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Mohab M. A. Khalil
Menoufia University, Mohab20005000@gmail.com

Mohamed K. Abd-ElMageed
Menoufia University

Mohamed R. El Kholy
Menoufia University

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Correlation of chest computed tomography score in coronavirus disease 2019-infected patients with oxygen saturation, disease severity, and prognosis

Mohamed K. Abd-ElMageed, Mohab M. A. Khalil, Mohamed R. El Kholy

Department of Radiodiagnosis, Faculty of Medicine, Menoufia University, Menoufia, Egypt

Correspondence to Mohab M.A. Khalil, MBBCh, Melig Shebin Elkom, Menoufia, Egypt Postal code: 32511; Tel: +20 109 256 2623; e-mail: Mohab20005000@gmail.com

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Objective

To detect the degree of illness in a computed tomography (CT) scan of coronavirus disease 2019 (COVID-19) infection based on disease lobe lesions and correlate that value with the patient's blood oxygen saturation level to further predict oxygen therapy needs.

Background

The indicators of lung lesions in COVID-19-infected patients help manage and speed up the entire hospital workflow, as patients with higher severity scores require early therapeutic intervention and critical care.

Patients and methods

This was a prospective descriptive study done at our Department of Radiology. It included 100 patients who underwent a chest CT scan without contrast from June 2020 to November 2021 and were confirmed to have COVID-19 infection by PCR. All patients underwent complete medical history, laboratory tests, pulse oximetry, and radiological examination using high-resolution CT technology.

Results

There was a statistically significant increase in CT chest score in severe disease cases compared with mild severity cases. There was a statistically significant increase in CT score in cases with decreased oxygen saturation compared with those with normal oxygen saturation (O_2) saturation. There was a statistically significant relation between the severity of lung affection and O_2 saturation.

Conclusion

O_2 saturation and CT chest are the first lines for rapid evaluation and patient stratification of COVID-19-infected patients. These cases require careful and close monitoring, as their strong correlation with oxygen saturation helps predict the need for oxygen therapy throughout the disease.

Keywords:

computed tomography, coronavirus disease 2019, oxygen saturation levels

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Introduction

Coronavirus disease 2019 (COVID-19), a severe dangerous viral disease attributed to severe acute respiratory syndrome coronavirus 2, is creating havoc globally, resulting in more than 3.8 million deaths worldwide. This has proven to be the most serious world health crisis since the 1918 influenza pandemic era [1].

A real-time PCR test with a nasopharyngeal swab was a diagnostic test used as a reference standard to confirm the disease [2]. Testing is the main parameter. However, small false-negative cases have been demonstrated [3].

High-resolution chest computed tomography (CT) imaging without contrast has an important part in early disease identification, especially in cases with false-negative RT-PCR results, and in guiding illness progression [4]. In addition, the degree of the disease can be determined from radiological findings. This greatly assists physicians in their clinical decisions and in ensuring effectiveness [5].

Chest CT scan is a useful tool in the identification of pulmonary changes, as well as in the screening, diagnosis, and clinical classification of patients suspected of infections [6]. Physicians can also use CT scans to follow up on patients after they have been discharged from the hospital. CT scans have been used to describe the imaging findings of COVID-19-induced lung infection. Bilateral and multilobe ground-glass opacities are the most common infection patterns [7,8]. The peripheral and lower lobes of the lung have also been proven to be the most affected regions. For patients infected with

COVID-19, other radiological abnormalities such as crazy paving patterns, airway alteration, and reverse halo signs were discovered [9,10].

The study aimed to detect CT-severity scores for COVID-19 infection focused on lobar involvement of the illness and compare the score with SpO_2 levels of the patients to predict oxygen therapy needs.

Patients and methods

This was a prospective descriptive study on 100 patients who were confirmed to have COVID-19 infection in the Department of Radiology at Bagor Hospital during the period between June 2020 and November 2021. Ethical approval for the study was obtained from the Faculty of Medicine, Menoufia University.

Either before or after the CT scan, RT-PCR test confirmed that all patients were positive for COVID-19 infection. Patients with negative RT-PCR test were excluded. SpO_2 was recorded for all patients within 24 h of admission. Oxygen (O_2) saturation of less than 93% was adopted as an indicator of O_2 supply (decreased O_2 saturation). Patients were followed for three to 45 days during hospitalization. All types of O_2 therapy were given to the patient, such as low-flow O_2 supply (low-flow nasal cannula or facemask) or high-flow O_2 supply (high-flow nasal cannula, bi-level positive airway pressure, and ventilator support after intubation).

