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Comparative Analysis of CORADS Score on HRCT Chest and RT-PCR Swab Test Outcomes in Suspected COVID-19 Cases – A Cross-Sectional Study

Case Report

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Abstract

Background: The COVID- 19 pandemic has brought about significant challenges in the healthcare industry, with a primary focus on identifying and diagnosing cases of SARS- CoV- 2 infection. The reverse transcription-polymerase chain reaction (RT-PCR) test is regarded as the definitive method for diagnosing COVID-19. High resolution computed tomography (HRCT) examination plays an important role because of its high sensitivity. Our study was planned to evaluate the Covid 19 reporting and data system (CORADS) scoring classification system for reporting COVID-19 pneumonia and to assess the correlation between HRCT findings and RTPCR test.

Methodology: A single centre, hospital based, cross-sectional, observational study was conducted from 1st July 2020 to 30th June 2020 and a total of 200 patients were included in the study.

Results: 86 cases (43%) were seen between 61- 80 years of age group, 70% (141) were male, 85% patients were symptomatic for COVID-19. 92% had ground glass opacities and 48% had crazy paving and were significantly associated with RTPCR (P- value <0.001). CORADS 1, CORADS 2, CORADS 3, CORADS 5, CORADS 6 were significantly associated (P- value <0.001) with RTPCR whereas CORADS 4 did not show any significant association with RTPCR in our study.

Conclusions: Our study demonstrates a significant correlation between CORADS scores and RT-PCR results in diagnosing COVID-19, particularly for CORADS categories 1, 2, 3, 5, and 6, which showed strong associations with RT-PCR outcomes. The high prevalence of ground-glass opacities and crazy paving patterns in CT findings further underscores the role of HRCT in detecting COVID-19 pneumonia. These findings suggest that the CORADS classification can serve as a valuable diagnostic tool, especially in settings with limited RT-PCR accessibility, to support early and accurate diagnosis of COVID-19, facilitating timely patient management and resource allocation..

Keywords: COVID-19; CORADS; RT-PCR

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Introduction

In late December 2019, Wuhan, China, became the center of an outbreak of pneumonia caused by a novel coronavirus, which was newly named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). More and more cases of SARS-CoV-2 pneumonia were reported worldwide causing a global concern.[1] COVID 19 outbreak was declared as a Public Health Emergency of International Concern (PHEIC) on 30 January 2020 and a pandemic on 11th March 2020 by the WHO Director General.[2] The COVID- 19 pandemic has brought about significant challenges in the healthcare industry, with a primary focus on identifying and diagnosing cases of SARS-CoV- 2 infection. Early diagnosis of COVID-19 is crucial for the isolation of patients and prevention of the spread of infection, as well as early patient intervention.

The reverse transcription-polymerase chain reaction (RT-PCR) assay is considered the most accurate method for diagnosing COVID-19. However, its sensitivity is variable as it depends on the duration of symptoms, viral load, the rate of viral replication in the upper respiratory tract, and quality of the The test sample has a pooled sensitivity reported at 64.8% (95% confidence interval (CI) 54.5–74.0) in clinical settings.

Computed tomography (CT) imaging is crucial in diagnosing COVID-19 in epidemic regions due to its high sensitivity. It has been reported that patients with negative RT-PCR results may have positive chest CT findings, and combining RT-PCR with CT scans is expected to improve the diagnosis of COVID-19. Multiple CT imaging features characteristic of COVID-19 pneumonia have been documented, with the most common findings being bilateral, peripheral or subpleural, and posterior ground-glass opacities, sometimes accompanied by consolidations. To streamline reporting, the Dutch Radiological Society developed the COVID-19 Reporting and Data System (CO-RADS), which uses a standardized five-point scale to indicate the level of suspicion for COVID-19 pneumonia in chest CT images. [4]

The COVID-19 Reporting and Data System (CORADS) is a structured assessment tool for chest CT scans in patients suspected of COVID-19, indicating the likelihood of lung involvement. Score ranges from 0 to 6. Its strong interobserver agreement and high discriminatory value make it highly suitable for clinical use. Chest CT has been suggested to possess the potential to diagnose COVID-19 with significant sensitivity, and even screen asymptomatic patients. [5]

