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Subclinical pleuro-pulmonary disease in patients with SLE: functional and radiological methods

Hanaa S. Hamed[1*], Mohammed M. N. Abozaid[1] and Enas Mekawy[2]

Abstract

Background Systemic lupus erythematosus (SLE) is a multisystem autoimmune disease with highest prevalence of chest involvement; however, early detection of subclinical pleuropulmonary diseases may improve the quality of life and prognosis of patients. This study aimed to identify the subclinical pleuro-pulmonary involvement in SLE patients without respiratory symptoms.

Methods A total of 228 patients diagnosed with SLE were recruited and subjected to high-resolution computed tomography (HRCT) chest, ultrasound (US) chest, and spirometry for further evaluation and finding of sub-clinical signs.

Results Around 52.63% of patients had pulmonary involvement in HRCT, while in US, it was 73.68%. Ground glass opacity was observed in 31.58% of HRCT cases, and > 1/3 of patients had pleural thickness in US. Spirometry showed that 26.32% of patients had small airway disease. SLE patients with subclinical lung involvement were significantly female and younger and had shorter disease duration, $p < 0.05$ for all. SLE severity showed a significant negative correlation with lung function, and was positively correlated with pleural thickness and effusion, and pleural nodules in US finding. However, diaphragmatic excursion showed a negative correlation. Moreover, ground glass opacities, honey combing opacities, interlobular septal thickening, pleural thickness, and effusion in HRCT showed positive correlation with disease severity, $p < 0.001$ for all, yet, the mosaic pattern showed a negative relationship.

Conclusion The radiological assessments of SLE patients via HRCT and ultrasound unveiled prevalent findings such as ground glass opacities and pleural abnormalities. The severity of SLE correlated significantly with pulmonary function tests in a negative way, plus the positive correlation with lung opacities and pleural abnormalities.

Keywords Systemic lupus erythematosus, Subclinical pleuro-pulmonary disease, High-resolution computed tomography, Chest ultrasound, Spirometry

Introduction

Systemic lupus erythematosus (SLE) is a multisystem autoimmune disorder with high incidence and prevalence worldwide. SLE is implicated in multiorgan involvement with serious damage to the involved organs. Pulmonary system is the commonest to be involved with multiple pleuropulmonary sequelae [1].

The clinical presentation and course of SLE are variable. Some patients have a benign course of the disease while others have a serious and a life-threatening sequelae with multiple relapses and remissions according to

*Correspondence:
Hanaa S. Hamed
hanaa.s.hamed2021@gmail.com
[1] Chest Department, Faculty of Medicine, Zagazig University, Zagazig 44519, Egypt
[2] Rheumatology Department, Faculty of Medicine, Zagazig University, Zagazig 44519, Egypt

the degree of damaged organ; meanwhile, arthritis and photosensitivity are among the commonest clinical presentation of SLE [2].

Systemic lupus erythematosus (SLE) can lead to pulmonary complications. These complications are common, with over half of SLE patients experiencing pleuro-pulmonary manifestations during their illness. These include pleural effusion, pneumonia, interstitial lung disease, pulmonary embolism, and pulmonary hypertension. Research has shown that pleuro-pulmonary involvement is associated with a higher mortality rate in SLE patients [3].

Chest symptoms due to SLE are variable but chest pain, cough, and/or breathlessness are usually the first. Breathlessness is the commonest symptom in more than 60% of the affected SLE patients, together with both HRCT and pulmonary function tests abnormalities [4]. Although lung abnormalities do not correlate with serum markers of lupus activity, computed tomographic scans reveal anomalies in 55–70% of SLE patients [5]. Asymptomatic involvement is more prevalent, with up to two-thirds of patients displaying abnormalities in pulmonary function tests, as per some studies [6].

Early detection and management of complications are crucial for improving the quality of life and prognosis of patients with SLE. To this end, our study aimed to identify subclinical pleuro-pulmonary involvement in SLE patients without respiratory symptoms, utilizing HRCT, chest US, and PFT.

Methods

Patients and study design

A cross-sectional study was conducted on 228 patients diagnosed with SLE based on the EULAR/ACR classification criteria with no history of previous chest disease or chest symptoms [7]. The study was carried out at the rheumatology, chest, and radiology departments of Zagazig University hospitals from January 2022 to March 2023. Approval of the research protocol by the research ethical committee of the Faculty of Medicine, Zagazig University, Institutional Research Board (IRB), was obtained. The Declaration of Helsinki, issued by the World Medical Association to ensure the protection of individuals participating in medical research, was strictly adhered to during this study. Informed verbal and written consent were obtained from the studied participants before joining the study. Patients below 18 years of age, those with chronic chest diseases such as COPD and ILD, patients with TB and current COVID-19 disease or any viral infection, patients treated with methotrexate, and those who had recently undergone abdominal or thoracic surgery were excluded from the study.

