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Original Research Article

Determining the Spectrum of High-Resolution Computed Tomography Chest Findings in Patients Diagnosed with COVID 19

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Abstract

Aim: COVID-19: Range of high-resolution computed tomography chest findings in DMCH, Darbhanga.

Material and Methods: This study was conducted in the department of Radiology, Katihar Medical college and Hospital, Katihar, Bihar, India for one year. 40 patients aged 22 to 83 years who were tested positive for COVID-19 by RT-PCR along with simultaneous conduction of HRCT chest in Radiology Department. These patients presented in either outpatient or emergency with symptoms of fever, cough/sore throat, or shortness of breath. PCR negative patients with positive HRCT chest findings for COVID-19 were excluded. All images were taken on 128 slice CT scanner with patient in supine position and scanning done from lung apices to costo-phrenic angles. The main scanning parameters were 120 KVP, 450 mAs, pitch 1.4, FOV of 406 mm and slice thickness of 1mm. CT was done without contrast. Images were sent to workstation and picture archiving and communication systems (PACS).

Results: The most frequent finding on HRCT chest was combined GGO and consolidation 19(47.5%) with posterior and sub-pleural distribution 37(92.5%). Bilaterality was seen in 37(92.5%) while one (2.5%) had unilateral finding. Associated findings were lymphadenopathy 11(27.5%), pleural effusion 6(15.0%), bronchiectasis 5(12.5%) and emphysema 2(5.0%). Among two patients of early stage (0-2 days), one had normal HRCT, while other had GGO alone. Consolidation, crazy-paving and vascular enlargement were absent. Of nine patients of progressive stage (3-5 days), combined GGO and consolidation 4(44.4%) and GGO alone 3(33.3%) were seen. During late stage (6-12 days), among 29 patients, combined GGO and consolidation 15(51.7%), sub-pleural lines/bands 14(48.3%), vascular enlargement 13(44.8%) and crazy paving pattern 11(37.9%) were noted.

Conclusion: HRCT chest evolving characteristics are effective in understanding variation in pattern of coronavirus disease. Identification of imaging patterns with respect to infection time course is an effective paramount for disease diagnosis, understanding progression and potential complications of disease.

Keywords: COVID-19, High Resolution Computed tomography (HRCT), CT Severity Score (CT-SS), Ground Glass Opacity (GGO)

Introduction

COVID-19, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has presented a wide array of clinical manifestations, among which respiratory involvement is the most significant. High-resolution computed tomography (HRCT) of the chest has become a crucial tool in the diagnosis, management, and follow-up of COVID-19 pneumonia due to its ability to detect subtle lung abnormalities early in the course of the disease. The range of HRCT findings in COVID-19 pneumonia is diverse and often correlates with the disease's severity and progression. [1-3] One of the hallmark features of COVID-19 pneumonia on HRCT is the presence of ground-glass opacities (GGO), which are typically bilateral and predominantly distributed in the peripheral and lower lung zones. These opacities represent a partial filling of air spaces in the lungs and are an early indication of viral pneumonia. In more advanced stages, these GGOs may progress to consolidation, indicating a denser filling of the lung parenchyma and suggesting more severe inflammation or secondary bacterial infection. Another frequent finding on HRCT in COVID-19 patients is the "crazy-paving" pattern, which refers to the presence of thickened interlobular septa and intralobular lines superimposed on a background of GGO. [4-8] This pattern suggests a combination of alveolar oedema and interstitial inflammation. Additionally, the "reverse halo" sign, characterized by a central GGO

surrounded by a denser consolidation, has also been reported in some COVID-19 patients, although it is less common. Pleural effusions and lymphadenopathy are relatively rare in COVID-19 pneumonia and, when present, may indicate a more severe disease course or the presence of a co-infection or other complications. Fibrotic changes, such as reticular opacities and traction bronchiectasis, may be observed in the later stages of the disease or in patients with prolonged illness, suggesting the potential for long-term pulmonary sequelae. [9-12] Overall, HRCT findings in COVID-19 are varied and can provide valuable insights into the severity and stage of the disease. Early detection and monitoring of these imaging features are critical for the timely management of patients, potentially improving outcomes and reducing mortality.

