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CHEST

CT features of SARS-CoV-2 pneumonia according to clinical presentation: a retrospective analysis of 120 consecutive patients from Wuhan city

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Abstract

Objectives To characterize the chest computed tomography (CT) findings of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) according to clinical severity. We compared the CT features of common cases and severe cases, symptomatic patients and asymptomatic patients, and febrile and afebrile patients.

Methods This was a retrospective analysis of the clinical and thoracic CT features of 120 consecutive patients with confirmed SARS-CoV-2 pneumonia admitted to a tertiary university hospital between January 10 and February 10, 2020, in Wuhan city, China.

Results On admission, the patients generally complained of fever, cough, shortness of breath, and myalgia or fatigue, with diarrhea often present in severe cases. Severe patients were 20 years older on average and had comorbidities and an elevated lactate dehydrogenase (LDH) level. There were no differences in the CT findings between asymptomatic and symptomatic common type patients or between afebrile and febrile patients, defined according to Chinese National Health Commission guidelines.

Conclusions The clinical and CT features at admission may enable clinicians to promptly evaluate the prognosis of patients with SARS-CoV-2 pneumonia. Clinicians should be aware that clinically silent cases may present with CT features similar to those of symptomatic common patients.

Key Points

- *The clinical features and predominant patterns of abnormalities on CT for asymptomatic, typic common, and severe cases were summarized. These findings may help clinicians to identify severe patients quickly at admission.*
- *Clinicians should be cautious that CT findings of afebrile/asymptomatic patients are not better than the findings of other types of patients. These patients should also be quarantined.*
- *The use of chest CT as the main screening method in epidemic areas is recommended.*

Keywords SARS-CoV-2 · Tomography · Chest · Fever

Abbreviation

ANOVA	Analysis of variance
CT	Computed tomography
GGO	Ground-glass opacities
ICU	Intensive care unit
LDH	Lactate dehydrogenase
MERS	Middle East respiratory syndrome
MERS-CoV	Middle East Respiratory Syndrome Novel Coronavirus
RT-PCR	Reverse transcriptase–polymerase chain reaction
SARS	Severe acute respiratory syndrome
SARS-CoV	Severe acute respiratory syndrome novel coronavirus
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2

Rui Zhang and Huangqing Ouyang contributed equally to this work.

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Introduction

An outbreak of novel coronavirus–infected (SARS-CoV-2) pneumonia in Wuhan City, China [1] has caused a global health emergency [2]. The number of patients is rapidly increasing out of China. The continuous expansion of COVID-19 has created a pandemic [3].

SARS-CoV-2 belongs to the new coronavirus of the genus β. The pneumonia that this coronavirus causes resembles severe acute respiratory syndrome (SARS) and

Table 1 Clinical features of patients with SARS-CoV-2 pneumonia by severity type at admission

Characteristics	All ($N = 120$)	Common type ($n = 90$)	Severe type ($n = 30$)	$P^{1,2}$
Demographics				
Survival status (alive, %)	113 (94%)	90 (100%)	23 (77%)	< 0.001
Age, mean (SD), years	45.4 (15.6)	40.2 (12.9)	61.2 (12.1)	< 0.001
Sex (male, %)	43 (36%)	30 (33%)	13 (43%)	0.323
Huanan seafood market exposure history (yes, %)	3 (3%)	2 (2%)	1 (3%)	1.000
Current smoking (yes, %)	6 (5%)	0	6 (20%)	< 0.001
Comorbidity[3] (yes, %)				
Any comorbidity	32 (27%)	10 (11%)	22 (73%)	< 0.001
Number, mean (SD)	0.4 (0.8)	0.2 (0.6)	1.2 (0.9)	< 0.001
Diabetes	7 (6%)	0	7 (23%)	< 0.001
Hypertension	19 (16%)	6 (7%)	13 (43%)	< 0.001
Cardiovascular	9 (8%)	4 (4%)	5 (17%)	0.035
COPD	4 (3%)	1 (1%)	3 (10%)	0.048
Malignancy	7 (6%)	2 (2%)	5 (17%)	0.011
Chronic liver disease	1 (1%)	0	1 (3%)	0.250
Other disease	5 (4%)	3 (3%)	2 (7%)	0.600
Symptoms (yes, %)				
Any symptom	104 (87%)	74 (82%)	30 (100%)	0.013
Fever	81 (68%)	52 (58%)	29 (97%)	< 0.001
Cough	75 (63%)	49 (54%)	26 (87%)	0.002
Dyspnea	38 (32%)	11 (12%)	27 (90%)	< 0.001
Myalgia or fatigue	57 (48%)	31 (34%)	26 (87%)	< 0.001
Headache	28 (23%)	10 (11%)	18 (60%)	< 0.001
Sneeze	17 (14%)	1 (1%)	16 (53%)	< 0.001
Sputum production	12 (10%)	0	12 (40%)	< 0.001
Pharyngalgia	16 (16%)	16 (18%)	0	0.201
Gastrointestinal discomfort	10 (8%)	5 (6%)	5 (17%)	0.119
Diarrhea	7 (6%)	2 (2%)	5 (17%)	0.011
No appetite	3 (3%)	3 (3%)	0	1.000
Laboratory findings				
WBC, mean (SD), 10^9/L	5.0 (2.2)	4.7 (1.7)	5.9 (3.2)	0.457
N, mean (SD), 10^9/L	2.0 (1.7)	1.6 (1.1)	3.1 (2.6)	0.338
L, mean (SD), 10^9/L	2.4 (1.8)	2.5 (1.5)	2.1 (2.6)	0.386
LDH, mean (SD), U/L	235.6 (109.6)	200.8 (55.9)	342.8 (157.2)	< 0.001

