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Spectrum of Chest Computed Tomography Findings in RT-PCR Positive Coronavirus Disease-19 (COVID-19) Patients

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Abstract: ***Medical imaging techniques have a potentially important role to play in early diagnosis and managing the treatment of patients infected with SARS-CoV-2. Chest CT, as a routine imaging tool for pneumonia diagnosis, is relatively easy to perform and can produce fast diagnosis. Several chest CT features of COVID-19 pneumonia are reported in previous studies; however, limited imaging data of Indian patients is available. The objectives of this study are to study the spectrum of chest computed tomographic (CT) imaging findings in coronavirus. disease-19 (COVID-19) infected Indian patients , to estimate CT severity index and mortality rate and to study the correlation of CT severity index with age, gender and mortality. This study included 220 patients with diagnosis of COVID-19 infection confirmed by nucleic acid testing. The lung parenchymal abnormality was seen in all patients. Bilateral lung involvement was present in 217 (98.6%) patients. GGO was the dominant opacity found in all 220 (100%) cases. There was no statistically significant correlation of CT severity score and gender (p value = 0.316).This study showed significant correlation of CT severity score and increasing age (p value = 0.003).There was significant correlation between high CT severity score and mortality rate (p-value= 0.001).***

Keywords: Covid, Ground glass opacity, chest CT, RT-PCR, Reticulations

1. Introduction

An outbreak of coronavirus disease-19 (COVID-19) infection began in December 2019 in Wuhan, the capital of central China's Hubei province [1]. Covid-19 is a highly contagious infection that has widely and rapidly spread all over the world with significant impacts upon healthcare delivery systems. The first cases of COVID-19 in India were reported on 30 January 2020 in three towns of Kerala, among three Indian medical students who had returned from Wuhan, the epicentre of the pandemic [2]. SARS-CoV-2 is a member of beta-corona viruses which are enveloped single-stranded RNA viruses [3]. About 20% of cases are severe, and mortality is approximately 3% [4]. Early diagnosis will enable patients to be isolated and treated in good time, essential for avoiding the spread of disease, improving prognosis, and reducing mortality.

Real-time reverse transcriptase polymerase chain reaction (RT-PCR) assay of nasal and pharyngeal swab specimens is currently the gold standard for the diagnosis of COVID-19. However, the sensitivity of the test is only 60 to 70%, depending on the quality of the sample and the rate of viral replication in the upper respiratory tract [5]. Altogether, RT-PCR testing is rather time-consuming and suboptimal for the rapid triaging of patients. Chest CT sensitivity for the diagnosis of COVID-19 is greater than 90% [6]. Given the diagnostic potential of chest CT scanning, it is crucial for radiologists to have knowledge of the salient imaging features of COVID-19 infection.

The aim of this study is to evaluate the typical and atypical CT features in COVID-19 patients, in order to help radiologists and clinicians to become more familiar with the wide spectrum of imaging findings of this disease.

2. Material and Methods

Patient cohort and study design:
This was a prospective observational study, conducted at the Department of Radiodiagnosis in Satguru Pratap Singh Hospital, Ludhiana, Punjab, India. The study followed 220 patients with a diagnosis of COVID-19 infection confirmed by nucleic acid testing. The duration of study was from June 2020 to June 2021.

Inclusion Criteria:
1) Laboratory proven RT-PCR positive COVID-19 cases.
2) Age >18 years

Exclusion Criteria:
1) RT PCR negative cases.
2) Pregnant females.
3) Pediatric age group.
4) Patients with severe artifacts on CT images.

2.1 Methodology

All patients taken were positive for COVID-19 at laboratory testing with real-time reverse-transcriptase polymerase chain reaction (RT-PCR) of respiratory secretions obtained by nasopharyngeal swab, or oropharyngeal swab.

CT Acquisition Protocol
All patients underwent non-contrast chest CT. Chest CT study was performed using a 64-row multi-detector CT unit (OPTIMA 660, 128 slice, GE, USA) with the following parameters: tube voltage 100–120 kVp, tube current 200-300 mAs, collimation of 64 × 0.6 and a pitch of 1.5. The CT images were acquired in a single inspiratory breath-hold. Images were reconstructed using increment of 0.7 mm into 1 mm thick slices. The images were viewed in both lung window settings (width 1200–1500 HU; centering –(500 to 600HU) and mediastinal window (width 300−400HU; centering 40HU).

Image analysis
The following features on CT were assessed:

Presence or absence of pulmonary opacities; location and type of opacities and the extent of opacities. The location of opacities were specified with regards to involvement of one lung (right, left) or both the lungs. The distribution of lung abnormalities was also divided into subpleural, peripheral(defined as outer one-third of the lung) , peri-bronchial, central(defined as the inner two-third of the lung tissue) and diffuse location [7].

Severity then was assessed using the following scoring system proposed by Pan et al, [8] which depends on the visual assessment of each lobe involved.

Visual severity scoring of CT chest was classified as:

Percentage of Lobar involvement	Score
5% or less	1
5%-25%	2
26%-49%	3
50%-75%	4
>75%	5

Score-1 (<5% area involved), Score-2 (5-25% area involved), Score-3 (25-50% area involved), Score-4 (50-75% area involved), Score-5 (>75% area involved), making the total score 25.

A CT Severity Score was assigned out of 25 based on the percentage area involved in each of the 5 lobes. The sum of the lobar scores indicated the overall severity:

Total Score (numerical)	Severity (category)
7 or less	Mild
8-17	Moderate
18 or more	Severe

Lung lesions were categorized using Fleischner society glossary of terms for thoracic imaging:-

GGO (ground glass opacity) is defined as an increase in the density of lung with non-obscuration of bronchial and vascular structures. **Halo sign** is seen on lung window settings and is defined as ground glass opacity surrounding a pulmonary nodule or mass. **Reversed halo sign**, also known as the **atoll sign**, is defined as central ground glass opacity surrounded by denser consolidation of crescentic shape (forming more than three-fourths of a circle) or complete ring of at least 2 mm in thickness. **Target sign/ bullseye sign –** It is considered as variant of the reverse halo sign. It has been described as a central high attenuation focus surrounded by one or more dense complete or incomplete ring-like consolidation, forming one or more circles.

Statistical analysis
Data was described in terms of range; mean ±standard deviation (± SD), median, frequencies (number of cases) and relative frequencies (percentages) as appropriate. A probability value (p value) less than 0.05 was considered statistically significant. All statistical calculations were done using SPSS (Statistical Package for the Social Science) SPSS 21 version statistical programme for Microsoft Windows.

3. Observation and Results

A total of 220 cases were enrolled in this study with a mean age of 55.44 years, age ranging from 18-90 years. Maximum number of patients were in age group of 40-60 years. Out of 220 patients, 171 were males and only 49 were females. Maximum percentage of patients were males (77.7%). Age-wise and sex-wise distribution is summarised in Table no 1.

Lung parenchymal abnormalities were observed in all 220 RT-PCR positive confirmed cases taken under study. Among these patients, bilateral lung involvement was the commonest, observed in 217/220 cases (98.6%).

