ORIGINAL RESEARCH

To determine the pattern of HRCT findings in active and inactive Pulmonary Tuberculosis and to evaluate their possible use in predicting disease activities

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Received: 13 February, 2023 Accepted: 17 March, 2023

ABSTRACT

Background: Tuberculosis (TB) is an ancient human disease caused by Mycobacterium tuberculosis which mainly affects the lungs, making pulmonary disease the most common presentation. The present study was planned and carried to determine the pattern of HRCT findings in active and inactive Pulmonary Tuberculosis and to evaluate their possible use in predicting disease activities. **Material & methods:** The present study was conducted among 103 patients who were clinically diagnosed with active pulmonary tuberculosis and inactive disease and was evaluated using high resolution computed tomographic spectrum (HRCT) chest scanning. Data so obtained was entered in Microsoft excel and was managed in SPSS version 16. **Results:** It was showing statistically significant relationship *(P<0.01)* of Centri - lobular nodule and/ or branching linear structure with active and inactive cases of pulmonary Tuberculosis, Tree - in - bud appearance findings with active and inactive cases of Pulmonary Tuberculosis and macro nodule with active and inactive cases of pulmonary tuberculosis. It was showing statistically significant relationship *(P<0.01)* of cavity with active and inactive cases of pulmonary tuberculosis, consolidation with active and inactive cases of pulmonary tuberculosis. It was showing statistically non-significant relationship *(P=0.097)* of collapse/atelectasis with active and inactive cases of pulmonary tuberculosis. There was a statistically significant relationship *(P=0.03)* of bronchial wall thickening with active and inactive cases of pulmonary tuberculosis. and non-significant relationship *(P=0.554)* of Ground glass opacity with active and inactive cases of pulmonary tuberculosis. There was a statistically non-significant relationship*(P=0.827)* of bronchiectasis with active and inactive cases of pulmonary tuberculosis and statistically significant relationship *(P<0.01)* of emphysema with active and inactive cases of pulmonary tuberculosis, statistically non-significant relationship *(P=0.07)* of bronchovascular distortion with active and inactive cases of Pulmonary Tuberculosis. There was statistically significant relationship *(P<0.01)* of fibrotic changes with active and inactive cases of pulmonary tuberculosis, statistically significant relationship (P=0.008) of calcified mediastinal lymph node enlargement with active and inactive cases of pulmonary tuberculosis and statistically non-significant relationship *(P=0.485)* of parenchymal calcification with active and inactive cases of pulmonary tuberculosis and statistically non-significant relationship *(P=0.315)* of pleural thickening or retraction with active and inactive cases of pulmonary tuberculosis. It was showing statistically significant relationship *(P<0.01)* of lymphadenopathy (>10mm) with active and inactive cases of pulmonary tuberculosis, statistically non-significant relationship *(P=0.291)* of pleural effusion with active and inactive cases of pulmonary tuberculosis and statistically non-significant relationship *(P=0.36)* of Miliary Nodules with active and inactive cases of pulmonary tuberculosis. **Conclusion:** The present study concluded that although chest radiography foremost imaging technique because of easy availability and cost effective in the evaluation of pulmonary TB, HRCT can be useful in certain circumstances and can provide important information in the diagnosis and management of the disease.

Keywords: HRCT, Pulmonary Tuberculosis, chest radiography

INTRODUCTION

Tuberculosis (TB), which is caused by bacteria of the Mycobacterium tuberculosis complex, is one of the oldest diseases known to affect humans and a major cause of death worldwide.[1] According to WHO, tuberculosis is a major killer of the human population

