Original Research Article

Chest Computed Tomography manifestations of Covid-19 : in relation to duration of symptoms

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Abstract

Purpose: To evaluate the abnormalities on thin-section chest Computed Tomographic (CT) scans in patients with COVID-19 and correlate findings to duration of symptoms.**Methods**: RT-PCR positive patients were classified according to the time after the onset of the initial symptoms, into stage-1 (0–4 days); stage-2 (5–9 days); stage-3 (10–14 days); stage-4 (15–21 days); stage-5 (22–28 days). Each lung lobe was evaluated for extent affected by ground-glass opacities (GGO), crazy-paving pattern and consolidation, in five categories of percentual severity. Summation of scores from all five lung lobes provided the total CT score (maximal CT score, 25).**Results:** The predominant patterns of lung abnormalities were ground glass opacities (GGO), crazy-paving pattern, consolidation and curvi-linear opacities. The distribution of pulmonary lesions on CT in COVID-19 pneumonitis patients was mostly peripheral in the stages 1 and 2. With the development of the disease, the lesions gradually spread from the periphery to the center. Most chest CT scans showed bilateral lung involvement during the course of the disease. **Conclusion:** Thin-section CT could provide semi-quantitative analysis of pulmonary damage severity. This disease changed rapidly at the early stage, then tended to be stable and lasted for a long time.

Keywords: COVID-19, Computed Tomography (CT).

Introduction

Coronavirus disease 2019 (COVID-19), a highly infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was firstly reported in Wuhan, Hubei Province, China, and rapidly spreads to other parts of the world[1]. On January 30 2020, the World Health Organization (WHO) declared this ongoing outbreak as a global public health emergency and raised the risk of COVID-19 to very high at the global level on February 28, 2020 [2]**.** As on May 2021, India reported more than 20 million covid cases [3]**.** SARS-CoV-2 is a single stranded RNA virus that belongs to order Nidovirales, family Coronaviridae, a family that also includes other viruses implied in the respiratory illnesses such as severe acute respiratory syndrome (SARS) and the Middle East Respiratory syndrome (MERS) [4]**.**A specific viral nucleic acid assay using real time reverse transcription - polymerase chain reaction (RT-PCR) is done to confirm the diagnosis of COVID-19 [5,6]**.**Currently, high resolution CT has been considered as one of the main tools for screening, primary diagnosis and evaluation of disease severity [7]**.**Chest CT scan shows 97% and 75% sensitivity for the diagnosis of specimen positive and negative patients respectively but with only 25% specificity [8]**.** There is evidence of the prognostic value of chest CT which has been shown by recent studies, where a specific score by CT scan could predict the mortality of patients with COVID-19 [9]**.**The aim of this study is to evaluate chest abnormalities on thin-section computed tomographic (CT) scans in patients with confirmed with COVID-19 and correlate findings based on duration of symptoms, therefore, was to understand the chronological changes of lung disease in COVID-19.

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Materials and methods

Study Population: Patients data was collected from the Department of the Radio-Diagnosis, Rajarajeswari Medical college and hospital, Bengaluru between June 2020 and January 2021. 183 males and 165 females with proven COVID-19 infection confirmed with RT- PCR were included in this study.

Inclusion criteria: Patients with positive RT-PCR status

Exclusion criteria: 1. Known pre-existing lung disease,**2.**Previous lung surgery.

Study design: This is an Observational Retrospective study performed at our institution.

Ethical approval - Institutional Review Board approval was obtained.

CT scanning protocol:A high-resolution CT (HRCT) scan was performed in all patients with 128-slice multi-detector row CT scanner. Patients were scanned in the supine position; head first, during breath-hold. Scanning parameters were tube voltage 100−120

kV, tube current 120 −260 mA, pitch 1.3, FOV 350−400 mm. The 0.6 mm thick images were reconstructed using a high-frequency reconstruction algorithm. All examinations were non-enhanced and no intravenous contrast medium was administered.

