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THE RADIOLOGICAL SEQUELAE OF PULMONARY AND PLEURAL TUBERCULOSIS IN TERTIARY CARE HOSPITAL

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ABSTRACT

Objective: To determine the frequency and pattern of radiological sequelae of pulmonary and pleural tuberculosis in patients presenting to a tertiary care hospital.
Study Design: Cross-sectional study.
Duration and Place of Study: Conducted from 10 April to 30 June 2026 at the Pulmonology Unit, Ayub Teaching Hospital Abbottabad.
Methodology: A total of 93 patients with previous history of pulmonary or pleural tuberculosis were included by using prevalence-based sample size calculation. Patients who completed full anti-tuberculosis therapy and had post-treatment radiological findings on chest X-ray or high-resolution computed tomography were enrolled. Radiological sequelae including fibrosis, bronchiectasis, cavitation, pleural thickening and fibrosing mediastinitis were assessed according to radiologist report. Chi-square test and Fisher exact test were applied for post-stratification analysis.
Results: Mean age of patients was 49.39 ± 19.40 years and mean duration after anti-tuberculosis therapy was 8.66 ± 5.61 years. Male patients were 53 (57.0%) and rural residents were 66 (71.0%). Radiological sequelae were present in 73 (78.5%) patients. Fibrosis was the most common finding observed in 63 (86.3%) patients, followed by bronchiectasis in 31 (42.5%), pleural thickening in 19 (26.0%), cavitation in 14 (19.2%) and fibrosing mediastinitis in 1 (1.4%) patient. Age above 50 years (p=0.022) and rural residence (p=0.004) showed significant association with radiological sequelae.
Conclusion: Radiological sequelae after tuberculosis were very common, with fibrosis being the predominant finding. Older age and rural residence were significantly associated with higher frequency of sequelae.

Keywords: Bronchiectasis, Fibrosis, Pleural diseases, Tuberculosis, Tuberculosis, pulmonary.

INTRODUCTION

Pulmonary tuberculosis (TB) and pleural TB are two common types of tuberculosis that predominantly occur in the lungs and pleura.[1] The former usually affects the pulmonary parenchyma and is associated with symptoms such as chronic cough, fever, weight loss, night sweats, and hemoptysis.[2] The latter usually affects the pleural cavity and is often associated with pleural effusion, chest pain, and dyspnea.[3] Despite being successfully treated by full anti-TB therapy, there are still patients who experience irreversible damage to their lungs.

Sequela following pulmonary tuberculosis in terms of radiology are quite common in chest x-rays and CT scanning.[4] The presence of fibrosis is one of the usual sequela that presents itself as fibrous bands, decreased volume, and distorted structures mainly in the upper lobes.[5] Another sequela in this form is the formation of bronchiectasis that occurs because of the damaged and enlarged airways which result in recurring chest infections and productive cough.[6] Cavitations are some patients even after treatment, and these cavities can either harbor fungi or cause recurrent hemoptysis.[7]

Pleural tuberculosis can result in pleural thickening and pleural calcifications that affect the breathing process due to limiting lung movement.[8] Chronic fibrosis of the pleura can lead to persistent breathing difficulties and pain.[9] Advanced cases of pleural tuberculosis may have fibrotic mediastinitis that involves the formation of excessive fibrosis

in the mediastinum resulting in narrowing of the bronchi, vessels and other mediastinal structures.[10] Radiological investigations have a key role in detecting these complications.

Tuberculosis still poses a significant challenge in terms of public health issues in underdeveloped countries like Pakistan. While many patients respond to antituberculous therapy, many others develop irreversible radiographic abnormalities like fibrosis, bronchiectasis, cavitary lesions, and pleural thickening, leading to persistent respiratory problems and decreased pulmonary function. The local literature about these radiological manifestations after tuberculosis is sparse. Therefore, this study is needed to identify the common radiological sequelae of pulmonary and pleural tuberculosis for better understanding of disease burden, early detection of complications and improvement in long term patient management.

METHODOLOGY

This cross-sectional study was conducted from 10 April to 30 June 2026 at the Pulmonology Unit of Ayub Teaching Hospital. Ethical approval was obtained from the Institutional Review Board of the hospital vide reference No. RC-EA-2025/288 before start of the study. The sample size was 93 and was calculated by using WHO sample size calculator taking prevalence of radiological sequelae after tuberculosis treatment as 40.36%,[11] confidence level 95%, and margin of error 10%.

