ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 04 | April - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

CORRELATION OF HRCT FINDINGS WITH SPUTUM MICROBIOLOGY IN ACTIVE PULMONARY TUBERCULOSIS

Medicine

Dr. Sunny Kumar Junior Resident Department Of Respiratory Medicine, Rama Medical College, Mandhana Kanpur

Dr. Rajeev Yadav Junior Resident Department Of Radiodiagnosis, Rama Medical College, Mandhana Kanpur

Dr. Zoya Raju Junior Resident Department Of Respiratory Medicine, Rama Medical College, Mandhana Kanpur

ABSTRACT

Objective: To evaluate whether CT findings suggesting active pulmonary tuberculosis correlate with sputum microbiological studies and to determine whether CT could predict infectivity. **Materials And Methods:** Total 200 patients with active pulmonary tuberculosis were enrolled. We reviewed CT findings and sputum microbiological studies. Then, we analysed the statistical difference in CT findings between the positive and negative groups of each sputum microbiological study (AFB smear, PCR, and culture). Also, we divided the patients into five groups according to sputum AFB smear grade and analysed linear trends of CT findings between the five groups **Results:** A total of 200 patients with active pulmonary tuberculosis were analysed. Both the frequency and extent of centrilobular micronodules (65% vs. 40%, p = 0.008 for frequency; 1.8 ± 1.5 vs. 0.7 ± 1.2, p < 0.001 for extent), tree-in-bud opacities (66% vs. 35%, p = 0.001; 1.9 ± 1.7 vs. 0.6 ± 1.0, p < 0.001, respectively), consolidation (97% vs. 83%, p = 0.002; 2.9 ± 1.4 vs. 1.5 ± 1.2, p < 0.001, respectively), and cavitation (89% vs. 35%, p < 0.001; 1.6 ± 1.3 vs. 0.5 ± 0.8, p < 0.001, respectively) were significantly higher in the sputum AFB-positive group compared to the AFB-negative group. These four CT findings also showed an increasing trend in both frequency and extent in the sputum PCR-positive group, though with varying statistical significance. However, no significant difference was observed between the sputum culture-positive and culture-negative groups. **Conclusion:** CT features representing active tuberculosis—centrilobular nodules, tree-in-bud, consolidation and cavitation—strongly correlate with the positivity and grading of AFB smear.

KEYWORDS

Tree in Bud, Active tuberculosis, Cavitations

INTRODUCTION

In pulmonary tuberculosis , CT provides valuable information for the diagnosis and management of the disease. Furthermore, CT can help distinguish active forms of the disease from its inactive forms [1,2]. The most common CT findings of active pulmonary TB are centrilobular micronodules, tree-in-bud opacities, consolidation, and cavitation [2]. Especially, centrilobular micronodules, tree-in-bud opacities, and cavitation are considered active disease processes [2–4]. Moreover, the bacterial count from the smear correlates with the degree of infectiousness of the patient as well as the severity of the disease [1]. There have been a few studies about the relationship between CT findings and the positivity/grading of sputum smears [1,5]. In these studies, the presence of cavitation and consolidation correlated with the results of sputum studies. However, the presence of micronodules did not. This is unexpected because all micronodules (but not miliary) in active TB have been considered to have centrilobular distribution representing bronchogenic spread [2,6]. Recently, we reported that micronodules with perilymphatic distribution are common in pulmonary TB which may represent lymphatic spread of TB [7]. We thought that all of the micronodules visible on CTs in pulmonary TB may not be centrilobular distribution reflecting bronchogenic spread, and that the presence of micronodules by exception for ones showing perilymphatic and miliary distribution may correlate with results of sputum studies.

