

HRCT Features of COVID-19 Patients Admitted out of Wuhan: Comparison against Common Pneumonia

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Abstract

Background: Chest CT is working as a first-line imaging modality for diagnosing Corona Virus Disease 2019 (COVID-19). Whether the CT findings could differentiate between the COVID-19 admitted out of Wuhan and common pneumonia has not been investigated. This study aimed to compare the chest CT features of patients with COVID-19 admitted out of Wuhan, as against the patients with common pneumonia.

Methods: This retrospective study enrolled 37 individuals with COVID-19 from six medical centers out of Wuhan from January 17 th to February 26 th . Another group of 41 patients with acute pneumonia collected from the same timeframe in 2019 were enrolled as the control group. All the patients had high-resolution chest CT (HRCT) scans. Clinical variables were recorded including exposure history, clinical symptoms and laboratory findings. For each HRCT, pulmonary lesions including ground-glass opacification (GGO), consolidation, and evidence of fibrosis were recorded. The Student's t test or Wilcoxon's test was used for comparison between COVID-19 and common pneumonia. Spearman correlation was used to evaluate correlations between the pneumonia findings on CT and clinical variables.

Results: A total of 37 patients (M/F:19/18; 43.73 ± 16.71 years) in COVID-19 group and 41(M/F:13/28; 49.77 ± 15.00 years) in common pneumonia group were evaluated. Patients with COVID-19 demonstrated a typical pattern of bilateral, multi-lobal GGO, sometimes with consolidation and fibrosis, but a mild degree of pneumonia findings than the control group ($P = 0.0024$). 23/37 (62.16%) patients with COVID-19 had a preferable subpleural distribution, while the patients with common pneumonia had higher frequency of peribronchovascular pattern (16/41, 39.02%, $P = 0.0046$). The duration between the illness onset and CT were significantly correlated with the severity scores in both groups.

Conclusion: Patients with COVID-19 admitted out of Wuhan demonstrated a milder pulmonary change and a preferable subpleural pattern on HRCT when comparing with the patients with common pneumonia.

Background

In the late December, 2019, cases of atypical pneumonia, caused by a newly discovered coronavirus (SARS-CoV-2) were firstly recognized in Wuhan, Hubei province, China. Very shortly, the novel coronavirus pneumonia (COVID-19) spread widely across China and began to appear in other countries(1). Although source of SARS-CoV-2 has not been completely confirmed, 66% the initial cases had exposure to the Huanan Seafood market in late December, 2019(2). As evidence of human-to-human transmission began to accumulate(3)(4). Wuhan was cut off rigorously to avoid further expansion, as well as several neighboring areas in Hubei province. Nevertheless, a certain number of people living in Wuhan had left the city before the official cut-off date, resulting in a cascade of patients exposed to the COVID-19

infection out of Wuhan (5). To date, a total of 80424 patients were diagnosed with COVID-19 pneumonia in China, among which, 2984 were dead and 6416 were severe cases.

According to the clinical guidelines from the National Health Commission of the People's Republic of China (NHC, PRC), patients with clinical suspicion should meet both of the two criteria below: (1) exposure history; (2) clinical symptoms (at least two out of the three rules as follows: fever or other respiratory symptoms; pneumonia findings on chest imaging; normal or reduced count of white blood cell (WBC), or reduced lymphocyte counts)(6). Then, the diagnosis of COVID-19 would be set up by performing real time reverse-transcription-polymerase chain reaction (RT-PCR) testing of the blood or specimens taken from the respiratory tract.

However, a number of patients had an initial false negative result of RT-PCR testing, resulting in the necessity of repeat testing and a delay in treatment. Chest imaging becomes vitally important for such patients since the suspected pneumonia findings can help clinicians to decide if they can start isolation and treatment earlier before the results of repeat testing comes out. Chest CT is being used as a first line imaging modality for diagnosis of COVID-19, as it has played an important role in the severe acute respirator syndrome (SARS) and the Middle East Respiratory syndrome (MERS) events. Thus, radiologists and clinicians should be equipped with the key points of differential diagnosis between the COVID-19 and other common pneumonia. However, the chest CT features of patients out of Wuhan have not been systematically compared from the cases with common pneumonia. The purpose of this study was to qualitatively and quantitatively compare the chest CT features of the patients diagnosed with COVID-19 out of Wuhan, as against the patients with acute common pneumonia.

Methods

The review board from the centers approved this study. The informed consents of the patients were waived for the retrospective study.

Study Participants

This multi-center, retrospective study composed of two groups of patients. For the COVID-19 group, continuous patients admitted to the centers out of Wuhan from January 17th, 2020 to the February 26th, 2020 were initially screened. Patients with an exposure history, suspected clinical symptoms, pneumonia signs on chest imaging, abnormal laboratory findings were suspected with COVID-19 (Fig. 1). Then, patients diagnosed with COVID-19 were finally enrolled. The diagnosis was based on the RT-PCR testing of the specimen collected from bronchoalveolar lavage fluid or sputum according to the guidelines from WHO and NHC, PRC. No exclusion was applied to this group.

Patient in the contrast group were selected similar in size to the COVID-19 cohort but with no possible exposure history of the SARS-CoV-2. To avoid the confounding effect of seasonal activity and clothing, we retrospectively reviewed the cases admitted in the centers through outpatient emergency service

during the same timeframe from January 17th to February 14th in 2019. Patients with a diagnosis of acute pneumonia (within two weeks) were included. Exclusion criteria were applied as follows for this group: (1) lung cancer, tuberculosis, severe interstitial lung disease, pulmonary edema or other conditions that might cause significant increase of the parenchymal opacities (2) the quality of whose HRCT was not good enough for further evaluation.

