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HRCT Chest Manifestations of COVID-19 Pneumonia in a Time Series

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Abstract: ***Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The disease was first identified in December 2019 in Wuhan, and has since spread globally, resulting in the ongoing 2019–20 coronavirus pandemic. Due to the widespread of the virus in the Kingdom of Saudi Arabia, the study tried to help find features of additional diagnostic methods (HRCT) for the disease to facilitate its detection and treatment in a timely manner before the complications increase. The purpose of this study was to assess the clinical features and HRCT chest manifestations of COVID-19 pneumonia by gathered a sample of (20) serial HRCT chest from the patients, three days after the symptoms began, then repeated after 48 hours, by this stage, the patient has had a positive nasopharyngeal swab for COVID-19 virus. The final HRCT was taken in the 10th day after symptoms. In 100% of patients, 55% were diagnosed with more diffused opacities in the all zones in 10th day of symptoms, a significant relationship was found between affected lung zones and the three-time series at p = 0.05.The study revealed a gradual spread that occurs over time for both GGO and consolidations, where the highest spread of both features was recorded on the tenth day in (90% and 85%) of patients for GGO and consolidation respectively, and there is a significant relationship between degree of GGO clarity, the amount of consolidation spread on HRCT and the three-time series at p = 0.01 for both features. Other findings like pleural effusion and crazy paving appearance …etc. were found in few patients, However, the study noted that those findings were more appear by time and significant relationship also noted between occurring of those other features in the three-time series after symptoms onset, and patients age at p=0.05. HRCT chest was more serviceable tool to follow the signs diffusion caused by COVID-19 virus in the lungs tissues over three different times. More sample size was recommended for future researches to emphasize the big role of HRCT chest that plays in diagnosis and follow up of COVID-19 virus.***

Keywords: Coronavirus Disease 2019, Severe Acute Respiratory Syndrome Coronavirus 2, High Resolution Computed Tomography and Ground Glass Opacities

1. Introduction

COVID-19 is an infectious disease caused by the most recently discovered coronavirus (SARS-CoV-2). This new virus and disease were unknown before the outbreak began in Wuhan, China, in December 2019 [1] .

Six coronaviruses are known to cause human disease. Two are zoonoses: the severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV), both of which may sometimes be fatal. The remaining four viruses cause the common cold[1,2].

As with many human infections, SARS-CoV-2 is zoonotic. The closest animal coronavirus by genetic sequence is a bat coronavirus, and this is the likely ultimate origin of the virus. The disease can also be transmitted by snakes [3].

This new coronavirus is spread from one person to another primarily through respiratory droplets generated when an infected person coughs or sneezes. According to recent reports, it may be possible that people infected with the novel coronavirus spread the virus before showing significant symptoms [8].

Some patients with confirmed infections with the novel coronavirus have showed little to no symptoms while others have become severely ill and died. Symptoms of infection include: Fever, cough and shortness of breath. At this time, it is believed that symptoms may appear in as few as 2 days or as long as 14 days after exposure [5].

Scientists are working hard to understand this new virus and produce a vaccine. Antibiotics do not work against viruses; they only work on bacterial infections [1]

The definitive test for SARS-CoV-2 is the real-time reverse transcriptase-polymerase chain reaction (RT-PCR) test. It is believed to be highly specific, but with sensitivity reported as low as 60-70% and as high as 95-97%. Thus, false negatives are a real clinical problem, and several negative tests might be required in a single case to be confident about excluding the disease [6,4]

Some papers suggest that HRCT chest has a sensitivity that could justify its use in the imaging in the acute setting. In a recent investigation, these chest HRCT findings had the highest discriminatory value ($p<0.001$) [6].

The study revealed the most important HRCT chest findings in a time series and studied the most changes that could be occurred to the lung tissues and the amount of diffusion of this features with a time progress.

2. Literature Survey

The study clearly states the features of COVID-19 pneumonia in high resolution CT chest in three-time series from the onset of symptoms.

3. Materials and Methods

3.1 Study design

A descriptive, cross sectional study design was used to examine a positive COVID-19 patient in a time series HRCT.