after HIV/AIDS.[1]Nearly two billion people (about one-quarter of the world population) are estimated to be infected with Mycobacterium tuberculosis. As per WHO report published in 2019, approximately 10 million individuals became ill with tuberculosis (TB) and 1.5 million died in 2018.[2]Tuberculosis manifests in active and latent forms. Active disease can occur as primary tuberculosis, developing shortly after infection, or post primary tuberculosis, developing after a long period of latent infection.[3] After primary infection, 90 percent of individuals with intact immunity control further replication of the bacilli, which may then be cleared or enter a "latent" phase.[4] The primary site of infection in the lungs is called the Ghon's focus.[5] Discovery of the specific infectious agent, the tubercle bacillus (Mycobacterium tuberculosis) was isolated by Robert Koch in 1882.[6]The diagnosis of pulmonary TB is definitively established by isolation of M. tuberculosis from a bodily secretion or fluid (e.g., culture of sputum, bronchoalveolar lavage, or pleural fluid) or tissue (e.g., pleural biopsy or lung biopsy).[7] Therefore, the principal means of testing for active tuberculosis is sputum analysis, including smear, culture, and nucleic acid amplification testing. Imaging findings, particularly the presence of cavitation, can affect treatment decisions, such as the duration of therapy. Patients who are suspected of having latent tuberculosis may undergo targeted testing with a tuberculin skin test or interferon-γ release assay.[3] Familiarity with the imaging, clinical, and laboratory features of tuberculosis is important for diagnosis and management.[3] However, computed tomography (CT) is superior to conventional radiography in detecting activity, furthermore, more lately, high resolution computed tomography (HRCT) is found to be superior to both conventional chest x-ray and standard CT in the localisation of disease in the pulmonary lobule and in the evaluation of pulmonary parenchymal disease due to its high resolution power and minimal partial volume effect.[8]Modern CT equipment enables a volume HRCT scan covering the whole lung tissue. HRCT slices can also be constructed from contrast-enhanced CT scans of the chest of the whole body. HRCT of the lungs can be applied to the diagnosis of both acute and more chronic diffuse diseases of the lung tissue and the airways.[9] The present study was planned and carried to determine the pattern of HRCT findings in active and inactive Pulmonary Tuberculosis and to evaluate their possible use in predicting disease activities.

MATERIAL & METHODS

The present hospital based cross sectional prospective observational study was conducted among 103 patients who were clinically diagnosed with active pulmonary tuberculosis and inactive disease who visited department of Radiodiagnosis and Imaging, LN Medical college & JK Hospital, Kolar Road, Bhopal at a time span of 1.5 year and was evaluated using high resolution computed tomographic spectrum (HRCT) chest scanning. Ethical permission was obtained from the ethical committee of our institute and an informed consent was taken from all the patients. Patients were enrolled using nonprobability sampling/ convenient sampling technique. For data collection, patients of all age group, male or female referred from OPD or IPD, to the department of Radiodiagnosis and Imaging, for CT evaluation of Pulmonary Tuberculosis was considered. Patients suspected and diagnosed with pulmonary tuberculosis centre were included for this study.Patients with known malignancy, Patients with Superimposed secondary Infections, all contraindication of CT to be considered and Any patient with concomitant cardio-vascular or chest disease that might affect his/her HRCT chest scan were excluded from the study.The clinical profile of all enrolled patients was noted as per the proforma and clinical symptoms were recorded on the proforma. Relevant past clinical history, including age, duration of symptoms, history of any drug intake, history of associated diseases was taken and entered in the proforma. **The diagnosis of active pulmonary tuberculosis was based on:**

a. Detection of acid-fast bacilli in sputum smears
b. Detection of acid-fast bacilli in cultures of sputum or bronchial washings
c. Radiographic and clinical improvement after administration of two or more anti- tuberculosis drugs for patients whose clinical and radiographic findings suggested a diagnosis of pulmonary tuberculosis, but smear and culture results were negative.

The diagnosis of inactive pulmonary tuberculosis was established based on the following criteria:

a. findings of residual fibrotic changes on chest radiography
b. absence of radiological progression comparing chest radiographs at recruitment with radiographs obtained six months previously or at follow up.
c. absence of acid-fast bacilli in sputum or bronchial washings on smear or culture.

