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Typical chest CT finding for corona virus pneumonia with relationships to positive RT-PCR testing

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Original Article

Summary

Background: COVID-19 disease is a major public health problem globally with high morbidity and mortality and big burden on health institutes. The computerized tomography (CT) scan played a significant role in diagnosis of COVID-19 especially in first year of health crises. Objective: To determine the validity of chest CT-scan in diagnosis of COVID-19 disease in patients with positive RT-PCR and find the chest abnormalities that caused by corona virus. Patients & methods: A retrospective cross sectional study conducted in Radiology department of three hospitals (Rizgari Teaching hospital, Rozh halat Emergency hospital and Rozhawa Emergency hospital) in Erbil city-Kurdistan region/Iraq through duration period of six months from first of June to 30th of November, 2021 on sample two hundred patients with positive real-time polymerase chain reaction. The data of enrolled patients were collected by from their saved records in hospitals and fulfilled in a prepared questionnaire. The chest CT-scan was implemented by Radiologists with assistance of the Radiographers. Results: The CT-scan findings were positive in 90% of COVID-19 patients with positive RT-PCR findings, while 10% of COVID-19 patients with positive RT-PCR findings had negative CT-scan findings (10% false positive rate for RT-PCR). Common positive CT-scan findings of COVID-19 patients with positive RT-PCR findings were multifocal ground glass opacification (56%), peripheral and basal distribution (46%), crazy paving (41%), ground glass with consolidation (40%) and unsharp demarcation (26%).Conclusions: The chest CT-scan is a valid tool in diagnosis of COVID-19 disease.

Keywords: *COVID-19 disease, Real-time polymerase chain reaction, CT-scan.*

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1. INTRODUCTION

In Wuhan city-China, frequent cases of pneumonia with unknown etiology were reported at end of the year 2019. After weeks, it was known that this pneumonia was related to infection by corona-virus 2 leading to severe acute respiratory syndrome corona-virus 2 (SARS-CoV2) or what is called corona-virus disease (COVID-19) (1). Millions of peoples around world were infected with COVID-19 disease in the next months and declaring the outbreak by World Health Organization (WHO) as pandemic (2). The screening and diagnosis of COVID-19 disease represented the main concern of physicians and health authorities globally. The clinical presentation and imaging techniques were the cornerstone in COVID-19 disease diagnosis (3, 4).

Real-time polymerase chain reaction (RT-PCR) technique is a nucleic acid amplification test capable in extracting RNA of corona-virus 2 in body fluids mainly the secretions of oropharynx and nasopharynx. This test was the main screening tool of COVID-19 disease with acceptable validity findings (65% 75% sensitivity and 90%-99% specificity) (5). Accuracy of RT PCR test is dependent on chronological history of infection, site of sampling and characteristics of applied kits. Unfortunately, the RT PCR test is characterized with high rates of false negative rates ranged between 20% to 68% depending on illness day at sampling. This high false negative rate is attributed to poor swabbing technique, testing at earlier days of disease course and inconsistency of test with new viral strains. The false positive reports of RT PCR are rare which may be due to cross contamination (6,7).

Despite disagreement of many radiologists and radiology organizations in implementing the imaging techniques for diagnosis of COVID-19 disease, many physicians all over the world preferred the chest computed tomography (CT) scan in confirming diagnosis, assessing severity and determining the size of lower respiratory system complexity (8). The typical CT-scan characteristics for COVID-19 disease are the CT-scan chest feature frequently detected and highly specific for COVID-19 pneumonia (9). Peripheral ground glass opacities (GGOs) accompanied by consolidation or not, crazy-paving picture, multi-focal GGOs and reverse halo sign are the common features of typical chest CT-scan of COVID-19 disease. Less specific CT-scan features (intermediate or atypical findings) indicative for COVID-19 disease are diffuse GGOs without specific distribution, consolidation without

GGOs, nodular picture, cavitations, bronchial wall thickening and pleural or pericardial effusion (10). Many classifications have been developed in standardization of CT-scan reports into typical, indeterminate and atypical features for which used in assessing the burden of lung involvement by COVID-19 disease and detecting the specific pattern (11).

