ORIGINAL RESEARCH ARTICLE

Role of High Resolution Computed Tomography (HRCT) Chest in Evaluation of Covid-19

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DOI: http://dx.doi.org/10.21276/ijcmsr.2021.6.3.3

How to cite this article: S. Asma Kousar, B.E. Panil Kumar, Balathimmaiah. Role of high resolution computed tomography (HRCT) chest in evaluation of Covid-19. International Journal of Contemporary Medicine Surgery and Radiology. 2021;6 (3):C9-C15.

A B S T R A C T

Introduction: The accurate diagnosis of viral pneumonia based on chest CT may indicate isolation and plays an important role in management of patients with suspected COVID-19 infection. Study aimed to evaluate the diagnostic accuracy of HRCT Chest in COVID19 and to investigate the imaging manifestations of corona virus disease.

Material and methods: This study was carried out over a period of 6 months from June 2020 to November 2020 in 915 patients with symptoms of COVID 19 who underwent HRCT Chest at Department of Radiodiagnosis,SRMC & GH,Nandyal. Patients who met the inclusion / exclusion criteria were included in the study.

Results: In our retrospective study of 915 patients,HRCT Chest examination had been performed .CT findings of COVID 19 were diagnosed in 740 patients.CT findings were positive for COVID 19 in 46 of 122 RT PCR negative patients.CT findings were positive for COVID 19 before laboratory results were positive for viral infection in 14 of 53 patients.Out of 740 patients positive for CT findings of COVID 19,580 patients have both ground glass opacities and patchy consolidation,120 patients have ground glass opacities without patchy consolidation,40 patients have patchy consolidation without ground glass opacities ,200 patients have absence of both ground glass opacities and patchy consolidation,185 patients have crazy paving pattern.

Conclusion: Chest CT had a low rate of missed diagnosis of COVID-19 and may be useful as a standard method for the rapid diagnosis of COVID-19 to optimize the management of patients.With CT diagnosis of viral pneumonia, patients with suspected disease can be isolated and treated in time so that the management of patients will be optimized, especially for the hospitals or communities lacking nucleic acid testing kits.

Keywords: Covid-19, High Resolution Computed Tomography (HRCT) Chest, Ground Glass Opacity, Consolidation.

INTRODUCTION

In December 2019, a large outbreak of a novel corona virus infection occurred in Wuhan, Hubei Province, China[1]. In humans, corona viruses are among the spectrum of viruses that cause the common cold as well as more severe respiratory diseases specifically, Severe acute respiratory syndrome (SARS)and Middle East respiratory syndrome (MERS), which have mortality rates of 10% and 37%, respectively; both SARS and MERS are zoonotic infections. The novel corona virus that was named severe acute respiratory syndrome corona-virus 2 (SARS-CoV-2) by the International Committee on Taxonomy of Viruses caused a pneumonia outbreak in China.The disease caused by the virus, named corona virus disease (COVID-19) by the World Health Organization (WHO), can be spread through human-to-human contact. On January 30,2020, the WHO declared a global public health emergency against the outbreak of COVID-19. As of February 19, 2020, several cases of COVID-19 had been confirmed in 24 other countries including Thailand, Australia, and the United States. This episode shows the need for rapid and accurate detection and identification methods that can be used in local hospitals and clinics responsible for the diagnosis of COVID-19 and management for patients.

Viral nucleic acid testing is playing an indispensable role in helping to prevent the spread of the COVID-19 epidemic. However, nucleic acid testing has rigorous laboratory specifications and requires a long time before results are available. In addition, some patients with suspected COVID-19 may have initial nucleic acid test results that are false-negative for virus infection, which is harmful for the control of infectious disease.The accurate diagnosis of viral pneumonia based on chest CT may indicate isolation and plays an important role in the management of patients with suspected SARS- CoV-2 infection, especially when there are no scientifically proven therapies for the treatment of COVID-19.

Study aimed to evaluate the diagnostic accuracy of HRCT

ISSN (Online): 2565-4810; (Print): 2565-4802 | ICV 2019: 98.48 |

Chest in COVID19 and to investigate the imaging manifestations of corona virus disease.

