Original Article

Pattern and Severity of Pulmonary Function Impairment in Patients with Post-Tuberculosis Lung Disease

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ABSTRACT

Objective: To determine the pattern and severity of pulmonary function impairment in patients with post-tuberculosis lung disease.

Study Design: Descriptive cross-sectional study.

Place and Duration of Study: This study was conducted at the Department of Pulmonology, Liaquat University of Medical and Health Sciences, Jamshoro, from Dec 2022 to Jan 2024.

Methods: The patients were selected using non-probability consecutive sampling, totalling 185 patients who had previously undergone anti-tuberculous (AT) therapy for pulmonary tuberculosis for at least six months. A structured proforma was used for the collection of demographic and clinical data. Spirometry was performed to determine pulmonary function, and ventilatory patterns were classified as obstructive, restrictive, mixed or normal.

Results: Mean age of the patients 43.7 ± 12.5 years and 112 (60.5%) were male. Forty-nine (29.5%) patients had pulmonary function abnormalities and 36 (19.5%) had normal pulmonary function. The most common spirometric pattern was the obstructive ventilatory defect, seen in 72 (38.9%) patients, followed by the restrictive defect, seen in 49 (26.5%) patients and the mixed ventilatory defect, seen in 28 (15.1%) patients. The majority of severity were moderate pulmonary impairment. There was significant association between smoking history, recurrent tuberculosis and extensive radiological fibrosis with the presence of abnormal pulmonary function ($p<0.05$). Mean FEV1 values were significantly lower among smokers compared to non-smokers (58.4 ± 14.7% vs 66.9 ± 13.2%, $p=0.003$).

Conclusion: Pulmonary function impairment is very common in patients with PBLD, and is most commonly characterized by an obstructive ventilatory defect. The impairment is worsened by smoking, recurrent TB and fibrotic lung changes. The post-tuberculous management should include routine spirometric assessment and long-term respiratory follow up for early diagnosis and treatment of chronic pulmonary sequels.

Key Words: Pulmonary tuberculosis, Post-tuberculosis lung disease, Spirometry, Pulmonary function impairment, Obstructive ventilatory defect, Chronic respiratory disease.

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INTRODUCTION

Tuberculosis (TB) is one of the leading infectious diseases causing morbidity and mortality worldwide and is still a significant public health problem globally[1].

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Although diagnosis and treatment have progressed considerably, tuberculosis of the lungs often leads to persistent lung damage and disease despite being cured of the infection. There is growing evidence that many patients who have completed an effective anti-tuberculous therapy still have ongoing respiratory symptoms, exercise intolerance and chronic pulmonary impairment, which is now known as Post tuberculosis Lung Disease (PTLD) [2,3].

Post-tuberculosis lung disease refers to a wide range of residual pulmonary abnormalities, such as fibrosis, bronchiectasis, cavitary destruction, pleural thickening, airway stenosis and emphysematous changes. These pathological alterations may lead to irreversible impairment of pulmonary function and substantial deterioration in quality of life. Pulmonary TB survivors have been shown to have obstructive, restrictive or combination (mixed) ventilatory defects on spirometry[4]. The burden of pulmonary impairment among TB survivors is a significant one, as noted by a recent systematic review and meta-analysis[5,6]. A high

percentage of treated TB patients still had abnormal spirometric results, with obstructive and mixed ventilatory patterns in particular being common, according to Ivanova et al[2]. In addition, there was evidence of significant lung damage in around 10-15% of the TB survivors, highlighting the long term respiratory impacts of TB[8]. In another recent meta-analysis, it was found that patients with TB had significantly lower FEV1 and FVC following the recovery than healthy controls, suggesting that the pulmonary reserve was lost and there is a persistent airflow limitation. [9]

PTLD is of special relevance in countries with high tuberculosis prevalence and limited healthcare resources in low- and middle-income countries. Factors such as delayed diagnosis, recurrent infection, smoking, multidrug-resistant tuberculosis, malnutrition, and poor socioeconomic conditions may further increase the risk and severity of post-tuberculous pulmonary dysfunction[10]. With the growing number of tuberculosis survivors in the South Asian countries like Pakistan, the provision of long-term respiratory health services becomes a significant challenge. However, there is a lack of recognition and study of the sequelae of TB after successful treatment in the local population.