The chest CT studies of 220 patients with COVID-19 showed that multiple lobe involvement was more frequent with all 5 lobes were involved in 173 (78.6%) cases, whereas single lobe involvement was seen in 2 (0.9%) cases and two lobes were involved in 4 (1.8%) cases.

The right upper lobe was involved in 210 of the 220 patients (98.6%), the right middle lobe was involved in 175 (79.5%), the right lower lobe was involved in 217 (98.6%), the left upper lobe was involved in 202 (91.8 %) and the left lower lobe was involved in 212 (96.4%).With regards to the distribution of opacities , peripheral distribution of opacities was the commonest seen in 100.0% cases, among which subpleural distribution was in 98.6% cases, central distribution in 51.4% cases, peri-bronchial distribution in 48.2 % cases and diffuse pattern was seen in 49.5% cases. None of the patients showed purely central distribution.

All CT images were evaluated and assessed for the presence or absence of various types of lung opacities as summarized in Table no.2 and Graph 1 & 2:

With regards to the type of opacity, GGO was the dominant abnormality found in all 220 (100%) cases. Pure GGO was observed in 86(39.1%) cases (fig. 1). GGO with interlobular

septal thickening and intralobular lines, producing crazy paving pattern was seen in 111(50.5 %) cases (fig.2). GGO mixed with consolidation was noted in 151(68.6%) cases (fig. 3). Pure consolidation was noted in 60(27.3%) cases (fig. 4). Reticulations were seen in 127 (57.7%) and subpleural curvilinear lines (fig.5) were noted in 62 (28.2%) cases. We observed peri-lesional or intra-lesional vessel enlargement in 76 (34.5%) cases (fig. 6). A small number of cases showed reverse halo sign (5.0%) (fig. 7, 8), nodules (2.7%) (fig. 9), halo sign (0.9%) and cavitation (1.4%) (fig. 10).

Some additional signs of COVID-19 lesions on CT images were also noted. Pleural effusion was seen in 31(14.1 %) patients, pleural thickening in 53(24.1%) and mediastinal lymphadenopathy in 32(14.5 %) cases. Pneumothorax was noted in 3 (1.4%) patients and pericardial effusion in 2 (0.9%) patients. Existing lung disease findings like emphysema and features of old healed tuberculosis was seen in 3(1.4%) cases each , whereas fibrosis/ILD features(fig. 11) was noted in only 2(0.9%) cases. Two cases shows pneumomediastinum (fig.12) and pulmonary thrombo-embolism (fig.13) is seen in one case.

The severity score was calculated based on lung involvement percentage for each patient by scoring the percentage of each lobe involvement individually and given a score from 1 to 5. Then, the final score will be the sum of individual lobar scores and will be out of 25 (total score).

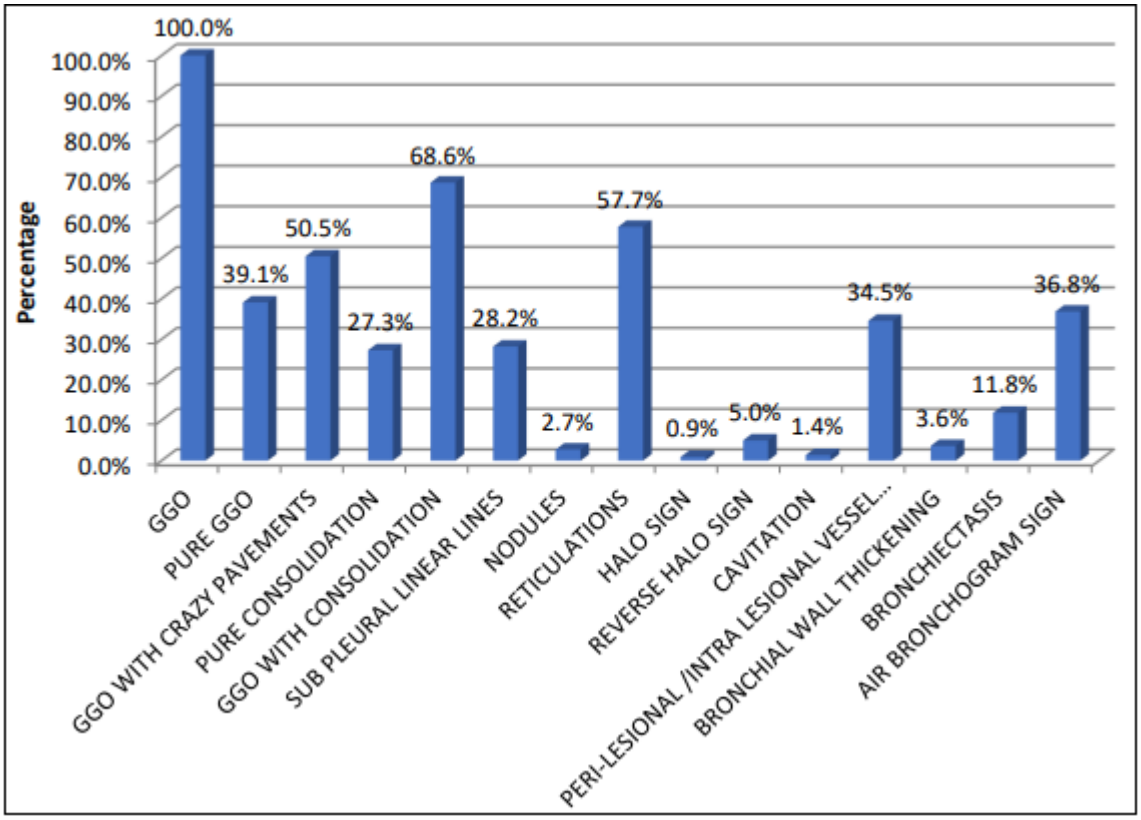
In our 220 cases, 106 patients were in severe disease category (figure 14) comprising 48.2%, whereas the CT severity score was moderate in 72(32.7%) and mild in 42(19.1%) patients (figure 15). The estimated mortality rate of covid-19 in our study is 13.2%.