MATERIAL AND METHODS

This hospital based retrospective study was carried out over a period of 6 months from June 2020 to November 2020 in 915 patients with symptoms of COVID 19 who underwent HRCT Chest at Department of Radiodiagnosis at Santhiram medical college and general hospital, Nandyal.

Inclusion criteria

1. Patient willing to participate in the study and willing to give written and informed consent.
2. Proved COVID 19 patients (RT PCR Positive)
3. Patients with symptoms of suspected COVID 19
4. Patients with high clinical or initial radiological suspicion of COVID-19 e.g., fever, cough ,shortness of breath, dependent on O2 and non specific patchy shadowing on chest X ray.

Exclusion criteria

1. Patient not willing to participate in the study and not willing to give written and informed consent.
2. Patients with interstitial lung disease.
3. Patients aged <10 years .

Method of study:

CT equipment-SIEMENS 32 slice SOMATOM SCOPE CT VC 40, H-SP spiral CT machine used in the study.

The amount of time between the initial appearance of patient symptoms (eg, fever, cough) and the date of both the first positive real-time RT-PCR test as well as the date of the initial chest CT examination was noted for each patient. If the time between the first clinical symptom and CT was 2 days or less, the patient was considered to have been imaged in the early phase of illness. If the time between symptom onset and CT was between 3 and 5 days, the patient was considered to have been imaged in the intermediate phase of illness. If the time between symptom onset and CT was between 6 and 12 days, the patient was considered to have been imaged in the late phase of illness[2].

For each patient Chest CT was evaluated for the following characteristics[2]:

a.) Presence of Ground glass opacities (Fig 1) with or without crazy paving pattern (Fig 2)
b.) Presence of patchy areas of consolidation (Fig 3)
c.) Laterality of Ground glass opacities and Consolidation
d.) Number of lobes affected
e.) Degree of involvement of each lung lobe measured by CT severity score
f.) Presence of nodules
g.) Presence of pleural effusion (Fig 4)
h.) Presence of mediastinal lymphadenopathy
i.) Airway abnormalities (bronchial wall thickening, bronchectasis, endolumial secretions) (Fig 5)
j.) Presence of vascular dilatation (Fig 6)
k.) Presence of underlying lung disease such as Emphysema,fibrosis
l.) Other abnormalities include-linear opacities/subpleural bands (Fig 7) ,opacities with halo sign (Fig 8) or reverse halo sign (Fig 9),lobar consolidation (Fig 10) opacities with intralesional cavitation

For each patient CORADS SCORE was given.CORADS SCORING[3] includes

CORADS	Level of suspicion for COVID 19	Summary
0	Not interpretable	Scan technically insufficient for assigning a score
1	Very low	Normal /non infectious
2	Low	Typical for other infection but not COVID-19
3	Equivocal /Unsure	Features compatible with COVID-19 but also other disease
4	High	Suspicious for COVID-19
5	Very high	Typical for COVID-19
6	Proven	RT PCR +ve For SARS-CoV -2

For each patient, according to the anatomic structure, the 18 segments of both lungs were divided into 20 regions, in which the posterior apical segment of the left upper lobe was subdivided into apical and posterior segmental regions, whereas the anteromedial basal segment of the left lower lobe was subdivided into anterior and basal segmental regions. The lung opacities in all of the 20 lung regions were subjectively evaluated on chest CT images using a system attributing scores of 0, 1, and 2 if parenchymal opacification involved 0%, less than 50%, or equal to or more than 50% of each region, respectively. The CT-SS was defined as the sum of the individual scores in the 20 lung segment regions, which may range from 0 to 40 points[4] .The CT severity score graded as score of less than 20 as Mild , more than 20 as Severe.

RESULTS

In our retrospective study of 915 patients; the majority of the patients lies between 30-70 yrs (Table 1). Among 580 (63%) Male, 335 (36%) female patients, HRCT Chest examination had been performed (Table 2). CT findings of COVID 19 were diagnosed in 740 patients. CT findings were positive for COVID 19 in 46 of 122 RT PCR negative patients. CT findings were positive for COVID 19 before laboratory results were positive for viral infection in 14 of 53 patients (Table 3 and Table 4).