Serial follow up radiographs was taken monthly in the inactive tuberculosis group for 3-6 months. Informed written consent was taken from all patients before CT procedure and evaluation. Imaging was done with GE OPTIMA 660 high end 128 slice MDCT Machine. Data so obtained was entered in Microsoft excel and was managed in SPSS version 16. Analysis was done in the form of percentages and proportions and represented as tables wherever necessary. Appropriate tests of significance were applied.

RESULTS

Table1: Age group wise distribution of subjects

Age Group (Years)	Frequency	Percent
<20	10	9.7
21-40	27	26.2
41-60	46	44.7
>60	20	19.4

It was found that there were 10 study subjects <20-year-old, 27 subjects aged ranges in between 21-40 year, 46 study subjects were 41-60 year old and 20 subjects were aged above 60 year.

Table 2: Gender wise distribution of subjects

	Frequency	Percent
Female	41	39.8
Male	62	60.2

There were 41 female and 62 male participants in study.

Table 3: Comparison of specific CT findings among active & Inactive subjects of pulmonary tuberculosis

CT Findings		Active		Inactive		Chi square value	p value
		Frequency	Percent	Frequency	Percent		
Centri - lobular nodule and/ or branching linear structure	**Absent**	32	43.8	30	100.0	27.99	<0.01*
	Present	41	56.2	0	0.0		
Tree - in - bud appearance	**Absent**	41	56.2	30	100.0	19.07	<0.01*
	Present	32	43.8	0	0.0		
Macro Nodule	**Absent**	50	68.5	30	100.0	12.17	<0.01*
	Present	23	31.5	0	0.0		

*Statistically significant

Centri-lobular nodule and/ or branching linear structure findings absent in 32 active cases and present 41 active cases, in inactive Pulmonary TB case this finding was absent in 30 subjects and none of inactive case present this finding in CT, it was showing statistically significant relationship *(P<0.01)* of Centri - lobular nodule and/ or branching linear structure with active and inactive cases of pulmonary Tuberculosis. it was revealed that Tree - in - bud appearance findings absent in 41 active cases and present 32 active cases, in inactive pulmonary TB case this finding was absent in 30 subjects and none of inactive case present this finding in CT. It was showing statistically significant relationship *(P<0.01)* of Tree - in - bud appearance findings with active and inactive cases of Pulmonary Tuberculosis. it was revealed that macro nodule absents in 50 active cases and present in23 active cases, in inactive pulmonary TB case this finding was absent in 30 subjects and none of inactive case present this finding in CT, it was showing statistically significant relationship *(P<0.01)* of macro nodule with active and inactive cases of pulmonary tuberculosis.

Table 4: Comparison of specific CT findings among active & Inactive subjects of pulmonary tuberculosis

CT Findings		Active		Inactive		Chi square value	p value
		Frequency	%	Frequency	%		
Cavity	**Absent**	29	39.7	23	76.7	11.6	<0.01*
	Present	44	60.3	7	23.3		
Consolidation	**Absent**	29	39.7	28	93.3	24.72	<0.01*
	Present	44	60.3	2	6.7		
Collapse/Atelectasis	**Absent**	55	75.3	17	56.7	3.52	0.097
	Present	18	24.7	13	43.3		
Bronchial wall thickening	**Absent**	54	74.0	28	93.3	4.91	0.03*
	Present	19	26.0	2	6.7		
Ground glass opacity	**Absent**	70	95.9	30	100.0	1.27	0.554
	Present	3	4.1	0	0.0		

