

Clinical Spectrum and Spirometry Assessment of Patients Diagnosed With Post-tubercular Lung Disease

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Research Article

Keywords: Post-tubercular lung disease, Spirometry, Sequelae, Pulmonary Tuberculosis

Posted Date: April 28th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9126408/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background: Post-tubercular lung disease (PTLD) encompasses chronic respiratory abnormalities that persist after microbiological cure of tuberculosis. Nearly half of all tuberculosis survivors experience long-term pulmonary sequelae and their risk of airflow obstruction or restrictive impairment is higher than people without tuberculosis. This study aimed at characterizing the clinical spectrum and spirometry patterns of patients with PTLD and to place these findings within the context of contemporary literature.

Methods: A cross-sectional study was conducted at a tertiary care center involving 100 adults who had completed treatment for pulmonary tuberculosis from March 2024 to October 2025. Demographic and exposure histories were recorded. All participants underwent radiological investigations, sputum examination and spirometry. All the details were included in case record format and in Microsoft Excel Sheet and Data was analyzed using appropriate statistical methods.

Results: The mean age was 48.9 ± 7.0 years and 77 % were male. Dyspnoea and cough were the most common symptoms. Radiological investigations revealed cystic bronchiectasis with interlobular septal thickening (28 %), cystic bronchiectasis alone (27 %) and fibrocavitary lesions (23 %), indicating significant post-inflammatory airway remodeling. Sputum culture was positive in 17 % patients and the most common organism isolated was *Pseudomonas aeruginosa*. Spirometry showed obstructive impairment in 37 %, restrictive impairment in 26 % and mixed impairment in 26 %, with only 11 % having normal lung function.

Conclusion: PTLD is associated with substantial radiological damage and lung function impairment. Obstructive or mixed ventilatory defects predominated, underscoring the need for routine spirometric monitoring of TB survivors. Integration of pulmonary rehabilitation, smoking cessation and early lung function assessment into TB programs is imperative to address the long-term sequelae of TB.

INTRODUCTION

Tuberculosis (TB) remains one of the leading infectious causes of morbidity and mortality in the world. It is estimated that nearly 10 million people developed tuberculosis in 2024 and about

12.5 lakh deaths occurred globally, with India accounting for nearly one-quarter of the global burden [1]. Although microbiological cure is achieved in most treated patients, structural and functional lung damage often persists beyond treatment completion.

Post-tuberculosis lung disease (PTLD) has emerged as an important clinical entity representing the long-term respiratory sequelae of pulmonary tuberculosis. PTLD includes chronic respiratory

conditions, with or without symptoms, attributable partly to previous tuberculosis infection [2, 3]. Sequelae following tuberculosis contribute remarkably to disease morbidity, accounting for up to 47% of tuberculosis burden in terms of Disability-Adjusted Life Years (DALYs) [3]. The condition imposes substantial physical, economic, and social challenges, emphasizing the need for both medical and social support.

The long-term functional burden after pulmonary TB is substantial. This is evident on meta-analysis of spirometry data from 14,621 individuals reported that approximately 22% of TB survivors had obstructive impairment, 23% restrictive impairment and 15% mixed impairment after treatment[4]. In South Ethiopia, post-TB participants had significantly more obstructive impairment than controls after treatment completion [5]. Similarly, a study from China showed

that airflow obstruction and small-airway dysfunction were more common in people with prior pulmonary TB than in those without TB [6]. In Brazil, a multicentre study of 378 treated patients found spirometric abnormalities in 62.7%, with obstructive defects predominating among those with previous lung disease and restrictive defects among those without it [7]. Beyond physiology, PTLD is also associated with substantial burden on health; a Nigerian study documented abnormal spirometry in most participants and poor quality of life, especially among patients with dyspnoea, cough and sputum production [8].

Available Indian and regional data also demonstrate marked heterogeneity in post-TB spirometric patterns. In Tripura, Saha et al. found abnormal spirometry in 71.7% of treated patients, with obstruction being the most frequent pattern [9]. In contrast, Satti et al. reported restrictive impairment as the commonest abnormality in their cohort, with radiological abnormalities present in 80% of patients and fibrotic bands being especially frequent[10]. Patil et al. in a large multicentric Indian study, showed that even asymptomatic post-TB patients may have substantial spirometric impairment, underscoring the need for routine lung function assessment irrespective of symptoms[11].

Despite the high TB burden in India, detailed data integrating symptoms, radiology, microbiology and spirometric patterns in PTLD remain limited. The present study was therefore undertaken to characterize the clinical spectrum, radiological changes, microbiological profile and spirometry patterns of patients with PTLD at a tertiary care centre, and to interpret these findings in the context of contemporary international and Indian evidence.

