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COVID-19 Reporting and Data System (CO-RADS) for Assessment of Pulmonary Involvement and CT Severity Score in Predicting Disease Severity

Sadaf Tufail Butt, Muhammad Wasim Awan, Sana Farid, Hafsa Aziz, Wajiha Arshad, Mashkoor Ahmad

ABSTRACT

Objective: To assess diagnostic accuracy of HRCT for COVID pneumonia keeping RT-PCR as reference standard.

Study Design and Setting: A retrospective cohort study, carried out in of Radiology Department of KRL hospital, Islamabad from January 2021 to May 2021.

Methodology: A total of 199 patients referred to Radiology Department for HRCT examination with clinical suspicion of COVID pneumonia were enrolled. Average age was 54yrs ± 14. PCR results of patients were retrieved from MIS.

HRCT chest scan report assessed pulmonary involvement and categorized according to CORADS on a scale from 1 to 5. CT severity score was also assessed on 20-segment model for scoring. Statistical analysis was carried using SPSS software. Sensitivity, specificity, negative predictive value, positive predictive value and diagnostic accuracy were calculated.

Results: The sensitivity was calculated to be 99.05%, the specificity was36.84%, the positive predictive value was 86.25%, the negative predictive value was 90.63% and diagnostic accuracy was 88.61%"

For CORADS categories 1, 2 and 6, CT was in good agreement with the PCR results. Maximum numbers of patients were from age bracket 51-60 yrs. Correlation of gender with disease showed more prevalence in males and CTSS was not different in genders.

Conclusion: HRCT chest has high sensitivity and negative predictive value for diagnosis of COVID pneumonia on the basis of CORADS reporting scheme. However it has low specificity. Disease has more prevalence in male gender. The most severely affected age bracket was 51-60 years.

Key words: CORADS, COVID-19, CTSS, HRCT, RT-PCR

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INTRODUCTION:

SARS-Cov-2 causes an infection-related respiratory syndrome and was named Corona virus Disease 2019 by the World Health Organization.COVID-19 has evolved into a pandemic worldwide and declared emergency of international concern.[1] It was first detected in China in 2019 and soon spread over the globe. Despite the fact that china has finally kept the issue under control within the country only rare outbreaks and sporadic cases reported some parts of the country. However, the pandemic can last even longer as the virus is still spreading around the world.[2] Diagnosis of SARS-Cov-2 infection has prime importance to control the disease. Clinical picture may not be useful because the majority of patients are asymptomatic or have only mild symptoms.[3] Therefore for the diagnosis of SARS-Cov-2 infection sensitive and specific test were required. As a result real time PCR assay and antibody assay for the detection have been developed.[4]

According to the latest guideline of Diagnosis and Treatment protocol for COVID 19 (tentative 8th edition), the diagnosis of COVID-19 must be confirmed by means of (RT-PCR) or

gene sequencing of respiratory or blood specimens should be taken as a key indicator for hospitalization. However RT PCR has significantly low positive rate compared with HRCT due to limitations of sample collection, transportation and limitations in kit performance.[5]

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However RT PCR has significantly low positive rate compared with HRCT due to limitations of sample collection, transportation and limitations in kit performance.[5]

HRCT chest has proved to be of diagnostic value during current COVID 19 pandemic. It is fast, convenient, and effective method for early recognition of suspicious cases, hence aids in early quarantine. It carries high sensitivity for COVID -19 pneumonia, however it has lower specificity.[7]

The Dutch Radiological Society developed COVID-19 Reporting and Data System (CO-RADS) similar to the reporting systems TIRADS, LIRADS and BIRADS. It measures the possible pulmonary involvement by COVID-19 on scale from very low to very high (1to5). CO-RADS have proven to be a useful method for determining COVID-19 pulmonary involvement. It exhibits significant inter observer agreement in individuals with moderate to severe symptoms, particularly for categories 1 and 5.[8]

METHODOLOGY:

A single center retrospective cohort study conducted in Radiology department of KRL Hospital, Islamabad from January 2021 to May 2021on patients referred to radiology department for HRCT. The study included all the referred patients in the radiology department who were clinical suspicions of COVID pneumonia. Pregnant females due to the risk of CT, patients having pulmonary disease and malignancy were excluded. The research was approved by an independent ethical review board (KRL-HI-PUB-ERC/Oct21/08).

