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Spectrum of Imaging Patterns on High Resolution Computed Tomographyin Lower Respiratory Tract Infections and Their Differential Diagnosis

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ABSTRACT

The present study concludes that high resolution computed tomography is an invaluable tool in defining the imaging features of lower respiratory tract infection and characterization of the disease based on variouspatterns.

Keywords:
spectrum, respiratory

1. Introduction

Lower respiratory tract infections (LRTI) are often endogenous caused by microbes in the patient‟s normal flora. The upper respiratory tract lies above thevocal cords: the lower respiratory tract is situated below the vocal cords. In a known or suspected case of LRTI the plain chest radiograph, Sputum smear and culture remain initial methods ofevaluation. [1] LRTI is often associated with a set of symptoms known as common cold, which, if prolonged, is one of the most common cause to see a clinician. One of the most significant problem is the need to estimate whether the patient with cough and fever presents with pneumonia or only has self-restricting acute bronchitis. The current gold standard for this distinction has been chest radiography. [2]

Chest radiography has been used for decades to identify pneumonia in patients suffering from acute lower respiratory tract infection. Because the diagnosis of the community acquired pneumonia cannot be confirmed or excluded with sufficient accuracy on the basis of symptoms and a physical examination, chest radiography is still recommended as standard method for confirming the diagnosis of pneumonia. However, the reliability of this test is limited by significant inter observer variability in radiograph interpretation. The true prevalence of the infiltrative disease in -LRTI is more than 1.5 folds compared to that seen at chest radiograph. Thus spiral CT and HRCT play an important role in detecting IRTI.[3-5] Conventional CT of the chest provides a two dimensional representation of a three dimensional cross sectional slice of the lung. Although it allows assessment of the entire chest, it has limited ability to demonstrate fine parenchymal details because all the structures within the thickness are averaged to the produce image.[6] HRCT is currently the best imaging modality for evaluation of the lower respiratory tract infections especially small airway disease. It is capable of imaging the lung parenchyma with excellent spatial resolution and providing anatomic detail similar to that seen in gross pathological examination.[7]

The HRCT technique is use of thin sections and image reconstruction with a high spatial frequency algorithm. Although standard CT usually provides an adequately detailed image of the lung parenchyma, high resolution CT provides fine interstitial details and may detect subtle pneumonias sooner than do other techniques. HRCT is particularly useful in immuno compromised patients, in whom infection can quickly overwhelm the depressed immune system. Lower respiratory tract infections show various patterns on HRCT including ground glass opacity, discrete consolidation, confluent consolidation, airspace nodules, peribronchovascular

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thickening, "tree-in- bud" pattern, free pleural fluid and septal thickening. An expiratory mosaic pattern can also be noted in nearly 20% patients reflecting a coexisting small airway obstruction.[9,10]

Small airway diseases manifest on HRCT as mosaic lung attenuation and centrilobular nodular opacities. The infective causes, such as endobronchial tuberculosis, mycobacterium avium complex, airway aspergillus infection, respiratory syncytial virus, cytomegalovirus etc. exhibit a centrilobular nodular or the "tree-in- bud" pattern. Bronchioles as small as 2mm may be seen onHRCT. [11] The study undertaken is an endeavor to define the various HRCT patterns of lower respiratory tract infections, characteristics of specific infective pathologies, and their differentiation.

2. Materials And Methods

The study was conducted in Department of Radiodiagnosis , Sri Lakshminarayana Institute of Medical Sciences, in association with Department of Medicine and Department of Emergency medicine.The study group included a total of 55 patients with suspected clinical diagnosis of lower respiratory tract infection presenting in department of medicine and pediatrics.

All the patients were evaluated along the following lines and findings were recorded on a separate Performa.

1. Clinicalassessment

A detailed history was elicited from each patient that included relevant symptoms, past history, relevant family history and—smoking habits, Findings of general and systemic examination were noted in each patient.

2. Laboratoryinvestigations

Relevant laboratory investigations including blood and sputum examination were recorded in each case.

