ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023

# CLINICO-RADIOLOGICAL EVALUATION AND CORRELATION OF HRCT CHEST IMAGING FINDINGS WITH DISEASE STATUS IN COVID-19 PATIENTS

**Dr. Sreedhar Mohan Menon[1], Dr. Kamal Kumar Sen[2], Dr. Sudhansu Sekhar Mohanty[3], Dr. Sangram Panda[4], Dr. Kolluru Radha Krishna[5*], Dr. Yalamanchi Rajesh[6]**

1. PG Resident, Department of Radio-diagnosis, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha - 751024, India. ORCID 0000-0003-2989-205X
2. Professor, Department of Radio-diagnosis, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha - 751024, India.
3. Assistant Professor, Department of Radio-diagnosis, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha - 751024, India.
4. Assistant Professor, Department of Radio-diagnosis, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha - 751024, India.
5. PG Resident, Department of Radio-diagnosis, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha - 751024, India.
6. PG Resident, Department of Radio-diagnosis, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha - 751024, India.

***Corresponding author: Dr. Kolluru Radha Krishna**
PG Resident, Department of Radio-diagnosis, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha - 751024, India.
Email: radhakrishna.kolluru@gmail.com

**Abstract**

**Background:** High-resolution computed tomography (HRCT) chest is rapid and has a strong sensitivity for diagnosing viral pneumonia including COVID 19 disease in its early stages in comparison to RT-PCR, thus being crucial in triaging patients for treatment and isolation, to prevent further transmission of the disease. In this study we are going to analyse the temporal changes in imaging findings of COVID-19 on HRCT chest.

**Methods:** prospective study was conducted in the Department of Radiology of an exclusive 500 bedded COVID Hospital in Bhubaneswar, Odisha, India. Evaluation of hundred patients was done based on inclusion and exclusion criteria, after obtaining informed consent over a period of 2 years from September 2020 to September 2022. All pertinent epidemiological data was gathered from hospital records. All COVID 19 RT-PCR positive patients who underwent HRCT Chest on admission and repeat scan within 30 days, following the progression of the disease were included. Those who were clinically suspected COVID cases but were RT PCR negative on RT-PCR testing, were excluded.

**Results:** HRCT chest demonstrated diffuse ground glass opacities to be the predominant finding (55%) with the associated findings of sub pleural atelectatic bands (31%) and septal thickening (23%). There was a positive correlation of blood parameters like CRP in COVID patients. A higher incidence was found in patients with Type-2 diabetes mellitus, followed by those with hypertension. In majority of the cases (80%) bilateral lungs and in about 81% cases, two or more lung lobes were involved. Mild and moderately ill patients were found to

ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023

have a CTSS (CT severity score) in the score range of 15-25. Typical category was the most common type followed by atypical and indeterminate categories.
**Conclusions:** 'Typical pattern' along with diffuse ground glass opacities of multiple lobes in the HRCT chest was the most common pattern of lung involvement. High Computer Tomography Severity Score (CTSS) corresponds to a higher disease severity, which helps in taking a timely decision for early treatment. HRCT Thorax has early and fast diagnostic capability as compared to RT-PCR in the detection of COVID-19. The elderly and those with comorbidities are at a higher risk of developing severe disease. Blood parameters like CRP can be used for disease monitoring and follow-up purposes.
**Keywords:** COVID-19, HRCT chest, Follow up scan, clinical correlation, Computer Tomography Severity Score (CTSS), typical, atypical.

