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ORIGINAL RESEARCH ARTICLE

Evaluation of Computed Tomography Imaging Findings in Suspected Pulmonary Infections with its Clinic-microbiological Association

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ABSTRACT

Introduction: Pulmonary infections are one of the most common infections encountered in outpatient and inpatient clinical care. The most useful imaging modalities available for the evaluation of the patient of suspected pulmonary infections are chest radiography and computed tomography (CT). The aim of the present study is to evaluate the computed tomography imaging findings in pulmonary infections with their clinicomicrobiological association.

Material an Methods: This hospital-based cross-sectional observational study included a total of 110 patients with suspected pulmonary infections referred for chest imaging. Initially, chest radiography examination was done in all the patients. Subsequently, all of the patients underwent either contrast-enhanced computed tomography or high-resolution computed tomography of the thorax as appropriate on SOMATOM definition flash 128 slice dual source energy CT or SOMATOM scope 32 slice CT. Imaging findings were interpreted independently and tabulated and subsequently associated with microbiological or pathological findings.

Results: The majority of participants belonged to the 41 to 60 years age group (37.3%). Male predominance was noted with 75.5%. For bacterial infections, CT had a sensitivity of 90.62%, specificity of 96.92%, PPV of 93.55%, and NPV of 95.45%. Tubercular infections demonstrated 96.23% sensitivity and PPV, with specificity and NPV of 95.35%. Fungal infections had a sensitivity and PPV of 92.31%, and specificity and NPV of 98.77%.

Conclusion: CT imaging is a valuable tool for diagnosing pulmonary infections, providing detailed insights into the nature and extent of the disease. When combined with microbiological and pathological tests, it offers a comprehensive approach to managing infections.

Keywords: Pulmonary infections, Chest radiography, CT, Tuberculosis, Consolidation

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INTRODUCTION

Pulmonary infections are conditions where pathogens infect the respiratory tract, particularly the lungs, leading to inflammation and damage to lung tissue. These infections can be caused by bacteria, viruses, fungi, or parasites, each manifesting distinct pathological and immunological responses. The diagnosis becomes even more difficult when CT imaging results are not integrated with clinical and microbiological data, which may cause treatment delays or patient mismanagement.

For patients with or suspected of having a lung infection, chest radiography and CT are the primary imaging tests needed. For the first evaluation of these individuals, CT is not advised; however, it is far more sensitive and specific than ordinary film radiography.[1] It must be performed when normal, unclear, or nonspecific radiography is present along with a strong clinical suspicion of pneumonia. This situation most frequently arises in individuals who are immunocompromised. CT can verify whether cavities are developing and whether there are any concomitant abnormalities such as lymphadenopathy, pleural effusion, and/or empyema.[2]

CT imaging provides crucial insights into the extent, distribution, and nature of pulmonary lesions, aiding in the differentiation between infectious agents and non-infectious causes of lung disease. However, its interpretation can be complex and may lead to diagnostic challenges when used in isolation.[3]

It is necessary to correlate CT results with clinical and microbiological data to distinguish between infectious agents and non-infectious causes in order to make an accurate diagnosis. To better understand how CT imaging can enhance diagnostic accuracy, guide treatment decisions, and ultimately optimize patient outcomes in cases of pulmonary infections, it is necessary to combine this research with clinical and microbiological findings. The aim of the study is to evaluate of computed tomography imaging findings in suspected pulmonary infections with its clinicomicrobiological association.

MATERIAL AND METHODS

Study Duration

It was a hospital-based observational study conducted over a period of 1 year from 1st June 2024 to 31st May 2025 in the Department of Radiodiagnosis, SRMSIMS Hospital, Bareilly, India. The study patient was drawn from patients who were referred to department of radio diagnosis for imaging from clinical departments. This study was conducted after getting an ethical clearance certificate from the Institute's Ethics Committee. Patients present with suspected pulmonary infections referred for chest computed tomography imaging and patients giving informed written consent to participate in the study were included. Patients with suspected or confirmed chest malignancy/secondary or any kind of allergy, or connective tissue disorder. Patients with pneumoconiosis/occupational lung diseases. Patients without a microbiological association were excluded

Sample Size

Sample size calculation done by using the formula: $n= z^2 PQ/d^2$, where P = 7.2% (Prevalence), Q = (100-P) %, d = 5% (Relative error). This comes out to be (n) 110.