Sample size

Based on the study conducted by Ghanem and colleagues [8], the odds ratio for asymptomatic pleuro-pulmonary manifestations in SLE is 0.44; therefore, to achieve a statistical power of 80% with a 95% confidence interval, the estimated sample size required for the study is 210 subjects, calculated using EPI-INFO version 6.

Measurements and endpoints

Patient demographic information, such as age, gender, disease duration, and presentation, was obtained from their medical records. To assess the severity and activity of the disease, we utilized the SLICC/ACR damage index [9] and the SLEDAI-2k activity score [10]. Alongside routine laboratory investigations like CBC, CRP, and ESR, we conducted various tests to assess pulmonary function, including basic spirometry, chest ultrasound (CUS), and high-resolution topography chest (HRCT).

Based on radiological finding, SLE patients were classified in to two groups; the first was those with positive radiological finding, and second for the negative one. Moreover, based on the spirometry reading, the patients were classified in to two groups, the first was those with small airway features, hence those with at least two of the following parameters below 65% predicted; PEF50, PEF75, and MMEF were considered positive for small airway disease, while second for the negative [11].

Finally, based on the positive concordance between the radiological and functional test, the patients then classified in to two groups; the first was SLE with pulmonary manifestation if they have at least one radiological feature plus one spirometry features, and the second was SLE without pulmonary manifestations if they did not fulfill the before mentioned criteria.

Statistical analysis

The data was initially collected in an Excel spreadsheet and later coded for further analysis using the SPSS statistical package version 26 (IBM Corp., Armonk, NY, USA). We assessed the normality of data using the Shapiro–Wilk test and expressed numerical data as mean and standard deviation (SD) and categorical data as number and percentage. We used an independent *t*-test for comparing two means and a Chi-square test for comparing the frequencies of two groups. All data was two-sided, and we considered *p*-values below 0.05 as significant.

Results

The demographic characteristics of patients diagnosed with SLE are summarized in Table 1. The average age of patients was 30 years, with a standard deviation

Table 1 General characteristics of patients with SLE

	Total (*n* = 228)	
Age, years (mean, SD)	30.26	9.26
F-sex (*n*, %)	180	78.95
Disease duration, years (mean, SD)	5.23	3.41
Fever (*n*, %)	72	31.58
Fatigue (*n*, %)	60	26.32
Arthralgia (*n*, %)	96	42.11
Arthritis (*n*, %)	120	52.63
Myalgia (*n*, %)	36	15.79
Alopecia (*n*, %)	132	57.89
Photosens (*n*, %)	36	15.79
Ulcers (*n*, %)	84	36.84
m. rash (*n*, %)	144	63.16
disc.rash (*n*, %)	24	10.53
sk. rash (*n*, %)	48	21.05
Purpura (*n*, %)	12	5.26
DVT (*n*, %)	24	10.53
Vasculitis (*n*, %)	24	10.53
Raynaud (*n*, %)	60	26.32
LL edema (*n*, %)	24	10.53
Seizures (*n*, %)	12	5.26
Psychosis (*n*, %)	24	10.53
Headache (*n*, %)	48	21.05
WBCs (mean, SD)	6.59	3.26
HB (mean, SD)	11.04	1.86
PLT (mean, SD)	217.89	98.02
ESR (mean, SD)	39.21	22.04
CRP (mean, SD)	8.79	22.02
BUN (mean, SD)	15.67	7.48
S. CRT (mean, SD)	1.01	0.75
24H PTN (mean, SD)	934.3	1369.2
CRT. CL. (mean, SD)	114.47	56.26
S. alb. (mean, SD)	3.37	0.57
ALT (mean, SD)	38.05	11.69
AST(mean, SD)	19.12	3.99
Pyuria (*n*, %)	84	36.84
Heamturia (*n*, %)	84	36.84
Casts (*n*, %)	48	21.05
ANA (*n*, %)	228	100
antidsDNA (*n*, %)	204	89.47
C3 (*n*, %)	204	89.47
C4 (*n*, %)	204	89.47
SLEDA (mean, SD)	12.79	10.00
SLEDA score (mean, SD)	2.47	1.14
SLICC damage index (mean, SD)	2.21	1.15

of 9 years. Most patients were female, accounting for 78.95% of the total, and the mean disease duration was approximately 5 years, with a standard deviation of 3 years.

Table 2 illustrates the radiological findings in SLE patients obtained through HRCT and ultrasound chest examinations. The most common radiological feature observed in HRCT was ground glass opacity, present in 31.58% of cases. In contrast, US revealed that more than one-third of patients exhibited pleural thickness, nodules, or comet tail artifacts. Spirometry results are summarized in Table 3. Notably, 26.32% of patients displayed signs of small airway disease based on spirometry parameters.