The scans were categorized according to the period of onset of symptoms into following stages:

- Stage 1: 0-4 days,
- Stage 2: 5-9 days,
- Stage 3: 10-14 days,
- Stage 4: 15 -21 days
- Stage 5: 22-28 days.

All the CT images were evaluated for following major parameters:

- Ground glass opacification (GGO- hazy areas of increased attenuation without obscuration of the underlying vessels)
- Consolidation (homogeneous opacification of the parenchyma with obscuration of the underlying vessels and air bronchogram)
- Crazy-paving pattern (GGO with interlobular and intralobular septal thickening)
- Linear opacities (disordered arrangement of coarse linear or curvilinear opacities or fine subpleural reticulation).

Some of the minor parameters is also assessed:

- Cavitation
- Bronchiectasis
- Pleural effusion
- Pneumothorax
- Pulmonary vessels dilatation – intra-lesional and peri-lesional pulmonary vessel dilatation
- Mediastinal lymphadenopathy – Short axis diameter more than 10 mm.

The distribution of pulmonary lesions based on location was subdivided into

- Peripheral (predominantly subpleural - involving mainly the peripheral 1/3rd of the lung),
- Central (involving mainly the central 2/3rd of the lung) and
- Diffuse (both subpleural and central regions).

For assessment of the CT severity score: Lungs are divided into five lobes as of anatomical delineation into Right upper lobe, right middle lobe, right lower lobe, left upper lobe and left lower lobe.

Each lung lobe was assigned a score which was based on the following criteria:

- Score 0 - 0% involvement;
- Score 1 - < 5% involvement;
- Score 2 - 5% to less than 25 % involvement;
- Score 3 - 25 % to less than 50 % involvement;
- Score 4 - 50 % to less than 75 % involvement; and
- Score 5 - 75 % or greater involvement.
  - Summation of scores provided a semi-quantitative evaluation for overall lung involvement (maximal CT score for both lungs was 25) [10, 11].

Severity is graded into mild, moderate and severe based on scores upto 8, 9-15 and more than 15 respectively.

Results

A total of 348 symptomatic patients with proven COVID-19 infection are included in this study, which includes 183 males and 165 females.

