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Thoracic Ultrasonography As A Diagnostic Tool In Post-Tuberculosis Lung Disease: Validation Against Spirometry

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Abstract:
Background: *Post Tuberculosis Lung Disease (PTLD) are anatomical and pathophysiological change in the lung which is secondary to complications of TB. The primary aim is to correlate lung ultrasound findings with spirometry and chest CT.*
Material and methods: *This study was conducted on 50 symptomatic patients with chest radiographic &/or CT thorax abnormalities following treatment of Pulmonary tuberculosis and tubercular pleural effusion presenting to outpatient clinic or admitted at The School of Excellence in Pulmonary Medicine, Netaji Subhas Chandra Bose Medical College and Hospital, Jabalpur, MP, India. Detailed history was taken and basic blood investigations, chest x ray/ CT thorax, SGRQ scoring and later USG assessment for thorax and diaphragm was done followed by spirometry evaluation before discharge.*
Result: *In this study, majority of patient were male who belong to age group of 45-64 years. We observed a Cohen's k of 0.322 which indicates that there was a fair agreement between USG and Spirometry interpretation which was statistically significant ($p<0.05$). Also the cases with restrictive patterns in spirometry, median USG score was higher compared to cases with Obstructive pattern in spirometry.*
Conclusion*: In this study, we found that post TB lung disease patients had decreased thickening ratio of diaphragm on USG assessment which points towards obstructive pathology of lungs which was further found in concordance with spirometry findings. Early assessment with USG can be done to alleviate their condition and make their life better.*
Keywords: *Post-Tuberculosis Lung Disease, Spirometry, Thoracic Ultrasonography.*

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I. Introduction

An estimated 58 million people have survived tuberculosis since 2000, yet many of them will suffer from post-tuberculosis lung disease (PTLD) [1]. PTLD is an overlapping spectrum of disorders that affects large and small airways (bronchiectasis and obstructive lung disease), lung parenchyma, pulmonary vasculature, and pleura and may be complicated by co-infection and haemoptysis [2]. People affected by PTLD have shortened life expectancy and increased risk of recurrent tuberculosis, but predictors of long-term outcomes are not known [3]. No data are available on PTLD in children and on impact throughout the life course. Due to a lack of controlled trials in this population, no evidence-based recommendations for the investigation and management of PTLD are currently available. Exacerbations in PTLD remain both poorly understood and under-recognised. Advocacy is needed to increase recognition for PTLD and its associated economic, social, and psychological consequences and to better understand how PTLD sequelae could be mitigated. Research is urgently needed to inform policy to guide clinical decision-making and preventative strategies for PTLD. The impact of post-TB sequelae is not only restricted to clinical outcomes but also includes the quality of life and psycho-social well-being.

There is insufficient data on post TB radiological sequelae. The aim of this study is to evaluate the post TB sequelae on chest ultrasound in patients who had completed the treatment for pulmonary and pleural TB at a tertiary care hospital of a high TB burden country. Lung ultrasound is an examination that allows the assessment of pulmonary involvement by analysing artefacts [5]. The primary aim is to correlate lung ultrasound findings

with spirometry and chest CT (wherever available). Among the methods in use to evaluate the structure and evolution of lung deterioration, there is chest x-ray and chest high-resolution computed tomography (HRCT), which is considered as the accepted standard option [5,6,7.] However, HRCT chest has numerous limitations, such as the use of radiation, restricting periodic reproduction of the exam, and anaesthesia in infant and preschooler children, as well as the high cost of the procedure [8]. In this context, there is a need to search for new methods to evaluate pulmonary damage in post tuberculosis lung disease, such as lung ultrasound. We found no studies on the use of lung ultrasound to evaluate or compare lung deterioration in PTLD. However, it is known that the presence of air in the lungs and calcium in the bone structure hinder pulmonary evaluation and the use of ultrasound treatment for respiratory disease because it limits the reach of the ultrasound beam, producing images with artifacts [9]. Technological advances in ultrasound transducer geometry, along with an understanding of artifacts that allows the evaluation of mediastinal and pleural lung lesions with acoustic anatomical windows (ie, supraclavicular, suprasternal, parasternal, and intercostal spaces) allow better evaluation of lung structures [10]. Until now, the most widely used request for lung ultrasound is to detect pleural effusion.

