

# Radiological findings in low dose CT for COVID-19 pneumonia in 182 patients: correlation of signs and severity with patient outcome

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## Research Article

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# Abstract

## OBJECTIVES

To characterize CT-findings of COVID-19 pneumonia and their value in diagnosis and outcome prediction.

## METHODS

Chest CTs of 182 patients with a confirmed diagnosis of COVID-19 infection by RT-PCR were evaluated for the presence of CT-abnormalities and their frequency. Regarding the patient outcome each patient was categorized in 5 progressive stages and the duration of hospitalization was determined. Regression analysis was performed to find which CT findings are predictive for patient outcome and to assess prognostic factors for the hospitalization duration.

## RESULTS

Multivariate statistical analysis confirmed a higher age (OR= 1.023,  $p= 0.025$ ), a higher total visual severity score (OR= 1.038,  $p= 0.002$ ) and the presence of crazy paving (OR= 2.160,  $p= 0.034$ ) as predictive parameters for patient outcome. A higher total visual severity score (+ 0.134 days;  $p= 0.012$ ) and the presence of pleural effusion (+ 13.985 days,  $p= 0.005$ ) were predictive parameters for a longer hospitalization duration.

## CONCLUSIONS

An increasing percentage of lung opacity as well as the presence of crazy paving and a higher age are associated with a worse patient outcome. The presence of a higher total visual severity score and pleural effusion are significant predictors for a longer hospitalization duration.

# Introduction

## Background

In December 2019 in Wuhan province, China, first reports were made of an outbreak of a new respiratory virus, now known as the highly contagious severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). On January 30, 2020, the World Health Organization (WHO) declared this ongoing outbreak as a global public health emergency. On March 11, 2020 it was reclassified as a global pandemic outbreak.

According to current insights in the literature, the characteristic radiological presentation of COVID-19 pneumonia is that of bilateral distribution of ground-glass opacities (GGO), with or without consolidation, mostly affecting the basal and peripheral lungs <sup>(1)</sup>. However, upon further analysis, a diversity of CT findings were found, including crazy-paving pattern, subpleural reticulation, airway changes, reversed halo sign, subpleural bands, vascular dilatation, pleural thickening, etc <sup>(1)</sup>. As reported in recent publications, the CT-appearance of COVID-19 pneumonia is depending on the time between symptom onset and the CT

scan <sup>(2)</sup>. CT is often normal in the first two days after symptom onset <sup>(3)</sup>. The first abnormal CT findings are described as hazy nodular GGO in a peripheral lobular distribution and typically with a lower lung predominance. With disease progression, the ground-glass opacities diverge while spreading along the bronchovascular bundles and consolidations are formed, frequently starting with a peripheral nodular or linear aspect which diverge to more circumscribed consolidations later on <sup>(2)</sup>.

## **Objectives**

The Fleischner Society Statement on Chest Imaging and COVID-19 stated that Chest CT is indicated in patients with COVID-19 who have worsening respiratory status or for medical triage of patients with suspected COVID-19 who present with moderate to severe clinical features and a high pre-test probability of COVID-19 pneumonia <sup>(4)</sup>. In accordance with the Fleischner Society Statement on Chest Imaging and COVID-19, we used low dose chest CT as a triage system, in correlation with clinical parameters (saturation%, dyspnoea) to assess the risk for disease progression in patients with moderate to severe clinical features and to evaluate the need for hospitalization, intensive care unit and/or intubation in COVID-19 pneumonia. The aim of this study was to evaluate the value of chest CT scan as a triage system for patients with COVID-19 pneumonia and to investigate how CT findings can be used as prognostic factors for patient outcome.

## **Materials And Methods**

### ***Study subjects***

Between March 21, 2020 and April 11, 2020, 763 patients underwent RT-PCR and non-contrast low dose chest CT scan. In 182 patients, RT-PCR was positive for COVID-19 and CT was performed before or within a time interval of four days of the RT-PCR; patients with a positive RT-PCR in a time interval of more than four days after the index CT were excluded because of the possible later onset of the infectious disease. All CT's were evaluated for the presence of CT-abnormalities and their frequency, to determine typical and atypical findings of COVID-19 pneumonia.

Regarding the patient outcome, each patient was categorized in the highest achieved stage of 5 progressive stages (quarantine at home, admission to a non-ICU, admission to the intensive care unit, intubation at the intensive care unit and mortality) and the duration of hospitalization was determined.