To assess the extent of lung involvement in COVID-19 disease by CT-scan, the categorical CT scheme (CORADS) was used. This CORADS scheme is ranged from category 1 with very low level suspicion to category 5 with very high level of suspicion. The category 0 indicated unpredictable findings and category 6 indicated COVID-19 disease proved by RT-PCR test (11,12) . COVID-19 disease severity could be to determine the clinical status of patients, management planning and considering the resources needs in hospitals (13). Many scoring systems were designed in regard to size of lung involvement by the virus (14-18). The CT-scan severity score (CT-SS) was firstly implemented and depends on previous method used for assessing severity of acute respiratory syndrome 14. The total severity score (CT-TSS) was implemented by measuring the proportions of involvement for each lung lobe and assigning 0-4 points according to involvement; 0 (0%), 1 (<5%), 2 (5-25%), 3 (26–49%), 4 (50-75%) and 5 (>75%), then the summing the score of five lobes in rage of 0-25 points 16. In spite of clinical significance of these scores in severity assessment of COVID-19 disease, some limitations were reported such as complexity, time consuming, interpretation difficulties and different sizes between both lungs with different measures of lung lobes in addition to fact that these quantitative methods required a special software with highly experienced staff (19).

In Kurdistan region/Iraq, the incidence of COVID-19 disease is high, but with lower incidence of severe to critical illness and low case fatality rate. Elderly age and co-morbidity with chronic disease are the main risk factors of severity and death in patients with COVID-19 disease (20,21). Since beginning of COVID-19 outbreak in Iraq, the CT-scan was applied commonly in diagnosis of clinically suspected cases with limited number of RT-PCR facilities especially at first one year of the health crises 20. The aim of this study was to determine the validity of chest CT-scan in diagnosis of COVID-19 disease in patients with positive RT-PCR and find the chest abnormalities that caused by corona virus.

2. PATIENTS and METHODS

The design of present study was a retrospective cross sectional study conducted in Radiology department of three hospitals through duration period of six months from June to November, 2021. Patients with positive RT-PCR test for COVID-19 referred to Radiology department were the study population. The inclusion criteria were irrespective than patients age and gender with COVID-19 disease (positive RT-PCR) and available CT-scan imaging. Exclusion criteria were negative RT-PCR, previous lung diseases, missing data, poor CT-scan image quality, co-existence with chronic lung diseases and CT-scan imaging before admission to hospital. The ethical considerations were implemented regarding ethical approval of Health authorities; an ethical approval was taken from Board Ethical Committee, agreement of hospitals authorities and confidentiality of data. A convenient sample of two hundred patients with COVID-19 disease was selected after eligibility to inclusion and exclusion criteria.

The data of enrolled patients were collected from their saved records in hospitals and fulfilled in a prepared questionnaire. The questionnaire was designed by the researchers, and included the following information: demographic characteristics of COVID-19 patients (age and gender), clinical features of COVID-19 patients (fever, SOB, cough, flue like illness, fatigue & myalgia and symptoms duration), CT-scan findings of COVID-19 patients (Multifocal GGO, peripheral or central distribution, border demarcation, vascular thickening, round pneumonia, carzy paving, GGO with consolidation, reverse halo sign, fibrous bands, sub-pleural bands, bronchial wall thickening, pleural or pericardial effusion, lymph adenopathy and number of lobes affected) and interpretation of CT-scan findings for COVID-19 patients (CT-scan findings, CO-RADS and CT-SS scale). The diagnosis of COVID-19 disease was done in regard to National Guidelines by RT-PCR, imaging and laboratory tests. The RT-PCR was done through oropharyngeal and nasopharyngeal swabbing . Chest CT scans were performed using a single inspiratory phase by two al multi-detector CT scanners; first (SOMATOM Emotions 16/6 slice) and second (GE Revolution EVO 1.0). the chest CT were performed using single inspiratory phase ,to minimize motion artifact the patients were instructed on breath hold. For CT acquisition the tube voltage was 120kVp with automated tube current modulation .From the raw data ,CT

image were reconstructed with a matrix size of 512x512 as axial image lung and mediastinal windows (thickness of 1.5 mm and increment of 1.5 mm) in transverse slice orientation with hybrid iterative using the multiplanar .

The CO-RADS of each patient was measured and interpreted according to Dutch Radiological Society; (0=Not interpretable, 1=Very low suspicion , 2=Low suspicion , 3= Equivocal/unsure, 4=High suspicion, 5=Very high suspicion and 6=Proven) 11. The CT-SS scale was measured and interpreted with visual assessment of CT-scan images for lung lobes by assessing percentage of lung involvement and classifying them into; 0 (0%), 1 (<5%), 2 (5-25%), 3 (26–49%), 4 (50-75%) and 5 (>75%), then the summing the score of five lobes in rage of 0-25 points 16.