All the clinical variables, including baseline characteristics, basic signs taken at the emergency department, exposure history, clinical symptoms, duration from illness onset to CT, and the clinical outcome within the study date range, were collected through the history and nursing recordings. According to the sixth version of clinical management guideline of COVID-19 from NHC, PRC, severe illness was defined as patients who fulfilled one of the three criteria or even severer: (1) respiratory distress, respiratory rate (RR) ≥ 30 beats/min; (2) oxygen saturation measured at fingertip $\leq 93\%$ at rest; (3) the ratio between arterial blood oxygen partial pressure and oxygen concentration ($\text{PaO}_2/\text{FiO}_2$) ≤ 300 mmHg (1 mmHg = 0.144 kPa).

Chest CT Scan

The patients were imaged in six centers. 65 and 7 patients were imaged with a 1-mm section thickness, 256-detector CT scanner (Revolution CT, GE Healthcare, Milwaukee, Wis) and a 2-mm section thickness 128-detector CT scanner (Ingenuity Core, Philips Healthcare, Best, The Netherlands) separately at two hospitals in city A; 5 patients were imaged with a 1-mm section thickness, a 64-slice spiral CT scanner (SOMATOM Definition Flash, Siemens, Germany), a 16-detector CT scanner (Brilliance, Philips Healthcare, Best, The Netherlands), or a 16-detector CT scanner (uCT 510, United Imaging, Shanghai, China) at three centers in city B. One patient was imaged with a 1-mm section thickness, 16-detector CT scanner (Philips Ingenuity, Philips Medical System, Netherlands) at one center in city C. (Detailed scanning parameters were provided in supplementary).

Image Analysis

Two radiologists with an over 5-year diagnostic experience analyzed the high-resolution chest CT (HRCT) scans independently and blindly to the clinical variables. Disagreement in imaging interpretation were solved by consensus.

For each case, the presence and number of involved lobes were recorded for the lung lesions including: (1) ground-glass opacity (GGO) (patchy or round morphology like lesions with an increase in lung parenchymal opacification without obscuration of the underlying vessels); (2) consolidation (an increase in lung parenchymal with obscuration of the underlying vessels); (3) Fibrosis (presence of irregular linear opacities, parenchymal bands, traction bronchiectasis and lung distortion based on the above two lesions). Nodule or mass, cavitation, lymphadenopathy, and pleural effusions were also noted.

Concerning the distribution pattern, each case was classified as unilateral or bilateral, unifocal or multifocal, cranial or caudal. In the transverse plane, the distribution pattern was recorded as upper, subpleural (or periphery), peribronchovascular (namely, central) or random(7).

The severity score was graded for each lobe and then summed, according to the visual grades used in previous CT studies of patients with SARS and MERS(8,9). In detail, 0 = no lesion; 1 = single or multiple nodule-like small (with a diameter less than 1 cm) GGO with an extent less than 10% of the lobe; 2 = single or multiple nodule-like medium (with a diameter between 1 to 3 cm) GGO with an extent of 10–30% of the lobe; 3 = single or multiple nodule-like large (with a diameter more than 3 cm) GGO with an extent within 30–60% of the lobe, or any extent of the GGO with consolidation; 4 = any diameter of GGO with an extent of 60–90% of the lobe, or with evidence of fibrosis. 5 = Diffuse extent of GGO with an over 90% extent of the lobe.

Statistical Analysis

Shapiro-Wilk test was used for normality testing, with histograms, and Q-Q plot. Parametrical data was expressed as mean \pm standard deviation (SD). Non-parametrical data was expressed as median with interquartile range (IQR). Two-sided non-paired Student's t test or Wilcoxon's test was used for comparison between the two groups. Categorical variables were presented as frequency and the corresponding percentage and Chi-square test was used for comparison. The relationship between HRCT severity scores and clinical variables was assessed by Spearman correlation analysis. The agreement between the radiologists on the maximal diameter of abnormal pulmonary findings was evaluated using the intraclass correlation coefficient (ICC), as well as expressed as bias \pm SD and graphically shown as difference plots according to Bland and Altman(10). A P value less than 0.05 was considered statistically significant. Statistical analysis was performed with R project (v. 3.3.1).

Results

Finally, 78 patients were included, including 32 males and 46 females. The median age of the include patients were 47.0 years (IQR: 34.0–58.0), with no difference between the two groups. In COVID-19 group, none had direct exposure to the Huanan Seafood Market. 18/37 (48.65%) patients had a history of residency or travel to Wuhan, 9/37 (24.32%) patients had close contact patients with either suspected or confirmed diagnosis of COVID-19, and 10/37 (27.03%) patients had no specific exposure history but reported at least once being in a crowd of people within the two weeks before onset of the symptoms.

Baseline clinical characteristics

In COVID-19 group, fever was the most common symptoms (n = 23, 62.16%), followed by cough (n = 22, 59.46%), sputum (n = 9, 24.32%), fatigue (n = 6, 16.22%) and chills (n = 6, 16.22%) on admission. While for the patients with common pneumonia, cough was the most common symptom (n = 39, 95.12%), followed

by fever (n = 28, 68.29%), sputum (n = 23, 56.10%), dyspnea (n = 13, 31.71%) and pharyngalgia (n = 8, 19.51%). No significant difference of basic life signs existed between the two groups. (See in Table 1)

Table 1
Baseline Clinical Characteristics between COVID-19 and Common Pneumonia

	COVID-19 (n = 37)	Common Peumonia (n = 41)	P value
Age, years [†]	43.73 ± 16.71	49.77 ± 15.00	0.1138
Sex, no. (%)			0.1659
Male	19/37 (51.35%)	13/41 (31.71%)	
Female	18/37 (48.65%)	28/41 (68.29%)	
Comorbidities, no. (%)			
HTN	3/36 (8.11%)	7/41 (17.07%)	0.5278
DM	1/36 (2.70%)	5/41 (12.20%)	0.2062
COPD	1/36 (2.70%)	0/41 (0.00%)	0.4675
CAD	2/36 (5.41%)	1/41 (2.44%)	0.5964
Exposure history, no. (%)		–	
Huanan Seafood Market	0/37 (0.00%)		
Wuhan	18/37 (48.65%)		
Contact with wuhan	9/37 (24.32%)		
No specific exposure	10/37 (27.03%)		
Suspicion of family cluster, no. (%)		–	
Yes	10/37 (27.03%)		
No	27/37 (72.97%)		
Clinical symptoms, no. (%)			
Fever	23/37 (62.16%)	28/41 (68.29%)	0.6375
Fatigue	6/37 (16.22%)	7/41 (17.07%)	1.0000
Cough	22/37 (59.46%)	39/41 (95.12%)	0.0002*
Sputum	9/37 (24.32%)	23/41 (56.10%)	0.0058*