### ***Chest CT scan parameters***

All CT examinations were performed on a 128 detector-row CT scanner (Siemens Definition Flash, Forchheim, Germany) with a single breath hold. A non-contrast low dose protocol was performed with the following parameters (gantry speed of 0.5 s per rotation, slice collimation: 128 x 0.6 mm, pitch factor 1.2, slice thickness 1 mm & 3 mm, slice increment 0.7 mm & 3 mm), except for mAs and kV settings depending on patient weight (<50 kg: 80 kV and 30 mAs; 50-80 kg: 120 kV and 20 mAs; >80 kg: 140 kV and 28 mAs).

## ***Evaluation of CT findings and severity***

Chest CT scans were evaluated for CT findings by four experienced thoracic radiologists. Typical CT findings described for COVID-19 include ground-glass opacities (GGO), consolidations, crazy-paving pattern, subpleural reticulation, air bronchogram, (reversed) halo sign, subpleural bands, vascular dilatation, focal pleural thickening and airway changes <sup>(1)</sup>. Examples of atypical CT findings are centrilobular nodules, tree-in-bud pattern, enlarged lymph nodes, pleural effusion and cavitation <sup>(1)</sup>. Based on the CT examination, patients were categorised into 3 groups: consistent, inconclusive and inconsistent for COVID-19 pneumonia. The consistent group was very suggestive for COVID-19 because of the presence of typical CT findings for COVID-19 pneumonia. In the inconclusive group, patients had typical findings as well as atypical CT findings and/or co-findings (e.g. signs of heart failure, tumoral masses, coinfection, hypoventilation GGO,...) that make it more difficult to exclude an underlying COVID-19 pneumonia. In the inconsistent group, CT was either normal or compatible with non-COVID pathology.

For estimating the severity, a visual scoring of the lung injury per lobe in 5 categories was used (0: no involvement, 1: 0-5% involvement, 2: 5-25% involvement, 3: 25-50% involvement, 4: 50-75% involvement, 5: >75% involvement).

## ***Statistical analysis***

Ordinal logistic regression (univariate and multivariate) analysis were performed to find which CT findings of COVID-19 positive patients are predictive for patient outcome and linear regression analysis was performed to assess prognostic factors for the hospitalization duration. Statistical analysis was performed using the IBM Statistical Package for Social Sciences (SPSS version 13, IBM Corp., Armonk, NY, USA); statistical significance level was 0.05.

## **Results**

Of 763 patients with CT and RT-PCR, 182 (23.9%) COVID-19 positive patients could be included with a summary of the patient characteristics listed in table 1. In the study group there were slightly more men (60.4%) in comparison with women (39.6%) affected by COVID-19 pneumonia and the median age was 65 years. The need for admission to a non-ICU was 84.6%, for admission to an ICU 25.8% and for intubation at the ICU 14.9% with an overall mortality rate of 11.5%.

Chest CT examination was reported in 78.6% (143/182) as consistent, in 11.0% (20/182) as inconclusive and in 10.4% (19/182) as inconsistent for COVID-19 pneumonia.

The occurrence rates of typical, atypical and rare CT findings for COVID-19 pneumonia as well as the distribution pattern and total visual score of lung injuries are described in table 2.

Bilateral lung involvement was observed in 95.1% and multilobular involvement in 93.4%. The left lower lobe was most frequently involved (96.7%), followed by the right lower lobe (95.1%), the both upper lobes

(87.9%) and 'least' frequent in the right middle lobe (80.8%). Most often there was a peripheral-central distribution with peripheral predominance (62.1%). The predominant peripheral and basal distribution may be due to the fact that the endobronchial spreading virus invades bronchioles and alveoli, causing bronchiolitis and subsequently inflammatory reactions in the alveoli and interstitium (airspace filling and interstitial thickening) which needs the participation of blood vessels and lymphatics who are more abundant in the peripheral and lower areas of the lungs as reported in earlier studies<sup>(5-6)</sup>. The large airways are less affected by the virus due to its better viral clearance (abundant cilia and strong immune function)<sup>(6)</sup>. In 2.2% no alterations on chest CT were reported and 17% demonstrated with a mildly/early stage of the disease with only peripheral and predominantly basal opacities.

Ground-glass opacities were reported in 97.3%, consolidations (Fig 1A) in 83.5% and bronchial wall thickening in 71% of cases. In the ground-glass opacities, a prominent central vascular structure was noted in 50% of cases and described as vascular dilatation. The subtle focal pleural thickening (Fig 1B, 88%), subpleural bands (Fig 1C, 85%), and subpleural reticulation (36%) are frequently present, confirming the 'organizing pneumonia-like' aspect of COVID-19 pneumonia. In the late stage of the disease, the repair of the lung injury was presumed to be accompanied by the formation of organization with straight edges of the consolidation areas, subpleural alterations and bronchiectasis. Centrilobular nodules are reported in 28% (Fig 1D), tree-in-bud pattern in 2%, enlarged lymph nodes in 16% (Fig 1E) and pleural effusion in 13% (Fig 1F). The presence of enlarged lymph nodes, pleural effusion, and/or clustered centrilobular nodules may suggest bacterial superinfection<sup>(1)</sup>.

