Diagnostic Accuracy of High-Resolution Computed Tomography in Assessing Activity of Pulmonary Tuberculosis

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Abstract

Background: High-resolution computed tomography (HRCT) has been used in the diagnosis of Pulmonary TB and rapid TB diagnosis is essential and critical for TB control.

Objective: To evaluate the role of High-Resolution Computed Tomography in diagnosing and assessing the activity of pulmonary tuberculosis in patients.

Methodology: Study Design: Cross-sectional study involving radiographic (HRCT) and clinical analysis of patients with suspected tuberculosis, from October 2018 to March 2019. This study was done on a group of 100 patients with suspected tuberculosis having symptoms of fever, cough with sputum, and hemoptysis. After informed consent first detailed clinical history was taken from patients. Criteria standardized for inclusion was; all age groups and both genders. Patients with a history of previous chest surgery and carcinoma were excluded. Then patients undergoing HRCT chest were analyzed and correlated with clinical findings. Features of primary TB include consolidation, lymphadenopathy, pleural effusion, and miliary nodules whereas post-primary TB include apical consolidation, nodules, and cavitation.

Results: Overall 80 (80%) out of 100 subjects were diagnosed with Pulmonary TB on High-Resolution Computed Tomography (HRCT). The most common HRCT findings were tree in bud appearance (77%), fibrotic changes (72%), consolidation (68%), cavitation (40%), bronchiectatic changes(18%), ground-glass haze (18%), and calcified granulomas(10%).

Conclusion: Although chest radiography is the foremost imaging technique in the diagnosis and evaluation of pulmonary tuberculosis in our setup, HRCT can be important in early diagnosis and management with greater sensitivity. Bud appearance and consolidation were the commonest patterns found.

Keywords: HRCT, Chest, Pulmonary Tuberculosis (PTB).

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Introduction

Pulmonary tuberculosis is widespread among the poor socioeconomic class. Tuberculosis (TB) is one of the major concerns of society and the leading single cause of death due to infection in the world accounting for three million deaths per year.[1,2,3] World Health Organization (WHO) ranks TB as "the world's most neglected crisis.[4,5] Like many other diseases such as malignancy pneumonia, and interstitial lung disease, TB also present clinically and radiologically.[4] Taking into account our lack of resources, conventional chest radiographs usually provide adequate information for the diagnosis of active pulmonary tuberculosis. Conventional computed tomographic features of tuberculosis have been defined.[6] The superiority of high resolution computed tomography (HRCT) over conventional computed tomography scans was demonstrated by analyzing the presence and distribution of CT signs suggesting parenchymal fibrosis.[7-9] Moreover, CT can contribute to distinguishing active from chronic infection. The objective of this study was to diagnose Pulmonary TB by using High-Resolution Computed Tomography (HRCT) and determine the pattern of HRCT findings in active pulmonary tuberculosis.

Methodology

A cross-sectional study was conducted over a period of six months, on 100 patients from October 2018 to March 2019, who was referred to our department from medicine and chest wards. In addition to routine detailed history taking, clinical examination, routine laboratory investigations, sputum examination for AFB using Ziehl-Neelsen stain, and conventional radiographic examination of the chest (PA and lateral), all patients were subjected to High-

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Resolution Computed Tomography (HRCT) of the chest. The scans were performed using a Phillips, CT scanner with 1 mm collimation, using 140 KV, 130 mA, 35- 40 cm field of view, 512 x 512 matrix, and bone algorithm at 10 mm intervals from the lung apices to the bases. Scanning was performed by holding maximal inspiration. The study was done after ethical clearance and informed consent, using the scan time of 1.5 seconds with the patient in a supine position. Intravenous contrast was not administered. The pattern of HRCT included; bud appearance, fibrotic changes, consolidation, cavitation, bronchiectatic changes, ground-glass haze, and calcified granulomas.

Results

This study included 100 patients, 70 males, and 30 females. Their ages ranged from 15 to 70 years, with a mean of 45.6 ± 12.36 years. Overall 80 (80%) out of 100 subjects were diagnosed with Pulmonary TB on High-Resolution Computed Tomography (HRCT). The presenting symptoms in the studied patients were fever, cough with sputum, and hemoptysis. As summarized in table-I, the patterns observed in our study were tree in bud appearance (77%), consolidation (68%), bronchiectatic changes (18%), ground-glass haze (18%), cavitation (40%), calcified granulomas (10%), fibrotic changes (72%).