*Statistically significant

Cavity was absent in 29 active cases and present 44 active cases, in inactive Pulmonary TB case this finding was absent in 23 subjects and 7 case present this finding in CT it was showing statistically significant relationship *(P<0.01)* of cavity with active and inactive cases of pulmonary tuberculosis. It was revealed that consolidation was absent in 29 active cases and present 44 active cases, in inactive pulmonary TB case this finding was absent in 28 subjects and 2 inactive cases present this finding in CT

it was showing statistically significant relationship *(P<0.01)* of consolidation with active and inactive cases of pulmonary tuberculosis. It was found that Collapse/Atelectasis absent in 55 active cases and present 18 active cases, in inactive pulmonary TB case this finding was absent in 17 subjects and 13 inactive cases present this finding in CT, it was showing statistically non-significant relationship *(P=0.097)* of collapse/atelectasis with active and inactive cases of pulmonary tuberculosis.It was revealed that bronchial wall thickening absent in 54 active cases and present 19 active cases, in inactive pulmonary TB cases this finding was absent in 28 subjects and 2 inactive cases presented this finding in CT, it was showing statistically significant relationship *(P=0.03)* of bronchial wall thickening with active and inactive cases of pulmonary tuberculosis. It was found that ground glass opacity absents in 70 active cases and present 3 active cases, in inactive pulmonary TB cases this finding was absent in 30 subjects and none of inactive case presented this finding in CT it was showing statistically non-significant relationship *(P=0.554)* of Ground glass opacity with active and inactive cases of pulmonary tuberculosis.

Table 5: Comparison of specific CT findings among active & Inactive subjects of pulmonary tuberculosis

CT Findings		Active		Inactive		Chi square value	Pvalue
		Frequency	Percent	Frequency	Percent		
Bronchiectasis	**Absent**	32	43.8	12	40.0	0.128	0.827
	Present	41	56.2	18	60.0		
Emphysema	**Absent**	63	86.3	19	63.3	6.91	<0.01*
	Present	10	13.7	11	36.7		
Broncho vascular distortion	**Absent**	60	82.2	19	63.3	4.231	0.07
	Present	13	17.8	11	36.7		
Fibrotic changes	**Absent**	37	50.7	3	10.0	14.817	<0.01*
	Present	36	49.3	27	90.0		

*Statistically significant

Bronchiectasis was absent in 32 active cases and present in 41 active cases, in inactive pulmonary TB case this finding was absent in 12 subjects and 18 cases present this finding in CT, it was showing statistically non-significant relationship*(P=0.827)* of bronchiectasis with active and inactive cases of pulmonary tuberculosis. It was revealed that emphysema absent in 63 active cases and present 10 active cases, in inactive pulmonary TB cases this finding was absent in 19 subjects and 11 inactive cases were presented this finding in CT, it was showing statistically significant relationship *(P<0.01)* of emphysema with active and inactive cases of pulmonary tuberculosis. It was found that bronchovascular distortion absent in 60 active cases and present in 13 active cases, in inactive pulmonary TB cases this finding was absent in 19 subjects and 11 inactive cases were presented this finding in CT, it was showing statistically non-significant relationship *(P=0.07)* of bronchovascular distortion with active and inactive cases of Pulmonary Tuberculosis. It was found that fibrotic changes absent in 37 active cases and present 36 active cases, in inactive pulmonary TB cases this finding was absent in 3 subjects and 27 cases were presented this finding in CT, it was showing statistically significant relationship *(P<0.01)* of fibrotic changes with active and inactive cases of pulmonary tuberculosis.

Table 6: Comparison of specific CT findings among active & Inactive subjects of pulmonary tuberculosis

CT Findings		Active		Inactive		Chi square value	p value
		Frequency	%	Frequency	%		
Calcified mediastinal lymph node enlargement	**Absent**	57	78.1	15	50.0	7.97	0.008*
	Present	16	21.9	15	50.0		
Parenchymal calcification	**Absent**	52	71.2	19	63.3	0.62	0.485
	Present	21	28.8	11	36.7		

*Statistically significant

It was found that calcified mediastinal lymph node enlargement absent in 57 active cases and present 16 active cases, in inactive pulmonary TB case this finding was absent in 15 subjects and 15 inactive cases were presented this finding in CT, it was showing statistically significant relationship (P=0.008) of calcified mediastinal lymph node enlargement with active and inactive cases of pulmonary tuberculosis. It was found that parenchymal calcification absents in 52 active cases and present 21 active cases, in inactive pulmonary TB case this finding was absent in 19 subjects and 11 inactive cases were presented this finding in CT it was showing statistically non-significant relationship *(P=0.485)* of parenchymal calcification with active and inactive cases of pulmonary tuberculosis.

