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Pulmonary Medicine

RADIOLOGICAL PROFILE OF PULMONARY TUBERCULOSIS IN HIV-POSITIVE PATIENTS AND ITS RELATION TO CD4 COUNT

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ABSTRACT Tuberculosis (TB) is the commonest opportunistic infection in people living with HIV, and progressive depletion of CD4+ T lymphocytes alters its radiological expression. This hospital-based cross-sectional study at a tertiary-care centre in Northeast India examined the chest radiographic profile of pulmonary TB in 40 HIV-positive adults and its relationship with CD4 count. Radiographic appearances were classified as typical (upper-zone opacity or cavitation) or atypical (lower-zone involvement, extensive or diffuse infiltrates, a miliary pattern, pneumothorax, or a normal radiograph), and patients were stratified as CD4 below 200 (n = 29) or 200 cells/mm³ or above (n = 11). Radiographic patterns were compared between strata by Fisher's exact test. Most patients were young adults with male predominance and a median CD4 count of 138 cells/mm³. Atypical radiographic patterns predominated in the CD4 below 200 group (23/29, 79.3%) compared with the 200 or above group (3/11, 27.3%); the association was significant (Fisher's exact p = 0.007; odds ratio 10.2, 95% confidence interval 2.1–50.8). Cavitation and upper-zone opacity were commoner with preserved CD4 counts, whereas lower-zone, extensive and miliary patterns, pneumothorax and all normal radiographs occurred predominantly or exclusively in advanced immunosuppression. CD4 count is thus a strong determinant of radiographic appearance in HIV-associated pulmonary TB, and a classical or normal radiograph cannot exclude TB in advanced HIV.

KEYWORDS : pulmonary tuberculosis, HIV, CD4 count, chest radiography

INTRODUCTION

Tuberculosis (TB) remains the leading infectious cause of death worldwide and the commonest opportunistic infection among people living with HIV (World Health Organization, 2023). HIV is the strongest known risk factor for progression to active TB, increasing risk several-fold through progressive depletion of CD4+ T lymphocytes (Kwan & Ernst, 2011; Selwyn et al., 1989). India carries one of the largest absolute burdens of both infections, and TB continues to be the most frequent opportunistic infection among Indians living with HIV (Central TB Division, 2024; National AIDS Control Organization, 2025).

CD4+ T cells orchestrate protective immunity against *Mycobacterium tuberculosis* by activating macrophages and maintaining the integrity of granulomas that contain the organism; their loss in HIV impairs this containment (Diedrich & Flynn, 2011; Flynn & Chan, 2001). As cell-mediated immunity wanes, the host response shifts from localised, granulomatous, cavitary disease toward poorly organised and disseminated forms (Pawlowski et al., 2012).

These immunological changes are mirrored in the radiological expression of pulmonary TB (Jones et al., 1993). With relatively preserved CD4 counts, patients display classical post-primary features—upper-zone infiltrates and cavitation—similar to HIV-negative individuals (Keiper et al., 1995; Perlman et al., 1997). With advancing immunosuppression, atypical appearances predominate: lower-zone or diffuse infiltrates, intrathoracic lymphadenopathy, a miliary pattern, and even a normal chest radiograph despite active disease (Greenberg et al., 1994; Jeong & Lee, 2008; Post et al., 1995).

This loss of the classical signature, with paucibacillary, often smear-negative disease, complicates diagnosis in advanced HIV (Getahun et al., 2007; Raviglione et al., 2017). The chest radiograph nonetheless remains a front-line, widely available investigation, and knowing how its appearance varies with CD4 count can sharpen clinical suspicion. Local data from the high-burden setting of Northeast India remain limited. We therefore examined the radiological profile of pulmonary TB in HIV-positive patients and its relation to CD4 count at a tertiary-care centre in Assam.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based, cross-sectional study was conducted in the Departments of Medicine, Radiology and Microbiology at Assam Medical College and Hospital (AMCH), Dibrugarh, a tertiary-care referral centre in Northeast India, over one year (January–December 2025). Participants were recruited from the medical wards and outpatient departments and the antiretroviral therapy centre.

