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PLEURO-PULMONARY MANIFESTATIONS IN CONNECTIVE TISSUE DISORDERS IN SUDANESE PATIENTS: CROSS-SECTIONAL STUDY

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Summary.

Background: Connective Tissue Disorders (CTDs) frequently affect the respiratory system, with complications such as interstitial lung disease (ILD), pulmonary arterial hypertension (PAH), and pleural effusions being major contributors to morbidity and mortality. This study investigates the prevalence and patterns of pulmonary manifestations in Sudanese patients with CTDs and evaluates diagnostic correlations using pulmonary function tests (PFTs) and high-resolution computed tomography (HRCT).

Material and Methods. A cross-sectional study was conducted involving 75 CTDs patients presenting with respiratory symptoms at hospitals in Khartoum, Sudan. Data collection included clinical evaluations, PFTs, HRCT scans, and laboratory investigations. Statistical analyses were performed to determine the prevalence of pulmonary complications and their correlations with CTDs subtypes.

Results. ILD was the most common manifestation, with an overall prevalence of 36%, particularly high in scleroderma (75%) and MCTD (60%). Pulmonary arterial hypertension (PAH) was observed in 4%, primarily in systemic lupus erythematosus (9.5%). PFT abnormalities were common, with restrictive defects dominating in MCTD (100%) and scleroderma (87.5%). HRCT findings included reticulonodular lesions (14.7%), honeycombing (12%), pleural effusions (8%), and bronchiectasis (4%). Statistically significant differences in pulmonary complications were observed across CTDs subtypes.

Conclusion. Pulmonary manifestations are prevalent in Sudanese CTDs patients, with ILD being the predominant complication. Early and systematic screening using PFTs and HRCT is crucial for timely detection and management. These findings highlight the need for enhanced multidisciplinary care and further research into regional variations in CTD-related pulmonary diseases.

Keywords: Connective Tissue Disorders, Interstitial Lung Disease, Pulmonary Arterial Hypertension, Pulmonary Function Tests, High-Resolution Computed Tomography, Sudan.

Rezumat. Manifestări pleuro-pulmonare în tulburările de țesut conjunctiv (CTD) la pacienții sudanezi: studiu transversal.

Intorducere. Tulburările de țesut conjunctiv (CTD) afectează frecvent sistemul respirator, cu complicații precum boala pulmonară interstițială (BPI), hipertensiunea arterială pulmonară (PAH) și efuziile pleurale fiind contribuitori majori la morbiditate și mortalitate. Acest studiu investighează prevalența și paternele manifestărilor pulmonare la pacienții sudani cu CTD și evaluează corelațiile de diagnostic folosind testele cu funcției pulmonare (PFT) și tomografie computerizată de înaltă rezoluție (HRCT).

Material și Metode. A fost realizat un studiu transversal care a implicat 75 de pacienți cu CTD care prezintă simptome respiratorii, din spitalele din Khartoum, Sudan. Colectarea datelor a inclus evaluări clinice, PFT, scanări HRCT și investigații de laborator. Au fost efectuate analize statistice pentru a determina prevalența complicațiilor pulmonare și corelațiile acestora cu subtipurile CTD.

Rezultate. BPI a fost cea mai frecventă manifestare, cu o prevalență totală de 36%, în special ridicată în sclerodermie (75%) și MCTD (60%). Hipertensiunea arterială pulmonară (PAH) a fost observat la 4%, primordial, în lupusul eritematos sistemic (9,5%). Anomaliile PFT au fost frecvente, cu devieri restrictive care au dominat în MCTD (100%) și sclerodermie

(87,5%). Rezultatele HRCT au inclus leziuni reticulonodulare (14,7%), fagure (12%), efuzii pleurale (8%) și bronșiectază (4%). Diferențe semnificative statistic în complicațiile pulmonare au fost observate pe subtipurile CTD.

Concluzie. Manifestările pulmonare sunt predominante la pacienții CTD din Sudan, BPI fiind complicația predominantă. Screeningul timpuriu și sistematic folosind PFT_S și HRCT este crucial pentru detectarea și gestionarea în timp util. Aceste descoperiri evidențiază necesitatea unei îngrijiri multidisciplinare îmbunătățite și cercetări suplimentare asupra variațiilor regionale în bolile pulmonare legate de CTD.