Data Collection

Before commencing the study, informed written consent was taken from all patients. All patients were handled by the same doctor to minimize bias. Using structured proforma information was collected. The patient's age and sex were noted, and only patients strictly fulfilling the following criteria were selected for the study.

Statistical Analysis

Pilot research, including 11 patients, was conducted to validate the methodology, with approval from the Institute's Ethics Committee. The data was collected, and then evaluated using frequency and percentage for the categorical variable. The results were visually presented using charts and graphs. Additionally, prediction values were produced to determine the effectiveness of the imaging techniques.

RESULTS

A total of 110 patients were included in the study. The 41 to 60 years category, contributing 41 (37.3%) to the total sample size, was the common age group among the study population, followed by the 61 to 80 years group with 31 (28.3%) cases, as shown in Table 1.

Table 2 represents the male predominance with 83 (75.5%) cases. Nodular lesions were the most common finding, observed in 94 (85.5%) participants, followed by ground glass opacity in 91 (82.7%) and consolidation in 87 (79.1%). Cavitation was present in 56 (50.9%) cases, and tree-in-bud appearance was seen in 44 (40.0%), as shown in Table 3.

The diagnosis of the most relevant pulmonary infection was then made based on characteristic findings observed on the CT scan. Tubercular pathology accounted for 51.8% (57) of cases. This was followed by non-tubercular bacterial infections, which constituted 31.8% (35). Fungal infections were observed in 13.6% (15) of cases, as shown in Table 4.

The distribution of microbiological/pathological diagnoses, as presented in Table 5, reflects a predominant observation of tubercular infection in 51.8% of cases, followed by non-tubercular bacterial infection observed in 32.7% of cases. The CT diagnosis is then compared with the gold standard microbiology or/and/or pathological diagnosis. The data highlights the association of microbiological and radiological diagnosis, which shows a statistically significant association between microbiological and radiological findings with a *p-value* < 0.001. Microbiologically, bacterial infections accounted for 36 cases. Out of these, 33 (91.6%) were radiologically classified as bacterial, while 1 (2.7%) was misclassified as fungal, and 2 (5.5%) were identified as neoplastic on imaging. Similarly, fungal infections were microbiologically confirmed in 15 cases, of which 93.3% were correctly identified radiologically, whereas 6.6% were misclassified as neoplastic.

Neoplastic conditions, though rare, comprised 2 cases that were microbiologically confirmed but radiologically classified as tubercular. Tubercular infections, the most common diagnosis, constituted 57 cases microbiologically, of which 96.5% were accurately classified as tubercular radiologically, while 3.5% were misdiagnosed as bacterial. These finding enlisted in Table 6

The diagnostic performance of CT scan for pulmonary infection varied across non-tubercular bacterial, tubercular, and fungal etiologies. For non-tubercular bacterial infections, the sensitivity was 90.62%, with a specificity of 96.92%, a positive predictive value (PPV) of 93.55%, and a negative predictive value (NPV) of 95.45%, indicating high reliability in identifying true non-tubercular bacterial cases and ruling out non-non tubercular bacterial cases. Tubercular infections demonstrated a sensitivity and PPV of 96.23%, along with a specificity and NPV of 95.35%, reflecting a highly

Table 1: Age-wise distribution of patients

Age	*Frequency*	*Percent*
0–20	8	7.3
21–40	26	23.6
41–60	41	37.3
61–80	31	28.2
81–100	4	3.6
Total	110	100

Table 2: Gender distribution among the study participants

Sex	*Frequency*	*Percent*
Male	83	75.5
Female	27	24.5
Total	110	100

Table 3: Distribution of parenchymal abnormalities on CT scan

Parenchymal abnormalities in CT scan	*Frequency (%)*
Consolidation	87 (79.1%)
Cavitation	56 (50.9%)
Nodular lesion	94 (85.5%)
Tree in bud appearance	44 (40.0%)
Ground glass opacity	91 (82.7%)
Interlobular septal thickening	30 (27.3%)
Bronchial wall thickening	20 (18.2%)
Lung abscess	9 (8.2%)

Table 4: Distribution of radiological diagnosis

Radiological diagnosis	*Frequency*	*Percent*
Fungal	15	13.6
Non-tubercular bacterial	35	31.8
Tubercular infection	57	51.8
Neoplastic	3	2.7
Total	110	100.0

Table 5: Distribution of microbiological/pathological diagnosis

Microbiological/Pathological findings	*Frequency*	*Percent*
Non-tubercular bacterial	36	32.7
Tubercular	57	51.8
Fungal	15	13.6
Neoplastic	2	1.8
Total	110	100.0

accurate identification of both positive and negative cases. Similarly, fungal infections showed a sensitivity of 92.31% and a PPV of 92.31%, coupled with a high specificity and NPV of 98.77%, indicating strong diagnostic precision. These findings are summarized in Table 7 and depicted in Figure 1.