Abbreviation: *SARS-CoV-2*, severe acute respiratory syndrome coronavirus 2; *n*, number of cases; *SD*, standard deviation; *WBC*, white blood cell; *N*, neutrophil; *L*, lymphocyte; *LDH*, lactate dehydrogenase

[1] For categorical variables, *p* values were derived from χ^2 test, Fisher's exact test. For continuous variables, *p* values were derived from Student *t* test or analysis of variance (ANOVA)

[2] *p* values for the comparison between severe and all common type patients

[3] Comorbidity included history of diabetes, hypertension, cardiovascular disease, chronic obstructive pulmonary disease (COPD), malignancy, chronic liver disease, and other chronic diseases

Middle East respiratory syndrome (MERS). However, the genome of SARS-CoV-2 is significantly different from that of SARS-CoV and MERS-CoV [4], and thus, this virus may cause different clinical presentations, including different chest CT findings [5–7]. To date, the severity of the illness has been reported to be milder than SARS with a mortality rate ranging from 4.3 [8] to 11% [9]. The incubation time (the time interval between initial contact with an infectious agent and appearance of the first sign or symptom of disease) tends to be longer (median 3 days, range 0–24 days) than that of SARS [10, 11]. The imaging findings of SARS-CoV-2 pneumonia [12–20] overlap