[†] Values given as mean ± standard deviation, otherwise median with (25th, 75th percentiles). COVID-19: Coronavirus Disease 2019; HTN: hypertension; DM: diabetes mellitus; COPD: chronic obstructive pulmonary disease; CAD, cardiovascular disease; CT, computed tomography; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; RR: respiratory rate; SpO2: Percutaneous oxygen saturation; WBC: white blood cell.

	COVID-19 (n = 37)	Common Peumonia (n = 41)	P value
Pharyngalgia	3/37 (8.11%)	8/41 (19.51%)	0.1485
Dyspena	2/37 (5.41%)	13/41 (31.71%)	0.0127*
Chills	6/37 (16.22%)	3/41 (7.32%)	0.2950
Headache	3/37 (8.11%)	3/41 (7.32%)	1.0000
Digestive system	1/37(2.70%)	2/41 (4.88%)	1.0000
Incubation period, days	5.00 (3.50-9.00)	–	
Duration from illness onset to CT, days	3.00 (1.75-5.00)	5.50 (1.25-10.00)	0.0915
Basic signs			
Temperature, °C	37.45 (36.43–38.29)	37.60 (36.40-38.85)	0.4837
SBP, mm Hg [†]	135.55 ± 16.23	129.85 ± 23.87	0.1999
DBP, mm Hg	82.00 (76.00–95.00)	80.50 (71.00-91.75)	0.4828
HR, bpm [†]	99.77 ± 16.15	103.05 ± 18.91	0.4435
RR, bpm	20.00(19.00–20.00)	20.00(19.00–20.00)	0.3795
SpO ₂	97.00 (96.00–98.00)	97.00 (93.00–98.00)	0.3632
Laboratory findings, x10 ⁹ /L			
WBC count	5.43 (4.34–6.49)	7.21 (5.78-9.00)	0.0003*
Lymphocyte count	1.17 (0.94–1.48)	0.98 (0.78–1.87)	0.5889
Neutrophil count	3.50 (2.72–4.67)	5.59 (3.88–6.87)	< 0.0001*
Eosinophils count	0.01 (0.00-0.04)	0.07 (0.01–0.10)	0.0016*
Disease severity, no. (%)		–	0.1519
Critical	1/37 (2.70%)	0/41 (0.00%)	
[†] Values given as mean ± standard deviation, otherwise median with (25th, 75th percentiles). COVID-19: Coronavirus Disease 2019; HTN: hypertension; DM: diabetes mellitus; COPD: chronic obstructive pulmonary disease; CAD, cardiovascular disease; CT, computed tomography; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; RR: respiratory rate; SpO ₂ : Percutaneous oxygen saturation; WBC: white blood cell.			

	COVID-19 (n = 37)	Common Peumonia (n = 41)	P value
Severe	7/37 (18.92%)	12/41 (29.27%)	
Moderate	26/37 (70.27%)	29/41 (70.73%)	
Mild	3/37 (8.11%)	0/41 (0.00%)	
[†] Values given as mean ± standard deviation, otherwise median with (25th, 75th percentiles). COVID-19: Coronavirus Disease 2019; HTN: hypertension; DM: diabetes mellitus; COPD: chronic obstructive pulmonary disease; CAD, cardiovascular disease; CT, computed tomography; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; RR: respiratory rate; SpO2: Percutaneous oxygen saturation; WBC: white blood cell.			

Concerning laboratory findings, COVID-19 patients had significantly lower WBC counts (5.43 (4.34–6.49) vs 7.21 (5.78-9.00), $P = 0.0003$), lower neutrophil counts (3.50 (2.72–4.67) vs 5.59 (3.88–6.87), $P < 0.0001$), and lower eosinophils counts (0.01 (0.00-0.04) vs 0.07 (0.01–0.10), $P = 0.0016$), than the patients with common pneumonia.

Within the study date range, 8/37 (21.62%) patients developed severe illness in the COVID-19 group, among which one patient dead. In the common pneumonia group, 12/41 (29.26%) patients developed severe illness and none patients from it.

Presence And Severity Of The Pulmonary Lesions On HRCT

Patient with COVID-19 had an average of 4.09 (ranging from 1 to 12) days, numerically shorter than the patients with common pneumonia of 5.17(ranging from 0 to 14) days). GGO was seen 34/37(91.89%) in COVID-19 and 41/41(100%) in the contrast group. Consolidation presented in 9/37 (24.32%) cases with COVID-19, less than the 28/41 (68.29%) ($P < 0.0001$) in the contrast group. Fibrosis presented in 10/37 (27.03%) cases in COVID-19 group and 24/41 cases (58.54%) in the common pneumonia group ($P = 0.0101$). Patients with COVID-19 had significantly lower severity scores (6.00 (2.00–8.00) vs 11.00 (5.00–16.00), $P = 0.0024$) (Table 2) (Fig. 2).