Lung ultrasound has several benefits. It is safe and free of any adverse effects, thus allowing serial evaluation. Lung ultrasound reduces radiation exposure, hospital cost, no need for sedation as well as less time consuming.

Important quantitative aspects of respiratory function are the changes in lung volume with inspiration and expiration and the absolute volume of air that lungs hold at various times during respiratory cycle. It defines pulmonary functional limitations in terms of obstruction and restrictions based on spirometry data. Lung USG findings have to be correlated with it and also to assess the impact of the disease on quality of life and psychosocial wellbeing via SGRQ, so that the overall impact and effect of the disease can be evaluated.

The primary objective of this study was to evaluate thoracic ultrasonography findings in stable Post-TB Lung Disease (PTLD) patients, with secondary objectives including correlating these findings with quality of life, Spirometric variables, radiologic abnormalities, and, where available, CT Chest results.

II. Materials And Methods

This cross-sectional study was carried out on 50 patients admitted in the department of Respiratory Medicine, School of excellence in Pulmonary medicine (SEPM), Netaji Subhash Chandra Bose Medical College & hospital, Jabalpur M.P) after taking ethical clearance from Institutional Ethical Committee. The study duration was of 1.5 years from 30th August 2022 to 20th February 2024. We evaluated the cases of PTLD via thoracic ultrasonography followed by spirometry and also evaluated the quality of life via SGRQ (Saint George Respiratory Questionnaire). All patients who had microbiologically or clinicoradiologically proven and treated pulmonary tuberculosis and tubercular pleural effusion was included in the study. Patients with active tuberculosis or active pulmonary infection, prior diagnosis of asthma or COPD, bronchiectasis due to non-tubercular causes, interstitial lung disease, pneumoconiosis (silicosis, coal miner's pneumoconiosis, and asbestosis and other causes of pulmonary fibrosis, history of thoracotomy, patients not willing to give consent were excluded from the study.

The age, gender, symptoms, CBC, KFT, LFT, exposure to biomass and tobacco, addiction history, history of antitubercular drug intake, history of exacerbation and hospitalization and treatment history was obtained at the time of admission. After admission ultrasonographic assessment of thorax was done and chest x ray antero-posterior view was obtained. Before discharge, spirometric evaluation was done of these patients.

USG was performed for every patient and results were analysed. All the data was recorded by using structured schedule and tabulated in Microsoft Excel sheet. Statistical analysis was done by appropriate statistical software using relevant test of statistical analysis.

III. Result

In this study, maximum number of the cases 14 patients (52%) were in 45-64 years age group, 12 patients (24%) in 45-54 years age group, 9 patients (18%) in 35-44 years age group, 9 patients (18%) in 65-75 years of age group, 3 patients (6%) in 15-24 years of age group and 3 patients (6%) in 25-34 years of age group with mean age of 49.69+-13.79 years. There were 43 (86%) male and 7 (14%) female patients, with male to female ratio of 43:7.

35 patients (70%) were smoker, 5 patients (10%) had biomass exposure, 3 patients (6%) were non-smokers, 3 patients (6%) were tobacco chewer, 2 patients (4%) were alcoholics and 2 patients (4%) had no addiction. All the 50 patients (100%) had presented with dyspnoea, followed by cough in 48 cases (96%), chest pain in 41 cases (82%) and haemoptysis in 6 cases (12%). 43 patients (86%) had pulmonary tuberculosis, 5 patients (10%) had tubercular pleural effusion and 2 patients (4%) cases had pulmonary tuberculosis with tubercular pleural effusion. 47 patients (94%) had drug-sensitive tuberculosis and 3 patients (6%) had multiple drug-resistant tuberculosis. Mode of diagnosis of tuberculosis was, 26 cases (52%) were smear positive, 14 (28%) cases were diagnosed clinical radiologically, 9 cases (18%) were CBNAAT positive, 1 case (2%) were both smear and CBNAAT positive. 46 cases (92%) were given single course of ATT, and 4 cases (8%) were given two courses

of ATT. Comorbidities associated were, hypertension in 15 cases (30%), diabetes in 14 cases (28%), asthma in 1 case (2%), RVD in 1 case (2%), bronchiectasis in 1 case (2%%) and 21 cases (42%) had no comorbidity.