Table 1: Age-wise and Sex-wise distribution

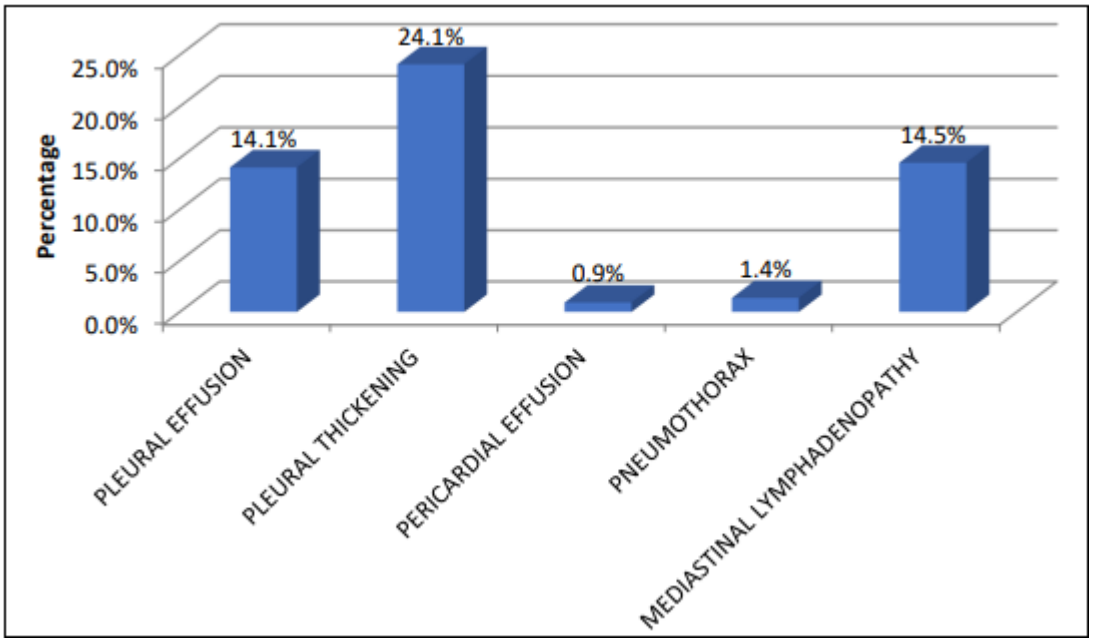
Age Group	No. of cases	Percentage
< 40	29	13.2%
40-60	101	45.9%
> 60	90	40.9%
Total	220	100.0%
Sex	No. of cases	Percentage
F	49	22.3%
M	171	77.7%
Total	220	100.0%

Table 2

Type of Lung Opacities	No. of cases	Percentage
GGO	220	100.0%
PURE GGO	86	39.1%
GGO WITH CRAZY PAVEMENTS	111	50.5%
PURE CONSOLIDATION	60	27.3%
GGO WITH CONSOLIDATION	151	68.6%
SUB PLEURAL LINEAR LINES	62	28.2%
NODULES	6	2.7%
RETICULATIONS	127	57.7%
HALO SIGN	2	0.9%
REVERSE HALO SIGN	11	5.0%
CAVITATION	3	1.4%
PERI-LESIONAL /INTRA LESIONAL VESSEL ENLARGEMENT	76	34.5%
BRONCHIAL WALL THICKENING	8	3.6%
BRONCHIECTASIS	26	11.8%
AIR BRONCHOGRAM SIGN	81	36.8%
ADDITIONAL FINDINGS		
PLEURAL EFFUSION	31	14.1%
PLEURAL THICKENING	53	24.1%
PERICARDIAL EFFUSION	2	0.9%
PNEUMOTHORAX	3	1.4%
MEDIASTINAL LYMPHADENOPATHY	32	14.5%
FINDINGS OF EXISTING LUNG DISEASE		
EMPHYSEMA	3	1.4%
SEQUELAE OF OLD HEALED TUBERCULOSIS	3	1.4%
FIBROSIS / INTERSTIAL LUNG DISEASE	2	0.9%



Graph 1: Types of lung opacities



Graph 2: Additional findings

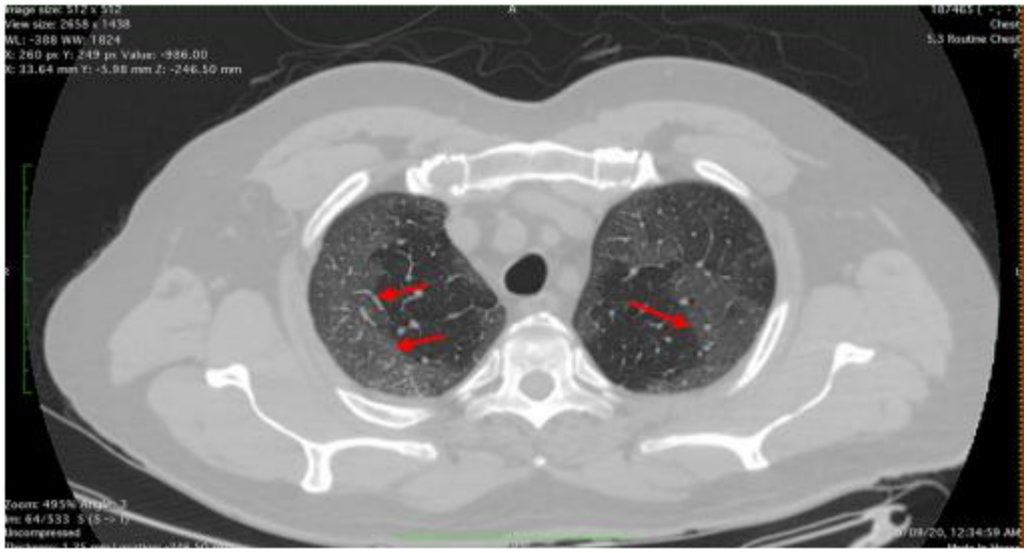


Figure 1: Non-contrast axial chest CT images in lung window settings showing multiple patchy ground glass opacities (red arrow), predominantly in peripheral and subpleural regions in bilateral upper lobes

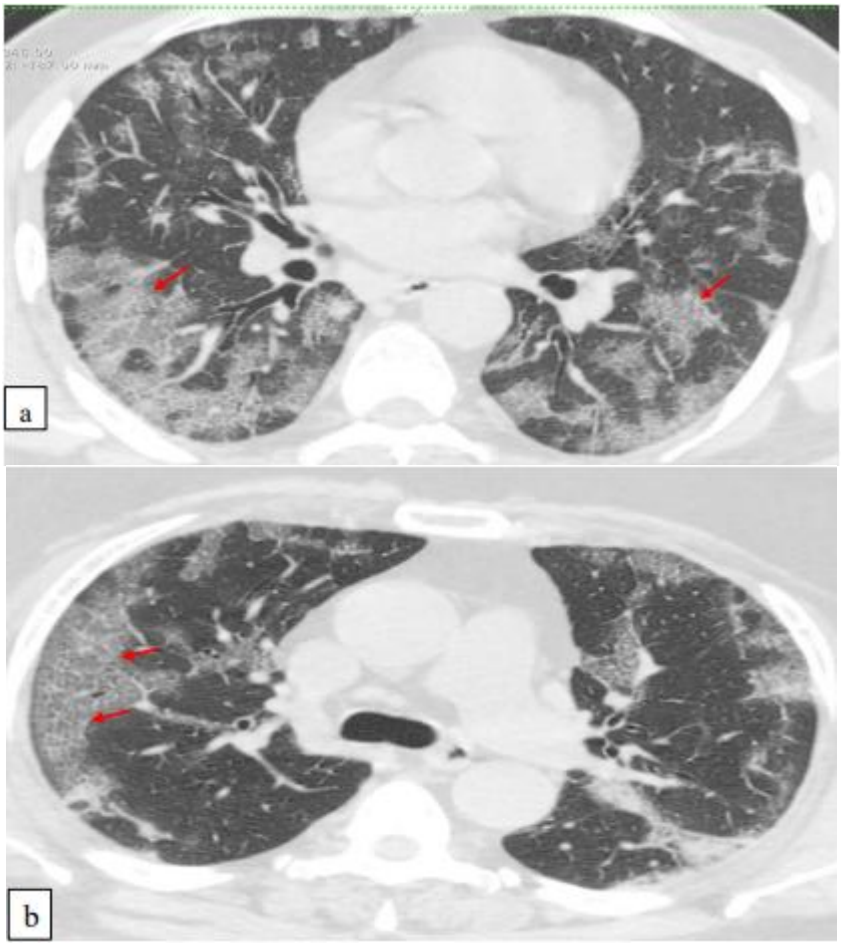


Figure 2 (a, b): Non-contrast axial chest CT images in lung window settings showing multiple patchy and diffuse ground glass opacities with interlobular septal thickening presenting as crazy paving pattern(red arrow).

