Association of Lung CT Findings in Coronavirus Disease 2019 (COVID-19) With Patients' Age, Body Weight, Vital Sings and Medical Regimen

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Abstract

COVID-19 spread quickly in Jordan in the past few months. Many changes have been observed in lungs of COVID-19 patients which required their hospitalization. So far, many studies have been conducted on the epidemiological features of COVID-19 illness; however, the evidence regarding the pathological influence on lungs is still lacking. Therefore, the main aim of the present study was to detect the possible association between lung computed tomography (CT) findings in COVID-19 and patients' age, body weight, vital sings, and medical regimen. The present cross-sectional study enrolled 230 COVID-19 patients in Prince Hamza Hospital in Jordan. Demographic data as well as major lung CT scan changes were obtained from the hospital records of the COVID-19 patients. The main observed major lung changes among the enrolled COVID-19 patients included ground glass opacification in 47(15.2%) patients and consolidation in 22(7.1%) patients. The higher percentage of patients with major lung changes (24%) was observed among patients above 60 years old, while (50%) of patients with no changes in their lung's findings in the age group of 18-29 years old. Results obtained from the present study showed that only patients with major CT lung changes (9.7%) were prescribed more than three antibiotics. Additionally, 41.6 % patients with major lung CT scan changes had either dry (31.0%) or productive (10.6%) cough at the admission. Several predictors of lung CT scan changes have been detected in this study including age, BMI, medications, severity of symptoms, and cough at admission.

Introduction

An outbreak of coronavirus disease-19 (COVID-19) infection began in December 2019 in Wuhan, the capital of central China's Hubei province [1]. The COVID-19 pandemic has changed the focus of healthcare practitioners around the globe to control the spread of this contagious virus. Globally, at the current time (December 2020), there have been 73,275,943 confirmed cases of COVID-19, including 1,650,348 confirmed deaths, reported to WHO. Jordan was affected with COVID-19 as in other most countries of the world [2], since the virus started to spread rapidly among the population within the past few months where currently the confirmed cases reached 271,215 and 3,518 deaths as confirmed by the Ministry of Health daily reports [3].

COVID-19 can affect anyone causing mild to severe symptoms depending on age and the presence of certain underlying medical conditions. These medical conditions include cancer, smoking, obesity [body mass index (BMI) of 30 kg/m2 or higher], heart diseases, chronic obstructive pulmonary disease, chronic kidney diseases, immunocompromised state, pregnancy, type 2 diabetes and sickle cell anemia[4]. Moreover, it was found that a higher risk of COVID-19 infection was associated with male gender, Asian race, Black/African American race, low air quality, housing insecurity or transportation insecurity, and living in senior living communities [5].

The clinical manifestations of COVID-19 include fever, cough, myalgia or fatigue, dyspnea, shortness of breath and/or sore throat and more severe symptoms have been noted in patients with certain risk factors which are mentioned before and those patients require hospitalization, admission to the ICU,

intubation or mechanical ventilation and death can result among these critically ill patients [6, 7].The severity of these clinical signs experienced by COVID-19 patients is mainly found to be associated with the degree of lung abnormality [8].

Radiological examinations are of paramount value in the detection, management and follow up of COVID-19. High resolution, spiral chest CT examination is considered as the first-line imaging modality in the diagnosis of COVID-19 as the lung was observed to be the most affected organ among COVID-19 patients. The most common CT findings include ground-glass opacification (GGO), calcified nodules, atelectasis, pleural effusion, infiltration, consolidation, fibrotic band, pneumonia and emphysematous changes [9].

To our knowledge from the beginning of the present study up to the present time, no data is available regarding the association of lung CT findings in COVID-19 with patients' medical prognosis. Thus, the main aim of the current study was to detect any possible associations between lung CT findings/changes in COVID-19 with patients' age, body weight, vital sings and medical regimen.