All participants were subjected to complete full history taking, general examinations, chest examination, laboratory study (complete blood picture, D-dimer, C-reactive protein, and pulse oximetry), as well as radiological investigations using a multidetector CT scanner (Toshiba Asteion four-slice), which was used for all examinations with high-resolution CT technique. Scanning parameters were identical to the manufacturer's standard recommended presetting for a thorax routine. Images were reconstructed with a 1-mm slice thickness in all cases using the classic filtered back-projection method with a soft tissue kernel of B20 and a lung kernel of B60. Coronal and sagittal multiplanar reconstructions were also available in all cases. Implementation of appropriate infection prevention and control measures were arranged in all CT cases, consisting of prompt sanitation of CT facility and patient's isolation. All initial chest high-resolution CT scans were performed on the day of patients' presentation. Patients were placed in a supine position with a single breath hold. Scanning parameters were scan direction (craniocaudally), tube voltage (120 kV), tube current (100–600 mA) smart mA dose modulation, slice collimation (64 × 0.625 mm), width (0.625 × 0.625 mm), pitch, rotation time (0.5 s), and scan length (60.00–1300.00 s).

All preliminary chest CT scans have been accomplished on the day of the patients' presentation, and in all instances, the scans have been reviewed by two expert radiologists (postscan analysis was performed by the two supervisor professors). The CT-severity scoring, as proposed by Pan and colleagues, relies upon the visible evaluation of every lobe involved. In all instances, a CT-severity score was calculated for each of the five lobes concerning the quantity of pathologic involvement. If lobar involvement was less than or equal to 5%, score 1 was given; from 5 to 25%, score 2; from 26 to 49%, score 3; from 50 to 75%, score 4; and more than or equal to 75%, score 5. The severity was then assessed using the following assessment system, depending on the visual assessment of each affected lobe. The sum of the lobar scores indicates the overall severity: mild severity was considered if the score was seven or less, moderate if the score ranged from 8 to 17, and severe if the score is 18 or more [11].

Statistical analysis

All data were collected, tabulated, and statistically analyzed using the statistical package for the Social Sciences (SPSS), version 22 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± SD for parametric data and median and range for nonparametric data. Qualitative data were expressed as frequencies and relative percentages. Data were handled using appropriate statistical tests of significance such as the independent *t* test and Mann–Whitney test, which were used to calculate the difference between quantitative variables in two groups. Receiver operating characteristic curve was used to detect the cutoff values to assess the relation between CT-severity and the need for high-flow O_2 supply.

Results

In our study, the age of patients ranged from 26 to 77 years, with a mean ± SD of 50 ± 15 years and a median of 51 years. A total of 52 (52%) patients were males and 48 (48%) were females, with a male to female ratio of 1.08: 1. There was a statistically significant increase in CT scores in severe disease compared with moderate severity ($P = 0.002$). Likewise, there was a statistically significant increase in CT score in moderate severity compared with mild severity ($P = 0.009$). Moreover, there was a statistically significant increase in CT scores in severe disease compared with mild severity ($P < 0.001$). The mean CT score in normal O_2

saturation was 11.03 ± 3.33 and it was 12.47 ± 2.87 in decreased O_2 saturation. There was a statistically significant increase in CT score in cases with decreased O_2 saturation compared with those with normal O_2 saturation ($P = 0.041$) (Table 1).

The current results revealed that regarding the distribution of abnormalities of COVID-19 pneumonia of each lobe, the disease involvement was mainly in the lower right and left lobes in 94 (94%) patients, with mean CT scores of 3.04 ± 1.37 and 3.66 ± 1.17, respectively, followed by the left upper lobe and middle lobe in 88 (88%) patients, with mean CT scores of 2.50 ± 1.11 and 1.82 ± 0.81, respectively. The mean total CT score was 11.92 ± 3.14. A total of 85 patients had moderate severity, nine patients had mild severity, and six patients had severe severity (Table 2).

Most of moderate and severe cases were hypoxic (62 from 85 cases and five from six cases, respectively). There was a statistically significant relation between the severity of lung affection and O_2 saturation ($P = 0.045$) (Table 3).