MATERIALS AND METHODS

Study design and participants

A cross-sectional study was done between March 2024 and October 2025 at a tertiary care hospital in India. Adults aged ≥ 18 years who had completed directly observed therapy (DOTS) for pulmonary TB at least six months prior and who provided verbal informed consent were eligible. Exclusion criteria

included current active TB, extra pulmonary TB, and patients with relative contraindications for spirometry.

Data collection

Demographic variables (age, sex etc), TB treatment history (time since treatment, number of courses), smoking status, biomass exposure, history of asthma or chronic obstructive pulmonary disease, and occupational exposures were recorded. Clinical evaluation included assessment of dyspnoea using the modified Medical Research Council (mMRC) scale and other symptoms at the time presentation and the details included in the case record proforma (CRF).

Radiological assessment

All participants underwent a postero-anterior chest X-ray. High-Resolution Computed Tomography (HRCT) was performed when chest X-ray findings were inconclusive or when there was discordance between symptoms and spirometry.

Microbiological evaluation

Sputum samples were collected from all the study participants on two consecutive days (one spot sample and one sample next morning) and sent for investigations like AFB (Acid Fast Bacilli) staining, Gram staining and Cartridge Based Nucleic Acid Amplification Test (CBNAAT).

Spirometry

Spirometry was conducted in all study participants and prior to measurement, the subjects were given detailed instructions along with the demonstration of the test[12]. COSMEDPFT (pulmonary function test) apparatus was used and spirometry protocol was followed as per American Thoracic Society (ATS) guidelines[13]. Ventilatory functions, including FEV1 (Forced Expiratory Volume in 1 Second), FVC (Forced Vital Capacity) and the ratio FEV1/FVC were measured for all participants and the ratio of FEV1 to FVC was expressed as a percentage.

Spirometry readings were checked for internal reliability [13] and data was entered in the case record sheet. Spirometry results were classified as per ATS guidelines [13]:

Normal	FEV ₁ /FVC ≥ 0.70 and FVC ≥ 80% predicted.
Obstructive	FEV ₁ /FVC < 0.70
Restrictive	FEV ₁ /FVC ≥ 0.70 and FVC < 80% predicted.
Mixed	FEV ₁ /FVC < 0.70 and FVC < 80% predicted

Statistical analysis

All the details including radiological findings, sputum microbiological investigation results and spirometric assessment data were included in case record format and in Microsoft Excel Sheet as well. Data was analyzed using SPSS version 21 software [14]. The results were expressed in terms of mean, percentages and absolute values. Results were compared with published studies for contextual interpretation.

RESULTS

The study included 100 participants (77% females, 23% males) with a mean age of 48.95 ± 7.01 years. Dyspnoea was reported by 88 participants (mMRC grade 1–5), cough by 77 and sputum production by 46; 12 had haemoptysis and 8 reported chest pain (Table-1).

TABLE-1: Demographics and Clinical characteristics of study participants (n = 100)

CHARACTERISTICS	NUMBER	%
AGE GROUP (YRS)		
21–30	20	20
31–40	15	15
41–50	30	30
51–60	5	5
61–70	20	20
> 70	10	10
GENDER		
Male	77	77
Female	23	23
RESIDENCE		
Urban	80	80
Rural	20	20
SMOKING		
Yes	15	15
No	85	85
BIOMASS FUEL EXPOSURE		
Yes	52	52
No	48	48
SYMPTOMS		
Shortness of Breath	88	88
Cough	77	77
Expectoration	60	60
Wheeze	62	62
Chest Pain	17	17
Haemoptysis	4	4
Malaise	8	8

TABLE-2: Treatment History of study participants (n=100)

PARAMETER	NUMBER	PERCENTAGE
Complete Treatment	75	75
Single Course	60	60
Multiple Course	15	15
Incomplete Treatment	25	25

Out of 100, 75 participants completed treatment as declared by treating physicians, out of whom 60 patients required a single course of treatment and 15 required multiple courses, as shown in Table 2.

TABLE-3: Radiological profile of the study participants (n = 100)

CHARACTERISTICS	NUMBER	%
Lobe Involvement		
Bilateral	55	55
Unilateral	45	45
Chest X-ray Findings		
Inhomogenous opacity	60	60
Homogenous opacity	23	23
Fibrotic changes	20	20
Collapsed Upper Zone	14	14
Cystic opacities	17	17
Cicatrized lung	12	12
Fibrocativary lesion	6	6
Bilateral Costophrenic angle blunting	9	9
HRCT Findings		
Cystic bronchiectasis with interlobular septal thickening	28	28
Cystic bronchiectasis	27	27
Fibrocativary Lesion	23	23
Varicoid Cystic Bronchiectasis	21	21
Cystic bronchiectasis with emphysematous changes	19	19
Ground Glass opacities	17	17
Mosaic Attenuation	14	14
Multiple Centrilobular nodules	12	12

Findings of radiological investigations done in study participants including Chest x-ray and HRCT are summarized in Table-3. High-resolution CT in our study revealed a high prevalence of cystic bronchiectasis with interlobular septal thickening (28%), followed by cystic bronchiectasis alone (27%) and fibrocavitary lesions (23%).