## 1. BACKGROUND

In December 2019, in a Chinese city named Wuhan there was an outbreak of febrile respiratory illnesses caused by a novel coronavirus, then named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). [1,2]
Till recently COVID-19 was screened using Rapid Antigen Testing, Reverse Transcriptase Polymerase Chain Reaction, and Computed Tomography. [3,4]. Compared to RT-PCR, HRCT is more rapid and has a stronger sensitivity for diagnosing viral pneumonia in its early stages. [5] HRCT provides valuable information earlier than RT-PCR, thereby helping healthcare providers to identify the disease even before the symptoms become evident in the patient. Early detection of the disease with appropriate care for the patient results in a better prognosis. [4,5]
The current study is performed so as to evaluate the temporal clinico-radiological changes over the course of the disease and to identify the HRCT chest imaging features of COVID19. The current study also focuses on the correlation of the chest imaging findings with the disease severity in the patients.

## 2. Methods

**Study Design:** This prospective study was conducted in the Department of Radiology of an exclusive 500 bedded COVID Hospital in Bhubaneswar, Odisha, India. Evaluation of hundred patients was done based on inclusion and exclusion criteria, after obtaining informed consent over a period of 2 years from September 2020 to September 2022. All pertinent epidemiological data was gathered from hospital records.
All COVID 19 RT-PCR positive patients who underwent HRCT Chest on admission and repeat scan within 30 days, following the progression of the disease were included. Those who were clinically suspected COVID cases but were RT PCR negative on RT-PCR testing, were excluded.
HRCT chest scans were obtained with multi-slice helical CT scanner (Siemens 64 slice (SOMATOM go. Up,) using SAFIRE (Sinogram Affirmed Iterative Reconstruction) technology. All the scans were taken during end-inspiration without intravenous contrast. Technical parameters of the scan are:

| | |
|---|---|
| Tube voltage | 110-120 kV |
| Effective mAs | 70-120 mAs |

ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023

| | |
|---|---|
| Pitch | 0.8 |
| Slice thickness | 0.5mm |
| Inter slice gap | 0 mm |

Assessment for extent of lung parenchymal involvement in CT chest images was done using CT severity score (CTSS). A score between 0 and 5 was assigned based on the percentage parenchymal involvement in each of the five lobes involved. [6] (1 for < 5% involvement, 2 for 5–25% involvement, 3 for 26–49% involvement, 4 for 50–75% involvement and 5 for > 75% involvements).

The CTSS is the sum of all lobar scores and can range from 0 (no involvement) to 25 (maximum involvement).

The pattern of CT changes was broadly divided into four types according to the RSNA Expert Consensus [7]:

1.Typical: - Peripheral, bilateral (multilobar) GGO or multifocal GGO of rounded morphology with or without consolidation or visible intralobular lines (crazy paving) - Reverse halo sign or other findings of organizing pneumonia.

2. Indeterminate: Absence of typical features and the presence of - Multifocal, diffuse, perihilar or unilateral GGO with or without consolidation and are non-rounded or non-peripheral. - Few very small GGO with a non-rounded& non peripheral distribution.

3. Atypical: Absence of typical or indeterminate features and presence of - Isolated lobar or segmental distribution without GGO. - Discrete small nodules (centrilobular, tree in bud). - Lung cavitation. - Smooth interlobular septal thickening with pleural effusion

4. Negative: No CT features to suggest pneumonia.

## 3. RESULTS

During this two-year study period, of the 100 patients that were positive for COVID 19 disease, 73% were male and 27% were female, showing a male preponderance. 39% of the patients belonged to the age group 40 to 60 years, followed by 32% to the age group 21 to 40 years. Rh positive was the more predominant blood group (with an incidence of 97%) in COVID 19 patients. In ABO blood group, 'O' positive showed a maximum incidence (43%), followed by B-positive (27%). 94% of patients were found to have symptoms like fever, headache, and shortness of breath while 6 % were asymptomatic. (Table-1). In this study in the COVID 19 patients the incidence of patients with Type-2 diabetes mellitus, hypertension and asthma was found to be 16%, 14% and 3% respectively, followed by CKD, hypothyroidism and anemia, which were found to be 1% each (Table- 2). Table -3 shows the percentage of patients with HRCT associated findings like sub pleural atelectatic bands, septal thickening, lymphadenopathy, pleural effusion, cavitatory lesions, bronchiectasis, pneumo-mediastinum, emphysema and pneumothorax on both the first and repeat scans. Involvement of bilateral lungs and more than two lobar involvements in both first and repeat scans was as shown in Table-3. The percentages of GGO, GGO with consolidation and pure consolidations were 8%, 87% and 3% respectively in initial scans and 13%, 83% and 1% respectively in repeat scans as shown in Table -3. Table-3 also shows the distribution of opacities along with lobar involvement and number of lobes affected.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023