3.2Place and duration of the study

This study was done at Dammam central hospital CT department (Eastern region_ Saudi Arabia). Data were collected in the period spanned from March 2020 up to April 2020. Verbal consent was obtained from all potential participants. The aims, benefits of the present study were explained to all participant's in details. Medical history of all study subjects were thoroughly reviewed directly from participants themselves.

3.3 Study population

A sample of (20) patients was collected. Inclusion criteria were as follows: Any patient suspected of COVID-19 pneumonia performed a HRCT chest in a sequential time, after the third day of symptoms onset and repeated 48 hours later then doing a nasopharyngeal swab for COVID-19 virus, only those with positively results are included in study, they were the ones who subsequently underwent a third HRCT after the tenth day of symptom onset.

3.4 Images evaluation

All HRCT chest images that done in a time series were evaluated by two radiologists and two technologists, and all patients were evaluated to identify any changes occurred within lungs tissue.

3.5 Data Analyses

The data were collect from CT reports and then collected in data sheet which prepared specially for this task. Data analysed by using Microsoft excel and Statistical Package for the Social Sciences (SPSS) IBM version 25.

3.6 Machine and parameters used

For all scanning techniques (axial, coronal and/or sagittal), American, general electric (GE) Hispeed 64 multidetector CT scanner was used to obtain the non-contrast HRCT chest. The scanning parameter was 120 kV, 200 mAs; matrix was 512×512; scanning time was 0.55 s/ circuit; collimator was 0.625 m; pitch was 0.89, FOV 360 mm; scanning thickness was 1 mm; reconstruction algorithm: high spatial frequency, window: lung window. The scan ranged from the thoracic entrance to the angle plane of the bilateral rib. Level of inspiration: full inspiration.

3.7 Patient preparation and position:

The patient was prepared for the scan by making him or her to sign a consent form. Had the patient ask to remove anything that contains metal include (nickels, hearing aids, keys and....etc). The patient wore a hospital gown and the procedure was explained. Female patients were excluded if suspected pregnancy. The patient was in supine position andarms elevated above head (feet first).

3.8 Radiation protection

Radiation dose associated with HRCT of chest is much higher than a routine chest scan, in addition that, studied patients were undergo for follow up in three different time series. So the dose reduction techniques have been used for all patients: lower mAs (~40 mA), sequential spaced acquisition for the full inspiration scan, increasing pitch, lowering tube current or kV, limiting the z-axis coverage to the region of interest and use of fixed scanning parameters, respective of patient size during follow-up.

4. Results and Discussion

A sample of (20) confirmed a positively nasopharyngeal swab for COVID-19 virus patients that included 60 % male and 40% female are studied in a time series non contrast HRCT chest scan as follows: on the third, fifth, and tenth day after appeared symptoms, table (2). The characteristics of all variables in the studied sample were described as frequencies, percentages and correlations. The study was applied in 20 patients ranged from (35-44) to (75-84) years old. And found that patients' age between (75-84) years old had the highest percentage (30%), table (1).

Table 1: Ranges of patient's age in frequencies and percentages:

		Frequency	*Percent*
Valid	From 35 to 44	3	15.0
	From 45-to 54	3	15.0
	From 55-to 64	3	15.0
	From 65-to 74	5	25.0
	From 75-to 84	6	30.0

Table 2: Ranges of patient's gender in frequencies and percentages:

		Frequency	*Percent*
Valid	Male	12	60.0
	Female	8	40.0
	Total	20	100.0

The most common affected lung was RT (50%) followed by both RT and LT lungs (75%) on the 3rd and 5th day respectively after onset of symptoms, while (95%) of patient are affected in the both RT and LT lungs on the 10th day after onset of symptoms, table (3). Regarding lung zones, the study noted that the most affected zone was lower zone in 55% of patients on the 3rd day of symptoms, then infection diffused and became in both middle and lower zones in 40% of patients in day 5th of symptoms and then unfortunately more diffused in the all zones was diagnosed in 10th day of symptoms in (55%) of patients, shown in table (4) and figure (1). A significant relationship was found between affected lung zones and the three-time series after symptoms onset, the 3rd, 5th and 10th days, at p = 0.05, table (13). There were not found previous studies done for comparison.