Material and Methods

This study was conducted in the department of Radiology, Katihar Medical college and Hospital, Katihar, Bihar, India for one year. 40 patients aged 22 to 83 years who were tested positive for COVID-19 by RT-PCR along with simultaneous conduction of HRCT chest in Radiology Department. These patients presented in either outpatient or emergency with symptoms of fever, cough/sore throat, or shortness of breath. PCR negative patients with positive HRCT chest findings for COVID-19 were excluded. All images were taken on 128 slice CT scanner with patient in supine position and scanning done from lung apices to Costo-phrenic angles. The main scanning parameters were 120 KVP, 450 mAs, pitch 1.4, FOV of 406 mm and slice thickness of 1mm. CT was done without contrast. Images were sent to workstation and picture archiving and communication systems (PACS). Two radiologists with seven and nine years of experience respectively reviewed all HRCT Chest images and described the findings as unilateral or bilateral ; pattern of involvement as GGO alone, combined GGO with consolidation, consolidation alone, crazy paving pattern, vascular enlargement, round opacity, reverse halo, sub-pleural lines/bands; segments and lobes involved; distribution as sub pleural/ peripheral, anterior or posterior, perihilar/ central, broncho vascular or diffuse. [11] Associated findings as emphysema, bronchiectasis, pleural effusion or lymphadenopathy were noted. Time between onset of symptoms and CT conduction was determined and patients were divided into early (0-2 days), progressive (3-5 days) or late (6-12 days) stage of disease. [12] According to WHO clinical classification, patients were divided into mild, moderate, severe or critical stages. Mild patients had clinical symptoms without evidence of viral pneumonia or hypoxia. Moderate disease had clinical signs of pneumonia with respiratory rate <30 breaths / minutes and oxygen saturation >90%. Severe cases have clinical signs of pneumonia with respiratory rate >30 breaths / min and oxygen saturation <90%. Critical cases have septic shock, acute respiratory distress syndrome or needs mechanical ventilation. [13,14] For sake of convenience, mild and moderate groups were merged while severe and critical cases were also combined into single group in this study. The CT-SS describes extent of involvement of 20 lung segments with 0: no parenchymal involvement, 1: <50% parenchymal involvement and 2: >50% parenchymal involvement. Total score is obtained by adding individual segments score ranging from 0 to 40. [15] The collected data was entered into SPSS 23 version and analysed. Quantitative variable including age and CT-SS were described as mean or standard deviation. Qualitative variables including clinical history, HRCT chest findings, lung lobes and segment involvement were described as frequency and percentages. CT-SS in mild and severe group were compared. ROC curve was drawn with threshold value for severe disease determined along with calculation of area under the curve. The inter- rater reliability score between two radiologists was calculated.

Results

Out of total 40 patients, 22(55%) were males and 18(45%) were females. Age ranged from 22 to 83 years with mean age of 50 years±14 years. Fever was seen in 39(97.5%), cough in 27(67.5%) and shortness of breath in 24(60%) patients. Diabetes and hypertension were the major comorbidities 5(12.5%) (Table-I).

Table I: Demographic and Clinical features of COVID-19.