Each of the CT findings in table 2 was evaluated by means of an ordinal logistic regression analysis and linear regression analysis to assess which CT findings are predictive for respectively patient outcome and hospitalization duration. The complete results are demonstrated in table 3 and 4.

An increase of one unit (in %) of lung opacity and consolidation as well as the presence of multilobular and bilateral lung involvement, air bronchogram, bronchial wall thickening, crazy paving, pleural effusion and enlarged lymph nodes are associated with a worse patient outcome by means of an univariate ordinal logistic regression model. In the multivariate analysis only a higher age, total visual severity score and the presence of crazy paving were associated with a higher need for admission to an (non-) ICU, intubation as well as a higher mortality rate.

Subsequently a significant longer hospital stay was obtained with a higher total visual severity score as well as the presence of bilateral lung pathology, multilobular lung pathology, pleural effusion, enlarged lymph nodes and crazy paving in the univariate linear regression model. In the multivariate analysis only a higher total visual severity score and the presence of pleural effusion are significant predictors for a longer hospitalization duration.

## Discussion

The higher rates in admission to a non-ICU/ICU, the need for intubation and the overall mortality rate in comparison to other studies<sup>(7)</sup> are probably caused by the biased patient cohort consisting of (mostly elderly) patients with a need for admission to the hospital.

In the proven COVID-19 positive patients, the occurrence rate of each category (conclusive, inconclusive and inconsistent) are similar to earlier studies<sup>(8-9)</sup>. The low degree of false negatives (10.4% inconsistent CTs) and the high degree of positive CTs (78.6% consistent CTs) are consistent with the reported higher sensitivity of Chest CT scan in comparison to RT-PCR<sup>(1-2-3)</sup>.

Concerning the Chest CT characteristics, the occurrence rates were difficult to compare with earlier studies because most published studies investigated the evolutive CT imaging features of COVID-19 pneumonia in time after symptom onset. In general, the study cohort contained patients in a moderately to advanced stage of COVID-19 pneumonia explaining the higher reported occurrence rate of bilateral and multilobular involvement, the lower only peripheral and basal involvement and the higher occurrence rate of GGO, consolidations, crazy paving and signs of bacterial superinfection<sup>(1-2-6)</sup>. The distribution pattern and the estimated involvement per lung lobe was similar compared to earlier studies<sup>(2-5)</sup>.

The significantly higher occurrence rate of bronchial wall thickening compared to other international studies<sup>(1)</sup>, can be due to the higher age (50/182 demonstrated bronchial wall calcifications) or underlying comorbidities (e.g. COPD) of the study group; also, 'pseudo' wall thickening caused by the incidental expiration phase of the Chest CT scan can cause an overestimation of bronchial wall thickening. Also, some of the bronchial wall thickening can be due to inflammatory damage of the bronchial wall by the endobronchial spreading disease who's more abundant in severe/critical patients.

The frequently reported finding of vascular dilatation may correspond to the reported vascular wall thickening and intraluminal thrombogenic material in the injured small lung vessels and the subsequently angiogenesis<sup>(10-11)</sup>.

The three most common typical CT findings in COVID-19 pneumonia are ground-glass opacities, subpleural bands and a focal pleural thickening adjacent to the opacities (Fig. 1). Centrilobular nodules, pleural effusion and enlarged lymph nodes are the three most common atypical CT findings (Fig. 1).

Consolidation, air bronchogram, crazy paving and pleural effusion were considered as an indication of disease progression in earlier studies<sup>(1)</sup>. Multivariate statistical analysis only confirmed a higher age, a higher total visual severity score and the presence of crazy paving as predictive parameters for patient outcome and a higher total visual severity score and the presence of pleural effusion as predictive parameters for a longer hospitalization duration. Pleural effusion can be a sign of superimposed bacterial pneumonia or heart failure, as pre-existing co-morbidity or secondary to COVID-19 myocardial injury or COVID-19 associated pulmonary embolism<sup>(4-11)</sup>. Air bronchogram, bronchial wall thickening and enlarged lymph nodes showed a tendency to be a prognostic factor, but there is no significant correlation for patient outcome or hospital duration. The presence of an air bronchogram is a not specific sign and

can be seen in other various pathologies. Enlarged lymph nodes and bronchial wall thickening are likely to be both a sign of bacterial co-infection or underlying comorbidity (e.g. COPD/emphysema and cardiac strain) rather than specific signs for COVID-pneumonia. This could be an explanation for the detected worse patient outcome and longer hospital duration in patient with these signs.