Methods

Data Collection

A cross-sectional, hospital-based study (n = 230, mean age 42.3, SD 15.4, 30.5% women) was conducted between March 17th and September 7th, 2020 to investigate the association between CT features and treatment course and vital signs. The study was carried out in Prince Hamza Hospital; the main hospital for COVID-19 patients' admission in Jordan. High resolution, spiral non-enhanced CT scans were examined at admission.

Major lung CT scan changes were considered when the CT scan shows bilateral GGO; calcified nodules; atelectasis and fibrosis; pleural effusion; consolidation; infiltration; pneumonia; and/or emphysematous changes. However, minor lung CT scan changes were unilateral, multifocal, and predominantly GGO.

Age (years), anthropometric (height (cm), weight (kg), BMI (kg/m²)), vital signs (pulse rate (bpm), respiratory rate (bpm), temperature at admission, temperature on discharge, systolic blood pressure (mm Hg), diastolic blood pressure (mm Hg), O2 saturation on room air (%), and O2 saturation at discharge (%)) data were collected from the patients' medical files and some missing data were collected by phone directly from the patients. Additionally, the data about medications and supplements (antimalarial, number of antibiotics, respiratory antihistamines, steroids, ascorbic acid, vitamin B-complex supplement, zinc sulfate supplement), severity of symptoms, oxygen therapy, cough at admission, and cough at discharge, and daily number of smoked cigarettes were all collected from patients' files.

With regard to severity of symptoms, it was graded as mild: if the patient is asymptomatic or complain of one or two symptoms that lasts for few days; Moderate: if the patient complains of more complicated symptoms that lasts for longer duration and/or have "bad" lung CT scan findings; and Severe: if the

patient complains of the symptoms same as "moderate" criteria plus that there was a need for oxygen therapy.

The Ethics Committee of Prince Hamza Hospital approved the study protocol (1630/1/(and verbal consent was obtained at the start of the phone call.

Statistical analysis

Analyses were performed in SPSS version 26. Data is presented as mean ± standard deviation (SD) with percentages for descriptive statistics. One-Way ANOVA with LSD (Least Significant Difference) Post Hoc Test were used to find the differences among the three levels of lung CT scans changes (normal, minor abnormalities, and major abnormalities). A chi-square (χ^2) was used to find differences between categorical variables. Linear regression was used to find the association between lung CT scans changes and some variables. *P*-value was set at ≤ 0.05.

Results

In the present study, 160 males and 70 females were enrolled to explore the association between lung changes during COVID-19, medical regimen and vital sings.

The reported lung CT scan changes among patients with major lung changes were GGO in 47(15.2%) patients; calcified nodules in 3(1.0%) patients; atelectasis and fibrotic band in 16(5.2%) patients; pleural effusion and consolidation in 22(7.1%) patients; infiltration and pneumonia in 11(3.5%) patients; and emphysematous changes in 11(3.5%) patients. Figure 1, 2, and 3 show three different cases with major lung changes. Figure 4 shows one case with minor lung changes.

The study participants' characteristics are shown in Table (1). The main characteristics of study participants were categorized based on grades of lung CT changes. A significant difference has been detected among the different age groups between the different grades of lung CT changes. Young age (18–29 years) seems to be protective against major lung changes; patients in this age group accounted for the highest percentage of patients (50%) with no changes in their lungs. However, the highest percentage in major lung changes (24%) was observed in patients a above 60 years old. Regarding the BMI, the higher percentage of obesity was observed patients with both minor and major lung CT scan changes (35.7 and 34.7%, respectively). The results of the present study showed that only patients with major CT lung changes (9.7%) were prescribed more than three antibiotics. Additionally, 41.6 % of patients with major lung CT scan changes had either dry (31.0%) or productive (10.6%) cough at admission.

Table (2) presents the means of anthropometric and medical variables among the study participants based on lung CT abnormalities. Table (2), demonstrates significantly higher values of age (mean (SD): 50.8(13.8) years), weight (85.4(15.1) kg) and BMI (29.4(5.2) kg/m²) in patients with major lung CT scan changes as compared with patients who had no or minor CT scan changes.