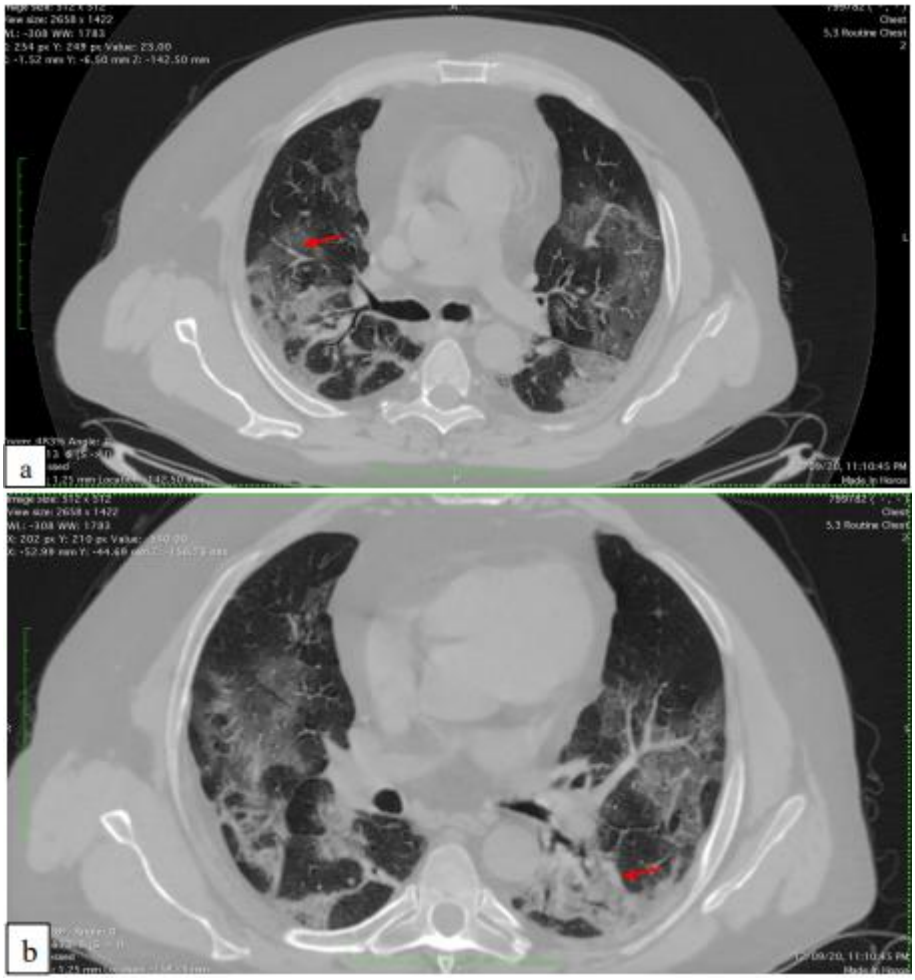
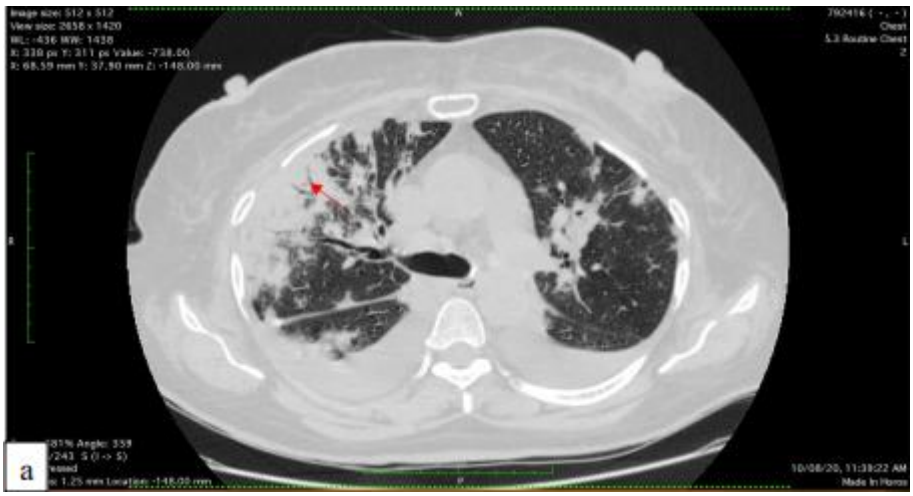


Figure 3 (a, b): Non-contrast axial chest CT image in lung window settings shows diffuse areas of ground glass opacities mixed with patches of consolidation predominantly in peripheral and subpleural distribution.



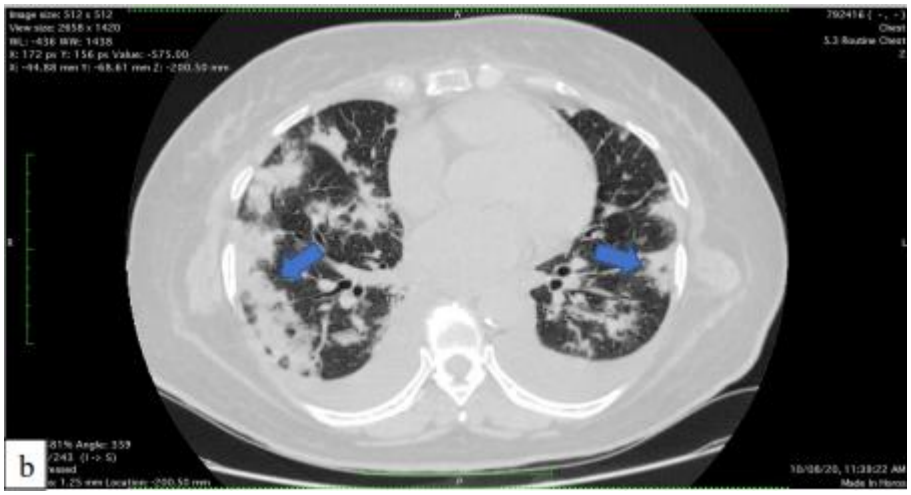


Figure 4 (a, b): Axial Chest CT scan showing large areas of consolidation (blue arrow) with an air bronchogram (red arrow) in right upper and lower lobe. Less extensive consolidations (blue arrow) can be seen in the left upper and lower lobe.