Image Gallery

Figures 2 to 8 shows radiological images of the infections caused by different microorganisms.

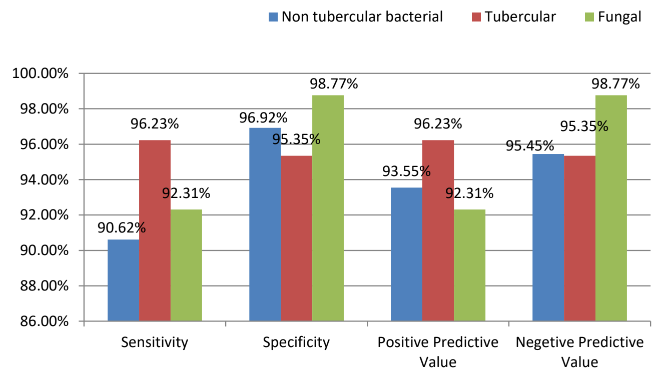

Figure 1: Diagnostic performance of CT scan in pulmonary infection

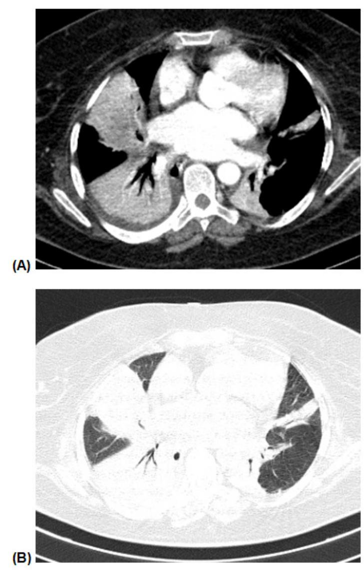

Figure 2: Bacterial (*Streptococcus pneumonia)* lobar pneumonia. CECT thorax axial section in A) Mediastinal window, and B) Lung window shows dense homogeneously enhancing lobar consolidations in the right lower lobe and basal segments of the left lung lower lobe with internal air bronchograms

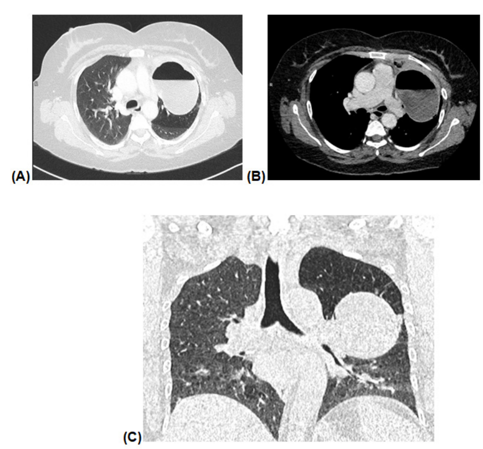

Figure 3: Methicillin-resistant *Staphylococcus aureus* lung abscess CECT thorax axial section in A) Lung window, B) Mediastinal window, and C) Coronal reformatted section in lung window shows a cavity with an air-fluid level within the left upper lobe with thin enhancing walls and perilesional consolidation

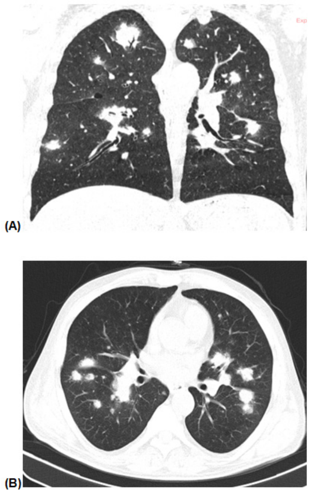

Figure 4: Microbiology proven case of fungal infection- A) Coronal, and B) Axial CT thorax images demonstrate multiple nodular lesions in bilateral lung fields with a surrounding rim of ground glassing

Figure 5: Miliary tuberculosis. A) Axial, and B) Coronal CT thorax images demonstrate innumerable well-defined micro-nodules throughout both lung parenchyma