Patients with CTSS (CT severity score) corresponding to mild, moderate and severe category in both initial and repeat scans is shown in Table -4. Typical category was the most common type, followed by atypical and indeterminate category of COVID cases. Fig 4 shows a positive correlation between clinical parameters like CRP with CTSS.

**Table 1:** Distribution of clinical presentation in the study group.

| **CLINICAL PRESENTATION** | **NO OF PATIENTS (%)** |
|---|---|
| Fever | 74 |
| SOB | 51 |
| Cough | 44 |
| Palpitation | 2 |
| Diarrhoea | 3 |
| Headache | 3 |
| Asymptomatic | 6 |

**Table 2:** Frequency of each comorbidity in the study population

| **COMORBIDITIES** | **NO OF PATIENTS (%)** |
|---|---|
| **T2DM** | 16 |
| **HTN** | 14 |
| **ASTHMA** | 3 |
| **CKD** | 1 |
| **HYPOTHYROIDISM** | 1 |
| **ANAEMIA** | 1 |

**Table 3:** Distribution of parenchymal opacification, associated findings, Opacity distribution, Number of lobes affected and lobes affected on initial vs repeat HRCT scans.

| **CT features** | **First scan (%)** | **Repeat Scan(<30days) (%)** |
|---|---|---|
| **Parenchymal opacifications** | | |
| Only GGO present | 8 | 13 |
| GGO and consolidation both present | 87 | 83 |
| Only consolidation | 3 | 1 |
| Normal Scan | 2 | 3 |
| **Associated findings** | **First scan** | **Repeat Scan** |
| Sub pleural bands/Atelectasis/Fibrotic stripes | 21 | 31 |
| Septal thickening (Crazy paving and Reticular pattern) | 23 | 20 |
| Pulmonary nodules | 6 | 5 |
| Thoracic lymphadenopathy | 6 | 8 |
| Pleural effusion | 2 | 5 |
| Cavitary lesion | 1 | 1 |
| Bronchiectasis | 2 | 4 |
| Pneumomediastinum | 0 | 1 |
| Pulmonary emphysema | 1 | 2 |

ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023

| | | |
|---|---|---|
| Pneumothorax | 0 | 2 |
| **Opacity distribution** | **First scan** | **Repeat Scan** |
| Peripheral | 55 | 56 |
| Both | 33 | 30 |
| Central | 1 | 0 |
| no involvement | 11 | 14 |
| **Number of lobes affected** | **First scan** | **Repeat Scan** |
| 1 | 6 | 9 |
| ≥2 | 81 | 78 |
| B/L lung disease | 80 | 79 |
| U/L | 10 | 8 |
| **Lobes affected** | **First scan** | **Repeat Scan** |
| Right Upper Lobe | 5 | 4 |
| Right Middle Lobe | 4 | 6 |
| Right Lower Lobe | 23 | 25 |
| Left Upper Lobe | 3 | 5 |
| Left Lower Lobe | 18 | 18 |
| All Lobes | 70 | 65 |