199 patients were recruited in this study to achieve 95% Level of the confidence interval and 5% margin error. Age range 20-92yrs (average age 54yrs ± 14). There were 77 females and 122 males.

These patients were tested by RT-PCR assays on material collected from throat with swab. The results of RT-PCR were obtained from hospital information system.

The RT-PCR results were extracted from the hospital information system.

HRCT chest scan of patients was done on 16-slicescanner; patients were scanned in supine position. History and clinical symptoms were recorded. A qualified radiologist reported the study. Each CT report assessed the pulmonary involvement and categorized according to CORADS on a scale from 1 to 5.

CORADS 1: normal or non-infectious, CORADS 2: typical for other infectious diseases rather than COVID 19, CORADS 3 : equivocal/uncertain features compatible with other diseases as well as COVID 19, CORADS 4 : high suspicious for COVID 19, CORADS 5: very high typical for COVID19), CORADS 6:(proven RTPCR positive for SARS-Cov-2.

CT severity score was also assessed and 20-segment model for scoring was followed and score was calculated out of total 40 points based on the percentage of lung parenchyma involved. Score of 19 out of 40 was considered as severe disease. Main CT features (ground-glass haze, crazy paving, consolidations, reticulation and/or thickened interlobular septa, nodules) were also described.

Patients were rejected when the time between RT-PCR test and the HRCT was more than seven days.

Statistical software (SPSS version 21) was used for analysis. Continuous variables are represented by means and standard deviation, while categorical variables are represented by counts and percentages.

RT-PCR assay was used as reference standard for COVID-19 infection.
CT –ve = CORADS 1 and 2
CT +ive = CORADS4, 5 and 6.
CT indeterminate/equivocal= CORADS 3

CT results in terms of CORADS were compared with PCR; the results were also studied in with respect to age and gender of patients The Pearson correlation coefficient test was used for correlations, and p-value less than 0.05 was defined statistically significant. The diagnostic accuracy sensitivity, specificity, positive predictive value (PPV) negative predictive value (NPV) were determined.

RESULTS:

All patients referred to KRL Radiology Department for HRCT were recruited in the study; their PCR reports were traced from database. A total of 199 patients were enrolled with age ranging 20-92 yrs (average age 54yrs ± 14) referred for HRCT examination with clinical suspicion of COVID pneumonia. There were 77 females and 122 males. Patients presented with cough, body aches, shortness of breath, fever and asymptomatic with history of contact, pre-surgical evaluation

Chi-square test was used to study the correlation between CT and PCR for diagnosis of COVID pneumonia. RT-PCR assay was used as reference standard for COVID-19 infection.

CORADS 1 and 2 considered CT negative for disease. CORADS 4, 5 and 6 CT positive for disease. CT indeterminate / equivocal= CORADS 3

Out of the PCR results, 105 patients turned out to be PCR positive and 94 were PCR negative. CT positive were 164, CT negative for disease were 35. The Sensitivity was

calculated as 99.05%, Specificity 36.84%, PPV 86.25%, NPV 90.63% and the diagnostic accuracy 88.61%. Table 1 shows sensitivity and specificity of CORADS.

For CORADS categories 1, 2 and 6,CT was in good agreement with the PCR results, and 99%patients were found PCR negative with p-value of <0.05. For CORADS category 3 which is indeterminate whether COVID pneumonia is present or not, all patients were PCR negative, p-value <0.001. For CORADS category 4, 50% patients were PCR negative although CORADS category states highly suspicious for COVID pneumonia. CORADS category 5 showed 71% were PCR negative and 28% were PCR positive and in agreement with the CT findings with significance value of <0.05.