Table 4 highlights the concordance between radiological findings and lung function tests. It reveals that 26.32% of SLE patients exhibited both abnormal radiological parameters and confirmed spirometry features of small airway disease, despite that 52.63% and 73.68% of patients showed pulmonary involvement based on HRCT and US, respectively.

Table 5 presents data on SLE patients with subclinical lung involvement. This subgroup exclusively consisted of female patients who were significantly younger

Table 2 Radiological finding in patients with SLE

	Total (*n* = 228)	
HRCT finding		
Consolidation (*n*, %)	12	5.26
Patchy infiltration (*n*, %)	12	5.26
Ground-glass opacity (*n*, %)	72	31.58
Honeycomb opacity (*n*, %)	12	5.26
Interlobular septal thickening (*n*, %)	48	21.05
Mosaic sign (*n*, %)	36	15.79
Bronchiectasis (*n*, %)	12	5.26
Pleural thickening (*n*, %)	48	21.05
Pleural effusion (*n*, %)	24	10.53
A- US finding		
Pleural nodules (*n*, %)	60	26.32
Pleural thickness (*n*, %)	72	31.58
Comet-tail artifacts/B-pattern (*n*, %)	60	26.32
DE (mean, SD)	3.09	0.39

Table 3 Spirometry features of patients with SLE

PFT	Total (*n* = 228)	
FEV1 (mean, SD)	85.26	3.87
FVC (mean, SD)	87.26	7.76
FEV1/FVC (mean, SD)	98.58	6.51
FEF25 (mean, SD)	74.84	12.28
FEF50 (mean, SD)	72.68	12.64
FEF75 (mean, SD)	75.58	12.47

Table 4 Concordance between radiological and pulmonary functional test of patients with SLE

	Positive		Negative	
	n	%	*n*	%
Pulmonary involvement (HRCT-based)	120	52.63	108	47.37
Pulmonary involvement (US-based)	168	73.68	60	26.32
Small airway disease (PFT-based)	60	26.32	168	73.68
Total subclinical lung affection	60	26.32	168	73.68

and had shorter disease duration. Moreover, they exhibited a higher prevalence of myalgia, alopecia, photosensitization, ulcers, malar rash, deep vein thrombosis (DVT), vasculitis, Reynaud's phenomenon, seizures, psychosis, and headaches.

In addition, laboratory investigations indicated specific abnormalities in SLE patients. Patients displayed lower white blood cell counts, hemoglobin levels, platelet counts, creatinine clearance, and serum albumin levels. Conversely, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), blood urea nitrogen (BUN), serum creatinine, 24-h urine protein, and alanine transaminase (ALT) levels were significantly elevated. All patients tested positive for anti-double-stranded DNA antibodies (antidsDNA), C3, and C4, and had a higher frequency of pyuria, hematuria, and casts in their urine samples. Furthermore, the SLE Disease Activity Index 2000 (SLEDAI-2k) score and the Systemic Lupus International Collaborating Clinics/American College of Rheumatology (SLICC/ACR) damage index were significantly higher in this patient cohort.

The correlation between SLE disease severities with parameters of PFT is summarized in Table 6, which was significantly negative with FEV1, FVC, PEF25, PEF50, and PEF75. Moreover, the disease severities showed positive correlation with presence of ground glass opacities, honey combing opacities, interlobular septal thickening, pleural thickness, and effusion, $p<0.001$ for all. However, the mosaic pattern revealed negative relationship. Additionally, the pleural nodules, pleural thickness, and comet-tail sign by US showed positive correlation with disease severity, $p<0.001$ for all. However, diaphragmatic excursion, DE, showed negative correlation, coefficient $= -16.56$, $p<0.001$ (Table 7).

Discussion

Chest involvement is prevalent among SLE patients owing to the abundance of connective tissues in that region. As a result, more than half of individuals with SLE exhibit one or multiple pulmonary manifestations affecting areas such as the pleura, pulmonary interstitium, parenchyma,

Table 5 Correlation between basic characteristics of SLE and subclinical lung involvement

