

ROLE OF CO-RADS CLASSIFICATION AND COMPARISON OF CHEST COMPUTERIZED TOMOGRAPHY WITH POLYMERASE CHAIN REACTION IN COVID-19 PATIENTS

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ABSTRACT

Objective: To determine the radiological parameters of COVID-19 patients based on CO-RADS classification and to compare the RT-PCR with chest CT.

Materials and Methods: This cross sectional study involved 180 participants who were hospitalised in COVID Unit of Farooq Hospital, West Wood, Lahore from April 2020 to July 2020. Data was collected from suspected COVID-19 patients who were subjected to CT chest and RT-PCR. SPSS version 22.0 was used to analyse the data. Frequency and percentages were calculated for categorical variables while mean and standard deviation was calculated for numerical variables.

Results: Of the total 180 patients, there was frequent manifestation of ground-glass opacities (GGOs) 168 (93%) followed by consolidation 121(67%) and reticulation/thickened interlobular septa 41 (23%) in radiological features of our study. Whereas, nodular lesions were completely absent. The highest number of patients 132 (73%) were in CO-RADS 5 classification. GGOs 126 (95%); and consolidations 93 (77%) were also highest in CO-RADS 5. Only 143(79%) of total RT-PCR tests were positive when compared with chest CT 158(88%).

Conclusion: CO-RADS categorical assessment scheme indicates a significant prevalence of GGOs in COVID-19 patients. RT-PCR of most of the patients was negative at the time of admission but on radiological analysis they had positive CT findings suggestive of COVID-19.

Keywords: COVID-19, Tomography, Pneumonia

INTRODUCTION

The rapid spread of the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS CoV-2) has culminated into a worldwide outbreak of respiratory malady ranging from mild, self-limited disease to severe pneumonia and acute respiratory distress syndrome (ARDS).^{1,2} Primary target of Coronavirus disease 2019 (COVID-19) is the respiratory system that can quickly escalate to ARDS. The advancing age and various comorbidities are linked to high mortality risk in such patients. The lung damage is

due to acute systemic inflammatory response which can progress to ARDS. There is destruction of epithelial and endothelial cells in this process as a result of the diffuse alveolar injury which marks the initial exudative phase.³

In this perfect storm situation, reverse transcriptase-polymerase chain reaction (RT-PCR) assay remains the mainstay for the diagnosis of COVID-19 in laboratories. However, diagnostic test efficacy of RT-PCR varies and is dependent on various factors; the significant ones being days after the symptom onset, quality, and type of sample taken and the use of dissimilar quality of kits. According to one study, the sensitivity of SARS CoV-2 RT-PCR in clinical practice has been reported to be in a range between 42% and 83% and hence can elicit false negative

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results. There have been various cases in which PCR remained negative or manifested positive results solely after repeated negative results in patients suffering from typical COVID-19 symptoms and imaging characteristics. Another downside is related to the turnaround time of RT-PCR results which due to an increase in demand may take time to deliver results. This may have implications in terms of burden in wards, particularly when admitting and releasing COVID-19 patients.^{4,5,6,7}

Chest computerized tomography (CT) is a valuable addition to RT-PCR and has demonstrated high sensitivity to diagnose COVID-19 patients. CT scan is not only used as a diagnostic tool but also it can help in predicting the disease advancement and monitoring the response to disease management.^{8,9}

There have been numerous efforts to standardize the reporting of CT for suspected COVID-19. In March 2020, the Dutch Radiological Society developed COVID-19 Reporting and Data System (CO-RADS) classification which is a six-category system that is used by radiologists to suspect and identify the progression of disease based on pulmonary involvement of COVID-19 on non-enhanced CT scan of the chest. CO-RADS 1 is characterized by a normal CT or CT findings with a non-infectious cause like emphysema, perifissural nodules, lung malignancy indicating a very less possibility of COVID-19 pulmonary involvement. Whereas, in CO-RADS 2, there is a low level of suspicion for pulmonary COVID-19 involvement as CT abnormalities are representative of infectious cause that is still not considered distinctive of COVID-19. This may include centrilobular nodular patterns, consolidation and lung cavitation. It is uncertain if COVID-19 infection is present in CO-RADS 3 because CT results also show lung involvement in other viral pneumonia or non-infectious causes. The observed findings may include ground-glass appearance either alone or in conjunction with a smooth interlobular septal thickening.