MATERIALS AND METHODS

The study was conducted from March 2023 to July 2024. Analysis of 200 patients with active pulmonary tuberculosis (TB) to evaluate the correlation between high-resolution CT (HRCT) findings and sputum microbiology results (AFB smear, PCR assay, and culture). Conventional and HRCT scans were obtained using MDCT scanners with or without contrast enhancement. CT scans, reviewed by two experienced chest radiologists, were analyzed for centrilobular micronodules(small rounded opacities with a diameter less than 7 mm and were classified by their distribution as either centrilobular, perilymphatic or random [8], tree-in-bud opacities, consolidation, cavitation, interlobular septal thickening, and bronchovascular bundle thickening, which are commonly associated with active TB. The extent of these findings was assessed based on the number of affected lobes. Patients were divided into sputum-positive and sputum-negative groups Results showed a significant increase in the frequency and extent of centrilobular micronodules, tree-in-bud opacities, consolidation, and cavitation in AFB smear-positive patients compared to smear-negative patients ($p < 0.05$). These findings also demonstrated an increasing trend in sputum PCR-positive patients, whereas no significant differences were observed between the sputum culture-positive and culture-negative groups. Additionally, as the AFB smear grade increased, the extent of pulmonary involvement also increased. The study highlights the diagnostic value of HRCT in predicting sputum smear positivity, providing critical insights into the radiological severity of pulmonary TB based on microbiological findings

RESULTS

Among 200 patients, all were included in this analysis. CT findings (conventional CT, n = 170; HRCT, n = 30) were evaluated in all 200 patients with pulmonary TB (137 men and 63 women; mean age, 45 years; age range, 16–92 years).

Fifty patients had a chronic illness, including diabetes (n = 20), chronic obstructive lung disease (n = 15), malignancy (n = 6), renal failure (n = 3), and collagen vascular disease (n = 6). Diagnoses of active pulmonary TB were confirmed by positive sputum microbiology results (acid-fast bacilli (AFB), n = 115; polymerase chain reaction (PCR), n = 110; culture, n = 125) in 180 patients. Twenty patients were diagnosed by positive microbiology results from bronchial lavage (AFB, n = 10; PCR, n = 15; culture, n = 12).

The clinical characteristics and frequencies of various CT findings in patients are summarized in **(Table 1).** Both frequencies and extents of centrilobular micronodules (68% vs 42%, p = 0.009 for frequency; 1.8 ± 1.7 vs 0.7 ± 1.2, p = 0.001 for extent), tree-in-bud opacities (68% vs 38%, p = 0.001; 1.8 ± 1.7 vs 0.6 ± 1.0, p < 0.001, respectively), consolidation (97% vs 84%, p = 0.002; 2.9 ± 1.6 vs 1.5 ± 1.2, p < 0.001, respectively), and cavitation (88% vs 36%, p < 0.001; 1.7 ± 1.3 vs 0.5 ± 0.8, p < 0.001, respectively) were significantly increased in the sputum AFB-positive group compared to the negative group **(Tables 2 and 3).**

Regarding PCR, consolidation (97% vs 74%, p = 0.001; 2.8 ± 1.7 vs 1.3 ± 1.1, p < 0.001, respectively) and cavitation (82% vs 38%, p < 0.001; 1.6 ± 1.4 vs 0.6 ± 0.8, p < 0.001, respectively) were more frequent and increased in extent in the sputum PCR-positive group. The extent of centrilobular micronodules was significantly increased in the sputum PCR-positive group (1.7 ± 1.7 vs 0.9 ± 1.3, p = 0.035).

However, frequencies of centrilobular micronodules (68% vs 42%, p =

0.069) and frequencies and extents of tree-in-bud opacities (65% vs 40%, p = 0.078; 1.7 ± 1.7 vs 0.9 ± 1.3, p = 0.062, respectively) were insignificantly greater in the sputum PCR-positive group. Frequencies and extents of centrilobular micronodules, tree-in-bud opacities, consolidation, and cavitation did not show significant differences between the sputum culture-positive and negative group.

As the sputum AFB grade increased, the frequencies of centrilobular micronodules **(Fig. 1)**, tree-in-bud opacities **(Fig. 2)**, consolidation**(Fig. 3)**, and cavitation**(Fig. 4)** also increased ($p < 0.001$, $p < 0.001$, $p = 0.004$, and $p < 0.001$, respectively, **(Table 4).** The sputum AFB grade also had a statistically significant and moderate positive correlation with centrilobular micronodules ($r = 0.428$, $p < 0.001$), tree-in-bud opacities ($r = 0.475$, $p < 0.001$), consolidation ($r = 0.543$, $p < 0.001$), and cavitation ($r = 0.592$, $p < 0.001$, **Table 5**).