Factors	SLE without PD ($n=168$)		SLE with PD ($n=60$)		*p*
Age, years (mean, SD)	33.71	8.17	20.6	3.53	<0.001†
F-sex (*n*, %)	120	71.43	60	100	<0.001*
Disease duration, years (mean, SD)	5.82	3.81	3.6	0.494	<0.001†
Fever (*n*, %)	48	28.57	24	40	0.11*
Fatigue (*n*, %)	48	28.57	12	20	0.19*
Arthralgia (*n*, %)	72	42.86	24	40	0.71*
Arthritis (*n*, %)	84	50	36	60	0.18*
Myalgia (*n*, %)	12	7.14	24	40	<0.001*
Alopecia (*n*, %)	84	50	48	80	<0.001*
Photosens (*n*, %)	12	7.14	24	40	<0.001*
Ulcers (*n*, %)	48	28.57	36	60	<0.001*
m. rash (*n*, %)	84	50	60	100	<0.001*
disc.rash (*n*, %)	24	14.29	0	0	<0.001*
sk. Rash (*n*, %)	48	28.57	0	0	<0.001*
Purpura (*n*, %)	12	7.14	0	0	0.03*
DVT (*n*, %)	12	7.14	12	20	0.005*
Vasculitis (*n*, %)	12	7.14	12	20	0.005*
Raynaud (*n*, %)	24	14.29	36	60	<0.001*
LL edema (*n*, %)	24	14.29	0	0	<0.001*
Seizures (*n*, %)	0	0	12	20	<0.001*
Psychosis (*n*, %)	0	0	24	40	<0.001*
Headache (*n*, %)	12	7.14	36	60	<0.001*
WBCs (mean, SD)	7.21	3.29	4.86	2.49	<0.001†
HB (mean, SD)	11.75	1.58	9.08	0.995	<0.001†
PLT (mean, SD)	232.4	97.5	177.4	88.1	<0.001†
ESR (mean, SD)	35.7	22	49	19.2	<0.001†
CRP (mean, SD)	4.15	3.47	21.8	40	<0.001†
BUN (mean, SD)	13.99	6.72	20.4	7.54	<0.001†
S. CRT (mean, SD)	0.736	0.259	1.8	1.06	<0.001†
24H PTN (mean, SD)	445	613	2304	1887	<0.001†
CRT. CL. (mean, SD)	127.4	58.9	78.2	22.9	<0.001†
S. alb. (mean, SD)	3.607	0.433	2.72	0.374	<0.001†
ALT (mean, SD)	35.1	12.1	46.4	4.21	<0.001†
AST(mean, SD)	18.89	3.94	19.8	4.1	0.13†
Pyuria (*n*, %)	48	28.57	36	60	<0.001*
Heamturia (*n*, %)	48	28.57	36	60	<0.001*
Casts (*n*, %)	24	14.29	24	40	<0.001*
antidsDNA (*n*, %)	144	85.71	60	100	0.002*
C3 (*n*, %)	144	85.71	60	100	0.002*
C4 (*n*, %)	144	85.71	60	100	0.002*
SLEDA (mean, SD)	8.29	5.73	25.4	8.5	<0.001†
SLEDA score (mean, SD)	2.14	1.06	3.4	0.807	<0.001†
SLICC damage index (mean, SD)	1.714	0.798	3.6	0.807	<0.001†

† independent t-test

* Chi square test, $p<0.05$ considered significant

Table 6 SLE disease severity in correlation with pulmonary function parameters

PFT		SLEDA	SLEDA score	SLICC damage index
FEV1	*r*	−0.54	−0.46	−0.44
	p	0.001	0.001	0.001
FVC	*r*	−0.69	−0.63	−0.69
	p	0.001	0.001	0.001
FEV1/FVC	*r*	0.60	0.62	0.64
	p	0.001	0.001	0.001
FEF25	*r*	−0.85	−0.62	−0.84
	p	0.001	0.001	0.001
FEF50	*r*	−0.80	−0.73	−0.86
	p	0.001	0.001	0.001
FEF75	*r*	−0.65	−0.61	−0.73
	p	0.001	0.001	0.001

The test of significant: Pearson correlation coefficient, the sign before "r" denoting the direction of relationship, $p < 0.05$ considered significant

and respiratory muscles throughout the progression of the disease [5, 6, 12].

The present data revealed that the HRCT chest and US chest reported one or more pulmonary features in 52.63% and 73.68% of patients, respectively. The most common HRCT lesion was in the interstitium; ground glass opacity was presented in 31.58% of cases followed by interlobular septal thickening and mosaic pattern (21% and 15.7%, respectively); however, the pleural affection was noticed in more than one-third of cases by US chest; 31.5% had pleural thickness and 26.3% had pleural nodules. The incidence of chest affection in patients of SLE ranged from 7 to 100% based on different reports [13–15].

The role of radiological evaluation of SLE patients is crucial in detecting small lung lesion especially in early stage of the disease [16]. A supportive study by Li et al. found the prevalence of chest abnormalities in SLE patients, with the most frequent being pulmonary interstitial lesions, followed by mediastinal or pleural lesions [17]. However, another contrarily studies found that the primary changes observed were pleurisy or pleural effusion, succeeded by pulmonary interstitial and parenchymal lesions [4]. Pulmonary interstitial lesions in SLE involve significant damage to the small airway walls in the lungs, along with capillary loss and the formation of fibrous scars. These alterations are likely a result of immune complex deposition in the lung interstitium, setting off a sequence where macrophages are involved. These macrophages release inflammatory substances, initiating an inflammatory response and prompting the growth of fibroblasts. CT scans typically reveal ground-glass, linear, honeycomb/reticular patterns, lines below the lung membrane, thicker partitions between lobes, emphysema, and bronchiectasis. Ground-glass patterns often indicate a potentially reversible lesion in the early stages, while reticular and honeycomb patterns usually suggest a longer duration of the disease [18–20]. This could explain the present finding; hence, the correlation between SLE disease severity indices was positive with presence of ground glass opacities, honey combing opacities, and interlobular septal thickening. Yet, the mosaic pattern revealed negative relationship.