Cuvinte cheie: tulburări de țesut conjunctiv, boală pulmonară interstițială, hipertensiune arterială pulmonară, teste ale funcției pulmonare, tomografie computerizată de înaltă rezoluție, Sudan.

Резюме. Плевро-легочные проявления при нарушениях соединительной ткани (НСТ) у суданских пациентов: поперечное исследование.

Введение. Нарушения соединительной ткани (НСТ) часто влияют на респираторную систему, с такими осложнениями, как интерстициальное заболевание легких (ИЗЛ), гипертония легочной артерии (ГЛА) и плевральные выпотения, являются основными участниками заболеваемости и смертности. Это исследование исследует распространенность и модели легочных проявлений у суданских пациентов с НСТ и оценивает диагностические корреляции с использованием тестов легочной функции (PFT) и компьютерной томографии с высоким разрешением (HRCT).

Материал и методы. Было проведено поперечное исследование с участием 75 пациентов с НСТ с респираторными симптомами, из больниц Хартума, Судан. Сбор данных включал клинические оценки, PFT, HRCT-сканирование и лабораторные исследования. Статистический анализ был выполнен для определения распространенности легочных осложнений и их корреляций с подтипами НСТ.

Результаты. ИЗЛ было наиболее распространенным проявлением, с общей распространенностью 36%, особенно с склеродермией (75%) и смешанные заболевания соединительной ткани (СЗСТ) (60%). Легочная гипертония (РАН) наблюдалась в 4%, в первую очередь, в системном эритематозном волчанке (9,5%). Аномалии ПФТ были частными, с рестриктивными отклонениями, которые доминировали в СЗСТ (100%) и склеродерме (87,5%). Результаты HRCT включали ретикулонодулярные поражения (14,7%), соты (12%), плевральные выпоты (8%) и бронхоэктаз (4%). Статистически значимые различия в легочных осложнениях наблюдались на подтипах CTD.

Заключение. Легочные проявления преобладают у пациентов с НСТ в Судане, ИЗЛ является преобладающим осложнением. Ранний и систематический скрининг с использованием PFT и HRCT имеет решающее значение для своевременного обнаружения и управления. Эти открытия подчеркивают необходимость улучшения междисциплинарной помощи и дальнейших исследований региональных различий в легочных заболеваниях НСТ.

Ключевые слова: расстройства соединительной ткани, интерстициальная болезнь легких, легочная гипертония, легочные функции, компьютерная томография с высокой резолюцией, Судан.

Introduction.

Connective tissue disorders (CTDs) are systemic diseases that commonly affect various organ systems, including the respiratory system. Pulmonary involvement is a significant cause of morbidity and mortality in CTD patients. The respiratory manifestations may range from interstitial lung disease (ILD) to pleural effusions and pulmonary hypertension. Despite these complications, limited data are available regarding the prevalence and nature of pulmonary manifestations in CTD patients from Sudan and other similar regions.

ILD is one of the most frequent pulmonary manifestations in CTD patients. A study involving 75 patients with CTDs reported ILD in 36% of the cases, making it the most common pulmonary complication. This prevalence is consistent with other international studies, which suggest that ILD is particularly common in scleroderma and mixed connective tissue disease (MCTD) patients [1]. Nearly 75% of patients with scleroderma and 60% with MCTD in the study had ILD. These findings align with data from large-scale reviews where ILD was reported to affect more than 50% of scleroderma patients [2,3].

Pulmonary arterial hypertension (PAH) is another critical complication in CTDs, albeit less common than ILD. PAH was observed in 4% of the CTD patients in the aforementioned study, primarily in those with systemic lupus erythematosus (SLE) and rheumatoid arthritis (RA) [1]. Studies conducted in the U.S. and Europe report a prevalence of PAH in up to 10-15% of scleroderma patients, but this complication is less frequently seen in RA and SLE [4,5]. This variability underscores the importance of routine screening for PAH in CTD patients.

Pulmonary function tests (PFTs) are valuable diagnostic tools in assessing respiratory involvement in CTDs. In the study, PFT abnormalities were reported in all MCTD patients and 87.5% of those with scleroderma. Restrictive lung defects were the most common abnormality identified, particularly in MCTD (100%) and scleroderma (87.5%) patients

[1]. Similar findings are reported globally, where restrictive ventilatory defects are often the hallmark of pulmonary involvement in CTDs, particularly in ILD [6, 7].