The data collected were analyzed statistically by Statistical Package of Social Sciences software version 22. Chi-square and Fishers exact tests were applied for analyzing categorical variables. Level of significance (p value) was regarded statistically significant if it was 0.05 or less.

3. RESULTS

This study included two hundred COVID-19 patients with positive RT-PCR findings presented with mean age of (44.6 years) and ranged between 7-80 years; 33% of them were at age of 70 years and more. The male gender COVID-19 patients were slightly more than females (51% vs. 49%). (Table 1). The clinical features reported by COVID-19 patients with positive RT-PCR findings were distributed commonly as followings; cough (73%), fatigue and myalgia (67%), fever (52%), shortness of breath (51%), flue like illness (23%). Mean symptoms duration was (9.8 days); 31% of COVID-19 patients had symptoms duration of less than 5 days, 34% of patients had symptoms duration of 5-10 days and 35% of patients had symptoms duration of more than 10 days. (Table 2). Main positive CT-scan findings of COVID-19 patients with positive RT-PCR findings were multifocal ground glass opacification (56%), peripheral and basal distribution (46%), crazy paving (41%), ground glass with consolidation (40%), unsharp demarcation (26%), round pneumonia (19%), vascular thickening (14%), bronchial wall thickening (14%), lymph adenopathy (12%), plueral effusion or pericardial effusion (8%), sub-pleural bands (6%) and reverse

halo sign (1%). The CT-scan showed no lobes affected in 10% of COVID-19 patients, while 59% of COVID-19 patients had 1-3 lung lobes affected and 31% of patients had 4-5 lung lobes affected. (Table 3). The CT-scan findings were positive in 90% of COVID-19 patients with positive RT-PCR findings, while 10% of COVID-19 patients with positive RT-PCR findings had negative CT-scan findings (10% false positive rate for RT-PCR). The CO-RADS of COVID-19 patients with positive RT-PCR findings were not interpretable in 4% of patients, very low in 6% of patients, low in 10% of patients, equivocal/unsure in 23% of patients and high in 33% of patients. The computed tomography severity score (CT-SS) scale of COVID-19 patients with positive RT-PCR findings was distributed as followings; scale 0 (10%), scale 1 (0), scale 2 (50%), scale 3 (22%) scale 4 (18%) and scale 5 (0). (Table 4). There was a highly significant association between increased age of COVID-19 patients and increased the CT-SS scale (p=0.04). No significant differences were observed between COVID-19 patients with different CT-SS scales regarding gender (p=0.37). (Table 5). No significant differences were observed between COVID-19 patients with different CT-SS scales regarding clinical features like fever (p=0.2), and fatigue and myalgia (p=0.38). There was a highly significant association between shortness of breath for COVID-19 patients and increased the CT-SS scale (p=0.003), 88.9% of patients with 4 scale had presented with shortness of breath. COVID-19 patients with productive cough were significantly related to increased CT-SS scale (p=0.04). There was a significant association between flu like illness symptoms of COVID-19 patients and decreased CT-SS scale (p=0.01). A highly significant association was observed between longer duration of COVID-19 symptoms and increase in CT-SS scale (p=0.001). (Table 6). The current study revealed a significant relationship between CT-SS scale and CO-RADS findings of COVID-19 patients with positive RT-PCR findings (p=0.002). (Table 7)

Table 1. Demographic characteristics of COVID-19 patients.

Variable		**No.**	**%**
Age (year)	<30	32	16
	30-39	42	21
	40-49	36	18
	50-59	24	12
	≥60	66	33
	Mean (SD)	47 (18.5)	
Gender	Male	102	51
	Female	98	49

Table 2. Clinical features of COVID-19 patients.

Clinical feature		**No.**	**%**
Fever		104	52.0
SOB		102	51.0
Cough	Dry	78	39.0
	Productive	68	34.0
	None	54	27.0
Flue like illness		46	23.0
Fatigue and myalgia		134	67.0
Duration of symptoms (days)	<5	62	31.0
	5 - 10	68	34.0
	>10	70	35.0
	Mean (SD)	9.8 (6.6)	-

Table 3. CT-scan findings of COVID-19 patients.

