ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCE

SCHOOL OF MEDICINE

DEPARTMENT OF CLINICAL RADIOLOGY

CHEST CT PATTERNS OF PULMONARY SEQUELAE FOLLOWING TUBERCULOSIS IN PATIENTS AT THE CHEST UNIT OF TIKUR ANBESSA SPECIALIZED HOSPITAL, ADDIS ABABA, ETHIOPIA

A RETROSPECTIVE CROSS SECTIONAL STUDY

By-Yonas Mulat

A RESEARCH THESIS SUBMITTED TO ADDIS ABABA UNIVERSITY, COLLEGE OF HEALTH SCIENCES, SCHOOL OF MEDICINE, DEPARTMENT OF RADIOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR CERTIFICATE OF RADIOLOGY

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SCHOOL OF MEDICINE

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Full title of the research project	Chest CT Patterns of Pulmonary Sequelae Following Tuberculosis in Patients at the Chest Unit of Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia
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I, the undersigned Radiology Resident, declared that I have submitted my original work on a title: "Chest CT Patterns of Pulmonary Sequelae Following Tuberculosis in Patients at the Chest Unit of Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia, 2025" for examination.

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APPROVAL BY BOARD OF EXAMINATION

This thesis by YONAS MULAT is accepted in its present form by the board of examiners as a requirement for the certificate of radiology.

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Statement of the author

By my signature below, I declare and affirm that this thesis is my own work. I have followed all ethical principles of scholarship in the preparation, data collection, data analysis and completion of this thesis. All scholarly matter that is included in the thesis has been given recognition through citation. I affirm that I have cited and referenced all sources used in this document. Every effort has been made to avoid plagiarism in the preparation of this thesis. I solemnly declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

JUNE 2025 ADDIS ABABA, ETHIOPIA

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Abbreviations

PTLD- Post-tuberculosis lung disease

WHO- World Health Organization

CT- computed tomograph

DM-diabetes mellitus

HIV-human immune deficiency virus

TB - Tuberculosis

RUL-right upper lobe

RML-right middle lobe

RLL-right lower lobe

LUL-left upper lobe

LL-lingual lobe

LLL- left lower lobe

PFTs- Pulmonary function tests

COPD- chronic obstructive pulmonary disease

DLCO- diffusing capacity for carbon monoxide

(SPSS) Statistical Package for Social Sciences

QoL- quality of life

NTPs- National TB Programmes

6MWT- 6 minute walking test

TASH- Tikur Anbesa Specialized Hospital

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Abstract

Background

Being one of the most important infectious diseases in the world; tuberculosis (TB) has a major impact on both socioeconomic development and public health. Globally, the prevalence of PTLD is increasing, paralleling with the growing burden TB. However, little attention has been given to the diagnosis and management of post-tuberculosis lung disease (PTLD). This is in contrary to TB control efforts, which have focused on the prompt diagnosis and efficient treatment of active cases, producing encouraging results over the past three decades. The long-term effects of PTLD are becoming more noticeable as TB control initiatives advance and more people survive the illness, necessitating the urgent need to comprehend and treat this condition. This study aims to characterize the CT imaging pattern of PTLD and associated clinical features to better understand the disease entity and recommended further management plan in Ethiopian setting.

Methods and Materials

A retrospective cross-sectional study was done on 150 patients with a prior documented history of pulmonary tuberculosis (TB) treatment and who have undergone chest CT scans. Chest CT images were evaluated including relevant clinical and demographic data. Data was collected using a structured check list and data processing and analysis was conducted using SPSS software.

Result

In our study of chest CT of 150 post TB patients, commonest radiological sequelae identified were fibrotic changes (84.7%), bronchiectasis (74.0%), and pleural thickening (19.3%). Parenchymal distraction was noted in 18.0% of patients and cavitation in 11.3% of patients. 82% of patients with cavity have imaging evidence of aspergilloma. Common presenting clinical symptoms include cough (81.3%), dyspnea (56.0%), and hemoptysis (21.3%). 87.3% of our patients has no imaging evidence of active TB, and out of 19/150 of our patients(12.6%) with imaging evidence of possible active TB infection, only 3/19 patients (15.7%) has microbiologic evidence for active Tb infection. Statically significant association identified between aspergilloma and hemoptysis.

Conclusion

This study highlights the importance of imaging and follows up in post TB patients for early diagnosis of PTLD and differentiation from active TB infection to reduce morbidity and avoid unnecessary repeated anti-TB drug treatment in Ethiopian setting, a high TB burden country. Hemoptysis is identified as a great clinical predictor for aspergilloma, and high fungal super infection burden also alerts for tailored national intervention and multidisciplinary approach in managing PTLD in Ethiopia.

CHAPTER ONE- INTRODUCTION

1.1 Background

The bacillus Mycobacterium tuberculosis is the primary cause of tuberculosis (TB), an infectious disease that is transmittable through the inhalation of micro droplets released into the air by TB patients. Although tuberculosis is both preventable and generally curable, it remained the leading cause of death from a single infectious agent in the year 2023 (1).

According to the Global Tuberculosis Report 2024, an estimated 10.8 million individuals developed tuberculosis (TB) in the year 2023, with approximately 1.25 million deaths attributed to the disease. It is one of the most common infectious illnesses worldwide, having a major effect on public health in many nations, especially in sub-Saharan Africa. Ethiopia is classified among the 30 high tuberculosis (TB) burden countries and has recently transitioned out of the list of high TB/HIV burden countries, with an estimated annual TB incidence of 146 cases per 100,000 populations, resulting in a serious burden to the health system and impacting individuals' household economies (1).

Despite advances in treatment, a significant proportion of patients still experience persistent lung problems that cause residual abnormalities, negatively impacting their respiratory function and overall quality of life (2, 3). Those include radiological abnormalities such as fibrosis, cavitation, pleural thickening, and bronchiectasis, commonly accompanied by respiratory symptoms and reduced functional capacity, leading to a significant limitation in quality of life (3.4).

1.2. Statement of the Problem

In spite of significant advancements in the management of active tuberculosis (TB), there remains a substantial gap in knowledge regarding post-TB lung disease. Imaging modalities, particularly computed tomography (CT) and chest X-rays (CXR), are crucial for monitoring and identifying post-TB sequelae. However, there is a lack of localized data detailing the specific imaging patterns observed in patients in Ethiopia. Additionally, the national TB treatment guidelines do not address post-treatment follow-up or strategies for diagnosing and managing residual respiratory complications. This deficiency in information can impede effective clinical management and follow-up care for individuals recovering from TB.

1.3. Significance and justification of the study

Tuberculosis (TB) remains a critical public health challenge in Ethiopia, with many patients suffering from persistent pulmonary sequelae despite successful treatment.
This study aims to systematically investigate the imaging patterns associated with post-TB sequelae in patients attending the chest unit at Tikur Anbessa Specialized Hospital in Addis Ababa.
By reviewing radiologic imaging and clinical data, this research seeks to enhance understanding of the long-term effects of TB on lung architecture. The findings will also ultimately inform improved management strategies and follow-up care for affected patients, addressing a significant gap in current healthcare practices.

CHAPTER TWO- LITERATURE REVIEW

2.1 Prevalence of Post-TB Sequelae

These are the pathophysiological and structural changes in the chest caused by primary or secondary pulmonary tuberculosis (TB) that may persist even after completion of treatment and full bacteriological cure (3, 4, 19, 20). This encompasses post-treatment sequelae characterized by a range of radiological findings, including fibrosis, cavitary lesions, pleural thickening, and bronchiectasis, along with spirometric abnormalities that may present as obstructive, restrictive, or mixed ventilatory patterns (3, 4). These sequelae are often associated with a range of clinical symptoms, including cough, dyspnoea, and limitations in performing daily activities, which can impair quality of life significantly (3, 4).

There was a retrospective study conducted in Pakistan on 321 adult patients ranging from the age of 25 to 63 years who were diagnosed and treated as PTB and pleural TB at tertiary hospital from January 2014 to August 2017 (2). Their result showed majority of showed some form of abnormality on chest radiography with 83% prevalence of PTLD (2). The most common radiologic abnormality was fibrosis contributing about 46% followed by pleural thickening 26% (2).

A prospective cross-sectional study done in India on 200 adult patients, the most common post tubercular symptom was dyspnea contributing 84% of participants followed by cough 63.5% and hemoptysis 11.5% (3). In their study, only 2% of patients had normal chest radiographs, while 94% demonstrated fibrotic changes. Additional findings included pleural thickening and calcification in 28.5%, healed lesions in 24%, destroyed lung in 22%, fibrocavitary changes in 17.5%, and bronchiectasis in 13.5% (3). The study further demonstrated that **91% of patients (182 out of 200)** possess **abnormal pulmonary function on spirometery**, indicating the significant **adverse impact of tuberculosis on lung function** (3).

Similarly according Meghji et al, a prospective cohort study done in Malawi, showed majority patients experience 60.7% one or more respiratory symptom at the end of TB treatment completion (4). Another study done in 180 PTLD patients attending a tertiary hospital in South Africa between 1 October 2021 and 30 September 2022 showed a statistically significant association between hemoptysis with both cavitation and fungal-associated disease. Their study also showed significant association between TB-associated obstructive lung disease (OLD) and dyspnea, chest pain and smoking (5).

2.2 Imaging Techniques

The importance of imaging in the diagnosis and follow-up of post-TB sequelae cannot be overstated. Computed tomography (CT) scans and chest X-rays (CXR) are the main modalities

utilized to assess lung pathology in patients with a prior history of tuberculosis. Chest X-rays can demonstrate abnormalities such as fibrotic opacities, cavitary lesions, and bronchiectasis, though their sensitivity for detecting subtle changes is limited. Whereas, CT scans provide superior resolution and detailed visualization of the lung parenchyma, airways, and pleura, allowing for more accurate identification of fibrotic alterations, bronchiectasis, and nodular opacities typically associated with post-tuberculosis lung disease (PTLD) (6) High-resolution CT (HRCT) is especially important in characterizing the lung abnormalities and magnitude of lung damage in PTLD

2.3 Common Imaging Patterns

A systematic review evaluating post TB pulmonary abnormalities on radiological imaging in individuals with a history of tuberculosis reported cavitation in 8.3% - 83.7%, bronchiectasis in 4.3% - 11.2%, and fibrosis in 25.0% - 70.4% of cases (6).The imaging patterns associated with post-TB lung disease are diverse and the common ones include:

Fibrosis: After receiving TB therapy, majority of patient with pulmonary TB frequently develop residual fibrotic abnormalities. Fibrotic changes of varied degrees of severity were found in 94% of patients with a history of tuberculosis in across sectional study by Gupta etal (3). Fibrosis may present as a restrictive pattern on pulmonary function tests and show reticular patterns on imaging, suggestive of lung scarring (7).