Age groups	**Frequency**
20-40y	11(27.5%)
41-60y	22(55%)
61-80y	6(15%)
>80y	1(2.5%)
Symptoms	
Fever	39(97.5%)
Cough	27(67.5%)
Sputum	1(2.5%)
Loss of taste or smell	8 (20%)
Shortness of breath	24(60%)

Respiratory rate	
<30	17(42.5%)
>30	23(57.5%)
Oxygen Saturation	
>93%	18(45%)
<93%	22(55%)
Comorbidities	
Diabetes & Hypertension	5(12.5%)
Diabetes	4(10%)
Diabetes & Ischemic heart disease	3(7.5%)
Hypertension	3(7.5%)
Pancreatitis	1(2.5%)
Liver parenchymal disease	1(2.5%)

The most frequent finding on HRCT chest was combined GGO and consolidation 19(47.5%) with posterior and sub-pleural distribution 37(92.5%). Bilaterality was seen in 37(92.5%) while one (2.5%) had unilateral finding. Associated findings were lymphadenopathy 11(27.5%), pleural effusion 6(15.0%), bronchiectasis 5(12.5%) and emphysema 2(5.0%). Among two patients of early stage (0-2 days), one had normal HRCT, while other had GGO alone. Consolidation, crazy-paving and vascular enlargement were absent. Of nine patients of progressive stage (3-5 days), combined GGO and consolidation 4(44.4%) and GGO alone 3(33.3%) were seen. During late stage (6-12 days), among 29 patients, combined GGO and consolidation 15(51.7%), sub-pleural lines/bands 14(48.3%), vascular enlargement 13(44.8%) and crazy paving pattern 11(37.9%) were noted. The distribution of disease was posterior, sub-pleural in 29(100%), broncho vascular in 20(69.0%), peri-hilar in 13(44.8%) and diffuse in 6(20.7%) during late stage. (Table-II). Severity of COVID-19 was associated with GGO alone (p=0.05), GGO and consolidation (p=0.01), crazy paving (p=0.001), vascular enlargement (p=0.005) and lung segment scores (p≤0.05).

Table II: HRCT Chest findings of coronavirus disease according to duration of infection.

CT Findings		**Total N=40**	**Early (0-2 days) n=2**	**Progressive (3-5 days) n=9**	**Late (6-12days) n=29**
GGO alone		15 (37.5%)	1(50%)	3(33.3%)	11(37.9%)
Consolidation alone		6(15%)	0	1(11.1%)	5(17.2%)
GGO & consolidation		19(47.5%)	0	4(44.4%)	15(51.7%)
Pattern of consolidation	Air bronchogram	13(32.5%)	0	3(33.3%)	10(34.5%)
	Segmental	4(10%)	0	2(22.2%)	2(6.9%)
	Sub segmental	17(25%)	0	2(22.2%)	15(51.7%)
	Segmental & sub segmental	2(5%)	0	0	2(6.9%)
Crazy paving pattern		12(30%)	0	1(11%)	11(37.9%)
Sub-pleural lines/bands		14(35%)	0	0	14(48.3%)
Vascular enlargement		15(37.5%)	0	2(22.2%)	13(44.8%)
Round opacity		5(12.5%)	0	3(33.3%)	2(6.9%)
Reverse Halo		1(12.5%)	0	1(11.1%)	0
Distribution	Posterior	37(92.5%)	1(50%)	7(77.8%)	29(100%)
	Anterior	27(67.5%)	0	3(33.3%)	24(82.8%)
	Sub-pleural	37(92.5%)	1(50%)	7(77.8%)	29(100%)
	Central /perihilar	15(37.5%)	0	2(22.2%)	13(44.8%)
	Broncho-vascular	24(60%)	0	4(44.4%)	20(69%)
	Diffuse	8(20%)	0	2(22.2%)	6(20.7%)

Clinically, 24 patients (60%) were in severe group and 16(40%) in mild group. Frequency of lobe involvement was right lower lobe 37(92.5%), left lower lobe 35(87.5%), right upper lobe 32(80%), right middle lobe in 32(80%) and left upper lobe 31(77.5%). On evaluation of CT-SS, most frequently involved segment was lateral segment of left lower lobe 34/40(85%), posterior and medial segments of right lower lobe 33/40 (82.5%), posterior segment of left lower lobe 33/40 (82.5%). Total mean CT-SS was 20±11.5. Mean CT score of mild groups was 10±7.4 and severe group was 27±7.6 (Table-III).