Table 2

Comparison of the distribution pattern and severity of the global pulmonary lesions on HRCT between COVID-19 and common pneumonia cases

	COVID-19 (n = 37)	Common Pneumonia (n = 41)	P value
Pulmonary findings, no./total no. (%)			
GGO	34/37(91.89%)	41/41 (100.00%)	0.2041
Consolidation	9/37(24.32%)	28/41 (68.29%)	< 0.0001*
Fibrosis	10/37(27.03%)	24/41 (58.54%)	0.0101*
Lymphadenopathy	3/37(8.11%)	16/41 (39.02%)	0.0036*
Pleural effusion	2/37(5.41%)	13/41 (31.71%)	0.0079*
Unilateral or bilateral, no. (%)			0.7693
Unilateral	12/37(32.43%)	11/41 (26.83%)	
Bilateral	25/37(67.57%)	30/41 (73.17%)	
Unifocal or multifocal, no. (%)			0.0330*
Unifocal	13/37(35.14%)	5/41 (12.20%)	
Multifocal	24/37(64.86%)	36/41 (87.80%)	
Caudal or cranial, no. (%)			0.1395
Not involved	3/37(8.11%)	0/41 (0.00%)	
Caudal type	12/37(32.43%)	9/41 (21.95%)	
Cranial type	8/37(21.62%)	9/41 (21.95%)	
Random	14/37(37.84%)	23/41 (56.10%)	
Transverse type, no. (%)			0.0046*
Not involved	3/37(8.11%)	0/41 (0.00%)	
Subpleural	23/37(62.16%)	13/41 (31.71%)	
Peribronchovascular	6/37(16.22%)	16/41 (39.02%)	
Random	5/37(13.51%)	12/41 (29.27%)	
Severity scores			

COVID-19: Corona Virus Disease 2019; GGO: ground-glass opacity

*significance.

	COVID-19 (n = 37)	Common Pneumonia (n = 41)	P value
Overall	6.00 (2.00–8.00)	11.00 (5.00–16.00)	0.0024*
Upper lobes	2.00 (0.00–4.00)	4.00 (1.00–4.05)	0.0126*
Lower lobes	3.00 (0.00–4.00)	5.00 (2.00–8.00)	0.0139*
Left lung	3.00 (1.00–4.00)	4.00 (0.00–7.00)	0.1306
right lung	2.00 (1.00–6.00)	8.00 (3.00–10.00)	0.0001*
COVID-19: Corona Virus Disease 2019; GGO: ground-glass opacity			
*significance.			

For segmental analysis, a total of 185 lobes from the COVID-19 patients and 205 lobes from the patients with common pneumonia were included. GGO presented in a total of 102/185 lobes (55.1%) in the COVID-19 group and 148/205 lobes (72.20%) in the control group ($P = 0.0257$). Further analysis showed difference of severity score presented at right upper lobe (1.00 (0.00–2.00) vs 2.00 (1.00–4.00), $P = 0.0014$), right middle lobe (0.00 (0.00–2.00) vs 3.00 (0.00–4.00), $P = 0.0018$), and right lower lobe (1.00 (0.00–3.00) vs 3.00 (1.00–4.00), $P = 0.0029$). (Table 3). No between-group differences were found in the left upper lobe and left lower lobe.

Table 3
Comparison of Distribution Pattern and Severity of the Lobal Pulmonary Lesions
on HRCT between COVID-19 and Common Pneumonia Cases.

	COVID-19 (n = 37)	Common Pneumonia (n = 41)	P value
Right upper lobe			0.0022*
Not involved	18/37(48.65%)	8/41(19.5%)	
subpleural	13/37(35.14%)	10/41(24.4%)	
peribronchovascular	3/37(8.11%)	16/41(39.0%)	
random	3/37(8.11%)	7/41(17.1%)	
severity	1.00 (0.00–2.00)	2.00 (1.00–4.00)	0.0014*
Right middle lobe			0.0164*
Not involved	21/37(56.76%)	14/41(34.1%)	
subpleural	10/37(27.0%)	9/41(22.0%)	
peribronchovascular	2/37(5.4%)	14/41(34.1%)	
random	4/37(10.8%)	4/41(9.8%)	
severity	0.00 (0.00–2.00)	3.00 (0.00–4.00)	0.0018*
Right lower lobe			0.0304*
Not involved	15/37(40.5%)	6/41(14.6%)	
subpleural	11/37(29.7%)	15/41(36.6%)	
peribronchovascular	3/37(%)	11/41(26.8%)	
random	8/37(21.6%)	9/41(22.0%)	
severity	1.00 (0.00–3.00)	3.00 (1.00–4.00)	0.0029*
Left upper lobe			0.2133
Not involved	14/37(37.84%)	16/41(39.0%)	
subpleural	15/37(40.54%)	9/41(22.0%)	
peribronchovascular	5/37(13.51%)	9/41(22.0%)	
random	3/37(8.11%)	7/41(17.1%)	
COVID-19: Corona Virus Disease 2019.			
*significance.			

	COVID-19 (n = 37)	Common Pneumonia (n = 41)	P value
severity	1.00 (0.00–2.00)	2.00 (0.00–3.00)	0.2645
Left lower lobe			0.0794
Not involved	15/37(40.54%)	13/41(31.7%)	
subpleural	14/37(37.84%)	9/41(22.0%)	
peribronchovascular	3/37(8.11%)	12/41(29.3%)	
random	5/37(13.51%)	7/41(17.1%)	
severity	1.00 (0.00–2.00)	2.00 (0.00-2.12)	0.0772
COVID-19: Corona Virus Disease 2019.			
*significance.			

Lymphadenopathy presented in 3/37 (8.11%) cases in the COVID-19 groups and 16/41 (39.02%) cases in the control group (P = 0.0036). Pleural effusion presented in 2/37 (5.41%) cases in the COVID-19 group (Fig. 3) and 13/41(31.71%) cases in control group (P = 0.0079).

Distribution Pattern Of The Pulmonary Lesions On HRCT

The distribution pattern was found significantly different in the transverse planes between the groups (Table 2 and Table 3). Globally, patients with COVID-19 had significantly higher frequency of subpleural pattern (23/37, 62.16%), while cases in the contrast group tended to have a higher frequency of peribronchovascular pattern (16/41, 39.02%) (P = 0.0046) (Fig. 4). No difference was found in terms of the unilateral or bilateral, and caudocranial distribution. At the lobal level, the difference existed for the right upper lobe, right middle lobe, and right lower lobe.