**Table 4:** Clinical Severity corresponding to the CT severity score.

| **CT Severity Score (CTSS)** | **CLINICAL SEVERITY** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **ASYMPTOMATIC** | | **MILD** | | **MODERATE** | | **SEVERE** | |
| | INITIAL SCAN (%) | REPEAT SCAN (%) | INITIAL SCAN (%) | REPEAT SCAN (%) | INITIAL SCAN (%) | REPEAT SCAN (%) | INITIAL SCAN (%) | REPEAT SCAN (%) |
| **0** | 2 | 2 | 3 | 5 | 6 | 6 | - | 2 |
| **1-7** | 1 | 2 | 10 | 16 | 8 | 11 | 1 | 1 |
| **8-14** | 2 | 1 | 16 | 9 | 7 | 9 | - | - |
| **15-25** | - | - | 15 | 14 | 22 | 17 | 7 | 5 |
| **TOTAL** | 5 | 5 | 44 | 44 | 43 | 43 | 8 | 8 |

## 4. DISCUSSION

The current study was done to analyse and correlate the HRCT chest findings in COVID-19 patients with their symptomatology and clinical severity. This study helps in evaluating the potential roles of HRCT in the diagnosis, treatment and prognosis of COVID-19 disease. Our study involves 100 patients admitted in our COVID dedicated hospital who were followed up with a repeat CT scan within 30 days.

Male preponderance, with a male to female ratio of 2.7:1 is noted in COVID-19 disease which is compatible with a study done by Bwire et al. [8]

**ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023**

39% of the patients belonged to the age group 40 years to 60 years followed by 32% in the age group 21 to 40 years, with a difference of only 7% which is similar to a study done by Ying Xiong et al. [9]

Around 83% of asymptomatic patients came under the age group of 21-40 years of age. A majority (74%) of patients had fever followed by Shortness of Breath (SOB) and cough accounting for about 51% and 44% respectively. Only 3% of the study group showed gastrointestinal symptoms. These findings are corroborated by Guan et al. [10], Chen et al. [11], Shi et al. [12]and Huang et al. [13]

Rh positive was the more predominant blood group (with an incidence of 97%) in COVID 19 patients. In ABO blood group, 'O' positive showed a maximum incidence (43%), followed by B-positive (27%). This is corroborated by a study done by Zietz M et al. [14]

Higher incidence was seen in patients with comorbidities especially with Type-2 Diabetes Mellitus (16%) followed by systemic hypertension (14%). Yang J, et al. [15] stated that the most prevalent comorbidities were hypertension ( 17±7, 95% CI 14-22% ) and diabetes ( 8±6, 95% CI 6-11% ).

We found maximum number of cases in initial scans to have GGO and consolidations (87%) and minimum with only consolidation (3%). However, repeat scan done within 30 days showed resolution of mixed GGO and consolidation pattern (83%) (Figure-1), along with only consolidation (1%) and increase in number of cases with GGO i.e. 13%. This suggests that consolidations gradually get absorbed leaving an increased number of cases with residual GGOs, which is consistent with a study done by Mahdavi A. et al [16] and Pan F et al. [6]

Numerous associated findings were found on radiologically positive cases in both initial and follow-up scans. Crazy paving pattern with septal thickening was predominant in the initial scan accounting for about 23% of cases, followed by curvilinear subpleural bands and atelectasis amounting to about 21% of cases. In the follow-up scans, there was an increment in the number of atelectasis resulting in 31% of curvilinear subpleural bands and atelectasis, followed by 20% of septal thickening (crazy paving pattern) which is in accordance with a study done by Mahdavi A. et al [16] and Pan F et al. [6]

Other findings including pulmonary nodules, thoracic lymphadenopathy, pleural effusion, cavitary lesions, bronchiectasis, pneumothorax, pneumomediastinum, and pulmonary emphysema, were also seen in few cases which are categorised in Atypical category. (Table 3) In our study, typical CT findings were seen in a significant proportion of cases (82%) and the most common finding on CT is ground glass opacity with or without consolidation. Other typical findings include peripheral location of the lesion, lower lobe preponderance, multi-lobar involvement, bilaterality, and septal thickening (crazy paving pattern), as seen in Fig. 2. Shi et al. [12] published their cohort study in 2020 wherein they showed a predominance of Ground Glass Opacity with or without consolidation which was predominantly bilateral peripherally located lesions. These are considered as the typical features of COVID-19 disease. Kwee TC et al. [17] stated the characteristics of typical, atypical and indeterminate pattern of COVID 19 in HRCT chest which is in accordance with our study.

