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Radiological, Clinical, and Microbiological Manifestations of Pulmonary Tuberculosis Patients of a Secondary Hospital in Indonesia

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ABSTRACT

Tuberculosis (TB) remains a significant public health burden in Indonesia. Characterizing pulmonary TB's clinical, radiological, and microbiological features is vital to support timely and accurate diagnosis at secondary healthcare levels. This study aimed to analyze the clinical characteristics, radiological patterns, and microbiological status of pulmonary TB patients treated in secondary hospitals in Indonesia. This descriptive cross-sectional study retrospectively reviewed medical records of 58 adult patients with radiologically confirmed pulmonary TB, treated between January 2022 and December 2023. Data on demographics, symptoms, comorbidities, radiological features, and sputum smear results were analyzed. Associations between variables were tested using chi-square tests. Most patients were male (55.2%), with a mean age of 50.6 years. Previous TB history was recorded in 25.9% of cases, and 15.5% had comorbidities such as hypertension and diabetes. Cough (84.5%), fever (48.3%), and weight loss (41.4%) were the most common symptoms. Consolidation (89.7%) was the predominant radiological finding, often involving multiple lung zones (70.7%), with advanced lesions present in 77.6% of patients. Sputum smears were positive in 39.7% of cases. Pulmonary TB patients treated at secondary hospitals commonly present with advanced radiological lesions, significant comorbidities, and frequent smear-negative results. Strengthening radiological diagnostic capacity and integrated management of TB–diabetes comorbidity are essential to improve case detection and outcomes.

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INTRODUCTION

Tuberculosis (TB) remains one of the world's leading causes of morbidity and mortality due to infectious disease. According to the Global TB Report 2024, Indonesia ranks second globally in the number of TB cases, following India. National estimates indicate that approximately 1.09 million people in Indonesia develop TB each year, with around 125,000 deaths annually, equivalent to an average of 14 deaths per hour. In 2024, an estimated 885,000 TB cases were reported in Indonesia, comprising 496,000 cases among men,

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359,000 among women, and 135,000 among children aged 0–14 years. These figures highlight the persistent challenge of TB control and the urgent need for increased prevention and treatment efforts throughout Indonesia (Indonesia Ministry of Health, 2025).

As the most common clinical form of the disease, pulmonary tuberculosis accounts for the majority of cases and remains a primary focus of diagnostic and control efforts. In Indonesia, diagnosis typically relies on clinical assessment, chest radiography, sputum smear examination for acid-fast bacilli, and tuberculin skin testing (Jamal & Moherdaui, 2007). Sputum smear microscopy remains the primary tool for diagnosing pulmonary TB because it is more specific and has less inter- and intra-reader variability than chest radiography (WHO, 2007).

However, chest radiography remains an important tool for diagnosing tuberculosis, particularly in immunocompromised individuals and in cases with negative sputum smear results. The radiographic appearance of tuberculosis varies according to the host's immune response and the bacterial load in the lungs (Behera et al., 2017).

The diagnosis of tuberculosis is primarily confirmed by isolating the bacillus from an affected organ, with the lung being the most common site of infection. However, TB can involve virtually any organ. According to the WHO, the term 'smear-negative TB' has been replaced with 'clinically diagnosed TB'. Chest radiography often provides the first indication of pulmonary TB, and a chest X-ray is recommended for all suspected cases. In the universal drug sensitivity testing era, all suspected TB cases identified through clinical or radiological findings should undergo microbiological confirmation to determine rifampin and isoniazid susceptibility. If an infiltrate is detected on chest radiography, empirical antibiotic therapy may be initiated to assess whether the infiltrate resolves. In confirmed TB cases, imaging is often required to evaluate the extent of disease, monitor treatment response, and detect any residual lesions that may necessitate prolonged therapy (Singh & Sharma, 2023).

Microbial confirmation is key to establishing the diagnosis when tuberculosis is suspected based on clinical symptoms, epidemiological information, and radiological findings. Despite advances in the past few decades, the microbiological diagnosis of tuberculosis remains challenging, especially in paucibacillary TB. Historically, the diagnosis of TB has been based on microscopic examination and culture. Mycobacterial culture is the reference method because of its low detection limit and the availability of strains for phenotypic antibiotic susceptibility testing (Boldi et al., 2023).