Table-I: High Resolution Computed Tomography (HRCT) findings in Pulmonary Tuberculosis

HRCT Findings	Disease Positivity
Tree-In-Bud	77%
Fibrotic changes	72%
Consolidation	68%
Cavity	40%
Ground-Glass Haze	18%
Bronchiectasis	18%
Calcific granuloma	10%

Discussion

Active pulmonary tuberculosis has a different pattern of appearance. Among it fibrotic changes are more common mainly involving the posterior segment of apical zones.[10] HRCT findings in patients with active pulmonary TB include; micronodules, the tree in bud appearance, airspace consolidation, nodules, ground-glass opacities, and cavities. Usually, multiple calcified lesions are noted in the lungs predominantly at the apical segment of upper and lower lobes because of poorly oxygenated regions. Most of the time it appears as consolidation in the initial phase.[8,9] In our study about 68% of patients present as initial patchy consolidation along with other appearance. This consolidation communicates with secondary bronchioles resulting in cavities formation. From this communication, this disease process spread to the lungs and other viscera's by cough reflux. Routine X-ray chest does not demonstrate the activity of the disease. Patient with sputum negative test are at a lesser risk for spread of tuberculosis as compared with sputum positive individuals, who can transmit this lethal infectious disease. The relative transmission rate of smear-negative TB patients in contrast to smear-positive TB patients has been ascertained at 22% utilizing a molecular epidemiologic method. About 50 % of tuberculous patients have smear-negative results so regarding the transmission of this disease this number is significant.

For urgent diagnosis polymerase chain reaction (PCR) the test is better but the sensitivity of this test is low. Most of the physicians remain in doubt to start anti-tuberculous treatment because of the high risk of adverse reactions of the antituberculous drugs. Then again, to short the cost and potential risk of empiric treatment correct identification of patients who are unlikely to have tuberculosis is important as well. Physicians have some difficulties about whether anti-tuberculous therapy should be started for these individuals. Prompt initiation of anti-tuberculous therapy for pulmonary tuberculosis is an important issue both because of its benefits for the patient and control of the disease.[10] Tree in Budd appearance is the most common pattern of the disease process.[11] In our study at Gujranwala population it also appeared to be in 77% of the positive cases. In addition to consolidation focal ground-glass patches is another form of the acute disease that can involve any lung segments but predominantly involving lower lobes. Miller and

panosian identified causes of TIB. It proved that mycobacteria (39%), viruses (3%), aspiration (25%), and multiple infections (4%) were the causes of Tree in Budd appearance(TIB).[12] Later Shimon et al, disagreed with the results and said that Tree in Budd appearance can be due to other infections not typical for mycobacterium. Other etiologies can be a malignancy, aspiration, and other infectious conditions of the chest.[13] Cavitating lesions predominantly in upper lobes or apical segment of the immunocompetent patient may be the initial presentation.[14] These cavities are surrounded by small nodules oftenly.[15]
In our study about 40 % of the cases present as cavitating lesions. Further, it is divided into acute or chronic lesions depend on wall thickness. Wall thickness 3 mm is the cut-off value used to differentiate between the chronic and acute forms of the cavity. Moreover, inner smooth margins were noted in chronic form and slight irregular margins were noted in the acute form of the cavitating disease. In acute form surrounding small ground-glass haze noted while in chronic form often no change or some time fibrotic changes are evident.
Associated hilar or mediastinal nodes present mainly in thick-walled cavities. But calcified nodes are strongly associated with thin-walled cavities. Calcified granulomas often present in the lungs. It means healed lesions. Tadatsune et al contradicted these findings.[16] According to their study many mycobacterium residues in calcified lesions. High-resolution Computed tomography is an easy and good tool to diagnose pulmonary tuberculosis.
For detections of small lesions High-Resolution Computed Tomography (HRCT) has been more sensitive than routine chest X-ray rather better in the diagnosis of slight or occult parenchymal disease and in assessing disease activity in pulmonary tuberculosis. The value of CT chest in diagnosing pulmonary tuberculosis was studied by many authors: Lee KS and colleagues[17] in 1996 studied the utility of CT in the evaluation of TB among patients without AIDS, they succeeded to predict the presence of TB in 133 out of 146 patients proved to have TB and to exclude TB in 32 out of 42 patients proved to have other diseases, they concluded that CT can be helpful in the diagnosis of pulmonary tuberculosis in most cases. On the basis of CT findings, the distinction of active from inactive disease can be made in most cases. Lee SW and colleagues in 2010 studied the use of CT in the investigation of TB outbreak and with the use of CT they could diagnose active TB in nine patients who had normal chest X-ray and they concluded that adding CT to the routine investigation of TB outbreak may be helpful in differentiating active tuberculosis from Latent TB infection. Matsuoka et al,[18] investigate the relationship between computed tomography (CT) findings in patients with active pulmonary tuberculosis (PTB) and the number of the acid-fast-bacilli (AFB) on sputum smears and they found that the frequency of micronodules and nodules did not significantly differ among the smear-positive and smear-negative groups.
In contrast, the frequency of consolidation and cavitation increased with the number of AFB. In another study by Kosaka and his colleagues[19] in 2005, they found that air space consolidation, cavitation, and ground-glass opacities occurred significantly more frequently in the smear-positive than in the smear-negative active PTB patients while the frequency of centrilobular nodules (micronodules) did not differ between the two groups. It allows a volumeteric thin slice of the chest for detail and better diagnosis. The latest ultrafast and dynamic HRCT can be performed in the whole respiratory cycle. Time duration is less than a minute. Inspiratory and expiratory images are obtained usually at full inspiration and expiration respectively, 1-2 cm spacing images obtained. Diseases involving basal segments can be better described by full inspiratory and expiratory images.
Prone images can be helpful to see the lung bases. Another very important factor is the reduction in radiation dose. For which prefer technique is low dose High-resolution CT scan. Usually, 40-45 mAs are used but it affects resolution standards. The images obtained are noisier than routine quality images. Some authors reported that similar anatomical details obtained in standard and low dose high-resolution chest scan.[17-19]
Other researchers have claimed that 160 mAs minimum dose required to identify subpleural lines and ground-glass opacities. Emphysema and ground glass haze better differentiate with low-resolution CT technique. HRCT has a high yield in the diagnosis of different pattern of disease such as emphysema, cystic lung disease, Interstitial lung disease, subpleural honey combing, sarcoidosis, and lymphangitic carcinomatosis. The pattern of disease