TABLE NO.01: Findings on chest X-Ray

Chest X ray		Number	Percentage
Lung involvement	Left	23	46%
	Right	25	50%
	Bilateral	2	4%
Type	Apical	26	52%
	Whole	21	42%
	No specific	3	6%
Volume loss	Yes	21	42%
	No	29	58%
Pleural calcification	Yes	7	14%
	No	43	86%
Parenchymal calcification	Yes	40	80%
	No	10	20%

Table no. 01 depicts, 23 cases (46%) had left lung, 25 cases (50%) had right lung and 2 cases (4%) had both lungs involvement. Volume loss was seen in 21 cases (42%), pleural calcification in 7 cases (14%) and parenchymal calcification in 10 cases (20%).

TABLE NO.02: Findings on USG

USG chest		Number	Percentage
Score (mean±SD)		4.00(1.00-10.00)	
Pleural irregularity	No	43	86%
	Yes	7	14%
Pleural effusion	No	45	90%
	Yes	5	10%
Left thickening ratio (median IQR)		1.57±0.19	
Right thickening ratio (median IQR)		1.63±0.20	
Total		50	100%

Table no. 02 depicts, USC findings with pleural irregularity was seen in 7 cases (14%) and pleural effusion in 5 cases (10%). The median USG score was 4 (1-10). The mean left thickening ratio was 1.5740.19 and right thickening ratio was 1.63:0.20.

TABLE NO.03: Spirometry pattern

Spirometry pattern	Number	Percentage
Obstructive	37	74%
Restrictive	13	26%
Total	50	100%

Table no. 03 depicts, 37 cases (74%) showed obstructive patterns and 13 cases (26%) showed restrictive pattern in spirometry pattern.

TABLE NO.04: SGRQ components scoring

Components of SGQR		Number	Percentage
Current health	Fair	7	14%
	Poor	25	50%
	Very poor	18	36%
Chest symptoms in 3 months	Few days a month	6	12%
	Several days a week	27	54%
	Most days a week	17	34%
Description of chest problem	Few problems	7	14%
	Very problematic	25	50%
	Biggest problem	18	36%
Total		50	100%

Table no. 04 depicts, 3 components of SGRQ scoring, where for current health component, 25 cases (50%) had poor health, 18 cases (36%) had very poor health and 7 cases (14%) had fair health. 17 cases (349%) had chest symptoms most days a week, 27 cases (54%) several days a week and 6 cases (12%) have few days a week.

TABLE NO.05: Association of spirometry findings with USG interpretation

USG interpretation	Spirometry		Total
	Obstructive	Restrictive	
Normal	2(100%)	0	2(100%)
Obstructive	25(86.2%)	4(13.8%)	29(100%)
Restrictive	10(52.6%)	9(47.4%)	19(100%)

Table no. 05 depicts, Cohen's k of 0.322, which indicates that there was a fair agreement between USG and Spirometry interpretation and which was statistically significant ($p<0.05$).

TABLE NO.06: Association of spirometry findings with USG interpretation

Spirometry	USG Score		P value
	Median	IQR	0.079
Obstructive	2.00	1.00-8.00	
Restrictive	8.00	4.00-12.00	

Table no. 06 depicts, among cases with restrictive patterns in spirometry, median USG score was higher as compared to cases with obstructive pattern in spirometry, although this difference was statistically insignificant using Mann-Whitney test (>0.05).

TABLE NO.07: Association of SGRQ with USG score

Components of SGQR		Median	IQR	P value
Current health	Fair	2	6.00-10.00	0.832
	Poor	2	1.00-10.50	
	Very poor	4	1.00-10.00	
Chest symptoms in 3 months	Few days a month	3	1.50-7.00	0.677
	Several days a week	4	1.00-10.00	
	Most days a week	4	1.00-13.50	
Description of chest problem	Few problems	2	0.00-6.00	0.393
	Very problematic	4	1.00-10.00	
	Biggest problem	5	1.00-12.25	

Table no. 07 depicts, on comparing the median USG score between subcomponents of SGRQ, there was no significant difference in median USG score between cases using Kruskal-Walis.