The CO-RADS classification, established by the Dutch Radiological Society, serves as a standardized system for reporting suspected COVID-19 cases, particularly in moderate to high prevalence settings. The system assesses the probability of COVID-19 infection using CT scan findings, with classifications ranging from CO-RADS 1 (indicating very low suspicion) to CO-RADS 5 (indicating very high suspicion) [4] (Table 1). Additionally, it evaluates the severity and stage of the disease while addressing potential comorbidities and providing a differential diagnosis. CORADS helps in easier communication with referring physician, thus helping better patient care.

Table 1: Overview of CORADS categories and corresponding level of suspicion for pulmonary involvement in COVID 19. [17]

Table 1: Overview of CORADS categories and corresponding level of suspicion for pulmonary involvement in COVID 19

CO-RADS Category	Level of Suspicion for Pulmonary Involvement of COVID-19	Summary
0	Not interpretable	Scan technically insufficient for assigning a score
1	Very low	Normal or noninfectious
2	Low	Typical for other infection but not COVID-19
3	Equivocal/unsure	Features compatible with COVID-19 but also other diseases
4	High	Suspicious for COVID-19
5	Very high	Typical for COVID-19
6	Proven	RT-PCR positive for SARS-CoV-2

Note.—CO-RADS = COVID-19 Reporting and Data System, COVID-19 = coronavirus disease 2019, RT-PCR = reverse transcription-polymerase chain reaction, SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2.

Below are the images assigned to cases with varying **CORADS (COVID-19 Reporting and Data System)** scores, categorized based on the imaging findings and their probability of COVID-19 involvement:

CORADS 0

Scan insufficient for assigning score (Figure 1)

CORADS-1 (Very Low Suspicion): Normal chest imaging or findings unrelated to infection, such as mild emphysema or bronchiectasis, fibrotic bands (Figure 2A) and (Figure 2B)

Figure 1: Technically insufficient scan leading to suboptimal evaluation.

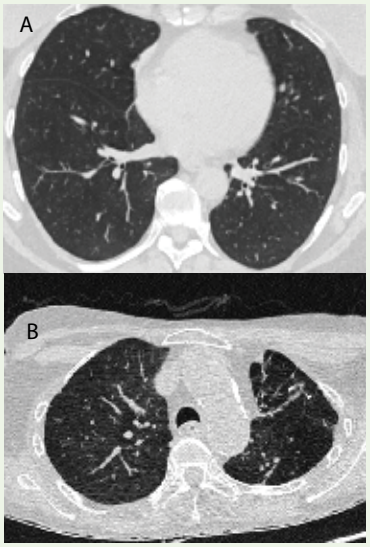

Figure 2: A: Clear lung fields with no evidence of ground-glass opacities or consolidation. B: Fibrotic parenchymal bands.

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CORADS-2 (Low Suspicion): Abnormalities consistent with other infections like tuberculosis with tree-in-bud centrilobular nodules and cavitatory consolidation or pleural effusion with cardiomegaly, multiple hilar ground glass opacities with septal thickening. (Figure 3A) and (Figure 3B)

CORADS 3 (Equivocal)

The findings here are indeterminate/ atypical, thus unsure of COVID 19 involvement. CT abnormalities seen in CORADS 3 are diffuse or perihilar, unifocal unilateral GGO, apical or central distribution, lack of specific distribution. The features indicate infection but unsure whether COVID 19 is involved.(Figure4A) and (Figure 4B)

CORADS 4 (High Suspicion)

Here the level of suspicion for COVID19 infection is high. Mostly these are suspicious CT findings but not extremely typical such as unilateral multiple ground glass, multifocal consolidations without any other typical finding, preexisting/ coexistant pulmonary disease. (Figure 5)

