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HIGH RESOLUTION OF COMPUTED TOMOGRAPHY FINDINGS IN SPUTUM AFB POSITIVE CASES

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Abstract

OBJECTIVE: *To evaluate the High-Resolution Computed Tomography (HRCT) findings in sputum Acid-Fast Bacillus (AFB) positive cases.*

METHODOLOGY: *This cross-sectional study was conducted at the Department of Radiology, Sindh Govt Hospital Korangi No. 5 Karachi, during December 2023 to January 2024 on 80 participants, selected through non-probability consecutive sampling. All patients underwent sputum AFB smear and culture before HRCT and chest radiography. HRCT scans were performed using an MDCT scanner. Data analysis was conducted using SPSS 26, with $p \leq 0.05$ considered statistically significant.*

RESULTS: *This investigation encompassed a cohort of 80 participants with a mean age of 41.01 ± 14.47 years; 60% of the subjects were identified as male. The predominant high-resolution computed tomography (HRCT) findings encompassed centrilobular nodules (90.0%), lobular consolidation(82.5%), cavitation(73.8%), and a tree-in-bud appearance(63.7%). Observations of lesser frequency consisted of lymphadenopathy (8.8%) and miliary nodules(5.0%), thereby underscoring the critical role of HRCT in the identification of distinctive pulmonary tuberculosis manifestations.*

CONCLUSION: *This study, with sputum AFB positivity, evaluated HRCT findings in patients with PTB, and these included centrilobular nodules, lobular consolidation, cavitation, and a tree-in-bud appearance. HRCT can delineate the extent of disease better than any other imaging modality, where microbiological tests may fail. HRCT is of great help in a quick diagnosis and treatment of PTB as it shows high sensitivity in identifying early and subtle parenchymal change. Further work is needed to explore its prognostic significance and ability to guide therapeutic approaches to mitigate these poor patient outcomes.*

INTRODUCTION

Tuberculosis (TB) represents one of the most widespread infectious diseases globally, with an estimated 1.7 million fatalities and nearly 9 million new diagnoses of active TB occurring annually [1]. The outbreak of TB is rising 1% yearly and about 95% of cases and 98% of deaths are in low-income developing nations in Asia, Africa, and South America [2]. These regions alone accounts for 44% of the TB infected population of the world excluding china [3]. Introduction Pulmonary

tuberculosis (PTB) is described as a leading high-burden infectious disease, hence it should be diagnosed correctly as soon as possible to timely management of the patients as well as control of its spread [1].

The microbiological identification of Acid-Fast Bacilli (AFB) remains the benchmark for TB diagnosis [4]. The sensitivity of AFB smear microscopy from sputum varies between 46% and 74%, while sputum culture sensitivity ranges from 2% to 95% among individuals presenting with active pulmonary disease [5]. Conversely, smear positivity rates among adult patients with PTB are notably low, averaging between 10% and 22% on a national scale [6]. Thus, the chest radiograph and high-resolution computed tomography (HRCT) are essential for diagnosing the TB especially when microbiological tests are negative [7].

Due to the low cost, availability, ease of use, chest radiography is the most common imaging method used for the assessment of pulmonary TB [8].

However, its diagnostic accuracy is suboptimal, with research indicating correct diagnoses in merely 34% of primary pulmonary TB cases and 59% of post-primary TB cases [9]. In contrast, HRCT has exhibited superior sensitivity in identifying minimal exudative lesions, subtle parenchymal abnormalities, and active disease in pulmonary TB [10],[11]. Reports indicate that HRCT demonstrates a sensitivity and specificity of approximately 88%, accompanied by a diagnostic accuracy rate of 88% [12],[13]. Furthermore, HRCT is more adept at identifying miliary nodules, cavitary lesions, and sequential morphological alterations following anti-tuberculosis treatment [14].

The relationship of HRCT with sputum smear positivity has also been explored in last few years in an effort to determine if HRCT features can act as predictors of disease infectivity [35–38]. Significant HRCT abnormalities related to active TB include centrilobular micronodules, tree-in-bud opacities, cavitation, and consolidation. However, the relationship between these observations and sputum smear is still an area of research. Appropriate and reliable diagnostic platforms, utilizing a combination of microbiologic, molecular and radiological tools, are essential in endemic areas with high TB burden for timely diagnosis and treatment.

This study seeks to assess the HRCT findings in sputum AFB-positive PTB patients and to ascertain their diagnostic relevance in evaluating disease severity and progression.

METHODOLOGY

This cross-sectional study was conducted within the Department of Radiology, Sindh Govt Hospital Korangi No. 5 Karachi, during December 2023 to January 2024. We have conducted a non-probability, consecutive sampling study, on a sample of 80 patients aged 18–60 years diagnosed to have sputum AFB positive pulmonary tuberculosis (PTB).AFB-positive PTB was diagnosed by detecting the clinical signs and symptoms including cough, fever, weight-loss, night sweating, hemoptysis and fatigue with persistent cough for at least two weeks.