Participants

Eligible patients were aged 13 years or older, HIV-positive (by ELISA or Western blot per national guidelines), with pulmonary TB confirmed by sputum smear microscopy, CBNAAT (Xpert MTB/RIF) and/or mycobacterial culture (World Health Organization, 2013). Pregnant or lactating women and those with prior antitubercular therapy were excluded. Assuming an HIV–TB coinfection proportion of about 30%, with 95% confidence and a 15% margin of error, the sample size was 40. Institutional ethics committee clearance and written informed consent were obtained from every participant.

Radiological Assessment and Pattern Classification

All patients underwent postero-anterior chest radiography, with thoracic computed tomography in selected cases. Appearances were classified as typical (classical post-primary)—upper-zone opacity or consolidation and/or cavitation—or atypical—lower-zone opacity, extensive or diffuse bilateral infiltrates, a miliary pattern, pneumothorax, or a normal radiograph despite confirmed active TB. Where features coexisted, the dominant pattern was used, miliary-predominant films being classified as atypical.

CD4 Count and Statistical Analysis

CD4+ T-cell counts were measured by flow cytometry, the most recent value within the preceding three months being used, and patients were stratified as CD4 below 200 or 200 cells/mm³ or above. Continuous variables (age, CD4 count) were summarised as mean ± standard deviation or median. Radiographic patterns were compared between strata using Fisher's exact test, preferred over the chi-square test because of small expected cell counts, with the odds ratio and 95% confidence interval calculated for the typical-versus-atypical comparison. A two-sided p-value below 0.05 was considered statistically significant. Analyses were performed using Python (SciPy).

RESULTS

Cohort Characteristics

Forty HIV-positive patients with pulmonary TB were studied. The mean age was 33.6 ± 10.6 years (range 20–55), the 21–30-year group being largest (47.5%), and 25 (62.5%) were male. Most were Hindu (72.5%); housewives, students and farmers were the commonest occupations. The median CD4 count was 138 cells/mm³ (range 14–645): 29 (72.5%) had a count below 200 (median 103) and 11 (27.5%) had 200 or above (median 296).

Radiological Patterns and Their Relation to CD4 Count

The distribution of chest radiographic patterns differed markedly between strata (Table 1, Figure 1). Cavitation occurred in 4/11 patients (36.4%) with preserved CD4 counts but in only 1/29 (3.4%) with CD4 below 200, and upper-zone opacity was proportionally commoner with preserved counts. In contrast, lower-zone opacity, extensive or diffuse infiltrates, pneumothorax and all three normal radiographs occurred exclusively or predominantly in the lower-CD4 stratum; a miliary pattern was seen in both strata.

When grouped, atypical radiographic patterns predominated in the lower-CD4 stratum (23/29, 79.3%) compared with the preserved-CD4 stratum (3/11, 27.3%), whereas typical patterns were proportionally commoner with preserved counts (8/11, 72.7%). This association was statistically significant (Fisher's exact p = 0.007), with an odds ratio of 10.2 (95% CI 2.1–50.8) for an atypical pattern in advanced immunosuppression. Notably, all three patients with a normal chest radiograph despite microbiologically confirmed active TB belonged to the lower-CD4 stratum.

Table 1. Chest radiographic patterns and their relation to CD4 stratum.

Radiographic pattern	CD4 <200 (n=29)	CD4 ≥200 (n=11)	p
Individual patterns, n (%)			
Upper-zone opacity	5 (17.2)	4 (36.4)	—
Cavitation	1 (3.4)	4 (36.4)	—
Lower-zone opacity	5 (17.2)	0 (0)	—
Extensive / diffuse infiltrates	8 (27.6)	0 (0)	—
Miliary pattern	5 (17.2)	3 (27.3)	—
Pneumothorax	2 (6.9)	0 (0)	—
Normal radiograph	3 (10.3)	0 (0)	—
Grouped pattern, n (%)			
Atypical	23 (79.3)	3 (27.3)	0.007
Typical	6 (20.7)	8 (72.7)	ref

Grouped (atypical vs typical) comparison by Fisher's exact test; odds ratio for an atypical pattern in CD4 <200 versus ≥200 cells/mm³ = 10.2 (95% CI 2.1–50.8). Individual patterns are shown descriptively.