CORADS 5

The findings here are typical of COVID 19. The CT findings include ground glass opacities, consolidations, bilateral (can be unilateral in early cases), peripheral, basal predominance, rounded/ nodular upto 50% cases, organizing pneumonia, atoll/ reverse halo sign, perilobular distribution.(Figure 6)

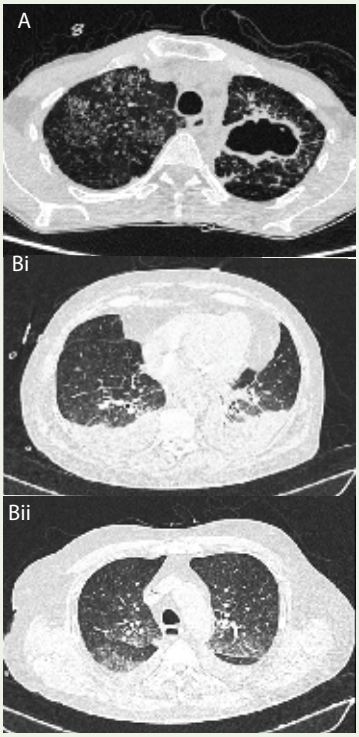

Figure 3 A: Thick-walled cavity in the left upper lobe with extensive centrilobular nodules bilaterally suggestive of tuberculosis. Bi and Figure 3Bii: Bilateral hilar ground glass opacities with smooth septal thickening and bilateral pleural effusion and cardiomegaly.

Figure 4 A and Figure 4B: Single or multiple ground-glass opacities without peripheral or bilateral predominance.

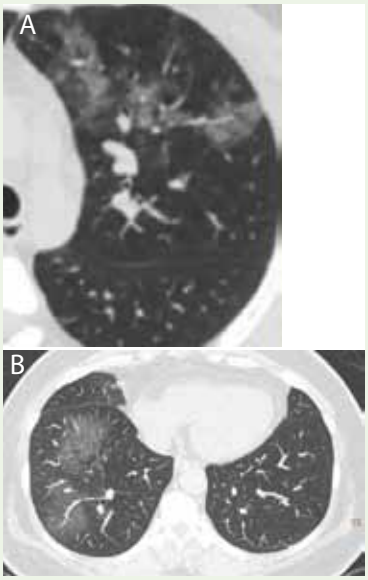

Figure 5 A and B: Unilateral multiple ground glass opacities.

CORADS 6

Patient with positive RTPCR test.

The local data on comparison of CORADS score and RTPCR results in diagnosis of coronavirus disease is scarce in literature.[6] This proposed system has not been extensively evaluated yet to our knowledge. Therefore, the purpose of our study is to evaluate the CORADS scoring classification system for reporting COVID-19 pneumonia and to assess the correlation between HRCT findings and RTPCR test.

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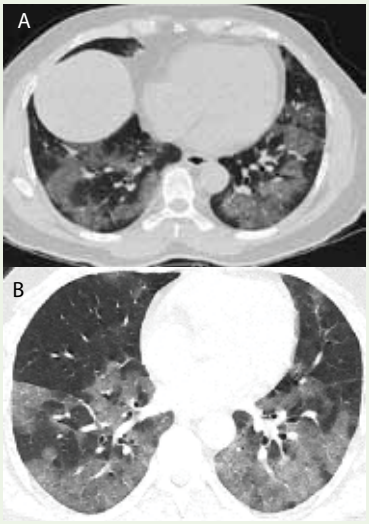

Figure 6 A and B: Multifocal bilateral peripheral ground glass opacities with posterior predominance, crazy paving and vascular dilatation.