The associations between lung CT scan changes and the possible predictors are shown in Table (3). While significant direct associations were observed between lung CT scan changes and age, BMI, number of antibiotics, steroids, severity of symptoms, and cough at admission, a marginally significant negative association was detected with O2 saturation on room air at admission.

Discussion

The severity of COVID-19 infection is multifactorial in nature which could be influenced by various medical and personal variables. Understanding the association between such factors and pathological lung changes would allow better utilization of the existing medical resources and alleviate the consequences of COVID-19 infection.

In agreement with our findings, previous studies showed that the most common hallmark in the COVID-19 virus-affected lungs is GGO followed by consolidation [10, 11]. The adverse manifestations progress during the course of COVID-19 infection. Early-phase of the disease was found to be characterized by the detection of GGO [12]. Also, the increased density of GGO lesions could be used as a marker for disease progression [11, 13]. Wang *et al.*, (2020) revealed a pattern for the progression of the adverse lung changes detected by CT scan, mainly, having late stages characterized by an elevation in GGO which peaked on illness days 6–11 [11]. However, the observed drift of patterns toward GGO is suggested to be associated with the recovery from the illness [11, 12].

Similar to our findings, symptoms, including fever, cough, respiratory distress, or requirement for mechanical ventilation, was previously reported to have higher intensity in patients with major lung changes detected by the CT scan [14]. On the other hand, a higher density of GGO, unlike consolidation, was reported to be associated with asymptomatic cases of COVID-19 infection [15]. Based on the number of confirmed cases and deaths, the mortality rate of COVID-19 (~ 2%) is lower than other viruses within the same family [such as SARS; 9.5% mortality rate][10]. Many factors could influence the disease process and the severity of illness such as BMI and age; however, the ability to identify such factors is limited to the rapidly evolving pandemic.

CDC data indicated an increased in mortality rate from COVID-19 infection among people who are 60 years and older, mainly those who suffer from other underlying comorbidities [13]. Here, we detected a direct positive trend [*p*-value = 0.001] between age and increased CT abnormalities, in which elder participants had a spectrum of major CT changes. Although the severity of the disease augmented with age; however, the highest incidence was observed among younger participants. This finding is in agreement with the age group-specific pattern of the incidence in the United States and Europe, where the highest incidence was observed in 20–29 years age group[16, 17]. The elevated incidence of infection among young individuals can be justified by the fact that this group contributes to the vast majority of workers in industries and frontline occupations that are highly exposed to the transmission of infection [16]. Moreover, the unintentional spread of infection is high in this age group due to the predominant lack of symptoms concomitant with the lack of proper social distancing [16, 17].

Expiratory reserve volume, functional capacity, and respiratory system compliance are negatively influenced with obesity, which suggests an aggressive course of COVID-19 infection [18, 19] and risk of mortality in obese patients [20]. The effects of obesity on respiratory functions could augment the increased need for careful attention and precise management to prevent the probable complications of the disease in this group of patients [18, 19].

Conclusion

A significant direct association between lung CT scan changes and age, BMI, number of antibiotics, steroids, the severity of symptoms, and cough at admission, a marginally significant negative association was detected with O2 saturation on room air at admission. Considering these factors could reduce the challenge confronted by physicians to provide effective treatment for patients infected with COVID-19.

Declarations

Ethical approval:

The study was approved by the IRB at Prince Hamza Hospital (1630/1/(□ □ □, and all participants were verbally consented to participate in the study.

Competing interests:

The authors declare that they have no competing interest.