Table 7: Comparison of specific CT findings among active & Inactive subjects of pulmonary tuberculosis

CT Findings		Active		Inactive		Chi square value	p value
		Frequency	Percent	Frequency	Percent		
Pleural thickening or retraction	**Absent**	58	79.5	21	70.0	1.06	0.315
	Present	15	20.5	9	30.0		
Lymphadenopathy (>10mm)	**Absent**	40	54.8	28	93.3	14.07	<0.01*
	Present	33	45.2	2	6.7		
Pleural effusion	**Absent**	55	75.3	26	86.7	1.623	0.291
	Present	18	24.7	4	13.3		
Miliary Nodules	**Absent**	71	97.3	30	100.0	0.838	0.36
	Present	2	2.7	0	0.0		

*Statistically significant

Pleural thickening or retraction was absent in 58 active cases and present in 15 active cases, in inactive pulmonary TB case this finding was absent in 21 subjects and 9 cases were presented this finding in CT, it was showing statistically non-significant relationship *(P=0.315)* of pleural thickening or retraction with active and inactive cases of pulmonary tuberculosis.

It was revealed that lymphadenopathy (>10mm) absents in 40 active cases and present 33 active cases, in inactive pulmonary TB case this finding was absent in 28 subjects and 2 inactive cases were presented this finding in CT, it was showing statistically significant relationship *(P<0.01)* of lymphadenopathy (>10mm) with active and inactive cases of pulmonary tuberculosis. It was found that pleural effusion absents in 55 active cases and present 18 active cases, in inactive pulmonary TB case this finding was absent in 26 subjects and 4 inactive cases were presented this finding in CT, it was showing statistically non-significant relationship *(P=0.291)* of pleural effusion with active and inactive cases of pulmonary tuberculosis. It was found that miliary nodules absent in 71 active cases and present 2 active cases, in inactive pulmonary TB case this finding was absent in 30 subjects and none of inactive case presented this finding in CT, it was showing statistically non-significant relationship *(P=0.36)* of Miliary Nodules with active and inactive cases of pulmonary tuberculosis.

DISCUSSION

India accounted for 26% of total cases of TB worldwide in 2012.[10] TB is one of the leading causes of mortality in India, killing two persons every 3 min, nearly 1000 every day.[11]The CT and HRCT chest findings seen in post-primary TB are numerous, varied and reflect the protean manifestation of this disease. Findings include airspace consolidation of varying degrees; cavitation; centrilobular nodules and branching linear opacities "tree-in-bud appearance" – that reflect endobronchial spread of infection; small, well-defined, randomly distributed nodules that indicate miliary or hematogenous spread of infection, pleural effusion; lymph node enlargement with central necrosis and changes of pulmonary fibrosis.[12]

The present study found that maximum cases of tuberculosis patients (44.7%) were in 41-60 years age group followed by 21-40 years (26.2%) patients and 60.2% patients were male. On comparison of specific CT findings among active and inactive patients of pulmonary tuberculosis, a significant difference was found in impression of centrilobular nodule and/ or branching linear structure which was present in 56.2% of active cases, tree - in - bud appearance which was present in 43.8% of active cases and macro-nodule which was present in 31.5 % of active cases whereas none of these impressions were seen among inactive cases of pulmonary tuberculosis.