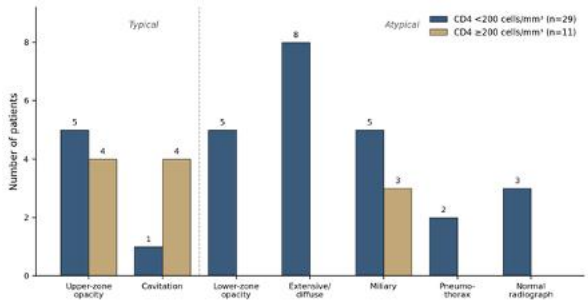

Figure 1. Distribution of chest radiographic patterns by CD4 stratum among 40 HIV-positive patients with pulmonary tuberculosis. Typical patterns (upper-zone opacity, cavitation) lie to the left of the dashed line; atypical patterns to the right.

DISCUSSION

In this cohort of HIV-positive patients with pulmonary TB, the chest radiographic appearance was strongly related to the degree of immunosuppression. Atypical patterns were about ten times as likely in patients with CD4 counts below 200 cells/mm³ as in those with preserved counts, while classical cavitary, upper-zone disease clustered among the less immunosuppressed. These observations place CD4 count at the centre of how pulmonary TB presents on imaging in HIV.

The findings are biologically coherent. Preserved CD4-mediated immunity supports a brisk granulomatous response with caseation and cavitation in the upper zones, whereas its loss reduces cavitation and permits haematogenous and diffuse spread (Diedrich & Flynn, 2011; Flynn & Chan, 2001; Pawlowski et al., 2012). The fall in cavitation as CD4 counts decline is well recognised and is reflected in its near-absence in the lower-CD4 stratum here (Greenberg et al., 1994; Keiper et al., 1995).

Our results accord with earlier series: Perlman et al. (1997) and Post et al. (1995) showed that radiographic patterns vary with the degree of HIV-related immunosuppression, while Keiper et al. (1995) found cavitation less frequent as CD4 counts decline and Greenberg et al. (1994) documented the spectrum of appearances, including normal radiographs, in patients with AIDS. Jeong and Lee (2008) emphasised atypical, disseminated patterns in advanced disease. This consistency across settings, now including Northeast India, supports using the radiographic pattern as a bedside marker of immune status while CD4 results are awaited.

A clinically important observation is that every patient with a normal chest radiograph despite confirmed active TB was profoundly immunosuppressed. A normal or atypical radiograph therefore cannot exclude pulmonary TB in advanced HIV (Lawn et al., 2013). This reinforces the need for early microbiological confirmation-particularly molecular testing with Xpert MTB/RIF, and urine lipoarabinomannan assays in the most immunosuppressed-rather than reliance on imaging alone (Cain et al., 2010; Lawn, 2012; World Health Organization, 2013).

LIMITATIONS

This was a single-centre study with a modest sample (n = 40) and unequal strata, limiting power for less common patterns and precluding multivariable analysis; the wide confidence interval around the odds ratio should be interpreted accordingly. Imaging relied predominantly on plain radiography without systematic high-resolution computed tomography, and radiographs were not read in a blinded, multi-reader fashion, so observer variability and under-recognition of subtle disease are possible. The cross-sectional design captured a single time point, and CD4 counts were not always concurrent with imaging. Larger, prospective, multicentre studies with systematic computed tomography and blinded interpretation are warranted.

CONCLUSION

In HIV-associated pulmonary TB, CD4 count strongly shapes the chest radiographic appearance. Preserved counts (200 cells/mm³ or above) are associated with classical upper-zone and cavitary disease, whereas advanced immunosuppression (below 200 cells/mm³) is associated with atypical patterns-lower-zone, extensive and miliary disease and pneumothorax-and even normal radiographs. Recognizing these CD4-dependent appearances, and not allowing a classical or normal radiograph to falsely reassure, supports earlier diagnosis and timely management of TB in people with advanced HIV.