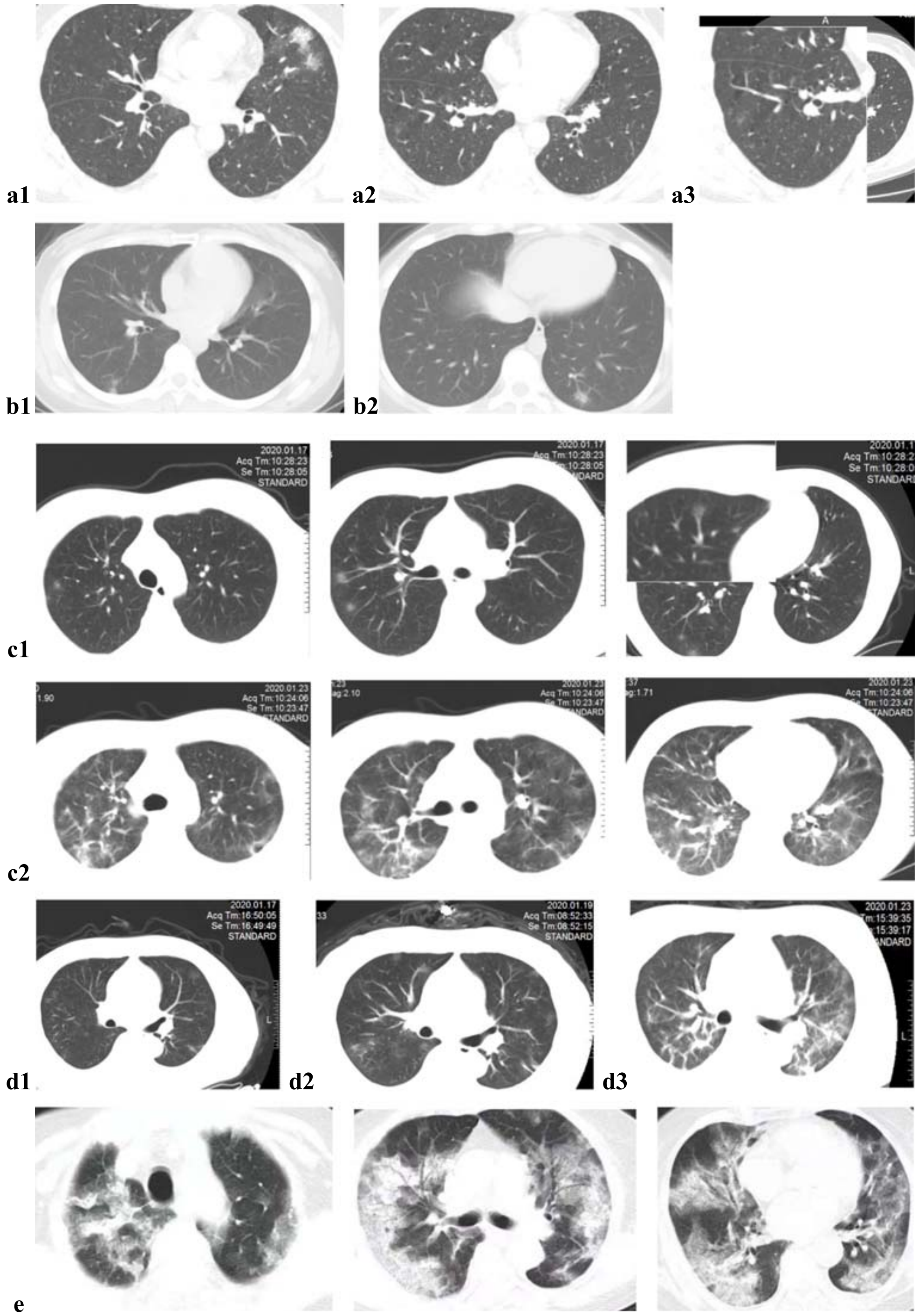
Table 2 CT image interpretations of patients with SARS-CoV-2 pneumonia categorized by severity type

Chest CT findings	*n* (%)			p^1
	All (*N* = 120)	Common type (*n* = 90)	Severe type (*n* = 30)	
Bilateral	68 (57%)	40 (44%)	28 (93%)	< 0.001
Ground-grass opacities	107 (89%)	78 (87%)	29 (97%)	0.181
Nodules	65 (54%)	53 (59%)	12 (40%)	0.072
Linear densities	75 (63%)	50 (56%)	25 (83%)	0.007
Consolidation	62 (52%)	37 (41%)	25 (83%)	< 0.001
Crazy paving	30 (25%)	9 (10%)	21 (70%)	< 0.001
Bronchiectasis	14 (12%)	6 (7%)	8 (27%)	0.007
Effusion	9 (8%)	0	9 (30%)	< 0.001
Lymphadenopathy	5 (4%)	1 (1%)	4 (13%)	0.134
Air bronchograms	24 (20%)	5 (6%)	19 (63%)	< 0.001
Tree-in-bud sign	9 (8%)	4 (4%)	5 (17%)	0.042
White lung	20 (17%)	0	20 (67%)	< 0.001
Lung lobes involved				
Upper right lobe	41 (34%)	16 (18%)	25 (83%)	< 0.001
Middle right lobe	50 (42%)	24 (27%)	26 (87%)	< 0.001
Lower right lobe	83 (69%)	55 (61%)	28 (93%)	< 0.001
Upper left lobe	48 (40%)	22 (24%)	26 (87%)	< 0.001
Lower left lobe	79 (66%)	50 (56%)	29 (97%)	< 0.001
Number of lobes involved				< 0.001
0	6 (5%)	6 (7%)	0	
1	43 (36%)	41 (46%)	2 (7%)	
2	24 (20%)	22 (24%)	2 (7%)	
3	8 (7%)	8 (9%)	0 (0)	
4	9 (8%)	7 (8%)	2 (7%)	
5	30 (25%)	6 (7%)	24 (80%)	
Predominant distribution				
Peripheral	109 (91%)	79 (88%)	30 (100%)	0.064
Central	39 (33%)	20 (22%)	19 (63%)	< 0.001
Predominant patterns				
Ground-glass opacities	111 (93%)	82 (91%)	29 (97%)	0.447
Consolidation	66 (55%)	41 (46%)	25 (83%)	< 0.001
Reticulation	22 (18%)	4 (4%)	18 (60%)	< 0.001
Total severity score, mean (SD)	4.4 (5.3)	2.0 (1.5)	11.6 (6.2)	< 0.001
Total level, mean (SD)	1.6 (1.0)	1.2 (0.5)	2.9 (1.0)	< 0.001