Methodology

A single centre, hospital based, cross-sectional, observational study was conducted by Department of Radiodiagnosis, Saifee hospital, Mumbai from 1st July 2020 to 30th June 2021. This study was conducted in compliance with ethical standards, and all necessary approvals were obtained from the institutional review board. Patients of all age groups irrespective of gender referred to CT Department for suspected COVID19 infection by the treating physician/surgeon were included in the study. Patients who did not give consent, follow up patients, patients without RT-PCR tests and uncooperative patients were excluded from the study. Sample size was obtained as 196 at a confidence interval of 95%, power of the study being 80%, absolute precision as 5% and considering an adjusted seroprevalence of 15% as per a study by Malani et al (2021).[7]

Convenient sampling i.e., every consecutive patient fulfilling inclusion and exclusion criteria, giving informed and written consent were enrolled to complete the sample size in the stipulated duration. Patient/Guardians were offered informed consent form, and after consent, the data was filled including information regarding biodata, symptoms, relevant examination findings and lab tests.

Data collection technique

- Requisition form requesting for HRCT chest.
- Detailed clinical history along with clinical examination findings was recorded.
- The procedure was explained to patient in detail and informed, written and valid consent as per the proforma was taken.
- Patient was evaluated with help of CT machine by multiplanar acquisition of images.
- CT machine used was Philips Brilliance iCT 256 slice volume scanners.

At the end of study, patients were divided into groups based upon CORADS scoring, imaging features, RT-PCR results, CT severity score and relevant statistical tests performed for possible correlation with baseline features.

The data was entered into the Microsoft excel for analysis from the customized proforma Descriptive statistics was evaluated using numbers and percentages. Data was presented as tables, bar diagrams and pie charts. For continuous variables, mean ± standard deviation was given. Pearson's chi square test and Fischer Exact test was used to determine the P value. P value of < 0.05 was taken as statistically significant.

Results

In the present study, out of 200 cases majority of them i.e., 86 cases (43%) were seen between 61- 80 years of age group, followed by 71 cases (36%) in 41-60 years of age group, 27 cases (13%) in 21-40 years of age group,14 cases (7%) had age more than 80 years and around 2 case (1%) had age less than 20 years. 70% (141) were male and around 30% (59) were female. About 85% patients were symptomatic and 15% were asymptomatic for COVID19, however scan was advised to rule out COVID19 for preoperative evaluation and pre-admission formalities. Most of the cases i.e., 58 cases (29%) had no co-morbidities, 47 cases (24%) had DM with HTN, 46 cases (23%) had HTN followed by 29 cases (15%) with only DM. In the current study, out of 200 cases 60 cases (30%) had CORADS-5, followed by 39 cases (19.5%) had CORADS-1 and CORADS-6 each, 26 cases (13%) had CORADS-3 & CORADS-4 each, and 10 cases (5%) had CORADS-2 SCORE (Table 2). Majority of the patients 111 (55.56%) who were RT-PCR positive had Ground glass opacities and 70 (35%) had crazy paving on HRCT. This association between RT-PCR and ground glass opacities on HRCT findings were found to be statistically highly significant (Table 4). In the current study, out of total 39 CORADS-1 cases about 90% (35 cases) were RT-PCR negative and 10% (4 cases) were RT-PCR positive, out of total 10 CORADS-2 cases all were RT-PCR negative i.e. 100% (10 cases), out of total 26 CORADS-3 cases about 81% (21 cases) were RT-PCR negative and 19% (5 cases) were RT-PCR positive, out of total 26 CORADS-4 cases about 46% (12 cases) were RT-PCR negative and 54% (14 cases) were RT-PCR positive, out of total 60 CORADS-5 cases about 12% (7 cases) were RT-PCR negative and 88% (53 cases) were RT-PC (Table 5). Sensitivity of the test was obtained as 92.86% and specificity as 75.71%, Area under curve (AUC) was obtained as 0.84 (95% CI 0.77-0.89). This suggests an 84% chance that the radiologist reading the image will correctly distinguish a normal from an abnormal patient based on the ordering of the image ratings. Positive likelihood ratio was obtained as 3.82 which means that patientwho have COVID- 19 have 3.8 times more chance to test positive on HRCT than patients without COVID- 19 who also test positive. (Figure 7)

Discussion

High resolution Computed tomography (HRCT) of the chest is increasingly recognized as strong evidence for early diagnosis, because the changes in chest imaging sometimes may be earlier than clinical symptoms and thus HRCT scan play an early warning role in the diagnosis of COVID-19.[8]