Cavitary Lesions: Cavities may persist even after active tuberculosis has resolved. About % 16.2 of patients had residual cavities, which are frequently linked to persistent respiratory problems (8). Clinical therapy may become more challenging when cavitary lesions are present, necessitating close observation for potential secondary infections. Cavitary lesions on imaging may resemble other illnesses, such as chronic pulmonary asperilosis, lung abscesses or cancers, necessitating further investigation (8).

Bronchiectasis: This is a common finding in post TB sequelae and it occurs due to destruction and fibrosis of the lung parenchyma with irreversible secondary bronchial dilatation (9). It can occur with both primary and secondary exposure. Bronchiectasis located in upper lobe is highly suggestive of a tuberculosis origin (10). According to Gupta at al (3), bronchiectasis was found in 13.5% of the TB survivors in their cross sectional study, highlighting the necessity of focused therapy. Bronchiectasis can have a major negative influence on quality of life and may require long-term care plans to avoid flare-ups.

2.4 Quality of Life and Functional Implications

Beyond physical health, post-TB lung illness has a substantial negative impact on patients' quality of life over the long term. Although the exact magnitude is poorly described across literatures; post TB morbidity include structural impairments, such as long-term lung and other

organ impairments, as well as psychosocial morbidities, such as prolonged socioeconomic impairment, social isolation, anxiety/depression, and stigma(11, 18).

According to Meghji et al. (4), TB survivors frequently experience reduced health-related quality of life due to ongoing respiratory symptoms and restrictions on everyday activities. In their study about 46% patients experience chest symptoms interfering with work at pTB treatment completion and 12% 1 year later. Hypoxaemia was also observed in 1.5% at rest and 3.8% after the 6- minute walk test at treatment completion.

Patients with PTLD also frequently experience psychological disorders, including anxiety, depression, and post-traumatic stress disorder (PTSD), as a result of the chronicity of the disease [12].

2.5 Challenges in Management

Managing post-TB sequelae presents several challenges. A significant obstacle is the absence of established guidelines for diagnosing and treating post-TB lung diseases. Empirical TB retreatment of pTB- survivors based on chronic symptoms is widespread suggesting that most PTLD patient presenting to health care may be end up on TB retreatment (13). However, the majority of those reporting chronic cough during follow- up did not have microbiological evidence of pTB when retested (4). So this Underdiagnosis and insufficient follow-up may be due to lack of awareness among healthcare practitioners regarding the distinct imaging patterns linked to post-TB lung disease. Furthermore, in resource-constrained environments such as Ethiopia, socioeconomic issues can restrict access to modern imaging techniques (1)

However recent studies has shined light on approach to effective management of PTLD and suggested it requires the integration of a multidisciplinary strategy comprising radiologists and pulmonologists as well infectious subspecialist. Management options for PTLD include pharmacologic, pulmonary rehabilitation and surgical interventions for selected patients (14). Pharmacologic treatments include bronchodilators, inhaled corticosteroid and mucolytic agents (14, 15). According to a review devoted to this topic, a comprehensive evaluation of patients is vital to assess the need for pulmonary rehabilitations during and after treat of pulmonary tuberculosis (16). Comprehensive evaluation of post-TB lung disease (PTLD) includes assessment of lung function (spirometry with bronchodilator testing, DLCO, arterial blood gases, and 6MWT), radiological imaging (chest X-ray and CT when available), and quality of life using general or disease-specific tools like the St. George’s Respiratory Questionnaire (17). Surgical options, such as bronchial artery embolization, lobectomy, segmentectomy, or lung transplantation, may be considered for PTLD patients based on disease severity and the patient's overall health (17). Therefore knowing imaging patterns of PTLG and proper evaluation is vital to offer appropriate therapy in these patient groups.

CHAPTER THREE- OBJECTIVES

3.1. General Objective

To systematically investigate the imaging patterns and long-term pulmonary sequelae associated with tuberculosis (TB) in patients attending the chest unit at Tikur Anbessa Specialized Hospital, Addis Ababa.

3.2. Specific Objectives

3.21. To analyze radiologic imaging data to identify common patterns of post-TB lung sequelae.

3.22. To correlate clinical data with imaging findings to assess the prevalence and severity of pulmonary complications following TB treatment.

3.23. To evaluate the impact of post-TB sequelae on lung architecture in affected patients.

3. 24. To provide evidence-based recommendations for improved management strategies and follow-up care for patients with post-TB sequela

CHAPTER FOUR - METHODOLOGY AND MATERIALS

4.1 Study area and period

The research was conducted at Tikur Anbesa Specialized Hospital, Addis Ababa, Ethiopia, from February 1 to May 30, 2025 G.C. TASH is a tertiary hospital and academic center, with well-established chest referral center, one of the few referral centers in the country, and its radiology department chest imaging unit provides radiographic services including x-ray and CT with image guided diagnostic and therapeutic services for patients sent to the hospital all around the country, this has an advantage of diverse population group representations.

4.2 Study design

This study employed a retrospective cross-sectional design to assess imaging patterns of pulmonary post-TB sequelae in patients with a prior history of TB attending the chest unit at Tikur Anbessa Specialized Hospital over a period of 2 years (January 2023 – January 2025). Patients with documented history of prior TB, and those who undergone chest CT scanning in the specified period were included in the study.

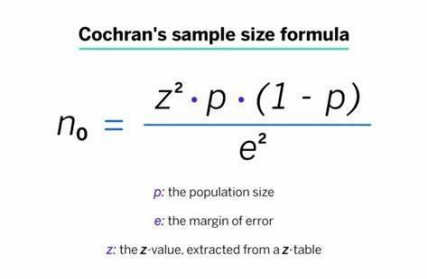
4.3 Study population

4.31 Source population -is patient who visited chest unit of TASH.

4.32 Study population-is patients with prior history TB who undergone chest CT scan

4.4 Sample size and sampling technique

The study will include adult patients (≥18 years) with a documented history of treated TB who are currently visiting the chest unit for evaluation. Size is calculated using the Cochran formula with confidence interval of 95%, with maximum tolerable margin of error of 5%, and prevalence of 83% was used and the estimated sample size is 217 patients. However, 150 patients were only available in the specified period fulfilling the criteria.



4.5 Inclusion and exclusion criteria

4.51 Inclusion Criteria

Adults aged 18 years and older presenting to the chest unit

Documented history of treated TB, confirmed through medical records

Patients who has chest CT imaging in the specified time duration

4.52 Exclusion Criteria

Patients who hasn't chest CT within the specified period.

4.6. Study variables

Dependent variable:- CT findings of parenchymal, air way, mediastinal and vascular post TB complications

Independent variables:- age, sex, respiratory toxin exposure status, underlying comorbidity, presenting clinical symptoms, frequency of anti TB medication treatment, lung function test results and sputum Gene xpert/AFB status**.**

4.7 Data Collection

Data was collected through medical record review and imaging studies (chest CT):

- Demographic and clinical Information: Age, sex, respiratory toxin exposure, underlying medical comorbidity, frequency of TB treatment, lung function test results and AFB/Gene xpert results was documented from the patient chart.
- Imaging Studies: CT scans was reviewed with senior chest imaging radiology subspecialists. The images were evaluated for the presence of post-TB changes, stratifying to **parenchymal, airway, pleural, mediastinal and vascular complication**.
- Key imaging complications include:-
    - Fibrosis: Assessing the extent and location of fibrotic changes.
    - Cavitary Lesions: Identifying residual cavitary formations.
    - Bronchiectasis: Evaluating the presence and severity of bronchial dilation.
    - Lung Nodules: Checking for any incidental findings of nodules.
    - Destroyed Lung: ≥1 lung lobe in which ≥90% of parenchyma is occupied by atelectasis or parenchymal banding, or destroyed by cavities/cystic airspaces.
    - Pleural Thickening/Fibrothorax

Table 1: imaging patterns of post pulmonary TB sequelae

Parenchymal	Air way	Pleural	Vascular	Mediastinal
Fibrosis	Bronchiectasis	Pleural thickening	Rasmussen aneurism	Calcified mediastinal lymph nodes
Cavitation	Tracheobronchial stenosis	Empyema	Vasculitis/thrombosis	Fibrosing mediastinitis
Granuloma/tuberculoma	Broncholithiasis	Chronic chylous effusion	Enlarged bronchial artery	Pericardial TB
Destroyed lung lobe	Tracheal diverticula			
Lung cancer				

4.7. Data Quality Control

The primary investigator ensured the completeness and quality of the data by verifying that it was accurate, comprehensive, clear, and consistent. All complete responses were entered into structure check list to spread sheet and subsequently exported to SPSS version 25.0 for analysis.

4.8 Data Analysis

The statistical software SPSS was used for the analysis. Demographic and clinical data, including means and standard deviations for continuous variables and frequencies and percentages for categorical variables, were summarized using descriptive statistics. Chi-square tests for categorical data and Pearson correlation coefficients for continuous variables were used in inferential statistics to investigate relationships between imaging results and clinical complaints. Statistical significance was determined by a p-value of less than 0.05.

4.9 Dissemnation of the results

The results will be disseminated to respective chest unit of radiology and internal medicine department of Tikur Anbesa specialized hospital, Addis Ababa Unversity through formal reporting and presentations as per departmental guidelines. Up on approval from the university the result will be disseminated to Ministy of health as it will be abase line for future development of PTLD diagnosis and treatment plan. Efforts will be made also to publish the study in the Ethiopian Journal of Health Development or other peer-reviewed scientific journals

4.10. Ethical Considerations

Ethical approval was obtained from the Ethical Review Board (IRB) of Addis Ababa University.

CHAPTER FIVE: RESULT

Result

A chest CT of 150 patients with previous history of treated pulmonary tuberculosis retrospectively analyzed including basic demographic and clinical data, with a mean age of 48.89 ±15.52 years (18-85 years). Of these patients, 80 were males (53.3%) and 70(46.7%) were females.