Disease severity as assessed by (Chest CT scan Severity Score) CTSS according to age groups was also studied. Patients were divided in to groups according to their age: 20-30years old, >30-40years old, >40-50years old, >50-60yers old, >60-70years old, >70-80years old,.80-90years old, >90yeras old. Table3. Maximum number of patients were from age bracket 51-60 years followed by 61-70 years. Correlation of gender with disease showed more prevalence in males and CTSS was not different in genders with significance P value of <0.05. Table 4 shows correlation of gender with severity of disease based on CTSS.

Figure 1: HRCT chest lung window showing areas of ground glass haze with interlobular septal thickening, and intervening areas of increased attenuation, patient had CORADS category 5, CTSS 33/40, severe disease.

Figure 2: HRCT CHEST lung window showing patchy areas of ground glass haze with interlobular septal thickening in subpleural location, Patient was reported as CORADS category 5

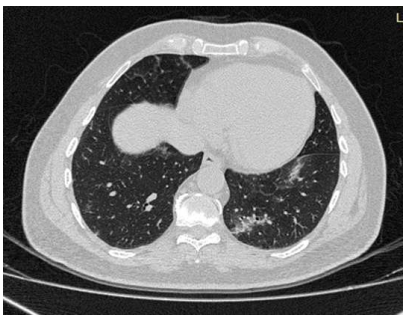

Table 1 Sensitivity and Specificity of the CORADS

CORADS	Gold Standard (PCR)		
	Positive	Negative	
Covid +ve	104	60	
Covid +ve	1	35	*P* <0.05
Total	105	95	
	Sensitivity 104/105*100=99.05%	Specificity 35/95*100=36.84%	

Table 2: Comparison of CT diagnosis based on CORADS vs PCR

CORADS	PCR +ve	PCR-ve	Total Patients
1	0	19	20
2	1	10	12
3	0	03	03
4	2	02	04
5	22	55	77
6	80	1	83

Table 3. Correlation of age groups with severity of the disease based on CTSS

Age Groups (Years)	CTSS (0-19) Mild	CTSS (20-40) Severe	Total No
20-30	12	0	12
>30-40	24	6	30
>40-50	24	5	29
>50-60	45	20	65
>60-70	27	11	38
>70-80	11	9	20
>80-90	3	0	3
>90	2	0	2

Table 4 .Correlation of gender of patients with severity of disease based on CTSS

Gender	CTSS (0-19) Mild	CTSS (20-40) Severe	Total No
Female	58	19	77
Male	90	32	122
	148	51	199

DISCUSSION:

COVID pneumonia has variable presentations. Patient may be an asymptomatic carrier. Due to its high infectivity it is important to isolate the infected person to further prevent spread of disease. This disease is susceptible to under diagnosis as well as misdiagnosis.[10] COVID-19 is diagnosed via detection of SARS-CoV-2 RNA using real time reverse-transcriptase polymerase chain reaction (RT-PCR), however as there is no gold standard investigation hence the performance of many SARS-CoV-2 RT-PCR assays is not entirely known. COVID 19 is diagnosed by real-time reverse transcriptase polymerase chain reaction to detect SARSCOV2 RNA .However the performance of various SARSCoV2 RT-

PCR assays is unknown due to the lack of gold standard research. Kanji et al. investigated the SARS-CoV-2 RT-false PCR's negative rate (FNR) and sensitivity, concluding that the assay's specificity is 100 percent and the false negative rate is affected by viral load changes over time.[11]