3. Radiologicalevaluation

(a) Plainradiography:

Standard posterior-anterior radiograph / anterior-posterior radiograph were obtained in all cases. Radiographs were evaluated to detect the involvement of both lung fields by the infective process. The following features werenoted:

1. Zonal distribution of the disease — upper, middle, lower or diffuse involvement
2. Predominant pattern of disease — reticular, nodular, reticulo-nodular, alveolar opacities,cystic lesion and / or bronchiectaticchange.
3. Volume of lungfields
4. Presence of pleuraleffusion/thickening
5. Presence/Absence oflymphadenopathy
6. Associated abnormality like the presence of cardiomegaly and mediastinaland /or hilar lymphadenopathy.

(b) Computed Tomography of thechest

Non contrast / Contrast enhanced spiral axial computed tomographic scans of the chest were obtained in each patient on the Siemens Somatom scope 16 Slice Dual core CT scanner. Patients

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were instructed to come after overnight fasting on the day of examination, Images were obtained using helical data acquisition with 2 mm section using a pitch of 1-1.5 mm in a caudocranial direction after giving bolus intravenous contrast agent(ml/kg of iodinated contrast). Non ionic contrast was used wherever indicated. Patients were asked to inspire fully and hold their breath while the data acquisition was completed. Images were evaluated on both mediastinal and lung windowsettings.

(c) High Resolution Computed tomographyscans

High resolution sequential axial scans of the chest with 1mm collimation at a scan interval of 5 mm in full inspiration were obtained in each patient.

The following features of the lung involvement by the lower respiratory tract infectious process were evaluated:

1. Zonal distribution of the disease — upper, middle, lower or diffuse involvement.
2. Predominant pattern of disease — reticular, nodular, reticulonodular alveolar opacities, cystic lesion and / or bronchiectaticchange.
3. Bronchiolar disease with centrilobular nodules and tree-in-budpattern
4. Bronchiolar disease with ground glass haze and mosaicattenuation.
5. Volume of lungfields
6. Presence and type of septalthickening
7. Presence and distribution of honey combing and its associated findings — traction bronchiectasis and conglomerate fibrosis.
8. Presence of pleural effusion Ithickening
9. Associated abnormality like the presence of cardiomegaly and mediastinaland or hilar lymphadenopathy.

Expiratory scans

High resolution end-expiratory scans were obtained wherever appropriate. Bore expiratory scanning, breathing instructions were given to all subjects. The following findings were noted:

1. Presence of airtrapping
2. Extent and distribution of airtrapping.

The HRCT findings were correlated in each case with the clinical profile and relevant laboratory investigations to arrive at the diagnosis.

3. Results

Fifty-five patients with clinically suspected diagnosis of lower respiratory tract infection (LRTI) underwent plain radiography of the chest followed by computed tomography. Of the 55 patients evaluated 50 patients were finally proven to have LRTI while 4 patients had a normal chest radiograph and HRCT and 1 patient had interstitial lung disease.

Table 1 shows the distribution of cases of LRTI based on final diagnosis

Distribution of Cases (n=50)

Type of infection	**Number**	**Percentage**
Mycobacterial Infection	23	46%

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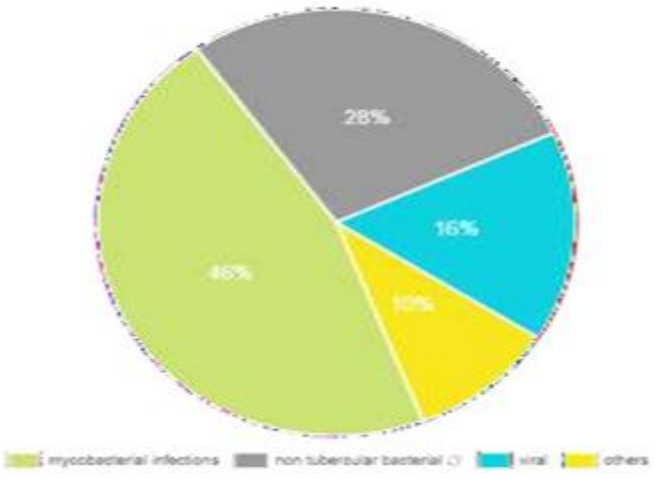
Non-Tubercular Bacterial Infections	14	28%
Gram positive organism infection	10	20%
Gram negative organism infection	2	4%
Anaerobic infections	1	2%
Mycoplasma	1	2%
Viral infection	**8**	**16%**
Fungal Infection	5	10%
Pneumocystics Jiroveci	1	2%
Aspergillus infection	4	8%