Tabe-2: Age and sex distribution of among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

AGE			
Mean	Range	Percentile (50%)	Standard deviation
48.89	18-85(67)	52.00	15.52
SEX	**FREQUENCY**	**PERCENTAGE**	
MALE	80	53.3%	
FEMALE	70	46.7%	

Based on their exposure status for respiratory toxin, the majority patients has no documented respiratory toxin exposure (137/150=91.3%) and among 13/150 patients with documented respiratory toxin exposure, 11/150(7.3%) patients have cigarette smoking history.

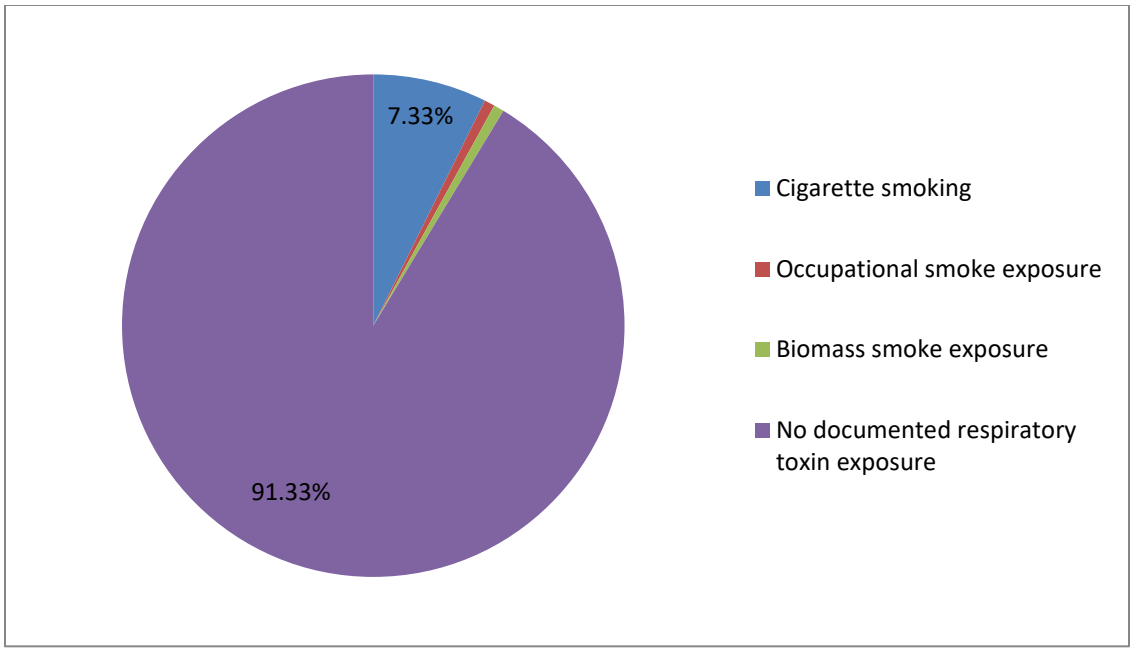


Figure-1: Pie chart illustrating the pattern of documented respiratory toxin exposure among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

Based on their status of underlying medical comorbidity, the majority (62.7%) of patients has no underlying comorbidity. Cardiovascular disease is the most common observed underlying comorbidity (16%), followed by HIV (12%) and DM (8. 6%).

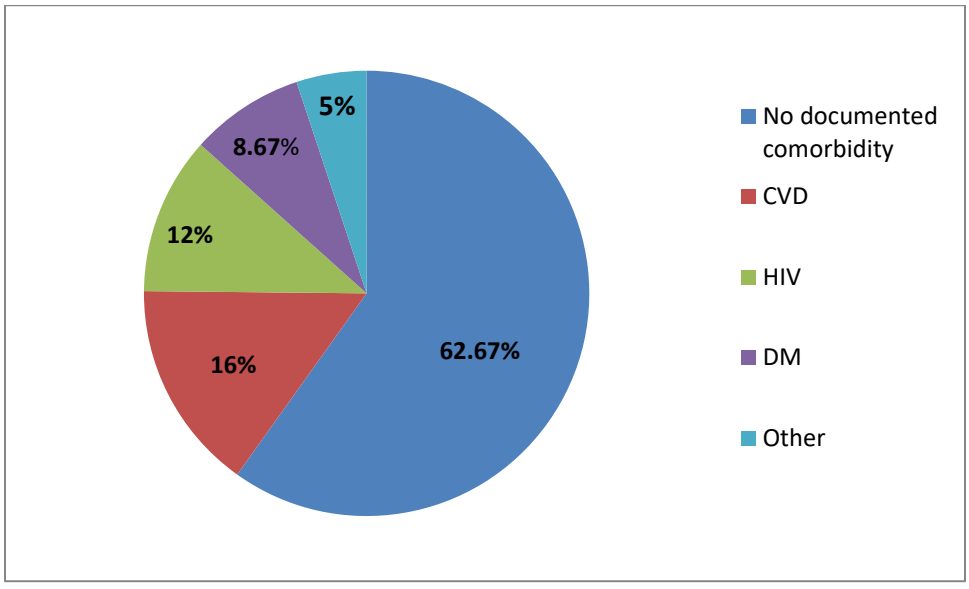


Figure-2: Pie chart illustrating the prevalence of underlying medical comorbidity among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

Cough is the most common presenting clinical symptom (81.3%), followed by dyspnea (56%) and hemoptysis (21.3%).

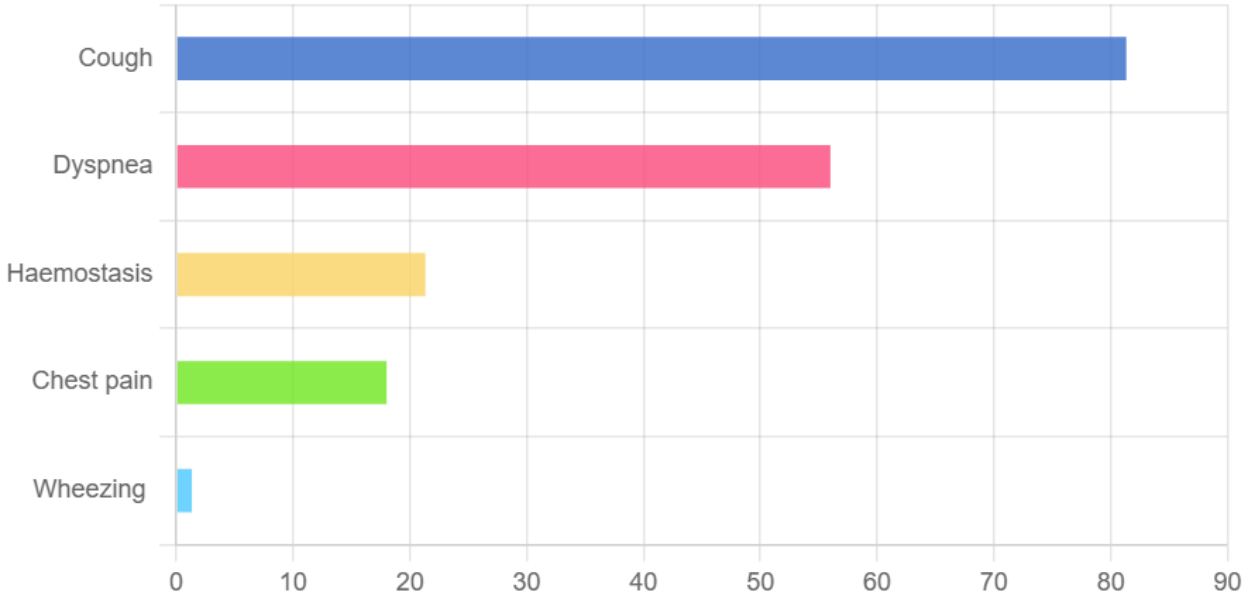


Figure-3: Bar chart showing the presenting clinical symptoms of post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

Table-3: Presenting clinical symptoms of post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

Presenting clinical symptom/s	Frequency	Percentage
Cough	122	81.33
Dyspnea	84	56
Hemoptysis	32	21.33
Chest pain	27	18
Wheezing	2	1.33

Among the 150 patients assessed, 32 (21.3%) presented with hemoptysis. Aspergilloma was identified in 17 (53.1%) of these patients, while only 4 (3.4%) of the 118 patients without hemoptysis showed imaging evidence of aspergilloma. The association between hemoptysis and aspergilloma was statistically significant, as demonstrated by a chi-square value of 51.69 ($p < 0.00001$). Patients with hemoptysis were found to have **32.3 times** greater odds of harboring aspergilloma compared to those without (95% CI: 9.6–107.9).

Similarly, pulmonary cavities were detected in 11 (34.4%) of the 32 patients with hemoptysis, in contrast to 6 (5.1%) of the 118 patients without hemoptysis. This association was also statistically significant ($\chi^2 = 21.50$, $p < 0.00001$), and the odds of having a lung cavity were **9.78 times** higher in patients with hemoptysis (95% CI: 3.3–29.0).

However, in a multivariate logistic regression including both aspergilloma and pulmonary cavity as predictors of hemoptysis, **only aspergilloma remained a statistically significant factor**. Aspergilloma was strongly associated with hemoptysis (OR = 0.017; 95% CI: 0.002–0.142; $p < 0.001$), whereas the association between lung cavity and hemoptysis was no longer significant (OR = 2.15; 95% CI: 0.213–21.69; $p = 0.517$).

Table 4: Multivariate Logistic Regression Analysis of lung cavity and aspergilloma for Predictors of Hemoptysis among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

Variable	B	S.E.	Wald	Df	*p*-value	OR (Exp(B))	95% CI for OR (Exp(B))
Aspergilloma	-4.089	1.091	14.050	1	<0.001	0.017	0.002 – 0.142
Cavity	0.765	1.180	0.420	1	0.517	2.149	0.213 – 21.691
Constant	1.231	0.623	3.904	1	0.048	3.426	—

Note: OR = Odds Ratio; CI = Confidence Interval; S.E. = Standard Error

Model Variables: Aspergilloma and lung cavity were included in the multivariate logistic regression model.

125 patients (83.3%) has treated only once for pulmonary TB, whereas 25 patients (16.7%) has treated two or more times.