Inclusion criteria: Both male and female patients aged 14–85 years with previous history of pulmonary or pleural tuberculosis, patients who completed full course of anti-tuberculosis therapy and patients having radiological findings suggestive of post-tuberculous sequelae on chest X-ray or HRCT were included in the study. Pulmonary tuberculosis was labelled in patients previously diagnosed on positive sputum smear, Gene-Xpert, culture for Mycobacterium tuberculosis, radiological findings suggestive of pulmonary tuberculosis, or clinical diagnosis for which complete anti-tuberculosis therapy was taken. Pleural tuberculosis was considered in patients with history of positive pleural fluid Gene-Xpert or lymphocytic exudative pleural effusion with completed anti-tuberculosis therapy.

Exclusion criteria: Patients with extra-pulmonary tuberculosis other than pleural tuberculosis, patients currently receiving anti-tuberculosis therapy, patients who completed anti-tuberculosis therapy within last 6 months, patients with evidence of active pulmonary tuberculosis on clinical, radiological, or microbiological evaluation, and patients having active bacterial or viral chest infection at presentation were excluded.

Written informed consent was taken from all eligible patients before data collection. Demographic variables including age, gender, residence and socioeconomic status were recorded. Detailed history regarding type of previous tuberculosis, duration after completion of anti-tuberculosis therapy, smoking status, recurrent tuberculosis, history of drug-resistant tuberculosis and immunocompromised status was obtained. Patients were clinically examined for evidence of active infection including fever, weight loss, productive cough, and anorexia. Radiological assessment was done by chest X-ray and/or high-resolution computed tomography chest. Radiological sequelae including fibrosis, bronchiectasis, cavitation, pleural thickening, and fibrosing mediastinitis were assessed according to radiologist report findings.

Radiological sequelae were labelled when one or more findings were present on chest X-ray or HRCT after completion of anti-tuberculosis therapy. Fibrosis was defined as permanent fibrotic scarring of lung parenchyma identified by fibrotic bands, reticular opacities, architectural distortion, traction changes, or volume loss. The diagnosis of bronchiectasis was based on bronchial dilatation, which is characterized by an increase in the bronchial width, loss of normal tapering of the bronchial structure, thickening of the bronchial wall, or appearance of bronchi within 1 cm of the pleura. The cavitation was described as the presence of a gaseous cavity inside the consolidated or fibrotic or nodular area in HRCT. Pleural thickening was referred to as pleural opacity or pleural thickness exceeding 3 mm in the presence of healed pleural tuberculosis.

Data was analysed by using SPSS version 26. Quantitative variables including age and duration after treatment completion were presented as Mean ± SD. Categorical variables including gender, residence, socioeconomic status, type of previous tuberculosis, smoking status, recurrent tuberculosis, history of drug-resistant tuberculosis, immunocompromised status, fibrosis, bronchiectasis, cavitation, pleural thickening and fibrosing mediastinitis were presented as frequencies and percentages. Radiological sequelae were stratified against age, gender, smoking status, history of drug-resistant tuberculosis, recurrent tuberculosis, duration after treatment completion and immunocompromised status. Post-stratification Chi-square test or Fisher's exact test was applied where required. A p-value ≤ 0.05 was taken as statistically significant.

RESULTS:

The study enrolled 93 patients with a mean age of 49.39 ± 19.40 years and a mean duration after anti-tuberculosis therapy (ATT) of 8.66 ± 5.61 years. Among the participants, 53 (57.0%) were male and 40 (43.0%) were female. Majority of the patients belonged to rural areas, accounting for 66 (71.0%) cases, whilst 27 (29.0%) were from urban

settings. Regarding socioeconomic background, 56 (60.2%) patients were from low socioeconomic class, 30 (32.3%) from middle class, and only 7 (7.5%) from high socioeconomic class. The most common type of previous tuberculosis was pulmonary tuberculosis, which were found in 64 (68.8%) patients, followed by pleural tuberculosis in 19 (20.4%) and both types in 10 (10.8%) patients. History of recurrent tuberculosis were present in 16 (17.2%) patients, and drug resistant tuberculosis was reported in 17 (18.3%) cases. Smoking were noted in 13 (14.0%) patients, and 15 (16.1%) patients were found to be immunocompromised (Table-I).