Correlation Between The Clinical Variables And The Severity Scores

For the patient with COVID-19, significant correlation of severity scores was found with the duration between the illness onset and CT ($\rho = 0.37$, P = 0.0321), eosinophils count ($\rho = -0.46$, P = 0.0060), and eosinophils percentage ($\rho = -0.37$, P = 0.0265). For patients with common pneumonia, the severity was found only significant correlated was found between the illness onset and CT ($\rho = 0.48$, P = 0.0016). (See in Table 4)

Table 4
Spearman's Correlation between the Clinical Variables with Severity Scores on HRCT.

Clinical Variables	All patients (n = 78)		COVID-19 (n = 37)		Common Pneumonia (n = 41)	
	coefficient	P value	coefficient	P value	coefficient	P value
Age	0.23	0.0444*	0.21	0.2114	0.10	0.5250
Duration between the illness onset and CT	0.46	< 0.0001*	0.37	0.0311*	0.48	0.0016*
Temperature	0.22	0.0558	0.28	0.0992	0.15	0.3222
WBC count	0.18	0.1168	-0.03	0.8845	0.15	0.3396
Neutrophils count	0.19	0.0899	0.08	0.6327	0.08	0.624
Neutrophils percentage	0.27	0.0170*	0.28	0.0928	0.18	0.2468
Lymphocyte count	-0.21	0.0679	-0.21	0.2203	-0.20	0.2136
Lymphocyte percentage	-0.25	0.0254*	-0.19	0.2708	-0.26	0.1912
Eosinophils count	-0.16	0.1646	-0.47	0.0048*	-0.22	0.1742
Eosinophils percentage	-0.21	0.0639	-0.38	0.0239*	-0.19	0.2237
COVID-19: Corona Virus Disease 2019; WBC: white blood cell.						
*significance.						

Interobserver Variability Of The Measurements

The inter-observer reproducibility for the diameter measuring was consistently high (ICC: 0.977, 95% confidence Intervals: 0.971–0.982) (Fig. 5a). Bland-Altman analysis showed a bias of 0.08 cm, with narrow limits of agreement (Fig. 5b).

Discussion

Chest imaging plays an unreplaceable role in the diagnostic workflow for patients suspected with the novel Coronavirus (COVID-19) pneumonia. For this study, we retrospectively investigated the chest HRCT features of 37 patients diagnosed with COVID-19, and compared the characteristics of pulmonary lesions against the patients with common pneumonia collected from the same timeframe in the last year. A preferable subpleural distribution pattern of pulmonary lesions, and a lower severity of the global lung was found in patients with COVID-19, as compared against the patients with common pneumonia.

Simultaneously, the severity of the lesions was found significantly correlated with the duration between the illness onset and CT for both groups.

Significant pulmonary lesions could be manifested by chest radiographs but purely GGO lesions could be missed (11)(3), thus, chest CT was recommended as the gold standard observing minimal abnormalities and thus in the differentiation diagnosis of pneumonia(12)(13)(14). Our study demonstrated a similar feature of pulmonary lesions, manifested as multi-focal GGO and consolidation, to those previously reported cases (15). Other than that, our study demonstrated that patients with COVID-19 out of Wuhan had a lower severity score on CT than the patients with common pneumonia collected from a similar period in 2019, as well as the cases reported in SARS(16) and MERS(17). We assume several reasons should be counted for this difference: firstly, only patients admitted out of Wuhan were included in this study; besides, the patients with COVID-19 included in our study had a lower duration between illness onset and the CT, which should have an impact on the severity of the pneumonia. Rationally, if not for this special period, patients tend not to go to the hospital as soon as the symptoms began to show, and thus the duration in the contrast group is relatively longer. Considering that patients at early stage may have false negative RT-PCR testing(18), and a typical mild status could be found for patients out of Wuhan, repeat testing should be required when faced with typical but mild pneumonia findings in these areas.

Regarding the anatomy distribution of the pulmonary lesions, 62.16% of the patients with COVID-19 had a tendency of subpleural distribution, similar but less frequently compared to the cases in previous SARS and MERS studies(17). Chung, Michael, et al reported no prominent distribution pattern in the patients with COVID-19(15). Nevertheless, the patients included in their studies had a milder opacity change and an even shorter duration between the illness onset and CT, further investigation might be needed to conclude the distribution pattern at more progressed stage of COVID-19.

The only dead case in this study had cardiovascular comorbidity and was at an old age, consistent with the risk factors concluded by Chen, NS, et al, from the initial patients admitted in Wuhan(19). Of note, the dead case in our study simultaneously had both lymphadenopathy and pleural effusion.

Lymphadenopathy and pleural effusion were rare in other cases, as with the cases reported in the SARS(15). However, considering pleural effusion was demonstrated as a risk factor for poor prognosis in MERS cases(20), further study would be needed to demonstrate whether the presence of lymphadenopathy and pleural effusion would indicate severe pulmonary change, or predict adverse clinical event.

Moreover, significant correlations were found in the severity score on CT with the duration between illness onset and CT, as well as the laboratory findings. As the previous study in SARS indicated a close relationship between the laboratory findings with the outcome(21), further study would be needed to investigate whether the above parameters could predict the clinical course or sequelae of the patients.

This study had several limitations: Firstly, this was a preliminary study of the patients with COVID-19, and within the study date range, most of the patients had not done follow-up CT. Analysis of the disease

progression would be done in future study. Secondly, this study could only partly reflect the features of cases for areas out of Hubei province. Comparison study between the patients in and out of Wuhan should be done in the future. Thirdly, although with rigorous variability tests, limited number of patients were collected in our study, and the subjective visual scoring might have potential bias.

Conclusion

In conclusion, our cross-sectional study demonstrated a generally mild pneumonia findings and subpleural distribution on HRCT for patients with COVID-19 out of Wuhan, compared against the patients with common pneumonia.