The distribution of opacities was seen peripherally (typical presentation) in most cases during the initial scan and repeat scan, with incidence values of 55% and 56% respectively. (Table 3). In this study, a vast majority of cases (80%) showed bilateral involvement of lungs and about 81% cases were found to have two or more lobes involved (Table 3). In the initial CT scan, all the lobes were affected in 70% of cases, among which lower lobes were involved predominantly (Table 3). Kwee TC et al [17] showed a similar distribution of lung opacities and lobar involvement as found in our study.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023

Typical features of COVID 19 HRCT chest images are reverse halo sign, peripheral ground glass opacities and crazy paving pattern (Fig.2). Atypical features of COVID 19 HRCT chest images such as subpleural curvilinear opacification; pneumothorax, pneumoediastinum and subcutaneous emphysema; mediastinal lymphadenopathy; tree in bud nodules; peripheral confluent ground glass opacifications; segmental consolidation(Fig.3).

The relationship between CT Severity score and Clinical severity of the COVID-19 disease was found to be highly relevant in our study as severely ill COVID-19 patients had CT severity scores (CTSS) more than or equal to 15 in both initial and repeat scans. Patients with mild to moderate disease had a CTSS ranging from 0-7 and among those, a majority showed complete resolution of the chest findings (Figure-1) along with improvement in disease status on repeat scans. Table-4 shows reduction in CTSS (8-14 and 15-25) in mild, moderate and severe cases in repeat scans, however there is relative increase in number of cases with CTSS between 1-7, as on resolution the cases with higher CTSS improved to a lower CTSS category, i.e. 1-7. The relevance of CT severity score has already been studied by Sharma S et al. [18], who showed the importance of CT severity scores in identifying the severity of the illness, thereby helping with the management of the same.

In the study, a positive Pearson's correlation was found between biochemical parameters like CRP with CT Severity Score which implies that disease severity increases with increase in blood parameters like CRP and TLC. (Fig 4,5) Therefore, disease severity can be monitored or followed up by using these blood parameters. Guan et al. [10] and Bhandari S et al. [19] and Ahmed NO et al [20] demonstrated that biochemical parameters like CRP also show a positive correlation with CT severity score.

## 5. CONCLUSIONS

Typical pattern along with diffuse involvement of multiple lobes in the HRCT chest is the most common pattern of lung involvement. High Computer Tomography Severity Score (CTSS) corresponds to a higher disease severity, which helps in taking a timely decision for early treatment. Elderly patients and patients with comorbidities are at high risk of developing severe disease. Blood parameter like CRP can be used for disease monitoring and follow-up purposes. COVID-19 is most prevalent in people with 'O' positive blood group. As the time progresses (>30 days) in HRCT chest, there is gradual clearance of lung opacities like ground glass opacities, consolidations with the formation of predominant subpleural atelectatic bands, fibrotic strands along with features of mild fibrosis (mild bronchiectasis) and multiple intraparenchymal cystic changes. HRCT Thorax has early and fast diagnostic capability as compared to RT-PCR in COVID-19 patients.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023

## Figures

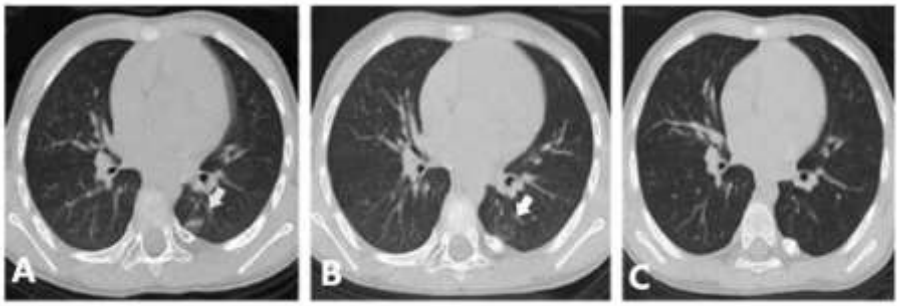


*Fig 1*

A 25-year-old male who has had a dry cough and fever for two days. Subpleural GGO with consolidation was visible on high-resolution CT in the left lower lobe (A). Repeat chest CT after 5 days of therapy revealed the lesion had healed (B). Chest CT 13 days after admission revealed full resolution (C).