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Tables

Table 1
Frequencies and percentages of sex, age, and medical variables among the study participants based on lung CT abnormalities

Variables	Lung CT Abnormalities n (%)				*P-value*
	Normal n = 78	Minor abnormality n = 37	Major abnormality n = 115	Total N = 230	
Sex					
- Male	50(64.1)	26(70.3)	84(73.0)	160(69.5)	0.908
- Female	28(35.9)	11(29.7)	31(27.0)	70(30.5)	
Age group					
- 18–29	39(50.0)	5(13.9)	8(6.9)	52(22.6)	
- 30–39	22(28.2)	6(16.7)	12(10.3)	40(17.4)	**0.001**
- 40–49	10(12.8)	13(36.1)	31(26.7)	54(23.5)	
- 50–59	5(6.4)	5(13.9)	37(31.9)	47(20.4)	
- 60–69	1(1.3)	5(13.9)	18(15.5)	24(10.4)	
- 70–79	1(1.3)	2(5.6)	7(6.0)	10(4.3)	
- > 80	0(0)	0(0)	3(2.6)	3(1.3)	
BMI					
- < 18.5	1(1.4)	0(0.0)	0(0.0)	1(0.5)	
- 18.5–24.9	29(41.4)	10(35.7)	20(20.4)	59(30.1)	**0.034**
- 25-29.9	23(32.9)	8(28.6)	44(44.9)	75(38.3)	
- 30-34.9	13(18.6)	9(32.1)	20(20.4)	42(21.4)	
- > 35	4(5.7)	1(3.6)	14(14.3)	19(9.7)	

- Data are presented as frequencies (N) and percentages (%).

- P-value for chi-square ≤ 0.05 considered significant.

Variables	Lung CT Abnormalities n (%)				*P-value*
	Normal n = 78	Minor abnormality n = 37	Major abnormality n = 115	Total N = 230	
Severity of Symptoms					
- Mild	67(87.0)	29(78.4)	65(56.5)	161(70.3)	0.174
- Moderate	10(13.0)	8(21.6)	37(32.2)	55(24.0)	
- Severe	0(0)	0(0)	10(8.7)	10(4.4)	
- Fatal	0(0)	0(0)	3(2.6)	3(1.3)	
Vitamin C Supplement					
- Yes	43(55.1)	20(54.1)	71(61.7)	134(58.5)	0.251
- No	35(44.9)	17(45.9)	43(37.4)	95(41.5)	
Vitamin B-Complex Supplement					
- Yes	14(17.9)	14 (37.8)	43(37.4)	71(30.9)	0.473
- No	64(82.1)	23(62.2)	72(62.6)	159(69.1)	
Zinc Sulfate Supplement					
- Yes	31(39.7)	19(51.4)	57(49.6)	107(46.5)	0.324
- No	47(60.3)	18(48.6)	58(50.4)	123(53.5)	
Antimalarial medication					
- Prescribed	47(60.3)	17(45.9)	56(48.7)	120(52.2)	0.119
- Not Prescribed	30(38.5)	19(51.4)	57(49.6)	106(46.1)	
- Hold or given with attention	1(1.3)	1(2.7)	2(1.7)	4(1.7)	

- Data are presented as frequencies (N) and percentages (%).

- P-value for chi-square ≤ 0.05 considered significant.

Variables	Lung CT Abnormalities n (%)				*P-value*
	Normal n = 78	Minor abnormality n = 37	Major abnormality n = 115	Total N = 230	
Number of Antibiotics					
- None	70(89.7)	34 (91.9)	61 (53.5)	165(72.1)	
- One	8 (10.3)	1 (2.7)	26 (22.8)	35(15.2)	**0.020**
- Two	0 (0.0)	2 (5.4)	16(14.0)	18(7.9)	
- Three	0 (0.0)	0 (0.0)	10 (8.8)	10(4.4)	
- Four	0 (0.0)	0 (0.0)	1(0.9)	1(0.4)	
Steroids					
- Prescribed	2(2.6)	3(8.1)	25(21.7)	30(13.0)	0.143
- Not Prescribed	76(97.4)	34(91.9)	90(78.3)	200(87.0)	
Respiratory\ Antihistamines Medications					
- Prescribed	7(9.0)	5(13.5)	34(29.6)	46(20.0)	0.072
- Not Prescribed	71(91.0)	32(86.5)	81(70.4)	184(80.0)	
Oxygen Therapy					
- Not Used	76(97.4)	37(100)	95(82.6)	208(90.4)	0.116
- O2 Mask\ Cannula	2(2.6)	0(0)	18(15.7)	20(8.7)	
- Ventilator	0(0)	0(0)	2(1.7)	2(0.9)	
Temperature at Admission					
- Normal	60(76.9)	27(73.0)	68(60.2)	155(68.0)	0.772
- Elevated	18(23.1)	10(27.0)	45(39.8)	73(32.0)	
Temperature on					
- Normal	78(100)	37(100)	110(97.3)	225(98.7)	0.228
- Elevated	0(0)	0(0)	3(2.7)	3(1.3)	