Findings		No.	%
Multifocal ground glass opacification		112	56.0
Peripheral and basal distribution		92	46.0
Unsharp demarcation		52	26.0
Vascular thickening		28	14.0
Round pneumonia		38	19.0
Crazy paving		82	41.0
Ground glass with consolidation		80	40.0
Presence of reverse halo sign		2	1.0
Fibrous bands		0	0.0
Sub-pleural bands		12	6.0
Bronchial wall thickening		28	14.0
Pleural effusion, pericardial effusion		16	8.0
Lymphadenopathy		24	12.0
Number of affected lobes	1 - 3	118	59.0
	4 - 5	62	31.0
	None	20	10.0

Table 4. Interpretation of CT-scan findings for COVID-19 patients.

Variable		**No.**	**%**
CT scan findings	Positive	180	90.0
	Negative	20	10.0
CO-RADS	Not interpretable	8	4.0
	Very low	12	6.0
	Low	20	10.0
	Equivocal/unsure	46	23.0
	High	66	33.0
CT-SS scale	0	20	10.0
	1	0	-
	2	100	50.0
	3	44	22.0
	4	36	18.0
	5	0	-

Table 5. Distribution of patients' demographic characteristics according to CT-SS scale

Variable		CT-SS scale						P. value
		2		3		4		
		No.	%	No.	%	No.	%	
Age (year)	<30	16	16.0	8	18.2	2	5.6	**<0.001** S
	30-39	26	26.0	4	9.1	6	16.7	
	40-49	12	12.0	18	40.9	4	11.1	
	50-59	16	16.0	2	4.5	4	11.1	
	≥60	30	30.0	12	27.3	20	55.6	
Gender	Male	48	48.0	24	54.5	14	38.9	0.37 NS
	Female	52	52.0	20	45.5	22	61.1	
S:Significant, NS: Not significant.								

Table 6. Distribution of patients' clinical features according to CT-SS scale.

Clinical features		CT-SS scale						P. value
		2		3		4		
		No.	%	No.	%	No.	%	
Fever		60	60	22	50	16	44.4	0.200 NS
SOB		42	42	24	54.5	32	88.9	<0.001 S
Cough	Dry	42	42	14	31.8	8	22.2	0.040 S
	Productive	36	36	12	27.3	18	50	
	None	22	22	18	40.9	10	27.8	
Flue like illness		28	28	8	18.2	2	5.6	0.010 S
Fatigue and myalgia		66	66	34	77.3	24	66.7	0.380 NS
Duration of symptoms (days)	<5	46	46	4	9.1	2	5.6	<0.001 S
	5-10	26	26	20	45.5	18	50	
	>10	28	28	20	45.5	16	44.4	
S:Significant, NS: Not significant.								

Table 7. Distribution of CO-RADS findings according to CT-SS scale.

CO-RADS	CT-SS scale						P. value
	2		3		4		
	No.	%	No.	%	No.	%	
Low	10	10	4	9.1	6	16.7	**0.002** S
Equivocal/unsure	32	32	8	18.2	6	16.7	
High	40	40	20	45.5	6	16.7	
Very high	18	18	12	27.3	18	50	
S:Significant, NS: Not significant.							

4. DISCUSSION

COVID-19 disease is a global major public health disaster.Chest CT-scan played a major role in this pandemic disease distributed into screening, diagnosis and severity classification. Nowadays, profound information regarding typical or atypical chest CT scan characteristics and multiple grading systems and classification are helpful in planning for treatment and better prognosis (22).

In the current study, the chest CT-scan findings were positive in 90% of COVID-19 patients with positive RT-PCR findings, while 10% of COVID-19 patients with positive RT-PCR findings had negative CT-scan findings (10% false positive rate for RT-PCR). This finding is close to results of Khatami et al (23) meta-analysis study in Iran which found that sensitivity, specificity, positive predictive value, and negative predictive value of chest CT scan in comparison to RT-PCR for diagnosis of COVID-19 disease were 87%, 46%, 69% and 89%, respectively. However, our study findings regarding sensitivity of chest CT-scan in diagnosis of COVID-19 disease is lower than results Malaguria et al (24) review study in USA which stated that chest CT scan had sensitivity of 98% and specificity of 25% in diagnosis of COVID-19 disease. On other hand, our study results are higher than results of Al-Sharif and Al-Qurashi study 25 in Saudi Arabia which revealed a low sensitivity (60-71%) and

specificity (25%) for chest CT-scan in diagnosis of COVID-19 disease. Both American and Saudi studies attributed the low specificity of CT-scan to its overlapping with other viral pneumonias (24, 25).