The pleural and pericardial effusion involves lymphocyte, monocyte, and plasma cell infiltration,

Table 7 SLE disease severity in correlation with radiological finding by HRCT and US

	SLEDA			SLEDA score			SLICC damage index		
HRCT	Coeff	SE	*p*	Coeff	SE	*p*	Coeff	SE	*p*
Ground glass opacity	−5.21	0.52	0.001	−0.36	0.09	0.001	−0.41	0.06	0.001
Honey comb opacity	−17.89	1.09	0.001	−0.84	0.16	0.001	−1.71	0.11	0.001
Interlobular septal thickening				−0.31	0.10	0.001	−0.40	0.10	0.001
Mosaic sign	2.00	0.69	0.001				0.30	0.10	0.001
Pleural thickening	−3.35	0.52	0.001	−0.42	0.08	0.001	−0.60	0.05	0.001
Pleural effusion	−2.89	0.62	0.001	−0.64	0.09	0.001	−0.31	0.06	0.001
US									
DE	−16.56	0.74	0.001	−1.10	0.12	0.001	−1.68	0.07	0.001
Pleural nodules	−7.52	0.33	0.001	−1.09	0.06	0.001	−1.01	0.03	0.001
Pleural thickness	−3.16	0.30	0.001	−0.29	0.05	0.001	−0.65	0.03	0.001
Comet-tail artifacts B-pattern	−9.83	0.34	0.001	−0.81	0.06	0.001	−0.90	0.03	0.001

Coeff. Coefficient, *SE* Standard error, the sign before coeff., reflecting the direction of relationship

The test of significant: general linear model

occasionally with minor vasculitis and varied fibrosis levels [12]. CT scans show pericardial/pleural effusion, thickened pleura, and swollen mediastinal lymph nodes. In SLE patients, moderate to small pleural effusions are frequent, while extensive effusions are uncommon. They may appear on one or both sides of the chest, with bilateral effusion evenly distributed across both sides of the thorax [21]. In our study, the pleural thickness and effusion that had been reported by CT as well as the pleural nodules, pleural thickness, and comet-tail sign by US showed positive correlation with disease severity.

HRCT is more sensitive in detecting lung parenchymal changes than other radiological methods [22]. However, reports indicate that US is more effective in identifying pleural changes than HRCT in some cases [23–26]. This discrepancy in the frequencies of lung and pleural issues observed by both techniques may explain the varying results in our study. Nonetheless, combining both modalities could enhance their collective ability to identify subtle manifestations of SLE in patients, serving as a valuable tool for regular follow-ups.

Evaluating lung function is recommended in SLE even with asymptomatic patients or no radiological evidence of pulmonary involvement. This simple test could establish a diagnosis and aid in the long-term follow-up of SLE patients [27, 28]. Studies on PFT in SLE patients have shown various disorders, often focusing on symptomatic cases and mainly using basic spirometry for forced vital capacity [29, 30]. More recent studies have emphasized gas transfer capability, particularly carbon monoxide, revealing reductions in lupus patients with pulmonary symptoms [31, 32]. The present study revealed that a SLE diseases severity was significantly negative with FEV1, FVC, PEF25, PEF50, and PEF75. Mohammad et al. discovered that PFT could detect early pulmonary involvement in some SLE patients despite normal radiological findings. They found abnormalities in VC and FVC [33]. However, another study recorded no significant correlation between radiological findings and abnormalities in PFT [34]. Additionally, several studies have attempted to link PFT results with clinical and serological aspects of SLE, but they have yielded conflicting conclusions [35, 36]. Moreover, Cervera et al. found no significant correlation between the classification or severity of pulmonary function abnormalities and other measures of lupus activity, such as serology, immune complexes in skin biopsy, and renal biopsy [35].

Strength and limitation

The strength of this study was emphasizing the importance of combining radiological assessments using both HRCT and ultrasound (US) alongside lung function evaluations in SLE patients. This approach proved particularly beneficial for those with subtle pleura-pulmonary manifestations. The findings indicated a significant positive correlation between radiological findings and disease severity, along with a negative relationship with lung function. However, it had a couple of limitations. Firstly, it relied on simple spirometry to assess lung function. Yet, a more comprehensive approach, such as a full pulmonary function test, might reveal hidden aspects of lung dysfunction that basic spirometry could miss. Secondly, the study was conducted at a single center, which may limit the broader applicability of the results to a more diverse population.