Abbreviations

COVID-19: Coronavirus Disease 2019; SARS: severe acute respiratory syndrome; MERS: Middle East Respiratory Syndrome; HTN: hypertension; DM: diabetes mellitus; COPD: chronic obstructive pulmonary disease; CAD, cardiovascular disease; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; RR: respiratory rate; SpO₂: Percutaneous oxygen saturation; WBC: white blood cell; HRCT, high-resolution chest computed tomography; GGO: ground-glass opacity; SD: standard deviation; IQR: interquartile range; ICC: intraclass correlation coefficient

Declarations

Ethics approval and consent to participate

The review board from the 6 centers approved this study. The informed consents of the patients were waived for the retrospective study.

Consent for publication

Not applicable.

Availability of data and materials

The data are not available for public access because of patient privacy concerns but are available from the corresponding author on reasonable request.

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Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

KD and PH are mainly in charge of the idea design and manuscript writing; TP and SH helped edit the table and figures, as well as the patient's image analysis; YD, ZC and XY are responsible for clinical data collection; YL is in charge of the patient's clinical data review and comment; ZY takes responsibility of the study design, has full access to the data in the study and has the final responsibility to submit for publication.

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Figures

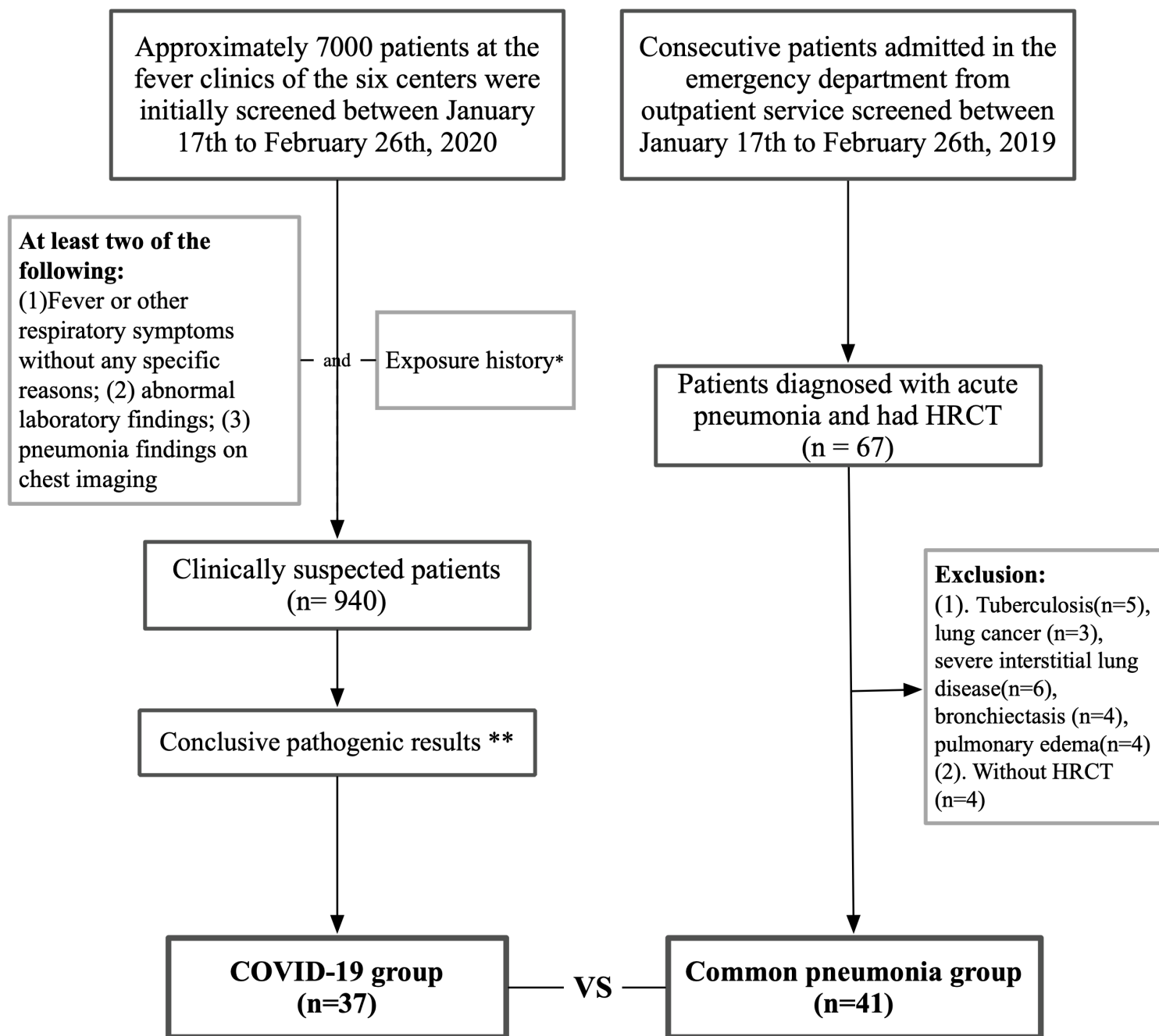


Figure 1

The diagnostic workup and study protocol. WBC: white blood cell; COVID-19: Corona Virus Disease 2019.

*: Exposure history was defined as with at least one of the following four situations: (1) history of residency or travel to Wuhan or the neighboring area with documented transmission of COVID-19 within at least 14 days before the illness onset; (2) close contact with the COVID-19 patients confirmed with pathogenic (nucleic acid testing) tests within at least 14 days before the onset of the symptoms; (3) close contact with the clinically suspected COVID-19 patients with fever or other respiratory symptoms coming from the area with documented transmission community within at least 14 days before the onset of the symptoms; (4) clustering cases. **: Pathogenic test refers to the PCR-RT or gene testing using the blood or specimen taken from the upper or lower respiratory tract from the patients.