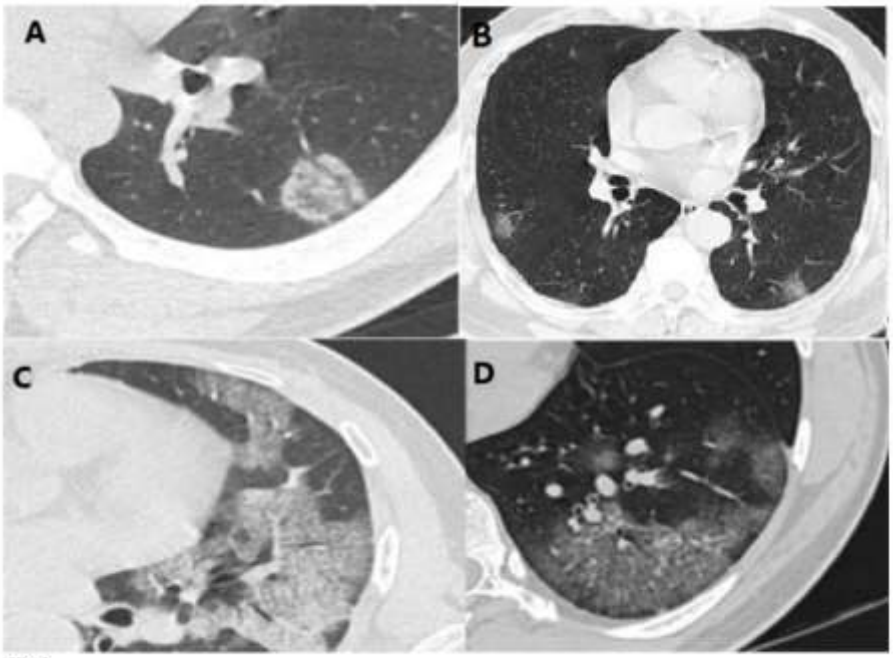


*Fig2*

Axial HRCT chest images showing typical features in COVID-19 reverse halo sign (**A**); peripheral ground glass opacities(**B**) and crazy paving pattern(**C,D**)

ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023

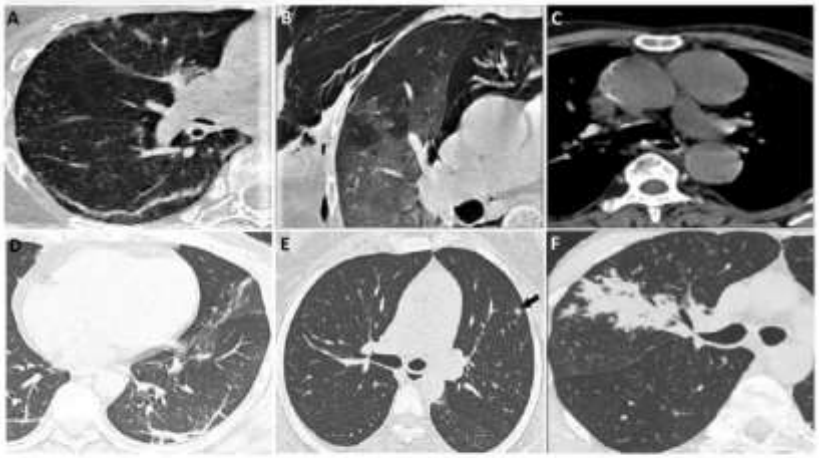


*Fig3*

Axial HRCT chest images of different patients depicting atypical imaging features. Subpleural curvilinear opacification (**A**); ground glass opacification, pneumothorax, pneumoediastinum and subcutaneous emphysema (**B**); mediastinal lymphadenopathy(**C**); tree in bud nodules(**D**); solitary ground glass opacification nodule(**E**); segmental consolidation(**F**)