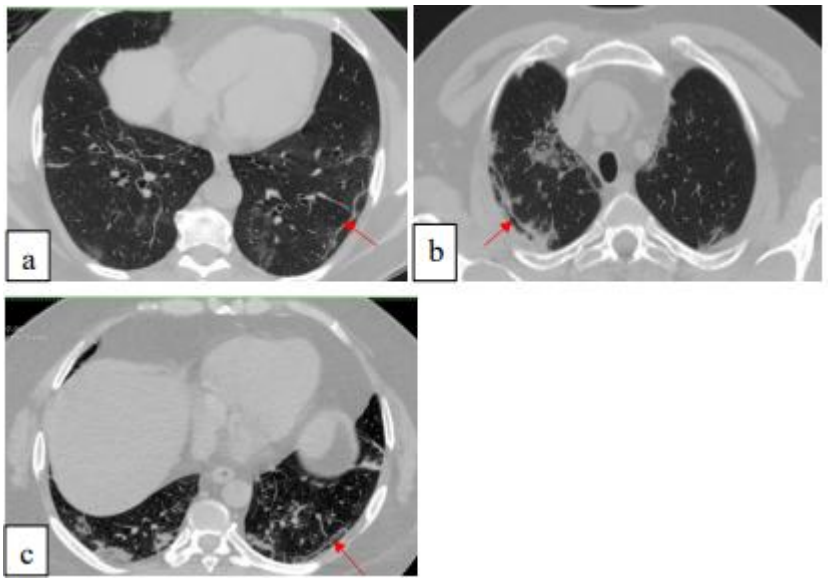
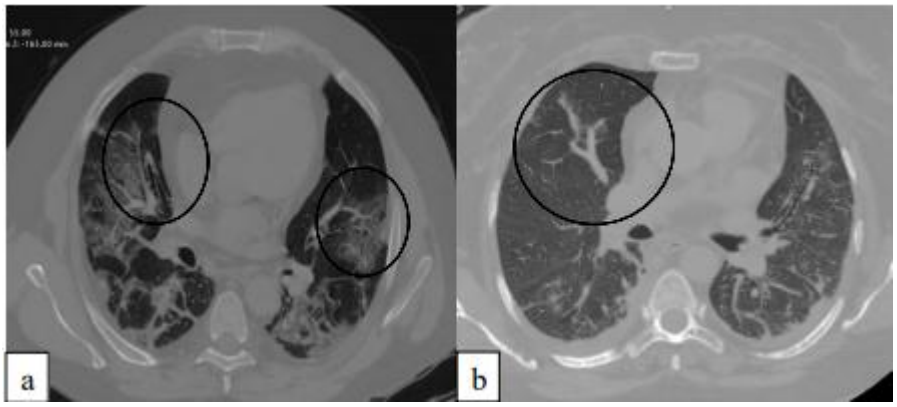


Figure 5 (a, b, c): Axial chest CT scan showing shows subpleural linear bands (red arrow)



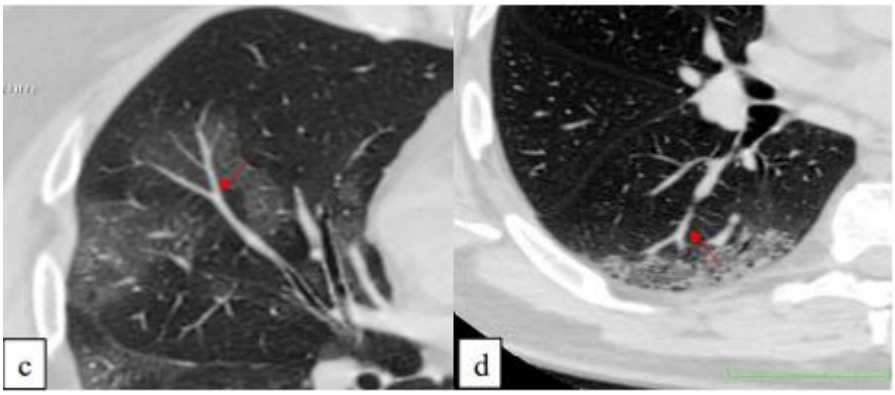


Figure 6 (a, b): Axial CT images and (c, d) magnified images shows ground glass opacities with perilesional and intralesional vascular enlargement (red arrow and black circle).

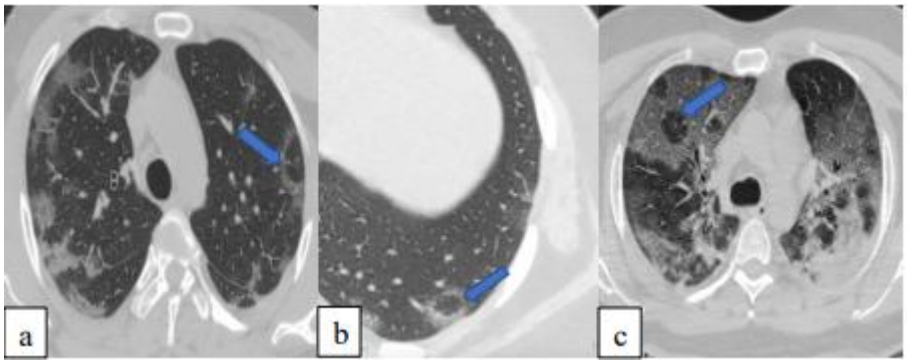


Figure 7(a, b, c): Non-contrast axial chest CT images in lung window settings showing areas of ground glass opacities with central area of lucency suggestive of reverse halo sign (blue arrow)

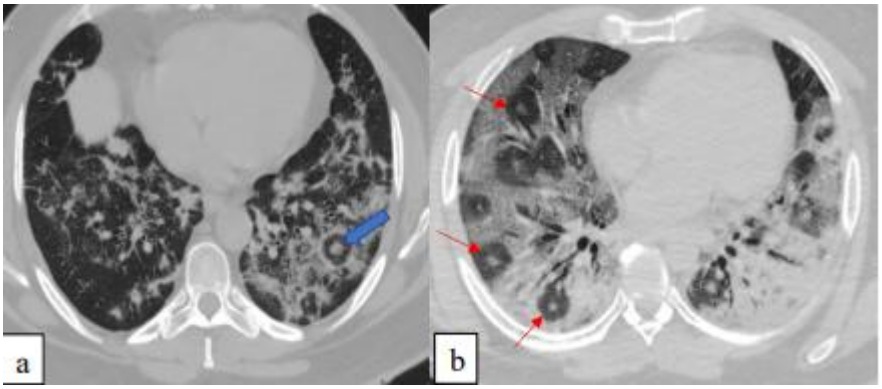


Figure 8: Axial Non-contrast axial chest CT images in lung window settings in two different COVID-19 positive patients shows (a) foci of central ground glass nodule surrounded by inner ring of air and an outer ring of ground glass(blue arrow). This appearance resembles a bullseye; (b) multiple reverse halo signs giving target appearance are seen in right lung(red arrow).