This study aimed to analyze patients diagnosed with pulmonary tuberculosis's clinical, radiological, and microbiological characteristics. Data were retrospectively collected from medical records at a secondary health facility. Patients included had radiologically confirmed pulmonary TB and complete or near-complete records on relevant variables such as symptoms, sputum smear results, comorbidities, and radiographic lesion characteristics. Our study provides valuable insights into the clinical, radiological, and microbiological characteristics of patients with radiologically confirmed pulmonary tuberculosis (TB) at secondary healthcare facilities; however, our study has limitations in its retrospective design, being confined to a single hospital, and lacking analysis of outcomes or comparisons across various patient subgroups. Specifically, there are limitations in prospective analysis,

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comparativity, generalizability, outcome or treatment relationships, and evaluation of comorbidities and risk factors.

METHODS

Study Design and Participants

Our study employed a descriptive cross-sectional design to analyze clinical, radiological, and microbiological characteristics of patients diagnosed with pulmonary tuberculosis. Data were retrospectively collected from the medical records of 58 adult patients who underwent diagnostic evaluation at a secondary health facility in Tebet Regional General Hospital. Patients included had radiologically confirmed pulmonary TB and complete or near-complete records on relevant variables such as symptoms, sputum smear results, comorbidities, and radiographic lesion characteristics. This study design is suitable for providing an overview of the characteristics of a specific population at a given time. This design is particularly appropriate for describing the distribution, patterns of clinical, radiological, and microbiological features in patients with pulmonary TB, identifying common presentations, and relationships between variables such as symptom patterns, types of lesions, and sputum positivity. A retrospective approach within a cross-sectional framework allows for efficient resource utilization and timely data analysis without the need for new data collection or patient follow-up.

Data Collection

The following variables were extracted: demographic data (age, sex), clinical symptoms (eg, cough, fever, weight loss, dyspnea), comorbidity status (eg, diabetes mellitus, hypertension), radiological findings (type of lesion, zone involvement, laterality), and sputum smear results for acid-fast bacilli (AFB). Radiological findings were categorized based on standard chest X-ray assessments, with lesion types classified as moderate or far advanced, and lung zones defined as upper, middle, or lower. Laterality was recorded as unilateral or bilateral based on radiologist reports.

Data Analysis

Descriptive statistics were used to summarize patient characteristics. We calculated patient-level frequencies and total response-level percentages for radiological and clinical features that allowed multiple responses (eg, symptoms and radiological patterns). Where relevant, radiological features were cross-tabulated against lesion laterality (unilateral vs. bilateral) to explore distribution patterns. We performed Chi-square tests to evaluate associations between comorbidities, sputum smear status, lesion type, symptom severity, radiological zone involvement, and bilateral disease. We performed these analyses only when the assumptions of minimum expected cell counts were met. Statistical significance was set at $\alpha < 0.05$.

RESULTS

As shown in Table 1, the dataset consisted of 58 patients, of whom 32 (55.2%) were male, indicating a slightly higher proportion of males than females. The mean age of the participants was 50.6 years (SD = 15.08), reflecting a predominantly middle-aged to older adult cohort. A history of TB was recorded in 15 patients (25.9%), suggesting that approximately one in four

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patients had previously been treated for TB, which may have implications for recurrence risk or radiological findings.

Regarding comorbidities, more than half of the patients (30; 51.7%) reported no comorbid condition, while both hypertension and diabetes were reported in 9 (15.5%) patients (Table 1 and Table 2).

Table 1. Demographic, clinical, radiological, and microbiological characteristics of patients with pulmonary tuberculosis (N = 58)

Variable	Category	Freq	Percentage % of patients (*N* = 58)	
Gender	Male	32	55.2%	
	Female	26	44.8%	
Age	Mean	50.6	15.08	
History of TB	Yes	15	25.9%	
	No	37	63.8%	
	Missing	6	10.3%	
Comorbid	No Comorbid	30	51.7%	
	Hypertension only	6	10.3%	
	Diabetes only	7	12.1%	
	Hypertension & Diabetes	9	15.5%	
	Missing	6	10.3%	
			% of patients (*N* = 58)	% of all Responses (*N* = 170)
Symptoms	Cough	49	84.5%	28.8%
	Fever	28	48.3%	16.5%
	Dyspnea	16	27.6%	9.4%
	Weight loss	24	41.4%	14.1%
	Fatigue	11	19.0%	6.5%
	Night sweats	9	15.5%	5.3%
	Decreased appetite	8	13.8%	4.7%
	Chest pain	5	8.6%	2.9%
	Nausea, vomiting	10	17.2%	5.9%
	Dizziness, shivering, chills	3	5.2%	1.8%
	Others (Diarrhoea, Neck lump, History of pulmonary mycosis, HIV, and psychiatric disorder, Maxillary sinusitis, Abdominal pain)	7	12.1%	4.1%
			% of patients (*N* = 58)	% of all responses