CO-RADS 4 is suggestive of high & CO-RADS 5 very high level of suspicion of COVID-19 pulmonary involvement. CO-RADS 4 is consistent with the findings of CO-RADS 5, but they are not located in contact with visceral pleura or are strictly confined unilaterally. Ground-glass opacities (with or without consolidation) in lung areas near to visceral pleural

surfaces are observed in CO-RADS 5 CT scans. Moreover, the crazy-paving pattern, opacities that resemble organizing pneumonia, such as reverse halo signs or ground glass with widespread consolidations and air bronchograms can appear. COVID-19 is confirmed in CO-RADS 6 CT scans and a positive RT-PCR further adds to the evidence.^{6,10}

To the best of our knowledge, no local data is available in the literature regarding CO-RADS classification of COVID-19 patients and this is the first study from Pakistan and was aimed to facilitate the accurate and prompt diagnosis of this life threatening infection. This study was conducted to look into radiological parameters of COVID-19 patients according to CO-RADS classification and to compare the RT-PCR with chest CT in patients suffering from COVID-19.

MATERIALS AND METHODS

This cross sectional study enrolled 180 participants admitted in COVID Unit of Farooq Hospital, West Wood, Lahore between April 2020 to July 2020. The study was authorised by the Research Ethical Committee (IRB) of Akhtar Saeed Medical and Dental College, Lahore and formal approval was taken from Medical Superintendent Farooq Hospital West Wood, Lahore. The written informed consent was waived owing to a pressing need for data gathering and also because patients were not subjected to any risk.

All the patients having a fever of $> 38^{\circ}\text{C}$, suspicion of COVID-19 and who underwent both CT of the chest and RT-PCR examinations at the time of admission were included in the study. Patients with other relevant abnormal laboratory parameters related to COVID-19 were excluded from the study.

All images were obtained on CT systems (Toshiba, Japan) with patients in a supine position. Tube voltage = 120 kVp, automatic tube current modulation (30 - 70 mAs), pitch = 0.99 - 1.22 mm, matrix = 512×512 , slice thickness = 10 mm, field of view = $350 \text{ mm} \times 350 \text{ mm}$ were the chief scanning specifications of CT systems. After that images were rebuilt with a slice thickness of 0.625 - 1.250 mm with alike increment. The radiologist was blinded to RT-PCR results, assessed all chest CT images and then reported CT findings. The radiologist had access to the epidemiological background and clinical

presentation, such as presence of fever and or dry cough. The chest CT was evaluated as positive or negative for COVID-19 by the radiologist.¹¹

The radiologists also described main CT features (ground-glass opacity, consolidation, reticulation/thickened interlobular septa, nodules) and classified the patient's level of suspicion and radiological (chest CT) changes according to CO-RADS classification given as follows:

CO-RADS 1: No suspicion. Normal or non-infectious abnormalities

CO-RADS 2: Low suspicion. Abnormalities consistent with infections other than COVID-19.

CO-RADS 3: Indeterminate suspicion. Unclear whether COVID-19 is present.

CO-RADS 4: High suspicion. Abnormalities suspicious for COVID-19.

CO-RADS 5: Very high suspicion. Typical of COVID-19.

CO-RADS 6: RT-PCR is positive.⁶

Statistical Package for the Social Sciences (SPSS) version 22.0 was used to examine the data. Frequency and percentages were generated for categorical clinical and demographic variables. Mean and standard deviation was calculated for the age of patients.

RESULTS

The mean age of the patients was 54.3 ± 13.7 (years), ranged from total 22 to 85 years. There were no cases in patients below 22 years of age as shown in table 1. Out of 180 patients, 137 (76%) were males with a median age 52 of males and 56 of females (Figure 1).

Ground glass opacities 12 (7%) and consolidations 59 (33%) were uncommon in few patients. Similarly, less number of thickened interlobular septa 139 (77%) were observed in these patients and only 34(19%) of patients had progressed to ARDS. The current study had the highest number of patients 132 (73%) in CO-RADS 5 classification. Out of 180 patients, 158 had positive findings on chest CT and the same 39 patients showed negative RT-PCR at the time of admission in hospital. The results are summarized in table 2.