Conclusion

The study concluded that the radiological assessments of SLE patients via HRCT and ultrasound unveiled prevalent findings such as ground glass opacities and pleural abnormalities. Notably, a subgroup of younger female patients exhibited subclinical lung involvement and a higher incidence of various associated symptoms. Laboratory investigations indicated distinct abnormalities, including lower blood cell counts and elevated inflammatory markers, such as ESR and CRP. Additionally, the severity of SLE correlated significantly with pulmonary function tests in a negative way, plus the positive correlation with lung opacities and pleural abnormalities.

Abbreviations

SLE	Systemic lupus erythematosus
HRCT	High-resolution computed tomography
US	Ultrasound
PFT	Pulmonary function tests
COPD	Chronic obstructive pulmonary disease
ILD	Interstitial lung disease
EULAR/ACR	European League Against Rheumatism/American College of Rheumatology
TB	Tuberculosis
CBC	Complete blood count
CRP	C-reactive protein
ESR	Erythrocyte sedimentation rate
SLEDAI	Systemic Lupus Erythematosus Disease Activity Index
SLICC/ACR	Systemic Lupus International Collaborating Clinics/American College of Rheumatology
PEF	Peak expiratory flow
MMEF	Maximum mid expiratory flow
DVT	Deep venous thrombosis
BUN	Blood urea nitrogen
ALT	Alanine transaminase,
Anti ds DNA	Anti double stranded DNA antibodies
C3	Complement 3
C4	Complement 4
FEV1	Forced expiratory volume in first second
FVC	Forced vital capacity
VC	Vital Capacity
DE	Diaphragmatic excursion
F – sex	Female sex
m. rash	Malar rash
Disc rash	Discoid rash
sk rash	Skin rash
L.L	Lower limb
WBCs	White blood cells

Hb	Hemoglobin
PLT	Platelet
s. crt	Serum creatine
24 H PTN	24 Hour protein in urine
ANA	Anti-nuclear anti body
SLEDA	Systemic lupus erythematosus disease activity
SLICC	Systemic Lupus International Collaborating Clinics
B pattern	Vertical artifacts that appear as echogenic lines from pleural line to lung parenchyma

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Authors' contributions
HH, MA, and EM all shared in the conception, design of the work, acquisition, analysis, and interpretation of the data. The authors read and approved the final manuscript.

