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Assessment of Right Ventricular Systolic Function in Systemic Lupus Erythematous Patients using Tissue Doppler Echocardiography

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Abstract
Background: The autoimmune illness systemic lupus erythematosus (SLE) may damage numerous organ systems, involving the cardiovascular system. **This study aimed to** assess the right ventricular systolic function in SLE patients by tissue Doppler echocardiography (TDE). **Methods:** This prospective single-center study was done on 100 SLE individuals at Banha University Hospital. Patients had a comprehensive medical history, physical examination, laboratory tests, and tissue Doppler imaging echocardiography. Pulmonary arterial hypertension (PAH) was diagnosed regarding tricuspid regurgitation velocity gradient. Various echocardiographic parameters were measured, including right ventricular (RV) end-diastolic diameter, RV anterior wall thickness, peak systolic velocity of tricuspid annulus (S wave), TAPSE, longitudinal strain and strain rate curves and also RV fractional area change (RVFAC). **Results**: The study revealed a substantial difference in Pulmonary artery systolic pressure (PASP) values among three groups based on PASP (PASP ≤ 30 mmHg for group A; PASP 30-50 mmHg for group B; PASP ≥ 50 mmHg for group C). There were statistically significant differences in various echocardiography measurements, such as TAPSE, RVFAC, RV anterior wall thickness, RV end-diastolic diameter and more between the three groups. Triglyceride levels showed a substantial change among groups, being lowest in group B. **Conclusion:** TDE is a helpful technique for examining RV systolic function in SLE patients.

Keywords: Tissue Doppler Echocardiography; Systemic Lupus Erythematosus; Right Ventricular; Systolic Function.

Introduction

Multiple organs and systems are affected by SLE, including the lungs, muscles, skin, joints, and heart, especially RV. Furthermore, RV performance is a critical prognostic factor for SLE patients (1).

RV function is a significant prognostic factor in a variety of cardiovascular diseases (2).

Pulmonary hypertension (PH) is a prevalent, severe, and deadly consequence of SLE, with an incidence ranging from 0.5% to 43.5%. A 3-year survival rate of 44.9 percent is an independent prognostic element for SLE (3).

SLE in conjunction with PH may result in malfunction, and its mortality is tightly tied to RV performance (4).

RV design consists of deep longitudinal layers and superficial oblique, although the predominant contribution to stroke volume during systole is the longitudinal myofibers deformation (5).

Due to its thin wall and complicated architecture, the right ventricle is difficult to evaluate: triangular from the lateral view and crescent-shaped from the sectional view. The RV is a complicated, crescent-shaped architecture, and classic echocardiographic approaches based on geometric model assumptions are frequently incorrect when estimating systolic functions (6).

While radionuclide angiography and cardiac magnetic resonance are regarded gold standards for measuring RV systolic performance, echocardiography is still commonly employed due to its ease of use, cheap cost, and non-invasive nature (4).

According to the literature, two-dimensional speckle tracking echocardiography (2D-SET) derived strain and strain rate imaging are considered innovative techniques with minimal dependence on the angle of imaging and reduced intra/inter-observer variability. These approaches have shown promising potential in consistently and qualitatively diagnosing mild right ventricular (RV) impairment (7).

This study aimed to assess RV systolic performance in systemic lupus erythematous patient using TDE.

Patients and methods

This prospective single-center study was performed at Banha University Hospital over a period of one year for March 2020 to February 2021 on 100 SLE patients, based on the following criteria: malar rash, renal impairment, oral ulcers, serositis, leukopenia, thrombocytopenia, positive ANA, and immunological disorder.

The patients gave their written informed permission. Every patient got an explanation of the

study's objective and was assigned a code number. The research was conducted following receiving approval from the Research Ethics Committee of Benha University's Faculty of Medicine.

Exclusion criteria were congenital heart disease, heart failure, history of myocarditis, moderate to severe pericardial effusion and pulmonary obstructive disease.

All patients underwent the following assessments:

A) Detailed medical history, involving age and risk factors such as smoking, alcohol consumption, drug allergies, pulmonary hypertension (PHTN), diabetes mellitus (DM), and hypertension (HTN).

B) Full physical examination, including pulse and blood pressure measurement, chest and abdominal examination, and cardiac examination involving inspection, palpation, and auscultation.

C) Laboratory investigations, including complete blood count (CBC), liver function tests (ALT, AST, direct and indirect bilirubin), kidney function tests (urea, creatinine, sodium, and potassium levels), random blood sugar (RBS), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and ANA antibodies.