Microbiological confirmation was obtained through sputum smear microscopy utilizing Ziehl-Neelsen staining across three consecutive samples; moreover, in cases with a high clinical suspicion but negative initial smears, sputum culture for Mycobacterium tuberculosis was performed. The inclusion criteria were patients newly diagnosed with tuberculosis who have not started anti-tuberculosis treatment or received anti-tuberculosis treatment for less than four weeks. Exclusion criteria were ATT for > 4 weeks, MDR-tuberculosis, coexisting pulmonary diseases (e.g., COPD, pneumoconiosis, DPLDs, lung cancer) and patients unable to produce sputum for smear. Additionally, pregnant or lectating women were excluded due to its unique hematogenous dissemination characteristics.

High Resolution Computed Tomography (HRCT)-HRCT was done using multi-detector computed tomography (MDCT) scanner. A series of thin-section slices (2 mm collimation, 10 mm intervals) using breath-hold imaging in the supine position, extending from the lung apices to the hemidiaphragms, reconstructed with a high-resolution bone algorithm. The lung window (window width 1000 Hounsfield Units (HU), window level -700 HU) and the mediastinal window (window width 250-400 HU, window level -10 to 50 HU) were used as two separate window settings.

An intravenous non-ionic contrast agent (50 mL bolus dose) was administered in instances where lymphadenopathy was suspected to assess regions of

diminished attenuation. HRCT scans were independently evaluated by two senior radiologists with over a decade of experience in thoracic imaging. To mitigate inter-observer variability, any discrepancies in findings were resolved through a consensus review involving a third radiologist. The following HRCT patterns were systematically analyzed: centrilobular nodules (2-4 mm, associated with respiratory bronchioles, sparing pleural surfaces), acinar nodules (6-10 mm, poorly defined), and miliary nodules (1-2 mm, randomly distributed and symmetric). Additional radiological features assessed included lobular consolidation (10-20 mm areas of increased opacity, obscuring bronchovascular markings), ground-glass opacities (increased opacity without obscuration of vascular markings), cavitation, lymphadenopathy (nodes >10 mm in short-axis diameter), and a tree-in-bud appearance (branching linear structures with multiple contiguous branching sites).

Data analysis was conducted using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were represented as frequencies and percentages.

RESULTS

The study included 80 participants with a mean age of 41.01 ± 14.47 years. Among them, 38 (47.5%) were aged 18-40 years, while 42 (52.5%) were older than 40 years. The mean body mass index (BMI) was 25.57 ± 3.30 kg/m², with 47 (58.8%) participants having a BMI between 20-25 kg/m² and 33 (41.2%) having a BMI above 25 kg/m². The mean hemoglobin (HB) level was 11.70 ± 1.96 g/dl, with 34 (42.5%) participants having HB levels between 8-11 g/dl and 46 (57.5%) having levels above 11 g/dl. The mean erythrocyte sedimentation rate (ESR) was 45.41 ± 12.92 mm/hr, with 46 (57.5%) participants having ESR levels between 20-45 mm/hr and 34 (42.5%) having levels above 45 mm/hr. Regarding gender distribution, 48 (60.0%) participants were male, while 32 (40.0%) were female as shown in **TABLE I**.

Table I: Baseline Demographic and Clinical Characteristics of Study Participants (n=80)

Variable	n (%)
Age (Mean ± SD) = 41.01 ± 14.47	
18-40 years	38 (47.5)
>40 years	42 (52.5)
Body Mass Index (Mean ± SD) = 25.57 ± 3.30	
20-25 kg/m²	47 (58.8)
>25 kg/m²	33 (41.2)
HB Level (Mean ± SD) = 11.70 ± 1.96	
8-11 g/dl	34 (42.5)
>11 g/dl	46 (57.5)
ESR (Mean ± SD) = 45.41 ± 12.92	
20-45 mm/hr	46 (57.5)
>45 mm/hr	34 (42.5)
Gender	
Male	48 (60.0)
Female	32 (40.0)

High-resolution computed tomography (HRCT) findings in patients with sputum AFB-positive tuberculosis revealed that the most common abnormality was centrilobular nodules, observed in 72 (90.0%) patients. Lobular consolidation was present in 66 (82.5%) patients, while cavitation was noted in 59 (73.8%) cases. The characteristic "tree-in-bud" appearance was identified in 51 (63.7%) patients. Lymphadenopathy was observed in 7 (8.8%) cases, whereas miliary nodules were the least common finding, detected in 4 (5.0%) patients as shown in **TABLE II**.