Table 3: The percentages of affected lung on each time series:

		3rd day of symptoms	*5th day of symptoms*	*10th day of symptoms*
Valid	RT	50.0	20.0	5.0
	LT	35.0	5.0	0.00
	RT and LT	15.0	75.0	95.0
	Total	100.0	100.0	100.0

Table 4: The percentages of affected lung zone on each time series in percentages:

		3rd day of symptoms	*5th day of symptoms*	*10th day of symptoms*
Valid	Upper zone	10.0	5.0	00.0
	Middle zone	15.0	0	00.0
	Lower zone	55.0	35.0	10.0
	Middle and lower lobes	20.0	40.0	35.0
	All lobes	00.0	20.0	55.0
	Total	100.0	100.0	100.0

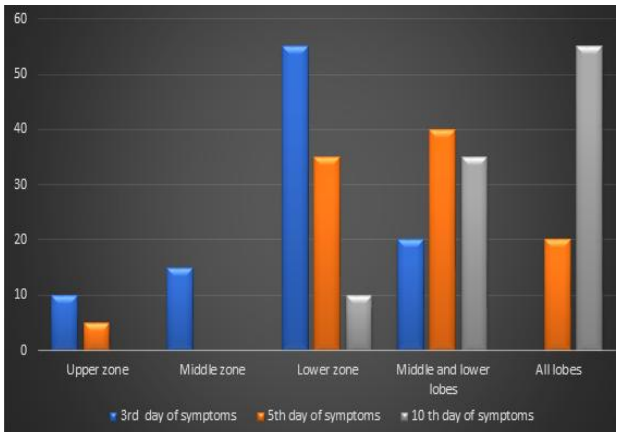

Figure 1: The percentages of affected lung zone on each time series in percentages

Moreover, the study showed that there were six patients who were diagnosed with normal chest X-ray on the third day after the onset of symptoms while their abnormal results were diagnosed when performing an HRCT examination at the same time, which confirmed the study done by (van der Bruggen-Bogaarts BA1, van der Bruggen HM, in 2018) [9] regarding sensitivity of HRCT over chest x-ray, table (5).

Table 5: Chest x-ray findings on the 3rd day of symptoms:

		Frequency	*Percent*
Valid	Normal	7	35.0
	Ground glass opacities	10	50.0
	Both GGO and consolidation	3	15.0
	Total	20	100.0

45% of patients were diagnosed with ill-defined ground glass opacities in day three since symptoms onset, while became clear multiple GGO in (65% and 90%) of patients on 5th and 10th day after appearing symptoms respectively, presented in table (6) and figure (2), which corresponding to study done by Cheng Z, Lu Y, Cao Q, et al in March 2020 [4].

The study represents a statistically significant relationship between degree of GGO clarity on HRCT and the three-time series after symptoms onset, the 3rd, 5th and 10thdays, at p = 0.01, table (9).

Table 6: Degree of GGO clarity on HRCT chest on each time series in percentages:

		3rd day of symptoms	*5th day of symptoms*	*10th day of symptoms*
Valid	ill defined	45.0	15.0	00.0
	Mild definition	35.0	20.0	10.0
	Clear multiple GGO	20.0	65.0	90.0
	Total	100.0	100.0	100.0