The study by Kanji et al evaluated the SARS-COV-2 RT PCR test sensitivity and false negative rate. It concludes that its specificity reaches 100% and the false negative rate of the assay is subject to viral load dynamics over time . False negative result is due to poor specimen collection, sampling at early stage of the disease process, low sensitivity of the assay, inappropriate sample type and low viral load[12-17]. We compared RT-PCR and HRCT chest for diagnosis of COVID pneumonia, keeping RT-PCR assay as reference standard for COVID-19 infection. The sensitivity was determined as 99%, the specificity was 58%, the positive predictive value was 54% the negative predictive value was 99% and the diagnostic accuracy was 72%. The study by Tao Ai[5] proposed that as RT-PCR has a low sensitivity, the false positive cases on CT can actually be the true positives as RT-PCR and found RT-PCR an imperfect gold standard test for the diagnosis of COVID-19. Our results were in agreement with the study conducted in Bangladesh by Haque S et al[18], they took RT-PCR as gold standard and calculated the diagnostic accuracy of HRCT. Their sensitivity was high about 96% in agreement with our study, specificity was low 66%, they had high PPV 97%, accuracy 90% and NPV 62%. Although it is not recommended to use CT chest for diagnosis of COVID 19 but it is shown to be helpful in assessment of complications, prognosis and severity. A study conducted by Korkmaz et al on the basis of their observations suggested that Chest CT can serve as a superior screening tool to RT-PCR in case of resource shortages in tests and "if patients with negative RT-PCR tests but positive CT findings are discharged without isolation or other precautionary measures, the rates of human-to-human transmission may increase, and the patients may deteriorate."[19] Our results were also in agreement with Mohammad Karam et al, they did meta-analysis of comparative studies assessing CT chest versus RT PCR, using RT-PCR as reference the sensitivity, specificity and accuracy was 0.91(0.82-0.98), 0.775 (0.25-1.00) and 0.87(0.68-0.99) respectively.[20] Efficacy of CT was assessed in terms of CORADS categories. For CORADS categories 1, 2 and 6, CT was in good agreement with the PCR results, and 99% patients were found PCR negative with P value of <0.05. For CORADS category 3 which is indeterminate whether COVID pneumonia is present or not, all patients were PCR negative, P value <0.05.As PCR had two categories, either the test has to be positive or negative, CT on the contrary reports in terms of probabilities, and for the purpose of calculation of sensitivity and specificity we considered CORADS 3 as disease negative. For CORADS category 4, 50% of the patients were PCR negative although CT based CORADS category states highly suspicious for COVID pneumonia.

CORADS category 5 showed 71% were PCR negative and 28% were PCR positive and in agreement with the CT findings with significance value of <0.05. A study by Prokop et al assessed diagnostic performance of CORADS and inter-observer agreement; they observed that CORADS permits the limits in terms of cut off points for clinical decision making. In addition it also provides good performance in anticipating COVID-19 patients with moderate to severe side effects. It have significant interobserver agreement, particularly for CO-RADS categories 1 and 5[8],however while assessing the diagnostic performance they found CORADS in good agreement with the reference standard (RT PCR), they also had a small group of patients who were both PCR and CT chest negative but clinical findings suggestive of COVID pneumonia.

In our study one of the reasons of low CT specificity might be the referral. As a part of medical department protocol, most of the patients referred for HRCT assessment were PCR negative and had strong clinical suspicion of COVID pneumonia, and those with PCR positive results were referred in less numbers. Only those PCR positive patients were referred to Radiology Department for HRCT who had some complications or had any comorbid. So there is probably sampling bias in our case. Still it shows high sensitivity and negative predictive value rendering it an effective tool for PCR negative cases with strong clinical suspicion.

Disease severity by CT Severity Score was also studied with respect to the age groups. We made groups of patients according to ages, groups were divided into 20-30yr, >30-40yr, >40-50yr, >50-60yr, >60-70yr, >70-80yr, 80-90yr and >90yr. Maximum number of patients were from age 51-70yrs, with highest CTSS in 51-60year age group. So either the younger age group is more resistant to infection or they get mild form of disease that does not reach hospital to get investigated. Our results were in agreement with the Saeed et al; they found severe disease mainly in 50-59 year age group, although they did 25 point scoring system and classified the disease severity into mild, moderate and severe on the basis of CTSS where as we classified it into two categories, mild and severewith 40 point scoring system.[21] Another study done by Zayed, et al[22] reported that both CTSS and CORADS scores performed well in predicting COVID-19 they also observed severe illness in the older age groups