D) Echocardiography:

In this study, the right ventricular end-diastolic diameter (RVED) and anterior wall thickness (RVAW) were measured in the middle third of the RV inflow and beneath the tricuspid annulus, respectively. Tricuspid annulus plane systolic excursion (TAPSE) and peak systolic velocity (S wave) of the tricuspid annulus were assessed using M-mode and pulse-wave tissue Doppler imaging (TDI), providing insights into RV systolic function. RV fractional area change (RVFAC) was calculated from echocardiographic images obtained in the RV-focused apical four-chamber view, playing a crucial role in evaluating RV systolic function (8).

Furthermore, pulmonary arterial hypertension (PAH) was diagnosed by measuring the velocity gradient of tricuspid regurgitation, and right atrial pressure (RA pressure) was estimated based on the inferior vena cava (IVC) diameter and collapsibility. Longitudinal strain and strain rate curves were generated for six distinct segments of the RV and LV, expressing myocardial deformation during systole. Additionally, pulmonary artery systolic pressure (PASP) was determined, and LV dimensions were evaluated according to European Society of Echocardiography guidelines, including peak systolic S-wave, early (e) and late (a) diastolic velocities, and the E/A ratio, providing insights into diastolic function for both ventricles.

Approval code:

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Armonk, NY, USA). Quantitative data were reported as mean ± standard deviation (SD), and qualitative data were presented as frequency and percentage. Various tests were employed for different comparisons: the independent-samples t-test for comparing two means, Mann Whitney U test for non-normally distributed data, Chi-square (X2) test for proportions among qualitative variables, and Fisher Exact test for 2 by 2 tables with small samples. Wilcoxon Signed-Ranks Test was utilized for paired means of non-normally distributed continuous data, and logistic regression was used for predicting dependent variables with a binary outcome. Receiver operating characteristic (ROC) curve analysis was employed to find the best cut-off values, and the Area under the Curve (AUC) was computed to evaluate prediction performance. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were all calculated. P-values below 0.05 were considered significant, p-values below 0.001 were regarded as highly significant, and p-values above 0.05 were considered insignificant. The optimal cut-off point was identified at the maximum accuracy point on the ROC curve.

Results

This table shows that mean ± SD of age is 28.59 ±8.24years old, 97% was female, 3% was male, mean ± SD of BMI is 26.43 ±4.28 and as regard PASP group A is 30%, group B 33% and group C 37%. Mean ± SD of HR is 86.14 ± 8.62, SBP is 120.9± 9.63and DBP was 78.0 ± 9.44. PASP group A is 30%, group B 33% and group C 37%. **Table 1**

Tabe (1) Distribution of the studied group

Value among all subjects (n=100)	
Age Mean ± SD (range)	28.59 ±8.24 (15-42)
Sex	
Male	3 (3.0)
Female	97 (97.0)
BMI, Mean ± SD (range)	26.43 ±4.28 (19.9-33.4)
HR	86.14 ± 8.62
SBP	120.9 ± 9.63

DBP		78.0 ± 9.44
	Group A	30%
PASP	**Group B**	33%
	Group C	37%

No substantially considerable changes were present among the 3 groups regarding neither age, sex nor BMI. **Table 2**

Table (2) Comparison between the studied groups according to personal data

Group A (PASP≤30) (n=30)			Group B (PASP 30-50) (n=33)		Group C (PASP ≥50)(n=37)		Statistical test	P value
	Mean	**±SD**	**Mean**	**±SD**	**Mean**	**±SD**		
Age	28.33	9.09	30.48	8.56	27.11	7.02	1.5	0.23
Sex (%)							FET=	1.0
Male Female	1(3.3) 29(96.7)		1(3.0) 32(97.0)		1(2.7) 36(97.3)		0.47	
BMI	26.5	4.5	26.41	4.22	26.4	4.28	0.006	0.99

The results of the comparison between the studied groups based on PASP values are highly significant and noteworthy. Group A, with PASP values less than or equal to 30, had a mean PASP of 24.2 ± 3.23 mmHg. Group B, with PASP values ranging from 30 to 50, had a higher mean PASP of 39.94 ± 5.72 mmHg. Finally, Group C, with PASP values greater than or equal to 50, exhibited the highest mean PASP of 64.49 ± 8.22 mmHg. The statistical analysis showed a substantial change in PASP values among groups of the study (p<0.001**). **Table 3**

Table (3) Comparison between the studied groups according to PASP value

	Group A (PASP≤30) (n=30)		Group B (PASP 30-50)(n=33)		Group C (PASP ≥50)(n=37)		Statistical test	P value
	Mean	±SD	Mean	±SD	Mean	±SD		
PASP	24.2	3.23	39.94	5.72	64.49	8.22	357.02	<0.001**