PFTs, especially spirometry, are a simple, non-invasive and reliable way of quantifying the nature and distribution of lung impairment in post-TB patients. Spirometric abnormalities may help identify patients who are at risk of developing chronic respiratory disability earlier in the disease process, for further follow-up, and for targeted interventions to prevent chronic respiratory disability.[11]

There is little information available in the area regarding the severity or pattern of changes in pulmonary function after TB treatment. Several international studies have been conducted to evaluate lung damage following TB treatment; nevertheless, there is a dearth of information regarding the pattern and severity of anomalies in pulmonary function in individuals with post-TB lung illness, particularly in Pakistan. In order to improve respiratory care following TB with long-term therapy, this study sought to evaluate the pattern and degree of pulmonary function decline in post-TB lung illness using spirometric measurement.

METHODS

This descriptive cross-sectional study was conducted in the Department of Pulmonology, Liaquat University of Medical and Health Sciences, Jamshoro from December 2022 to January 2024. The study included patients who were between the ages of 18 and 70, had a history of pulmonary TB, had finished anti-tuberculous treatment at least six months before being enrolled, and had a history of respiratory symptoms or radiological suspicion of post-tuberculosis lung disease. Those with active TB, bronchial asthma diagnosed prior to TB, known ILD, lung malignancy, acute respiratory infection less than 4 weeks prior to study, past thoracic surgery, severe cardiac disease and who didn't have satisfactory spirometry were excluded.

The sample size was determined from the single population proportion formula with a presumed proportion of post tuberculosis patients with pulmonary function impairment of 50%, 95% level of confidence and a margin of error of 7.5% based on limited local data[12]. The calculated sample size was 171 patients, with additional allowance for incomplete spirometry or missing data, the final sample size was raised to 185 patients. Eligible participants were recruited using non-probability consecutive sampling. Written informed consent was obtained from all participants before enrolment.

The data collection was done using a structured proforma, which included details of age, gender, place of residence, smoking habit, BMI, duration since the completion of TB treatment, past treatment category, TB recurrence, current respiratory symptoms, and relevant radiological features. Standard acceptability and reproducibility criteria were used for the measurement of pulmonary function with a calibrated spirometer. Forced vital capacity, forced expiratory volume in one second and FEV1/FVC ratio were taken. Spirometric patterns were classified into obstructive, restrictive, mixed or normal. Severity was classified based on percentage predicted values.

SPSS version 26.0 was used to analyze the data. Data for quantitative variables were provided as mean ± standard deviation, whereas data for qualitative factors were presented as frequencies and percentages. The relationship between pulmonary function impairment and clinical variables was evaluated using the chi-square test. The independent sample t test was used to evaluate and compare continuous data. To find variables that were independently linked to poor pulmonary function, multivariable logistic regression was used. A statistically significant p-value was regarded as ≤ 0.05. The institutional review board of LUMHS, Jamshoro, approved the ethical considerations.

RESULTS

There were 185 patients in all. The majority of patients were between the ages of 31 and 50, with a mean age of 43.7 ± 12.5 years. There were 73 (39.5%) females and 112 (60.5%) males. Of the patients, 68 (36.8%) had a history of smoking. The mean BMI was 22.1 ± 4.3 kg/m².

Persistent respiratory symptoms were common among study participants. Dyspnea was the most frequently reported symptom and was observed in 128 (69.2%) patients, followed by chronic cough in 111 (60.0%), sputum production in 84 (45.4%), wheezing in 51

(27.6%), and hemoptysis in 14 (7.6%) patients. Radiological abnormalities suggestive of post-tuberculous sequelae were identified in the majority of participants, with fibrotic changes and bronchiectatic lesions being the most common findings. Table-2

Table No. 1: Demographic and Clinical Characteristics (n=185)