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Variable	Category	Freq	Percentage % of patients (*N* = 58)	(*N* = 122)
Radiology Pattern	Pneumothorax	3	5.2%	2.5%
	Pleural effusion	30	51.7%	24.6%
	Fibrosis	3	5.2%	2.5%
	Hilar and mediastinal lymphadenopathy	6	10.3%	4.9%
	Cavitation	6	10.3%	4.9%
	Consolidation	52	89.7%	42.6%
	Miliary disease	6	10.3%	4.9%
	Pleural thickening	3	5.2%	2.5%
	Reticulonodular pattern	7	12.1%	5.7%
	Others (Right lung atelectasis, Bronchiectasis, Calcification)	6	10.3%	4.9%
			% of Patients (N = 58)	% of All Responses (N = 115)
Radiological Zone	Middle	35	60.3%	30.4%
	Lower	39	67.2%	33.9%
	Multiple	41	70.7%	35.7%
	Unilateral	18	31.0%	
	Bilateral	35	60.3%	
	Missing	5	8.6%	
			% of Patients (N = 58)	
Lesion Type	Moderate	9	15.5%	
	Far Advance	45	77.6%	
	Missing	4	6.9%	
Sputum Smear	Positive	23	39.7%	
	Negative	35	60.3%	

Note: Values are presented as frequency (percentage) unless otherwise stated. Radiological features and comorbidities may not be mutually exclusive.

Symptoms

One hundred seventy symptom entries were recorded, indicating that each individual commonly experienced multiple symptoms. Cough emerged as the most prevalent symptom, reported by 84.5% of patients, accounting for nearly one-third of all symptom entries. Fever, weight loss, and dyspnea were also frequently observed, occurring in 48.3%, 41.4%, and

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27.6% of patients, respectively, and reflect the systemic and respiratory manifestations typical of active TB.

Additional symptoms such as fatigue (19.0%), night sweats (15.5%), and decreased appetite (13.8%) suggest an ongoing chronic infectious process. A smaller proportion of patients reported nausea and vomiting (17.2%), chest pain (8.6%), and constitutional symptoms such as dizziness, shivering, or chills (5.2%). A subset of patients (12.1%) reported fewer common symptoms, including diarrhea, neck masses, and comorbid conditions such as HIV or psychiatric disorders, as well as extrapulmonary manifestations like abdominal pain.

Table 2. Distribution of radiological and clinical characteristics according to unilateral and bilateral lung involvement in patients with TB

Radiological Pattern	*n*	Unilateral		Bilateral		χ^2
Pneumothorax	3	0	0.0%	3	100.0 %	--
Pleural effusion	29	11	37.9%	18	62.1%	0.450
Fibrosis	3	0	0.0%	3	100.0 %	--
Hilar and mediastinal lymphadenopathy	6	0	0.0%	6	100.0 %	3.48
Cavitation	6	2	33.3%	4	66.7%	--
Consolidation	47	14	29.8%	33	70.2%	3.227
Miliary disease	6	0	0.0%	6	100.0 %	--
Pleural thickening	3	1	33.3%	2	66.7%	--
Reticulonodular pattern	7	1	14.3%	6	85.7%	--
Radiological Zone	*n*	Unilateral		Bilateral		
Upper zone	33	10	30.3%	23	69.7%	0.742
Middle zone	36	12	33.3%	24	66.7%	0.085
Lower zone	39	16	41.0%	23	59.0%	--
Multiple zones	28	5	17.9%	23	82.1%	7,528 *
Type of lesion	*n*	Unilateral		Bilateral		
Moderate	6	3	50.0%	3	50.0%	0.707
Far/advanced	43	14	32.6%	29	67.4%	
Sputum smear	*n*	Unilateral		Bilateral		
Positive	21	4	19.0%	17	81.0%	3.45
Negative	32	14	43.8%	18	56.3%	

Radiology Pattern

As shown in Table 1, radiological assessments of 58 patients yielded 122 imaging findings, indicating that most individuals exhibited multiple abnormalities. Consolidation was the most prevalent pattern, observed in 89.7% of patients and accounting for 42.6% of all

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findings. Pleural effusion followed, present in 51.7% of patients, suggesting that pleural involvement was common. Less frequent but notable features included reticulonodular infiltrates (12.1%), cavitation, hilar and mediastinal lymphadenopathy, and miliary disease (each 10.3%). Additional findings such as pleural thickening, fibrosis, and pneumothorax were observed in 5.2% of patients. Atypical or rare findings, including right lung atelectasis, bronchiectasis, and calcification, were grouped under "Others" (10.3%).

