe s-1) and late (SRa s-1) diastolic strain rate were significantly lower in SLE patients compared with control subjects the peak global early (SRe s-1) was lower in patients with active SLE than patient with non-active SLE. Also, the results of this study reach agreement with the result of<sup>13</sup> which evaluated 50 SLE patients compared with 25 healthy subjects recruited as a control group. They found LV global early (SRe s-1) diastolic strain rate was significantly lower in the SLE vs. control group but no statistically difference between two group regard late (SRa s-1) diastolic strain rate.



**Figure (3): 2D STE for calculation of LV Peak segmental circumferential strain basal, mid and apical SAX view**

This study was discordant to the result of<sup>6</sup> that evaluated Left ventricular systolic and diastolic function in SLE adults. They found that there is no relationship between the LV diastolic dysfunction and SLEDAI and this could be explained by the racial difference and small number of patients included in our study.

In our Study, there was a negative correlation between reduction of LV global early (SRe s-1) diastolic strain rate using 2 D speckle tracking Echocardiography and E/Em in patients group.

This goes in harmony with<sup>17</sup> who stated that Em value is load independent and E/Em ratio can be used to estimate LV filling pressure as E/Em ratio >15 is highly specific for elevated LV end diastolic pressure. This was further confirmed by<sup>18</sup> who demonstrated the ability of DTI derived parameters for evaluation Of LV filling pressure and early detection of diastolic dysfunction in patients with normal systolic function in contrast to conventional mitral inflow velocities alone which correlate poorly with LV filling pressure in such patients.

In the present study, these LV subclinical abnormalities cannot be explained by increased prevalence of traditional CV risk factors such as smoking, HTN or DM because patients having them were excluded. The patients had however significantly higher cholesterol and triglyceride levels compared to controls. This may be the result of prednisolone which was prescribed to all patients. It is generally perceived that glucocorticoids have adverse effect on the lipid profile causing increase in both total cholesterol and triglycerides.<sup>19</sup>

This high level of cholesterol and triglycerides may have induced subclinical coronary atherosclerosis in our patients. A high prevalence of myocardial perfusion abnormalities were detected in asymptomatic SLE patients without overt CV disease using single photon emission computed tomography.<sup>20</sup> In a study by<sup>21</sup> subclinical atherosclerosis has been shown to be more prevalent in SLE patients. Patients with carotid abnormalities were significantly older, had higher blood pressure and total serum cholesterol levels, and had taken a higher prednisone cumulative dosage than those without any lesions. By multivariate analysis, the cumulative prednisone dose remained associated with plaque formation after adjusting it for the classical Framingham atherosclerosis risk predictors. A significant association between carotid plaque formation in SLE patients and cumulative corticosteroid dosage as well as duration of treatment has been also reported by<sup>1</sup> In another study on Egyptian SLE patients, an increased prevalence of subclinical LV dysfunction was reported. SLE patients with positive tissue Doppler findings were of old age, had long disease duration, high disease activity and

nephritis.<sup>22</sup>In a study of diabetic patients, those with coronary atherosclerosis as evidenced by increased calcium score in multi-slice computerized tomography scanner showed an impaired LV GLS, even though the LVEF was still preserved compared to those with no evidence of coronary atherosclerosis.<sup>23</sup>

Hence, premature subclinical atherosclerosis may be the underlying cause of these subtle changes in LV function.

This finding highlights the advantages of 2D-STE over DTI in the detection of early impairment of LV systolic function. Furthermore, the present study showed a significantly reduced value of diastolic strain rate in Patients groups compared to the control group. Hence, it was concluded that speckle tracking imaging may be helpful for early detection of subclinical changes in LV diastolic function in SLE patients.

#### Study Limitation

The accuracy of STE largely depends on image quality; however, many patients were excluded from our study because of inadequate image quality. Speckle-tracking Echocardiography is dependent on frame rate, as well as image resolution. Low frame rates result in the speckle pattern changing too much from frame to frame, which prevents the precise characterization of regional myocardial motion and impacts the overall temporal resolution of the regional strain map. In contrast, increasing the frame rate reduces scan-line density, which reduces image resolution. Radial strain was not performed in the present study as this modality not available, our results were based on the 2D echocardiographic technique which is inferior to 3D echocardiography or magnetic resonance imaging and At last, our study included subjects with different onset and of SLE, the small number of the study participants may have influenced our results.

#### Conclusion

In conclusion the relatively new STE can be used to diagnose subtle abnormalities in LV function in SLE patients which could not be detected by conventional TTE or TDI.

#### Recommendation

Regular monitoring of cardiac function by speckle tracking echocardiography is recommended for SLE patients with high disease activity and regular assessment of disease damage index and its relation to our result.