Variables	Frequency (%) / Mean ± SD
Age (years)	43.7 ± 12.5
18–30 years	38 (20.5%)
31–50 years	96 (51.9%)
>50 years	51 (27.6%)
Male	112 (60.5%)
Female	73 (39.5%)
Smokers	68 (36.8%)
Non-smokers	117 (63.2%)
BMI (kg/m²)	22.1 ± 4.3
Duration since TB treatment completion	3.8 ± 2.1 years

Table No. 2: Clinical Symptoms and Radiological Findings Among Study Participants (n=185)

Variables	Frequency (%)
Dyspnea	128 (69.2%)
Chronic cough	111 (60.0%)
Sputum production	84 (45.4%)
Wheezing	51 (27.6%)
Hemoptysis	14 (7.6%)
Fibrotic changes on imaging	102 (55.1%)
Bronchiectatic changes	74 (40.0%)
Cavitary lesions	29 (15.7%)
Pleural thickening	21 (11.4%)

Table No. 3: Spirometric Patterns and Severity of Pulmonary Function Impairment (n=185)

Variables	Frequency (%)
Normal spirometry	36 (19.5%)
Abnormal spirometry	149 (80.5%)
Obstructive pattern	72 (38.9%)
Restrictive pattern	49 (26.5%)
Mixed ventilatory defect	28 (15.1%)
Mild impairment	51 (34.2%)
Moderate impairment	61 (40.9%)
Severe impairment	37 (24.8%)

Pulmonary function abnormalities were detected in 149 (80.5%) patients, whereas only 36 (19.5%) patients demonstrated normal spirometric findings. Obstructive ventilatory defect was the predominant spirometric pattern observed in 72 (38.9%) patients, followed by restrictive defect in 49 (26.5%) and mixed ventilatory defect in 28 (15.1%) patients. Among patients with abnormal pulmonary function, moderate impairment was the most frequent severity category, identified in 61 (40.9%) patients, while severe impairment was observed in 37 (24.8%) patients. Table-3.

The mean forced expiratory volume in one second (FEV1) was significantly reduced among smokers compared to non-smokers (58.4 ± 14.7% predicted vs 66.9 ± 13.2% predicted, p=0.003). Similarly, patients with recurrent tuberculosis demonstrated significantly lower mean FEV1 and FVC values compared to those without recurrence ($p<0.05$). A statistically significant association was observed between duration since completion of tuberculosis treatment and severity of pulmonary impairment, with greater impairment noted among patients with longer disease duration (p=0.021). Table-4

Table No. 4: Comparison of Pulmonary Function Parameters According to Clinical Variables

Variables	Mean FEV1 (% Predicted)	Mean FVC (% Predicted)	p-value
Smokers	58.4 ± 14.7	64.2 ± 13.5	0.003
Non-smokers	66.9 ± 13.2	71.6 ± 12.8	
Recurrent TB	54.7 ± 15.1	60.3 ± 14.4	0.001
Non-recurrent TB	67.1 ± 12.9	72.8 ± 12.1	

Smoking history, recurring tuberculosis, and severe radiological fibrosis were found to be independent predictors of poor pulmonary function using multivariable logistic regression analysis. While recurrent tuberculosis was linked to a 2.9-fold greater risk of severe pulmonary impairment (AOR: 2.9, 95% CI: 1.4–5.8, p=0.006), smoking increased the likelihood of pulmonary function impairment by around 2.4 times (AOR: 2.4, 95% CI: 1.2–4.9, p=0.014). Table 5

Table No. 5: Multivariable Logistic Regression Analysis for Predictors of Pulmonary Function Impairment

Variables	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
Smoking history	2.4	1.2–4.9	0.014
Recurrent tuberculosis	2.9	1.4–5.8	0.006
Extensive fibrosis	3.1	1.5–6.2	0.002
Duration since TB treatment >5 years	1.8	1.1–3.7	0.021

DISCUSSION

The current study revealed that the burden of pulmonary function impairment was high in patients with post tuberculosis lung disease and abnormal spirometry was seen in 80.5% of patients. Chushkin et al[13] found pulmonary impairment in 47.7% of treated tuberculosis patients, which was lower than our findings. Similarly, Lema et al found abnormal pulmonary function in 47.3% of patients following completion of treatment[14]. This may be due to higher numbers of patients in our study being recruited from hospital with symptoms of disease, delayed presentation, recurrent disease, and higher structural lung damage.