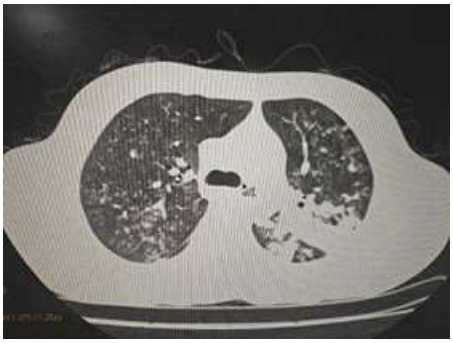

Figure 1

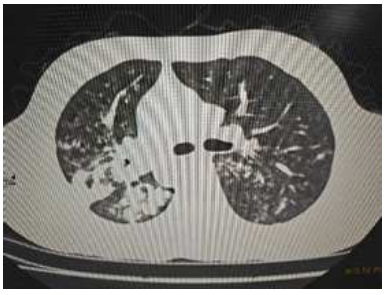

Figure 2

Figure 3

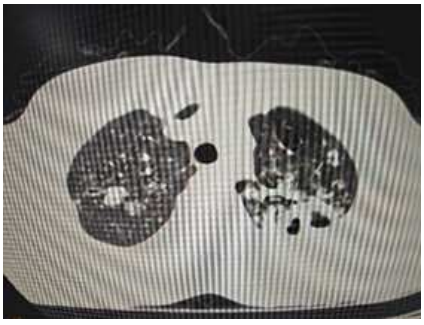

Figure 4

Table 1 – Clinical characteristics and frequencies of various CT findings

Patients' Characteristics	Values
Number of patients	200
Age	42 ± 16 (15–88)
Sex (M:F)	138:62
Grade of sputum AFB smear	1.5 ± 1.3
AFB smear-positive sputum	120/195 (62%)
PCR-positive sputum	145/180 (81%)
Culture-positive sputum	160/185 (87%)
Findings	**Number of Patients (%)**
Micronodules	190 (95%)
Centrilobular	110 (55%)
Perilymphatic	172 (86%)
Peribronchovascular	168 (84%)
Septal	130 (65%)
Subpleural	110 (55%)
Random	5 (3%)
Tree-in-bud	112 (56%)
Consolidation	186 (93%)
Cavitation	140 (70%)
Bronchovascular bundle thickening	188 (94%)
Septal thickening	140 (70%)

Table 2 – Frequencies of Common CT Findings According to Microbiology Test Positivity

CT Findings	Sputum AFB	p Value	Sputum PCR	p Value	Sputum Culture	p Value
	Negative (n = 80)	Positive (n = 120)		Negative (n = 40)	Positive (n = 145)	
Micronodules	74 (93%)	118 (98%)	0.029	35 (88%)	140 (97%)	0.081
Centrilobular micronodules	36 (45%)	76 (63%)	0.008	18 (45%)	90 (62%)	0.067
Perilymphatic micronodules	69 (86%)	104 (87%)	0.812	30 (75%)	125 (86%)	0.201
Peribronchovascular	66 (83%)	102 (85%)	0.731	31 (78%)	120 (83%)	0.491
Septal	52 (65%)	72 (60%)	0.502	22 (55%)	82 (57%)	0.701
Subpleural	38 (48%)	64 (53%)	0.375	17 (43%)	74 (51%)	0.341
Tree-in-bud	32 (40%)	80 (67%)	0.001	19 (48%)	98 (68%)	0.045
Consolidation	68 (85%)	118 (98%)	0.002	30 (75%)	140 (97%)	0.001
Cavitation	30 (38%)	102 (85%)	<0.001	16 (40%)	110 (76%)	<0.001
Bronchovascular bundle thickening	72 (90%)	114 (95%)	0.215	35 (88%)	138 (95%)	0.410
Interlobular septal thickening	54 (68%)	84 (70%)	0.622	24 (60%)	98 (68%)	0.590

Table 3 – Extent (Mean Number of Involved Pulmonary Lobes) of Common CT Findings According to Microbiology Test Positivity