Gene xpert and AFB was done for 118 patients (78.6%) and out of those only 3 patients have positive result (2.5%) and majority has negative result (97.5%) (Figure-4)

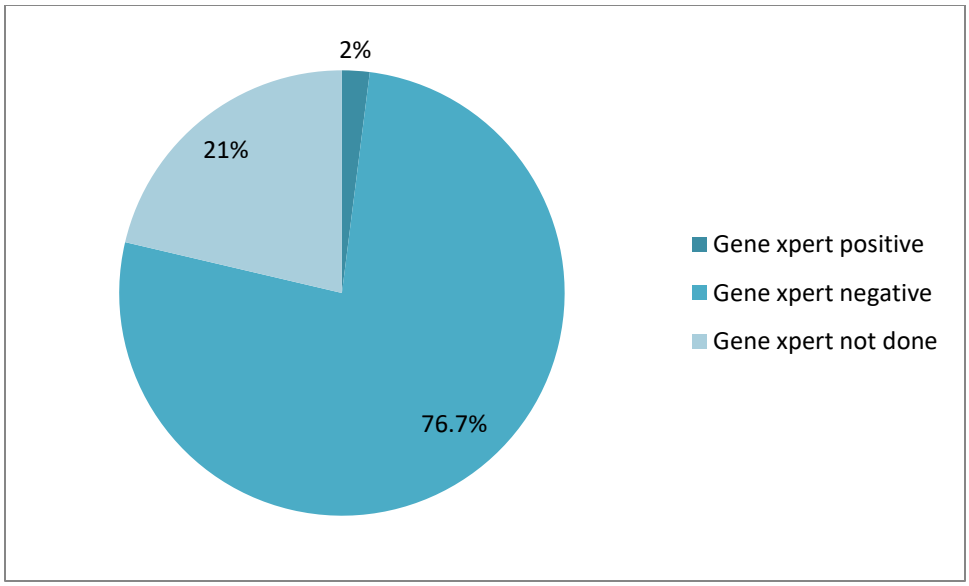


Figure-4: Pie chart illustrating the result of sputum Gene xpert among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025.

Spirometery was done only for 44 patients (29%) and out of those 15/44 (34%) patients have normal result, another 15/44 (34%) patients showing obstructive pattern, 12/44(27%) patients showing restrictive pattern and the remaining 2/44 patients (4.5%) showing mixed pattern. (Figure-5).

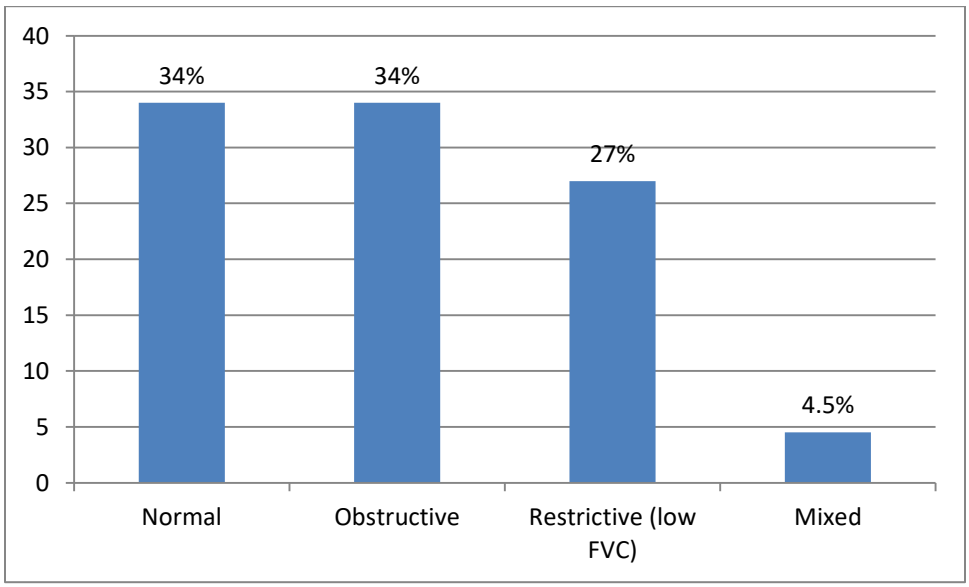


Figure-5. Column chart showing pattern of pulmonary function test result of post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025.

CT findings were analyzed based on parenchymal, airway, pleural, mediastinal, and vascular sequelae of tuberculosis.

The parenchymal complications were further analyzed based on the presence of fibrosis, tuberculoma, cavity and destroyed lobe. Most common parenchymal complication is fibrosis which is founded on 127 patients (84.7%) followed by tuberculoma seen in 31 patients (20.7%).

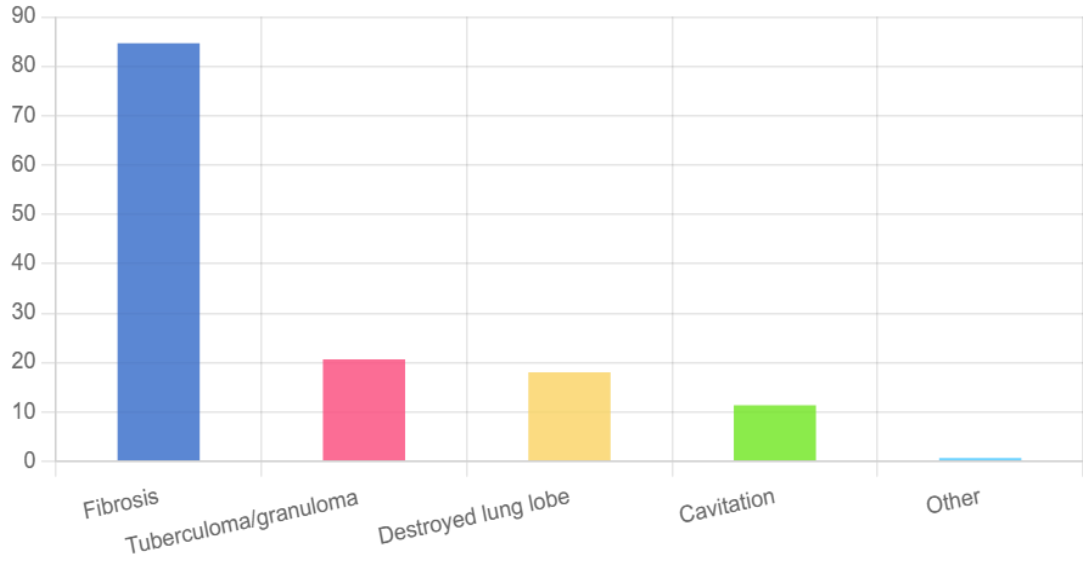


Figure-6: Column chart demonstrating the pattern of parenchymal complication among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025.

Table-5: showing pattern of post TB parenchymal complications of post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

Parenchymal complications	No	%
Fibrosis	127	84.67
Tuberculoma/granuloma	31	20.67
Destroyed lung lobe	27	18
Cavitation	17	11.33
Other	1	0.67

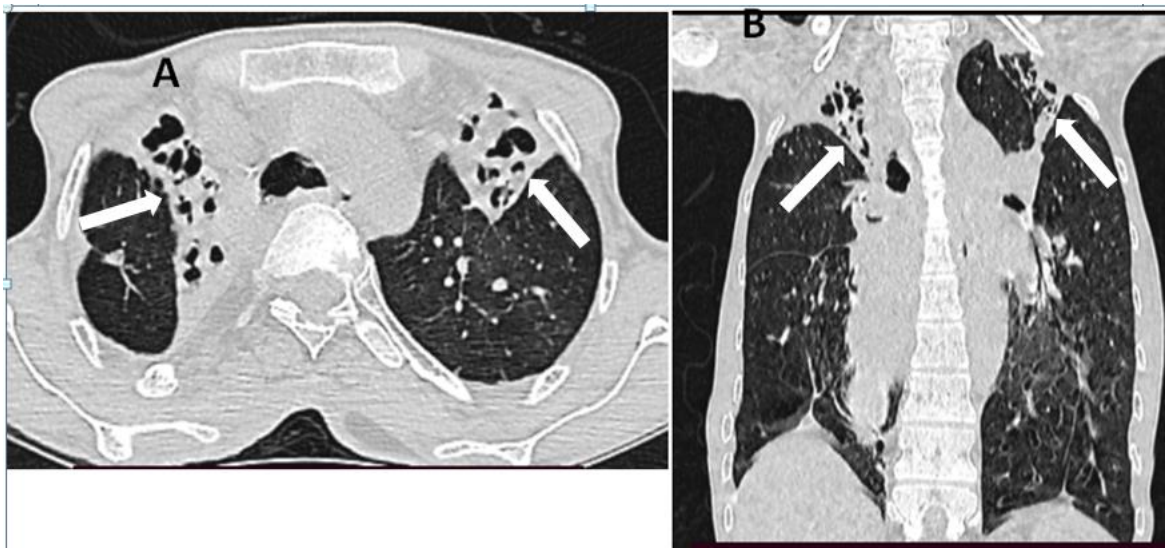


Figure A1. Lung window HRCT with axial **(A**) and coronal (**B**) reconstruction demonstrates bilateral upper lobe fibrosis, architectural distortion and volume loss with traction cystic bronchiectasis (white arrow in A and B).

Out of 127 patients (84.67%) who has fibrosis, 70/127patient have bilateral fibrosis (55%) and 57/127 patients have unilateral fibrosis (45%). Based the location of fibrosis, left upper lobe involvement is seen 86 patients (67.7%) and right upper lobe involvement is noted in 78 patients (61%).