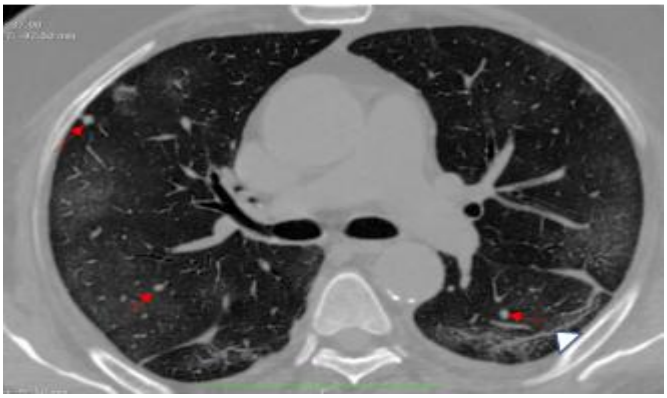


Figure 9: Axial CT image shows bilateral patchy areas of ground glass opacities with subpleural reticulations (arrowhead) and few nodules (red arrow) are seen in bilateral upper lobes.

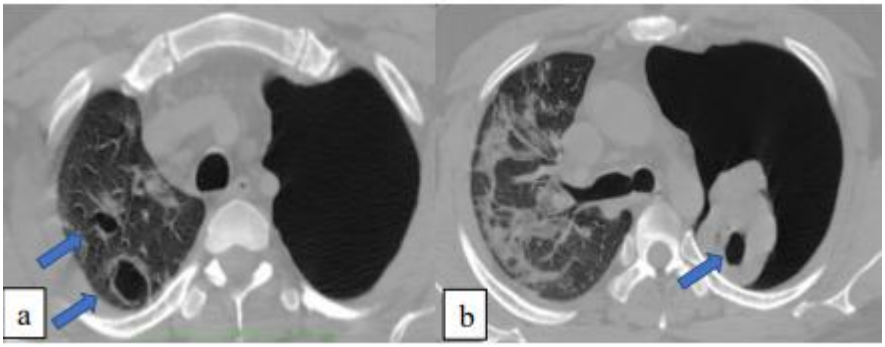


Figure 10 (a, b): Axial CT images in lung window settings shows large pneumothorax on left side with cavitatory changes in right upper lobe and visualized collapsed part of left lung (blue arrow). Patchy areas of consolidation admixed with ground glass opacities predominantly in peripheral distribution are seen in right upper lobe.

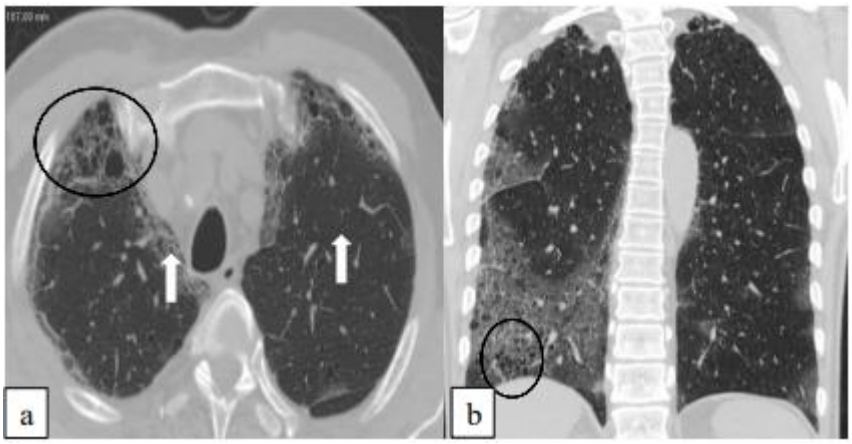


Figure 11(a, b): Diffuse areas of ground glass opacities with interlobular septal thickening, subpleural linear band and reticulations on underlying features of interstitial lung disease (black circle).

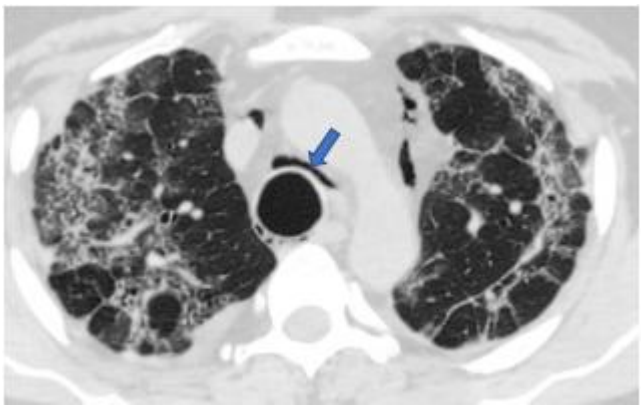


Figure 12: Axial CT image shows pneumomediastinum (blue arrow) with ground glass opacities with interlobular septal thickening and reticulations in bilateral upper lobes.

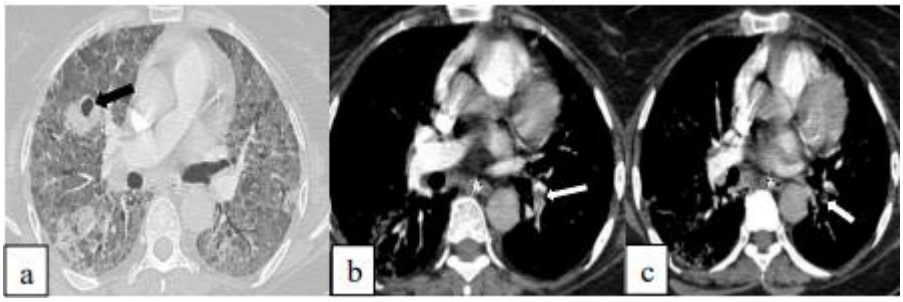


Figure 13 (a, b, c): Axial post contrast CT image in lung window setting of a patient with COVID-19 complicated pulmonary embolism in worsening stage of illness (a) shows bilobar diffuse ground glass opacities with interlobular septal thickening and consolidative cavitation (black arrow) in the right upper lobe; (b, c) CT angiographic image shows thrombus in the descending branch of left pulmonary artery(white arrow).

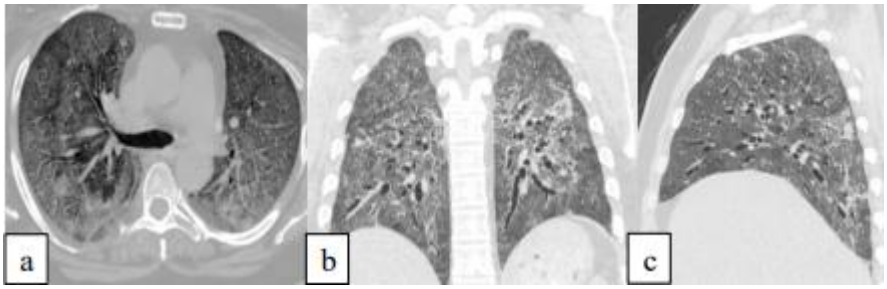


Figure 14 (a, b, c): Axial, Coronal and Sagittal CT images of a patient with severe disease [CT severity score 25] shows diffuse ground glass opacities with interlobular septal thickening associated with focal consolidations affecting all the lobes and lungs progressed to "white lung" stage

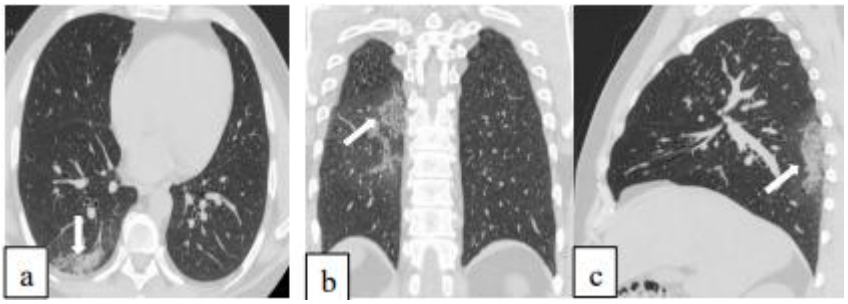


Figure 15 (a, b, c): Axial, Coronal and Sagittal CT images of a patient in mild disease category shows patch of consolidation with surrounding ground glass opacity in subpleural location in right lower lobe(white arrow).