Table-4: Sputum culture results of the study participants (n = 100)

Growth Visible	Number	%
	17	17
Pseudomonas aeruginosa	6	6
Staphylococcus aureus	5	5
Acinetobacter	4	4
Haemophilus influenzae	2	2
Total	17	17
No Growth	83	83

Sputum culture was positive in 17 patients (17%). The most common isolates were

Pseudomonas aeruginosa followed by *Staphylococcus aureus*. (Table – 4)

Table 5
– Spiro metric assessment of the participants (n = 100)

Parameter	MALES (n = 77)	FEMALES (n = 23)	TOTAL (n = 100)
1. Normal Spirometry	6	5	11
2. Abnormal Spirometry	71	18	89
3. OBSTRUCTION			
• Mild	6	4	10
• Moderate	9	4	13
• Severe	5	2	7
• Very Severe	4	3	7
• TOTAL	24	13	37
4. RESTRICTION	15	11	26
5. MIXED	14	12	26

Spirometry demonstrated that only 11% of participants had normal lung function. The predominant abnormality on spirometry was obstruction (in 37% patients). Other details of spirometric assessment are as mentioned in Table-5.

DISCUSSION

Globally, it is estimated that nearly one-third to one-half of individuals who successfully complete TB treatment may develop some degree of chronic respiratory abnormality. Patients with PTLD are twice as likely as the general population to have spirometric abnormalities, and

about 10% lose more than 50% of lung function [15]. Given that more than 150 million people worldwide have survived tuberculosis, the cumulative burden of PTLD represents a significant but often under-recognized public health challenge [16].

The pathophysiology of PTLD involves complex structural changes affecting multiple components of the respiratory system. These changes may manifest as bronchiectasis, fibrotic destruction, cavitation, pleural thickening, and emphysematous alterations, ultimately leading to chronic respiratory impairment [17]. Recent large-scale analyses have further demonstrated that individuals with prior tuberculosis exhibit significantly reduced lung function, particularly affecting FEV₁ and the FEV₁/FVC ratio, resulting in mixed ventilatory impairment with predominant airflow obstruction [18, 19]. Despite the growing evidence of its impact, long-term respiratory assessment of TB survivors remains limited in many TB control programs [20].

This cross-sectional study shows that PTLD remains associated with substantial residual respiratory morbidity despite completion of anti-tubercular therapy. Most patients in our cohort were middle-aged adults, with a mean age of 49 years, indicating that PTLD affects individuals in their economically productive years, like other post-TB cohorts from Ethiopia and Brazil [5, 7]. Smoking & biomass exposure were reported by 15% and 52% of participants respectively and these inhalational exposures may have contributed to chronic airway injury; this is supported by the Ethiopian study, which identified smoking as an important risk factor for persistent airflow limitation after TB [5], as well as by broader reviews highlighting post-TB airway remodeling and chronic obstructive sequelae [2].

Symptomatically, shortness of breath was the most frequent complaint, followed by cough, wheeze and expectoration. This pattern is similar to the study by Ozoh et al. [8] where dyspnoea, cough and sputum production were strongly associated with poor health-related quality of life,

and also aligns with the general PTLD spectrum described by Gai et al. [2]. The high symptomatic burden in our cohort therefore supports the view that microbiological cure often does not equate to clinical recovery.

Regarding treatment history, 75% of patients had completed treatment as declared by treating physicians; out of which 60% had received a single course and 15% had undergone multiple courses while 25% had incomplete treatment. Although the cited comparison studies do not uniformly report treatment-completion patterns in the same format; recurrent disease and delayed or inadequate treatment are recognized contributors to more severe post-TB structural damage and long-term functional loss [2, 4]. Thus, incomplete, or repeated treatment exposure in our cohort may partly explain the high burden of radiological and spirometry abnormalities.

Radiologically, bilateral involvement was more common than unilateral disease, suggesting that extensive parenchymal damage is frequent in PTLT. The most common abnormality noted was cystic bronchiectasis with interlobular septal thickening (28%), followed by cystic bronchiectasis alone (27%) and fibrocavitary lesions (23%). These findings are in line with the established structural spectrum of PTLT described in the literature [2, 4, 6], suggesting that distal airway injury and bronchiectatic change are central components of PTLT, complementing study data showing persistent fibrotic and tractional abnormalities [10].