### ***Biases and limitations***

As mentioned above, the patient cohort consists of (mostly elderly) patients with a more severe grade of COVID-19 pneumonia and a higher need for hospital admission because of clinical deterioration. Asymptomatic and clinical less severe affected patients (usually younger patients) did not receive RT-PCR and Chest CT.

The retrospective study used the personal CT evaluation of 4 experienced thoracic radiologists. Deep learning based software has the potential to reduce the subjective factor by providing corrective measurements of the lung injury instead of a visual estimated severity score. Even more, there are no reliable thresholds in the evaluation of bronchial wall thickening and vascular dilatation so it's predominantly a subjective assessment on a low dose Chest CT scan.

The study cohort included patients during the endemic period of COVID-19 infection in Belgium. We would like to confirm the low degree of false negatives and the high predictive value of Chest CT for COVID-19 infection when the virus is still circulating in a small amount of people and during yearly periods when seasonal flu and other respiratory infections are more common.

The study was conducted in one institution with a uniform clinical policy of the triage process based on CT examination and clinical parameters. Thanks to this policy, the availability of critical care beds was always sufficient enough during this period.

## **Conclusion**

Chest CT scan is useful in diagnosis and triage of patients, respectively based on the appearance of typical and atypical chest CT findings in COVID-19 pneumonia and their predictive value on patient outcome and hospital duration. The three most common typical CT findings in COVID-19 pneumonia are ground-glass opacities, subpleural bands and a focal pleural thickening adjacent to the opacities. Centrilobular nodules, pleural effusion and enlarged lymph nodes are the three most common atypical CT findings who are combined very suggestive for bacterial superinfection.

An increasing percentage of lung opacity as well as the presence of crazy paving and a higher age are associated with a worse patient outcome. The presence of a higher total visual severity score and pleural effusion are significant predictors for a longer hospitalization duration. Pleural effusion, considered an atypical CT finding of COVID-19 pneumonia, turned out to be predictive for a worse outcome; this is likely to be explained by superimposed bacterial pneumonia or heart failure. Even more, enlarged lymph nodes and bronchial wall thickening had a tendency to predict a worse patient outcome and longer hospital

duration (significant in univariate analysis, but not enough in multivariate analysis); they are both possible signs of bacterial co-infection or underlying comorbidity (e.g. COPD/emphysema or cardiac strain) rather than typical signs of COVID-19 pneumonia. In this regard, a quick quantifiable evaluation of the lung injury (by means of a visual scoring system or deep learning based software) as well as visual screening for the presence of crazy paving and signs of bacterial co-infection or underlying comorbidity (e.g. COPD/emphysema or heart failure) can play an important role in the triage of patients with COVID-19 pneumonia.

## Abbreviations

- *COVID-19: Coronavirus disease 2019*

- *GGO: ground-glass opacities*

- *RT-PCR: real time reverse transcription polymerase chain reaction*

- *COPD: chronic obstructive pulmonary disease*

## Declarations

### Disclosure:

Written informed consent was waived by the Institutional Review Board (approved by the Ethics Committee Research UZ/KU LEUVEN).

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.

## References

<sup>1</sup> Ye Z, Zhang Y (2020) Chest CT manifestations of new coronavirus disease 2019 (COVID-19): a pictorial review. Radiol. DOI: [10.1007/s00330-020-06801-0](https://doi.org/10.1007/s00330-020-06801-0)

<sup>2</sup> Bernheim A, Mei X (2020) Chest CT Findings in Coronavirus Disease-19 (COVID-19): Relationship to Duration of Infection. Radiol. DOI: [10.1148/radiol.2020200463](https://doi.org/10.1148/radiol.2020200463)

<sup>3</sup> Waller JV, Kaur P (2020) Diagnostic Tools for Coronavirus Disease (COVID-19) : Comparing CT and RT-PCR Viral Nucleic Acid Testing. AJR. DOI: [10.2214/AJR.20.23418](https://doi.org/10.2214/AJR.20.23418)

<sup>4</sup> Rubin GD, Ryerson CJ (2020) The Role of Chest Imaging in Patient Management during the COVID-19 Pandemic: A Multinational Consensus Statement from the Fleischner Society. Radiol. DOI: [10.1148/radiol.2020201365](https://doi.org/10.1148/radiol.2020201365)