Present study showed that common positive CT-scan findings of COVID-19 patients with positive RT-PCR findings were multifocal ground glass opacification (56%), peripheral and basal distribution (46%), crazy paving (41%), ground glass with consolidation (40%) and unsharp demarcation (26%). These findings are close to results of Sultan et al (26) retrospective cross sectional study in Iraq on 96 patients with positive RT-PCR test for COVID-19 disease which reported that main pulmonary manifestations recorded by CT-scan were ground glass opacification, consolidation and crazy paving with predominant bilateral and peripheral distribution. Ishfaq et al (27) systematic review and meta-analysis study in Pakistan also reported that GGO with peripheral distribution was the common CT-scan characteristic pattern of COVID-19 disease. The less common chest CT-scan findings of COVID-19 disease in our study were round pneumonia (19%), vascular thickening (14%), bronchial wall thickening (14%), lymphadenopathy (12%), pleural effusion or pericardial effusion (8%), sub-pleural bands (6%) and reverse halo sign (1%). These findings are close to results of Hammoodi et al (28) observational retrospective study in Iraq on 1378 patients with positive RT-PCR for COVID-19 disease which found that the classical picture of chest CT-scan of patients included commonly ground glass opacification, ground glass with consolidation and crazy paving, while less commonly showed vascular thickening, bronchial wall thickening, sub-pleural bands and reverse halo sign. More than half of our patients had 1-3 lung lobes affected, while 31% of them had 4-5 lung lobes affected. Dai et al (29) study in China reported that number of lobes affected detected by CT-scan is related to severity of COVID-19 disease and disease duration. The current study showed that CO-RADS of COVID-19 patients with positive RT-PCR findings were not interpretable in 4% of patients, very low in 6% of patients, low in 10% of patients, equivocal/unsure in 23% of patients and high in 33% of patients. These findings are parallel to results of Prokop et al (30) study in Netherlands which documented a higher specificity of CO-RADS reporting in classification of chest CT-scan findings especially for category 1 and category 6. The computed tomography severity score (CT-SS) scale of COVID-19 patients with positive RT-PCR findings in present study the most common scale was scale 2 (50%) ,followed by scale 3

then scale 4 and scale 0 respectively. These findings are different from results of Abdel-Tawab et al (21) retrospective study in Iraq on 213 patients with positive RT-PCR for COVID-19 disease which reported the most CT-SS scale of COVID-19 patients scale 2 and 0 (25.8%), (then scale 1 ,3,4 and 5 respectively. These differences might be due to differences in severity of COVID-19 and different in age and comorbidity of patients and different date admission of them to the hospital.

Present study found a highly significant association between increased age of COVID-19 patients and increased the CT-SS scale ($p<0.001$). This finding coincides with results of Al-Mosawe et al (31) prospective cross sectional study in Iraq on 172 patients with positive RT-PCR for COVID-19 disease which reported a significant positive correlation between CT-SS scale classification and elderly age. Our study revealed a highly significant association between each of shortness of breath and cough for COVID-19 patients and increased the CT-SS scale ($p<0.001$, $p=0.04$, respectively). This finding is similar to results of Zayed et al (32) study in Egypt which found that shortness of breath and cough were significant symptoms of severe COVID-19 disease. We reported a significant association between flu like illness symptoms of COVID-19 patients and decreased CT-SS scale ($p=0.01$). Consistently, Zayet et al (33) study in France reported that COVID-19 patients presented with flue like illness had mild clinical course of the disease. In our study, there was a highly significant association between longer duration of COVID-19 symptoms and increase in CT-SS scale ($p=0.001$). This finding coincides with results of Lieveld et al (34) study in Netherlands. The current study revealed a significant relationship between CT-SS scale and CO-RADS findings of COVID-19 patients with positive RT-PCR findings ($p=0.002$). This finding is in agreement with results of many studies such as Özel et al (35) study in Turkey and Lessmann et al (36) study in Turkey which reported good agreement between CO-RADS and chest CT-SS scale in predicting COVID-19 severity.

5. CONCLUSIONS

Chest CT-scan is a valid tool in diagnosis of COVID-19 disease. The CO-RADS and chest CT-SS classifications are helpful in predicting severity of COVID-19 patients which in turn helping in monitoring and management planning of the disease. This study recommended implementation of chest CT-scan as alternative to RT-PCR in diagnosis and management of COVID-19 disease.

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