CT Findings	Sputum AFB	p Value	Sputum PCR	p Value	Sputum Culture	p Value
	Negative (n = 80)	Positive (n = 120)		Negative (n = 40)	Positive (n = 145)	
Micronodules	2.5 ± 1.5	3.8 ± 1.7	<0.001	2.0 ± 1.4	3.7 ± 1.8	<0.001
Centrilobular micronodules	0.7 ± 1.0	1.7 ± 1.5	0.001	0.9 ± 1.1	1.6 ± 1.5	0.029
Perilymphatic micronodules	2.2 ± 1.4	3.3 ± 2.0	0.016	1.9 ± 1.5	3.1 ± 2.0	0.005
Peribronchovascular	2.1 ± 1.4	3.0 ± 1.9	0.012	1.9 ± 1.5	3.2 ± 2.1	0.014
Septal	1.1 ± 0.8	1.2 ± 1.1	0.250	0.9 ± 1.0	1.1 ± 1.1	0.520
Subpleural	0.8 ± 1.0	1.0 ± 0.9	0.620	0.6 ± 0.7	1.0 ± 1.1	0.221
Tree-in-bud	0.6 ± 0.9	1.7 ± 1.5	<0.001	0.9 ± 1.1	1.6 ± 1.5	0.060
Consolidation	1.4 ± 1.0	2.8 ± 1.5	<0.001	1.2 ± 1.0	2.7 ± 1.6	<0.001
Cavitation	0.5 ± 0.7	1.6 ± 1.2	<0.001	0.5 ± 0.8	1.5 ± 1.3	<0.001
Bronchovascular bundle thickening	1.5 ± 1.0	2.3 ± 1.2	<0.001	1.4 ± 1.1	2.1 ± 1.2	0.002

Table 4 – Frequencies of Common CT Findings According to Sputum AFB Smear Grade

CT Findings	AFB Smear Grade	p Value
	0 (n = 75)	1+ (n = 40)
Micronodules	66 (88%)	40 (100%)
Centrilobular micronodules	28 (37%)	22 (55%)
Perilymphatic micronodules	63 (84%)	35 (88%)

Peribronchovascular	61 (81%)	36 (90%)
Septal	50 (67%)	27 (68%)
Subpleural	32 (43%)	24 (60%)
Tree-in-bud	26 (35%)	18 (45%)
Consolidation	60 (80%)	38 (95%)
Cavitation	25 (33%)	30 (75%)
Bronchovascular bundle thickening	67 (89%)	38 (95%)
Interlobular septal thickening	50 (67%)	28 (70%)

Table 5 – Extent (Mean Number of Involved Pulmonary Lobes) of Common CT Findings According to Sputum AFB Smear Grade

CT Findings	AFB Smear Grade	r Value	p Value
	0 (n = 75)	1+ (n = 40)	2+ (n = 35)
Micronodules	2.5 ± 1.6	3.4 ± 1.7	4.0 ± 1.9
Centrilobular micronodules	0.7 ± 1.1	1.2 ± 1.2	1.6 ± 1.8
Perilymphatic micronodules	2.2 ± 1.6	3.0 ± 1.8	3.8 ± 2.3
Peribronchovascular	2.1 ± 1.5	2.8 ± 1.8	3.7 ± 2.5
Septal	1.1 ± 1.0	1.3 ± 1.2	1.8 ± 1.6
Subpleural	0.8 ± 1.1	1.3 ± 1.5	1.2 ± 1.2
Tree-in-bud	0.6 ± 1.0	1.0 ± 1.1	1.5 ± 1.8
Consolidation	1.4 ± 1.1	2.2 ± 1.3	2.7 ± 1.5
Cavitation	0.5 ± 0.8	1.2 ± 1.2	1.4 ± 0.8
Bronchovascular bundle thickening	1.5 ± 1.1	1.9 ± 1.1	2.7 ± 1.5
Interlobular septal thickening	1.2 ± 1.0	1.6 ± 1.6	1.8 ± 1.2

DISCUSSION

Cavitation, consolidation, centrilobular micronodules, and tree-in-bud opacities were the most significant CT features associated with positive sputum microbiology results in pulmonary TB. The frequencies of these four findings correlated with sputum AFB grade, reinforcing their role in TB infectivity due to their association with bronchogenic dissemination and local invasion [4,9,11]. Consolidation represents caseous pneumonia, while cavitation occurs when TB lesions erode the bronchial tree, leading to expectoration and possible bronchogenic spread [9,11]. The onset of caseous necrosis is linked to a rapid increase in AFB numbers [12]. Prior studies have reported similar findings, indicating that consolidation and cavitation correlate with smear-positive TB, though centrilobular micronodules were not significantly associated in some cases [1,5]. This could be due to the smaller number of micronodules and their distance from the central airway [2,6]. Our study found that perilymphatic micronodules were more common than centrilobular ones. After excluding perilymphatic and randomly distributed micronodules, centrilobular micronodules showed a strong correlation with sputum study results. Previous studies have reported interstitial and peribronchovascular nodules in TB, suggesting pulmonary lymphatic involvement [13-16].