TABLE NO.08: Association of mode of diagnosis with extent of lung involved

Mode of diagnosis	Apical	Whole	No involvement	Total
CBNAAT +ve	3(33.3%)	4(44.4%)	2(22.2%)	9(100%)
Clinicoradiologically	6(42.9%)	7(50%)	1(7.1%)	14(100%)
Smear +ve	16(61.5%)	10(38.5%)	0	26(100%)
Smear & CBNAAT +ve	1(100%)	0	0	1(100%)
Grand total	26	21	3	50

Table no. 08 depicts, among cases with CBNAAT positive, apical part was involved in 3 cases (33.3%), whole lung was involved in 4 cases (4.4%) and 2 cases (22.2%) had no lung involvement. Among smear positive cases, apical part was involved 16 cases (61.5%), and in 10 cases (38.5%) whole lung was involved.

TABLE NO.09: Median USG score with different mode of diagnosis

Mode of diagnosis	USG score	Test of significance
CBNAAT +ve (n=9)	1(0.5-10)	0.384
Clinicoradiological (n=14)	5(1-11.25)	
Smear +ve (n=26)	4(2-8.5)	
Smear & CBNAAT +ve (n=1)	1(1-1)	

Table no. 09 depicts, the median USG score among cases diagnosed clinic-radiologically was 5, in smear positive cases was 4, in CBNAAT positive cases was 1 and smear & CBNAAT positive cases was 1. There was no significant difference in median USG score among cases diagnosed with different modalities (>0.05).

IV. Discussion

In our study, 52% of cases were in 45-64 years age group and least 12% of cases were in age group of 15-34 years age group. The mean age was 49.69+-13.79 years. Majority, 86% of patients were male, and 14% were female. Maximum patients (70%) were smoker, 5(10%) patients have biomass exposure, 3(6%) were non-smoker and 2(%) had no addiction history. Since majority of patients had exposure history, its contribution in their current health status not clear.

In this study, 100% cases presented with dyspnoea, followed by cough in 96% cases, chest pain in 82% and haemoptysis in 12% cases in our OPD. 86% of cases had a history of pulmonary tuberculosis, 10% cases had history of tubercular pleural effusion and 4% cases had history of Pulmonary tuberculosis with tubercular pleural effusion. 94% of cases had a history of drug-sensitive tuberculosis in the past and only 6% of cases had a history of multiple drug-resistant tuberculosis. Patients with history of MDR tuberculosis had more extensive lesion leading to increased morbidity. 52% of cases were diagnosed on the basis of sputum smear for acid fast bacilli (AFB) positivity, while 28% (who took ATT) on the basis of clinicoradiological findings and 18% were diagnosed by CBNAAT. Among cases with CBNAAT +ve, apical part was involved in 33.33% of cases, whole lung was involved in 44.4% of cases and 22.2% had no lung involvement. Among cases with history of sputum smear positive tuberculosis, apical part was involved in maximum cases i.e, 61.5% of cases and whole lung was involved in 38.5% of cases. The median USG score in cases with tuberculosis diagnosed clinicoradiologically was 5, in cases with history of smear positive was 4, and least USG score of 1 was seen in CBNAAT positive cases and smear & CBNAAT positive cases. There was no significant difference found in median USG score among cases diagnosed with different modalities ($p>0.05$). 92% had history of one course of ATT (after which their treatment was declared complete), while 8% had history of two course of ATT (the second course of ATT taken was first line as they had a history of relapse after the completion of first course of ATT intake). Bronchiectasis and asthma was not present prior to the occurrence of pulmonary tuberculosis, RVD was diagnosed while routine investigation for diagnosis of pulmonary tuberculosis was being done in the past. Additional contribution of these comorbidities in the current health status of these patients need further evaluation and study.

