

## Diagnostic Accuracy of High Resolution Computed Tomography Chest in Active Pulmonary Tuberculosis

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### ABSTRACT

**Introduction:** Pulmonary Tuberculosis is a common health problem in our country. It is one of the top 10 causes of death in Nepal. The diagnostic guidelines are primarily based on Acid Fast Baccili (AFB) smear on sputum and Gene Xpert test. The objective of this study is to determine the diagnostic accuracy of HRCT chest in pulmonary tuberculosis.

**Methods:** This was a retrospective study conducted in Patan Hospital from January 2020 to December 2024 who underwent HRCT chest in the radiology department for suspected tuberculosis and its findings were correlated with AFB smear and Gene Xpert test.

**Results:** A Total of 486 cases underwent HRCT chest for suspected cases of Pulmonary Tuberculosis. Diagnostic accuracy of HRCT chest in diagnosing active PTB was 69.75% with sensitivity (95.8%), specificity (54.63%), positive predictive value (55%), and negative predictive value (95.73%).

**Conclusions:** This study concluded that HRCT chest has high diagnostic accuracy in diagnosing disease activity of pulmonary tuberculosis.

**Keywords:** Nepal; Sputum; Tuberculosis

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## INTRODUCTION

Pulmonary Tuberculosis (PTB) is a common health problem in developing countries like Nepal. Worldwide, PTB is the second leading infectious disease after COVID-19. In 2022, an estimated 10.6 million people fell ill with tuberculosis. Globally, the estimated pulmonary tuberculosis incidence rate was 133 per 100,000 population in 2022 and an estimated 1.3 million deaths same year. TB is one of the top 10 causes of death in Nepal. It is estimated that about 17,000 people die due to TB every year in Nepal. Incidence of TB was estimated to be 245 per 100,000 population in Nepal by the end of the year 2019/2020.<sup>1,2</sup>

The diagnostic guidelines for TB are primarily based on the demonstration of AFB on sputum microscopy and chest x-ray findings. Active PTB usually presents with cough for more than two weeks, hemoptysis, and sputum. The patient may also have low-grade fever, chest pain, shortness of breath, weight loss, night sweats, and loss of appetite. Laboratory findings include the Gene XpertMTB/Rif test, which is approved by WHO, and those who do not have access to this test must test a sputum sample for smear test.<sup>3,4</sup>

Chest x-ray is an initial modality of choice with clinically suspected PTB, which is less sensitive in the detection of subtle or occult parenchyma disease and assessing disease activity. Therefore, high-resolution computer tomography (HRCT) is used for the detection, characterization, and distribution of both subtle parenchymal disease. This study is to determine the diagnostic accuracy of HRCT chest in the diagnosis of PTB and correlate the findings with Gene Xpert/Acid-fast bacilli (AFB) smear/ cultures.<sup>5,6</sup>

## METHODS

This was a retrospective study done in the Radiology and Imaging Department and the Department of Pathology of Patan Hospital for a period of 5 years (from January 2020 to December 2024). All patients with clinically suspected PTB who underwent HRCT chest scan in the radiology department were retrieved by using the imaging console and encounter numbers. HRCT chest was performed in a PHILIPS Injenuity machine with a 128-slice and sequential axis of 0.8mm slice thickness was

obtained from the lung apex to the base with the patients in supine position. The HRCT was taken using imaging protocol 0.5 sec rotation time, pitch 0.81 and 120KV. All reports were available from the radiology department's computer records, where all the reports were stored using the patient's name, date of scan, and CT scan number, along with the encounter number. The images were available in the console of the CT scan reporting room. All patients with sputum or bronchial lavage with Gene xpert/ AFB smear and culture result were also included in the study. All Gene xpert/ AFB smear and culture reports were retrieved from the Department of Pathology using the encounter number. From the radiology department records, we collected all data regarding HRCT chest and its findings were correlated with sputum and BAL samples. The HRCT chest findings of clinically suspected PTB were evaluated and also compared with the sputum/BAL sample.

The HRCT findings of the PTB disease pattern were computed first using the number and percentage. These features were correlated with sputum/BAL examination using the chi-square test. Finally, sensitivity and specificity, along with positive predicted value and negative predicted value of each diagnostic test, were calculated individually and in combination. All the data were presented using a dummy table and a chart. Data were entered in Microsoft Excel spreadsheet software and analyzed using SPSS.