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Table 2: Distribution of patients according to RT-PCR and CORADS

HRCT CHEST FINDINGS		FREQUENCY	PERCENTAGE
LUNG INVOLVEMENT	NONE	36	18%
	RIGHT	10	5%
	LEFT	6	3%
	BILATERAL	148	74%
DISTRIBUTION	NONE	36	18%
	CENTRAL	8	4%
	PERIPHERAL	93	46%
	CENTRAL + PERIPHERAL	63	32%
PLEURAL EFFUSION	YES	13	6%
	NO	187	94%
ATTENUATION	GROUND GLASS OPACITIES	152	92%
	CENTRILOBULAR NODULES	6	4%
	CRAZY PAVING	80	48%
	SUB PLEURAL FIBROSIS	12	7%
	CONSOLIDATION	16	10%
	CAVITATION	1	1%
	BRONCHIECTASIS	5	3%
	BASAL DEPENDENT DENSITIES	5	3%
	HONEY COMBING	2	1%
	CENTRILOBULAR EMPHYSEMA	1	1%
LYMPH NODE INVOLVEMENT ON HRCT CHEST	YES	9	5%
	NO	191	95%
CT SEVERITY SCORE	NONE	46	23%
	MILD	103	52%
	MODERATE	41	20%
	SEVERE	10	5%
PARENCHYMAL INVOLVEMENT	YES	164	82%
	NO	36	18%

Table 3: HRCT chest findings

HRCT CHEST FINDINGS		RT-PCR		
		Positive	Negative	P value
GROUND GLASS OPACITIES	Yes	111	41	< 0.001#*
	No	4	44	
CRAZY PAVING	Yes	70	10	< 0.001*
	No	45	75	
CENTRILOBULAR NODULES	Yes	11	5	0.34
	No	104	80	
CONSOLIDATION	Yes	1	5	0.08#
	No	114	80	
CAVITATION	Yes	0	1	0.24#
	No	115	84	
BRONCHIECTASIS	Yes	3	2	1#
	No	112	83	
BASAL DEPENDENT DENSITIES	Yes	1	4	0.16#
	No	114	81	
HONEY COMBING	Yes	1	1	1#
	No	114	84	
SUBPLEURAL FIBROSIS	Yes	8	4	0.56#
	No	107	81	
CENTRILOBULAR EMPHYSEMA	Yes	0	1	0.24#
	No	115	84	

*P value less than 0.05 was considered statistically significant.
Fischer exact test was applied.

Table 5: Association of CORADS score on HRCT chest with RT-PCR results

CORADS		RT-PCR		
		Positive (n- 115)	Negative (n- 85)	P value
CORADS-1	Yes	4 (3.48%)	35 (41.18%)	< 0.001#*
	No	111 (96.52%)	50 (58.82%)	
CORADS-2	Yes	0	10 (11.76%)	< 0.001#*
	No	115 (100%)	75 (88.24%)	
CORADS-3	Yes	5 (4.35%)	21 (24.71%)	< 0.001*
	No	110 (95.65%)	64 (75.29%)	
CORADS-4	Yes	14 (12.17%)	12 (14.12%)	0.68
	No	101 (87.83%)	73 (85.88%)	
CORADS-5	Yes	53 (46.09%)	7 (8.24%)	< 0.001*
	No	62 (53.91%)	78 (91.76%)	
CORADS-6	Yes	39 (33.91%)	0	< 0.001#*
	No	4 (3.48%)	42 (49.41%)	

*P value less than 0.05 was considered statistically significant.
#Fischer exact test was applied.

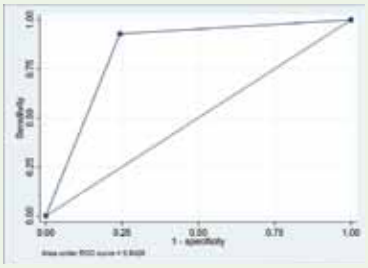

Figure 7 ROC curve of CORAD Scoring.