#### References:

1. Manzi S, Selzer F, Sutton-Tyrrell K, et al. Prevalence and risk factors of carotid plaque in women with systemic lupus erythematosus. *Arthritis Rheum* 1999; 42:51.
2. Doria A, Iaccarino L, Sarzi-Puttini P, et al. Cardiac involvement in systemic lupus erythematosus. *Lupus* 2005;14(9):683–6.
3. Geyer H, Caracciolo G, Abe H, et al. Assessment of myocardial mechanics using speckle tracking echocardiography: fundamentals and clinical applications. *J Am Soc Echocardiogr* 2010;23:351–69.
4. Lang RM, Bierig M, Devereux RB, et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. *J Am Soc Echocardiogr* 2015;18(12):1440–1446.
5. Nagueh SF, Smiseth OA, Appleton CB, et al. Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging 2016;29:277-314.
6. Anwar AM. Global and segmental myocardial deformation by 2D speckle tracking compared to visual assessment. *World Journal of Cardiology* 2012. Dec. 2012; 4(12):341.
7. Filali T, Gzara M, Ajili F, Lahidheb D, et al. Left ventricular dysfunction in asymptomatic patients with systemic lupus erythematosus. *Arch Cardiovasc Dis* 2011;104(4):276–80.
8. Urheim S, Edvardsen T, Torp H, et al. Myocardial strain by Doppler echocardiography. Validation of a new method to quantify regional myocardial function. *Circulation*. 2000; 102:1158–1164.
9. Geyer H, Caracciolo G, Abe H et al. Assessment of myocardial mechanics using speckle tracking echocardiography: fundamentals and clinical applications. *J Am Soc Echocardiogr* 2010;23:351–69.
10. Tan YT, Wenzelburger F, Lee E, et al. The pathophysiology of heart failure with normal ejection fraction: exercise echocardiography reveals complex abnormalities of both systolic and diastolic ventricular function involving torsion, untwist, and longitudinal motion. *J. Am. Coll. Cardiol.* 2009; 54:36–46.
11. Nashwa T. A, Hanan E.A., Nehal H, et al: Evaluation of left ventricular myocardial function in Egyptian patients with systemic lupus erythematosus: Tissue Doppler study and its relation to disease activity, *The Egyptian Rheumatologist* (2013) 35, 217–223.
12. Buss SJ, Wolf D, Korosoglou G, Max R, et al.

- Myocardial left ventricular dysfunction in patients with systemic lupus erythematosus: new insights from tissue Doppler and strain imaging. *J Rheumatol* 2010;37:79–86.
13. Sameh W.G., Mohamed, Alshaimaa R. et al. Assessment of left ventricular function in systemic lupus erythematosus patients by speckle tracking echocardiography: Relation to circulating endothelial progenitor cells, *The Egyptian Rheumatologist* (2015) 37, S33–S41.
  14. Huang H, Yao HM. Left ventricular remodeling and dysfunction in systemic lupus erythematosus: a three dimensional speckle tracking study. *Echocardiography* 2014;31:1085–94.
  15. Wang J, Khoury DS, Yue Y, et al. Preserved left ventricular twist and circumferential deformation, but depressed longitudinal and radial deformation in patients with diastolic heart failure. *European Heart Journal* 2008; 29:1283–1289.
  16. Wislowska M, Deren' D, Kochman' ski M et al. Systolic and diastolic heart function in SLE patients. *Rheumatol Int* 2009;29:1469–76.
  17. Mak GS, DeMaria A, Clopton P et al. Utility of Bnatriuretic peptide in evaluation of left ventricular diastolic function: comparison with tissue Doppler imaging recordings. *Am Heart J* 2004;148(5):895–902.
  18. Elnoamany MF, Abdelhameed AK. Mitral annular motion as a surrogate for left ventricular function: correlation with brain natriuretic peptide levels. *Eur J Echocardiogr* 2006;7:187–98.
  19. Ettinger WH, Klinefelter HF, Kwiterovitch PO. Effect of shortterm, low-dose corticosteroids on plasma lipoprotein lipids. *Atherosclerosis* 1987;63:167–72.
  20. Bruce IN, Burns RJ, Gladman DD, et al. Single photon emission computed tomography dual isotope myocardial perfusion imaging in women with systemic lupus erythematosus. I. Prevalence and distribution of abnormalities. *J Rheumatol* 2000;27:2372–7.
  21. Doria A, Shoenfeld Y, Wu R et al. Risk factors for subclinical atherosclerosis in a prospective cohort of patients with systemic lupus erythematosus. *Ann Rheum Dis*, 2003; 62(11): 1071-1077.
  22. Allam NT, Darweesh HEA, Hamadnallah N, et al. Evaluation of left ventricular myocardial function in Egyptian patients with systemic lupus erythematosus: tissue Doppler study and its relation to disease activity. *Egypt Rheumatology* 2013;35(4):217–23.
  23. Scholte AJ, Nucifora G, Delgado V, et al. Subclinical left ventricular dysfunction and coronary atherosclerosis in asymptomatic patients with type 2 diabetes. *Eur J Echocardiogr* 2011;12:148–55.

12/25/2016