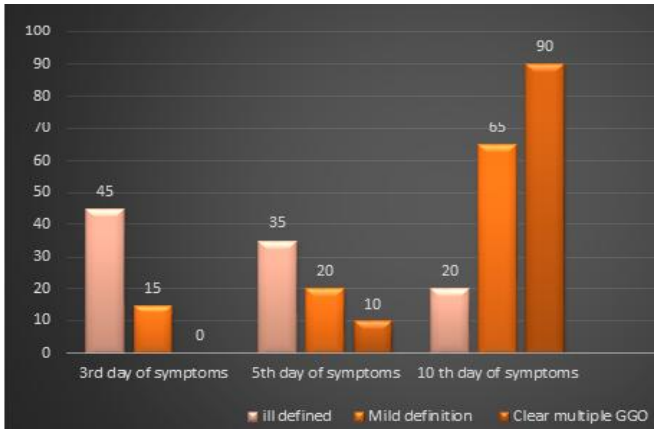

Figure 2: Degree of GGO clarity on HRCT chest on each time series in percentages

The study also noted that 75% of patients were free from lung consolidation until 3rd day after symptoms, while this percentage was change after only 48 hours and 50% of patients were diagnosed with diffuse lung consolidation, then percentage raised to 85% of patient diagnosed with diffuse consolidations after 10th day from symptoms, shown in table (7) and figure (3), and that was congruent to the same study done by Cheng Z, Lu Y, Cao Q, et al in March 2020 [4].

It also has explained a significant relation between the amount of consolidation spread on HRCT and the three-time series after symptoms onset, the 3rd, 5th and 10thdays, at p = 0.01, table (10).

Table 7: Amount of consolidation spread on HRCT chest on each time series in percentages:

		3rd day of symptoms	*5th day of symptoms*	*10th day of symptoms*
Valid	No consolidation	75.0	20.0	5.0
	ill defined	25.0	30.0	10.0
	Diffuse	00.0	50.0	85.0

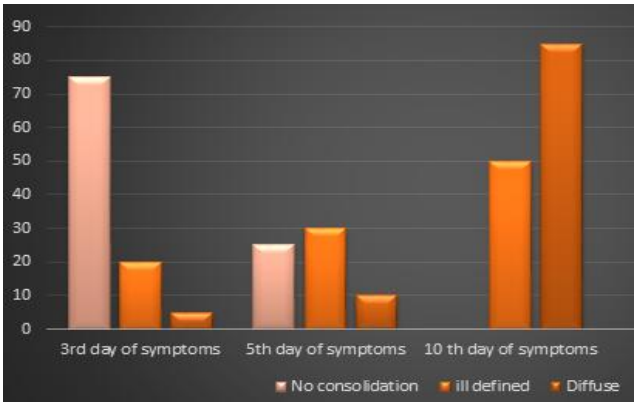

Figure 3: Amount of consolidation spread on HRCT chest on each time series in percentages.

Other findings like pleural effusion and crazy paving appearance, were found in 3 patients for each, during 10th day scan. 85 and 80% of patients were free from any other findings on the 3rd and 5th days since onset symptoms respectively. And then this percentage decreased in 10th day of symptom onset to reach 60%, table (8). The study also revealed a significant relationship between those other HRCT findings like pleural effusion, crazy paving appearance…etc. and the three-time series after symptoms onset, the 3rd, 5th and 10th days, at p = 0.01, table (12) It has proven also a significant relation between patients age and those other HRCT findings in the three-time series after symptoms onset, the 3rd, 5th and 10thdays, at p = 0.05, table (11), this agree with paper published in Feb 2020 by Kanne JP [7].

Table 8: Other CT findings on each time series in percentages

		3rd day of symptoms	*5th day of symptoms*	*10th day of symptoms*
Valid	No other findings	85.0	80.0	60.0
	Pleural effusion	00.0	00.0	15.0
	Lymphoadenopathy	00.0	00.0	5.0
	Crazy paving appearance	10.0	15.0	15.0
	Bronchovascular thickening	5.0	5.0	5.0
	Total	100.0	100.0	100.0

Table 9: Cross tabulation explains the degree of GGO clarity on HRCT chest in a time series, P≤0.01**

Correlations			*Degree of GGO clarity on HRCT chest in the 4th day of symptoms*	*Degree of GGO clarity on HRCT chest in the 6th day of symptoms*	*Degree of GGO clarity on HRCT chest in the 12th day of symptoms*
Spearman's rho	Degree of GGO clarity on HRCT chest in the 4th day of symptoms	Correlation Coefficient	1.000	.036	-.078-
		Sig. (2-tailed)	.	.879	.744
		N	20	20	20
	Degree of GGO clarity on HRCT chest in the 6th day of symptoms	Correlation Coefficient	.036	1.000	.581**
		Sig. (2-tailed)	.879	.	.007
		N	20	20	20
	Degree of GGO clarity on HRCT chest in the 12th day of symptoms	Correlation Coefficient	-.078-	.581**	1.000
		Sig. (2-tailed)	.744	.007	.
		N	20	20	20
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 10: Relation explain the amount of consolidation spread on HRCT chest in a time series, P≤0.01**