FIGURE 1: Diagrammatic representation of sample size as per etiology



Mycobacterial infection formed the largest group with 23 out of 50 cases constituting approximately 46% of the total patientgroup.Non tubercular bacterial infections were the second

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commonest cause of LRTI seen in 14/15 patients(23.6%) and Viral infections accounted for 16% and fungal infections for 10% of the total cases.

Figure 2: HRCT scans of the lung reveal multiple centrilobular

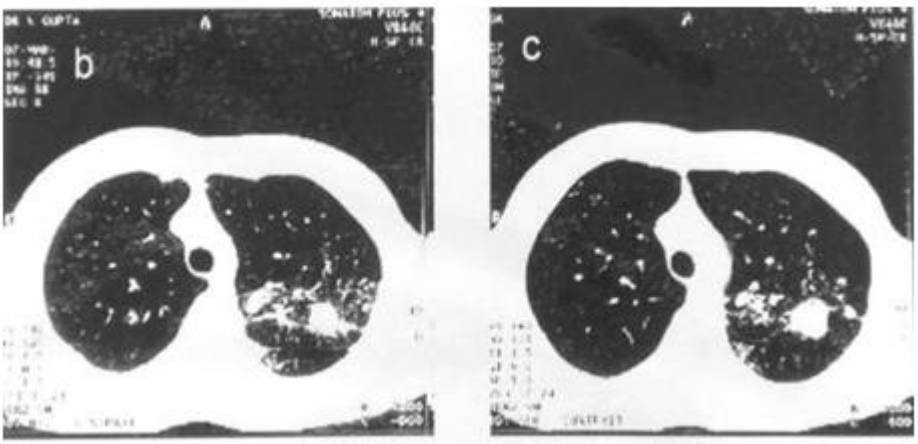

Fig 2 (b,c) HRCT scans of the lung reveal multiple centrilobular nodules in apicoposterior segment of left upper lobe with peribronchial thickening. A nodular area of consolidation is also seen in posterior segment in this sputum positive case of tuberculosis.

Table 2:CLINICAL FEATURES IN PATIENTS WITH LRTI INFECTIONS (n=50)

Clinical features	**Mycobacterium infection (23)**		**Non- tubercular bacterial infection (14)**				Viral infection (8)		Fungal Infection (5)	
			Pyogenic (13)		**Mycoplasma (1)**					
	No	%	No.	%	No.	%	No.	%	No.	%
Fever	18	78.2%	12	92.3%	1	100%	8	100%	-	-
Cough	8									
Dry Cough		34.7%	1	7.6%	1	100%	4	50%	2	40%
	12									
Productive cough		52.1%	11	84.6%		-	4	50%	-	-
	4				-					
Hemoptysis										

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		17.3%	2	15.3%	-	-	-	-	2	40%
Dyspnea	7	30.4%	7	53.8%	-	-	2	25%	1	20%
Wheezing	1	4.3%	2	15.3%	1	100%`	4	50%	1	20%

Cough was the most common presentation seen in association with all types of infection . Productive/ dry cough was a presentation in 43 out of 50 LRTI patients (86%). Productive cough was commoner with tubercular/ pyogenic bacterial infection whereas nonproductive was more commonly seen in association with mycoplasma, viral and fungalinfection.Fever was the second most common symptom seen in 39/50 patients(78%).Hemoptysis was present in 8 patients of LRTI 16%, at the time ofpresentation.Audible wheeze was the least common presentation in LRTI, seen in only 9 out of 50 cases (18%) of which 4 causes where of viraletiology.