- Data are presented as frequencies (N) and percentages (%).

- P-value for chi-square ≤ 0.05 considered significant.

Variables	Lung CT Abnormalities n (%)				*P-value*
	Normal n = 78	Minor abnormality n = 37	Major abnormality n = 115	Total N = 230	
Cough at Admission					
- No Cough	67(85.9)	30(81.1)	66(58.4)	163(71.5)	
- Dry Cough	8(10.3)	6(16.2)	35(31.0)	49(21.5)	**0.037**
- Productive Cough	3(3.8)	1(2.7)	12(10.6)	16(7.0)	
Cough on Discharge					
- No Cough	78(100)	37(100)	108(97.3)	223(98.7)	0.133
- Dry Cough	0(0)	0(0)	3(2.7)	3(1.3)	
- Data are presented as frequencies (N) and percentages (%).					
- P-value for chi-square ≤ 0.05 considered significant.					

Table 2
Means of anthropometric and medical variables among the study participants based on lung CT abnormalities

Variable	Lung CT Abnormalities mean (SD)				P-value
	Normal	Minor abnormality	Major abnormality	Total	
Age (years)	31.5(11.5)[a]	45.2(14.9)[b]	50.8(13.8)[c]	43.4(15.8)	**0.001**
Height (cm)	172.8(10.5)	171.4(10.5)	170.7(9.2)	171.6(9.8)	0.510
Weight (kg)	77.7(18.1)[a]	77.8(10.6)[a]	85.4(15.1)[b]	81.6(16.1)	**0.020**
BMI (kg/m²)	25.9(5.1)[a]	26.8(4.9)[a]	29.4(5.2)[b]	27.7(5.3)	**0.001**
Pulse Rate (bpm)	81.22(8.53)	84.21(7.58)	81.4(8.32)	81.77(8.31)	0.185
Respiratory Rate (bpm)	19.91(8.60)	18.67(1.79)	19.45(5.21)	19.47(6.19)	0.642
Systolic Blood Pressure (mm Hg)	121.0(9.8)	122.6(8.8)	123.7(13.6)	122.7(11.8)	0.331
Diastolic Blood Pressure (mm Hg)	74.9(7.6)	75.9(7.3)	77.5(10.3)	76.4 (9.1)	0.191
O2 Saturation on Room Air (%)	96.3(4.6)	95.8 (3.2)	95.1(4.2)	95.6(4.2)	0.157
O2 Saturation at Discharge (%)	96.9(2.5)	96. 9(2.1)	96.4(3.1)	96.6 (2.7)	0.398
Number of Cigarettes	8.1(13.3)	2.5(6.8)	4.9(11.0)	5.9(11.7)	0.153

Data are presented as mean ± SD

Significance was set at P-value ≤ 0.05; ANOVA and LSD tests were used to assess the significance.

Different three letters (a,b,c) mean that there is a significant differences between three variables and same letters mean that there is no significant differences between variables.