No statistically substantial changes were observed between study groups as regard laboratory data except for Triglyceride there is statisticaldifference between groups where it was lowest level in group B. **Figure 1** A substantially critical change was seen among study groups concerning each of TAPSE, RV FAC, RVAWT, RVEDD, RVPWT, and RVESD, while there was no statistical difference between groups regarding ejection fraction. **Table 4**

Table (4) Comparison between the studied groups according to echo and histochemicalfindings

Group A (PASP≤30) (n=30)			**Group B (PASP 30-50) (n=33)**		**Group C (PASP ≥50) (n=37)**		**Statistical test**	**P value**
	Mean	±SD	Mean	±SD	Mean	±SD		
TAPSE (cm)	2.3	0.23	2.18	0.2	1.69	0.24	5.18	0.007**
RV FAC %	52.4	4.23	48.27	4.25	40.93	5.17	11.94	<0.001**
RVAWT (mm)	7.04	1.18	8.26	1.72	8.39	1.80	6.81	0.002**
RVEDD (mm)	50.92	6.06	50.73	6.14	47.11	6.35	4.2	0.018*
RVPWT (mm)	7.27	1.4	7.87	1.43	8.36	1.35	5.06	0.008**
RVESD (mm)	30.85	5.05	33.63	5.82	34.53	6.28	3.53	0.033*
EF%	63.09	6.63	63.55	6.83	66.3	6.44	2.38	0.098

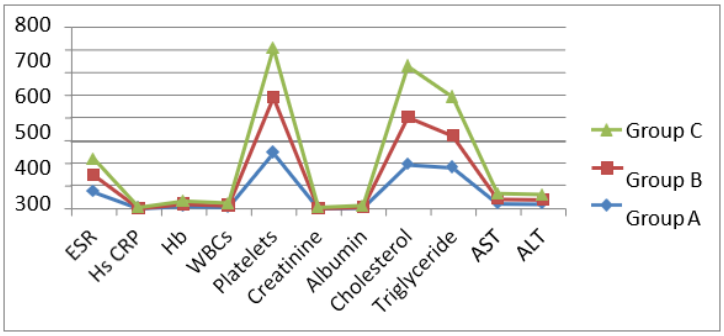

Fig. (1) Bar chart showing distribution of groups as regard laboratory data

There was no significant difference between thethree groups regarding echocardiography findings. **Table 5**

Table (5) Comparison between the studied groups according to echocardiography

	Group A (PASP≤30) (n=30)		Group B (PASP 30-50) (n=33)		Group C (PASP ≥50) (n=37)		Statistical test	P value
	Mean	±SD	Mean	±SD	Mean	±SD		
AO(mm)	24.97	2.51	25.19	2.89	25.38	3.16	0.17	0.85
E wave (cm/s)	90.17	21.73	92.61	18.82	89.35	21.56	0.23	0.80
A wave (cm/s)	76.43	16.44	80.55	15.78	84.19	18.48	1.72	0.18
IVRT (ms)	71.97	12.16	74.93	12.55	79.09	14.81	2.43	0.094
MPI	0.62	0.13	0.62	0.13	0.64	0.11	0.23	0.79
Med E (cm/s)	8.4	2.89	8.8	2.79	9.15	2.82	0.59	0.56
Med A (cm/s)	5.53	1.91	6.62	2.48	6.45	2.64	1.89	0.16
Med S (cm/s)	7.93	1.63	7.26	1.74	7.48	1.41	1.46	0.24
Lat E (cm/s)	8.88	3.83	9.98	4.0	8.48	4.21	1.27	0.29
Lat A (cm/s)	6.97	4.21	7.58	3.13	6.73	3.09	0.54	0.58
Lat S (cm/s)	8.02	1.68	8.54	1.6	8.16	1.56	0.91	0.41
Lat E/E	11.27	4.56	11.49	4.66	10.48	4.53	0.47	0.63

Between groups A and B, no significant changes were observed in all the parameters. However, in groups C, the values for ε (longitudinal strain), SRs (systolic strain rate), SRe (early diastolic strain rate), and SRa (late diastolic strain rate) for each segment were markedly reduced when compared to groups A and B. **Table 6**