## RESULTS

There were a total of 486 cases that underwent HRCT chest for suspected cases of PTB, with a mean age of 52.13, and the age varied from 8 to 96 years. Among 486 cases, a total of 273 (56.2%) were male and 213 (43.8%) were female. A total of 207 (42.6%) cases were diagnosed as active PTB, 117 (24.1%) cases were diagnosed as sequelae of PTB, and 162 (33.3%) cases were diagnosed as reactivation of old PTB by HRCT chest. (Table 1)

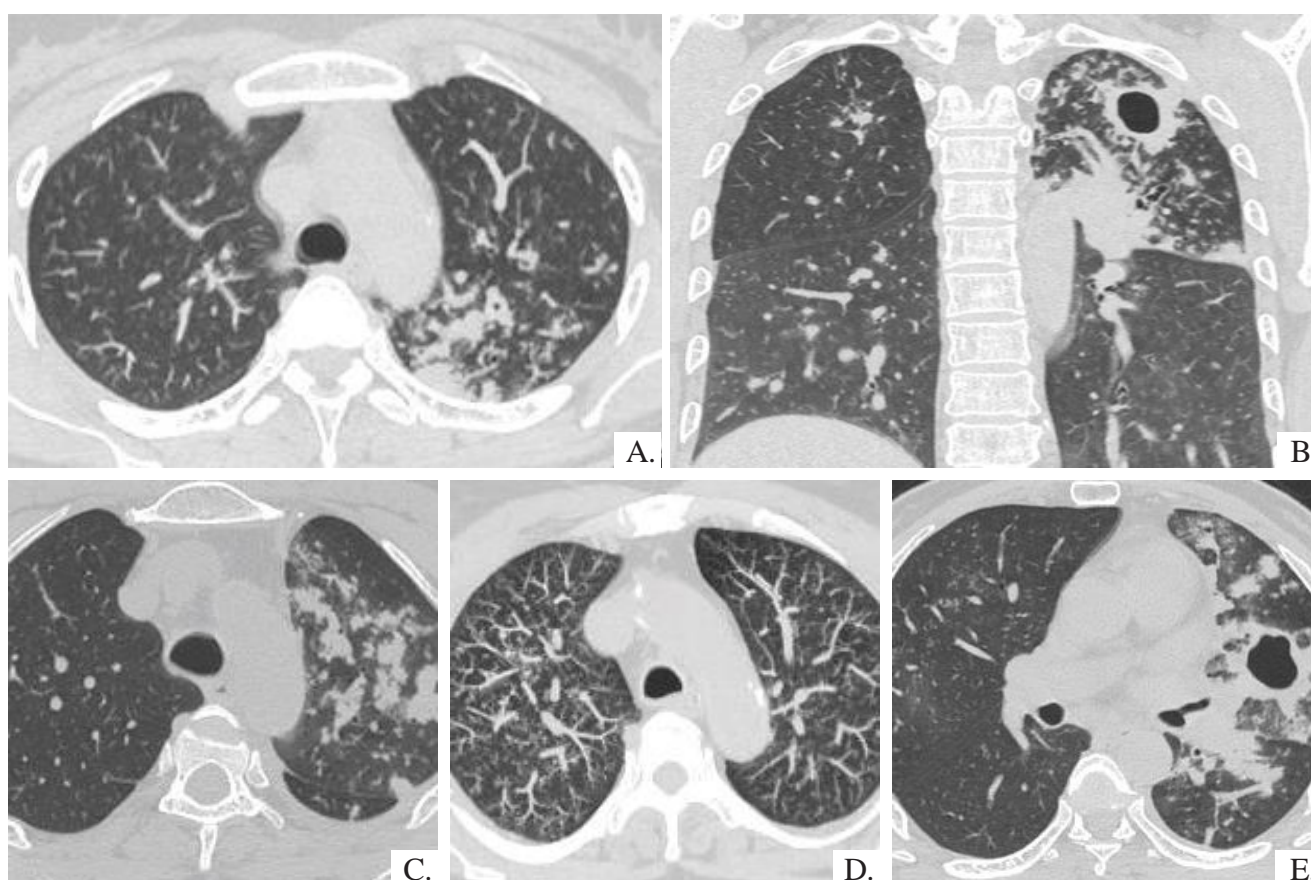
The most common parameter in active PTB was centrilobular nodules (n=250, 67.8%). Fibrosis with traction bronchiectasis was (99.3%) most common parameter seen in sequelae of PTB. (Table 1 & 2) (Figure 1)