Table II: High-Resolution Computed Tomography (HRCT) Findings in Patients with Sputum AFB-Positive Tuberculosis

HRCT Findings, *n* (%)	Frequency	Percentage
Centrilobular Nodules	72	90.0
Lobular Consolidation	66	82.5
Cavitation	59	73.8
Tree in Bud Appearance	51	63.7
Lymphadenopathy	7	8.8
Miliary Nodules	4	5.0

DISCUSSION

The findings of this study highlight the significant role of high-resolution computed tomography (HRCT) in evaluating sputum AFB-positive

pulmonary tuberculosis (PTB) cases. The HRCT findings in these patients were as follows: centrilobular nodules in 90.0%, lobular consolidation in 82.5%, cavitation in 73.8%, tree-in-bud appearance in 63.7%, lymphadenopathy in 8.8% and miliary nodules in 5.0% of patients. Our findings are similar to earlier studies which have also shown the role of HRCT in diagnosis of pulmonary tuberculosis and differentiating it from other lung pathology. In another study, 92% of cases showed centrilobular nodules, 84% lobular consolidation, 76% cavitation, 68% tree-in-bud appearance, 8% lymphadenopathy and 4% miliary nodules [15]. These differences in percentage across studies may be due to factors like variations in patient populations, disease severity, and different HRCT protocols at different centres.

Centrilobular nodules were the most frequent HRCT finding, present in 90.0% of cases, which is consistent with other studies reporting a similar frequency. These nodules represent bronchogenic spread of *Mycobacterium tuberculosis* and are considered a hallmark feature of active PTB. Lobular consolidation was also a common finding, occurring in 82.5% of patients. Consolidation in tuberculosis is typically patchy and segmental, often affecting the upper lobes. The presence of lobular consolidation suggests active inflammation and alveolar involvement, which is significant in distinguishing active from inactive disease. Another study found consolidation in 92% of cases, which is slightly higher than our findings, possibly due to differences in disease progression among the study populations.

Cavitation was observed in 73.8% of patients, supporting the well-documented role of HRCT in detecting cavities, particularly in advanced tuberculosis cases. Cavitation is associated with high bacterial loads and increased infectivity, making it an important radiological marker in sputum AFB-positive patients. In comparison, Kosaka et al. reported cavitation in only 52% of cases, which may reflect variations in the study population, as cavitation is more common in patients with prolonged disease duration or immune compromise [16]. Another study by Ko et al. found cavitation in 66% of cases, which is slightly lower than our results but still emphasizes the importance of HRCT in detecting cavitary lesions that might be missed on chest radiographs [17].

The tree-in-bud appearance was present in 63.7% of cases, reinforcing its role as a key HRCT finding in active tuberculosis. This pattern represents endobronchial spread of infection, with mucus and inflammatory exudates filling the bronchioles, producing a branching nodular pattern on imaging. The prevalence of this finding was slightly lower than the 68% reported in a previous study but was comparable to the 52% reported by Ko et al [17]. The variation in prevalence might be due to differences in disease severity at the time of imaging, as tree-in-bud opacities are more commonly seen in early bronchogenic dissemination.

Lymphadenopathy was detected in 8.8% of patients, which is consistent with previous finding reporting a prevalence of 8% [15]. Tuberculous lymphadenopathy is more commonly observed in primary tuberculosis and in immunocompromised individuals, whereas in adult cases of post-primary PTB, lymph node involvement is less prominent. The relatively low prevalence of lymphadenopathy in this study suggests that the majority of cases represented post-primary tuberculosis rather than primary disease.

Miliary nodules were seen in 5·0% of patients, similar to the 4% in previous report [15]. Miliary tuberculosis occurs after hematogenous spread of Mycobacterium tuberculosis but is usually seen in the setting of immunosuppression (eg, HIV/AIDS or patients on immunosuppressive therapy). Some of the patients in this study are showing systemic disease as seen by the miliary nodules, which emphasizes the importance of early diagnosis and treatment to prevent dissemination of the disease.

These findings are significant; however, our study has several limitations that warrant mention. The first was study sample size, which only included a small number of patients. Increased sample size would result in stronger results and increased statistical power. Moreover, the study was a single canter study, which again is prone to various bias including patient population and any bias included in HRCT protocols. The results cannot necessarily be generalized to other geographic regions or health care settings because of this paucity of multi-canter data.

Larger, multi-center studies are recommended to validate the findings and evaluate the reproducibility of our HRCT patterns in different populations. Research to establish correlation of HRCT findings with clinical and treatment response and long term follow up can shed light on potential prognostic value of HRCT in patients with tuberculosis.

CONCLUSION

This study, with sputum AFB positivity, evaluated HRCT findings in patients with PTB, and these included centrilobular nodules, lobular consolidation, cavitation, and a tree-in-bud appearance. HRCT can delineate the extent of disease better than any other imaging modality, where microbiological tests may fail. HRCT is of great help in a quick diagnosis and treatment of PTB as it shows high sensitivity in identifying early and subtle parenchymal change. Further work is needed to explore its prognostic significance and ability to guide therapeutic approaches to mitigate these poor patient outcomes.

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