Of the total 180 patients, 11(6%) of patients who were classified as CO-RADS 3 tested maximum negative on RT-PCR 3(27%). Similarly, only 1(9%) of patient had no viral pneumonia in CO-RADS 3. Of the patients classified as CO-RADS 5, the overall maximum number of patients were diagnosed with ground glass opacities 126(95%) as compared to RT-PCR positivity. Whereas, overall in CO-RADS 4, viral pneumonia was more prominent followed by GGOs 34 (92%). Likewise, consolidation was observed in 21 (57%) of the patients who were classified as CO-RADS 4 and in 93 (77%) of the patients classified as CO-RADS 5 (Figure 2).

Representative CT patterns of some COVID-19 patients based on CO-RADS classification are shown in figure 3-6.

DISCUSSION

Timely diagnosis and management of SARS COV-2 are essential.¹¹ Most of the radiologists

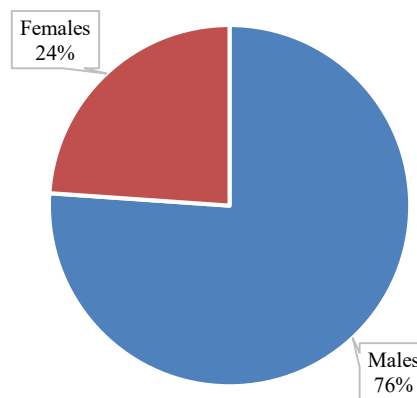


Fig 1: Gender distribution of COVID-19 patients (N = 180)

used number of lung segments affected, type and distribution of opacities in radiological images of suspected COVID-19 patients.¹² However, in our study, we used CO-RADS scoring to determine the level of suspicion in probable COVID-19 patients and compared it with RT-PCR. Our study revealed more predilection for COVID-19 in males (76%) as compared to females (24%). These findings were almost similar when compared with various studies of China.^{13,14,15,16} Similarly, alike results of our mean age was found in a study conducted in China where the mean age of the patients was 51 ± 15 years.¹¹ On

Table 1: Age distribution of COVID-19 patients

Age range (years)	Frequency (Percentage)	Median age of Gender (years)
22-39	21 (11.66)	Males 52
40-59	93 (51.66)	Females 56
>60	66 (36.66)	

(N=180)

Table 2: RT-PCR & radiological characteristics of COVID-19 patients

Characteristic	Description	Frequency (Percentage)
Total RT-PCR	Negative	39 (21%)
	Positive	143 (79%)
Total CT scan chest	Negative	22 (12%)
	Positive	158 (88%)
Viral Pneumonia	No	39 (22%)
	Yes	141 (78%)
Ground Glass opacity	No	12 (7%)
	Yes	168 (93%)
Consolidation	No	59 (33%)
	Yes	121 (67%)
Reticulation/Thickened	No	139 (77%)
Interlobular Septa	Yes	41 (23%)
Nodular Lesions	No	180 (100%)
	Yes	0 (00.0)
ARDS	No	146 (81%)
	Yes	34 (19%)
CORADS Classification	CORAD3	11 (6%)
	CORAD4	37 (21%)
	CORAD5	132 (73%)

(N=180)