***Table 1: HRCT parameters in active PTB***

Parameters in Active PTB	Numbers (n)	Percentage (%)
Centrilobular nodules	250	67.8
Tree in bud opacities	202	54.7
Consolidation	195	52.8
Mediastinal lymphadenopathy	174	47.2
Ground glass opacities	171	46.3
Large nodules	127	34.4
Cavitation	98	26.7
Pleural effusion	78	21.3
Pneumothorax	18	5

***Table 2: HRCT parameters of sequelae of PTB***

Parameters of sequelae of PTB	Numbers (n)	Percentage (%)
Fibrosis with traction of bronchiectasis	280	99.3
Calcification	273	96.8
Emphysematous changes	199	70.6
Cavitation	89	31.6



**Figure 1:** Pattern of HRCT in pulmonary tuberculosis. (A) Centrilobular nodules with tree in bud (B), Consolidation with cavitation (C), Large nodules (D), Micronodules (E), Cavity, few centrilobular nodules and consolidation.

The predominant involvement of both upper lobes was seen in 117 cases (24.1%), followed by all lobes in 115 (23.1%), in which the right lung field is more than the left, as shown in Table 3.

***Table 3: Distribution of radiological lesions in lung lobes***

	Numbers(n)	Percentage (%)
Both upper	117	24.1
All lobes	115	23.4
Right upper lobe	64	13.2
Right lung	53	10.9
Left lung	41	8.4
Left upper lobe	32	6.6
Both lower	21	4.3
Right lower lobe	20	4.1
Left lower lobe	18	3.7
Pleura	3	6
Middle lobe	2	0.4

Table 4 demonstrates the association of HRCT with sputum/bronchoalveolar lavage and AFB/ GeneXpert revealed statistically significant results.

***Table 4: Association of HRCT with Sputum/ BAL results***

Sputum/BAL result	HRCT			Chi-square test
	Active PTB (n=207)	Sequelae of PTB (n=117)	Reactivation of PTB (n=162)	
AFB positive	26	0	11	P-value <.0001
AFB negative	53	52	59	
GeneXpert positive	88	5	40	value <.0001
GeneXpert negative	40	59	111	

Accuracy of HRCT chest in diagnosing active PTB was found to be with sensitivity (95.8%), specificity (54.63%), positive predictive value (55%), negative predictive value (95.73%) and diagnostic accuracy 69.75% as shown in table 5. While combining with reactivation of PTB, diagnostic accuracy was 57% and sensitivity (97%), specificity (35.44%), positive predictive value (44.72%), negative predictive value (95.72%)

***Table 5: Diagnostic accuracy of HRCT findings of PTB with Sputum/BAL results in case of active and sequale of PTB***

Diagnosis	Sputum/BAL						Diagnostic Accuracy
	Positive	Negative	Sensitivity	Specificity	Positive predictive value	Negative predictive value	
HRCT: Active PTB (n=207)	114	93	95.8%	54.63%	55%	95.73%	69.75%
HRCT: Sequelae of PTB (n=117)	5	112					



## DISCUSSION

This study was conducted in a total of 486 cases over 5 years, who underwent HRCT chest with clinical suspicion of PTB. The role of HRCT chest was to evaluate the diagnostic accuracy and disease activity of pulmonary tuberculosis. Out of 486 cases, (207=n) cases were diagnosed as active PTB, (117=n) cases were diagnosed as sequelae of old PTB, and (162=n) cases were diagnosed as reactivation of old PTB radiologically. Final assessment was done with sputum or bronchial lavage with Gene xpert/ AFB smear and culture result, and finally correlated with HRCT findings. This study was conducted to evaluate the diagnostic accuracy, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of HRCT chest.

In our study diagnostic accuracy of HRCT chest in diagnosing active PTB was found to be with sensitivity (95.8%), specificity (54.63%), positive predictive value (55%), negative predictive value (95.73%) and diagnostic accuracy was 69.75% while combining with reactivation of old PTB was found to be sensitivity (97%), specificity (35.44%), positive predictive value (44.72%), negative predictive value (95.72%) and diagnostic accuracy of 57%. This was similar to the study done by Aamir et al. that stated sensitivity 96%, specificity 50%, PPV 67% and NPV 93% whereas study done Yeh JJ et al. found sensitivity of 96.4% and the specificity, positive predictive value (PPV), and negative predictive value (NPV) were 90.9%, 96.4%, 90.0% and 96.8% respectively.<sup>7,8</sup>

