Original Article

Role of HRCT for Rapid Triage of Patients with COVID-19 Pneumonia

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[1] Conception of study
[1,2] Experimentation/Study conduction
[1,2,3] Analysis/Interpretation/Discussion
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Abstract

Objective: To assess the diagnostic performances of HRCT for COVID 19 pneumonia for efficient triage of patients, in comparison with RT-PCR reverse transcription-polymerase chain reaction test.

Materials and Methods: It is a retrospective comparative study conducted in Benazir Bhutto hospital affiliated with Rawalpindi medical university from March 25th to April 25th, 2021. HRCT of 500 patients was selected from a central computer server and their RT-PCR results were also obtained from the HMS system of the hospital. HRCT was reported as “Definitely COVID positive”, “Possible COVID positive” or “COVID negative” by experienced radiologists. Sensitivity, Specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using the final RT-PCR test as a standard of reference.

Results: RT-PCR test of 207 patients were positive, whereas 293 were reported negative. HRCT was reported as “Definitely COVID positive” in 222 cases (44.4 %), “Possible COVID positive” in 24 cases (4.8%), and “COVID negative” in 254 cases (50.8%). Comparing only Definitely COVID positive category with RT-PCR results sensitivity, specificity. PPV and NPV were 90.3%, 88%,84.2% and 92.8%.

Conclusion: CT chest is the most reliable, sensitive, and rapid tool for triaging of patients as COVID positive or negative in busy emergency departments as compared to RT-PCR which is time-consuming and has limitations such as faulty sampling technique, limited kits, and variable sensitivity.

Keywords: Coronavirus, High resolution Computed Tomography, RT-PCR, Sensitivity, and Specificity, Positive predictive value, negative predictive value.

Introduction

COVID-19 pandemic has changed our lives irrevocably. It has put a huge strain on our already weak health care system.[1] The health care workers and medical resources are stretched to their maximum capacity.[2] Although in the current pandemic every patient with respiratory symptoms is taken as suspected COVID it also becomes imperative to effectively triage such patients into COVID positive or negative so that effective measures could be taken to timely manage the potential COVID complications. RT-PCR test has variable sensitivity, its time consuming with limitations of shortage of kits as well as faulty sampling technique. In this context, quick triage of patients as COVID positive or COVID negative is essential to support not only critically ill patients, patients requiring emergency surgery but also for the protection and safety of health care workers.[3,4]

HRCT has an important role in the diagnosis, detection of complications, and prognostication of coronavirus disease 2019 (COVID-19).[5] The fact of limited availability of FDA-approved RT-PCR testing kits, the delay in test results, and different values of sensitivity of PCR tests across the globe have further emphasized the growing interest in the role of early detection of COVID-19 by HRCT. Although reverse transcription-polymerase chain reaction (RT-PCR) is the standard laboratory test to confirm the diagnosis of COVID-19[6], HRCT may represent a quick and valid tool in the initial assessment of the suspected COVID patient population.

Due to resource constraints, all the patients suspected of COVID-19 were not elected for HRCT in our study. The patients who developed worsening of respiratory status or developed complications were referred to our department for HRCT. At the same time, virological testing of these patients was also being performed.

This study aimed to analyze the efficiency of the HRCT for quick triage of patients with COVID-19 as COVID Positive or COVID Negative compared to reverse transcription-polymerase chain reaction (RT-PCR) as a method of reference.

Materials and Methods

This retrospective study was conducted in Benazir Bhutto Hospital (Tertiary care hospital) from March 25th to April 25th, 2021. All CT examinations requested by departments of (medicine, surgery, gynecology, and ICU) during this period were extracted from our Radiology Electronic Requesting system. Patients under 18 years old, pregnant females, patients already known to have interstitial lung disease and pulmonary edema were excluded. A total of 1300 CT were requested, including 730 chest CT among which 500 were indicated for COVID-19 suspicion and were at risk for disease progression. All these 500 patients (sex-ratio M/F=282/218) also underwent RT-PCR test.

CT Protocol and Analysis:

HRCT was performed on patients with volume reconstruction at 0.625 mm to 1.5 mm slice thickness (gapless). CT images were acquired during a single inspiratory breath-hold

Proper precautions were taken during patient transfer and scanning to reduce the likelihood of the spread of disease with proper PPE, adequate donning and doffing technique, and post scanning decontamination measures.

CT scans were analyzed by senior radiologists from the radiology department.

Common imaging features of COVID disease were ground-glass opacities, crazy paving, consolidations, (preferably bilateral and peripheral) [7], focal vessel enlargement, sub-pleural bands, and architectural distortion. Possible complications include pneumothorax, pneumo-mediastinum, ARDS, and pulmonary embolism. [8]

On the final HRCT report, patients were TRIAGED according to guidelines proposed by the Radiological Society of North America as "Definitely COVID Positive" when typical signs were found including peripheral bilateral ground-glass opacities with or without consolidation or visible intralobular lines(crazy-paving), multiple ground-glass opacities with or without consolidation or visible intra-lobular lines, reverse halo sign or other signs of organizing pneumonia.