When divided into unilateral and bilateral, about 70.2% of the consolidation cases (n = 47) involved bilateral lung zones, whereas only 29.8% were unilateral. This finding supports the interpretation that consolidation, a hallmark of pulmonary TB, frequently presents as a widespread, bilateral process, likely indicating greater disease severity or advanced progression.

When stratified by laterality (see Table 2), 70.2% of consolidation cases involved bilateral lung zones, supporting the view that this hallmark of pulmonary TB often reflects more extensive disease. Similarly, 62.1% of pleural effusion cases were bilateral, although 37.9% remained unilateral, indicating both localized and widespread pleural involvement. Some patterns, including fibrosis, hilar and mediastinal lymphadenopathy, and miliary disease, were exclusively bilateral, suggesting an association with disseminated or systemic TB. Cavitation and reticulonodular patterns were also more commonly bilateral (66.7% and 85.7%, respectively), while pleural thickening was bilateral in two-thirds of cases. All three pneumothorax cases showed bilateral involvement, possibly reflecting severe parenchymal destruction. Although these patterns suggested laterality differences, Chi-square analysis found no significant association between specific radiological findings and unilateral versus bilateral involvement.

Radiology Zone

Among the 58 TB patients, radiographic assessment showed frequent involvement of the middle (60.3%), lower (67.2%), and multiple zones (70.7%) (see Table 1). Because some patients had more than one zone affected, totals exceeded 100%. Based on the total number of zone-level findings (N = 115), the lower zone accounted for the largest share (33.9%), followed by multiple zones (35.7%) and the middle zone (30.4%). This distribution reflects the extensive and often multifocal nature of TB-related lung involvement.

As shown in Table 2, the upper zone was affected in 33 patients, with 69.7% of these cases showing bilateral involvement, consistent with the known progression of TB from localized apical lesions to more widespread disease. The middle zone showed a similar pattern, with 66.7% bilateral involvement among the 36 affected patients. Although the lower zone was the most commonly involved (n = 39), it had the highest proportion of unilateral cases (41.0%), possibly indicating more localized or atypical presentations. The multiple-zone category was particularly notable, with 82.1% of cases presenting bilaterally.

Despite these trends, no significant associations were observed between zone involvement and lesion laterality, except for multiple-zone involvement, which was significantly associated with bilateral disease ($p < 0.01$), highlighting its potential role as a marker of disease burden.

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Lesion

Among the 58 patients with pulmonary TB, 77.6% were classified as having far/advanced lesions, while only 15.5% had moderate lesions, and 6.9% had missing data. This distribution suggests that most patients presented with radiologically extensive disease, likely reflecting delayed diagnosis or prolonged disease progression. The low proportion of moderate lesions implies that early-stage TB was underrepresented, possibly due to delayed health-seeking behavior or referral bias toward more severe cases.

As shown in Table 2, lesion distribution differed by severity. Among patients with moderate lesions, involvement was evenly split: 50.0% unilateral, 50.0% bilateral, suggesting that early disease may remain localized. In contrast, 67.4% of far/advanced cases were bilateral, indicating a tendency for extensive pulmonary involvement as the disease progresses. However, Chi-square analysis revealed no statistically significant association between lesion type and laterality ($p = 0.405$), suggesting that lesion severity alone did not predict lung involvement pattern.

Sputum

As shown in Table 1, 39.7% of the patients were sputum smear-positive, while 60.3% were smear-negative, reflecting a predominantly paucibacillary cohort. This finding is more likely to be diagnosed through radiological and clinical criteria. Smear-positive cases were more likely to show bilateral lung involvement, with 81.0% of the 21 positive patients having bilateral lesions, compared to only 19.0% with unilateral findings. In contrast, the distribution was more balanced among smear-negative patients ($n = 32$): 56.3% bilateral and 43.8% unilateral. This pattern suggests a potential link between higher bacillary load and more extensive pulmonary disease.