Table 3
Predictors of lung CT changes among the study participants

Variable	R^2	ANOVA	Model	B	ß	P-Value
Lung CT Scan Changes	0.295	F = 95.239	Age	0.031	0.543	**0.001**
	0.000	F = 0.005	Sex	0.009	0.005	0.945
	0.096	F = 14.413	BMI	0.054	0.310	**0.001**
	0.005	F = 1.243	Antimalarial	-0.123	-0.074	0.266
	0.066	F = 16.089	Number of Antibiotics	0.252	0.257	**0.001**
	0.022	F = 5.190	Respiratory\ Antihistamines	0.337	0.149	**0.024**
	0.017	F = 3.872	Steroids	0.346	0.129	**0.050**
	0.002	F = 0.405	Ascorbic Acid	0.071	0.042	0.525
	0.006	F = 1.419	Vitamin B-Complex Supplement	0.149	0.079	0.235
	0.005	F = 1.058	Zinc Sulfate Supplement	0.124	0.068	0.305
	0.023	F = 5.306	Severity of Symptoms	0.231	0.151	**0.022**
	0.000	F = 0.001	Pulse Rate	0.000	-0.002	0.971
	0.001	F = 0.159	Respiratory Rate	-0.004	-0.028	0.690
	0.010	F = 2.217	Systolic Blood Pressure	0.008	0.101	0.138
	0.015	F = 3.321	Diastolic Blood Pressure	0.012	0.123	0.070
	0.017	F = 3.722	O2 Saturation on room air at admission	-0.028	-0.130	**0.051**

P-value was ≤ 0.05.

Linear regression was used to assess predictors of lung CT changes among the study participants.

Variable	R^2	ANOVA	Model	B	ß	P-Value
	0.008	F = 3.163	O2 Saturation at discharge	-0.028	-0.087	0.201
	0.016	F = 3.613	Oxygen Therapy	0.350	0.125	0.059
	0.002	F = 0.502	Temperature at Admission	-0.091	-0.047	0.479
	0.011	F = 2.578	Temperature on Discharge	0.841	0.106	0.110
	0.038	F = 8.861	Cough at Admission	0.284	0.194	**0.003**
	0.015	F = 3.524	Cough During on Discharge	0.852	0.124	0.062
P-value was ≤ 0.05.						
Linear regression was used to assess predictors of lung CT changes among the study participants.						