Our study included 200 patients suspected of COVID 19 referred by the physician to the department of radio diagnosis, Saifee Hospital, Mumbai for HRCT thorax.

The mean age of the patients in our study was found to be 59.14 ± 15.86 years with majority of patients belonging to the age group of 61-80 years of age. This correlated with the findings of **Tao Ai et al 2020** (mean age was 51 ± 15 years and majority were above 40 years of age), [9] **Hanif et al 2020** (mean age was 46.54 ± 15.22 years and majority were in the age group 45-65 years), [6] **Abdel-Tawab et al 2021** (mean age was 45 ± 16.9 years), [10] **Alam et al 2020** (mean age 49.97 ± 13.6 years and majority were in the age group 51-60 years). [11]

Male predominance with 70% male and only 30% female was reported in our study. Similarly male predominance was also seen in studies done by **Hanif et al 2020,**[6] **Abdel-Tawab et al 2021,**[10] and **Yan li et al2020** [12] and **Sharma et al 2021** [13] whereas female predominance in a study by **Tao Ai et al 2020.**[9]

About 85% patients had symptomatic clinical presentation and only 15% were asymptomatic. This correlates with findings of **Sharma et al 2021** [13] which showed 91.22% were symptomatic and 8.78% were asymptomatic. 57% were RTPCR positive and 43% were RTPCR negative in our study which was similar to **Tao Ai et al 2020** which reported 59% as RTPCR positive and 41% RTPCR negative. [9] **Alam et al** reported 96% RTPCR positive.[11]

Since the start of the outbreak, it has been seen that co-morbid individuals had higher chance of acquiring COVID 19 infection. We

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saw that around 24% patients had both DM with HTN, followed by 23% having only HTN, followed by 15% with only DM. About 29% did not have any co-morbidities whereas rest 71% had some or the other comorbid condition. Similar findings were also reported by **Islam et al (2020)** where about 35% study participants were diabetic and around 28.4% were hypertensive. [14]

Out of 200 patients about 165 patients showed attenuation on HRCT chest and among those about 92% had ground glass opacities, 48% had crazy paving, 10% had consolidation, 7% had subpleural fibrosis, 4% had centrilobular nodules, and only 3% showing basal dependent densities and bronchiectasis (Table 3). Study by **Hanif et al 2020** reported ground glass opacity as the most frequent pattern on CT findings with 92.3% which correlates with our findings. [6] **Yan li et al2020** reported ground glass opacity or consolidation or both in 96.1% patients, crazypaving was seen in 70.6% [12] **Sharma et al 2021** had similar findings with ground glass opacity being most common finding with 74.6%.[15] Their study also showed that 13.3% had consolidation and 2.62% had bronchiectasis which were similar to our findings. However, crazy paving was seen only in 1.32%.[13] Other studies such as **Tao Ai et al 2020** reported ground glass opacities in 46% and consolidations in 50%, [9] whereas **Ishfaq et al 2021** reported ground glass opacities in 71.64%, interlobular septal thickening in 43.28%, nodules in 14.84%[16] **Alam et al 2020** reported 96% had ground glass opacities, crazy paving was seen in 50.78%.[11]

Only 6% had pleural effusion and 5% had lymphadenopathy out of 200 patients. This finding correlates with **Ishfaq et al 2021** were pleural effusion and lymphadenopathy was reported to be 5.08% and 7.64% respectively.[16] **Sharma et al 2021** reported 27.92% lymphadenopathy. [13] **Yan li et al2020** reported 2% pleural effusion. [12]

Bilateral involvement of lung was seen in majority of patients i.e 74%. **Hanif et al 2020 and Alam et al 2020** reported bilateral lung involvement in 97.4% and 92.19% respectively.[6,11] **Tao Ai et al 2020** also reported bilateral lung involvement in 90%. [9]

Lower lobe involvement was seen in majority patients with 90% involving the RLL, followed by 87% involving LLL. Similar results were shown by **Alam et al 2020** where RLL was most commonly involved with 93.75% followed by LLL involvement with 91.41%.[11]