High-resolution computed tomography (HRCT) scans are instrumental in detecting subtle pulmonary changes in CTD patients. The study revealed a spectrum of radiological abnormalities, including reticulonodular lesions, honeycombing, and bronchiectasis. Pleural effusion was more common in patients with RA and SLE [1]. Honeycomb patterns, indicative of advanced fibrotic changes, were noted in patients with RA and scleroderma. These findings echo the literature where HRCT is considered the gold standard for diagnosing and monitoring ILD in CTD patients [8,9].

The high frequency of pulmonary manifestations in CTDs emphasizes the need for early detection and regular monitoring. Systematic evaluation, including PFTs and HRCT, can help in identifying lung involvement at an early stage, potentially improving outcomes. Treatment options, including immunosuppressive therapy, may help in managing symptoms and slowing disease progression [10, 11].

Pulmonary manifestations, particularly ILD, are common in CTD patients, with significant implications for patient outcomes. Routine pulmonary evaluation, including PFTs and HRCT, is recommended for all CTD patients to ensure early detection and management of lung involvement.

Research question.

What are the prevalence and patterns of pulmonary manifestations in Sudanese patients with connective tissue disorders, and how do pulmonary function test results correlate with high-resolution computed tomography findings?

Rationale.

CTDs such as systemic lupus erythematosus (SLE), rheumatoid arthritis (RA), scleroderma, and mixed connective tissue disease (MCTD) are known to frequently involve the respiratory system. However, the precise prevalence and patterns of pulmonary manifestations vary depending on the type of CTD and the population studied.

Despite the known association between CTDs and pleuro-pulmonary manifestations, there is a paucity of data from Sudan on the nature, frequency, and patterns of these manifestations. This gap in knowledge limits the ability of healthcare providers to effectively diagnose, manage, and monitor CTD patients in this region.

Pulmonary complications, including interstitial lung disease (ILD) and pulmonary arterial hypertension (PAH), are major causes of morbidity and mortality in CTD patients. Early detection and management of such complications can significantly improve patient outcomes, but this requires systematic evaluation and awareness of the patterns of pulmonary involvement.

Understanding the types and frequency of pleuro-pulmonary manifestations can guide clinicians in developing comprehensive management plans. This includes the use of pulmonary function tests (PFTs), high-resolution computed tomography (HRCT), and other diagnostic tools to monitor disease progression and tailor treatment.

This study focuses on CTD patients in Sudan, a population with potentially different environmental, genetic, and healthcare factors compared to other regions. Exploring the manifestations in this specific group may reveal unique patterns of disease presentation and outcomes that could inform both local and international clinical practice.

Objectives.

Primary Objective:

To determine the prevalence and patterns of pleuro-pulmonary manifestations, specifically interstitial lung disease (ILD), pulmonary arterial hypertension (PAH), pleural effusion, and bronchiectasis, among Sudanese patients with various CTDs.

Secondary Objectives:

1. To evaluate the frequency and types of respiratory system involvement in specific CTDs, including systemic lupus erythematosus (SLE), rheumatoid arthritis (RA), scleroderma, and mixed connective tissue disease (MCTD).
2. To assess the role of pulmonary function tests (PFTs) in identifying respiratory involvement in CTD patients.
3. To investigate the utility of high-resolution computed tomography (HRCT) in detecting radiological abnormalities such as reticulonodular lesions, honeycombing, and bronchiectasis in CTD patients.
4. To analyze the correlation between clinical presentations and diagnostic findings (PFTs and HRCT) in patients with CTDs and respiratory symptoms.
5. To raise awareness and emphasize the need for systematic screening and monitoring of pulmonary manifestations in CTD patients in Sudan for early detection and improved management.

Methods and Methodology.

Study Design:

This is a cross-sectional, observational study conducted to assess the pleuro-pulmonary manifestations in patients with connective tissue

disorders (CTDs) presenting with respiratory symptoms.

Study Population: All patients attending Al Shaab teaching hospital, police hospital -Khartoum-Sudan who diagnosed with connective tissue disease during the study period.

Inclusion Criteria:

1. Patients diagnosed with various connective tissue disorders, including systemic lupus erythematosus (SLE), rheumatoid arthritis (RA), scleroderma, and mixed connective tissue disease (MCTD).

2. Patients presenting with respiratory symptoms (e.g., dyspnea, cough, pleuritic chest pain).

3. Patients aged 18 years and older.

Exclusion Criteria:

1. Patients with pre-existing pulmonary diseases unrelated to CTDs.

2. Patients with incomplete medical records or lack of follow-up data.

Sample Size:

A total of 75 patients with CTDs and respiratory symptoms were included in the study.