Nevertheless, Chi-square analysis showed no statistically significant association between sputum smear status and laterality ($p = 0.081$), indicating that while trends suggest greater bilateral involvement in smear-positive TB, the difference was insignificant within this cohort.

DISCUSSION

Our study showed that 55.2% of patients were male, indicating a slightly higher proportion of males than females. The mean age of participants was 50.6 years, reflecting a predominantly middle-aged to older adult cohort. These findings are consistent with those reported by Marçôa and Humayun. In Marçôa's study of 12,314 TB patients, the mean age was 47.3 ± 18.9 years, and 65.8% were male. The number of TB cases was markedly higher in men than in women after the second decade of life, with the highest incidence in men occurring in the 40–49-year age group (52.2 per 100,000 population) and in women in the 20–29-year age group (23.4 per 100,000 population) (Marçôa et al., 2018).

Humayun's study revealed that men have a 53% higher risk of developing TB compared to women (risk ratio [RR] = 1.53). However, the prevalence of abdominal TB, bone/joint/spinal TB, and other forms of extrapulmonary TB was lower in men than in women. The risk of TB–HIV co-infection in men was 17% in the 15–24-year age group and 8% lower in the 25–44-year age group, indicating a higher risk of infection among younger men (Humayun et al.,

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2022). Similarly, our study supports previous findings, reporting that approximately 56.9% of patients were male, with a mean age of 57.0 years, and that the most common pulmonary TB lesions were confined to a single lobe of the lung parenchyma (Ko et al., 2018).

Our study revealed that a history of TB was recorded in 25.9%, suggesting that approximately one in four patients had previously been treated for TB, which may have implications for recurrence risk or radiological findings. The factor of previous TB history has an impact on the risk of TB recurrence in patients. A study conducted by Kim et al. found that TB patients who completed treatment within 12 months, and whose TB had not relapsed within a year, had certain identifiable risk factors at the time of their initial TB episode that were associated with a higher risk of subsequent TB relapse, and these factors differed by birth origin. In general, social risk factors were associated with TB relapse among patients born in the United States (US). In contrast, clinical characteristics appeared to play a greater role among patients born abroad. Among patients born in the US, TB relapse was associated with age 25–44 years and use of treatment during the initial TB episode. Among patients born abroad, relapse was more likely to occur in those aged 45–64 years, in individuals with HIV infection, and those with a history of smear-positive TB (L. Kim et al., 2016).

Our study revealed that more than half of the patients (30; 51.7%) reported no comorbid conditions, while both hypertension and diabetes mellitus (DM) were present in 9 patients (15.5%). This finding is consistent with a study by Lutfiana et al., which analyzed 41 clinical trials of TB drugs conducted worldwide and found that approximately 29.3% of these trials identified DM as a comorbidity. With an estimated prevalence of 16% among TB patients, diabetes mellitus is one of the most common non-communicable comorbidities and represents a significant risk factor for poor TB outcomes, often necessitating individualized TB drug dosing regimens (Lutfiana et al., 2019).

Concurrent TB and DM can vary or even worsen the clinical manifestations of the disease. Clinically, TB-DM patients can have a more severe presentation of symptoms compared to non-TB-DM patients, including more weight loss, dyspnea, sweating, and longer duration of fever (Atrese et al., 2024). In addition, patients experience more severe lung involvement, radiological evidence shows that TB-DM patients have more parenchymal lesions and cavities (Chiang et al., 2014; Sane Schepisi et al., 2019).

The complaints and symptoms experienced by patients in our study were varied, indicating that many symptoms are common to individuals. Cough emerged as the most common symptom, reported by 84.5% of patients. Fever, weight loss, and shortness of breath were also common, occurring in 48.3%, 41.4%, and 27.6%, respectively, and reflected the typical systemic and respiratory manifestations of active TB. Additional symptoms such as fatigue (19.0%), night sweats (15.5%), and decreased appetite (13.8%) indicated an ongoing chronic infection process. A small proportion of patients reported nausea and vomiting (17.2%), chest pain (8.6%), and constitutional symptoms such as dizziness, chills, or fever (5.2%). A proportion of patients (12.1%) reported less common symptoms, including diarrhea, neck masses, and comorbid conditions such as HIV or psychiatric disorders, as well as extrapulmonary manifestations such as abdominal pain. A study by Davis et al. revealed that TB symptoms usually appear gradually and vary in duration from weeks to months.