Absence of typical findings or presence of features like multifocal, peri-hilar, central, unilateral ground-glass opacities with or without consolidation lacking the specific distribution and are non-rounded or non-peripheral, isolated lobar or segmental consolidation without ground-glass opacities, discrete small nodules (tree-in-bud appearance), lung cavitation or associated with large pleural effusion or lymphadenopathy)[9] were categorized as "Possible COVID"

"COVID Negative" when the HRCT was normal or there were no CT features to suggest pneumonia or HRCT demonstrating another disease[10].

PCR Testing:
This test was performed after RNA extraction by a real-time RT-PCR detection system with internal and external positive controls using the SARS COV-2 protocols. Samples were collected from nasopharyngeal and oropharyngeal swabs. The average time taken to acquire results is 48 hours in our setup.

Results

On the RT-PCR test, 207 patients were tested positive to COVID-19 whereas 293 were reported negative.

Chest CT was triaged as "COVID Positive" in 222 cases (44.4%), "Possible COVID Positive" in 24 cases (4.8%), and "COVID Negative" in 254 cases (50.8%).

Our study included 500 patients with Males (56.4%) and Females (23.8%). Common presenting complaints were Shortness of breath (84%), fever (73%), and cough (25%). The majority of patients had co-morbidities like tuberculosis (31%), hypertension (20%), Ischemic heart disease (14%), and diabetes mellitus (16%). The most common complication was Acute Respiratory Distress Syndrome (22.6%). See Table 1 for the detail of these characteristics

Table 1: Base-line characteristics of patients

Characteristics		*COVID-19 Negative*	*COVID-19 Positive*
Age (years)			
Mean +SD		37+18.1	45+15.5
Gender			
Male		163(32.6%)	119(23.8%)
Female		130(26%)	88(17.6%)
Smoking			
	No	180(36%)	190(38%)
	Yes	74(14.8%)	56(11%)
Symptoms			
Fever	No	66(13.2%)	67(13.4%)
	Yes	169(33.8%)	198(39.6%)
Cough	No	200(4%)	174(34.8%)
	Yes	41(8.2%)	85(17%)
Shortness of breath	No	30(6%)	47(9.4%)
	Yes	137(27.4%)	286(57.2%)
Sore throat	No	200(40%)	234(46.8%)
	Yes	31(6.2%)	35(7%)
Loss of smell	No	236(47.2%)	250(50%)
	Yes	4 (0.8%)	10(2%)
Diarrhea	No	200(40%)	162(32%)
	Yes	96(19%)	42(8.4%)
Travel history	No	163(32.6%)	280(56%)
	Yes	39(7.8%)	18(3.6%)
Co-morbidities			
Diabetes	No	202(40.4%)	211(42.2%)
	Yes	33(6.6%)	54(10.8%)
Hypertension	No	171(34%)	226(45.2%)
	Yes	70(14%)	33(6.6%)
CKD	No	292(58%)	176(35%)
	Yes	25(05%)	07(1.4%)
Tuberculosis	No	230(46%)	115(23%)
	Yes	135(27%)	20(04%)
Asthma	No	290(58%)	199(19.8%)
	Yes	08 (1.6%)	03(0.6%)

Cardiac problems	No	168(33%)	263(52.6%)
	Yes	65(13%)	04(0.8%)
Lung involvement			
Unilateral (either right/ left lung involved)	No	22(4.4%)	17(3.4%)
	Yes	7(1.4%)	6(1%)
Bilateral	No	141(28.2%)	74(14.8%)
	Yes	123(24.6%)	110(22%)
Disease distribution			
Peripheral	No	68(13.6)	08(1.6%)
	Yes	49(9.8%)	70(14%)
Central	No	58(11.6%)	41(8.2%)
	Yes	17(3.4%)	7(1.4%)
Diffuse	No	38(7.6%)	41(8.2%)
	Yes	63(12.6%)	40(08%)
Involvement of Lobes			
Upper	No	22(44%)	20(04%)
	Yes	17(3.4%)	39(7.8%)
Middle	No	23(4.6%)	36(7.2%)
	Yes	54(10.8%)	27(5.4%)
Lower	No	102(20.4%)	51(10.2%)
	Yes	75(15%)	34(6.8%)
Lymphadenopathy	No	256(51.2%)	220(44%)
	Yes	11(2.2%)	13(2.6%)
Pleural effusion	No	310(62%)	169(33%)
	Yes	13(2.6%)	08(1.6%)
Lung fibrosis	No	279(55.8%)	200(40%)
	Yes	18(3.6%)	3(0.6%)
Attenuation			
Ground glass appearance	No	222(70%)	06(06%)
	Yes	20(30%)	252(94%)
Consolidation	No	95(19%)	150(30%)
	Yes	89(17%)	166(33%)
Complications			
ARDS	No	190(38%)	200(40%)
	Yes	40(8%)	70(14%)
Pneumothorax	No	212(43%)	215(43%)
	Yes	68(13%)	5(1%)
Pneumo-mediastinum	No	240(48%)	25150%)
	Yes	4(0.8%)	5(1%)