Table I: Patient Demographics

Demographics	**Mean ± SD / n (%)**
Age (Years)	49.39 ± 19.40
Duration After ATT (Years)	8.66 ± 5.61
Gender	
Male n (%)	53 (57.0%)
Female n (%)	40 (43.0%)
Residence	
Rural n (%)	66 (71.0%)
Urban n (%)	27 (29.0%)
Socioeconomic Status	
Low n (%)	56 (60.2%)
Middle n (%)	30 (32.3%)
High n (%)	7 (7.5%)
Type of Previous TB	
Pulmonary Tuberculosis n (%)	64 (68.8%)
Pleural Tuberculosis n (%)	19 (20.4%)
Both n (%)	10 (10.8%)
History of Recurrent TB	
Yes n (%)	16 (17.2%)
No n (%)	77 (82.8%)
History of Drug Resistant TB	
Yes n (%)	17 (18.3%)
No n (%)	76 (81.7%)
Smoking Status	
Yes n (%)	13 (14.0%)
No n (%)	80 (86.0%)
Immunocompromised Status	
Yes n (%)	15 (16.1%)
No n (%)	78 (83.9%)

Radiological sequelae were observed in 73 (78.50%) out of 93 patients, whilst 20 (21.50%) patients showed no such findings. Among those who had radiological sequelae, fibrosis were the most frequently encountered pattern, being present in 63 (86.30%) patients. Bronchiectasis was found in 31 (42.50%) cases, followed by pleural thickening in 19 (26.00%), cavitation in 14 (19.20%), and fibrosing mediastinitis in only 1 (1.40%) patient (Table-II).

Table II: Frequency and Pattern of Radiological Sequelae of Pulmonary and Pleural Tuberculosis n=93

Radiological Sequelae	Frequency	%age
Yes	73	78.50%
No	20	21.50%
Total	93	100%
Pattern of Radiological Sequelae (n=73)	**Frequency**	**%age**
Fibrosis	63	86.30%
Bronchiectasis	31	42.50%
Pleural Thickening	19	26.00%
Cavitation	14	19.20%
Fibrosing Mediastinitis	1	1.40%

On stratified analyses, age above 50 years were significantly associated with higher frequency of radiological sequelae as compared to younger patients (89.1% vs 68.1%, p=0.022). Rural residence also showed a statistically significant association, with 86.4% of rural patients having sequelae compared to 59.3% of urban patients (p=0.004). Other factors including gender, socioeconomic status, type of previous tuberculosis, duration after ATT, history of recurrent or drug resistant tuberculosis, smoking, and immunocompromised status did not showed statistically significant associations with radiological sequelae (Table-III).

Table III: Association of Radiological Sequelae with Demographic and Clinical Factors

Factors	Subgroups	Yes n (%)	No n (%)	p-value
Age (years)	≤50	32 (68.1%)	15 (31.9%)	0.022**
	>50	41 (89.1%)	5 (10.9%)	
Gender	Male	40 (75.5%)	13 (24.5%)	0.414*
	Female	33 (82.5%)	7 (17.5%)	
Residence	Rural	57 (86.4%)	9 (13.6%)	0.004*
	Urban	16 (59.3%)	11 (40.7%)	
Socioeconomic Status	Low	48 (85.7%)	8 (14.3%)	0.052**
	Middle	19 (63.3%)	11 (36.7%)	
	High	6 (85.7%)	1 (14.3%)	
Type of Previous TB	Pulmonary Tuberculosis	49 (76.6%)	15 (23.4%)	0.682**
	Pleural Tuberculosis	15 (78.9%)	4 (21.1%)	
	Both	9 (90.0%)	1 (10.0%)	
Duration After ATT (years)	≤5	26 (81.3%)	6 (18.8%)	0.639*
	>5	47 (77.0%)	14 (23.0%)	
History of Recurrent TB	Yes	13 (81.3%)	3 (18.8%)	1.000*
	No	60 (77.9%)	17 (22.1%)	
History of Drug Resistant TB	Yes	12 (70.6%)	5 (29.4%)	0.513**
	No	61 (80.3%)	15 (19.7%)	
Smoking Status	Yes	11 (84.6%)	2 (15.4%)	0.727**
	No	62 (77.5%)	18 (22.5%)	
Immunocompromised Status	Yes	12 (80.0%)	3 (20.0%)	1.000**
	No	61 (78.2%)	17 (21.8%)	

*Chi-Square Test **Fischer Exact Test

DISCUSSION

This study was conducted to evaluate the radiological sequelae of pulmonary and pleural tuberculosis in patients who had completed anti-tuberculosis therapy. The findings revealed that a considerable proportion of patients, 73 (78.50%), had developed radiological sequelae, which suggest that structural lung damage persists even after successful treatment of tuberculosis. This high frequency was likely because tuberculosis causes extensive inflammatory destruction and fibrotic changes in the lung parenchyma, which does not fully resolve after the infection is cleared . Fibrosis was the most prevalent complication, seen in 63 (86.30%) cases. This was predictable because of the irreversible nature of healing of the tissue from tuberculosis through replacement of necrotic and granulomatous tissue

by fibrous tissue. The presence of bronchiectasis was reported in 31 (42.50%) cases, which can be attributed to the fact that chronic inflammation and fibrosis cause dilatation and destruction of the bronchial walls. Pleural thickening was present in 19 (26.00%) cases, which is well-known as a complication due to pleural inflammation and fibrin deposition in cases of tuberculosis involving the pleura.