In a similar study by KaramMB et al, one hundred and two patients clinically suspected of having active pulmonary TB with chest-X-ray appearances suggestive of the disease, underwent HRCT chest examination. The HRCT chest findings showed that the combination of the two main HRCT chest appearances, the centrilobular nodule and "tree-in-bud" signs confirms TB diagnosis accurately. Thus, cavitation was seen in chest radiography in 40% to 87% patients. The most common complication of tuberculous cavitation is endobronchialspread which was detected radiographically in 19% to 58% and by CT in up to 98% of cases.[13]

Comparison of specific CT findings among active and inactive subjects of pulmonary tuberculosis it was revealed that cavity was present in 60.3% active cases and 23.3% inactive cases which revealed statistically significant difference of this finding in active and inactive cases of pulmonary tuberculosis. The other finding consolidation was present in 60.3% active cases and 6.7% among inactive pulmonary tuberculosis cases and the difference in cases was statistically significant.

Typical CT findings in bronchogenic spread of pulmonary tuberculosis are centrilobular branching linear structure, relatively poorly defined centrilobularperibronchiolar nodules 2-3 mm in size, acinar shadows 4-10 mm in size, and large lobular consolidations.[14]

There were also significant correlations between the degree of smear positivity and the scores of different HRCT chest findings. There were significant differences for the scores of HRCTchest findings between smear-positive and smear-negative

patients.Similarly bronchial wall thickening was seen in 26% of active cases and 6.7% inactive cases and the difference in cases was statistically significant. However, collapse/atelectasis and ground glass opacity showed non-significant difference among active and inactive cases.

The other specific CT findings bronchiectasis was present among 56.2% active and 60% inactive cases, emphysema was present among 13.7% active and 36.7% inactive cases, broncho vascular distortion was present among 17.8% active and 36.7% inactive cases and fibrotic changes was present among 49.3% active and 90% inactive cases. Significant differences were seen among findings of emphysema andfibrotic changes among active and inactive cases. In the present study, calcified mediastinal lymph node enlargement was present in 21.9% active cases and 50 % inactive cases and the difference in this finding among cases was statistically significant whereas parenchymal calcification showed statistically non-significant difference among active and inactive cases of pulmonary tuberculosis. Pleural thickening or retraction was seen among 20.5% active and 30% inactive cases (statistically non-significant difference), lymphadenopathy (>10mm) was seen among 45.2% active and 6.7% inactive cases (statistically significant difference), pleural effusion was seen among 24.7% active and 13.3% inactive cases (statistically non-significant) difference, miliary nodules was seen among 2.7% active and none of the inactive cases (statistically non-significant difference) on CT findings of pulmonary tuberculosis patients.

Im JG e t al[15] studied the high-resolution CT findings of newly diagnosed active post-primary pulmonary tuberculosis in 41 patients. The findings were centrilobular lesions appearing as a nodule or a branching linear structure (95%), bronchial wall thickening (73%), a poorly defined nodule (61%), a cavity (51 %), and lobular consolidation (41 %) which corresponds to findings of the present study.

The HRCT chest signs of active tuberculosis as reported in the literature by Agrons GA et al[16], Raviglione MC et al[17] are patchy unilateral or bilateral airspace consolidation, cavitation, scattered airspace nodules, tree-in-bud appearance, miliary disease, pleural effusion, empyema and bronchopleural fistula, and low density hilar/mediastinal lymph nodes.

Another study comparable to our present study commenced by Raj S et al[18], HRCTchest findings of centrilobular nodules, “tree in bud” pattern, cavity, consolidation, mediastinal lymphadenopathy and bronchiectasis reported a statistically significant association with sputum positivity which is similar to our findings in active cases.

CONCLUSION

HRCT chest is a reliable tool in the distinction of active form inactive TB. HRCT chest is better than plain chest radiograph in identification of extent of pulmonary TB, especially subtle areas of consolidation, cavitation, bronchogenic and lymphadenopathy. Therefore, HRCT chest is superior to chest radiography in assessing tuberculosis activity. Henceforth, HRCT chest is recommended when the radiographic findings are normal or inconclusive and tuberculosis is suspected clinically for the confirmation of diagnosis and determination of activity.

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