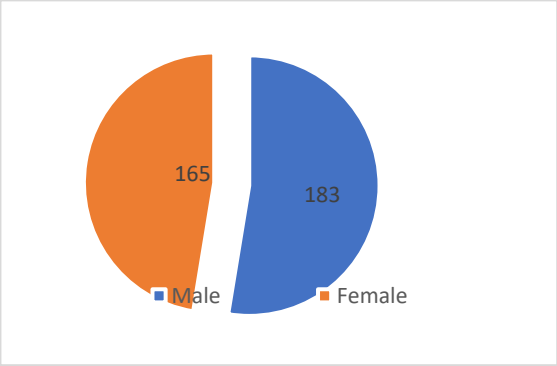


Fig 1: Pie chart show the sex distribution of the patients

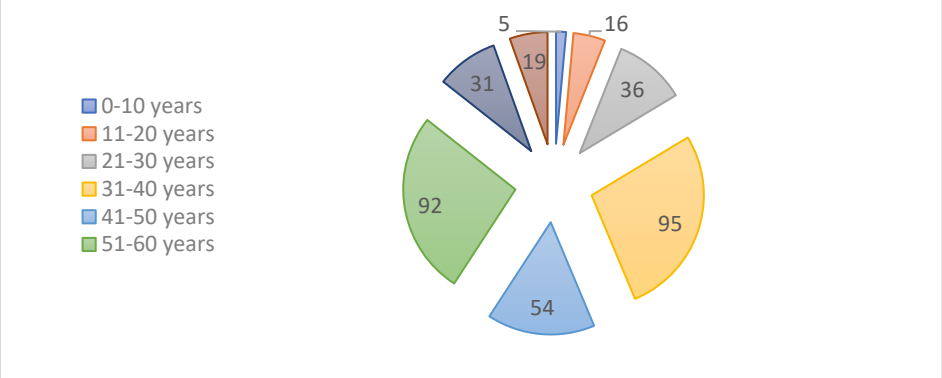


Fig 2: Pie chart shows the age distribution of the patients

Table 1: Shows the frequency of the type of the pathology in each of the stages

Total 348	Stage 1 (n=56)	Stage 2 (n=86)	Stage 3 (n=95)	Stage 4 (n=68)	Stage 5 (n=43)
GGO	39	85	94	56	36
Consolidation	11	79	95	59	31
Crazy paving	9	21	84	45	29
Curvi-linear opacities	5	22	35	34	38
Cavitation	0	0	0	0	1
Bronchiectasis	0	2	3	1	0
Pneumothorax	0	0	0	1	0
Pleural effusion	0	0	0	3	1
Lymphadenopathy	0	3	7	6	7
Vessel dilatation	0	3	11	8	5

The most frequent CT findings of COVID-19 pneumonia were Ground glass opacities, Consolidation, Crazy-paving pattern and Curvi-linear opacities. The distribution of pulmonary lesions on CT in COVID-19 pneumonitis patients was mostly peripheral in the stages 1 and 2 with the highest rate (89.7%) at stage 1. With the development of the disease, the lesions gradually spread from the periphery to the center. Mixed type of lesions was seen maximum in stage 3 (86.1 %). Overall, mixed lesions (both central and peripheral) were more common than central lung lesions in all the stages. Most chest CT scans showed bilateral lung involvement during the course of the disease.

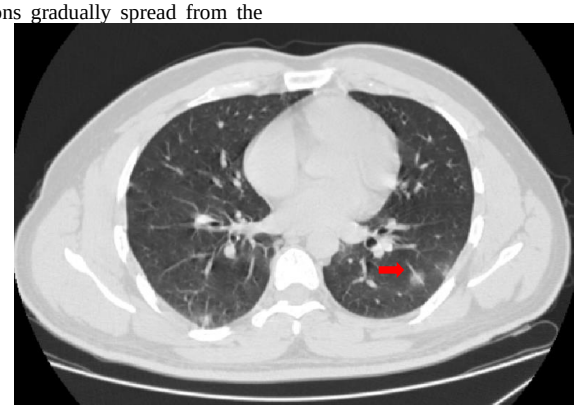


Fig 3: Axial HRCT CHEST lung window of patient after 2 days from onset of symptoms (Stage 1) shows ground glass opacities in the peripheral aspects of both lower lobes.