Table III: CT-SS in mild & severe groups in different lung segments.

Right Lung			**Severity of COVID**				**Left Lung**		**Severity of COVID**				
			Mild/ Moderate	**Severe**	**Total**	**P-Value**			**Mild/ Moderate**	**Severe**	**Total**		p-value
UPPER LOBE	Apical Segment	0	16(40%)	5(12.5%)	21(52.5%)	0.01	Upper Lobe	Apical Segment	0	18(45%)	4(10%)	22(55%)	0.000
		1	4(10%)	9(22.5%)	13(32.5%)				1	2(5%)	14(35%)	16(40%)	
		2	0	6(15%)	6(15%)				2	0	2(5%)	2(5%)	
	Anterior Segment	0	13(32.5%)	1(2.5%)	14(35%)	0.000		Anterior Segment	0	14(35%)	1(2.5%)	15(37.5%)	0.000
		1	7(17.5%)	11(27.5%)	18(45%)				1	6(15%)	16(40%)	22(55%)	
		2	0	8(20%)	8(20%)				2	0(0%)	3(7.5%)	3(7.5%)	
	Posterior Segment	0	8(20%)	0(0%)	8(20%)	0.000		Posterior segment	0	12(30%)	0	12(30%)	0.000
		1	12(30%)	6(15%)	18(45%)				1	8(20%)	8(20%)	16(40%)	
		2	0	14(35%)	14(35%)				2	0	12(30%)	12(30%)	
MIDDLE LOBE	Medial segment	0	12(30%)	1(2.5%)	13(32.5%)	0.000		Superior lingula segment	0	14(35%)	3(7.5%)	17(42.5%)	0.01
		1	8(20%)	10(25%)	18(45%)				1	6(15%)	10(25%)	16(40%)	
		2	0	9(22.5%)	9(22.5%)				2	0	7(17.5%)	7(17.5%)	
	Lateral segment	0	12(30%)	2(5%)	14(35%)	0.000		Inferior lingula segment	0	11(27.5%)	2(5%)	13(32.5%)	0.000
		1	7(17.5%)	6(15%)	13(32.5%)				1	9(22.5%)	8(20%)	17(42.5%)	
		2	1(2.5%)	12(30%)	13(32.5%)				2	0	10(25%)	10(25%)	
LOBE LOWER	segment	0	8(20%)	0	8(20%)	0.000	LOBE LOWER	Superior segment	0	11(27.5%)	0	11(27.5%)	0..000
		1	11(27.5%)	8(20%)	19(47.5%)				1	8(20%)	10(25%)	18(45%)	
		2	1(2.5%)	12(30%)	13(32.5%)				2	1(2.5%)	10(25%)	11(27.5%)	
	Anterior segment	0	11(27.5%)	1(2.5%)	12(30%)	0.000		Anterior segment	0	11(27.5%)	1(2.5%)	12(30%)	0.000
		1	9(22.5%)	9(22.5%)	18(45%)				1	9(22.5%)	7(17.5%)	16(40%)	
		2	0	10(25%)	10(25%)				2	0	12(30%)	12(30%)	
	Lateral segment	0	9(22.5%)	0	9(22.5%)	0.000		Lateral segment	0	6(15%)	0	6(15%)	0.01
		1	10(25%)	6(15%)	16(40%)				1	11(27.5%)	6(15%)	17(42.5%)	
		2	1(2.5%)	14(35%)	15(37.5%)				2	3(7.5%)	14(35%)	17(42.5%)	
	Medial	0	7(17.5%)	0	7(17.5%)	0.02		Medial	0	11(27.5%)	1(2.5%)	12(30%)	0.000