**Pearson's Correlation Between Serum CRP values with CT severity score.**

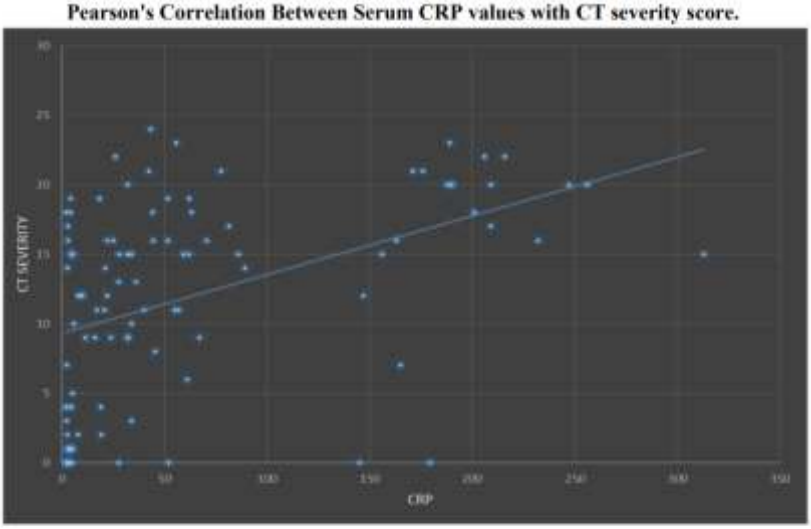


*Fig 4*

Pearson's correlation showing a positive correlation between CRP and CT severity score.

**List of abbreviations**

| | |
|---|---|
| **COVID-19** | Corona Virus Disease 2019 |
| **SARS-CoV-2** | Severe Acute Respiratory Syndrome Corona Virus-2 |
| **WHO** | World Health Organization |
| **RT-PCR** | Reverse Transcriptase Polymerase Chain Reaction |
| **HRCT** | High-resolution Computed Tomography |
| **CT** | Computed Tomography |
| **GGO** | Ground glass opacities |
| **CoV** | Corona Virus |
| **CKD** | Chronic kidney disease |
| **HTN** | Hypertension |
| **T2DM** | Type 2 diabetes |

ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023

| | |
|---|---|
| **SpO2** | Oxygen saturation |
| **kV** | Kilo Volt |
| **mAs** | Milliampere-seconds |
| **Mm** | Millimeter |
| **CTSS** | CT Severity Score |
| **CRP** | C-reactive protein |
| **TLC** | Total Leukocyte Count |
| **SAFIRE** | Sinogram Affirmed Iterative Reconstruction |