Figures

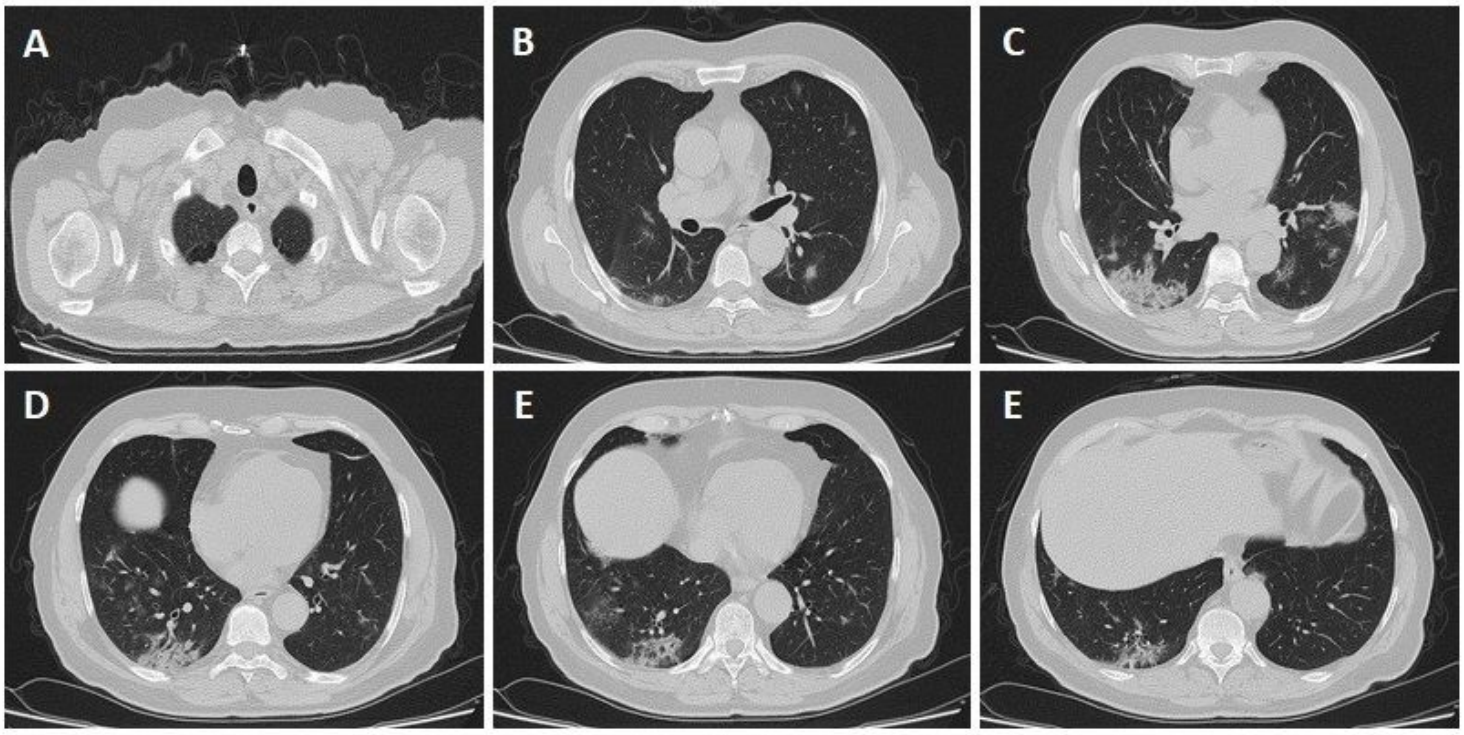

Figure 1

High resolution, axial non-enhanced spiral chest CT images (lung window) of a 69-years old patient who was confirmed to be infected by COVID-19 and admitted to hospital with fever and dry cough. CT images show (A) emphysematous changes in the apices of both lungs and multiple patchy consolidation predominantly in the lower lobe of the right lung (B-E).