<sup>5</sup> Zhou S, Zhu T (2020) Imaging features and evolution on CT in 100 COVID-19 pneumonia patients in Wuhan, China. Eur Radiol. DOI: [10.1007/s00330-020-06879-6](https://doi.org/10.1007/s00330-020-06879-6)

<sup>6</sup> Wu J, Pan J (2020) Interpretation of CT signs of 2019 novel coronavirus (COVID-19) pneumonia. Eur Radiol. DOI: [10.1007/s00330-020-06915-5](https://doi.org/10.1007/s00330-020-06915-5)

<sup>7</sup> Immovili P, Morelli N (2020) COVID-19 mortality and ICU admission: the Italian experience. Critical Care. DOI: [10.1186/s13054-020-02957-9](https://doi.org/10.1186/s13054-020-02957-9)

<sup>8</sup> Fang Y, Zhang H (2020) Sensitivity of Chest CT for COVID-19: Comparison to RT-PCR. Radiol. DOI: [10.1148/radiol.2020200432](https://doi.org/10.1148/radiol.2020200432)

<sup>9</sup> Ai T, Yang Z (2020) Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases. Radiol. DOI: [10.1148/radiol.2020200642](https://doi.org/10.1148/radiol.2020200642)

<sup>10</sup> Ackermann M, Verleden SE (2020) Pulmonary Vascular Endothelialitis, Thrombosis, and Angiogenesis in COVID-19. NEJM. DOI: [10.1056/NEJMoa2015432](https://doi.org/10.1056/NEJMoa2015432)

<sup>11</sup> Poyiadji N, Cormier P (2020) Acute Pulmonary Embolism and COVID-19. Radiol. DOI: [10.1148/radiol.2020201955](https://doi.org/10.1148/radiol.2020201955)

## Tables

**Table 1: Summary of patient characteristics (n = 182)**

<i>Parameter</i>	<i>n(%)</i>	<i>Parameter</i>	<i>n(%)</i>
Sex		Symptoms	
Men	110 (60.4)	Fever	134 (73.6)
Women	72 (39.6)	Cough	108 (59.3)
Age (y)		Dyspnoea	135 (74.2)
Mean	65	Myalgia	23 (12.6)
Standard deviation	16.22	WBC count 10 <sup>9</sup> /L (ref 4-10.00)	
Range	22-91	Mean	6.71
Smoking		Standard deviation	4.46
Active smoker	10 (5.5)	Range	<0.10-281.67
Ex-smoker	61 (33.5)	Lymphocyte count 10 <sup>9</sup> /L (ref 1.2-3.6)	
Non smoker	88 (48.4)	Mean	1.06
Unknown status	23 (12.6)	Standard deviation	0.79
BMI		Range	0-277
Mean	27.4	CRP mg/dl (ref. <5,0)	
Standard deviation	0.47	Mean	76.25
Range	10.8-47.1	Standard deviation	69.79
Outcome		Range	<0.3-441.1
No admission	28 (15.4)	Duration of hospitalization	
Admission to a non-ICU	154 (84.6)	Mean	11.15
Admission to ICU	47 (25.8)	Standard deviation	0.78
Admission to ICU & intubated	29 (15.9)	Range	0-44
Mortality	21 (11.5)		

**Table 2: Findings at Chest CT Examination (n = 182)**

<i>Finding</i>		<i>n(%)</i>	<i>Finding</i>		<i>n(%)</i>
<b>Involvement</b>			<b>Typical findings</b>		
Bilateral		173 (95.1)	Ground-glass opacities (GGO)		177 (97.3)
Multilobular		170 (93.4)	Nodular GGO		152 (83.5)
Frequency of lobe involvement			Focal pleural thickening <sup>1</sup>		160 (87.9)
Right upper lobe		160 (87.9)	Calcified plaques		10 (5.5)
Right middle lobe		147 (80.8)	Subpleural bands <sup>2</sup>		155 (85.2)
Right lower lobe		173 (95.1)	High opacities		152 (83.5)
Left upper lobe		160 (87.9)	Round opacities		74 (40.7)
Left lower lobe		176 (96.7)	Linear opacities		141 (77.5)
<b>Distribution pattern</b>			Bronchial wall thickening		130 (71.4)
Peripheral		31 (17.0)	Calcified		50 (27.5)
Peripheral-central		147 (80.8)	Vascular dilatation		91 (50.0)
.Peripheral predominance		113 (62.1)	Subpleural reticulation		66 (36.3)
Central		0 (0)	Halo sign		39 (21.4)
No lung involvement		4 (2.2)	Crazy-paving		34 (18.7)
			Air bronchogram		31 (17.0)
<b>Visual scoring n (%)</b>					
	LUL	LLL	RUL	RML	RLL
0: 0% involvement	22 (12.1)	6 (3.3)	22 (12.1)	35 (19.2)	9 (4.9)
1: 0-5%	77 (42.3)	58 (31.9)	80 (44.0)	80 (44.0)	53 (29.1)
2: 5-25%	49 (26.9)	62 (34.1)	41 (22.5)	40 (22.0)	60 (33.0)
3: 25-50%	26 (14.3)	41 (22.5)	24 (13.2)	21 (11.5)	42 (23.1)
4: 50-75%	8 (4.4)	11 (6.0)	11 (6.0)	4 (2.2)	12 (6.6)
5 :> 75%	0 (0.0)	4 (2.2)	4 (2.2)	2 (1.1)	6 (3.3)
			<b>Atypical findings</b>		
			Centrilobular nodules		51 (28.0)
			Enlarged lymph nodes		29 (15.9)
			Pleural effusion		24 (13.2)
			Tree-in-bud pattern		4 (2.2)
			Cavitation		0 (0)
			<b>Rare findings</b>		
			Bronchiectasis		18 (9.9)
			Pre-existing		7 (3.8)
			Reversed halo (atoll) sign		6 (3.3)
			Pneumothorax		2 (1.1)
			Cysts		1 (0.5)