Abbreviation: *SARS-CoV-2*, severe acute respiratory syndrome coronavirus 2; *n*, number of cases

[1] For categorical variables, *p* values were derived from χ^2 test, Fisher's exact test. For continuous variables, *p* values were derived from Student *t* test or analysis of variance (ANOVA)

[2] *p* values for the comparison between severe and all common type patients



with those of other viral pneumonia [21, 22]. However, COVID-19 might still be classified by some distinguishable features. The longer incubation time and relatively mild symptoms at presentation may allow this disease to more easily spread from humans to humans due to little concern. Prompt screening for the early identification and isolation of the patients are of particular importance. Therefore, chest CT scans might be ideal for this purpose.

Other recently published studies have shown that descriptions of CT abnormalities of SARS-CoV-2 pneumonia as a function of clinical severity are still limited. Little is known about afebrile pneumonia cases. Less is known about asymptomatic pneumonia cases. Therefore, we attempt to systematically assess these issues in a retrospective cohort of 120 consecutive patients with positive chest CT findings at admission.

◀ **Fig. 1** (**a**) Unenhanced axial CT images of an afebrile 37-year-old male doctor with a history of exposure to confirmed SARS-CoV-2 patients. (**a1**) Patchy ground-glass opacities (GGOs) in the left upper lobe. (**a2**) Small GGO nodule in the contralateral lower lobe. (A3) Enlarged image of the right lower lobe. (**b**) Unenhanced axial CT images of an afebrile 28-year-old female with a history of exposure to confirmed SARS-CoV-2 patients presenting with a mild sore throat. (**b1**) A rounded, ground-glass nodular opacity (GGO) is seen in a subpleural location in the right lower lobe. (**b2**) Another focal GGO is seen in a subpleural location, in the posterobasal segment of the left lower lobe. (**c**) Unenhanced axial CT images of a 27-year-old male doctor with a history of exposure to confirmed SARS-CoV-2 patients, initially presenting with fever (39 °C), non-productive cough, dyspnea, and myalgia (**c1**) who progressed to a severe case requiring oxygen supplementation (**c2**). (**c1**) Multifocal, limited GGO is seen in the peripheral zone of both lungs. (**c2**) Six days later, while oxygen supplementation has been instore, diffuse, bilateral, and ill-defined GGO has developed. Superimposed linear consolidations can be observed, consistent with areas of organizing pneumonia. (**d**) Unenhanced axial CT images of a 52-year-old male doctor with asthma and exposure to confirmed SARS-CoV-2 patients, initially presenting with fever (39 °C), non-productive cough, dyspnea, and myalgia who rapidly progressed to a severe form requiring mechanical ventilation. (**d1**) Multifocal, limited GGO in the periphery of both lungs, predominantly affecting left lung. (**d2**) Two days later, focal GGO has increased in size and density, and new diffuse ill-defined GGO has developed. (**d3**) After 4 days of mask oxygen supplementation, disease progressed further, with more patchy consolidations and linear densities observed in nearly all lung zones except the anterior part of both lungs. (**e**) Unenhanced axial CT images of a 57-year-old male with an exposure history initially presenting with fever (38 °C), non-productive cough, dyspnea, myalgia, and headache, being treated for hypertension for 12 years. Diffuse consolidation with air bronchograms is seen in both lungs, with relative sparing of peri-hilar and anterior lung areas, extending from the lung apices to the lung bases. These findings are consistent with a "white lung" appearance