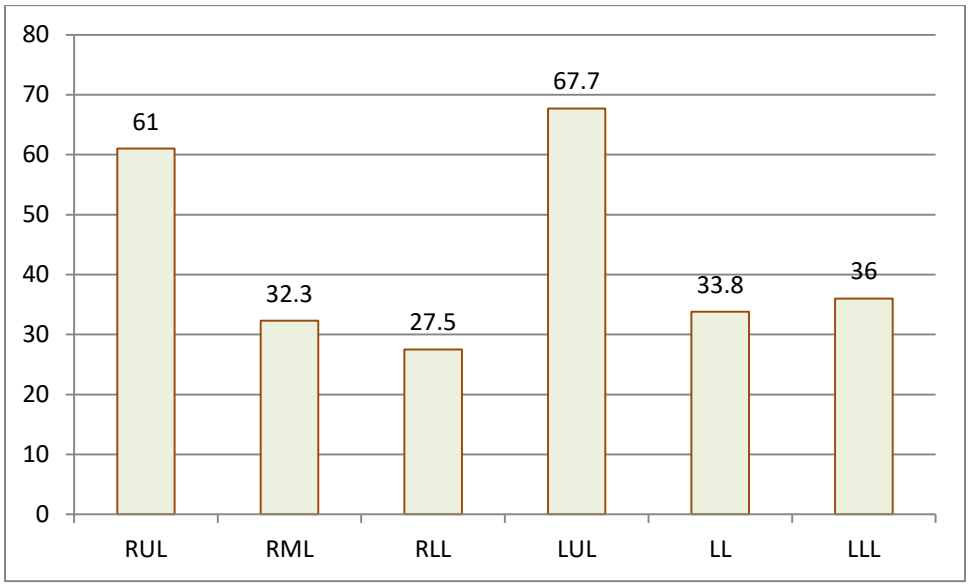


Figure-7: column chart illustrating distribution of fibrosis among the lung lobes of post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

Out of 31 patients with tuberculoma, 17/31(54.8%) are bilateral and 14/31 (45%) are unilateral. The majority is calcified (77%) and the average diameter is 7.6mm with standard deviation of 5.7mm.

27 out of 150 patients (18%) have one or more destroyed lobe. 15/27 patients (55.5%) have two or more destroyed lobe and 12 /27 (44%) patients have only one destroyed lobe.

Lung cavity was seen in 17 patients (11.3%); and 12/17 of those patients (70.5%) had single cavity and 5/17 patients (29.4%) have two or more cavity. The most common location is left upper lobe (42%) followed by superior segment of left lower lobe 27% and right upper lobe (11.5%). The average wall thickness of the cavity is 5.06mm with standard deviation of 2.9mm. Imaging evidence of aspergiloma was noted in in the cavity among 14/17 patients with cavity (82%).

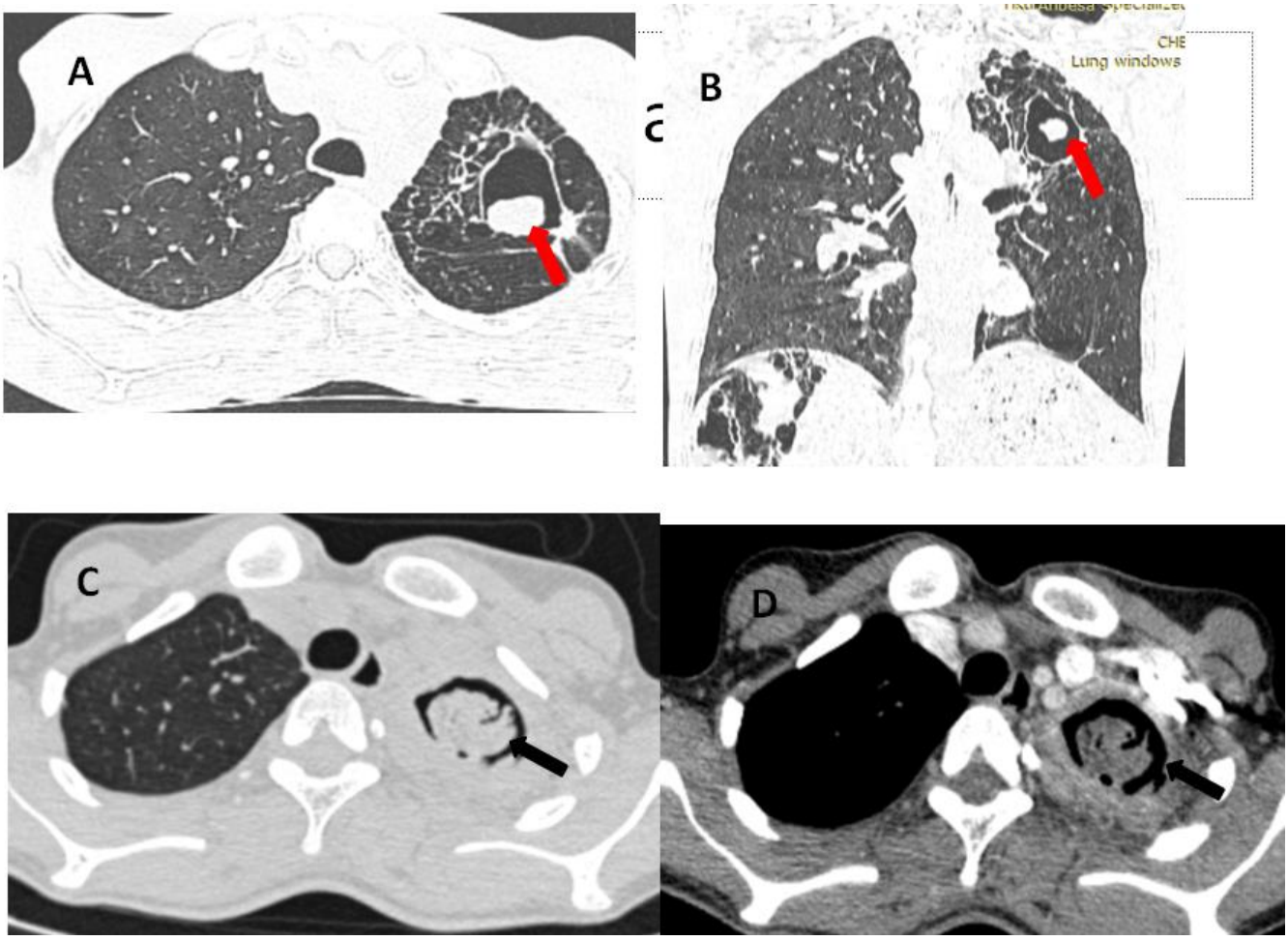


Figure A2. **A** &**B**) Axial and coronal reconstruction lung window HRCT of a 49 year's old post TB patient with left upper lobe thin walled fibrocavitary lesion and fungal ball(red arrow) representing aspergilloma. **C** & **D**) A 29 years old female with previous history of TB, Chest CT pre contrast lung

window (C) and post contrast mediastinal window (D) images showing left upper lobe thick walled cavity with internal soft tissue content(fungal ball) and monad sign(black arrow in C and D).

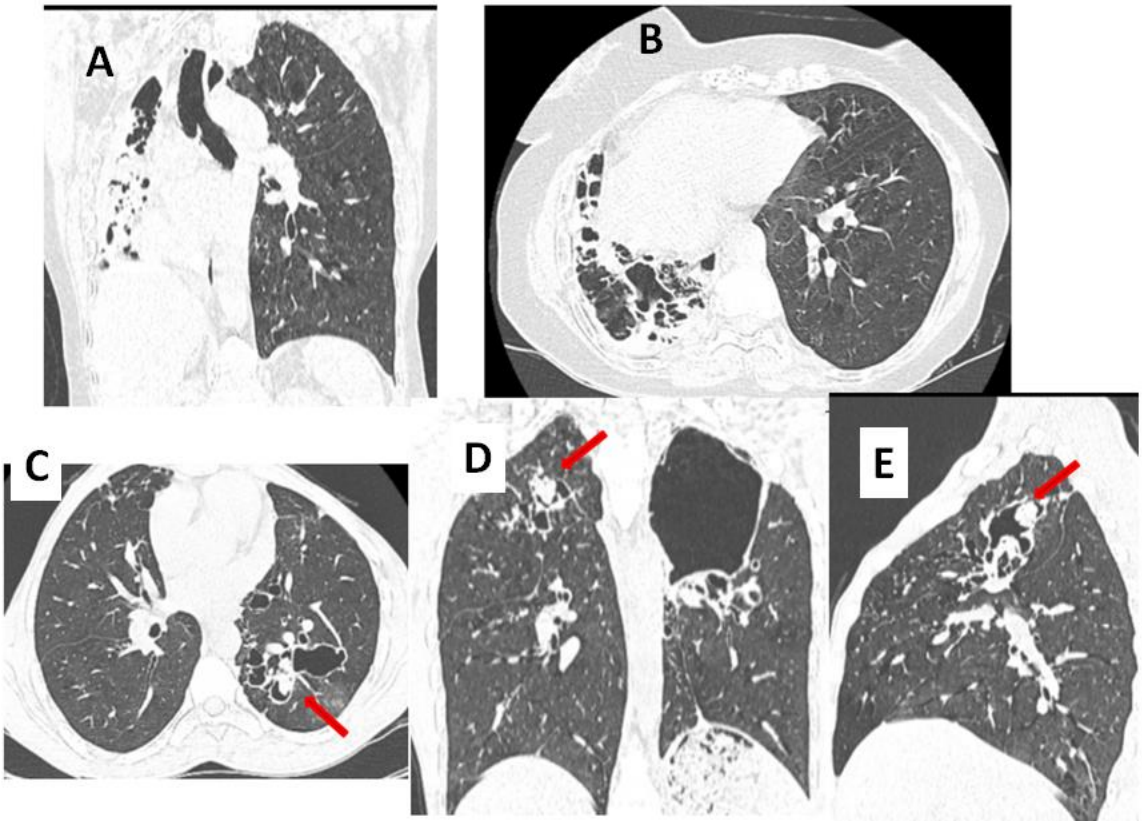


Figure A3. **A&B**) Coronal and axial lung window chest CT image of 58 years old female post TB patient showing right completely destroyed lung with cystic traction bronchiectasis. **C, D &E**) Axial, coronal and sagittal reconstruction lung window chest CT images of 28 years old male post TB patient, demonstrating bilateral lung cystic bronchiectasis with fungal ball (aspergilloma)(red arrows).