Correlation of CT severity index with age, sex & mortality:

This study showed that the high percentage male patients had severe CT severity index as compared to female patients. However, the correlation of CT severity index with sex is not statistically significant (p value = 0.316). This study showed significant correlation of CT severity score and increasing age (p value = 0.003). There is significant correlation between high CT severity score and mortality rate (p-value= 0.001). Mortality rate is 21.7% in patients with severe CT severity score, 8.3% in patients with moderate CT severity score. No mortality is seen in patients with mild CT severity score.

4. Discussion

We conducted this prospective observational study to determine radiological spectrum of 220 patients presenting to our hospital with COVID-19 infection.

On studying the demographic profile of patients, we found that most of the patients (45.9%) were in the age group of 40-60 years and out of 220 patients, 171 (77.7%) were males and only 49 (22.3%) were females. This is in agreement with previous studies. **Liu Y et al.** [9], who studied 221 COVID-19 patients and divided them into two age groups taking age 60 years as the threshold. 136 (61.5%) were aged <60 years and other cases were aged > 60 years (38.5%). **Xu et al.** [10], who studied 62 patients reported that most of the COVID-19 patients were male 35(56%) and females were 27(44%).

In the present study, lung parenchymal abnormality was seen in all patients with RT-PCR confirmed SARS-CoV-2. This is in accordance with study of **Yu M et al.** [11] reported a CT positivity rate of 100 % in their study cohort. The high prevalence of CT findings in laboratory confirmed symptomatic SARS-CoV-2 patients in our population compared to the reported data from other countries raises the possibility of divergent course of the disease in different populations.

In the present study, considering the distribution of opacities, peripheral distribution of opacities was the commonest seen in 100.0% cases, among which subpleural distribution was in 98.6% cases, central distribution in 51.4% cases, peri-bronchial distribution in 48.2% cases and diffuse pattern was seen in 49.5% cases. None of the patients showed purely central distribution. **Parry et al**. [7] reported bilateral lung involvement was the commonest, observed in 76.5 %. Multiple lobe involvement was seen more frequently. Peripheral distribution was the commonest, seen in 100 % cases among which 70.6 % had only peripheral distribution whereas as 29.4% had both peripheral and central distribution. With regards to the type of opacity, GGO was the dominant abnormality found in all 220 (100%) cases. Among other studies, **Khanduri et al** [12]**,** reported that among 110 patients, ground-glass opacity (GGO) was the common abnormality found in almost all cases (100.0%). **Parry AH et al** [7], found that out of 147 RT-PCR positive COVID-19 patients, in patients who had abnormal CT findings , the most common findings were bilateral (76.5 %), multilobar (88.2%) lung involvement with mainly peripheral and posterior distribution. The most common opacity was ground glass opacity (GGO) present in all cases (100.0%). Peri-lesional or intralesional segmental or subsegmental pulmonary vessel enlargement was seen in 70.6% cases. The important finding of intra-lesional or peri-lesional pulmonary vessel enlargement was observed in 34.5% patients in our study. The finding of pulmonary vascular enlargement seems to have a diagnostic value as it has not been reported previously in any other infectious disease setting [12].

Halo sign is rare finding seen in only 0.9 % cases. It is not considered to be specific for COVID-19 as it has only been reported in a few case series. The reverse halo sign is uncommon finding found in 5% cases in our study. Few cases also develop target sign which is considered to be as variant of reverse halo sign. It is a new chest CT sign that has not been previously reported in covid-19 studies or any other pulmonary disease [13].

Existing lung disease findings like emphysema and features of old healed tuberculosis was seen in 3(1.4%) cases, whereas fibrosis/ILD features was noted in only 2(0.9%) cases. Lymphadenopathy is reported in 14.5% of patients with COVID-19 and it has been suggested as a likely significant risk factor for COVID-19-patients with severe/critical pneumonia.

CT scans may reveal diffuse opacities in both lungs, as well as the so-called white lung manifestation in severe cases [14]. In this stage, however, there are fewer patients, the ventilation function will be seriously impaired, requiring continuous oxygen inhalation and even ECMO (extracorporeal membrane pulmonary oxygenation)[14], therefore, early diagnosis is of paramount importance.

Out of 220 cases, severe, moderate, and mild CT severity scores were present in 106 (48.2%), 72(32.7%), and 42(19.1%) patients, respectively. In a similar study, **Saeed et al** [15]found that mild disease was seen in 36.5% patients, moderate in 34.3% , and severe in 6.8% patients.

This study showed positive correlation of CT severity score and increasing age (p value = 0.003). 106 patients were in severe disease category of which 48(45.3%) was of age group of >60 years. 72 patients had moderate CT severity score, of which 34(47.2%) was of age group of >60 years. This is in line with the findings of some previous studies. **Farghaly S et al**[16] also found that there was a positive strong significant correlation of total CT severity lung score with the age of the patient ($r = 0.64$, $P<0.001$).

In the present study, 106 (48.1%) patients had severe CT severity score, of which 84 (79.2%) were male patients and 22(20.8%) were female patients. 72 (32.7%) patients has moderate CT severity score of which 58 (80.6%) were male and 14(19.4%) were female (p value = 0.316). There is no significant correlation between CT severity index and gender, however percentage of severe CT score is overall higher in male gender.

The estimated mortality rate of covid-19 in our study is 13.2%. There was significant positive correlation between high CT severity score and mortality rate (p-value= 0.001). Mortality rate was 21.7% in patients with severe CT severity score, 8.3% in patients with moderate CT severity score. Similarly, **Hu Y et al**[17] reported dead patients to have more severity of disease than live patients. The present study was limited in the sense that there was lack of comparison between severity score and patient comorbidities.

This study has the potential to give valuable information to health system policymakers in India to use this information for the development of treatment strategies for COVID-19. A fairly reasonable number of cases were studied. So, it gives a fair idea of the CT scan findings in COVID-19 infected patients across various age groups and gender encountered in a hospital setting.