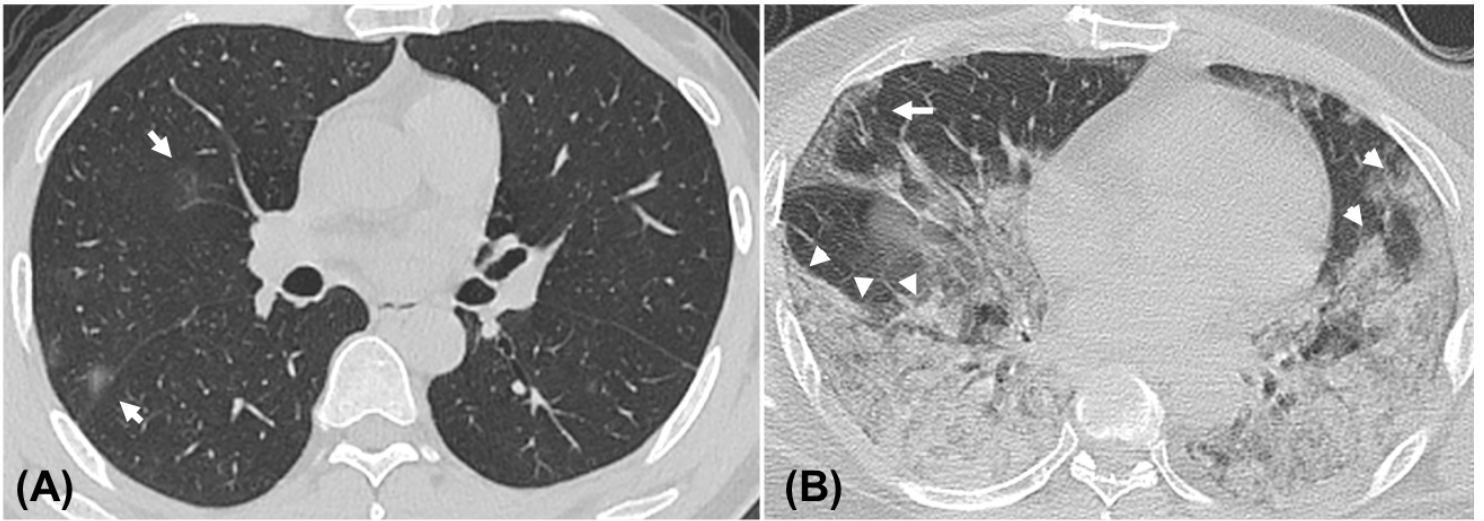


Figure 2

An axial CT image from a 49-year-old male (Panel A) in the COVID-19 group presents multiple ground-glass opacities with rounded morphology at both right upper lobe and left lower lobe (arrow) (severity score: 2). An axial CT image from a 50-year-old male (Panel B) shows severer change bilaterally with diffuse ground-glass opacities (arrow) and consolidation (arrowhead).

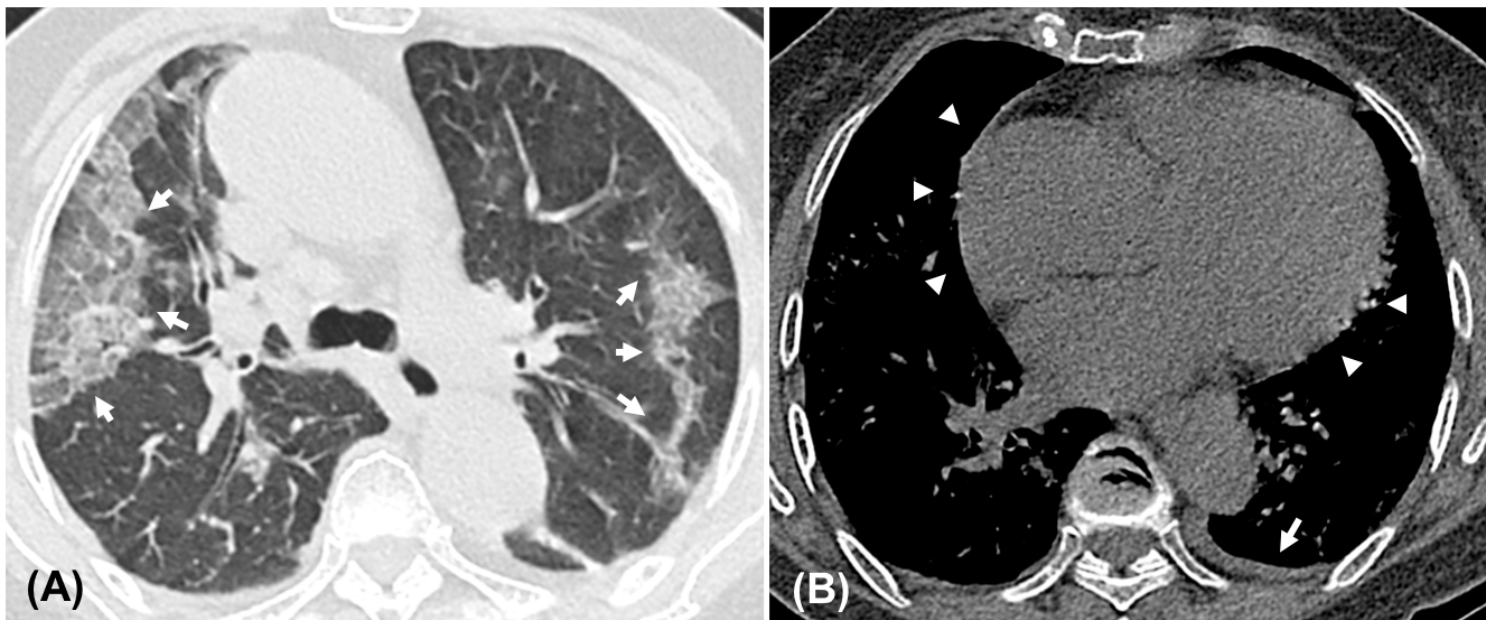


Figure 3

Case of an 80-year-old female. An axial CT image with lung window (Panel A) shows patchy ground-glass opacities with inter- and intralobular septal thickening in the subpleural area at bilateral upper lobes (arrow). An axial image with soft-tissue window (Panel B) shows enlarged heart (arrowhead), as well as unilateral pleural effusion (arrow). This patient developed severe illness rapidly and died soon after being sent to intensive care unit.