**Table 3: Ordinal regression univariate and multivariate analysis to find significant influencing CT characteristics on patient outcome**

***Univariate Ordinal Regression Analysis***

	OR	95% CI	Wald $\chi^2(1)$	<i>p</i>
<i>Visual score of lung opacity</i>	1.058	1.039–1.076	39.369	< 0.0001*
<i>Bilateral lung pathology</i>	6.931	1.956–24.582	8.998	0.003*
<i>Multilobular lung pathology</i>	4.860	1.659–14.253	8.305	0.004*
<i>GGO</i>	3.227	0.595–18.084	1.857	0.173
<i>Nodular GGO</i>	0.680	0.330–1.402	1.092	0.296
<i>Consolidation</i>	1.725	0.808–3.677	1.988	0.159
<i>Round opacities</i>	1.423	0.820–2.472	1.570	0.210
<i>Linear opacities</i>	1.756	0.899–3.432	2.712	0.100
<i>Nodules</i>	1.134	0.619–2.077	0.166	0.684
<i>Halo sign</i>	0.791	0.411–1.520	0.494	0.482
<i>Vascular dilatation</i>	1.234	0.717–2.125	0.576	0.448
<i>Subpleural bands</i>	1.020	0.476–2.186	0.003	0.960
<i>Bronchial wall thickening</i>	4.104	1.039–16.200	4.060	0.044*
<i>Bronchial wall calcifications</i>	1.480	0.792–2.762	1.512	0.219
<i>Prior lung disease</i>	1.297	0.628–2.678	0.496	0.482
<i>Tree-in-bud pattern</i>	1.223	0.196–7.629	0.046	0.830
<i>Cavitations</i>	-	-	-	-
<i>Enlarged lymph nodes</i>	4.166	2.002–8.680	14.540	< 0.0001*
<i>Air bronchogram</i>	2.675	1.307–5.474	7.257	0.007*
<i>Crazy paving</i>	4.446	2.342–8.440	20.8	< 0.0001*
<i>Pleural effusion</i>	4.191	1.912–9.189	12.808	< 0.0001*
<i>Pleural thickening</i>	1.808	0.784– 4.166	1.929	0.165
<i>Pleural calcifications</i>	1.790	0.166–1.885	0.880	0.348
<i>Pneumothorax</i>	0.530	0.037–7.546	0.219	0.640
<i>Pulmonary embolism</i>	2.361	0.473–11.787	1.096	0.295
<i>Subpleural reticulation</i>	1.127	1.980 – 0.642	0.174	0.677

***Multivariate Ordinal Regression Analysis***

	OR	95% CI	Wald $\chi^2(1)$	<i>p</i>
<i>Visual score of lung opacity</i>	1.038	1.014–1.062	10.010	0.002*
<i>score</i>				
<i>Bilateral lung pathology</i>	2.105	0.787–12.346	0.681	0.409
<i>Multilobular lung pathology</i>	0.688	0.143–3.311	0.218	0.641
<i>Air bronchogram</i>	1.616	0.724–3.597	1.371	0.242
<i>Crazy paving</i>	2.160	1.060–4.386	4.506	0.034*
<i>Pleural effusion</i>	1.597	0.657–3.891	1.069	0.301