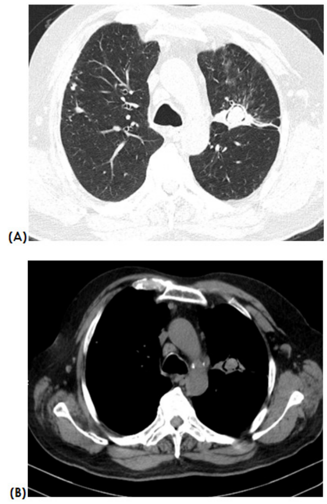

Figure 6: Pulmonary Aspergilloma - Axial CT thorax images demonstrate a thin-walled cavitary lesion in the apicoposterior segment of the left upper lobe adjacent to the fissure with an intracavitary oval-shaped soft tissue component and a peripheral rim of air

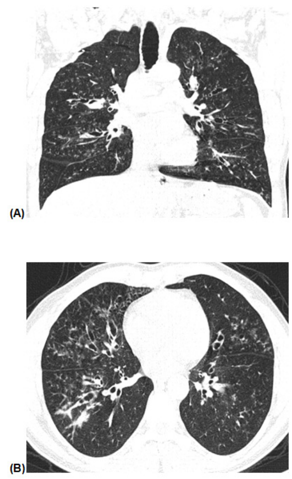

Figure 7: Allergic Bronchopulmonary Aspergillosis CT thorax. A) Coronal section, and B) Axial section demonstrate cylindrical and saccular bronchiectasis in bilateral lung fields involving segmental and subsegmental bronchi, with a few of them showing high attenuation mucus within

Table 6: Association of CT with microbiological/pathological diagnosis

Microbiological/Pathological	*Radiological*				*Total*	*p-value*
	Non-tubercular bacterial	*Fungal*	*Neoplastic*	*Tubercular*		
Non-tubercular bacterial	33	1	2	0	36	
	91.6%	2.7%	5.5%	0.0%	100.0%	
Fungal	0	14	1	0	15	
	0.0%	93.3%	6.6%	0.0%	100.0%	
Neoplastic	0	0	0	2	2	<0.001
	0.0%	0.0%	0.0%	100.0%	100.0%	
Tubercular	2	0	0	55	57	
	3.5%	0.0%	0.0%	96.5%	100.0%	
Total	35	15	3	57	110	
	31.8%	13.6%	2.7%	51.8%	100.0%	

#*p-value* calculated using Chi-square test

Table 7: Diagnostic performance of CT scan in pulmonary infection

Pulmonary infection	*Sensitivity (%)*	*Specificity (%)*	*Positive predictive value (%)*	*Negative predictive value (%)*
Non-tubercular bacterial	90.62	96.92	93.55	95.45
Tubercular	96.23	95.35	96.23	95.35
Fungal	92.31	98.77	92.31	98.77

(A)

(B)

Figure 8: Tubercular cavitation. A) X-ray chest PA view shows a large cavitary lesion with a surrounding rim of consolidation in the left upper lung zone. B) Axial CT thorax image of the same patient demonstrates large cavitation with a surrounding rim of consolidation with internal air bronchograms in the apico-posterior segment of the left lung upper lobe

DISCUSSION

The current study identifies the 41 to 60 years age group as the most common category among study participants (37.3%), followed by the 61 to 80 years group (28.2%). These findings align with studies emphasizing the higher prevalence of pulmonary infections in middle-aged and older adults due to declining immunity and higher exposure to comorbidities. For instance, a study by Ko *et al.*[4] observed a similar pattern where 34.7% of tuberculosis cases were found in the 41 to 60 age group, with a significant proportion in the elderly, reinforcing the role of age-related immunosuppression in infection susceptibility. In contrast, a study by Obmann *et al.*[12] on fungal infections highlighted a predominant age group of 61 to 80 years (42.5%), suggesting that older age groups bear a higher burden of invasive fungal diseases due to factors such as immune senescence and frequent hospitalization. These findings contrast with the current study, where the middle-aged group (41–60 years) showed the highest prevalence, indicating a possible demographic or regional variation in pulmonary infection dynamics. The current study demonstrates a significant male predominance in pulmonary infections, consistent with several studies. Ko *et al.*[4] observed that males constituted 70.2% of tuberculosis cases, attributing this to lifestyle factors like smoking, occupational exposures, and higher prevalence of risk factors such as COPD and alcohol use. Similarly, Obmann *et al.*[12] reported a male-to-female ratio of 3:1 in fungal pulmonary infections, emphasizing the role of immune-modulating effects of sex hormones and environmental exposures. These findings are consistent with the current study's male predominance of 75.5%, indicating a shared pattern across different pulmonary pathogens.