is different with reference to etiology and can be easily diagnosed with a volumeteric scan. Similarly primary and post-primary tuberculosis well differentiates by this technique. Tree in bud appearance, cavity, centrilobular nodules, consolidation, ground-glass opacity (GGO), lymphadenopathy, main lesion in S1, S2, S6, lobular consolidation, and other minute nodules was significantly linked with pulmonary tuberculosis on regression analysis. Causes of tree-in-bud appearance are respiratory infections with mycobacteria, bacteria, or viruses, cystic fibrosis, allergic bronchopulmonary aspergillosis (ABPA), aspiration, and graft versus host disease.[13,14] Tree-in-bud opacities arise from extensive bronchiolar mucoid impaction in the presence or absence of additional involvement of adjacent alveoli.

Complications of this disease such as effusion, calcification, empyema, and fistula are delineated properly with the use of a high-resolution scan.[16] Post-primary tuberculosis appears as bronchiectasis which has a typical appearance, It appears as dilated bronchi larger in cross-section than the adjacent pulmonary artery. Bronchial wall thickening some time associated it. Signet ring appearance can be seen on cross-section images. Dilated bronchi due to peribronchial fibrosis along with air-fluid levels. Emphysema appears as low attenuation focal area without definable walls, which distinguishes empysema from cystic lung diseases.[16]

The most common type is centrilobular empysema, common in smokers with upper lobe distribution. Early empysematous changes are characterized by round black holes that may appear in the central part of secondary pulmonary lobules adjacent to the central pulmonary artery. The ultimate result of pulmonary tuberculosis is fibrotic changes. Compensatory empysematous changes were noted around the scar site. These changes can easily be described with the help of high-resolution chest images.[12]

The endobronchial spread of disease appears as tree in budd and centrilobular nodules. Considering the 3D capability of the modern scanner, the endobronchial spread of tuberculosis have high diagnostic accuracy along with help in follow up of the disease process by HRCT. Tuberculosis one of the worst reality of our national issues. Though the continuous medical support and efforts are in steamline still we can not eradicate this disease. HRCT of the chest will be a good tool in the early diagnosis of this disease. Moreover, it can be helpful in the diagnosis of its complications, progression of the disease process, and effectiveness of its medications. HRCT can be helpful in the early detection of the lesions and thus helpful in the early treatment of the disease process. In this way, this new modality will be utilized for the healthy nation which is the dream of every Pakistani.

Conclusion

High-Resolution Computed Tomography can disclose the presence of radiological features suggesting the diagnosis of tuberculosis when the conventional radiological findings are inconspicuous while tuberculosis is clinically suspected. In the detection of active disease, HRCT has proven to be more sensitive than chest radiography.

Authors Contribution: MWA: Conception of work, design of work and revising. **NR:** Acquisition and analysis of data and drafting. **SA:** Interpretation of data and drafting. **SS:** Interpretation of data and revising.

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