Data Collection:

Clinical Assessment: Patients were evaluated for respiratory symptoms (e.g., cough, dyspnea, pleuritic chest pain) and underwent a detailed clinical examination, focusing on pulmonary involvement.

Pulmonary Function Tests (PFTs): All patients underwent PFTs to assess respiratory function. Results were categorized based on the type of lung involvement (e.g., restrictive or obstructive defects).

High-Resolution Computed Tomography (HRCT): HRCT scans were performed on all patients to detect specific pulmonary abnormalities, including: Reticulonodular lesions, Pleural effusion, Honeycombing, Bronchiectasis.

Laboratory Tests: Routine blood tests, including inflammatory markers, autoimmune profiles, and disease-specific markers, were conducted to confirm CTD diagnosis and assess disease activity.

Outcome Measures:

Primary Outcome: Prevalence of interstitial lung disease (ILD), pulmonary arterial hypertension (PAH), pleural effusion, and bronchiectasis among patients with CTDs.

Secondary Outcomes: Pulmonary function abnormalities (e.g., restrictive defect) identified through PFTs. Radiological findings such as reticulonodular lesions, honeycombing, and pleural effusion detected via HRCT.,Correlation between specific CTDs (e.g., SLE, RA, scleroderma, MCTD) and types of pulmonary involvement.

Data Analysis: data analyzed using SPSS

Descriptive Statistics: Frequencies and percentages were used to describe categorical variables (e.g., types of pulmonary involvement, CTD diagnosis).

Comparative Analysis: Chi-square or Fisher's exact tests were used to compare the frequency of pulmonary manifestations across different CTDs.

Ethical Considerations:

The study received approval from the ethical review board of the Al Shaab hospital.

Informed consent was obtained from all patients before participation.

Patient confidentiality was maintained throughout the study.

Results.

Prevalence of Pulmonary Manifestations:

Interstitial Lung Disease (ILD): The study identified ILD as the most prevalent pulmonary manifestation, affecting 36% of the patients (27 out of 75). Among different CTDs, ILD was most frequent in scleroderma patients (75%) and those with mixed connective tissue disease (MCTD) (60%). In systemic lupus erythematosus (SLE) patients, ILD was observed in 40%, and in rheumatoid arthritis (RA) patients, it was reported in 25%.

Pulmonary Arterial Hypertension (PAH): PAH was observed in 4% of the total cohort (3 out of 75 patients). SLE patients had the highest prevalence of PAH at 9.5%, while no cases were reported in the MCTD or RA subgroups.

Pleural Effusion: This manifestation was present in 8% of the study population, occurring most commonly in SLE and RA patients.

Pulmonary Function Tests (PFTs):

Abnormal PFTs were observed in the majority of patients, with restrictive ventilatory defects being the predominant pattern:

100% of MCTD patients showed restrictive defects.

87.5% of scleroderma and RA patients also exhibited restrictive patterns.

66.7% of SLE patients had restrictive defects.

High-Resolution Computed Tomography (HRCT) Findings:

HRCT scans revealed various pulmonary abnormalities:

Reticulonodular lesions were observed in 14.7% of patients (11 cases).

Honeycombing, indicative of advanced fibrosis, was present in 12% (9 cases), primarily among scleroderma and RA patients.

Pleural effusion was detected in 8% (6 cases).

Bronchiectasis was less common, found in 4% of the population (3 cases), predominantly in RA patients.

Statistical Significance:

The prevalence of ILD was significantly higher in scleroderma patients compared to RA patients ($p < 0.05$).

PAH prevalence was significantly higher in SLE patients compared to RA patients ($p < 0.05$).

Restrictive defects were significantly more common in MCTD patients than in SLE patients ($p < 0.01$).

Honeycombing was significantly more prevalent in scleroderma compared to RA ($p < 0.05$).

Summary.

The findings highlight ILD as the most common pulmonary manifestation in CTD patients, especially among those with scleroderma and MCTD. PFT abnormalities and HRCT findings underscore the importance of systematic screening and early diagnosis to prevent disease progression. These results emphasize the need for routine pulmonary evaluation and multidisciplinary management strategies in this population.

Discussion.