Pleural thickening was the most common (19.3%) pleural complication followed by empyema (8%). Out of 29 patients with pleural thickening, calcification was noted on 13/29patients (44%). The average pleural thickness is 6.3mm+_3.3mm and majority showed smooth thickening (21/29, 72.3%) while nodular thickening was noted on 8/29 patients (27.6%)

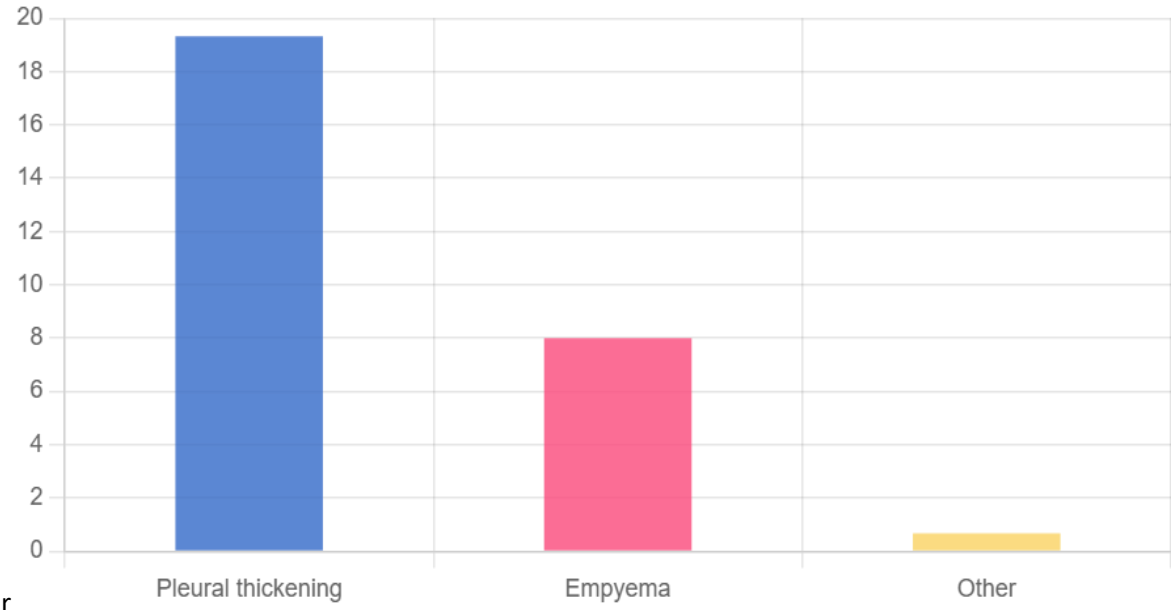


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Figure-8: column chart showing the magnitude of pleural complication among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025.

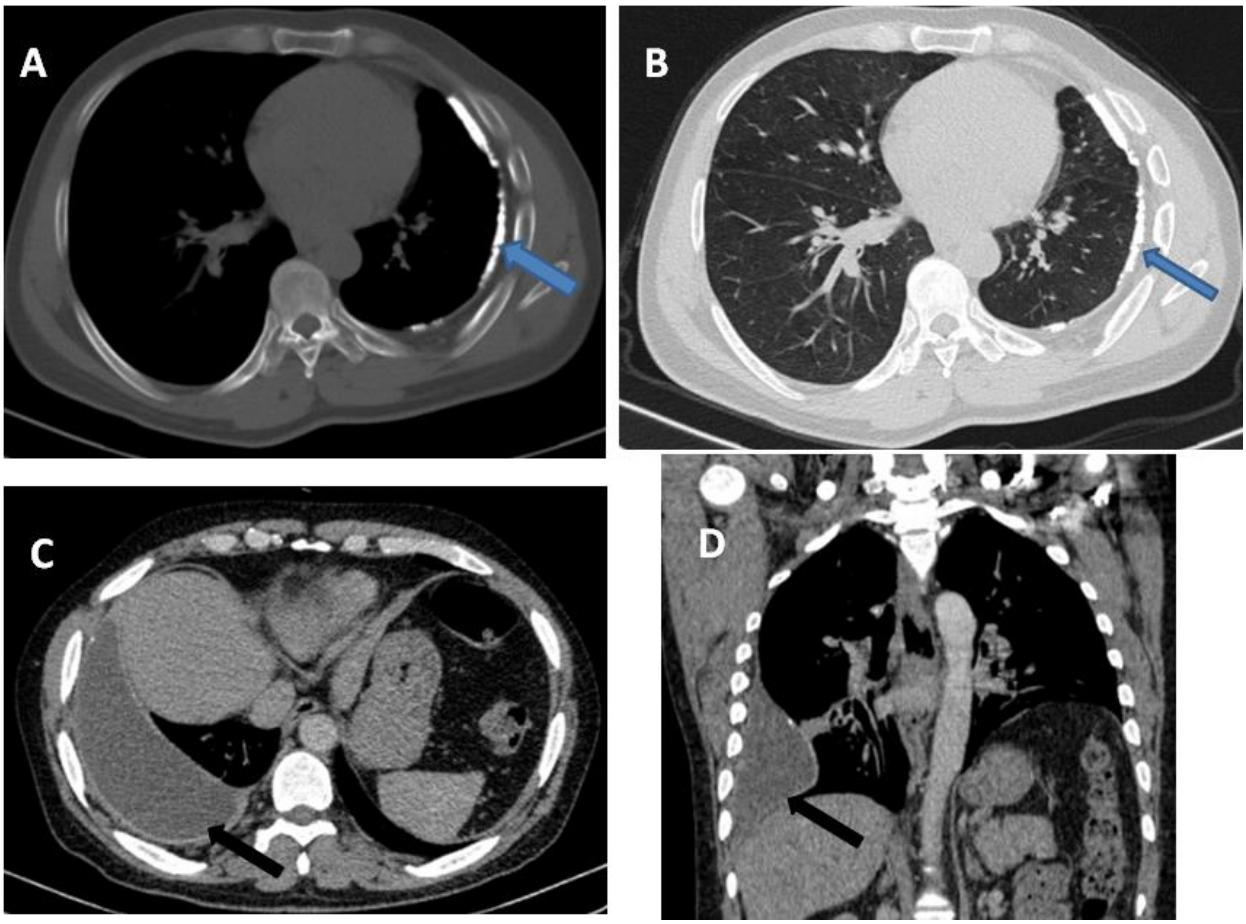

Figure A4. A &**B**) Axial bone and lung window chest CT images showing smooth left costal pleural thickening and sheet of calcification (blue arrow). **C**&**D**) Axial and coronal chest CT images showing right loculated pleural collection with smooth enhancing pleural thickening and punctate calcification representing chronic empyema.

Air way complication was assessed for the presence of bronchiectasis with its associated morphology, location and severity; and for the presence of tracheobronchial stenosis as well broncho pleural fistula. (Figure 9). Bronchiectasis was the most common presenting airway complication seen in 111 patients (74%). Bronchopleural fistula was noted in two patients (1.33%). Tracheobronchial stenosis noted in 5 patients (3.3%) and tracheal diverticula in the remaining 4 patients (2.6%).

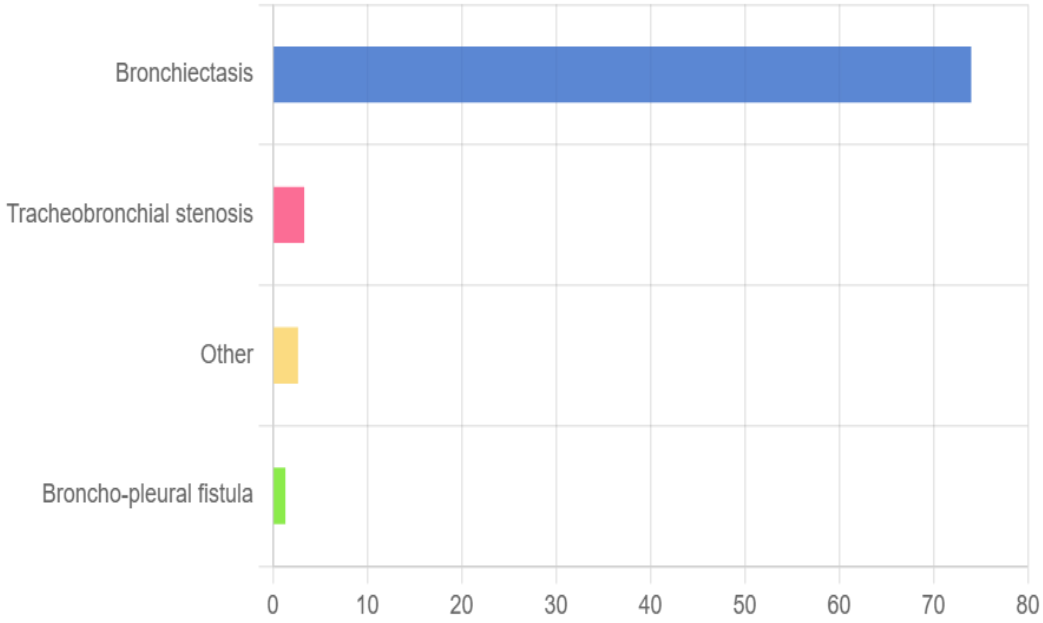

Figure-9: Bar chart illustrating the pattern or air way complication among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

93.6% of patients has either cystic or varicoid bronchiectasis, representing the most common morphology and cylindrical morphology was noted only on 6.3% of patients with post TB bronchiectasis. Moderate bronchiectasis was noted in 54 /111(48.6/%), mild bronchiectasis in 30/111(27%), and severe bronchiectasis seen in 27/111(24%). The upper lobes are the most common locations, left upper lobe seen in 63% of patients with bronchiectasis and right upper lobe seen in 55.8%. Imaging findings of aspergilloma was noted in ectatic bronchus among 8/111patients (7.2%) with bronchiectasis.