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Availability of data and materials
The database used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the administrative council of the Chest Department and Institutional Board Review of Zagazig University (ZU-IRB # 10807–17/5–2023). Patients included in this study gave their informed and signed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Almeida MD, Pires CF (2022) Lung in systemic lupus erythematosus: a single-center experience. Open Access Libr J 9(9):1–9
2. Fortuna G, Brennan MT (2013) Systemic lupus erythematosus: epidemiology, pathophysiology, manifestations, and management. Dent Clin North Am 57(4):631–655. https://doi.org/10.1016/j.cden.2013.06.003. PMID: 24034070
3. Mittoo S, Fell CD (2014) Pulmonary manifestations of systemic lupus erythematosus. Semin Respir Crit Care Med 35(2):249–254. https://doi.org/10.1055/s-0034-1371537. Epub 2014 Mar 25 PMID: 24668539
4. Kamen DL, Strange C (2010) Pulmonary manifestations of systemic lupus erythematosus. Clin Chest Med 31(3):479–488. https://doi.org/10.1016/j.ccm.2010.05.001. PMID: 20692540
5. Kakati S, Doley B, Pal S, Deka UJ (2007) Pulmonary manifestations in systemic lupus erythematosus (SLE) with special reference to HR CT. J Assoc Physicians India 55:839–841 PMID: 18405129
6. Hannah JR, D'Cruz DP (2019) Pulmonary complications of systemic lupus erythematosus. Semin Respir Crit Care Med 40(2):227–234. https://doi.org/10.1055/s-0039-1685537. Epub 2019 May 28 PMID: 31137062
7. Aringer M, Costenbader K, Daikh D, Brinks R, Mosca M, Ramsey-Goldman R, Smolen JS, Wofsy D, Boumpas DT, Kamen DL, Jayne D, Cervera R, Costedoat-Chalumeau N, Diamond B, Gladman DD, Hahn B, Hiepe F, Jacobsen S, Khanna D, Lerstrøm K, Massarotti E, McCune J, Ruiz-Irastorza G, Sanchez-Guerrero J, Schneider M, Urowitz M, Bertsias G, Hoyer BF, Leuchten N, Tani C, Tedeschi SK, Touma Z, Schmajuk G, Anic B, Assan F, Chan TM, Clarke AE, Crow MK, Czirják L, Doria A, Graninger W, Halda-Kiss B, Hasni S, Izmirly PM, Jung M, Kumánovics G, Mariette X, Padjen I, Pego-Reigosa JM, Romero-Diaz J, Rúa-Figueroa Fernández Í, Seror R, Stummvoll GH, Tanaka Y, Tektonidou MG, Vasconcelos C, Vital EM, Wallace DJ, Yavuz S, Meroni PL, Fritzler MJ, Naden R, Dörner T, Johnson SR (2019) 2019 European League Against Rheumatism/American College of Rheumatology Classification Criteria for Systemic Lupus Erythematosus. Arthritis Rheumatol 71(9):1400–1412. https://doi.org/10.1002/art.40930. Epub 2019 Aug 6. PMID: 31385462; PMCID: PMC6827566
8. Ghanem S, Ghanem M, Hegazy M et al (2016) AB0507 early detection of asymptomatic pleuropulmonary manifestations in systemic lupus erythematosus by high resolution CT and pulmonary function tests. Ann Rheum Dis 75:1078–1079
9. Gladman DD, Urowitz MB, Goldsmith CH, Fortin P, Ginzler E, Gordon C, Hanly JG, Isenberg DA, Kalunian K, Nived O, Petri M, Sanchez-Guerrero J, Snaith M, Sturfelt G (1997) The reliability of the systemic lupus international collaborating clinics/American college of rheumatology damage index in patients with systemic lupus erythematosus. Arthritis Rheum 40(5):809–813. https://doi.org/10.1002/art.1780400506. PMID: 9153540
10. Gladman DD, Ibañez D, Urowitz MB (2002) Systemic lupus erythematosus disease activity index 2000. J Rheumatol 29(2):288–291 PMID: 11838846
11. Knox-Brown B, Mulhern O, Amaral AFS (2021) Spirometry parameters used to define small airways obstruction in population-based studies: systematic review protocol. BMJ Open 11(10):e052931. https://doi.org/10.1136/bmjopen-2021-052931. PMID:34610942; PMCID: PMC8493897
12. Shin JI, Lee KH, Park S, Yang JW, Kim HJ, Song K, Lee S, Na H, Jang YJ, Nam JY, Kim S, Lee C, Hong C, Kim C, Kim M, Choi U, Seo J, Jin H, Yi B, Jeong SJ, Sheok YO, Kim H, Lee S, Lee S, Jeong YS, Park SJ, Kim JH, Kronbichler A (2022) Systemic lupus erythematosus and lung involvement: a comprehensive review. J Clin Med 11(22):6714. https://doi.org/10.3390/jcm11226714. PMID: 36431192; PMCID: PMC9698564
13. Keane MP, Lynch JP 3rd (2000) Pleuropulmonary manifestations of systemic lupus erythematosus. Thorax 55(2):159–166. https://doi.org/10.1136/thorax.55.2.159. PMID: 10639536; PMCID: PMC1745678
14. Amarnani R, Yeoh SA, Denneny EK, Wincup C (2021) Lupus and the lungs: the assessment and management of pulmonary manifestations of systemic lupus erythematosus. Front Med (Lausanne) 18(7):610257. https://doi.org/10.3389/fmed.2020.610257. PMID: 33537331; PMCID: PMC7847931
15. Ali AA, Yousef RN, Elsheikh MS, Salamah AR, Wu LL, Alnaggar AR, Khalil NM, Behiry ME (2023) YKL-40 in serum: a promising biomarker of juvenile SLE and strongly correlated with disease duration. Ir J Med Sci. https://doi.org/10.1007/s11845-023-03545-w. Epub ahead of print. PMID: 37874503
16. Di Matteo A, Smerilli G, Cipolletta E, Salaffi F, De Angelis R, Di Carlo M, Filippucci E, Grassi W (2021) Imaging of joint and soft tissue involvement in systemic lupus erythematosus. Curr Rheumatol Rep 23(9):73. https://doi.org/10.1007/s11926-021-01040-8. PMID: 34269905; PMCID: PMC8285327
17. Li P, Li S, Li L, Wang M (2017) Chest CT findings in systemic lupus erythematosus and its correlation with serum markers. Radiol Infect Dis 4(1):7–13
18. Pego-Reigosa JM, Medeiros DA, Isenberg DA (2009) Respiratory manifestations of systemic lupus erythematosus: old and new concepts. Best Pract Res Clin Rheumatol 23(4):469–480. https://doi.org/10.1016/j.berh.2009.01.002. PMID: 19591778
19. Pannu N, Bhatnagar A (2020) Oxidative stress and immune complexes: pathogenic mechanisms in pristane induced murine model of lupus. Immunobiology 225(1):151871
20. Li F, Yang Y, Zhu X, Huang L, Xu J (2015) Macrophage polarization modulates development of systemic lupus erythematosus. Cell Physiol Biochem 37(4):1279–1288
21. Silva CI, Müller NL (2008) Intrathoracic manifestations of collagen vascular diseases on high-resolution chest computed tomography. Radiol Bras 41:189–197
22. Jeny F, Brillet PY, Kim YW, Freynet O, Nunes H, Valeyre D (2019) The place of high-resolution computed tomography imaging in the investigation of interstitial lung disease. Expert Rev Respir Med 13(1):79–94. https://doi.org/10.1080/17476348.2019.1556639. Epub 2018 Dec 12 PMID: 30517828