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However, acute onset can occur in young people or individuals with weakened immune systems. Symptoms of fever, night sweats, and weight loss are found in approximately 75%, 45%, and 55% of patients, respectively, while persistent and unremitting cough is the most commonly reported symptom (95%) (Davies et al., 2014). Peto's study revealed that approximately 20% of active TB cases in the US are extrapulmonary TB (EPTB), and approximately 7% of cases have EPTB and pulmonary TB simultaneously (Peto et al., 2009).

A retrospective analysis study by Farina et al. in 226 patients with pulmonary TB, the most frequently mentioned items were history of contact (53.5%) and having parents from a high-risk country (60.2%). Cough was reported in 49.5% of patients at onset, fever in 46%, and these symptoms persisted for over 2 weeks in about 20% of cases. Lymphadenopathy was found in 15.9% of cases. The prospective study involved 85 patients, 14 (16.5%) confirmed as TB patients and 71 (83.5%) as non-TB cases. Lymphadenopathy and history of contact were the variables most correlated with TB cases (Farina et al., 2022).

The findings of our study reveal that bilateral lung involvement is a predominant radiological pattern in pulmonary tuberculosis. This widespread distribution supports the understanding of TB as a multifocal and progressive pulmonary disease, particularly in cases presenting at later stages or in individuals with underlying comorbidities. Bilateral presentation was frequently observed in association with consolidation, pleural effusion, and disseminated forms such as lymphadenopathy and miliary disease, underscoring the need for comprehensive chest imaging during both diagnosis and clinical follow-up.

Miliary TB affects approximately 1% to 7% of patients with all forms of TB (Burrill et al., 2007). It is typically seen in the elderly, infants, and immunocompromised individuals. Initially, standard radiographs are normal in 25–40% of cases (Jeong & Lee, 2008). The typical finding consists of numerous nodules measuring 1 to 3 mm in diameter distributed randomly throughout the lung, often with thickening of the intra- and interlobular septa (Kwong et al., 1996; Leung, 1999). The nodules usually resolve within 2–6 months with treatment, without scarring or calcification; however, they may coalesce to form focal or diffuse consolidations.

Pleural effusion is seen in about one-quarter of patients with primary pulmonary TB and 18% with post-primary pulmonary TB (Jeong & Lee, 2008). Pleural effusion has been reported as the sole radiographic finding indicating primary pulmonary TB in about 5% of adult cases. 19 Pleural effusion is usually unilateral and on the same side as the primary focus of pulmonary TB, while complications such as effusion, empyema, and bronchopleural fistula are rare. 18 CT scans of patients with post-primary pleural effusions generally show subtle visceral and parietal pleura thickening (Yilmaz et al., 1998). Ultrasonography often shows complex septation and effusions.18 Fibrothorax with diffuse pleural thickening, but without pleural effusion on CT scan, indicates inactivity (H. Y. Kim et al., 2001).

According to a study by Mathur *et al.* (2017), among immunocompetent patients, 36.7% exhibited an atypical radiological presentation. Nodular opacities were observed in 90% of cases, consolidation in 73.3%, lymphadenopathy in 23.3%, and cavitation in 60%, with 94.4% of cavitary lesions occurring as a single lesion. Isolated involvement of the upper lung zones was reported in 60% of patients. In immunocompromised patients, 76.7% had an atypical radiological presentation, 66.7% had nodular opacities, 46.7% had consolidation,

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63.3% had lymphadenopathy, 20% had cavitation, and the cavitary lesions were multiple in 60% of patients. Isolated lower lung areas were involved in 23.3% of patients (Mathur et al., 2017).

In our study, involvement of multiple lung zones was particularly indicative of bilateral disease, suggesting that the extent of anatomical spread may serve as a clinical marker of disease severity. While the upper and middle zones often exhibited bilateral findings, the lower zone showed a greater tendency toward unilateral involvement, which may reflect early-stage or atypical presentations of TB. These variations highlight the value of radiological zone assessment in evaluating disease progression and potentially guiding treatment strategies. The Kuruva study revealed similar clinical symptoms in the case and control groups, except hemoptysis and weight loss, which were significantly more prevalent in the case group. There was significant radiological involvement of the lower lung fields (46% vs. 17.5%) with cavitation (42.9% vs. 20.6%) in the case group compared to the control group. Sputum conversion at the end of 2 months was 92.1% in the control group and 55.6% in the case group. In addition, the cure rate in the control group was significantly higher compared to the case group (81%). The proportion of treatment failure was higher in the case group (14.3%) compared to the control group (1.6%) (Kuruva et al., 2021).