Enlarged lymph nodes	1.422	0.603-3.236	0.700	0.403
Bronchial wall thickening	1.112	0.236-5.236	0.018	0.893
<i>Age</i>	1.023	1.003-1.044	5.042	0.025*
<i>Gender</i>	1.198	0.653-2.199	0.340	0.560
<i>Dyspnea</i>	1.664	0.829-3.333	2.046	0.153

**Table 4: Linear regression univariate and multivariate analysis to find significant influencing CT characteristics on hospital duration**

***Univariate Linear Regression Analysis***

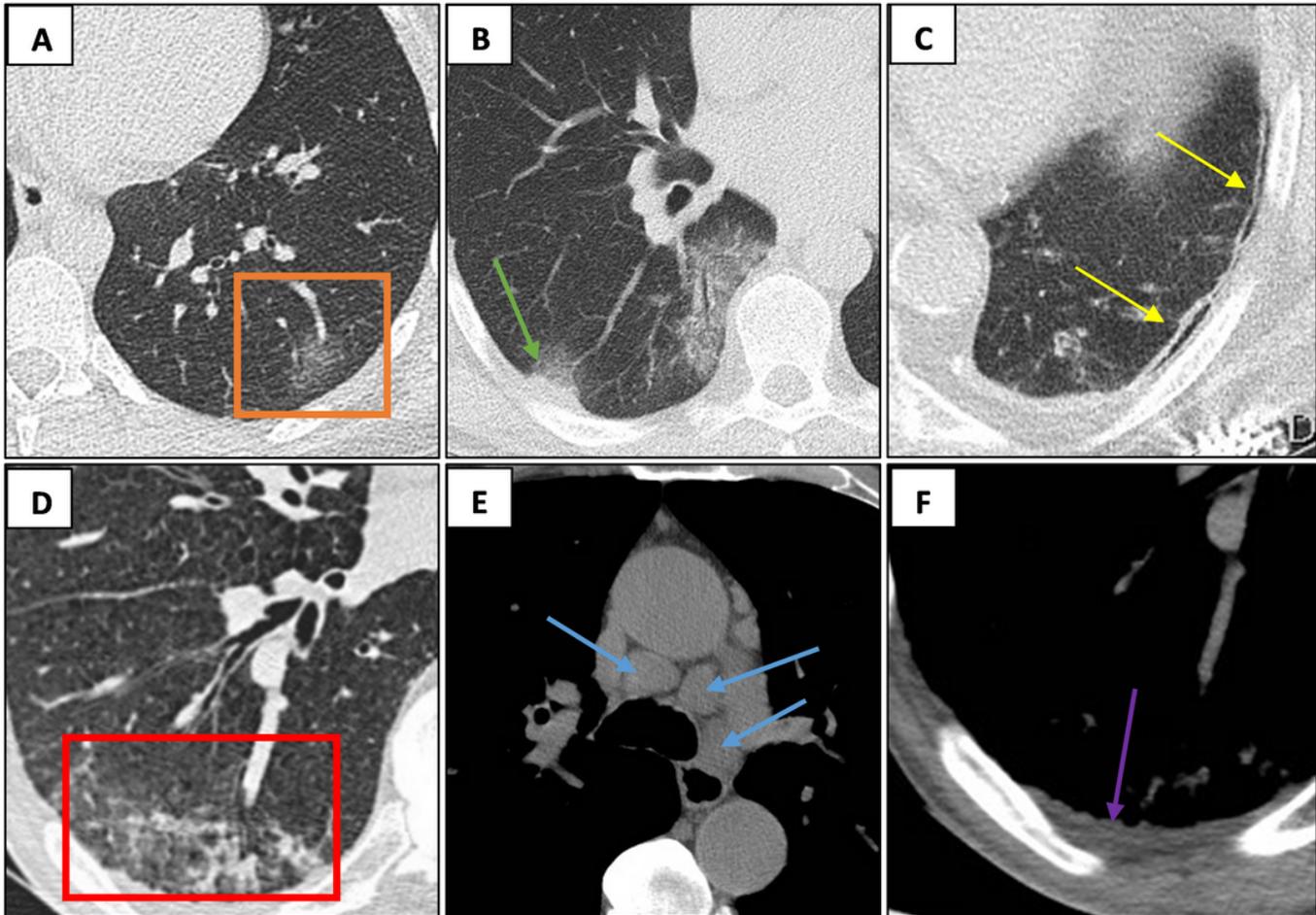
	B (days)	Mean(days)	95% CI	Partial $\eta^2$	<i>p</i>
<i>Visual score of lung opacity</i>	0.271	1.739	0.195-0.348	0.215	< 0.0001*
<i>Bilateral lung pathology</i>	8.632	11.632	2.011-15.252	0.036	0.011*
<i>Multilobular lung pathology</i>	8.838	11.838	3.222-14.455	0.051	0.002*
<i>GGO</i>	8.798	11.398	0.511-18.106	0.019	0.064
<i>Nodular GGO</i>	-1.852	10.848	-2.281-5.986	0.004	0.378
<i>Consolidation</i>	3.674	11.743	0.490-7.839	0.017	0.083
<i>Round opacities</i>	2.946	12.880	0.151-6.043	0.019	0.062
<i>Nodules</i>	-2.115	9.612	-1.338-5.568	0.008	0.228
<i>Crazy paving</i>	7.407	16.63	4.068-10.746	0.097	< 0.0001*
<i>Reversed Halo sign</i>	-0.332	10.833	-8.272-8.936	0.000	0.939
<i>Halo sign</i>	-0.137	11.049	-3.543-3.817	0.000	0.942
<i>Vascular dilatation</i>	2.994	12.693	0.056-6.044	0.021	0.054
<i>Subpleural bands</i>	1.009	11.305	3.312-5.330	0.001	0.646
<i>Bronchiectasis</i>	4.763	15.471	0.470-9.997	0.018	0.074
<i>Bronchial wall thickening</i>	5.001	11.376	2.457-12.459	0.010	0.187
<i>Bronchial wall calcification</i>	0.937	11.864	2.652-4.525	0.001	0.607
<i>Pleural thickening</i>	1.771	11.380	2.847-6.389	0.450	0.003*
<i>Pleural calcifications</i>	0.789	11.900	5.952-7.530	0.000	0.818
<i>Prior lung disease</i>	2.532	13.267	1.594-6.657	0.008	0.228
<i>Tree-in-bud pattern</i>	0.669	10.500	9.808-11.147	0.000	0.900
<i>Cavitations</i>	-	-	-	-	-
<i>Enlarged lymph nodes</i>	9.204	18.833	5.291-13.118	0.107	< 0.0001*
<i>Air bronchogram</i>	3.317	13.903	0.743-7.376-	0.014	0.109
<i>Pleural effusion</i>	9.799	19.600	5.575-14.023	0.105	< 0.0001*
<i>Subpleural reticulation</i>	-1.269	10.348	-1.926-4.464	0.003	0.434
<i>Pulmonary embolism</i>	8.366	19.200	0.918-17.649	0.017	0.077
<i>Pneumothorax</i>	-4.707	6.500	-10.012-19.426	0.002	0.529