FIGURE 3: Clinical presentations in Mycobacterial infection{n-23}

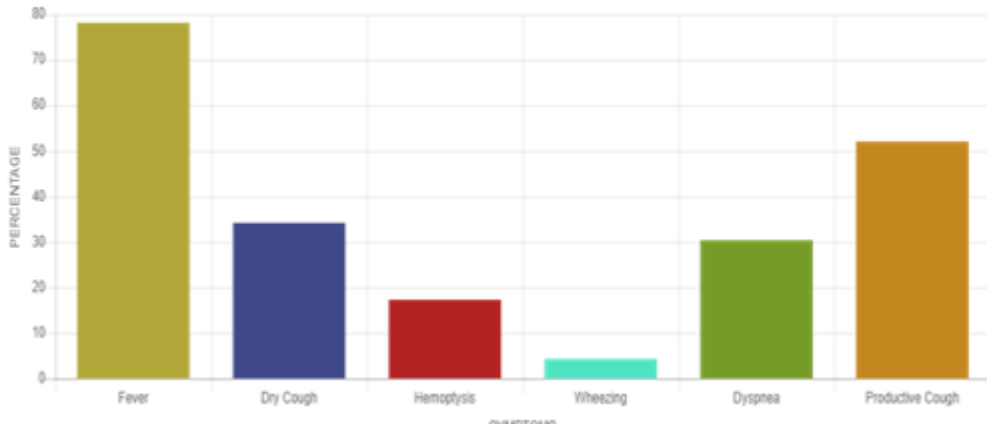

FIGURE 4: Clinical presentations in Non-Tubercular Bacterial infection{n-14}

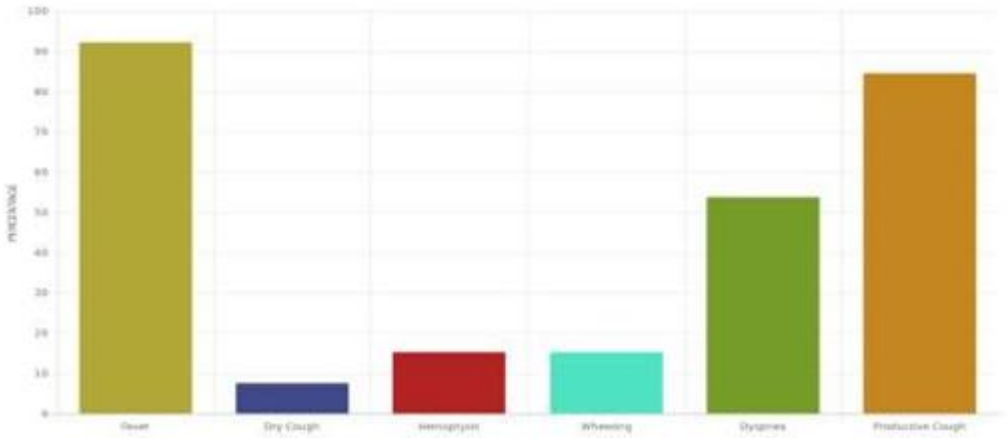

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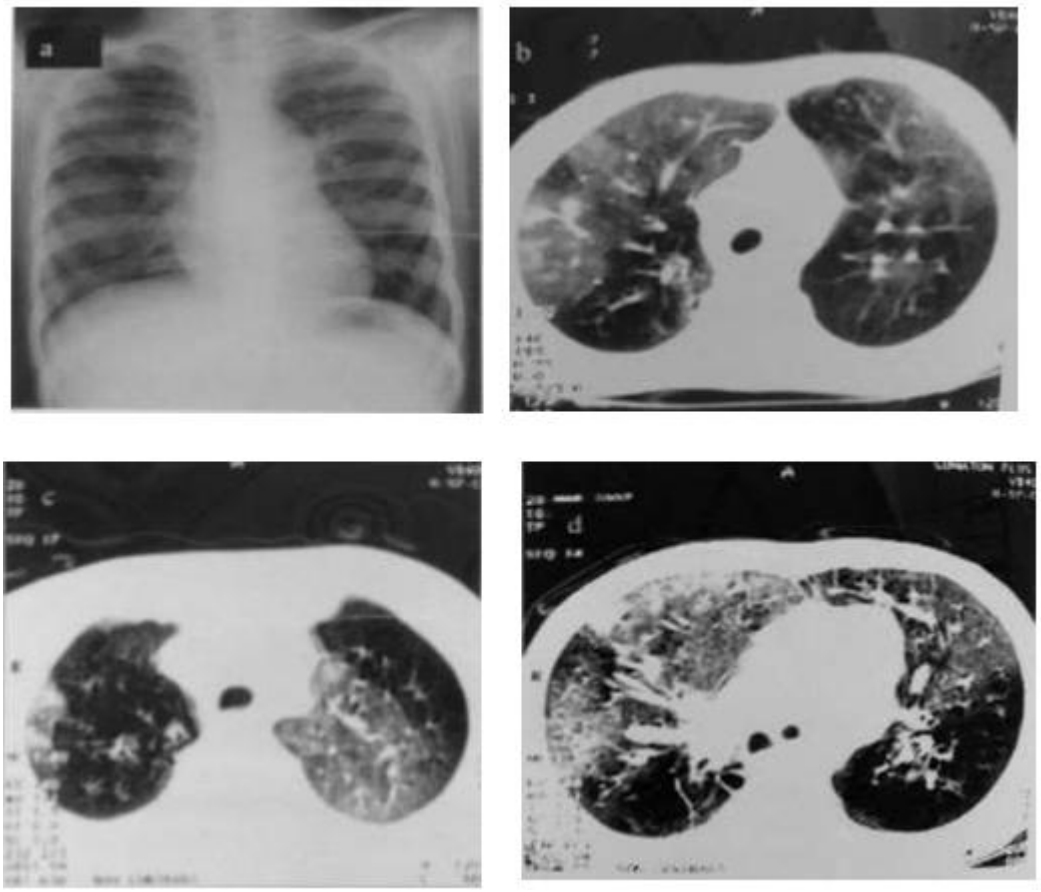
Fig 5: Known case of cystic fibrosis with superimposed Pseudomonas infection.



(a) Chest radiograph shows few lucencies in right middle zone suggestive of bronchiectasis Cardiomegaly with right atrial enlargement and pulmonary artery segment prominence seen. (b-d) conventional and HRCT scans reveal patchy ground glass opacification bilaterally with bronchiectasis.