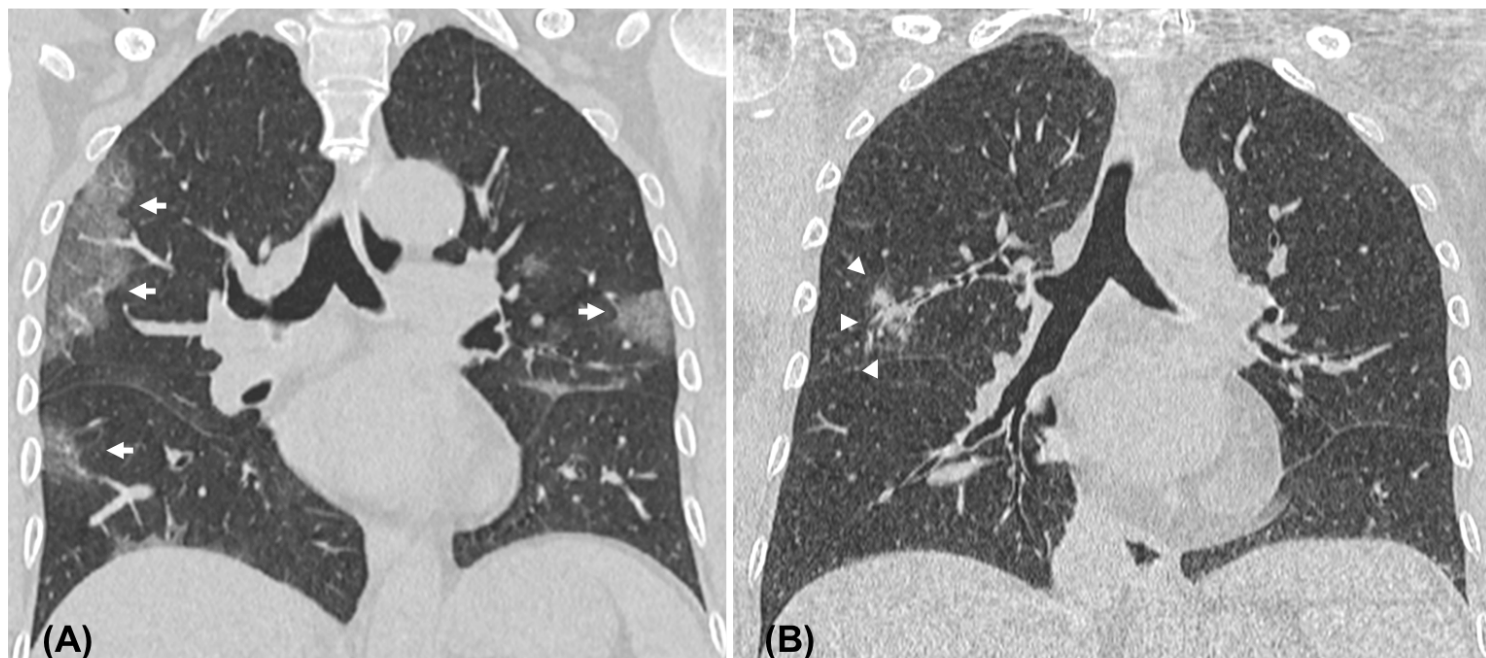


Figure 4

A coronary CT image from a 65-year-old female (Panel A) in the COVID-19 group presents patchy opacity at right upper lobe and rounded morphology like ground-glass opacity at left upper lobe. A coronary CT image from a 56-year-old female (Panel B) shows irregular-shaped mixed ground-glass and consolidation opacities (arrowhead).

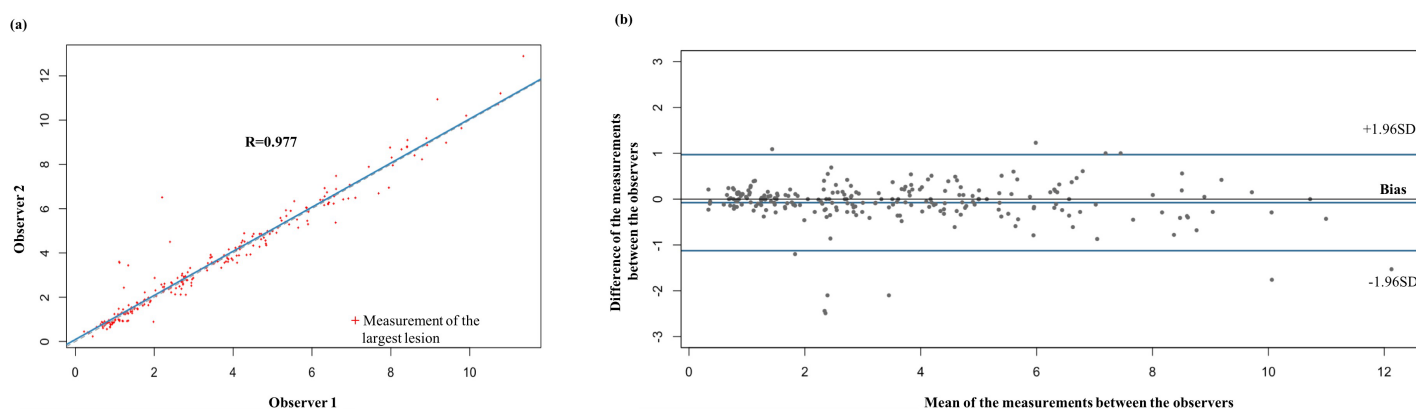


Figure 5

Reproducibility Tests between the Observers. (a)Correlation and (b)Bland-Altman plots of the measurements on the largest pulmonary lesions between the two observes.

Supplementary Files

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- [Supplementarymaterial03.docx](#)