A key limitation of this study was the retrospective analysis of CT images with 3–5 mm slice thickness, which may have underestimated small cavitations or micronodules. While conventional contrast-enhanced CT is preferred over HRCT for evaluating lymphadenitis or other associated findings, advancements in MDCT technology allow for improved assessment of subtle abnormalities using multiplanar reconstruction [Syngo.via, Siemens Healthcare]. In conclusion, CT features indicating bronchogenic spread and local invasion in active pulmonary TB correlate with sputum microbiology results. Thus, CT can serve as a valuable tool not only for diagnosis but also for predicting TB infectivity.

REFERENCES

[1] S. Matsuoka, K. Uchiyama, H. Shima, et al., Relationship between CT findingsof pulmonary tuberculosis and the number of acid-fast bacilli on sputum smears, Clin. Imaging 28 (2) (2004) 119–123.

[2] Y.J. Jeong, K.S. Lee, Pulmonary tuberculosis: up-to-date imaging and management, AJR Am. J. Roentgenol. 191 (3) (2008) 834–844.

[3] L. Curvo-Semedo, L. Teixeira, F. Caseiro-Alves, Tuberculosis of the chest, Eur. J.Radiol. 55 (2) (2005) 158–172.

[4] O.N. Hatipoglu, ˘ E. Osma, M. Manisali, et al., High resolution computedtomographic findings in pulmonary tuberculosis, Thorax 51 (4) (1996)397–402.

[5] N. Kosaka, T. Sakai, H. Uematsu, et al., Specific high-resolution computed tomography findings associated with sputum smear-positive pulmonary tuberculosis, J. Comput. Assist. Tomogr. 29 (6) (2005) 801–804.

[6] A.N. Leung, Pulmonary tuberculosis the essentials, Radiology 210 (1999) 307–322.

[7] J.M. Ko, H.J. Park, C.H. Kim, Clinicoradiologic evidence of pulmonary lymphatic spread in adult patients with tuberculosis, AJR Am. J. Roentgenol. 204 (1) (2015) 38–43.

[8] D.M. Hansell, A.A. Bankier, H. MacMahon, T.C. McLoud, N.L. Muller, J. Remy, Fleischner society glossary of terms for thoracic imaging, Radiology 246 (3) (2008) 697.

[9] J.G. Im, H. Itoh, Y.S. Shim, et al., Pulmonary tuberculosis: CT findings—earlyactive disease and sequential change with antituberculous therapy, Radiology 186 (3) (1993) 653–660.

[10] K.S. Lee, J.W. Hwang, M.P. Chung, H. Kim, O.J. Kwon, Utility of CT in the evaluation of pulmonary tuberculosis in patients without AIDS, Chest 110 (4) (1996) 977–984.

[11] P.C. Pratt, Pathology of tuberculosis, Semin. Roentgenol. 14 (3) (1979) 196–203.

[12] G. Canetti, The Tubercle Bacillus in the Pulmonary Lesion of Man: Histobacteriology and Its Bearing on the Therapy of Pulmonary Tuberculosis, Springer Publishing Company, 1955.

[13] C. Poey, F. Verhaegen, J. Giron, J. Lavayssiere, P. Fajadet, B. Duparc, High resolution chest CT in tuberculosis: evolutive patterns and signs of activity, J. Comput. Assist. Tomogr. 21 (4) (1997) 601–607.

[14] T.C. Allen, Pathology of small airways disease, Arch. Pathol. Lab. Med. 134 (5) (2010) 702–718.

[15] O.Y. Cheung, J.R. Muhm, R.A. Helmers, et al., Surgical pathology of granulomatous interstitial pneumonia, Ann. Diagn. Pathol. 7 (2) (2003) 127–138.

[16] R.J. Basaraba, E.E. Smith, C.A. Shanley, I.M. Orme, Pulmonary lymphatics are primary sites of Mycobacterium tuberculosis infection in guinea pigs infected by aerosol, Infect. Immun. 74 (9) (2006) 5397–5401.