Out of 740 patients positive for CT findings of COVID 19,580 patients have both ground glass opacities and patchy consolidation,100 patients have ground glass opacities without patchy consolidation,40 patients have patchy consolidation without ground glass opacities ,200 patients have absence of both ground glass opacities and patchy consolidation,10 patients have lobar consolidation ,185 patients have crazy paving pattern (Table 5).

In our study most of the patients are CORADS 6 with 150 patients having CTSS of 0-10, 240 patients having CTSS of 11-20, 250 patients having CTSS of 21-30, 100 patients

Age (years)	Number of patients	Percentage
10-20	20	2.1%
21-30	64	6.9%
31-40	181	19.7%
41-50	185	20.2%
51-60	189	20.6%
61-70	196	21.4%
>70	80	8.7%
Total	915	100%

Table-1: Distribution of Age.

Sex	Number of patients	Percentage
Male	580	63.3%
Female	335	36.6%
Total	915	100%

Table-2: Distribution of Sex

RT PCR	Number of patients	Percentage
Positive	720	78.6%
Negative	141	15.4%
Test not done	54	5.9%

Table-3: RT PCR test

RT PCR	CT Findings of COVID 19	
	Present	Absent
Positive (720)	680	40
Negative (122)	46	76
Not done (53)	14	39

Table-4: Presence and Absence of CT Findings of COVID 19

Pattern	Number of patients
Ground glass opacities without patchy consolidation	100
Patchy Consolidation without ground glass opacities	40
Presence of Ground glass opacity +Patchy Consolidation	580
Absence of Ground glass opacity +Patchy Consolidation	200
Lobar consolidation	10
Crazy paving pattern	185

Table-5: Distribution of CT pattern of COVID 19 Disease

CORADS	Number of patients	Percentage
6	740	80%
5	60	6.5%
4	20	2.1%
3	10	1%
2	14	1.5%
1	71	7.7%

Table-6: Distribution of CORADS Score

CTSS	Number of patients	Percentage
0-10	150	20.2%
11-20	240	32.4%
21-30	250	33.7%
31-40	100	13.5%
Total	740	100%

Table-7: Distribution of CT Severity Score

Clinical Findings	Number of patients
Fever	750
Fatigue	600
Dry cough	700
Dyspnoea	600
Copious sputum	18
Sore throat	25

Table-8: Distribution of Clinical Symptoms

Lung involvement	Number of patients	Percentage
Unilateral	110	14.8%
Bilateral	630	85.1%

Table-9: Distribution of Lung involvement

Lobe involved	Number of patients	Percentage
Upper lobe	100	12.8%
Middle lobe	60	7.6%
Lower lobe	320	41%
Multilobar	300	38%

Table-10: Distribution of involvement of lung lobes

Lung Zone	Number of patients	Percentage
Peripheral zone predominance	580	78.3%
Central zone predominance	50	6.7%
Both Peripheral and central zone	110	14.8%

Table-11: Distribution of involvement of Lung Zones

Other Findings	Number of patients	Percentage
Pleural effusion	50	6.4%
Halo sign	4	0.5%
Reverse halo sign	5	0.6%
Emphysema	45	5.7%
Bronchectasis	39	5%
Fibrosis	96	12.3%
Mediastinal lymphadenopathy	42	5.3%

Table-12: Other findings

Clinical Outcome	Number of patients	Percentage
Discharged	209	28.2%
In admission	461	62.6%
Died	30	4.0%
Transferred to another hospital	40	5.4%

Table-13: Distribution of Clinical outcome at the end of study

ISSN (Online): 2565-4810; (Print): 2565-4802 | ICV 2019: 98.48 |

Figure-1: Axial HRCT image showing multifocal ,bilateral ground glass opacities

Figure-2: Axial HRCT image showing diffuse ground glass attenuation with superimposed interlobular septal thickening (Crazy Paving Pattern)

Figure-2: Axial HRCT image showing diffuse ground glass attenuation with superimposed interlobular septal thickening (Crazy Paving Pattern)

Figure-4: Axial HRCT scan of COVID-19 patient shows minimal left pleural effusion