Percentage of positive RT-PCR and radiological parameters

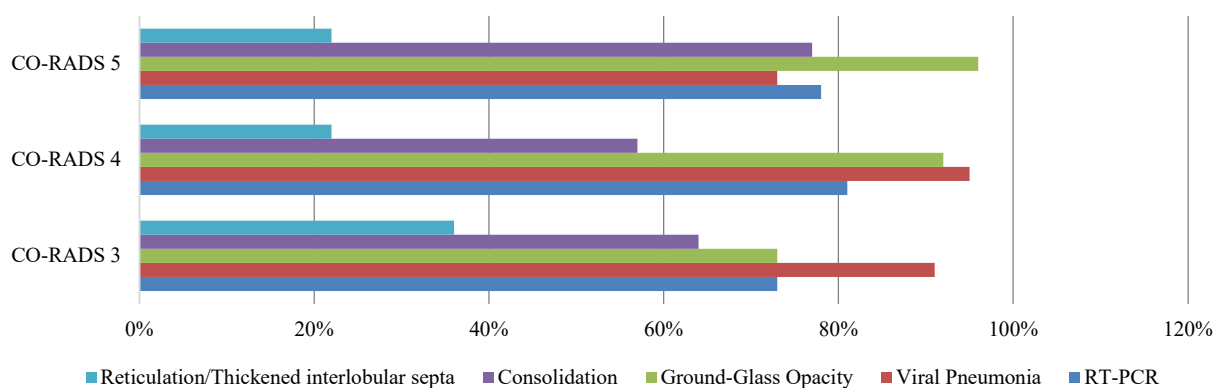


Fig 2: Comparison of RT-PCR and radiological parameters with CO-RADS scoring in COVID-19 patients (N = 180)

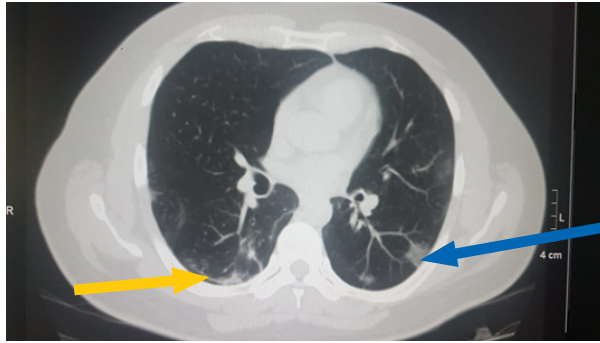


Fig 3: Sub-pleural band (orange arrow) & sub-pleural early ground-glass opacities - CO-RADS 4. Ground-glass opacity (blue arrow).

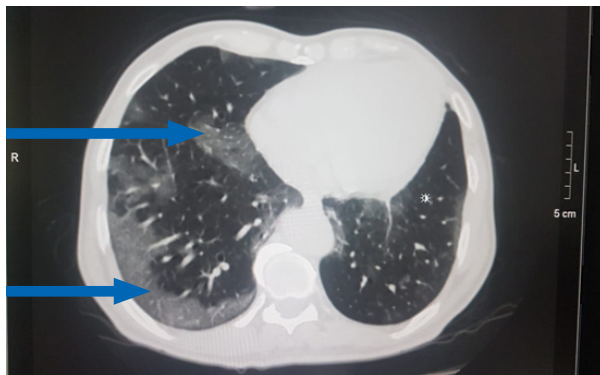


Fig 4: Sub-pleural ground-glass opacities (blue arrows) more so in the lower lobes- CO-RADS 5

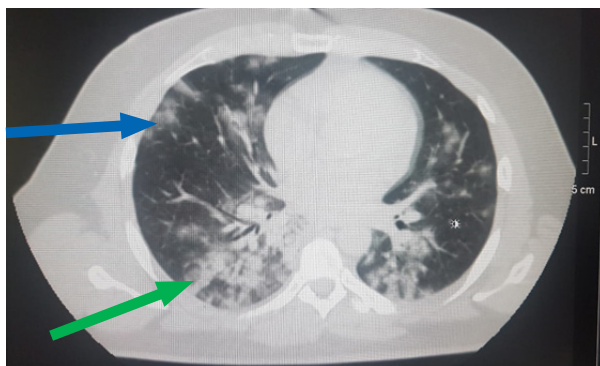


Fig 5: Ground-glass opacities with patchy sub-segmental consolidations- CO-RADS 5. Ground-glass opacity (blue arrow) & consolidation (green arrow)

the contrary, mean age was more (62 ± 16 years) in a study conducted Japan.¹⁶

There are multitude of imaging features related to COVID-19 pneumonia, ranging from normal appearance to diffuse changes in the lungs.¹⁷ There was frequent manifestation of GGOs (93%) followed by consolidation (67%) and reticulation/thickened interlobular septa (23%) in radiological features of our study. Whereas, nodular lesions were inconspicuous