The most common spirometric defect in our study was obstructive ventilatory defect followed by a restrictive and mixed pattern. This is in line with the results of Xing et al who found obstruction as the most common abnormality in post-tuberculosis patients[15]. Gupta et al also introduced the concept of post-tuberculosis obstructive lung disease as a specific clinical phenotype that needs special consideration[16]. Airway fibrosis, bronchiectasis, narrowing of the airways and chronic inflammatory remodeling due to pulmonary tuberculosis could be responsible for the predominance of obstruction. Other studies, however, have found that the predominant pattern is a restrictive one particularly in those with extensive fibrosis and destroyed lung[17]. These differences could be due to differences in the severity of the disease, smoking history, radiological extent and the time of assessment of lung function by a spirometer among different populations.

Uncontrolled smoking was found to be strongly correlated with reduced FEV1 in the current study, indicating that the harmful effect of cigarette smoke is additive to the effect of the already damaged lung parenchyma. This is biologically plausible as smoking and TB both cause chronic airway inflammation and airflow limitation. In a study by, Ralph et al showed that the risk of chronic airflow obstruction is significantly higher in people with pulmonary tuberculosis [18]. Hnizdo et al in contrast did not find a strong link between smoking and the residual respiratory disability in their population[19]. The difference may be attributed to the differences in smoking intensity, environment exposures, nutritional status and socioeconomic status of the study population.

Another important factor associated with pulmonary impairment in our study was recurrent TB. Those with recurrent disease had significantly lower FEV1 and FVC than patients with non-recurrent disease. The same was observed by Woldesemayat et al, who showed that pulmonary TB had cumulative damages to the lungs and chronic pulmonary function impairment in the patients[20]. Chronic and recurrent infections are likely to result in progressive fibrosis, cavitation, airway distortion and permanent destruction of the parenchymal tissue, thus compromising the long-term pulmonary prognosis.

Abnormal spirometry was significantly correlated with radiological fibrosis in the present study. Nightingale et al also found that there was a significant relationship between cavitary and fibrotic lesions and pulmonary function decrease[21]. Lee et al also found that the structural sequelae following TB treatment are present for many years after treatment, and lead to long-term respiratory disability[22]. Fibrosis causes a decrease in the compliance of the lung and can result in restrictive or obstructive abnormalities depending on the amount and distribution of lung involvement.

The most common symptoms were dyspnea and chronic cough, similar to Ashraf et al findings in a Pakistani population[23]. However, the severity of the symptoms is not always directly related to spirometric impairment. After treatment, persistent respiratory symptoms were observed with gradual improvement in lung function, as reported by Meghji et al[24]. This may account for the fact that some patients do not improve even with only mild spirometric abnormalities, perhaps because of the bronchiectasis, deconditioning, recurrent infections or psychological factors.

There are some limitations in the present study, which needs to be addressed. The results of the present study were obtained from a single center, therefore the findings may not be applicable to the general population and causal relationship could not be drawn. Selection bias might have been introduced due to non-probability consecutive sampling and did not have baseline pre-tuberculosis spirometric data to assess the actual extent of lung function damage caused by tuberculosis. Furthermore, the importance of the factors of biomass exposure, occupational hazards, environmental pollution and detailed radiological quantification were not evaluated comprehensively. No long-term follow-up was done to evaluate the progression or recovery of pulmonary impairment over time.

CONCLUSION

According to the current study, patients with post-tuberculosis lung disease had a significant incidence of pulmonary function abnormalities, with obstructive ventilatory defects being the most prevalent spirometric pattern. Significant factors influencing the severity of pulmonary impairment were smoking history, recurrent tuberculosis and radiological fibrosis. The results indicate that successful completion of anti-tuberculous therapy does not necessarily lead to normal pulmonary function and call for regular post-treatment follow-up of respiratory function after tuberculosis, early evaluation of pulmonary function using spirometric tests, and long term follow-up of TB survivors to

minimize chronic respiratory morbidity and enhance quality of life.

Author's Contribution:

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