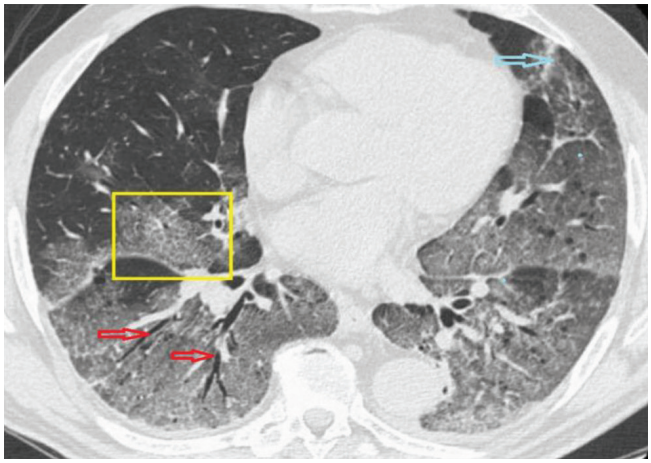

Figure-5: Axial HRCT scan of COVID-19 patient shows GGO with crazy paving pattern (yellow box), bronchiolar dilatation (red arrows) at right lower lobe, fibrotic changes (blue arrow) .

Figure-6: Axial HRCT image showing vascular dilatation and bronchiolar dilatation

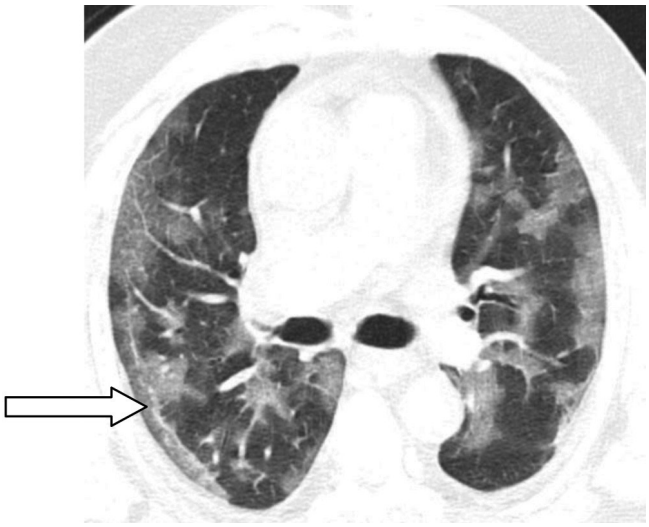

Figure-7: Axial HRCT image showing multifocal ground glass opacities. Note the presence of subpleural parenchymal band.

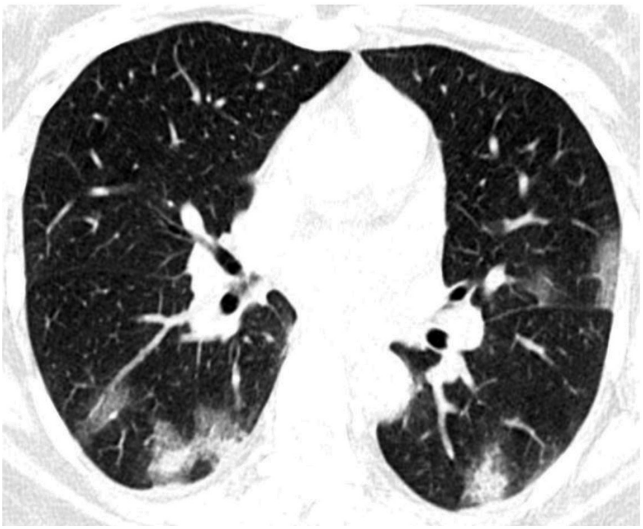

Figure-8: Axial HRCT image showing multifocal consolidations with surrounding ground glass opacities (Halo Sign)

Figure-9: Axial HRCT image showing central ground glass opacity surrounded by peripheral consolidation (Atoll sign or reverse halo sign)