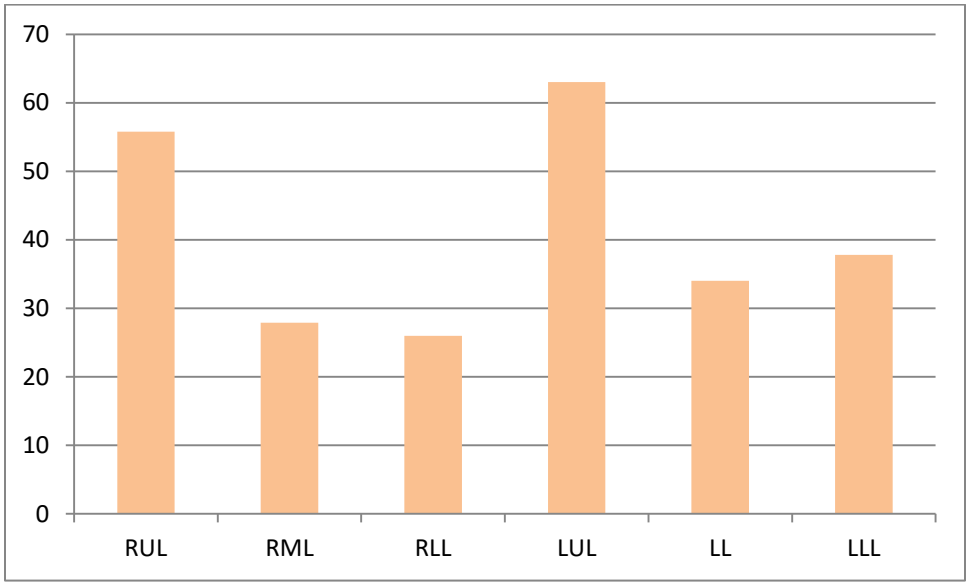

Figure-10: A column chart showing the distribution of bronchiectasis by lung lobes among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

Vascular complication was assessed for the presence of rasmussen aneurism, for pulmonary arterial vasculitis/thrombosis and enlarged prominent bronchial artery. Only 3/150 (2%) patients showed enlarged prominent bronchial arteries and none of the patients showed rasmussen aneurism or vasculitis/thrombosis.

Mediastinal complications were assessed for the presence of calcified mediastinal lymph nodes, fibrosing mediastinitis and pericardial TB. Calcified mediastinal lymph node was the most common mediastinal complication seen in 23/150(15.3%) patients followed by pericardial TB 6/150(4%) and fibrosing mediastinitis 2/150(1.3%).

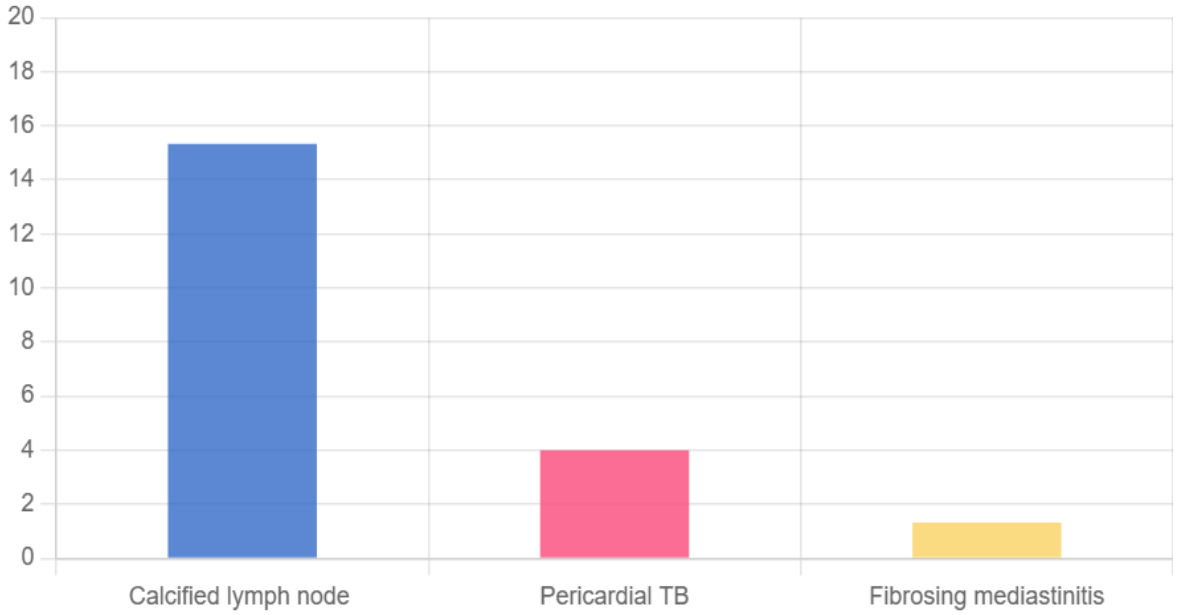

Figure-11: column chart showing the prevalence of mediastinal post TB complication among post TB patients who have chest CT at TASH, Radiology department, from a period of January 2023 – January 2025

The most common location of calcified mediastinal lymph nodes is sub-carinal (69.5%) followed by hilar (52%) and lower para-tracheal (43%).

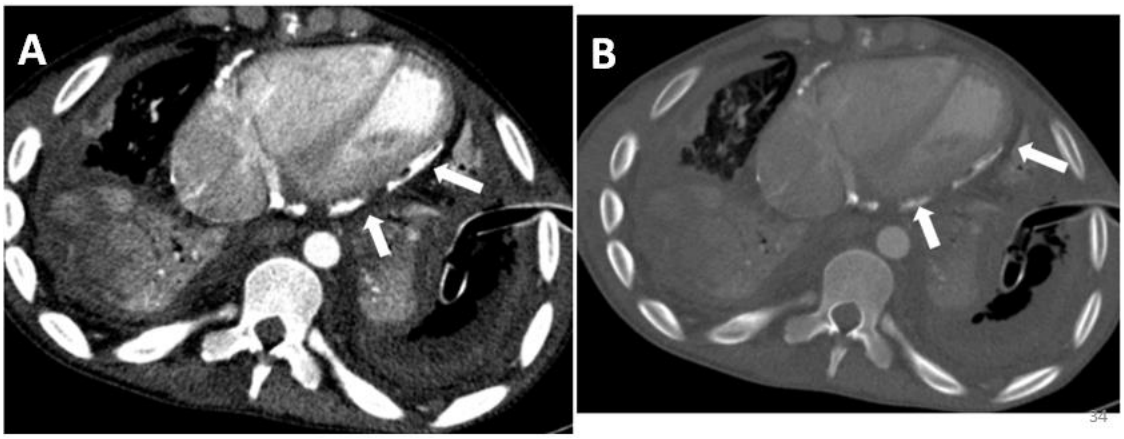

Figure A5. Axial post contrast chest CT with mediastinal and bone algorism demonstrating circumferential smooth pericardial thickening and coarse calcification (white arrows) in 19 years old male post TB patient consistent with constrictive pericarditis.

The CT scan was also evaluated for imaging evidence of active TB infection for the presence of consolidation, ground glass opacity, cavitary consolidation and tree in bud nodules. 19/150 patients (12.6%) showed imaging evidence of possible active pulmonary TB infection and 131/150 patients (87.3%) have no imaging evidence of active infection. All 19 patients have imaging evidence of fibrosis and bronchiectasis, and 4/19 patients started on anti-TB treatment whereas 15/19 patients treated for bronchopneumonia. Only 3/19 patients with imaging evidence of active TB has positive microbiologic evidence for active TB infection (positive Gene xpert).

CHAPTER SIX- DISCUSSION

Our study identifies the chest CT imaging pattern of post-tuberculosis lung disease (PTLD) among 150 patients who had prior history of TB treatment and has had chest CT at Tikur Anbessa Specialized Hospital, department of radiology, Ethiopia from a period of January 2023 – January 2025. 80 of our patients were males (53.3%) and 70(46.7%) were females, and the mean age was 48.89 ±15.52 years (18-85 years). The age distribution highlights the fair distribution of PTLD in both young and old patient population. The predominant radiological sequelae were fibrotic changes, bronchiectasis, and pleural thickening, seen in 84.7%, 74.0%, and 19.3% of our patients respectively.

Destroyed lung lobes were noted in 18.0% of patients and cavitation was noted also in 11.3% of patients. Common presenting clinical symptoms include cough (81.3%), dyspnea (56.0%), and hemoptysis (21.3%), and only a few of sputum studies demonstrated active disease (2.5% Gene Xpert positivity).

There was statically significant association identified between hemoptysis and imaging findings of aspergilloma. The odds of having aspergilloma were **32.3 times higher** among patients with hemoptysis compared to those without hemoptysis (95% CI: 9.6–107.9). The result aligns to the prospective study done in South Africa(5) which identified statically significant association between clinical presentation and structural post TB changes demonstrating association of hemoptysis with cavitary and fungal-associated disease and dyspnea with TB related OLD.

There was also no statically significant difference in the prevalence of structural lung disease complications among patients with underling medical disease and those without underlying medical disease as well with the frequency of anti-TB drug treatment and the age of the patients.

The majority of the patients have only treated once for pulmonary TB (83.3%) which is similar with prospective study done in Mexico on post TB patients by Baez-Saldana et al (7) which showed 85% of their participant suffered only once with pulmonary TB.

Comparison of key radiologic sequelae with prior studies

Fibrosis: - defined in pot TB setting as parenchymal scaring with volume loss by the 1st international symposium of PTLD (11), was noted in 84.7% of our cases which closely aligns with the prospective

cross-sectional study done in India by Gupta et al. (3) on 200 adult patients and they reported 94% of their patients showing evidence of fibrosis on the plain chest radiography at the end of anti TB treatment. It also falls near the 25–70% range summarized by Meghji et al (6) on their systematic review in which they assessed pulmonary abnormalities with radiological imaging among people with a history of TB. The bilateral predominant involvement in over half of our cases also is in concordance with similar findings by Satish et al. (21) which they analyzed imaging pattern post TB sequelae on chest CT of 100 post TB patients retrospectively and reported bilateral upper lobe involvement as the most common pattern of fibrosis.

Bronchiectasis: it is an irreversible air way dilatation which can occur in the setting TB as primary air way involvement due to direct air way granulomatous inflammation and subsequent fibrosis or it can also be secondary due to parenchymal fibrosis resulting traction associated air way dilatation. We found bronchiectasis in 74.0% of our patients, markedly higher than the 13.5% reported rate form Indian study by Gupta et al. (3) but comparable to the 77% report by Satish et al. (21). It can be explained by the difference imaging modality between our study and the study by Gupta et al. (3), in which they used plain radiography, which can potentially overlook air way complication and the fact that our participants are symptomatic patient referred for tertiary care also potentially overestimate the complications. A systematic review by Meghji et al. (6) reported bronchiectasis range of 35.0– 86.0% from CT based study of post TB patient which is in accordance with our result. The severity distribution (moderate in 48.6%, severe in 24.3%) emphasizes the degree of chronic airway damage that often follows TB and supports the need for long-term follow up and better management strategies.