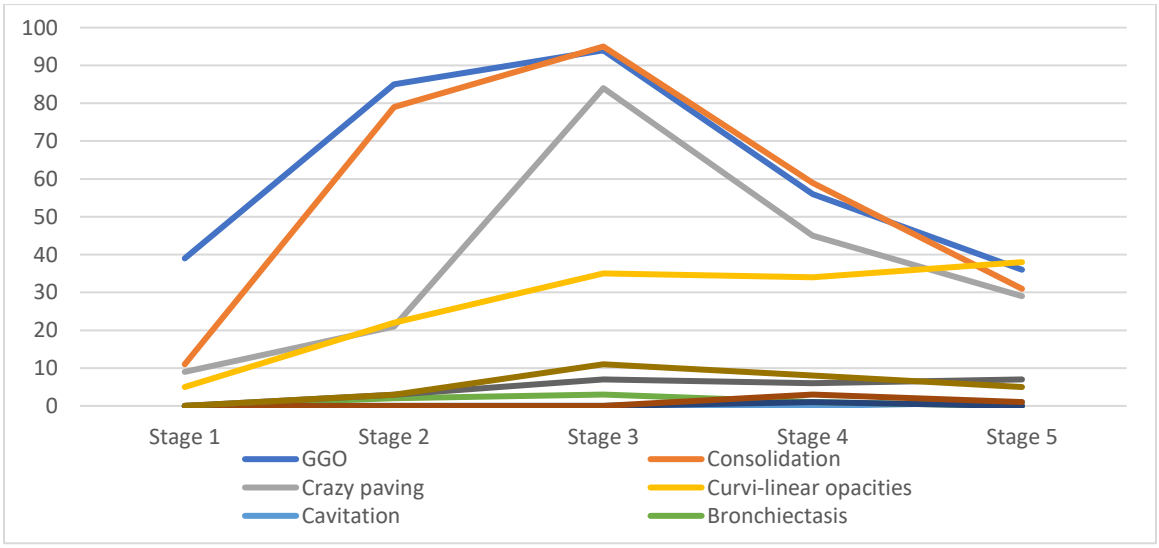


Fig 4: Line diagram showing the frequency of the type of the pathology in each of the stages

The most common CT findings in stage 1 are GGO (39 of 56 patients [69.6%]) with consolidation (11 of 56 scans [19.6%]), crazy-paving pattern (9 of 56 scans [16%]) and curvilinear opacities (5 of 56 scans[8.9%]).

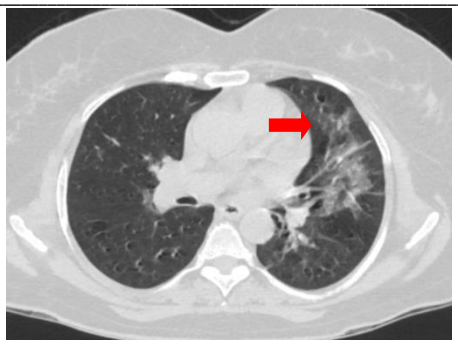


Fig 5: Axial HRCT CHEST lung window of patient after 3 days from onset of symptoms (Stage 1) shows ground glass opacities in the central and peripheral aspects of the left lung.

In stage 2, the GGO (85 of 86 scans [98.8%]) extended to more pulmonary lobes with more consolidation (79 of 86 scans [91.8 %]), crazy-paving pattern (21of 86 scans [24.4 %]) and curvi-linear opacities of (22 of 86 [25.5%]).

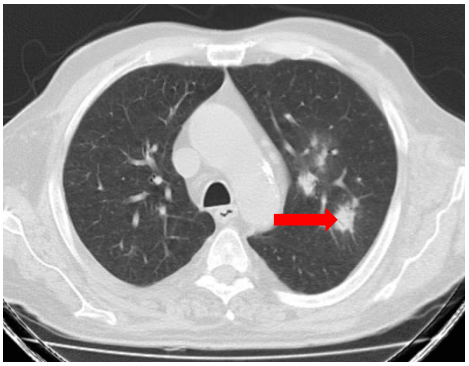


Fig 6: Axial HRCT CHEST lung window of patient after 5 days from onset of symptoms (Stage 2) shows patchy consolidation in the central aspects of the left upper lobe.

In stage 3, consolidation (95 of 95 scans [100%]) was the main finding, with GGO (94 of 95 scans [98.9 %]) and crazy-paving pattern (84 of 95 scans [88.4 %]) seen in the majority of cases.

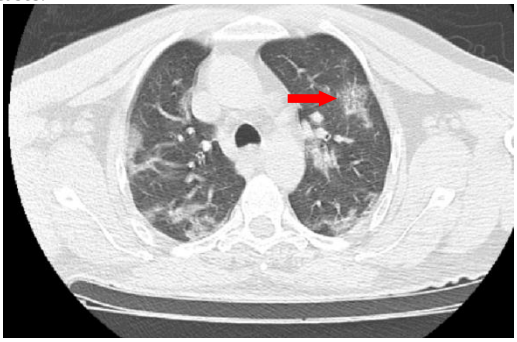


Fig 7: Axial HRCT CHEST lung window of patient after 12 days from onset of symptoms (Stage 3) shows crazy paving pattern in the left upper lobe.