The frequency of radiological sequelae in the present study were 73 (78.50%), which is comparatively higher than the findings reported by Mehta et al. [12] where radiological abnormalities were observed in 60.3% of patients in the form of fibrotic changes. This difference may be because the present study included both pulmonary and pleural tuberculosis patients, whilst Mehta et al. [12] focused primarily on pulmonary tuberculosis sequelae. Similarly, Zubair et al. [11] also reported post-tuberculosis radiological sequelae to be common in high-burden countries like Pakistan, which is consistent with the present findings and supports the notion that persistent structural lung damage is a frequent outcome in such settings.

Fibrosis were the most frequently observed sequela in the present study, found in 63 (86.30%) patients, which is in agreement with Jain et al. [13] who reported fibrotic bands in 66% of patients after completion of anti-tuberculous therapy, and with Bhalla et al. [14] who described fibrosis as a hallmark feature of healed tuberculosis. The slightly higher frequency of fibrosis in the present study may relates to the longer mean duration after ATT of 8.66 ± 5.61 years, which allows more progressive fibrotic remodelling of lung tissue over time.

Bronchiectasis were identified in 31 (42.50%) patients in the present study, which is comparable to Jain et al. [13] who found bronchiectasis in 41.5% of post-treatment patients on HRCT, and to Chakraborty et al. [15] who documented various forms of bronchiectasis as predominant radiological findings in post-tubercular lung disease. However, this frequency were considerably higher than that reported by Hussain et al. [16] where bronchiectasis were detected in only 20.4% of patients. This discrepancy may be because Hussain et al. [16] relied on chest radiography with clinical findings for diagnosis, which is a less sensitive modality compared to CT-based evaluation, and therefore likely underestimates the true frequency of bronchiectasis.

Pleural thickening was observed in 19 (26.00%) patients in the present study, which reflects the inclusion of pleural tuberculosis cases, as fibrin deposition and chronic pleural inflammation during pleural tuberculosis is well known to result in irreversible pleural thickening. This finding is supported by Zubair et al. [11] who similarly reported pleural thickening as a recognised sequela in patients treated for both pulmonary and pleural tuberculosis. Cavitation were noted in 14 (19.20%) patients, which is comparable to findings of Mehta et al. [12] who reported residual cavities in 20.7% of cases, suggesting that incomplete resolution of cavitary lesions remain a consistent post-treatment finding across different study populations.

Older age above 50 years were significantly associated with higher frequency of radiological sequelae (89.1% vs 68.1%, p=0.022), which is consistent with observations by Yadav et al. [17] who highlighted that host immune responses and delayed diagnosis contributes to more extensive and permanent lung destruction. Rural residence were also significantly associated with higher frequency of sequelae (86.4% vs 59.3%, p=0.004), which can be explained by limited healthcare access in rural populations, possibly leading to delayed treatment initiation and more advanced disease at presentation, as was also suggested in the context of low socioeconomic and rural patients discussed by Bonadonna [18] where majority of tuberculosis patients belonged to younger age groups and low socioeconomic backgrounds with prolonged symptom duration prior to diagnosis.

There are certain limitations associated with this research that need to be considered. First, this is a study carried out in one center only, and thus the results obtained cannot be generalized to the larger population. Secondly, the sample size is relatively small since there were only 93 participants involved in this study. Lastly, recall bias may have been an issue since the clinical history relied on the patient's memory of the past treatments.

CONCLUSION

In conclusion, the study reveals the presence of very high incidences of radiological abnormalities among individuals having completed anti-tuberculosis treatment. The abnormalities include fibrosis as the major one followed by bronchiectasis and pleural thickening. Age and rural background have been found to be important determinants of the occurrence of these abnormalities.

Disclaimer: Not needed for this study.

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Ethical Approval: Approval for conducting this research was obtained from ethical review committee. All procedure of study was done according to committee instruction and Helsinki declaration principle.

Patient Consent: Written informed consent was took from every patient before inclusion in study. Patients were told that all information will be kept private and they can leave the study whenever they want.

Conflict of Interest: The authors has no conflict of interest regarding this research work.

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