Methods

Study design and participants

This was a single-center, retrospective, observational study conducted at a tertiary hospital. A cohort of 120 consecutive patients with confirmed SARS-CoV-2 infection from January 1 to February 10, 2020, at the Renmin Hospital of Wuhan University were included. Cases were initially identified by abnormal findings on chest CT scan. And the patients were also diagnosed based on the WHO interim guidance [23]; that is, specimens from the respiratory tract of patients were collected for SARS-CoV-2 testing by RT-PCR. The definition of severe type in this study included all severe type and critical ill type diseases defined by the National Guidelines of China [24]. Severe COVID-19 was designated when the patients met one of the following criteria: (1) respiratory distress with a breathing rate ≥ 30/min; (2) pulse oximeter oxygen saturation ≤ 93% at rest; (3) oxygenation index (artery partial pressure of oxygen/inspired oxygen fraction, PaO_2/FiO_2) ≤ 300 mmHg; (4) respiratory failure requiring mechanical ventilation; (5) shock; and (6) combined with other organ failure requiring intensive care unit (ICU) monitoring and treatment. Patients were then confirmed as SARS-CoV-2 pneumonia by test of reverse transcriptase–polymerase chain reaction (RT-PCR) for SARS-CoV-2 RNA from paired nasopharyngeal swabs [10, 25], following the recommendation by the National Institute for Viral Disease Control and Prevention of China [26]. We additionally categorized two mild types among the common types: (1) asymptomatic type: patients with no symptoms; and (2) afebrile type: patients have symptoms but a body temperature < 37.3 °C. Since all patients included in this cohort had positive chest CT findings, we defined them as patients with SARS-CoV-2 pneumonia instead of COVID-19.

Data collection

Epidemiological, clinical, laboratory, and radiological characteristics and outcomes data were obtained with standardized data collection form created by EpiData software (version 3.1). Clinical data were double-entered by two medical residents (H.K.J. and H.J.L.). The final data were obtained by consensus when there was a discrepancy.

The following epidemiological and clinical data were collected, including age, sex, Hunan seafood market exposure history, smoking status, the final clinical diagnosis, comorbidities (diabetes, hypertension, cardiovascular disease, chronic obstructive pulmonary disease, malignancy, and chronic liver disease) and clinical symptoms (fever, highest body temperature (°C), cough, dyspnea, myalgia or fatigue, headache, sneezing, rhinorrhea, sputum production, hemoptysis, gastrointestinal discomfort; loss of appetite and diarrhea), and survival status. The following laboratory tests were collected: white blood cell count, neutrophil count, lymphocyte count, and lactate dehydrogenase (LDH, U/L) at admission, where other test results such as liver function test and renal function test were not collected because all results were found to be within normal range during the quick review.

Image acquisition and interpretation

All CT examinations for the screening of SARS-CoV-2 pneumonia were performed with two GE scanners (64-section Optima CT680 and 16-section BrightSpeed) without the use of contrast material. The main scanning protocol was as follows: tube voltage, 120 kVp; tube current modulation, 120 mA–380 mA; detector configuration, 64 × 0.625 mm or 16 × 0.625 mm; rotation time, 0.5–0.7 s; slice thickness, 5 mm; and pitch, 0.984. Reconstruction kernel was lung with a thickness and an interval of 0.625 mm. All images were viewed in both lung (width, 1200 HU; level, − 700 HU) and mediastinal (width, 350 HU; level, 40 HU) settings. Two radiologists (Z.R. and F.L.L.) with 6–7 years of experiences who were blinded to the other clinical information reviewed the chest CT scans independently and in random order, and then reached a decision by consensus. For interpretation disagreement between the two primary radiologists, a senior radiologist (O.Y.H.Q.) with 20 years of experience provided a final decision.

The images were interpreted using the lung window setting. The CT images were assessed, following a standardized protocol, for the presence and distribution of the following abnormalities: (a) ground-glass opacities (GGO, defined as hazy areas of increased attenuation without obscuration of the underlying vascular markings); (b) nodules (centrilobular, perilymphatic, or random in distribution); (c) linear densities (interlobular septal thickening, intralobular septal line, parenchymal bands); (d) crazy paving; (e) consolidations (parenchymal opacities obscuring underlying vessels); (f) architectural distortion, or traction bronchiectasis; (g) pleural effusion; (h) lymphadenopathy (defined as lymph node with a short-axis dimension of > 1.0 cm); (i) air bronchogram; (j) tree-in-bud sign (defined as multiple areas of centrilobular nodules with a linear branching pattern); and (k) white lung (defined as diffuse consolidations in a large area of the lung that appear like the lung is turning white on CT imaging). The overall anatomic distribution (subsegmental, segmental, lobar), zonal predominance (upper, middle, lower lung; central, middle, or peripheral location), and extent (focal, multifocal, and diffuse) of the lesions were also recorded. The predominant patterns of abnormality on high-resolution CT were classified into consolidation, GGOs, reticulation, and mixed patterns. A mixed pattern can be described as presence of crazy paving and of air bronchogram. Each of the five lung lobes was assessed for degree of involvement and classified as follows: none (0%) corresponded to a lobe score of 0, mild (1–25%) corresponded to a lobe score of 1, moderate (26–50%) corresponded to a lobe score of 2, severe (51–75%) corresponded to a lobe score of 3, and critical (76–100%) corresponded to a lobe score of 4. The "total severity score" was calculated by summing the scores of all five lobes (range of possible scores, 0–20).