Table 3: CHEST RADIOGRAPH FINDINGS IN VIRAL LRTI (n=8)

Chest radiograph findings*	**No. of patients**	**Percentage**
Predominant pattern		
- **Lobularconsolidation**	1	12.5%
- **Lobularconsolidation**	2	25%
- **Nodular**	-	
- **Reticulonodular**	2	25%

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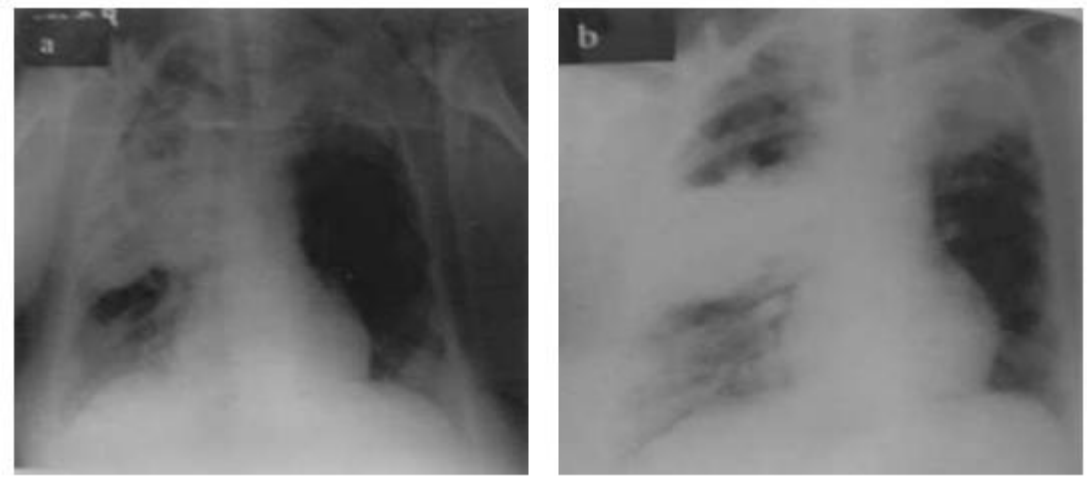
- **Reticular**	2	25%
Predominant zone - **UZ** - **MZ** - **LZ**	- 4 5	 50% 62%
Cavitation	-	-
Bronchiectasis	2**	25%
Volume loss	-	
Lymphadenopathy	-	-
Pleural Effusion	1	12.5%
No significant abnormality	1	12.5%

*Many patients showed multiple findings on chest radiography
**Both patients had evidence of bronchiectasis on 3-5 yrs old previous radiographs also.