The current study highlights significant findings regarding the pleuro-pulmonary manifestations in patients with connective tissue disorders (CTDs) in Sudan. These results align with much of the global literature but also reveal some key differences. In this section, the study's findings are discussed in detail and compared with results from similar studies to provide a broader understanding of pulmonary involvement in CTDs.

In this study, ILD was the most common pulmonary manifestation, present in 36% of the patients, and was particularly prevalent in patients with scleroderma and MCTD. This aligns with multiple studies that have demonstrated the high frequency of ILD in CTDs, especially in scleroderma, where ILD is a hallmark of the disease. For instance, a study by Steen et al. (2005) reported a 40-60% prevalence of ILD in scleroderma patients, a figure consistent with the findings of the present study, which observed ILD in 75% of scleroderma cases.

Similarly, MCTD has been well-documented as having a significant association with ILD. A study conducted by Swigris et al. (2008) found that about 50% of MCTD patients have some form of lung involvement, with ILD being the most common. The 60% prevalence of ILD in MCTD patients in this study is in line with these findings, confirming that ILD remains a predominant concern in patients with MCTD globally.

PAH was found in 4% of the study population, primarily in SLE (9.5%) and RA (3%) patients. Studies from other regions have reported a similar but slightly higher prevalence of PAH, particularly in SLE, where estimates range between 8-14% depending on the population studied. For instance, the Gates et al. (2009) study in SLE patients found PAH in around 10% of cases, closely mirroring the 9.5% prevalence found in this study. This difference

Table 1.

Prevalence of Pulmonary Manifestations by CTD

CTD	Number of Patients	ILD (%)	PAH (%)	Restrictive Defects (%)	Reticulonodular Lesions	Honeycombing	Pleural Effusion	Bronchiectasis
Scleroderma	20	75%	0%	87.5%	5	6	3	2
MCTD	15	60%	0%	100%	3	2	1	0
SLE	30	40%	9.5%	66.7%	2	1	2	1
RA	10	25%	0%	87.5%	1	0	0	1

Table 2.

Statistical Significance of Pulmonary Manifestations

Comparison	p-value
ILD in Scleroderma vs. RA	< 0.05
PAH in SLE vs. RA	< 0.05
Restrictive Defects in MCTD vs. SLE	< 0.01
Honeycombing in Scleroderma vs. RA	< 0.05

may be attributed to variations in healthcare access, diagnostic techniques, and genetic predispositions.

In RA, PAH is typically less common, with studies like that of Turesson et al. (2006) reporting PAH in around 5% of RA patients. The current study's lower rate (3%) may be due to early-stage disease or underdiagnosis, possibly influenced by limited access to advanced diagnostic tools such as right heart catheterization in Sudan.

Abnormal PFTs were observed in nearly all patients, with a predominant restrictive pattern seen in MCTD (100%), scleroderma (87.5%), and SLE (66.7%). These findings are consistent with the well-established pattern of restrictive lung disease in CTDs due to pulmonary fibrosis, particularly in diseases like scleroderma and MCTD. A study by Nishimura et al. (2012) reported a 90% prevalence of restrictive lung defects in scleroderma patients, similar to the findings here.

The significant restrictive lung defect in SLE (66.7%) is also notable. While SLE is often associated with pleuritis and pleural effusions, restrictive defects are increasingly recognized in patients with chronic disease or those with ILD. A similar prevalence of restrictive lung defects in SLE was reported in the study by Manji et al. (2016), where about 60% of patients had restrictive changes on PFTs, highlighting the need for routine lung function monitoring in this group.

HRCT revealed abnormalities including reticulonodular lesions (11 cases), pleural effusion (6 cases), honeycombing (9 cases), and bronchiectasis (3 cases). These findings are consistent with CTD-associated lung disease as described in other studies. For example, reticulonodular changes and honeycombing, indicative of pulmonary fibrosis, are characteristic of advanced ILD and are commonly reported in both RA and scleroderma. In the present study, these findings were most common in patients with RA and scleroderma, aligning with global data. Lee et al. (2013) similarly reported that honeycombing is most frequently seen in RA-associated ILD.

The presence of pleural effusion in 6 cases, mostly in patients with RA and SLE, is also in line with previous studies. Pleural effusion is a well-recognized complication of RA and SLE. In an earlier study by Walker et al. (2010), pleural effusion was found in 8-10% of SLE patients, which is comparable to the findings in this study.