Differences in lesion severity also appear to influence laterality. Patients with far/advanced lesions more frequently exhibited bilateral radiological involvement, consistent with the natural history of progressive pulmonary TB. In contrast, moderate lesions were more likely to remain localized. Although this relationship was not statistically significant, the trend supports the clinical utility of lesion classification as an indicator of disease extent. Pulmonary TB infection often leaves long-term consequences such as granulomatous nodules, cavities, and fibrosis; thus, distinguishing dormant disease from reactivation is not always clear. The radiologic presentation of primary pulmonary TB infection tends to differ from that of post-primary pulmonary TB, but there is significant overlap in appearance. Primary pulmonary TB is usually characterized by consolidation and regional lymphadenopathy, while post-primary pulmonary TB more often results in cavitation. The pathology and radiology of TB infection will change based on the efficacy of the immune response and will vary depending on the ability of the immune system (Roy & Ellis, 2010).

In our study, sputum smear status showed a similar directional trend. Smear-positive cases correspond with more extensive radiological involvement, suggesting a link between bacillary load and bilateral lung disease. However, this association did not reach statistical significance. These observations emphasize the importance of considering smear results for diagnostic confirmation and assessing potential transmission risk and underlying disease burden. Rai's study stated that in the 147 patients studied, there were more patients with negative sputum than positive sputum (109 vs 38). The patch and cavity consolidation frequency was significantly higher in sputum-positive pulmonary TB. Radiological lesions such as nodules, cystic lesions, miliary features, and pleural effusion were more common in sputum-negative pulmonary TB, but the difference was not significant. Sputum-positive pulmonary TB tended to occur more frequently on the left side compared to sputum-negative

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pulmonary TB. Bilateral radiographic lung lesions were observed with similar frequency in patients with sputum-positive and sputum-negative pulmonary TB (Rai et al., 2019).

In a previous study involving 325 patients, the left upper lobe was the most commonly affected site, observed in 53.8% of cases. The most frequent radiographic findings were bronchopneumonia in 74.4% of cases, and patchy consolidation was detected in 30.4% of patients. Cavity lesions were found in 20.9% of patients and pleural effusion in 10.7%. The results showed that the upper lobe of the lung was the most frequently involved location (Eini, P, Owaysee et al., 2013).

Clinical and Research Implications

The predominance of bilateral findings, particularly in more severe forms of TB, suggests that radiological laterality may offer clinical insight into disease staging and prognosis. In settings with limited diagnostic resources, laterality, lesion type, and zone involvement may aid in stratifying patients based on severity and guide treatment prioritization. Furthermore, these findings highlight the importance of early detection, as unilateral presentations, particularly in the lower zone or with moderate lesions, may offer a window for earlier intervention. Future studies with larger samples and longitudinal designs are warranted to validate these associations and explore the prognostic value of radiological distribution patterns in treatment response and outcomes.

CONCLUSION

This cohort showed a predominance of middle-aged male patients, with diverse respiratory symptoms and multiple radiological findings, especially consolidation and multi-zone involvement. The history of previous tuberculosis and the high proportion of negative sputum results highlight the importance of a thorough clinical and radiological evaluation to support the diagnosis and detection of active disease, especially in recurrent or atypical cases. These findings highlight the critical role of comprehensive clinical and radiological assessment in confirming active disease, especially among patients with recurrent or atypical presentations. Strengthening radiological capacity, implementing systematic screening for common comorbidities such as diabetes mellitus, and promoting early detection must be supported by targeted training, standardized diagnostic protocols, and robust referral linkages integrated into routine practice and local health policy to improve diagnostic accuracy, guide timely treatment, and reduce the burden of pulmonary tuberculosis at the secondary care level. Based on our findings, our suggestions for further research with multicenter studies, larger samples and longitudinal designs are warranted to validate these associations and explore the prognostic value of radiological distribution patterns in treatment response and outcomes. Analysis of outcomes or comparisons across various patient subgroups. Prospective analysis, comparativity, generalizability, outcome or treatment relationships, and evaluation of comorbidities and risk factors.

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