CT severity score categorized as mild, moderate and severe showed that majority of the patients had mild CTSS with 52%, 20% had moderate CTSS and only 5% had severe CTSS. **Alam et al 2020** reported 69% had 1-5 CTSS, followed by 25.78% had 6-10 CTSS, 11-15 CTSS had 21.09%,16-20 CTSS had 19.53%.[11]

CORADS 1, CORADS 2, CORADS 3, CORADS 5, CORADS 6 were significantly associated with RTPCR whereas CORADS 4 did not show any significant association with RTPCR in our study. Out of total CORADS-1 cases about 90% were RT-PCR negative and 10% are RT-PCR positive. Similarly, **Hanif et al 2020** also reported 2.5% patients with positive RTPCR had normal scan. The RTPCR positive may be due to early conduction of HRCT chest or due to presence of greater number of patients with moderate to severe cases. [6] **Tao Ai et al 2020** also reported 21 patients out of total 1014 study participants had positive RTPCR results without any lesions on chest CT. [9]

Out of total 10 CORADS-2 cases all were RT-PCR negative i.e., 100%; Out of total 26 CORADS-3 cases about 81% were RT-PCR negative and 19% are RT-PCR positive; out of total 26 CORADS-4 cases about 46% are RT-PCR negative and 54% are RT-PCR positive; out of total 60 CORADS-5 cases about 12% are RT-PCR negative and 88% are RT-PCR positive, out of total 39 CORADS-6 cases all 100% are RT-PCR positive. **Tao Ai et al 2020** had similar correlate with 308 patients out of 1014 suggestive of COVID 19 but their RTPCR was negative. Of these 308 patients, 256 patients had bilateral lung lesions consisting of GGO and consolidation at chest CT. [9]

ROC analysis confirmed the significant diagnostic power of CT-CORADS with AUC = 0.84 (95%CI 0.77-0.89) to predict COVID-19 positivity (Figure 1). D Smet K et al confirms this diagnostic power with similar AUC of 0.891 (95%CI 0.868-0.911) on a larger cohort of 859 symptomatic patients with a prevalence of 41.7% SARS-CoV-2 infections, indicating robustness of the scoring system.[17]

The findings of this study reveal that use of HRCT chest with CORADS can help in early diagnosis of COVID 19 patients and thereby help in planning the management. The study observed that ground glass opacities are the most common imagining finding with peripheral distribution being more frequent. Also, lower lobe predominance was much more compared to other lobes. In addition to its diagnostic value, chest CT is evidently also useful to assess the overall severity of pulmonary involvement (number of affected lobes and residual amount of well-aerated functional tissue) in COVID-19, and provides a direct view on the temporal evolution of SARS-CoV-2 infection as proxy for its immunological stage. Finally, chest CT allows the detection of other medical conditions with similar symptoms as COVID-19 such as bacterial pneumoniae, pleural effusion, lung cancer, pneumothorax and cardiac failure. Our findings indicate that chest CT should be utilized for COVID-19 screening, thorough evaluation, and follow-up, particularly in high-prevalence areas where there is a strong pretest probability of the disease.

Limitation

The main limitation of our study is that it was conducted in the pandemic phase of COVID- 19 infection, in a time frame with low prevalence of other respiratory viral infections such as influenza that can induce similar radiological abnormalities.

Conclusion

Chest HRCT should be considered for COVID-19 screening, comprehensive evaluation, and follow-up, especially in areas with high pretest probability for disease. In conclusion, the study demonstrates that the CORADS scoring system is a useful tool for the initial assessment of COVID-19, with CORADS scores 1 to 3 and 5 showing a good correlation with RTPCR results. However, CORADS 4 did not show a strong correlation with RTPCR findings, suggesting that it may require additional clinical correlation for accurate diagnosis. These results underscore the importance of integrating imaging findings with clinical evaluation, particularly for cases with ambiguous or inconclusive CORADS 4 scores.

Conflict of interest: The authors declare that they have no potential conflicts of interest.

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