Cavitation and tuberculoma: cavitation prevalence (11.3%) in our study approximates to the study by Page et al. (8) on 398 patients of treated pulmonary patients in Uganda in which they reported 16.2% prevalence of residual cavities, and another study by Gupta et al (3) reported 17.5% fibrocavitary lesion occurrence by the end of anti TB treatment completion. Our result also falls under the 8.3–83.7% range of cavity prevalence reported by Meghji et al. (4) in their systematic review. However, there is significantly high rate of fungal colonization of cavities with 82.4% aspergilloma prevalence in the cavities which is contrary to prior global studies. Aspergilloma prevalence among patients with post-TB cavities was estimated by Page et al. (8) to be 26% and Satish et al. (21) to be 19%.The possible explanations could be increased environmental mold exposure, selection bias (since our cohort is taken from symptomatic individuals referred for tertiary hospital care), and poor follow up and or rehabilitation of post TB patients with residual fibrocavitary lesion.

Tuberculoma were seen in 20.7% with 77% calcification which is lower than 54% prevalence of tuberculoma reported by Satish et al (21) and 25.0–55.8% range by the systematic review by Meghji et al (4) but the fact that the majority of tuberculoma being calcified is consistent with those reported in South African cohorts (calcification in ~75% of nodules) (5).

Pleural disease: Pleural thickening (19.3%) and empyema (8.0%) approximate the 26% thickening and 2–5% empyema rates documented in Pakistan (2) and India (3) respectively. 19.3% of our patients showing pleural thickening and 44% of which having calcification closely relates the report of 22% prevalence of pleural thickening with 40.9% of them demonstrating calcification by Satish et al (21) on their retrospective cross sectional study on 100 chest of post TB patients. The predominance of smooth over nodular thickening further supports the hypothesis that low-grade inflammation drives chronic pleural fibrosis in PTLD.

Mediastinal and vascular sequelae: Calcified mediastinal lymphadenopathy occurred in 15.3% of our patients, a lower prevalence than the 25–68% range described in the literature, possibly reflecting differences in referral patterns. Rasmussen aneurysms and arterial thrombosis were notably absent, which could be explained by the rarity of their occurrence and partly due to sensitivity difference by the different CT protocol used in our study.

Bronchial artery enlargement was low and noted only in 2% of patients which similar to 3% report by Satish et al. (21)

Active TB imaging: CT features suggested active TB in only 19/150 of patients (12.7%), and only 3/19 of those patients (15.8%) had microbiological confirmation. This low prevalence of both imaging and microbiologic evidence of active TB parallels Meghji et al.'s observations in Malawi (2020)(4); where fibrosis and bronchiectasis mimicked active disease clinically, resulting to unnecessary anti TB retreatment.

The 97.5% negativity rate on sputum Gene-Xpert/AFB and discordance of imaging evidence of active TB with microbiologic confirmation necessitates the urgent need for biomarkers to differentiate active TB from post-infectious sequelae and other superimposed bacterial infection.

Comorbidities and Functional Impairment

The majority of patients (62%) has no underlying medical comorbidity which closely resembles to the result from the study done in tertiary hospital of Pakistan on 321 post TB patients in which they showed 57.6% of their participants has no known underlying medical comorbidity (2). cardiovascular disease (16.0%) and HIV (12.0%) rates mirror Ethiopia's dual disease burden both communicable and non-communicable disease, per WHO 2023 data (1). The fact that the majority of patients(62.7%) not having underlying medical comorbidity and the age distribution in our study, fairly affecting both young and elderly patients, highlights the need for follow of all post TB patients following treatment completion regardless of age and underlying comorbidity and to have clear national guide line to PTLD management. There is low documented respiratory toxin exposure (7.3% cigarette smokers) can be attributed due to low smoking habit of the Ethiopian population . However, chronic biomass fuel use (smoke exposure), a known bronchiectasis risk factor (Bhatta et al., 2008)(9), and occupational smoke exposures were also very low(<1%), likely due to lack of targeted documentation of important clinical data's which is missed due to retrospective nature of the study. Spirometery (done only for 29.3% of our patients) showed obstructive (34.1%) and restrictive (27.3%) patterns, correlating with Gupta et al.'s functional data (2022) (3). But the fact that only 29.3% undergoing pulmonary function testing versus 91% in Gupta et al.'s study(3), reflect resource constraints in Ethiopian tertiary care which could hinder functional assessment of these patients population as a result affecting delivery of appropriate management. Common presenting nonspecific clinical symptoms like cough (81.3%) and dyspnea (56.0%) exceeds Malawian cohorts (60.7%, Meghji et al. 2020)(4), possible due to our patient populations are symptomatic patients referred to our institution for tertiary level care.

Strengths and limitations

Strength:

Our study's strengths include its sizeable sample, comprehensive CT characterization, and systematic correlation with clinical and functional data. To our knowledge, it is to be the first in Ethiopian setting to analyze imaging patterns of PTLD patients based on cross sectional imaging with this significant sample size and clinical/functional correlation. This will be a base line for future prospective study in our setting and sets an important input for preparation of comprehensive PTLD program.

Limitation:

This study has several limitations inherent to retrospective designs.

- TASH's tertiary status may over represent severe and symptomatic cases which limits generalizability of the results for the whole patient population.
- Data Quality: The reliance on existing medical records can lead to inconsistencies and errors.

Finally, since it's across sectional study design, pattern of disease progression and temporal changes cannot be also assessed.

CHAPTER SEVEN: CONCLUSION

Our study showed PTLD manifests in our setting as a syndrome of predominantly severe parenchymal fibrosis and bronchiectasis, compounded by fungal colonization and diagnostic ambiguity between active disease and post-infectious inflammation. PTLD affected all age groups regardless of underlying comorbidity or frequency of prior anti TB treatment, and microbiologically confirmed concomitant active TB infection is low in our setting. Statistically significant association identified between hemoptysis and aspergilloma, alerting clinicians for its high clinical predictive value for fungal colonization. While the pattern of radiological sequelae are comparable with global patterns in anatomical distribution, the aspergilloma burden and functional management gaps highlight peculiar systemic deficiency in post-TB care in our setting.

CHAPTER EIGHT- RECOMMENDATION

- ✓ Prospective, longitudinal studies are needed on TB patients following treatment completion to quantify PTLD incidence in Ethiopia
- ✓ **National PTLD treatment Guidelines**: Integrating CT surveillance for symptomatic and high-risk groups (recurrent TB, cavitary disease)
- ✓ **Fungal Co-infection Protocols**: Given aspergilloma high prevalence, aspergillus antibody testing availability and appropriate early treatment has to be sought.

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Annex-1 Data collection checklist

1. Imaging findings

1.1. Is there parenchymal Changes of post TB sequelae? Absent/ present

If present, mention types

A. **Fibrosis**
B. **Cavitation**
C. **Tuberculoma/granuloma**
D. **Destroyed] lung/lobe**
E. **Lung cancer**
F. **Other**

1.111. Uni/bi laterality of fibrosis

A. **Unilateral**
B. **bilateral**

1.112. Location of fibrosis

A. **RUL**
B. **RML**
C. **RLL**
D. **LUL**
E. **LL**
F. **LLL**

1.121. Number of cavity/if present

A. **One**
B. **Two and more**

1.122. Location of cavity

A. **RUL**
B. **RML**
C. **RLL**
D. **LUL**
E. **LL**
F. **LLL**

1.123. Average wall thickness of the cavities-------mm

1.124. Is there mycetoma in the cavity?

A. **Absent**

B. present

1.131. Number of destroyed lobe?if present

A. 1
B. 2
C. 3 or more

1.141. Tuberculoma distribution: / if present

A. Unilateral
B. Bilateral

1.142. Type of tuberculoma based on calcification

A. Non calcified
B. Calcified
C. Both

1.143. Tuberculoma average diameter ----mm

1.2. Is there chronic pleural disease? Absent/ present

If present, mention types

A. Pleural Thickening:
B. Empyema
C. Chronic chylous pleural effusion (fat fluid level)
D. Other

1.21. Average thickness of pleural thickening----mm/if present

1.22. Type of pleural thickening/if present

A. Smooth
B. Nodular

1.23. Presence of calcification with pleural thickening

A. Absent
B. present

1.3. Is there airway complication/disease? Absent/ present

If present, mention types

A. **Tracheobronchial stenosis**

B. Bronchiectasis

C. Broncholithiasis

D. Other

1.31. Type of bronchiectasis- if present

I. Cystic

II. Varicoid

III. Cylindrical

1.32. Severity of bronchiectasis-**(assessed according to Bronchiectasis Radiologically Indexed CT Score (BRICS))**

I. Mild

II. Moderate

III. Sever

1.33. Distribution (Location) of bronchiectasis?

I. RUL

II. RML

III. RLL

IV. LUL

V. LL

VI. LLL

1.4. **Is there vascular complications?- Absent/ present**

If present, mention types

A. **Rasmussen's aneurism**

B. Vascultis/thrombosis

C. Dilated bronchial arteries

D. **Other**

1.5. Is there mediastinal complication? **Absent/ present**

If present, mention types

A. Calcified lymph node

B. Fibrosing mediastinitis

C. Pericardial TB

1.51. mention location of calcified mediastinal lymph nodes

A.Hilar

B. Subcarinal

C. lower praratracheal

D. upper paratracheal

E. Other

1.5 is there imaging evidence of **active infection? Absent/ present**

If present, mention types

A. **Ground-glass Opacities**
B. **Consolidation**
C. **Cavitary consolidation**
D. Tree-in-bud Pattern
E. **Other**

2. Clinical data and demographic data

2.1. Demographic data

Age -

Sex

A. Male
B. Female
C. Not specified

2.2. Anti TB treatment history:-

2.11. Prior TB treatments

A. One time

B. Two or more

2.12. Any on-going anti TB management

A. Yes

B. No

2.3. Is there comorbidities? Absent/present

If present, mention type/types

A. HIV
B. DM
C. Cardiovascular disease
D. Other

2.4. is there documented respiratory toxin exposure? Absent/present

If present, mention type/types

A. Smoking
B. Biomass smoke
C. Occupational smoke exposure
D. Other

2.5. What is/are the presenting clinical symptom/symptoms

A. Cough
B. Dyspnoea
C. Haemostasis
D. Wheezing
E. Chest pain
F. Other

2.5. Is Gene x-pert/AFB done? Yes/no

If yes/, result

A. Positive
B. Negative

2.6. is spirometery(lung function test) done ? yes/no

If yes, result

A. Obstructive
B. Restrictive(low FVC)
C. Mixed
D. Normal