In our study, almost equal cases were seen with left (46%) and right (50%) side involvement, hence, no predisposition regarding laterality of condition can be commented upon. 4% of cases had bilateral involvement and 42% had whole lungs involvement. 42% cases had volume loss on radiographic film with parenchymal calcification in 80% of cases and pleural calcification in 14% of cases. Calcification is found in those cases who had history of tubercular pleural effusion with or without pulmonary involvement. Upon thoracic ultrasonography. pleural irregularity was seen in seven 14% of cases while pleural effusion was seen in 10% of cases and in rest of patients, USG depicted the presence of fibrosis and/or consolidation or neither of these. On this basis, USG Scoring was done after examining all twelve sections of thorax. The median USG score was 4 (1-10). USG of the diaphragm was also conducted bilaterally and thickening ratio was calculated. The mean left thickening ratio was 1.57+-0.19 and the right thickening ratio was 1.63 +-0.20. Those with thickening ratio >=1.8 have no evidence of obstructive lung pathology which is similar to the findings of the study conducted earlier in Turkey by Topewoğlu C, Yümin ET, Hizal M, Konuk S. This was published in 2022 in Turkey Journal of medicine. Those with thickening ratio less than 1.60 on the left side and less than 1.65 on the right side had presented with obstructive pathology. It is similar to the findings of the study mentioned above. Such patients did not have marked lung fibrosis found on ultrasound study of thorax.

In our study spirometry was conducted before discharging the patient. 74% cases showed obstructive pattern and 26% cases showed restrictive pattern. To study the association between spirometry findings and USG, interpretation, Cohen's k was calculated. In our study, after USG study of thorax and diaphragm, 58% cases were interpreted as having obstructive pathology, out of which 25 (86.2%) were confirmed to have the same after spirometric evaluation. 38% cases were interpreted to have restrictive pathology after USG study out of which 9 (47.4%) were confirmed as having the same after spirometric evaluation.

In our study Cohens k of 0.322 indicates that there was a fair agreement between USG and spirometry interpretation and this agreement was statistically significant ($p<0.05$). In our study, patients with obstructive pathology as per spirometry had median USG score of 2.00 (IQR 1.00-8.00) and those with restrictive pathology according to spirometry had median USG score of 8.00 (QR 4.00-12.00). Among cases with restrictive pattern in spirometry median USG score was higher as compared to the cases with obstructive pattern on spirometery, although this difference was statistically insignificant using Mann- Whitney test ($p>0.05$). Presence of consolidation in patients with obstructive lesions as per spirometry, lead to increase in the IQR of the USG score, making the difference between median USG score for both the patterns statistically insignificant.

In our study, SGRQ was used to assess the quality of life of the patient. For current health component, 50% cases had poor health, followed by very poor health in 36% cases, and rest 14% had fair current health. 34% had chest symptoms on most days a week, 54% had it on several days of week and 12% had chest symptoms on few days of a week. 50% of subjects described the chest problem as very problematic compromising their work and daily life while 36% of subjects reported it as their biggest problem currently which shows the extent to which their everyday life is compromised. The current study points towards the poor quality of life with low productivity among most of PTLD patients, which was found in the observational study conducted at a tertiary care centre in north India done by Agarwal et al. where patients of age more than 18 years with history of pulmonary TB were included in the study and persistent respiratory symptoms, radiographic and spirometric abnormalities, were present in most of the PTLD patients as a sequelae. Quality of life as measured by SGRQ and SOLQ questionnaires was found to be significantly impaired in the majority of patients.

In our study, we compared the median USG score between subcomponents of SGRQ. There was no significant difference noted in median USG score between the cases using Kruskal-Wallis test ($p>0.05$). Therefore, the USG scoring median does not show significant correlation with the quality of life which was assessed based on subjective perception of people regarding their current health via SGRQ.

V. Conclusion

In our study, correlation was found between spirometry report and USG assessment of thorax. In this study we found that post TB lung disease patients had decreased thickening ratio of diaphragm on USG assessment which pointed towards obstructive pathology of lungs which was further found in concordance with spirometry findings. In our study, we found that majority of our patients had poor quality of life as assessed by SGRQ, which was interfering with their daily life and productivity. Thus, early assessment with USG can be done to alleviate their condition and make their life better.

Limitations

Our study had some limitations which are small number of study population was taken as most had had one or more exclusion criteria, status the extent to which the coexistence of addictions like smoking, alcohol intake along with the condition of post TB lung disease would have further affected the overall health and contributed to the ill health of patients was not studied separately in this study. Majority of comorbidities which contributes to the patient's current health scenario was not assessed separately. There was no objective assessment done to know the quality of life of the patient. Contributory socioeconomic and educational factor in the current condition of the patient was not assessed. Data collection for the current study took place in a single tertiary centre, hence the result cannot be extrapolated.

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