(Figures are presented as whole numbers with percentages in brackets)

We divided the results into two categories and calculated Sensitivity, Specificity, PPV, NPV, and Diagnostic accuracy for each category and then compared the results.

In Category 1, Group I was "Definitely positive" on HRCT (total= 222), and Group II included "Possible Positive" on HRCT and "CT Negative" cases (total= 278). (Table 2)

Table 2: (Category 1)

	RT-PCR (+)	*RT-PCR (-)*	*Total*
CT (+) Group I	A=**187** (TRUE POSITIVE)	B=**35** (FALSE POSITIVE)	**222**
CT(-) Group II	C=**20** (FALSE NEGATIVE)	D=**258** (TRUE NEGATIVE)	**278**
Total	**207**	**293**	

In Category 2, Group I included both "Definitely Positive on CT" and "Possible Positive on CT" (Total=246), whereas Group II was CT Negative (Total= 254). (Table 3)

Table 3: (Category 2)

	RT-PCR (+)	*RT-PCR (-)*	*Total*
CT (+) Group I	A=**193** TRUE POSITIVE	B=**53** FALSE POSITIVE	**246**
CT (-) Group II	C=**14** FALSE NEGATIVE	D=**240** TRUE NEGATIVE	**254**
Total	**207**	**293**	

Comparison between Category 1 & 2 shows Sensitivity, Specificity, PPV, NPV, and Diagnostic Accuracy values. (Table 4)

Table 4:

	Category 1	*Category 2*
Sensitivity	90.3%	93.2%
Specificity	88%	81.9%
Positive predictive value	84.2%	78.4%
Negative predictive value	92.8%	94.4%
Accuracy	89%	86.6%

Adding the "Possible Positive" group to "Definitely Positive" cases has impaired the Diagnostic accuracy, PPV, and Specificity of HRCT. In this study our purpose was to quickly segregate the patients into COVID Positive and Negative categories, so the inclusion of atypical cases was not suitable as it has decreased PPV of HRCT.

Discussion

With the rapid resurgence in the cases of COVID-19 in the current situation[11,12] physicians in outpatient departments and emergencies have to face overwhelming patient load and need to decide within the short time frame which patient needs immediate on the spot hospitalization and critical care to minimize potentially serious outcomes. Triage of COVID patients is also important for isolation of COVID + patients in order to control the spread of disease[13] Although RT-PCR is the investigation of choice[14] for COVID-19, however high number of false-negative cases[15], the limited number of testing kits[16] and time is taken to get the results have convinced the clinicians to consider an alternate test. In our study due to resource constraints, CT chest was not performed for all the patients with clinical symptoms suspicious of COVID-19 but in this retrospective study, we only included the patients referred to our department either due to worsening of respiratory symptoms or those who developed complications.

We further categorized data into two groups. The first one with 'Definitely COVID +' on CT was compared with RT-PCR results with a sensitivity of 90.3% and specificity of 88%. On contrary, in previously published studies it was found to be 60% to 98% and 25% to 53% respectively. In this study, specificity turned to be higher as compared to the previous study where it was found to be 25-80%.[15] It can be because a patient who presented to us did not have CT features overlapping with the typical features of COVID-19 thus reducing the number of false-positive cases. In this group, PPV and NPV are 84.2% and 94.8%. NPV can be high due to the reason that patients referred to us were having worsening respiratory symptoms reducing the possibility of false-negative cases on CT. The diagnostic accuracy of the CT chest is 89% making it a reliable tool for COVID -19 testing.[17]

In the second group where we have considered "Definitely COVID positive'" and "Possible COVID" both as positive cases, the sensitivity and specificity turned out to be 93.2% and 81.9%.PPV has decreased from 84% to 78% as compared to other group. This shows that while triaging the patients into POSITIVE and NEGATIVE cases, the patients with atypical features labelled as 'POSSIBLE COVID' should not be included in COVID positive group. The National Health Commission of the People's Republic of China even stated that diagnosis of COVID-19 could solely be based on chest CT findings[(8)]. Our findings add value for delivering timely treatment and optimizing the use of medical resources in the pandemic of COVID-19.