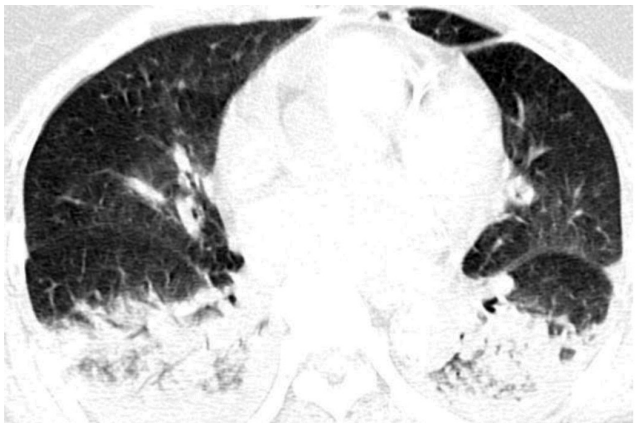

Figure-10: Axial HRCT image showing Lobar consolidation in both lungs.

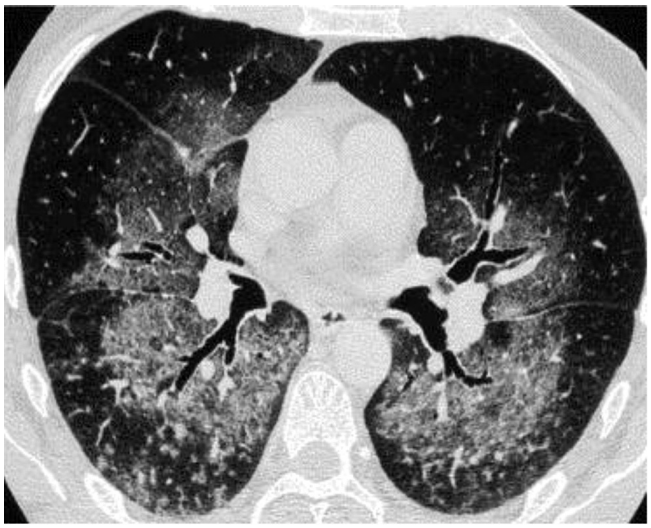

Figure-11: Axial HRCT image showing diffuse ground glass opacities predominantly in central zone

having CTSS of 31-40 (Table 6 and Table 7). Majority of the patients present with fever, fatigue, dry cough, dyspnoea (Table 8).Out of 740 patients positive for CT findings of COVID 19,630 patients (85.1%) have bilateral lung involvement,110 patients (14.8%) have unilateral involvement (Table 9). 100 patients (12.8%) have upper lobe predominance, 60 patients (7.6%) have middle lobe predominance, 320 patients (41%) have lower lobe predominance, 300 patients (38%) have multilobar predominance (Table 10). 580 patients (78.3%) have predominantly peripheral distribution of opacities,50 patients (6.7%) have predominantly central distribution of opacities (Fig 11), 110 patients (14.8%) have both peripheral and central distribution of opacities (Table 11). 4 patients have halo sign,5 patients have reverse halo sign (Table 12).

Out of 740 patients positive for CT findings of COVID 19,209 patients (28.2%) are discharged,461 patients (62.6%) are in admission, 40 patients (5.4%) transferred to another hospital, 30 patients (4%) died (Table 13).Out of 30 patients who were died, 12 patients have CT severity score of >35 ; 9 patients have CT severity score between 31 to 35 ; 7 patients have CT severity score between 25 to 30 ; 2 patients have CT severity score of 24.

ISSN (Online): 2565-4810; (Print): 2565-4802 | ICV 2019: 98.48 |

Imaging classification and CT features of COVID 19 Pneumonia[6]		
Imaging Classification	**Rationale**	**CT Features**
Typical appearance	Commonly reported imaging features of greater specificity for COVID19 pneumonia	Peripheral, bilateral ground glass opacities with or without consolidation or visible intralobular lines (crazy paving pattern) Multifocal ground glass opacities of rounded morphology with or without consolidation or visible intralobular lines (crazy paving pattern) Reverse halo sign or other findings of organizing pneumonia (seen later in the disease)
Indeterminate appearance	Non specific imaging features of COVID 19 pneumonia	Absence of typical features and presence of following features: multifocal ,diffuse , perihilar ,or unilateral ground glass opacity with or without consolidation lacking a specific distribution and that are nonrounded or nonperipheral distribution
Atypical appearance	Uncommonly or not reported features of COVID 19 pneumonia	Absence of typical or indeterminate features and presence of following features:isolated lobar or segmental consolidation without ground glass opacities;discrete small nodules (centrilobular,tree in bud appearance);lung cavitation ;smooth interlobular septal thickening with pleural effusion
Negative for Pneumonia	No features of pneumonia	No CT features to suggest pneumonia.