Table (6) Comparison between the studied groups according to parameters of strain rateand strain of the SLE patients

strain	Group A (PASP≤30) (n=30)	Group B (PASP 30-50) (n=33)	Group C (PASP ≥50) (n=37)
ε, %			
Basal	-34.41 ± 6.1	-31.92 ± 8.6	-26.8 ± 8.9$^{\uparrow *}$
Middle	-30.9267 ± 7.1	-29. 9 ± 7.30	-21.92 ± 7.9$^{\uparrow *}$
Apical	-25.45 ± 6.99	-27.51 ± 2.47	-19.64 ± 8.65$^{\uparrow *}$
SRs , s^{-1}			
Basal	-2.31 ± 0.36	-2.41 ± 0.41	-1.81 ± 0.38$^{\uparrow *}$
Middle	-1.77 ± 0.31	-1.69 ± 0.51	-1.58 ± 0.42$^{\uparrow *}$
Apical	-1.52 ± 0.51	-1.51 ± 0.53	-1.33 ± 0.43$^{\uparrow *}$
SRe , s^{-1}			
Basal	2.46 ± 0.78	2.41 ± 0.67	1.91 ± 0.51$^{\uparrow *}$
Middle	2.02 ± 0.53	2.07 ± 0.46	1.75 ± 0.56$^{\uparrow *}$
Apical	1.82 ± 0.63	1.81 ± 0.62	1.32 ± 0.62$^{\uparrow *}$
SRa, s^{-1}			

Basal	1.64 ± 0.61	1.61 ± 0.65	$1.42 \pm 0.58^{\uparrow *}$
Middle	1.54 ± 0.69	1.57 ± 0.63	$1.26 \pm 0.40^{\uparrow *}$
Apical	1.89 ± 0.51	1.84 ± 0.65	$1.61 \pm 0.54^{\uparrow *}$

SRs: systolic strain rate; SRe: early diastolic strain rate; SRa: late diastolic strain rate, $^{\$}p$ <0.05 vs. group A, $^{*}p < 0.05$ vs. group B, $^{\#}p < 0.05$ vs. group C.

Discussion

In our study, we aimed to assess RV performance in SLE individuals by conventional, 2D-SET, and TDE. The study involved 100 SLE patients, categorized into three groups based on their PASP levels: Group A with PASP less than 30 mmHg, Group B with PASP between 30-50 mmHg, and Group C with PASP greater than 50 mmHg.

The results showed that the mean age ± SD was 28.59 ± 8.24 years old, with 97% being female and 3% male. The mean BMI ± SD was 26.43 ± 4.28. As for the PASP groups, 30% were in Group A, 33% in Group B, and 37% in Group C. The mean ± SD heart rate was 86.14 ± 8.62, SBP was 120.9 ± 9.63, and DBP was 78.0 ± 9.44. No substantially critical changes were seen among study groups concerning age, sex, or BMI.

In a study, it was observed that the majority of SLE patients, both with and without PAH, were women. Additionally, there was no significant difference in age, gender, or disease duration between the two groups. (9).

In a previous study, right heart catheterization was done on 133 SLE patients. They reported specific findings related to PAH (10).

Our study indicated that a highly substantial change was seen in PASP among study groups. However, no substantial changes were seen among study groups concerning laboratory data, except for triglyceride levels, which were lowest in Group B.

Furthermore, the results showed significant differences between the three groups in several parameters related to right ventricular function, including TAPSE, RV FAC, RVAWT, RVEDD, RVPWT, and RVESD. However, there was no significant difference in RV ejection fraction or TDE findings between the groups.

In contrast to our findings, a study observed increased RV diastolic diameter in SLE patients compared to controls (11).

A study reported higher mean PASP in the SLE group compared to the control group, along with lower RVEF in the SLE group (12).

A study found differences in various parameters of RV function between different groups of SLE patients (4).

A study noted that SLE patients had moderate to severe enlargement of the right atrium and right ventricle, along with reduced RV function. The study also demonstrated that changes in systolic RV strain over time were predictive of survival and disease severity (13).

Another study reported reduced RV PLSS in SLE patients compared to controls, while RV PLSSR did not show significant differences between the groups (11).

A study did not find a significant correlation between SLE activity index, disease duration, and RV GLS (14).

A study found that RV function parameters, such as global/regional RV strain and TAPSE, were significantly decreased in SLE patients with PAH compared to those without PAH (15).

Conclusion

From our findings we can conclude that TDE imaging and SR imaging might reveal RV dysfunction in SLE patients with PH, particularly those with moderate PH, at an early stage. This is useful for directing early treatment in clinical settings, improving the prognosis, and enhancing life quality of SLE patients with PH.

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Author contribution

Authors contributed equally in the study**.**

Conflicts of interest

No conflicts of interest

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