Statistical analysis

Continuous variables were reported with means and were compared with Student t test or analysis of variance (ANOVA); categorical variables were expressed as percentage and compared by χ^2 test or Fisher's exact test. Inter-observer agreement for the radiographical abnormalities was evaluated and expressed with the Kappa statistic. The agreement was classified as follows: excellent, Kappa > 0.80; good, Kappa = 0.61–0.80; moderate, Kappa = 0.41–0.60; fair, Kappa = 0.21–0.40; and poor, < 0.20. p values ≤ 0.05 (2-sided probability) were considered statistically significant. All analyses were conducted using SPSS 23.0 software (IBM Corp).

Results

Clinical and laboratory findings

Patients' characteristics according to disease severity are presented in Table 1. There were 43 men and 77 women included in this study. Among the 120 patients, 16 were totally asymptomatic, 74 had typical common cases, and 30 were severe. All 6 current smokers are found in severe cases, and all 7 deaths were severe cases. Severe cases were on average 21 years older than common cases (61.2 vs. 40.2 years old, $p < 0.001$). Comorbidities were more frequent in severe patients than in patients with common case severity (73% vs. 11%, $p < 0.001$). Sneezing, sputum production, and diarrhea were commonly seen among severe patients but not among common ones. Hemoptysis was rarely found for all patients. Regarding laboratory test results, common patients had lower neutrophil counts (mean 1.6×10^9/L) and lower LDH levels (mean 200.8 U/L, normal range < 250 U/L) than the severe patients (mean 342.8 U/L). However, there was no evidence of difference in sex distribution, Huanan seafood market exposure history, and white blood cell count or lymphocyte count.

Radiologic findings

At admission, the most frequent CT finding was GGOs, which were present in 87% and 97% of common and severe type patients, respectively ($p = 0.181$). A comparison between common and severe type imaging features is presented in Table 2. Consolidation, air bronchogram, white lung appearance, and pleural effusion were more frequently seen in severe patients ($p < 0.001$), with crazy-paving patterns, linear densities, bronchiectasis, nodules, and tree-in-bud signs also being more frequent. Regarding the repartition, bilateral diffuse involvement was more frequent in severe type, with all 5 lobes' involvement more frequently seen and higher lobar score severity. Common cases showed more frequent peripheral and lower lung predominance, with limited, focal, or multifocal subsegmental extent. Illustrative cases are presented Fig. 1.

A comparison of the CT features between totally asymptomatic and symptomatic common cases is presented in Table 3. There were no significant differences in individual signs, patterns, zonal predominance, or extent of CT abnormalities. Similarly, there were no significant differences in CT features between febrile and afebrile common patients, as shown in Table 4.

The Kappa statistic for inter-observer agreement was evaluated as good for most CT findings, and detailed information is demonstrated in Supplementary Table.

Table 3 CT image interpretations of common type patients with SARS-CoV-2 pneumonia based on symptoms

Chest CT findings	*n* (%)		p^1
	Common type		
	Asymptomatic (*n* = 16)	Symptomatic (*n* = 74)	
Bilateral	9 (56%)	31 (42%)	0.366
Ground-grass opacities	11 (69%)	67 (91%)	0.035
Nodules	10 (63%)	43 (58%)	0.746
Linear densities	7 (44%)	43 (58%)	0.295
Consolidation	5 (31%)	32 (43%)	0.377
Crazy paving	5 (31%)	4 (5%)	0.008
Bronchiectasis	2 (13%)	4 (5%)	0.289
Effusion	0	0	–
Lymphadenopathy	1 (6%)	0	0.178
Air-bronchogram	0	5 (7%)	0.581
Tree-in-bud sign	0	4 (5.4%)	1.000
White lung	0	0	–
Zonal predominance			
Upper	7 (44%)	22 (29%)	0.277
Middle	3 (19%)	25 (34%)	0.373
Lower	13 (81%)	57 (77%)	1.000
Predominant distribution			
Peripheral	15 (94%)	64 (86%)	0.681
Central	4 (25%)	16 (22%)	0.748
Predominant patterns			
Ground-glass opacities	15 (94%)	67 (91%)	1.000
Consolidation	9 (56%)	32 (43%)	0.344
Reticulation	3 (19%)	1 (1%)	0.017
Total severity score, mean (SD)	1.9 (0.9)	2.0 (1.6)	0.565