Microbiologically, sputum culture was positive in only 17% of patients, with *Pseudomonas aeruginosa* being the most common, followed by *Staphylococcus aureus*, while 83% were culture negative. Direct comparative sputum culture data are limited in the cited PTLT studies, but our finding of predominantly negative cultures is consistent with the concept that on-going symptoms in PTLT are usually driven by structural sequelae rather than active infection [2, 4].

At the same time, secondary bacterial colonization remains relevant in bronchiectatic lungs, which may explain the isolation of organisms such as *Pseudomonas* in a subset of our patients.

Spirometry was abnormal in 89% of patients, with obstructive pattern (37%) being the most common abnormality, followed by restrictive pattern (26%) and mixed pattern (26%). This is broadly comparable to the other meta-analysis by Ivanova et al. [4] which reported pooled frequencies of 22% obstruction, 23% restriction and 15% mixed defects. Our findings are also similar to the Ethiopian study by Woldesemayat et al. [5], which showed a significantly greater burden of obstructive impairment among post-TB individuals, and to the Chinese study by Xing et al. [6], which demonstrated excess airflow obstruction and small-airway dysfunction after pulmonary TB. Among Indian studies, Saha et al. [9] reported abnormal spirometry in 71.7% of patients with obstruction as the predominant pattern (44.08%), while Patil et al. [11] likewise found obstruction to be the dominant abnormality even in some asymptomatic treated cases. In contrast, Satti et al. [10] reported restrictive impairment as the commonest pattern, underscoring the heterogeneity of PTLT across cohorts. Overall, our higher proportion of mixed defects likely reflects more extensive and heterogeneous structural lung damage.

PTLT also has a major impact on quality of life, with persistent dyspnoea, cough and exercise limitation contributing to long-term disability [8]. Since abnormal spirometry may present even in asymptomatic individuals, routine lung function assessment after TB treatment is important [11]. However, most TB programs still focus mainly on microbiological cure, with limited emphasis on long-term pulmonary outcomes [16]. Early recognition and management through spirometric follow-up, pulmonary rehabilitation, smoking cessation, vaccination, and treatment of respiratory comorbidities may reduce long-term morbidity and improve quality of life.

Strengths and limitations

Our study provides a comprehensive description of radiological, microbiological and spirometric findings in a cohort of TB survivors in India. The inclusion of HRCT allowed detailed assessment of airway

pathology. However, the study has limitations: it was conducted at a single center, limiting causal inference and generalizability; spirometry was performed at variable time points after treatment; and exposures such as biomass fuel use and occupational dust were self-reported.

CONCLUSION

PTLD represents a major public health issue in TB-endemic countries. In this cohort of TB survivors, most patients exhibited bilateral radiological disease, and obstructive or mixed ventilatory defects predominated. Sputum cultures were positive only in one-fifth of the patients, underscoring that persistent respiratory symptoms are usually sequelae of structural lung damage rather than active infection. Our findings align with international evidence that roughly one-fifth of TB survivors develop obstructive or restrictive impairment while another fraction develops mixed impairment. Given the global estimate that up to half of TB survivors experience chronic respiratory abnormalities; routine spirometric evaluation, timely HRCT and integrated pulmonary rehabilitation should become standard components of post-TB care.

Abbreviations

- **PTLD** : Post-Tuberculosis Lung Disease
- **TB**: Tuberculosis
- **HRCT**: High-Resolution Computed Tomography
- **CBNAAT**: Cartridge-Based Nucleic Acid Amplification Test
- **DOTS** : Directly Observed Treatment, Short-course

- **mMRC** : Modified Medical Research Council
- **CRF** : Case Record Form
- **AFB** : Acid Fast Bacilli
- **PFT** : Pulmonary Function Test
- **FVC** : Forced Vital Capacity
- **FEV₁** : Forced Expiratory Volume in One Second
- **ATS** : American Thoracic Society

- **SPSS** : Statistical Package for the Social Sciences
- **cm** : centimetre
- **kg** : kilogram
- **%** – percent
- **n** – number (sample size)

Declarations

- **Ethics approval and consent to participate:** The institutional review board of Dr. D. Y. Patil Vidyapeeth, Pune, Maharashtra, India approved the study. (Reference Number: DPU / R&R

(M) / 216/ 67/ 2024, Dated: 26/3/2024). Written and informed consent was obtained from all the study participants.

- **Availability of data and material:** All data generated or analyzed during this study will be made available from the corresponding author on reasonable request, following publication.
- **Competing interests:** Not applicable.
- **Funding:** The study received no external funding.

• Authors' contributions:

PC & SD formulated the concept & design of the study. PC, SD & MSB searched appropriate clinical studies. PC has done the data acquisition. PC, SD & MSB has done the data analysis. Manuscript preparation was done by PC & SD. All authors were involved in manuscript editing, approval of the final version of the manuscript.

- **Acknowledgements:** Not applicable.

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