23. Lacedonia D, Scioscia G, Giardinelli A, Quarato CM, Sassani EV, Foschino Barbaro MP, Maci F, Sperandeo M (2021) The role of transthoracic ultrasound in the study of interstitial lung diseases: high-resolution computed tomography versus ultrasound patterns: our preliminary experience. Diagnostics 11(3):439
24. Ruaro B, Baratella E, Confalonieri P, Confalonieri M, Vassallo FG, Wade B, Geri P, Pozzan R, Caforio G, Marrocchio C, Cova MA (2021) High-resolution computed tomography and lung ultrasound in patients with systemic sclerosis: which one to choose? Diagnostics 11(12):2293
25. Xirouchaki N, Magkanas E, Vaporidi K, Kondili E, Plataki M, Patrianakos A, Akoumianaki E, Georgopoulos D (2011) Lung ultrasound in critically ill patients: comparison with bedside chest radiography. Intensive Care Med 37:1488–1493
26. Man MA, Dantes E, Domokos Hancu B, Bondor CI, Ruscovan A, Parau A, Motoc NS, Marc M (2019) Correlation between transthoracic lung ultrasound score and HRCT features in patients with interstitial lung diseases. J Clin Med 8(8):1199
27. Ciancio N, Pavone M, Torrisi SE, Vancheri A, Sambataro D, Palmucci S, Vancheri C, Di Marco F, Sambataro G (2019) Contribution of pulmonary function tests (PFTs) to the diagnosis and follow up of connective tissue diseases. Multidiscip Respir Med 15(14):17. https://doi.org/10.1186/s40248-019-0179-2. PMID: 31114679; PMCID: PMC6518652
28. Lazovic B, Sarac S, Stojanovic L, Milic R, Zugic V (1910) Examining pulmonary function measures in patients with systemic lupus erythematosus (SLE). Eur Respir J 2020:56. https://doi.org/10.1183/13993003.congress-2020.1910
29. Andonopoulos AP, Constantopoulos SH, Galanopoulou V, Drosos AA, Acritidis NC, Moutsopoulos HM (1988) Pulmonary function of nonsmoking patients with systemic lupus erythematosus. Chest 94(2):312–315. https://doi.org/10.1378/chest.94.2.312. PMID: 3396409
30. Rolla G, Brussino L, Bertero MT, Bucca C, Converso M, Caligaris-Cappio F (1996) Respiratory function in systemic lupus erythematosus: relation with activity and severity. Lupus 5(1):38–43. https://doi.org/10.1177/096120339600500108. PMID: 8646223
31. Le Tallec E, Bourg C, Bouzillé G, Belhomme N, Le Pabic E, Guillot S, Droitcourt C, Perlat A, Jouneau S, Donal E, Lescoat A (2023) Prognostic value and predictors of the alteration of the diffusing capacity of the lungs for carbon monoxide in systemic lupus erythematosus. Rheumatology (Oxford) kead558. https://doi.org/10.1093/rheumatology/kead558. Epub ahead of print. PMID: 37831905
32. Al-Adhoubi NK, Bystrom J (2020) Systemic lupus erythematosus and diffuse alveolar hemorrhage, etiology and novel treatment strategies. Lupus 29(4):355–363. https://doi.org/10.1177/0961203320903798. Epub 2020 Feb 9. PMID: 32036761; PMCID: PMC7436451
33. Mohammad HA, Hassan AA, Osman NM, Mohamed MS (2014) Detection of pulmonary involvement in lupus patients with and without clinical pulmonary symptoms. Egypt J Chest Dis Tuberc 63(2):463–469
34. Kakati S, Doley B, Dihingia P, Pegu U, Pal S, Deka UJ (2007) A clinical study of pulmonary manifestations in systemic lupus erythematosus with special reference to CT findings. India J Rheumatol 2(4):133–136
35. Cervera R, Khamashta MA, Font J, Sebastiani GD, Gil A, Lavilla P, Doménech I, Aydintug AO, Jedryka-Góral A, de Ramón E et al (1993) Systemic lupus erythematosus: clinical and immunologic patterns of disease expression in a cohort of 1,000 patients. The European Working Party on Systemic Lupus Erythematosus. Medicine (Baltimore) 72(2):113–124 PMID: 8479324
36. Fidler L, Keen KJ, Touma Z, Mittoo S (2016) Impact of pulmonary disease on patient-reported outcomes and patient-performed functional testing in systemic lupus erythematosus. Lupus 25(9):1004–1011. https://doi.org/10.1177/0961203316630818. Epub 2016 Feb 3 PMID: 26846692

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