In stage 4, the consolidation (59 of 68 scans [86.7%]) was seen in most patients with GGO(56 of 68 scans [82.3 %]).

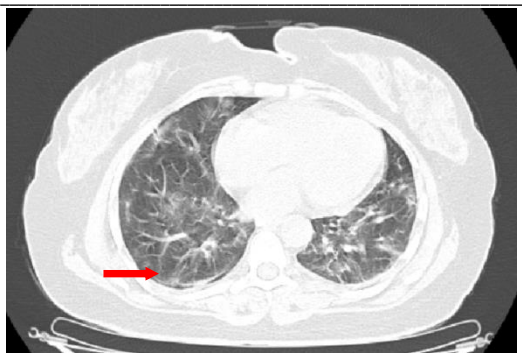


Fig 8: Axial HRCT CHEST lung window of patient after 16 days from onset of symptoms (Stage 4) shows subpleural curvi-linear opacities in the right lower lobe.

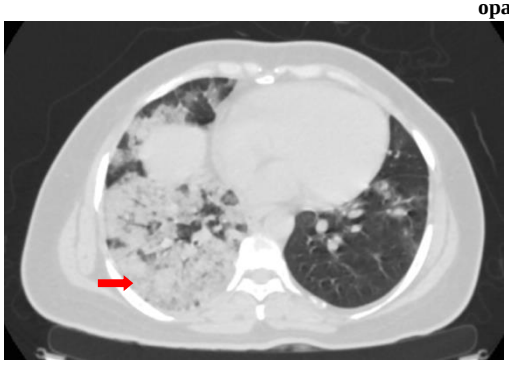
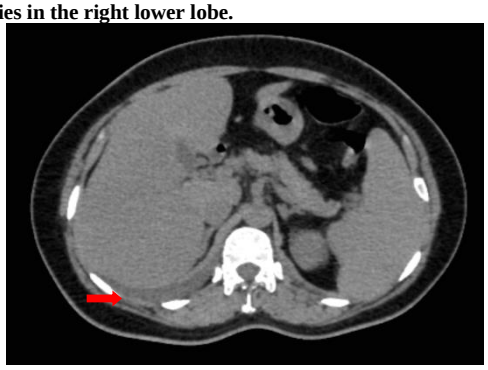

(a)

(b)

Fig 9: Axial HRCT CHEST lung (a) and mediastinum (b) window of patient after 20 days from onset of symptoms (Stage 4)shows extensive consolidation in the right lower lobe with minimal right pleural effusion.

In stage 5, curvilinear opacities was main pattern of involvement (38 of 43 scans [88.3%]) along with ground glass opacities (36 out of 43 scans [83.7%]).

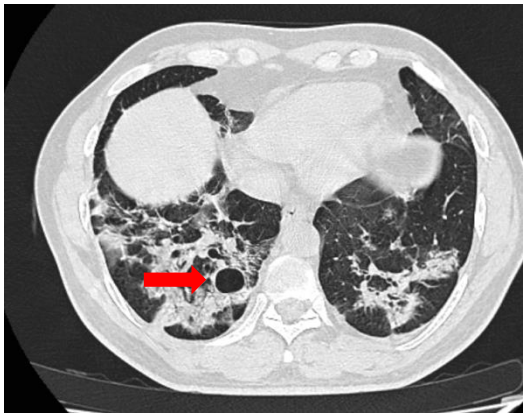


Fig 10: Axial HRCT CHEST lung window of patient after 25 days from onset of symptoms (Stage 5)shows consolidation in the both lower lobes with thin walled cavity in the right lower lobe.

Other CT findings of COVID-19 pneumonia included bronchiectasis seen in stage 2, 3 and 4 (2.3 %, 3.1 %, 1.4 %) respectively.