Association of gender with disease was also studied, it was found to be more prevalent in males, however the disease severity as assessed by CTSS was not different between genders. Saeed et al also found male predominance in disease.[21] Our results were in disagreement with the study by E forsblom et al, they found that both sexes were equally infected by SARS-CoV2, although this study was population based registry, it was not imaging based study; it was rather

based of clinical and pathological parameters.[23] They also found more severe disease in males as compared to female population. In our study one of the reasons of low CT specificity might be the referral which is one of the limitations of the study. As most of the patients referred for HRCT assessment were PCR negative and had strong clinical suspicion of COVID pneumonia, while those with PCR positive results were referred in less numbers. Only those PCR positive patients were referred to Radiology Department for HRCT who had some complications or had any comorbid. So there is probably sampling bias.

CONCLUSION:

HRCT chest has high sensitivity and negative predictive value for diagnosis of COVID pneumonia on the basis of CORADS reporting scheme. However, it has low specificity when RT PCR is taken as reference standard. Disease has more prevalence in male gender, however the disease severity as assessed by CTSS was not different between genders with the most severely affected age bracket 51-60yrs.

Authors Contribution:
Sadaf Tufail Butt: Conception, design, analysis and interpretation of data, drafting paper
Muhammad Waseem Awan: Concept, design
Sana Farid: Design and Data Collection
Hafsa Aziz: Data analysis
Wajiha Arshad: Interpretation of data
Mashkoor Ahmad: Interpretation of data