Abbreviation: *SARS-CoV-2*, severe acute respiratory syndrome coronavirus 2; *n*, number of cases

[1] For categorical variables, *p* values were derived from χ^2 test, Fisher's exact test. For continuous variables, *p* values were derived from Student *t* test or analysis of variance (ANOVA)

Prognosis factors for patients with SARS-CoV-2

Table 5 shows significant associations of select patient characteristics with severe disease after a multivariate model analysis. Overall, statistically significant associations with the risk of severe disease were observed among those with older age, those with symptoms of dyspnea, and those chest CT findings of crazy-paving patterns (OR = 15.3, 95% CI = 2.6–89.5) and air bronchogram (OR = 41.8, 95% CI = 5.9–298.4).

Discussion

In this study, we reported the clinical characteristics and chest CT findings at presentation for all types of SARS-CoV-2 pneumonia severity. We found that severe type patients showed differ rent CT features as compared with common type individuals, but we also report that asymptomatic patients may present with the same CT findings as presented by symptomatic common type patients. Our findings compensated for the knowledge gaps in previous reports on this newly emerging disease.

Consistent with previous studies [8, 9, 11], the main symptoms at presentation were fever, dry cough, myalgia or fatigue, and dyspnea. Some atypical symptoms such as headache, sneezing, and diarrhea were only found in severe patients.

In line with other studies [12–19], the predominant patterns of abnormalities on CT for our 120 patients were GGOs with a peripheral distribution and bilateral, multifocal lower lung involvement. Compared with those of common cases, some CT features were more common in severe cases, such as crazy-paving patterns, bronchiectasis, hilar or mediastinal lymph node enlargement, white lung, air bronchogram, and pleural effusion. We also found that severe cases usually presented as consolidation larger than segmental consolidation, and only severe cases showed an overall lobar or diffuse pneumonia distribution pattern, which indicated that the affected area or volume could

Table 4 CT image interpretations of common type patients with SARS-CoV-2 pneumonia based on having fever or not

Pneumonia chest CT findings	*n* (%)		p^1
	Common type		
	Afebrile (*n* = 38)	Febrile (*n* = 52)	
Bilateral	18 (47%)	22 (42%)	0.776
Ground-grass opacities	29 (76%)	49 (94%)	0.014
Nodules	23 (61%)	30 (58%)	0.787
Linear densities	19 (50%)	31 (60%)	0.365
Consolidation	16 (42%)	21 (40%)	0.870
Crazy paving	6 (16%)	3 (6%)	0.118
Bronchiectasis	3 (8%)	3 (6%)	0.694
Effusion	0	0	–
Lymphadenopathy	1 (3%)	0	0.422
Air-bronchogram	0	5 (10%)	0.071
Tree-in-bud sign	2 (5%)	2 (4%)	1.000
White lung	0	0	–
Zonal predominance			
Upper	11 (29%)	18 (35%)	0.570
Middle	12 (32%)	16 (31%)	0.935
Lower	28 (74%)	42 (81%)	0.425
Predominant distribution			
Peripheral	34 (89%)	45 (87%)	0.754
Central	9 (24%)	11 (21%)	0.776
Predominant patterns			
Ground-glass opacities	33 (87%)	49 (94%)	0.275
Consolidation	19 (50%)	22 (42%)	0.470
Reticulation	3 (8%)	1 (2%)	0.307
Total severity score, mean (SD)	1.8 (1.2)	2.1 (1.6)	0.767

Abbreviation: *SARS-CoV-2*, severe acute respiratory syndrome coronavirus 2; *n*, number of cases

[1] For categorical variables, *p* values were derived from χ^2 test, Fisher's exact test. For continuous variables, *p* values were derived from Student *t* test or analysis of variance (ANOVA)

also be an important determinant for the disease severity of SARS-CoV-2 pneumonia. However, these patterns also often overlap because CT manifestations are dynamic [15, 16], and depend on various factors, such as disease severity, the evolution of the disease course [14, 15, 20], treatment [12], comorbidity, and complications. Usually, as the disease progressed, the range of GGO patches and consolidation increased. Afterwards, condition would improve, GGO and consolidation disappeared, and fibrous stripes (reticulation) may appear [20].