Reticulonodular, reticular and multifocal lobular consolidations were observed with equal frequency, each seen in 25% of patients (2 cases) with viralLRTI.Most common zone involved in viral infections was middle/ lowerzone.Lobar consolidation was an uncommon finding seen in only 12.5% (1 case) of patients.Cavitation, volume loss and lymphadenopathy were not seen in any of the cases.One out of 8 cases of viral LRTI had no abnormality on chest radiograph but showed abnormalities onHRCT

Fig 3 Serial chest radiographs in a diabetic patient.



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(a) & (b) Demonstrates right upper lobe consolidation with exudative expansion of the lobe causing bulging of horizontalfissure.

Table 4:CHEST RADIOGRAPH FINDINGS IN FUNGAL LRTI (n=5)

Chest radiograph findings	**No. of patients**	**Percentage**
Predominant pattern		
- **Lobularconsolidation**	2	40%
- **Lobularconsolidation**	1	20%
- **Nodular**	-	
- **Reticulonodular**	-	
- **Reticular**	1	20%
Predominant zone		
- **UZ**	3	60%
- **MZ**	3	60%
- **LZ**	-	
Cavitation	1	20%
Bronchiectasis	1	20%
Volume loss	1	20%
Lymphadenopathy	-	-
Pleural Effusion	-	-
No significant abnormality	1	20%

- Confluent lobar consolidation and multifocal lobular consolidation were the most chest radiographic patters observed, seen in 3 out of 5 cases together constituting 60% of total patients with fungalLRTI.
- Upper and middle zone involvement was equally common seen in 3 out of 5 cases (60%), of fungalinfections.
- Cavitations, reticular pattern and volume loss was seen in one patient each(20%) with fungalinfection.

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4. Discussion

The present study was undertaken to detect and characterize high resolution computed tomography patterns of tower respiratory tract infections (LRTI), in our hospital. Fifty five patients with clinical suspicion of LRTI and referred for chest computed tomography were included in thestudy.Fifty out of 55 patients showed features suggestive of lower respiratory tract infection on HRCT. The diagnosis was established based on the clinical profile, laboratory investigations and imaging findings.Mycobacterial infection the largest group in our study consisted of 23150 cases. %). Nontubercular bacteria infection was the second largest group in this study comprisingof14cases(28%).ViralandfungalLRTIwasseenin8(16%)and5(10%) patients respectively.Our findings are similar to those of Sherwani et al (2005) who also reported tuberculosis as the most common etiology among infectious causes of opacities on chest radiograph followed by pyogenic infections. [12-14]

In a survey of community-acquired pneumonia in adults in British hospitals62 and another study by Griliner et al63however, report pyogenic bacterial infection as the most important cause of LRTI. The above studies reflect commoner occurrence of pyogenic infections in comparison to tuberculosis in western world.Our findings are similar to those of Philippart (2006) who stated that LRTI is suggested by clinical signs i.e. cough and sputum associated with fever. [15] However, clinical as well as radiographic signs cannot reliably identify the etiology. Wheezing was seen in 50% of patients of viral infections in our study as opposed to 4% of bacterial infections . These findings are in agreement with those of Michelow et al (2004) who also reported wheezing to be commoner with viral and atypical infections.[16]