5. Conclusion

To conclude, most of the COVID-19 infected patients belonged to 40-60 years of age. Males were affected more than females. CT scan images showed lung parenchymal abnormality in all patients, with majority having bilateral lung involvement, upper and lower lobes of both lungs affected, and multiple lobe involvement seen. The peripheral distribution of opacities was present in our all cases, with subpleural distribution being most common. GGO was the dominant opacity. Other findings were reticulations, subpleural curvilinear lines, reverse halo sign, nodules, halo sign, cavitations, peri-lesional or intra-lesional vessel enlargement, air-bronchogram sign, and bronchiectasis. Severe cases were seen in almost half of the patients and mortality rate was reported to be 13.2%. Increment in CT severity score showed strong positive correlation with increasing age and mortality.

6. Future Recommendations

- Follow-up CTs are recommended for evaluation of the rapid progression of COVID-19 pneumonia (either in aggravation or absorption).
- The baseline/initial CT scores can be useful for stratification of patients, which is significantly helpful in this pandemic, particularly for appropriate management.
- CT scans can be helpful for physicians for management of COVID-19 as it can indicate the severity of disease and its outcomes.
- Further studies should be conducted for clarifying the role of chest CT for prognostication in COVID-19 disease, comprising correlation with outcomes in patients.
- More multicentre studies should be conducted for validation of the accuracy of the findings.

References

[1] Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., Zhao, X., Huang, B., Shi, W., Lu, R., Niu, P., Zhan, F., Ma, X., Wang, D., Xu, W., Wu, G., Gao, G. F., Tan, W., & China Novel Coronavirus Investigating and Research Team (2020). A Novel Coronavirus from Patients with Pneumonia in China, 2019. *The New England journal of medicine*, *382*(8), 727–733. https://doi.org/10.1056/NEJMoa2001017

[2] Andrews, M. A., Areekal, B., Rajesh, K. R., Krishnan, J., Suryakala, R., Krishnan, B., Muraly, C., & Santhosh, P. V. (2020). First confirmed case of COVID-19 infection in India: A case report. *Indian Journal of Medical Research*, *151*(5), 490 https://doi.org/10.4103/ijmr.ijmr_2131_20

[3] Chen, Y., & Li, L. (2020). SARS-CoV-2: virus dynamics and host response. *The Lancet. Infectious diseases*, *20*(5), 515–516.

https://doi.org/10.1016/S1473-3099(20)30235-8

[4] Wang, W., Tang, J., & Wei, F. (2020). Updated understanding of the outbreak of 2019 novel coronavirus (2019-nCoV) in Wuhan, China. *Journal of medical virology*, *92*(4), 441–447. https://doi.org/10.1002/jmv.25689

[5] Tahamtan, A., & Ardebili, A. (2020). Real-time RT-PCR in COVID-19 detection: issues affecting the results. *Expert review of molecular diagnostics*, *20*(5), 453–454. https://doi.org/10.1080/14737159.2020.1757437

[6] Fang, Y., Zhang, H., Xie, J., Lin, M., Ying, L., Pang, P., & Ji, W. (2020). Sensitivity of Chest CT for COVID-19: Comparison to RT-PCR. *Radiology*, *296*(2), E115–E117. https://doi.org/10.1148/radiol.2020200432

[7] Parry, A. H., Wani, A. H., Yaseen, M., Dar, K. A., Choh, N. A., Khan, N. A., Shah, N. N., & Jehangir, M. (2020). Spectrum of chest computed tomographic (CT) findings in coronavirus disease-19 (COVID-19) patients in India. *European journal of radiology*, *129*, 109147. https://doi.org/10.1016/j.ejrad.2020.109147

[8] Pan, F., Ye, T., Sun, P., Gui, S., Liang, B., Li, L., Zheng, D., Wang, J., Hesketh, R. L., Yang, L., & Zheng, C. (2020). Time Course of Lung Changes at Chest CT during Recovery from Coronavirus Disease 2019 (COVID-19). *Radiology*, *295*(3), 715–721. https://doi.org/10.1148/radiol.2020200370

[9] Liu, Y., Mao, B., Liang, S., Yang, J., Lu, H., Chai, Y., Wang, L., Zhang, L., Li, Q., Zhao, L., He, Y., Gu, X., Ji, X., Li, L., Jie, Z., Li, Q., Li, X., Lu, H., Zhang, W.,... Xu, J. (2020). Association between age and clinical characteristics and outcomes of COVID-19. *The European Respiratory Journal*, *55*(5), 2001112. https://doi.org/10.1183/13993003.01112-2020

[10] Xu, X., Wu, X., Jiang, X., Xu, K., Ying, L., Physician, C., MA, Li, S., Wang, H., Zhang, S., Gao, H., Sheng, J., Cai, H., Qiu, Y., & Li, L. (2020). Clinical findings in a group of patients infected with the 2019 novel coronavirus (SARS-Cov-2) outside of Wuhan, China: retrospective case series. *BMJ*, m606. https://doi.org/10.1136/bmj.m606

[11] Yu, M., Xu, D., Lan, L., Tu, M., Liao, R., Cai, S., Cao, Y., Xu, L., Liao, M., Zhang, X., Xiao, S., Li, Y., & Xu, H. (2020). Thin-Section Chest CT Imaging of COVID-19 Pneumonia: A Comparison Between Patients with Mild and Severe Disease. *Radiology*, *2*(2), e200126. https://doi.org/10.1148/ryct.202020012611; 2(2):e200126.

[12] Khanduri, S., Chawla, H., Khan, A., Ali, I., Krishnam, A., Malik, S. U. R., Khan, N. D., Patel, Y. D., Surbhi, & Rehman, M. (2021). Spectrum of Chest Dual-Energy Computed Tomography Findings in COVID Patients in North India. *Cureus* https://doi.org/10.7759/cureus.12489

[13] Caruso, D., Zerunian, M., Polici, M., Pucciarelli, F., Polidori, T., Rucci, C., Guido, G., Bracci, B., De Dominicis, C., & Laghi, A. (2020). Chest CT Features of COVID-19 in Rome, Italy. *Radiology*, *296*(2), E79–E85. https://doi.org/10.1148/radiol.2020201237

[14] Pan, Y., & Guan, H. (2020). Imaging changes in patients with 2019-nCov. *European radiology*, *30*(7), 3612–3613. https://doi.org/10.1007/s00330-020-06713-z

[15] Saeed, G. A., Gaba, W., Shah, A., Al Helali, A. A., Raidullah, E., Al Ali, A. B., Elghazali, M., Ahmed, D. Y., Al Kaabi, S. G., & Almazrouei, S. (2021). Correlation between Chest CT Severity Scores and the Clinical Parameters of Adult Patients with COVID-19 Pneumonia. *Radiology research and practice*, *2021*, 6697677. https://doi.org/10.1155/2021/6697677

[16] Farghaly, S., & Makboul, M. (2021). Correlation between age, sex, and severity of Coronavirus disease-19 based on chest computed tomography severity scoring system. *Egyptian Journal of Radiology and Nuclear Medicine*, *52*(1). https://doi.org/10.1186/s43055-021-00408-1

[17] Hu, Y., Zhan, C., Chen, C., Ai, T., & Xia, L. (2020). Chest CT findings related to mortality of patients with COVID-19: A retrospective case-series study. *PLOS ONE*, *15*(8), e0237302. https://doi.org/10.1371/journal.pone.0237302