***Multivariate Linear Regression Analysis***

	B (days)	Mean(days)	95% CI	Partial $\eta^2$	<i>p</i>
<i>Visual score of lung opacity</i>	0.134	20.523	0.030 -0.238	0.038	0.012*
<i>Bilateral lung pathology</i>	-9.017	20.523	-29.204-47.239	0.001	0.642
<i>Multilobular lung pathology</i>	7.578	20.523	6.831-21.987	0.007	0.301
<i>Crazy paving</i>	0.069	20.523	-19.253-19.390	0.000	0.994
<i>Pleural effusion</i>	13.985	20.523	4.384-23.587	0.048	0.005*
<i>Enlarged lymph nodes</i>	8.972	20.523	1.574-19.518	0.017	0.095
<i>Age</i>	0.029	20.523	-0.068-0.125	0.002	0.559

**Figures**

**Fig. 1 Top 3 typical and atypical CT findings**



**Figure 1**

Top 3 typical and atypical CT findings A Nodular ground-glass opacity: appearance of a hazy nodular ground-glass opacity (orange box), typically bilateral and in the peripheral and lower parts of the lungs in COVID-19 pneumonia. B Pleural thickening: adjacent to the peripheral opacities there is frequently a subtle focal pleural thickening confirming the 'organizing pneumonia-like' aspect. C Subpleural bands: axial CT image in a COVID-19 positive patient shows subpleural bands (yellow arrows) basal in the lung. Subpleural bands are defined as thin curvilinear opacities (1-3 mm thickness) lying subpleural and parallel to the pleural surface. Centrilobular nodules (D), enlarged lymph nodes (E) and pleural effusion (F) are the top 3 atypical CT findings: superimposed aspiration pneumonia in a COVID-19 positive patient with known CPFE (centrilobular emphysema and combined systemic sclerosis/scleroderma-related fNSIP). Axial CT image shows peripheral areas of ground-glass opacity and some clustered centrilobular nodules (red box) basal in the right lung. The mediastinal window shows enlarged mediastinal lymph nodes (blue arrows) and a small pleural effusion (purple arrow) basal in the right lung. The combined findings of nodules, enlarged lymph nodes and pleural effusion are suggestive for bacterial superinfection.