The CT thorax findings in the current study reveal a diverse range of parenchymal and pleural abnormalities characteristic of pulmonary infections. Nodular lesions, identified in 85.5% of participants, were the most common parenchymal finding. Similarly, nodular opacities are frequently observed in fungal infections, as noted by Obmann *et al.*[5], particularly in invasive aspergillosis. Ground glass opacities (82.7%) and consolidation (79.1%) are consistent with acute inflammatory processes and alveolar filling, commonly seen in viral and bacterial pneumonia. Ko *et al.*[11] similarly highlighted these findings in tuberculosis and mixed infections, emphasizing their utility in assessing active disease. Cavitation (50.9%) was frequently observed, consistent with advanced stages of bacterial or fungal infections and mycobacterial diseases. Tree-in-bud patterns, present in 40% of cases, are indicative of endobronchial dissemination, a characteristic feature of tuberculosis and bronchogenic spread of infections.

The diagnostic outcomes based on CT imaging in the current study underscore the utility of radiological patterns in identifying specific pulmonary infections. Tubercular pathology, accounting for 50% of cases, reflects the high prevalence of tuberculosis (TB) in this cohort. This finding aligns with Ko *et al.*[4], where TB constituted a significant proportion of pulmonary infections, particularly in regions with endemic disease. Radiological findings like nodules, cavitation, and tree-in-bud appearance strongly correlate with TB diagnosis (Ko *et al.*, 2018). Bacterial infections (30%) were the second most common aetiology, consistent with their global prevalence in acute pulmonary infections. Features such as consolidation and ground-glass opacities are indicative of bacterial pneumonia. Similar distributions have been reported in studies on bacterial infections where rapid progression and distinct CT findings are diagnostic (Obmann *et al.*, 2021). Fungal infections (12.7%), including aspergilloma (3.6%), allergic bronchopulmonary aspergillosis (ABPA) (1.8%), and mucormycosis (0.9%), highlight the importance of CT in detecting invasive fungal diseases. Obmann *et al*.[5] noted similar patterns, where fungal infections presented as nodular opacities, cavitation, or ground-glass attenuation. Mucormycosis, though rare, is critical to identify early due to its aggressive nature.

The current study, emphasizing the predominance of tubercular infections (49%) diagnosed through microbiological methods, finds resonance with Ko *et al*.[4], where techniques such as TRUENAT MTB PLUS and smear microscopy were essential for TB confirmation. The reliance on molecular diagnostics like TRUENAT (33.3%) and fluorescent smear staining (32.1%) in resource-limited settings mirrors findings from Ghimire *et al*.[6], which highlight the necessity of rapid diagnostics in tuberculosis-endemic regions. However, contrasting findings emerge from Hatipoglu *et al*.[7], where high-resolution computed tomography (HRCT) was pivotal in early pulmonary TB detection, suggesting imaging as a primary diagnostic tool in settings with advanced resources. For bacterial infections (31.8%), the utility of sputum gram staining and culture (45.9%) aligns with Shah *et al*.[8], who stressed the effectiveness of traditional microbiology in community-acquired pneumonia.

The current study highlights the significant association ($p < 0.001$) between microbiological and radiological findings in diagnosing pulmonary infections, emphasizing their complementary diagnostic role. The 91.2% concordance between radiological features and microbiologically confirmed bacterial infections aligns with Obmann *et al*.[5], who demonstrated that imaging patterns like consolidation and air bronchograms are typical of bacterial pneumonia, reducing diagnostic ambiguity.

The diagnostic performance of CT imaging in identifying pulmonary infections demonstrates significant agreement with prior studies while offering nuanced distinctions in context and focus. For bacterial infections, the sensitivity (90.62%) and specificity (96.92%) observed in this study align closely with findings from Obmann *et al*.[5], who emphasized CT's efficacy in identifying bacterial pneumonia through key radiological features like consolidation and air bronchograms. This parallels observations by Shah *et al*.[8], who reported that CT imaging outperforms conventional methods, particularly in distinguishing bacterial pneumonia within heterogeneous clinical populations. For tubercular infections, the current study's sensitivity (96.23%) and specificity (95.35%) underscore the utility of CT in detecting hallmark signs of TB, such as cavitation and tree-in-bud patterns. Similar high accuracy is reported by Ko *et al*.[4], who noted CT's superior diagnostic role in resource-limited environments. Additionally, Hatipoglu *et al*.[8] confirmed these findings, detailing that HRCT reliably captures TB-associated lesions.