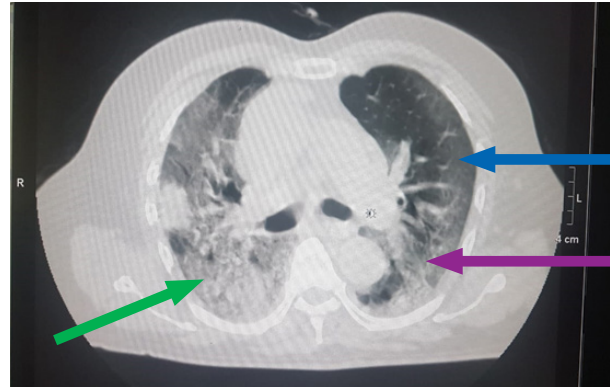


Fig 6: Extensive ground-glass confluence opacities (blue arrow) with prominent interstitium giving early crazy paving appearance (purple arrow) and sub segmental consolidations- Early ARDS due to CO-RADS 6. Consolidation (green arrow)

in our patients. The present results are in accordance with numerous studies reported from China, Italy and Iran. In almost all of these studies, GGOs were the commonest radiological features.¹⁸⁻²² Notably Inui et al and Xu et al reported 100% and 94% GGOs in their studies respectively. Consolidation was also reported maximum (100%) by Inui.^{16,23} Likewise Li & Xia stated 62% consolidation which was near to our results.⁷

Viral pneumonia reported in all the enrolled patients in the present study was 78%. The aforementioned CT chest findings may coincide with other viral pneumonia; for instance, H1N1 influenza pneumonia also presents GGO in a patchy pattern, with interlobular septal thickening and consolidation. Nevertheless, consolidation is reported to be a regular feature of H7N9 influenza pneumonia.¹² Patients with COVID-19 pneumonia who were in the early stages of the disease had more pure GGO than patients who were in the later stages of the disease, which more commonly involved pure consolidations. Thus, it can be contemplated that pure GGO may be related to the initial or mild stage of disease, whereas pure consolidation may show severe clinical manifestation or more later stage of the disease.²⁴

GGOs and consolidation remained on the topmost in CO-RADS 5 classification. However, reticulation/thickened interlobular septa trend was found in equal number (22%) for both CO-RADS 4 & CO-RADS 5 classification. Surprisingly viral pneumonia was more prominent (95%) in CO-RADS 4 and least (73%) found in CO-RADS 5. Salehi

et al published an updated systemic review of CT chest findings, including 30 studies and proposed a grading system with five (0, 1, 2A, 2B, 3) COVID-RADS categories based on the level of suspicion. The COVID-RADS 3 corresponds to our CO-RADS 5 scoring. Based on this study, the vast majority of the patients present with typical chest CT findings (COVID-RADS 3), which are commonly described as a peripheral, multifocal ground-glass pattern.²⁵

Results were variable for RT-PCR in different CO-RADS scoring, being 81% of patients positive in CO-RADS 4 followed by 78% in CO-RADS 5. We assessed 180 patients out of which 79% tested positive with RT-PCR, while chest CT findings were positive in 88% of the cases. A study conducted by Fang et al was inconsistent with our results in patients having chest CT more positive (98%) as compared to RT-PCR (70.5%).²⁶ Other studies also showed similar results where chest CT remained predominant test over RT-PCR in COVID-19 patients.^{11,21,27} On the contrary, few studies reported either an equal number of patients or more positive PCR as compared to chest CT.²⁸⁻³²

CONCLUSIONS

CO-RADS categorical assessment scheme indicates a significant prevalence of GGOs in COVID-19 patients. RT-PCR of most of the patients was negative at the time of admission but on radiological analysis, they had positive CT findings suggestive of COVID-19. Therefore, a chest CT can be useful in prompt detection of COVID-19 and tracking its course when compared with RT-PCR in the epidemic areas.

LIMITATION

We did not perform the sensitivity and specificity of the chest CT and RT-PCR. Further studies are required to evaluate the sensitivity and specificity of these above mentioned tests.

ACKNOWLEDGEMENTS

We would like to thank Muhammad Shakeel for his assistance in the data entry. We are also grateful to our front-line medical staff who are working tirelessly in treating COVID-19 patients.

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