REFERENCES

1. Tang JW, Tambyah PA, Hui DS. Emergence of a novel coronavirus causing respiratory illness from Wuhan, China. Journal of infection. 2020;80(3):350-71. DOI: 10.1016/j.jinf.2020.01.014
2. Gui-Qiang W, Lei Z, Xia W, Yan-Mei J, Fu-Sheng W. Diagnosis and Treatment Protocol for COVID-19 Patients (Tentative 8th Edition): Interpretation of Updated Key Points. Infectious Diseases & Immunity. 2021;1(01):17-9. doi.org/10.1097/ID9.0000000000000002
3. Kovács A, Palásti P, Veréb D, Bozsik B, Palkó A, Kincses ZT. The sensitivity and specificity of chest CT in the diagnosis of COVID-19. European Radiology. 2021;31(5):2819-24. DOI: 10.1007/s00330-020-07347-x
4. Aziz H, Fatima S, Mahmood H, Muhammad S, Saeed MA, Khurshid S, et al. Antibody Response to SARS-CoV-2 in Relation to the Contributing Factors in COVID-19 Patients. Viral Immunology. 2022. DOI: 10.1089/vim.2021.0097
5. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, et al. Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. Radiology. 2020;296(2):E32-E40. doi: 10.1148/radiol.2020200642
6. Aziz H, Fatima S, Iqbal H, Faheem M. Recent advances in molecular diagnosis curbing the COVID-19. International Journal of Infectious Diseases. 2020;97:322-5. DOI: 10.1016/j.ijid.2020.06.004
7. Xu B, Xing Y, Peng J, Zheng Z, Tang W, Sun Y, et al. Chest CT for detecting COVID-19: a systematic review and meta-analysis of diagnostic accuracy. European radiology. 2020;30(10):5720-7. DOI: 10.1007/s00330-020-06934-2
8. Prokop M, Van Everdingen W, van Rees Vellinga T, Quarles van Ufford H, Stöger L, Beenen L, et al. CO-RADS: a categorical CT assessment scheme for patients suspected of having COVID-19—definition and evaluation. Radiology. 2020;296(2):E97-E104. DOI: 10.1148/radiol.2020201473
9. Yang R, Li X, Liu H, Zhen Y, Zhang X, Xiong Q, et al. Chest CT severity score: an imaging tool for assessing severe COVID-19. Radiology: Cardiothoracic Imaging. 2020;2(2):e200047. DOI: 10.1148/ryct.2020200047
10. Waller JV, Kaur P, Tucker A, Lin KK, Diaz MJ, Henry TS, et al. Diagnostic tools for coronavirus disease (COVID-19): comparing CT and RT-PCR viral nucleic acid testing. American Journal of Roentgenology. 2020;215(4):834-8. DOI: 10.2214/AJR.20.23418
11. Kanji JN, Zelyas N, MacDonald C, Pabbaraju K, Khan MN, Prasad A, et al. False negative rate of COVID-19 PCR testing: a discordant testing analysis. Virology journal. 2021;18(1):1-6. DOI: 10.1186/s12985-021-01489-0
12. Kinloch NN, Ritchie G, Brumme CJ, Dong W, Dong W, Lawson T, et al. Suboptimal biological sampling as a probable cause of false-negative COVID-19 diagnostic test results. The Journal of infectious diseases. 2020;222(6):899-902. DOI: 10.1093/infdis/jiaa370
13. Kucirka LM, Lauer SA, Laeyendecker O, Boon D, Lessler J. Variation in false-negative rate of reverse transcriptase polymerase chain reaction–based SARS-CoV-2 tests by time since exposure. Annals of internal medicine. 2020;173(4):262-7. DOI: 10.7326/M20-1495
14. Prinzi A. False negatives and reinfections: the challenges of SARS-CoV-2 RT-PCR testing. American Society for Microbiology, april. 2020;27:2020.
15. Yang Y, Yang M, Shen C, Wang F, Yuan J, Li J, et al. Evaluating the accuracy of different respiratory specimens in the laboratory diagnosis and monitoring the viral shedding of 2019-nCoV infections. MedRxiv. 2020. doi: 10.1016/j.xinn.2020.100061
16. Pan Y, Long L, Zhang D, Yuan T, Cui S, Yang P, et al. Potential false-negative nucleic acid testing results for severe acute respiratory syndrome coronavirus 2 from thermal inactivation of samples with low viral loads. Clinical chemistry. 2020;66(6):794-801. DOI: 10.1093/clinchem/hvaa091
17. He X, Lau EH, Wu P, Deng X, Wang J, Hao X, et al. Temporal dynamics in viral shedding and transmissibility of COVID-19. Nature medicine. 2020;26(5):672-5. DOI: 10.1038/s41591-020-0869-5
18. Haque S, Chowdhury N, Nabi S, Ara H, Mahfuza M, Shamsunnahar S, et al. Role of HRCT Imaging in Diagnosis And Prognosis of Novel Corona (Covid-19) Pneumonia, Radiologists Experience in Dhaka Medical College Hospital Correlated with Rt-PCR. Journal of Dhaka Medical College. 2020;29(2):110-5. doi.org/10.3329/jdmc.v29i2.51184
19. Korkmaz I, Dikmen N, Keleº FO, Bal T. Chest CT in COVID-19 pneumonia: correlations of imaging findings in clinically suspected but repeatedly RT-PCR test-negative patients. Egyptian Journal of Radiology and Nuclear Medicine. 2021;52(1):1-9. doi.org/10.1186/s43055-021-00481-6
20. Karam M, Althuwaikh S, Alazemi M, Abul A, Hayre A, Alsaif A, et al. Chest CT versus RT-PCR for the Detection of COVID-19: Systematic Review and Meta-analysis of Comparative Studies. MedRxiv. 2020. DOI: 10.1177/20542704211011837
21. Saeed GA, Gaba W, Shah A, Al Helali AA, Raidullah E, Al Ali AB, et al. Correlation between chest CT severity scores and the clinical parameters of adult patients with COVID-19 pneumonia. Radiology Research and Practice. 2021;2021. DOI: 10.1155/2021/6697677
22. Zayed NE, Bessar MA, Lutfy S. CO-RADS versus CT-SS scores in predicting severe COVID-19 patients: retrospective comparative study. The Egyptian Journal of Bronchology. 2021;15(1):1-10. doi.org/10.1186/s43168-021-00060-3