Correlations			*Amount of consolidation spread on HRCT chest in the 3rd day of symptoms*	*Amount of consolidation spread on HRCT chest in the 5th day of symptoms*	*Amount of consolidation spread on HRCT chest in the 10th day of symptoms*
Spearman's rho	Amount of consolidation spread on HRCT chest in the 3rd day of symptoms	Correlation Coefficient	1.000	.196	.242
		Sig. (2-tailed)	.	.407	.304
		N	20	20	20
	Amount of consolidation spread on HRCT chest in the 5th day of symptoms	Correlation Coefficient	.196	1.000	.633**
		Sig. (2-tailed)	.407	.	.003
		N	20	20	20
	Amount of consolidation spread on HRCT chest in the 10th day of symptoms	Correlation Coefficient	.242	.633**	1.000
		Sig. (2-tailed)	.304	.003	.
		N	20	20	20
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 11: Relation between patient age and other HRCT chest findings in a time series, P≤0.05*

Correlations		*Patient age*	*Other HRCT chest findings on the 3rd day of symptoms*	*Other HRCT chest findings on the 5th day of symptoms*	*Other HRCT chest findings on the 10th day of symptoms*
Patient age	Pearson Correlation	1	.465*	.314	.291
	Sig. (2-tailed)		.039	.177	.214
	N	20	20	20	20
Other HRCT chest findings on the 3rd day of symptoms	Pearson Correlation	.465*	1	.584**	.703**
	Sig. (2-tailed)	.039		.007	.001
	N	20	20	20	20
Other HRCT chest findings on the 5th day of symptoms	Pearson Correlation	.314	.584**	1	.916**
	Sig. (2-tailed)	.177	.007		.000
	N	20	20	20	20
Other HRCT chest findings on the 10th day of symptoms	Pearson Correlation	.291	.703**	.916**	1
	Sig. (2-tailed)	.214	.001	.000	
	N	20	20	20	20
*. Correlation is significant at the 0.05 level (2-tailed).					

Table 12: Cross tabulation describes the other HRCT chest findings in a time series, P≤0.01**

Correlations		*Other HRCT chest findings on the 5th day of symptoms*	*Other HRCT chest findings on the 10th day of symptoms*	*Other HRCT chest findings on the 3rd day of symptoms*
Other HRCT chest findings on the 5th day of symptoms	Pearson Correlation	1	.916**	.584**
	Sig. (2-tailed)		.000	.007
	N	20	20	20
Other HRCT chest findings on the 10th day of symptoms	Pearson Correlation	.916**	1	.703**
	Sig. (2-tailed)	.000		.001
	N	20	20	20
Other HRCT chest findings on the 3rd day of symptoms	Pearson Correlation	.584**	.703**	1
	Sig. (2-tailed)	.007	.001	
	N	20	20	20
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 13: Correlation between affected lung zones in a time series, P≤0.05*

Correlations		*The affected lung zone on the 3rd day of symptoms*	*The affected lung zone on the 5th day of symptoms*	*The affected lung zone on the 10th day of symptoms*
The affected lung zone on the 3rd day of symptoms	Pearson Correlation	1	.252	-.057-
	Sig. (2-tailed)		.284	.811
	N	20	20	20
The affected lung zone on the 5th day of symptoms	Pearson Correlation	.252	1	.525*
	Sig. (2-tailed)	.284		.017
	N	20	20	20
The affected lung zone on the 10th day of symptoms	Pearson Correlation	-.057-	.525*	1
	Sig. (2-tailed)	.811	.017	
	N	20	20	20
*. Correlation is significant at the 0.05 level (2-tailed).				

4. Conclusion

During this ongoing 2019–20 coronavirus pandemic, the HRCT chest findings note for the presence of the disease have included GGO, consolidation, and other findings like pleural effusion, with their distributions were progressed with time, starting in the lower lung in the most patients and then observed more extensively diffusion by time in the all lung zones.

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