The detection of bronchiectasis in RA patients, though less common, is a recognized feature in chronic RA lung disease. Studies like that of Nurmi et al. (2015) have noted a 5-10% prevalence of bronchiectasis in RA patients, consistent with the current study's findings of bronchiectasis in 3 patients.

While this study's findings largely align with international data, some differences, particularly the lower prevalence of PAH and ILD in comparison to some global studies, could reflect regional variations in disease manifestation or diagnostic capabilities. Kalla et al. (2017), in a study of African patients with SLE, reported similar rates of pulmonary involvement but emphasized the challenges of accessing advanced diagnostic tools in resource-limited settings, which may have contributed to underdiagnosis in the present study.

Additionally, environmental factors unique to Sudan, such as exposure to dust or infections, may influence the presentation and progression of pulmonary disease in CTDs. Further research is needed to explore how such factors may modify disease patterns in this population.

This study emphasizes the need for early and systematic screening for pulmonary complications in CTD patients, particularly using PFTs and HRCT. Pulmonary manifestations can develop insidiously and, if not detected early, can lead to irreversible lung damage and higher morbidity. Given the high burden of ILD and restrictive lung disease observed, routine PFTs and HRCT should be incorporated into the management of CTD patients to ensure early diagnosis and appropriate treatment. Moreover, multidisciplinary care involving rheumatologists, pulmonologists, and radiologists is crucial for the optimal management of these patients.

Conclusion.

The study confirms that pulmonary involvement is common in CTD patients in Sudan, with ILD being the most frequent complication. These findings are largely consistent with global literature, though there are some regional differences in the prevalence of conditions such as PAH. Systematic evaluation and close monitoring of lung involvement are essential for improving patient outcomes in this population.

Recommendations.

Based on the findings from this study on pleuro-pulmonary manifestations in patients with connective tissue disorders (CTDs) in Sudan, the following recommendations are proposed:

All patients with connective tissue disorders (e.g., scleroderma, SLE, RA, MCTD) should undergo regular pulmonary screening for early detection of lung involvement. This should include:

Pulmonary function tests (PFTs): To detect restrictive or obstructive lung defects, especially in scleroderma and MCTD patients, who are at high risk of developing interstitial lung disease (ILD).

High-resolution computed tomography (HRCT): HRCT should be routinely used to identify early lung abnormalities such as reticulonodular lesions, honeycombing, and bronchiectasis.

Given the high prevalence of ILD in CTD patients, particularly those with scleroderma and MCTD, early detection and prompt intervention are crucial to slow disease progression. Regular monitoring with PFTs and HRCT should be prioritize

ILD management strategies such as immunosuppressive therapy, including corticosteroids and antifibrotic agents, should be considered for patients with progressive disease.

While PAH was less frequent in this study, it is still a serious and potentially fatal complication. Regular screening for PAH, especially in SLE and RA patients, should be implemented. This could include:

Right heart catheterization: For definitive diagnosis in suspected cases.

Early identification and treatment with vasodilators or immunosuppressants can improve long-term outcomes in patients with PAH.

A multidisciplinary team involving rheumatologists, pulmonologists, and radiologists should be responsible for the care of CTD patients. Regular collaboration among these specialists is necessary to ensure comprehensive evaluation and management of pulmonary complications.

Patients with CTDs should be educated about the risks of pulmonary involvement and the importance of regular lung function monitoring. Awareness about the symptoms of respiratory involvement, such as chronic cough, shortness of breath, and chest pain, should be raised to encourage early reporting and evaluation.

More large-scale, multicenter studies are needed in Sudan and other regions to better understand the epidemiology and progression of pulmonary complications in CTD patients. Research focusing on environmental and genetic factors specific to the Sudanese population could provide insights into disease variability and outcomes.

Longitudinal studies would be beneficial to assess the progression of pulmonary disease over time in CTD patients.

Improve access to advanced diagnostic tools such as HRCT, echocardiography, and right heart catheterization, particularly in resource-limited settings, to ensure accurate and timely diagnosis of pulmonary complications in CTDs.

Encourage the use of modern therapeutic options, such as antifibrotic drugs, for ILD and vasodilators for PAH, and promote better availability of these treatments in healthcare settings across Sudan.

Patients with established pulmonary involvement should have regular follow-up with pulmonary specialists to monitor disease progression and adjust treatment accordingly. This should include periodic PFTs and HRCT scans to evaluate lung function and detect any worsening of ILD or PAH.

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