Pleural effusion is seen in stage-4 in 3 patients (4.4 %), and in stage-5- only 1 patient (2.3 %). Only 1 patient in stage 4 had pneumothorax (1.4%).

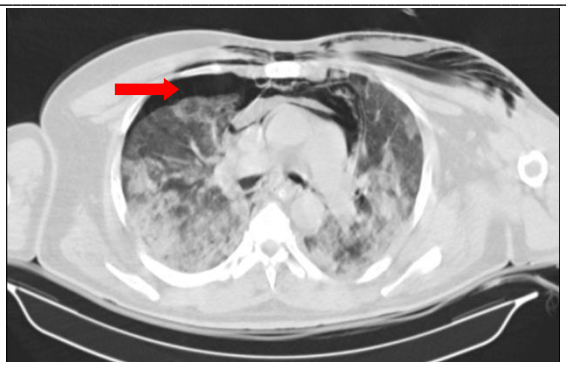


Fig 11: Axial HRCT CHEST lung window of patient after 18 days from onset of symptoms (Stage 4) shows right pneumothorax, pneumo-mediastinum, soft tissue emphysema in the anterior chest wall, consolidation in the both lungs.

Mediastinal lymphadenopathy was not seen in stage 1, seen in very few patients of other stages.

Segmental or subsegmental intra-lesional or peri-lesional pulmonary vessel enlargement was seen in less patients, maximum seen in stage 3 out of all other stages (11 of 95 patients - 11.5 %).In all patients, the lesions were present in bilaterally. Among the lobes, lower lobes are seen to be involved more commonly in all the stages. More diffuse involvement of the both lungs are seen in the stages 3 and 4.

Fig 12: Distribution of the lung lesions in the different stages of the disease based on lung lobe involved.

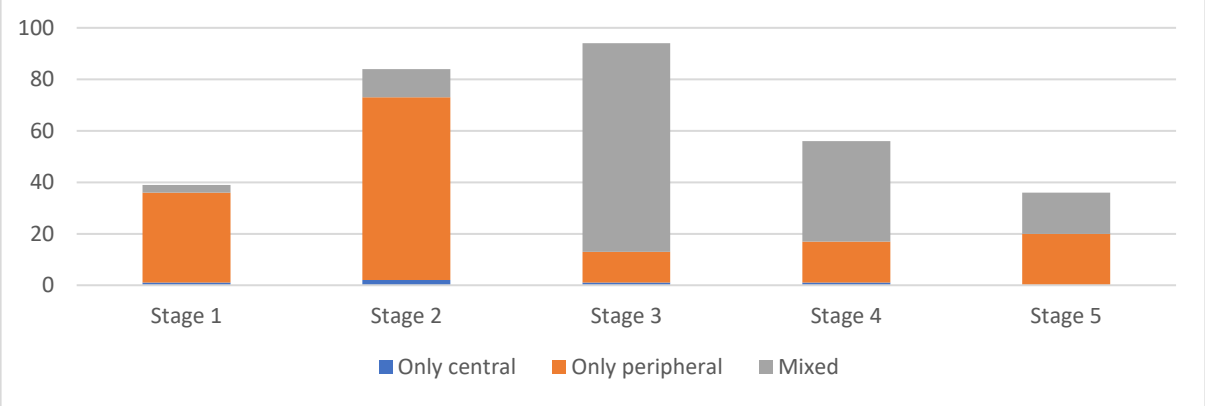


Fig 13: Bar diagram shows distribution of the lesions depending on location.

Based on CT severity score: In stage 1, Majority of the patients showed mild involvement (62.5 %) with increase in the severity as duration of the disease increases. Moderate involvement of the lungs is maximum in the stages 3 and 4 seen in the 43.1 % and 51.4 % respectively. Severe involvement is maximum seen in the stages 2 and 3 in 17.4 % and 16.8 % respectively.