The most common cause of hemoptysis was mycobacterial infection 4/8 cases (50%). These findings were similar to that of Stebbings et al who reported pulmonary tuberculosis and post-tuberculous bronchiectasis as the most common causes of haemoptysis.[17] In the present study raised total leukocyte count was the most common but Nonspecific laboratory abnormality, seen in 52.6% ofpatients.These findings are similar to those of Mictielow et at (2004) who also observed that the type of infection was not related to total leukocyte count. Sputum examination in our study was positive in 43.4% patients with mycobacterial bacterial infection and 53.4% of pyogenic infection.Our findings are similar to a study at DOTS centre in which they found that sputum positive cases constitute 46.23% of total cases of pulmonary tuberculosis and Sabira et al who found that sputum samples were accurate in only 52.3 percent of patients with community acquired pneumonia (CAP). Centrilobular nodules were less commonly observed seen in only 2 out of 8 patients. Tree-in-bud pattern was seen in one of the patients. Lower lobe involvement was most commonly observed seen in 5 out of 8 patients of viral infections. Marked bronchial wall thickening and ground glass opacity were noted in 1patient.[18,19]

Present study also included a patient of CRF on dialysis with viral pneumonia showing extensive areas of ground glass opacities bilaterally.These findings were similar to those reported by Kang et al and Kim et al (2002) who also reported ground-glass attenuation, nodules, consolidation and irregular linear attenuation in patients of CMV pneumonia.[20]Our study also concurs with those of Jane et al in 2000 who described ground glass opacities, bronchial dilatation, bronchial wall thickening, bronchial wall dilatation, and tree in bud appearance in lung transplant patients with RSV infection.

In fungal infections most common HRCT patterns observed with fungal infections were centrilobular nodules & ground glass opacity seen in 60% and40% of patients respectively Lobar and multifocal lobular consolidation was the second most common pattern each seen in one out of five patients. Upper lobe involvement was most commonly observed seen in 60 % of patients.

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[21,22]Bronchiectasis was noted in one out of five of patients of fungal infection seen in the case with ASPA with cystic dilatation of airway and mucus plugging resulting in bronchoceles formation. In addition centrilobular nodules and peribronchial thickening wasnoted.Our findings were similar those observed by Panchal et al in their study of 23 patients with ABPA; central bronchiectasis could be identified in 85% of lobes and 52% of lung segments. Central bronchiectasis occurred in association with bronchial occlusion due to mucous plugging, air fluid levels in dilated, cystic airways and bronchial wall thickening. Central bronchiectasis was seen in 95% of patients, mucous plugging in 67 % and centrilobular nodules were seen in 93% ofcases.In our study case with pneumocystis pneumonia showed findings of ground glass haze, patchy areas of consolidation and centrilobular nodules, which are in agreement with those of Bergin et al in a study of 14 patients of pneumocystis pneumonia. The study showed predominant HRCT finding of ground glass opacity or consolidation or both.In another study by Hartmann et al reported similar CT findings in PCP pneumonia patients including ground glass opacity (92%), patchy areas of consolidation(38%) and centrilobular nodules(25%), cystic change (33%), pleural effusion (17%), and lymphadenopathy in 25% cases.[23]
HRCT scans of a patient with angioinvasive aspergillosis in our study showedlarge areas of consolidation with cavitations and volume loss. Multiple nodular opacities were seen with surrounding ground glass attenuation. These finding were consistent with those described who described characteristic CT finding in angioinvasive aspergillosis consist of nodules surrounded by a halo of ground glass attenuation ("halo sign") or pleura-based, wedge- shaped areas of consolidation.Observed that cavitation were common in cases of angioinvasive aspergillosis and were sometimes manifested by air cresent.[24]

5. CONCLUSION

Lower respiratory tract infections showed no obvious age predilection. LRTI were found to be nearly uniformly distributed among all agegroups.Mycobacterial infections were the most common group followed by non- tubercular pyogenicinfections.aboratory investigations including raised total leukocyte count observed in association with all etiological groups was also nonspecific. Sputum examination was conclusive in only half of thecases.Consolidation (lobar I lobular) was the most common chest radiographic pattern observed in mycobacterial, pyogenic and fungal LRTI. Reticulonodular, reticular and multifocal lobular consolidations were observed in viralLRTI.In fungal infections most common HRCT patterns observed with fungal infections were centrilobular nodules & patchy ground glassopacity.The present study concludes that high resolution computed tomography is an invaluable tool in defining the imaging features of lower respiratory tract infection and characterization of the disease based on variouspatterns.
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Ethical approval: The study was approved by the Institutional Ethics Committee

Conflict of interest
The authors declare no conflict of interest.

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