We did not find any appreciable CT imaging difference between common patients with or without fever, or even between those with or without any symptoms. Ai et al [27] suggested that with RT-PCR results as a reference, the sensitivity, specificity, and accuracy of chest CT in indicating SARS-CoV-2 infection were 97% (95% CI 95–98%, 580/601 patients), 25% (95% CI 22–30%, 105/413 patients), and 68% (95% CI 65–70%, 685/1014 patients), respectively. Thus, quick recognition of the radiological manifestations and a prompt evaluation of the patient's exposure history is imperative in the early detection and assessment of the severity of SARS-CoV-2 pneumonia. Numerically, more consolidation and reticulation patterns were found on the CT image of silent and afebrile patients than those of typic patients. This indicated a later detection of mild disease. The transmissibility for these silent cases needs to be further assessed. In addition, during the long incubation period (0–24 days, mostly 3 days) [11], patients might also be unwitting vehicles of disease spread.

Our study has several limitations. As with any retrospective study, the probability of selection bias and the availability of needed data is a concern. RT-PCR-based tests were used to confirm the infection status, which may minimize the misclassification error. The findings of the statistical tests should be interpreted with caution even though our cohort is relatively large. However, the strong associations we found can still can alert physicians to potentially poor prognoses in some cases. The subjectivity of image interpretation may also introduce

Table 5 Final multivariate analysis of the association for selected characteristics with the severity of SARS-CoV-2 pneumonia

Characteristics	n, %		p value[1]	OR (95% CI)[1]
	Common ($n = 90$)	Severe ($n = 30$)		
Baseline[2]				
Age mean (SD)	40.2 (12.9)	61.2 (12.1)	0.003	1.1 (1.0–1.1)
Comorbidity mean (SD)	0.2 (0.6)	1.2 (0.9)	0.138	1.8 (0.8–3.8)
LDH > 250 U/L	18 (20%)	21 (70%)	0.116	2.5 (0.8–7.8)
Symptoms[3]				
Dyspnea	11 (12%)	27 (90%)	< 0.001	31.1 (6.5–148.8)
Headache	10 (11%)	18 (60%)	0.102	3.9 (0.8–19.6)
CT findings[4]				
Crazy paving	9 (10%)	21 (70%)	0.002	15.3 (2.6–89.5)
Air bronchogram	5 (6%)	19 (63%)	< 0.001	41.8 (5.9–298.4)

Abbreviation: *SARS-CoV-2*, severe acute respiratory syndrome coronavirus 2; *n*, number of cases; *LDH*, lactate dehydrogenase

[1] Derived from multivariate analysis of logistic regression models

[2] Retained in this model were age, comorbidity (number of comorbidities) and LDH > 250 U/L.

[3] Retained in this model were age, comorbidity (number of comorbidities), LDH > 250 U/L, dyspnea (yes) and headache (yes)

[4] Retained in this model were age, comorbidity (number of comorbidities), LDH > 250 U/L, crazy paving (yes) and air bronchogram (yes)

measurement errors, but these errors were likely to be random. We took a systematic approach that allowed us to obtain valuable statistics and to quantify the imaging changes, thus minimizing the subjectivity. Moreover, we followed a standardize protocol; thus, inter-observer agreement was good for the evaluation of most radiographical abnormalities. As previously described, our cohort may be unique in that the patients admitted were first screened by chest CT, and were admitted from nearby communities to a general hospital rather than a specialized hospital of infectious disease. Thus, these patients are more representative of the community population.

In conclusion, the typical CT features we described and some radiological findings (e.g. consolidation, air bronchogram, and diffuse extent.), together with some clinic-biological characteristics of severity (older age, comorbidities, diarrhea, and elevated LDH level), may help clinicians in assessing the severity of SARS-CoV-2 pneumonia quickly at admission of patients. The non-difference in CT findings between asymptomatic or nonfebrile patients and symptomatic common patients highlight the importance of CT screening for silent patients for the timely diagnosis and transmission prevention.

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Compliance with ethical standards

Guarantor The scientific guarantor of this publication is Zhenming Fu.

Conflict of interest The authors of this manuscript declare no relationships with any companies whose products or services may be related to the subject matter of the article.

Statistics and biometry No complex statistical methods were necessary for this paper.

Informed consent Written informed consent was not required for this study because this is a retrospective observational study.

Ethical approval This retrospective study was approved by the institutional review board of Renmin Hospital of Wuhan University (No. WDRY2020-K007).

Methodology
• Retrospective
• Observational
• Performed at one institution

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