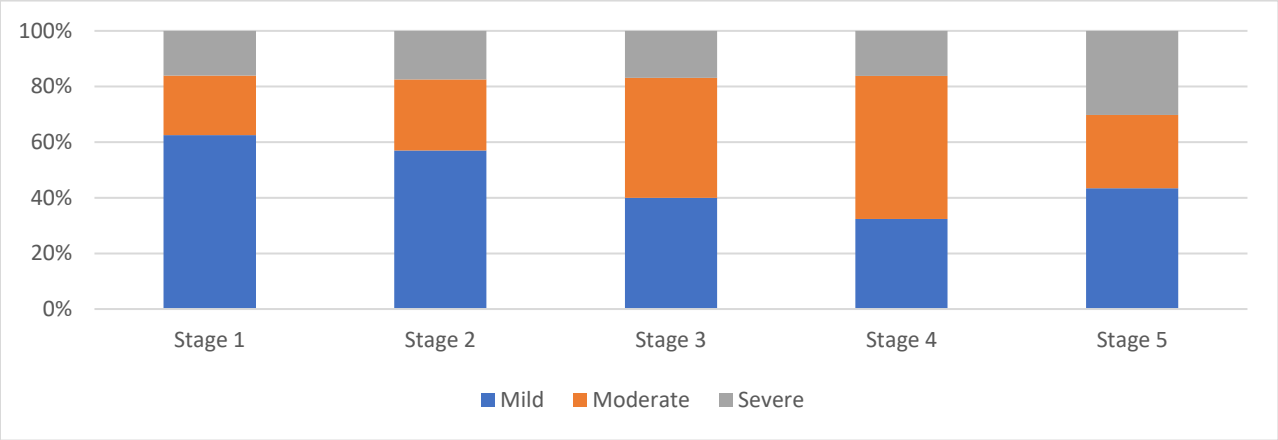


Fig 14: Bar diagram shows CT severity score in the different stages.

Discussion

Chest CT is a non-invasive, rapid, convenient imaging diagnostic tool and can detect mild lung abnormalities at the early stage of COVID-19 pneumonia. Although the RT-PCR test is the gold standard for the diagnosis of COVID-19 infection, chest CT examination is essential for the early identification of potential patients and helps to determine treatment strategies. In this study, we analyzed the chest CT features and scores of patients with COVID-19 in different stages of disease.The main radiological feature of early infection is ground glass opacities that coalesce into dense consolidation and then gradually evolve and organize in often a more linear pattern confined mainly to the lung periphery and slightly with a crazy-paving pattern[12]**.** Koo et al. [13] reported that confluent patches of GGO and consolidation distributed at peripheral parts of both lungs (subpleural) were two prime CT signs of COVID-19 pneumonia in their study and were confined to the middle and lower zones of the lung on the initial chest CT. Follow-up CT showed that with the advance of the disease, consolidation, and coalescing infiltrates intervened in the lungs affecting the upper lobes in some patients. [14]**.** Findings in our study are also corresponding to these pattern of involvement.In the study performed by Dinga et al. [15]**,** In CT abnormalities, peripheral GGO was the most important imaging manifestation (76.5%), indicating the disease may mainly invade the terminal respiratory bronchi or alveoli at first. Some patients also showed crazy-paving pattern (36.1%), consolidation (25.5%), and linear opacities (6.3 %) on the early stage CT. In our study also in stage -1, most common manifestation were peripheral GGO (69.6%) followed by consolidation of 19.6%, crazy-paving of 16%, and curvilinear opacities (8.9%).Also, Pan et al. [16] found in their study that CT features of the lesions were variable in the progressive stage (5–9 days). Crazy-paving pattern, consolidation, and linear opacities increased significantly, denoting interstitial edema and alveolar exudation. In our study also similar findings were noted (consolidation – 91.8%, crazy- paving 24.4% and curvi-linear opacities 25.5%).Our findings are not in concurrence with Yan Li et al. who reported vascular enlargement in 82.4 %.[17]**.**

Limitations: This study has some limitations. First, this is a short-term retrospective study and long-term radiological follow-up is needed to monitor the pulmonary outcome due to the novel coronavirus infection.