Fungal infections exhibited high diagnostic accuracy, with sensitivity and PPV of 92.31% and specificity and NPV of 98.77%. These metrics are supported by Kang *et al*.[9] underscore CT's precision in diagnosing fungal complications in febrile neutropenic patients, reflecting consistent findings. The consistently high specificity and NPV observed across all infection types highlight CT's role in excluding false positives and reducing unnecessary interventions. This consensus is echoed in studies like Ghimire *et al*.[6], which stressed CT's importance in public health strategies for pneumonia diagnosis. In contrast, Qin *et al*.[10] noted that in post-transplant patients, CT findings alone might not be definitive due to frequent mixed infections, underscoring the need for multimodal diagnostic approaches. Overall, CT imaging emerges as a robust diagnostic tool, with substantial evidence supporting its application across diverse patient settings.

The present study identifies the importance of combining CT imaging with microbiological and pathological findings to diagnose and understand pulmonary infections. The findings showed that CT imaging is highly effective in identifying different types of infections, such as non-tubercular, tubercular, and fungal infections, with high accuracy. The study revealed that certain CT scan patterns, such as tree-in-bud appearance, cavitation, and lymphadenopathy, are particularly helpful in diagnosing tubercular infections. The ability of CT imaging to differentiate these patterns is essential for making the right diagnosis, especially when other methods, like microbiological tests, take longer or are inconclusive. The results also showed a strong agreement between CT imaging and microbiological findings, with very few cases of misclassification. This highlights how imaging can play a key role in guiding initial treatment decisions while waiting for laboratory results.

CONCLUSION

CT imaging is a valuable tool for diagnosing pulmonary infections, providing detailed insights into the nature and extent of the disease. When combined with microbiological and pathological tests, it offers a comprehensive approach to managing infections. These findings emphasize the need for healthcare professionals to use imaging as part of a broader diagnostic strategy to improve patient outcomes.

REFERENCES

1. Marrie TJ. Epidemiology of community-acquired pneumonia in the elderly. Semin Respir Infect 1990;5(4):260–268.
2. Thorpe JE, Baughman RP, Frame PT, *et al*. Bronchoalveolar Lavage for Diagnosing Acute Bacterial Pneumonia. J Infect

Dis. 1987;155(5):855–861.
3. Marras TK, Wagnetz U, Jamieson FB, Patsios DA. Chest computed tomography predicts microbiological burden and symptoms in pulmonary Mycobacterium xenopi. Respirology 2013;18(1):92–101.
4. Ko Y, Lee HY, Park YB, Hong SJ, Shin JH, Choi SJ, *et al*. Correlation of microbiological yield with radiographic activity on chest computed tomography in cases of suspected pulmonary tuberculosis. PLOS ONE 2018;13(8):e0201748.
5. Obmann VC, Bickel F, Hosek N, Ebner L, Huber AT, Damonti L, *et al*. Radiological CT Patterns and Distribution of Invasive Pulmonary Aspergillus, Non-Aspergillus, Cryptococcus and Pneumocystis Jirovecii Mold Infections - A Multicenter Study. Rofo 2021;193(11):1304–1314.
6. Ghimire M, Bhattacharya SK, Narain JP. Pneumonia in South-East Asia Region: Public health perspective. Indian J Med Res 2012;135(4):459–468.
7. Hatipoğlu ON, Osma E, Manisali M, Uçan ES, Balci P, Akkoçlu A, *et al*. High resolution computed tomographic findings in pulmonary tuberculosis. Thorax 1996;51(4):397–402.
8. Shah BA, Singh G, Naik MA, Dhobi GN. Bacteriological and clinical profile of Community acquired pneumonia in hospitalized patients. Lung India 2010;27(2):54–57.
9. Kang M, Deoghuria D, Varma S, Gupta D, Bhatia A, Khandelwal N. Role of HRCT in detection and characterization of pulmonary abnormalities in patients with febrile neutropenia. Lung India 2013;30(2):124–130.
10. Qin J, Xu J, Dong Y, Tang W, Wu B, An Y, *et al*. High-resolution CT findings of pulmonary infections after orthotopic liver transplantation in 453 patients. Br J Radiol 2012;85(1019):e959-965.