DISCUSSION

In our study viral pneumonia was diagnosed on the basis of CT findings in 740 of 915 patients (80%). The clinician prescribed isolation and supportive treatment in time for recovery in these 740 patients.Our findings is comparable with study done by Yan Li and Liming Xia in which viral pneumonia was diagnosed on the basis of CT findings in 49 of 51 patients (96.1%),but the result is higher i.e,16% than our findings[1].Our results show that GGO and consolidation were two main signs on CT images of COVID-19 lesions. CT showed GGO or consolidation or both in 720 of 740 patients (97.2%). Our findings is comparable with study done by Yan Li and Liming Xia in which CT showed GGO or consolidation or both in 49 of 51 patients (96.1%)[1].

In our study,4 patients have halo sign (0.5%),5 patients have reverse halo sign (0.6%). Our findings is comparable with study done by Yan Li and Liming Xia in which 9 patients have halo sign (3.9%),2 patients have reverse halo sign (17.6%).,but the result is higher than our findings[1]. Our results grades CT severity score as score of less than 20 as Mild ,more than 20 as Severe with 82% sensitivity and 92% specificity. Our results are compared with study done by Yang et al in which optimal CT severity score threshold for identifying severe COVID-19 was 19.5 with 83.3% sensitivity and 94% specificity but the results is insignificant[4]. The sensitivity and specificity of HRCT Chest in role of evaluation of COVID-19 is 93.6% and 65.5%.The positive and negative predictive value of HRCT Chest in role of evaluation of COVID-19 is 94.4% and 62.2%.Our results are compared with study done by Hefeda showed reported sensitivity is 60-98% and specificity is 25-56%, the positive predictive value is 92% and negative predictive value is 42%,but the results have higher sensitivity and low specificity in both studies[5].

The CT hallmarks of COVID-19 were bilateral peripheral ground-glass opacities, consolidation with the advance of the disease more consolidation is there with linear opacities and crazy-paving pattern[6] .After more than 2 weeks, the lesions are gradually absorbed with residual GGO and subpleural parenchymal bands.The diagnosis of viral pneumonia based on CT was available 3 days earlier than that based on nucleic acid results[1].CT has high accuracy and may be used as a standard method for diagnosis of COVID 19.The use of CT for diagnosis of viral pneumonia allows patients with suspected SARS-CoV-2 infection to be isolated and treated in time for recovery, thus optimizing patient management.

Intervals from symptom onset were divided into four stages by interquartile range:

Stage-1, ≤ 15 days; Stage-2, 16-29 days;

Stage-3, 30-63 days; Stage-4, ≥ 64 days.

At stage-1 (≤ 15 days after symptom onset)- The predominant patterns in patients were GGO , consolidation and crazy-paving pattern.At stage-2 (16-29 days after symptom onset)- Predominant patterns of lung abnormalities were consolidation and GGO.At stage-3 (30-63 days after symptom onset) - Predominant pattern of consolidation decreased, while subpleural parenchymal bands emerged. At stage-4 (≥ 64 days after symptom onset) - The most common pattern at last follow-up chest CT were subpleural parenchymal bands and complete radiological resolution [7].

CONCLUSION

Chest CT had a low rate of missed diagnosis of COVID-19 and may be useful as a standard method for the rapid diagnosis of COVID-19 to optimize the management of patients[1].Pattern of ground glass and consolidative pulmonary opacities, often with a bilateral and peripheral lung distribution, is emerging as the chest CT hallmark of COVID-19 infection.Rapid diagnosis can lead to early

control of potential transmission.With CT diagnosis of viral pneumonia, patients with suspected disease can be isolated and treated in time so that the management of patients will be optimized, especially for the hospitals or communities lacking nucleic acid testing kits.

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Source of Support: Nil; **Conflict of Interest:** None

Submitted: 25-06-2021; **Accepted:** 17-07-2021; **Published online**: 11-08-2021