Second, there was a small number of pediatric population.

Conclusion

In summary, the CT features of the COVID-19 pneumonia were diverse and changed with duration of symptoms. Our data suggested that thin-section CT could serve as a useful tool for evaluating the change of pulmonary abnormalities in patients during the acute and convalescent periods of the illness.

References

1. Zhu N, Zhang D, Wang W et al .A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med. 2020:1
2. World Health Organization (2020) Coronavirus disease 2019 (COVID-19) situation report–39. World Health Organization, Geneva. Available via https://www.who.int/docs/default-source/ coronaviruse/ situation-reports/20200228-sitrep-39-covid-19.pdf? sfvrsn=5bbf3e7d_2
3. Https://www.mohfw.gov.in/
4. Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X et al.CT Imaging Features of 2019 Novel Coronavirus (2019-nCoV). Radiology. 2020;295(1): 202–207
5. V.M. Corman, O. Landt, M. Kaiser, R. Molenkamp, A. Meijer, D.K.W. Chu, T. Bleicker, S. Brunink, J. Schneider, M.L. Schmidt, D. Mulders, B.L. Haagmans, B. van der Veer, S. van den Brink, L. Wijsman, G. Goderski, J.L. Romette, J. Ellis,M. Zambon, M. Peiris, H. Goossens, C. Reusken, M.P.G. Koopmans, C. Drosten, Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR, EuroSurveill. 2020;25 (3):1
6. Y. Fang, H. Zhang, J. Xie, M. Lin, L. Ying, P. Pang, W. Ji, Sensitivity of chest CT for COVID-19: comparison to RT-PCR, Radiology (2020) 200432.
7. Y. Pan, H. Guan, S. Zhou, Y. Wang, Q. Li, T. Zhu, Q. Hu, L. Xia, Initial CT findings and temporal changes in patients with the novel coronavirus pneumonia (2019-nCoV): a study of 63 patients in Wuhan, China, Eur. Radiol. 2020:1
8. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W et al Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases. Radiology.2020:200642
9. Yuan M, Yin W, Tao Z, Tan W, Hu Y . Association of radiologic findings with mortality of patients infected with 2019 novel coronavirus in Wuhan, China. PLoS One 2020;15(3):e0230548
10. F. Pan, T. Ye, P. Sun, S. Gui, B. Liang, L. Li, D. Zheng, J. Wang, R.L. Hesketh, L. Yang, C. Zheng, Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia, Radiology 2020:200370.
11. Y.C. Chang, C.J. Yu, S.C. Chang, J.R. Galvin, H.M. Liu, C.H. Hsiao, P.H. Kuo, K.Y. Chen, T.J. Franks, K.M. Huang, P.C. Yang, Pulmonary sequelae in convalescent

patients after severe acute respiratory syndrome: evaluation with thin-section CT, Radiology.2005; 236 (3) : 1067–1075.
12. Bernheim A, Mei X, Huang M, et al (2020) Chest CT findings in coronavirus disease 2019 (COVID-19): relationship to duration of infection. Radiology 295:685–691).
13. Koo HJ, Lim S, Choe J, et al. Radiographic and CT features of viral pneumonia. RadioGraphics .2018;38:719–739)
14. Li Y, and Xia L .Coronavirus disease 2019 (COVID-19): role of chest CT in diagnosis and management AJR.2020; 214:1280–1286
15. Dinga X, Xub J, Zhouc J et al.Chest CT findings of COVID-19 pneumonia by duration of symptoms. European Journal of Radiology.2020; 127:109009
16. Pan F, Ye T, Sun P et al (2020) Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. Radiology 200370
17. Y. Li, L. Xia, Coronavirus disease 2019 (COVID-19): role of chest CT in diagnosis and management, Am. J. Roentgenol. 2020: 1–7.

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