To categorize the patients into "Definitely COVID positive", "Possible COVID" and "COVID negative" we followed the imaging guidelines as proposed by The Radiological Society of North America (RSNA) accredited by the Society of Thoracic Radiology and the American College of Radiology (ACR). The cardinal CT chest findings of COVID 19 pneumonia are Ground glass opacities or consolidations in peripheral distribution, predilection to bi-basal posterior regions.[18]

Consolidation or ground-glass opacities could have different morphological appearances, it may present as patchy, nodular, homogenous, ill-defined, amorphous, or as rounded infiltrates. Other associated features supporting the "definitely COVID-19" pneumonia were thickened interlobular septa superimposed on GGO labelled as crazy paving pattern, reverse hallo sign, bronchovascular thickening, and air Broncho gram sign. (Figure 1)

Figure 1: A

Figure 1: B

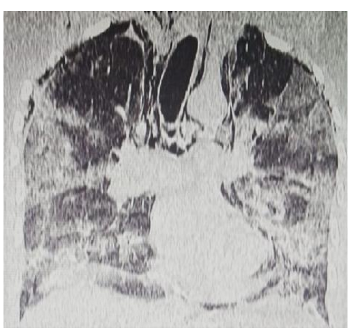

Figure 1: C

Figure 1 shows Axial unenhanced chest CT images (lung window) in a 49-year-old man (A) and a 57-year-old man (B), each with positive RT-PCR test results for SARS-CoV-2, show bilateral areas of confluent mixed ground-glass opacities, inhomogenous organizing consolidations with air bronchogram in the peripheral distribution along with bronchovascular bundles and subpleural distribution. Few intervening areas of crazy-paving, traction bronchiectasis as well as peripheral subpleural curvilinear parenchymal bands are also appreciated. Coronal Reformatted image (C) (lung window) is also consistent with classical findings of definitely covid + pneumonia.

While multifocal, diffuse, perihilar, central, or unilateral Ground Glass Opacification (GGO) or consolidation lacking a specific or peripheral distribution are categorized as "Possible COVID" or atypical COVID pneumonia with opacities also being non-rounded in configuration. (Figure 2)

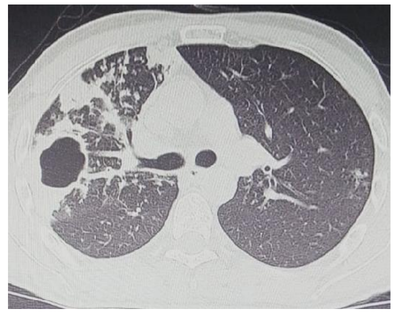

Figure 2: A

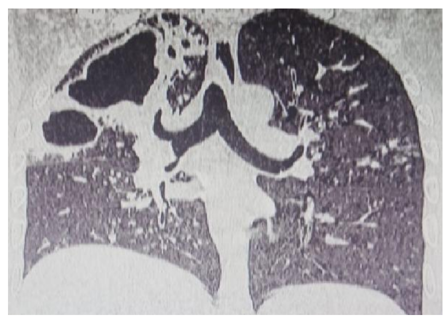

Figure 2: B

Axial and coronal nonenhanced chest CT image (lung window) of a young male patient who presented with fever, Shortness of breath, and mimicking clinical features of covid shows subtle centrilobular tree-in-bud opacities in both upper lobes more pronounced on the right side. At least two large evolving cavities with adjacent interlobular septal thickening are also appreciated. Provisional diagnosis of tuberculosis was made and the patient was triaged and sent back to medical discipline for further clinical and laboratory evaluation. The RT-PCR test results were also negative for SARS-CoV-2.

Large pleural effusion, major lymph node size increase, or bronchiolitis pattern are also included in this domain. Scans were deemed COVID negative when the HRCT was normal or demonstrated another pathology. Ground glass Opacification was defined as partial hazy Opacification of lung parenchyma with no obliteration or bronchovascular markings while consolidation was defined as homogenous dense opacification with resultant obscuration of underlying lung parenchyma.

Limitations

There are few limitations to our study. Firstly the limited sample size as we have selected patients who were referred to our department and not all the patients visiting the hospital for COVID which can result in higher false-negative results [(19)]Another limitation was that we had no follow-up HRCT available owing to heavy workload. Follow-up scans could pave a way for further elaborated studies to look for interval change in the disease process as well as disease complex patterns and varied imaging presentations.

In our country due to limited resources, CT chest is not the first investigation done for COVID-19 diagnosis, however, during this retrospective study we found out that high sensitivity and high NPV of HRCT as compared to PCR should be taken into account and in the future, the clinicians might prefer HRCT as the preferred diagnostic test for COVID-19.

Conclusion

CT chest is the most reliable, sensitive, and rapid tool for triaging of patients as COVID positive or negative in busy emergency departments as compared to RT-PCR which is time-consuming and has limitations such as faulty sampling technique, limited kits and variable sensitivity.[20]

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