A study done by Raseed et al. stated that the diagnostic accuracy of HRCT chest in diagnosing pulmonary tuberculosis was found to be sensitivity 89.09%, specificity 79.25%, PPV 81.67% and NPV 87.50%. A study done by Raghuvanshi et al. postulated that HRCT could not only diagnose PTB but also could exclude patients not having PTB, which stated that sensitivity was 82.9% and specificity was 96.43% in cases of sputum smear-negative patients. In our study, specificity was very low, 54.63% in the case of active PTB and

35.4% in the reactivation of PTB. It was likely due to out of 207 cases, 79 cases were smear negative due to sputum AFB stain/culture test only, and no Xene expert test. In reactivation of PTB, out of 162 cases, 70 cases had AFB/culture smear test only. Lathiya et al., which was a study done in 2020, showed that the sensitivity was 97.22%, specificity was 85.71%, PPV 94.59%, NPV 92.31% and the diagnostic accuracy was 94% which was higher than our study. Studies done by Raseed et al. and Lee HM et al. stated that the specificity for smear-negative cases was less in comparison to smear-positive smear, which were 77.50% and 70.5% respectively both studies. Eisenhuber E et al. and Hatipoğlu On et al. stated that the presence of the tree-in-bud-sign has high sensitivity and low specificity for the diagnosis of active pulmonary tuberculosis.<sup>4,5,9,10,11,12</sup>

In this study the most common parameter in active PTB were centrilobular nodules (67.8%), then tree in bud appearance (54.7%), consolidation (52.8%) followed by mediastinal lymphadenopathy (47.2%), ground glass opacities (46.3%), large nodules (34.4%) and least parameters were pneumothorax (5%), pleural effusion (21.3%) and cavitation (26.7%). The centrilobular nodules were the most common findings in active PTB, followed by the tree-in-bud pattern in our study, which were similar to various studies. The other radiological parameters, consolidation, mediastinal lymphadenopathy, groundglass opacities, large nodules, pneumothorax, pleural effusion, and cavitation were also observed in active PTB, which were also listed in other various studies. In studies done by Drusty K et al. found that tree-in-bud appearance (77%), ill-defined nodules (72%), and consolidation (68%) had high predictive value in diagnosing disease activity, and cavities had the least predictive value (40.9%), which is almost similar to our study. HRCT findings in active disease were patchy consolidation, cavitation, centrilobular nodules, tree-in-bud appearance, pleural effusion, empyema, bronchopleural fistula, and hilar or mediastinal lymphadenopathy

in studies done by Lee KS et al. and Woodring JH et al., which is similar to our study. In study by Caliskan et al. found that micronodules (87%), large nodules (63%), and centrilobular nodules (62%) were the most common findings in HRCT chest whereas in our study, centrilobular nodules, tree in bud, and consolidation are the most common findings. In this study most common parameters in sequelae of PTB were fibrosis with traction bronchiectasis (n=280) 99.3% followed by calcification (n=273) 96.8%, emphysematous changes (n=199) 70.6% and cavitation (n=89) 31.6%, suggesting radiological stability, which is similar to various studies done previously.<sup>5,6,7,12,13,14,15,16,17,18,19</sup>

In this study, the predominant involvement of both upper lobes was seen in 117 cases (24.1%), followed by all lobes, 115 (23.1%), in which the right lung field is more than the left. The least findings were in the pleura and middle lobe, which is similar to studies done in 2017., A Study done by Jeong et al the majority of lesions are in the superior segment of the lower lobes. In our study, there was no significant difference in lobar predominance, and the majority of cases had predominance of all lobes. In our study, fibrosis with traction bronchiectasis, calcification, and emphysematous changes were the main findings in sequelae of PTB, which is similar to studies done by Harsh L et al. and Lee KS et al. Chi-square analysis showed a strong positive correlation between the final diagnosis of PTB and HRCT diagnosis in our study, which is  $p < 0.0001$ . This is similar to a study done by Aamir R et al., which shows the chi-square test showed a strong positive correlation between the final diagnosis and HRCT diagnosis<sup>5,6,17,19,20,21</sup>

The main limitation was that GeneXpert tests were not carried out in all cases of suspected PTB. A large sample size could not be included in this study due to the COVID-19 crisis period. Most of the cases overlapped with COVID-19 infection.

## CONCLUSION

This study concluded that HRCT chest has high

diagnostic accuracy in diagnosing pulmonary tuberculosis. These HRCT findings help in such cases of sputum/BAL AFB test and culture negative, and clinician can initiate antitubercular treatment of clinically suspected PTB. HRCT chest can help in management as it can differentiate between active from inactivity of disease.

## CONFLICT OF INTEREST

None

## SOURCES OF FUNDING

None

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