	Segment	1	11(27.5%)	10(25%)	21(52.5%)			segment	1	8(20%)	7(17.5%)	15(37.5%)	
		2	2(5%)	10(25%)	12(30%)				2	1(2.5%)	12(30%)	13(32.5%)	
	Posterior Segment	0	7(17.5%)	0	7(17.5%)	0.000		Posterior segment	0	7(17.5%)	0	7(17.5%)	0.000
		1	11(27.5%)	6(15%)	17(42.5%)				1	10(25%)	5(12.5%)	15(37.5%)	
		2	2(5%)	14(35%)	16(40%)				2	3(7.5%)	15(37.5%)	18(45%)	

Discussion

As the COVID-19 is still prevailing worldwide with emergence of second, third and now fourth wave in most of the countries, it is mandatory to procure the reliable diagnostic services. Availability and timely utilization of these tools is essential for clinical experts so that early diagnosis and treatment strategies can be planned accordingly. HRCT is useful in understanding extent of damage to lungs due to coronavirus with sensitivity of 98% in contrast to RT-PCR sensitivity of 71%. [16] Present study showed mixed GGO and consolidation in 19(47.5%), GGO alone in 15(37.5%) and vascular enlargement in 15(37.5%) in sub-pleural posterior distribution (92.5%) as the predominant feature. The reason for GGO alone for being second prevalent feature is that majority of patients had CT done in late stage of disease when GGO alone is less frequently seen. Due to lack of awareness about the early utility of CT scan, very few patients were being imaged in less than two days' time. Song et al. described pure GGO in 77%, GGO with consolidation in 59% and pure consolidation in 51% with bilateral lung involvement (86%) in sub-pleural posterior distribution mainly in lower lungs. [17] Zhoa et al. reported GGO alone, combined GGO and consolidation and vascular enlargement in 87(86.1%), 65 (64.4%) and 72(71.3%) patients respectively. [18] HRCT findings were initially GGO alone (50%) which changed into combined GGO and consolidation (44.4%) in progressive stage in the current study. The unilateral findings in sub-pleural distribution at onset of symptoms changed into bilateral changes involving peri-hilar (44.8%), broncho vascular (69%) and diffuse (20.7%) distribution in late stage. [19] Zhou et al. described fever in 87%, cough in 56% and dyspnoea in 27% cases. He also reported GGO and reticular pattern (58%) along with GGO and consolidation in early progressive stage (1-7 days), while increase frequency of sub-pleural lines, fibrotic stripes, GGO and consolidation in advanced stage (8-14 days). [20] Bernheim et al. reported linear opacity, crazy paving and reverse halo in 20%, 20%, and 4% in late stage. Total 56% patients in early stage had normal CT without any GGO or consolidation. The most frequent lobe involvement was lower lobe(Right 65%, Left 63%)and left upper lobe in 48%. [12,21] Current study showed high frequency of sub segmental consolidation(51.7%) following air bronchogram consolidation (34.5%) in late stage .Zhou *et al* in another study in 62 patients in Wuhan ,China reported a significant difference in early and late phase CT findings of ground glass opacity (47% vs 27%),ground glass with reticular opacity (50% vs 86%) and air bronchogram (62% vs 90% respectively). [22] Yang et al. on analysis of ROC curve reported 19.5 as threshold value for severe disease with sensitivity of 83.3% and specificity of 94% (18.5 and 20.5 threshold value for two radiologists in current study). Posterior basal segment of lower lobe (right 81.4%, left 79.4%), left lateral basal segment (77.5%) were frequently involved segment. There was higher scoring in severe group than in mild group. Both these studies also shared more involvement of lower lobes than upper lobes in each group. [15] These scores in correlation with clinical symptoms helps in predicting clinical outcome and mortality rate at an early stage. [23]

Conclusion

HRCT chest evolving characteristics are effective in understanding variation in pattern of coronavirus disease. Identification of imaging patterns with respect to infection time course is an effective paramount for disease diagnosis, understanding progression and potential complications of disease. CT-SS plays an important role in predicting disease severity, prognosis and clinical outcome. We recommend that early HRCT chest scan will leads to better diagnosis and management of COVID-19 patients.

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