## 6. REFERENCES


1. Li Y, Xia L (2020) Coronavirus disease 2019 (COVID-19): role of chest CT in diagnosis and management. Am J Roentgenol 214(6):1280–1286.
2. Ksiazek TG, Erdman D, Goldsmith CS, Zaki SR, Peret T, Emery S, Tong S, Urbani C, Comer JA, Lim W, Rollin PE. A novel coronavirus associated with severe acute respiratory syndrome. New England journal of medicine. 2003 May 15;348(20):1953-66.
3. Xie X, Zhong Z, Zhao W, Zheng C, Wang F, Liu J. Chest CT for typical 2019-nCoV pneumonia: relationship to negative RT-PCR testing. Radiology. 2020 Feb 12.
4. Lipsitch M, Swerdlow DL, Finelli L. Defining the epidemiology of Covid-19—studies needed. New England journal of medicine. 2020 Mar 26;382(13):1194-6.
5. Fang Y, Zhang H, Xie J, Lin M, Ying L, Pang P, Ji W. Sensitivity of chest CT for COVID-19: comparison to RT-PCR. Radiology. 2020 Aug 19.
6. Pan F, Ye T, Sun P, Gui S, Liang B, Li L, Zheng D, Wang J, Hesketh RL, Yang L, Zheng C. Time course of lung changes at chest CT during recovery from coronavirus disease 2019 (COVID-19). Radiology. 2020 Jun;295(3):715-21.
7. Foust AM, Phillips GS, Chu WC, Daltro P, Das KM, Garcia-Peña P, Kilborn T, Winant AJ, Lee EY. International expert consensus statement on chest imaging in pediatric COVID-19 patient management: imaging findings, imaging study reporting, and imaging study recommendations. Radiology: cardiothoracic imaging. 2020 Apr 23:e200214.
8. Bwire GM. Coronavirus: why men are more vulnerable to Covid-19 than women? SN comprehensive clinical medicine. 2020 Jul;2(7):874-6.
9. Xiong Y, Sun D, Liu Y, Fan Y, Zhao L, Li X, Zhu W. Clinical and high-resolution CT features of the COVID-19 infection: comparison of the initial and follow-up changes. Investigative radiology. 2020.
10. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, Liu L, Shan H, Lei CL, Hui DS, Du B. Clinical characteristics of coronavirus disease 2019 in China. New England journal of medicine. 2020 Apr 30;382(18):1708-20.
11. Chen H, Guo J, Wang C, Luo F, Yu X, Zhang W, Li J, Zhao D, Xu D, Gong Q, Liao J. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. The lancet. 2020 Mar 7;395(10226):809-15.
12. Shi H. et al. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. Lancet Infect. Dis. 20, 425–434 (2020).
13. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020;395(10223):497–506.
14. Zietz M, Zucker J, Tatonetti NP. Associations between blood type and COVID-19 infection, intubation, and death. Nature communications. 2020 Nov 13;11(1):1-6.
15. Yang J, Zheng Y, Gou X, Pu K, Chen Z, Guo Q, Ji R, Wang H, Wang Y, Zhou Y.

**ISSN: 0975-3583,0976-2833 VOL14, ISSUE04, 2023**

Prevalence of comorbidities in the novel Wuhan coronavirus (COVID-19) infection: a systematic review and meta-analysis. Int J Infect Dis. 2020 Mar 12;94(1):91-5.
16. Mahdavi A, Haseli S, Mahdavi A, Bakhshayeshkaram M, Foroumandi M, Nekooghadam SM, Raoufi M, Taheri MS. The role of repeat chest CT scan in the COVID-19 pandemic. Academic Radiology. 2020 Jul 1;27(7):1049-50.
17. Kwee TC, Kwee RM. Chest CT in COVID-19: what the radiologist needs to know. Radiographics. 2020 Nov;40(7):1848.
18. Sharma S, Aggarwal A, Sharma RK, Patras E, Singhal A. Correlation of chest CT severity score with clinical parameters in COVID-19 pulmonary disease in a tertiary care hospital in Delhi during the pandemic period. Egyptian Journal of Radiology and Nuclear Medicine. 2022 Dec;53(1):1-8.
19. Bhandari S, Rankawat G, Bagarhatta M, Singh A, Singh A, Gupta V, Sharma S, Sharma R. Clinico-Radiological Evaluation and Correlation of CT Chest Images with Progress of Disease in COVID-19 Patients. J Assoc Physicians India. 2020:34-42.
20. Ahmed NO, Abbas SN, Mostafa MM, Ghani AM, Deif MS. Chest computed tomography severity score and its correlation with age group, sex, and laboratory test results among coronavirus disease 2019 health-care workers. The Egyptian Journal of Chest Diseases and Tuberculosis. 2022 Jan 1;71(1):88.