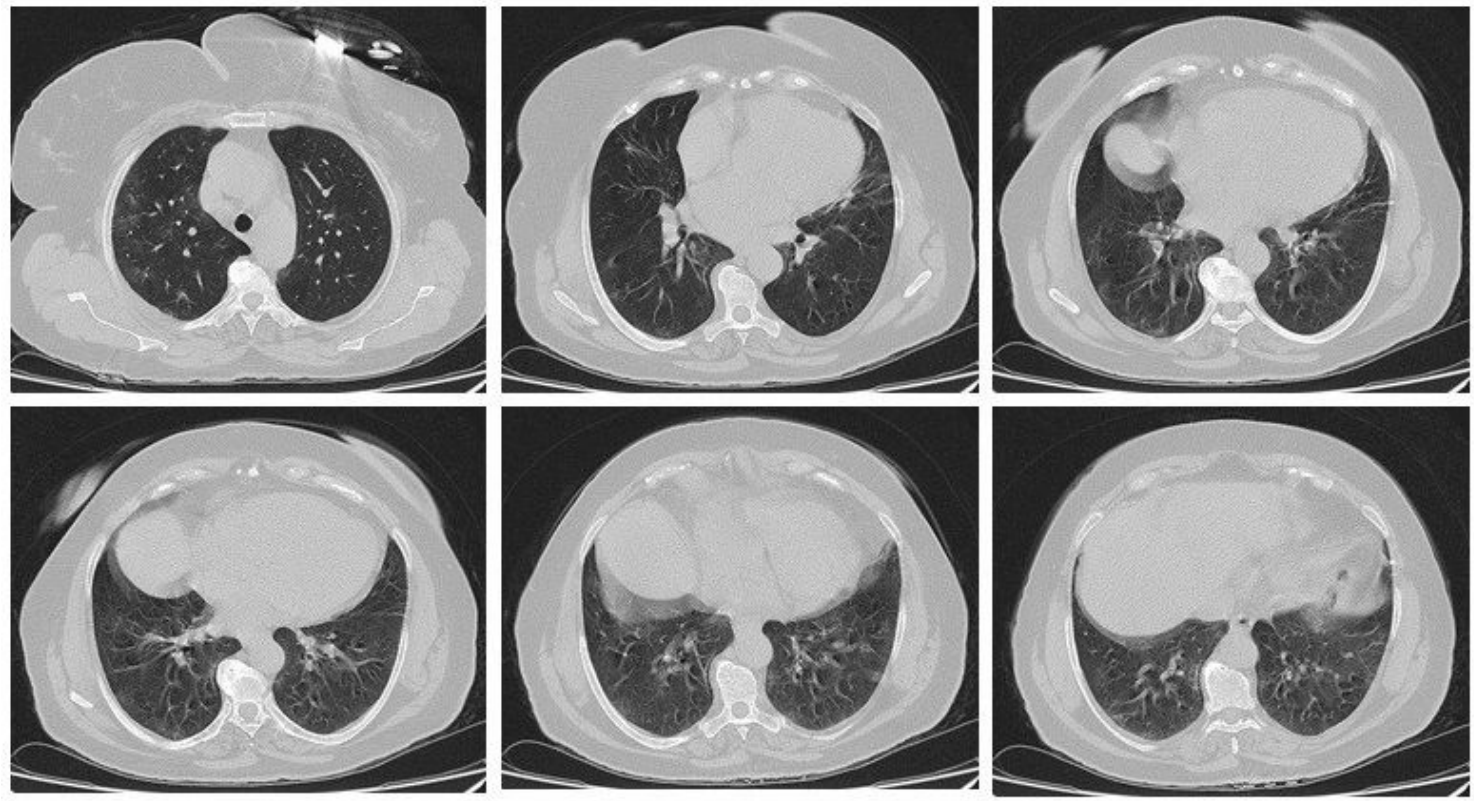

Figure 2

High resolution, axial non-enhanced spiral chest CT images (lung window) of a 59-years old patient who was confirmed to be infected by COVID-19 and admitted to hospital with Flu-like symptoms and gastrointestinal tract symptoms (mostly diarrhea). CT images show multiple faint patchy consolidation disseminated in ground-glass pattern.

Figure 3

High resolution, axial non-enhanced spiral chest CT images (lung window) of a 50-years old patient who was confirmed to be infected by COVID-19 and admitted to hospital with fever and dry cough. CT images

show a number of airspace opacities, ground-glass shadows, and multiple sub-segmental consolidation most pronounced in the lower lobe of both lungs.

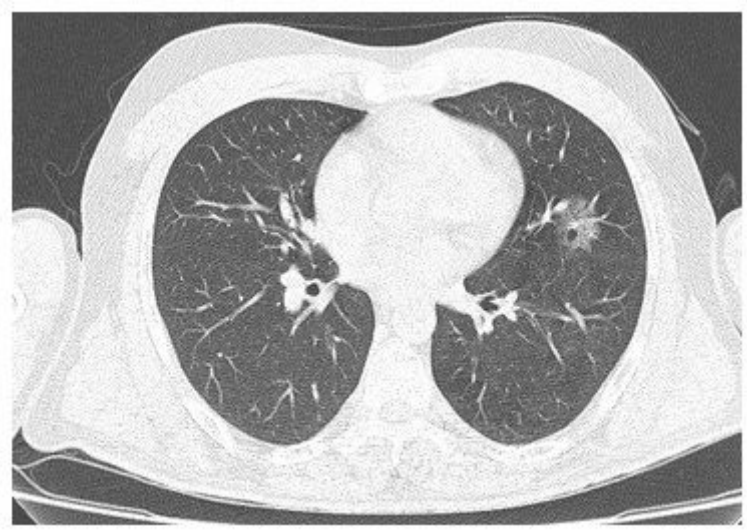

Figure 4

High resolution, axial non-enhanced spiral chest CT image (lung window) of a 44-years old patient who was confirmed to be infected by COVID-19 and admitted to hospital with no symptoms (asymptomatic). CT image shows only small ground-glass pattern in the lower aspect of anterior segment of the upper lobe of the left lung.