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REFERENCES

1. Cain, K. P., McCarthy, K. D., Heilig, C. M., Monkongdee, P., Tasaneeyapan, T., & Kanara, N. (2010). An algorithm for tuberculosis screening and diagnosis in people with HIV. *New England Journal of Medicine, 362*(8), 707–716.
2. Central TB Division. (2024). *India TB report 2024: National Tuberculosis Elimination Programme*. Ministry of Health and Family Welfare, Government of India.
3. Diedrich, C. R., & Flynn, J. L. (2011). HIV-1/Mycobacterium tuberculosis coinfection immunology. *Infection and Immunity, 79*(4), 1407–1417.
4. Flynn, J. L., & Chan, J. (2001). Immunology of tuberculosis. *Annual Review of Immunology, 19*, 93–129.
5. Getahun, H., Harrington, M., O'Brien, R., & Nunn, P. (2007). Diagnosis of smear-negative pulmonary tuberculosis in people with HIV infection or AIDS in resource-constrained settings: Informing urgent policy changes. *The Lancet, 369*(9578), 2042–2049.
6. Greenberg, S. D., Frager, D., Suster, B., Walker, S., Stavropoulos, C., & Rothpearl, A. (1994). Active pulmonary tuberculosis in patients with AIDS: Spectrum of radiographic findings (including a normal appearance). *Radiology, 193*(1), 115–119.
7. Jeong, Y. J., & Lee, K. S. (2008). Pulmonary tuberculosis: Up-to-date imaging and management. *American Journal of Roentgenology, 191*(3), 834–844.
8. Jones, B. E., Young, S. M., Antoniskis, D., Davidson, P. T., Kramer, F., & Barnes, P. F. (1993). Relationship of the manifestations of tuberculosis to CD4 cell counts in patients with human immunodeficiency virus infection. *American Review of Respiratory Disease, 148*(5), 1292–1297.
9. Keiper, M. D., Beumont, M., Elshami, A., Langlotz, C. P., & Miller, W. T. (1995). CD4 T lymphocyte count and the radiographic presentation of pulmonary tuberculosis. *Chest, 107*(1), 74–80.
10. Kwan, C. K., & Ernst, J. D. (2011). HIV and tuberculosis: A deadly human syndemic. *Clinical Microbiology Reviews, 24*(2), 351–376.
11. Lawn, S. D. (2012). Point-of-care detection of lipoarabinomannan (LAM) in urine for diagnosis of HIV-associated tuberculosis: A state-of-the-art review. *BMC Infectious Diseases, 12*, 103.
12. Lawn, S. D., Meintjes, G., McIlleron, H., Harries, A. D., & Wood, R. (2013). Management of HIV-associated tuberculosis in resource-limited settings: A state-of-the-art review. *BMC Medicine, 11*, 253.
13. National AIDS Control Organization. (2025). *HIV estimation 2025: Technical report*. Ministry of Health and Family Welfare, Government of India.
14. Pawlowski, A., Jansson, M., Sköld, M., Rottenberg, M. E., & Källenius, G. (2012). Tuberculosis and HIV co-infection. *PLOS Pathogens, 8*(2), e1002464.

15. Perlman, D. C., El-Sadr, W. M., Nelson, E. T., Matts, J. P., Telzak, E. E., & Salomon, N. (1997). Variation of chest radiographic patterns in pulmonary tuberculosis by degree of human immunodeficiency virus-related immunosuppression. *Clinical Infectious Diseases, 25*(2), 242–246.
16. Post, F. A., Wood, R., & Pillay, G. P. (1995). Pulmonary tuberculosis in HIV infection: Radiographic appearance is related to CD4+ T-lymphocyte count. *Tubercle and Lung Disease, 76*(6), 518–521.
17. Raviglione, M. C., De Cock, K. M., & Zumla, A. (2017). HIV-associated tuberculosis. *The Lancet, 389*(10070), 1215–1227.
18. Selwyn, P. A., Hartel, D., Lewis, V. A., Schoenbaum, E. E., Vermund, S. H., & Klein, R. S. (1989). A prospective study of the risk of tuberculosis among intravenous drug users with human immunodeficiency virus infection. *New England Journal of Medicine, 320*(9), 545–550.
19. World Health Organization. (2013). *Automated real-time nucleic acid amplification technology for rapid and simultaneous detection of tuberculosis and rifampicin resistance: Xpert MTB/RIF assay*.
20. World Health Organization. (2023). *Global tuberculosis report 2023*.