The patients needed O_2 therapy as follows: 35 patients required a facemask, 40 patients required a nasal cannula, five patients required a BiPAP or HFNC, 16 patients required intubation, and only four required a nonrebreather mask. At follow-up period, all patients with mild disease were discharged either after 3 months (six cases) or 6 months (three cases). Most patients with moderate disease were discharged when improved O_2 saturation in the first 3 weeks except three cases on facemask became on nonrebreather and O_2 supply was downgraded from high-flow to low-flow O_2 supply, except two of 10 cases on intubation and four of five cases on HFNC/BIPAP. Four cases of moderate severity died after 3 weeks (two patients on intubation, one patient on BIPAP, and another one on nonrebreather), but only two cases were deteriorated from nasal cannula to become on facemask. All severe cases died within 6 weeks of admission (Table 4).

Table 1 Relation between computed tomography score and severity of pneumonia

Parameters	Studied patients (*n*=100)	*P*
Age (years)		
Mean±SD	50.28±15.3	–
Sex		
Female	48	48.0%
Male	52	52.0%
Severity of pneumonia according to CT score mean±SD		
Mild (*P*1)	6.00±0.82	<0.001*HS *P*1–2=0.009 *P*1–3≤0.001 *P*2–3=0.002
Moderate (*P*2)	11.80±2.10	
Severe (*P*3)	17.60±0.55	
O_2 saturation according to CT score (mean±SD)		
Decreased	12.47±2.67	0.041** S
Normal	11.03±3.33	

CT, computed tomography; HS, highly significant; O_2, oxygen; S, significant. *Independent samples Kruskal–Wallis test. **Independent samples Mann–Whitney *U* test.

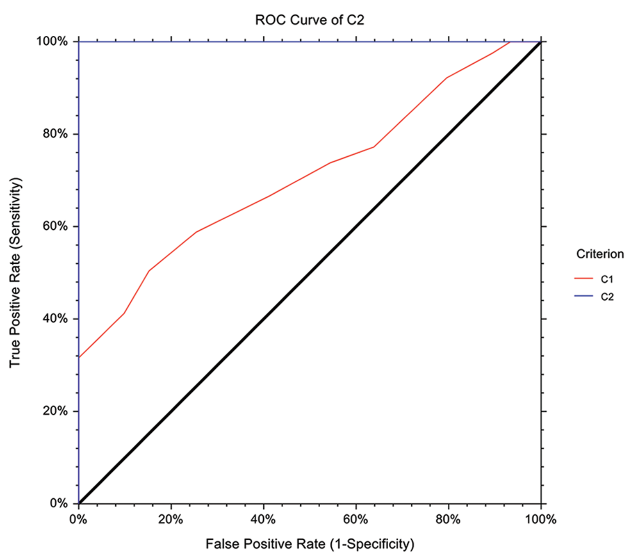
All presented patients were managed with different forms of O_2 supply under follow-up whatever the CT score to prevent sudden complications of disease severity; this protocol was performed at our isolation hospital. Fig. 1 shows the cutoff point of CT-severity score of cases in need of high-flow rather than low-flow O_2 supplementation. When the cutoff point of CT-severity was at 12, with area under the curve of 0.7106, the sensitivity of CT score was 73.8% and specificity was 45.5% (95% confidence interval range, 55.3–62.1%), and when cutoff point of CT-severity at 15, with area under the curve of 0.503, the sensitivity of CT score was 50.3% and specificity was 84.7% (95% confidence interval range, 82.1–87.1%).

Discussion

SARS-CoV2 caused by the outbreak of COVID-19 is rapidly spreading worldwide. Most COVID-19 cases have a mild disease, but some patients rapidly worsen from the appearance of symptoms to serious disease if ARDS is present or not (especially within seven to 14 days) [12].

Detection of cases with risk of serious symptoms with COVID-19 is clinically important. In some studies,

Figure 1



Receiver operating characteristic curve for the need for high-flow rather than low-flow oxygen supplementation.

Table 2 Frequency of involvement of each lobe with related computed tomography score in the studied patients

Parameters	Studied patients (*n*=100) [*n* (%)]
Right upper lobe	
No	20 (20.0)
Yes	80 (80.0)
Score	
Mean±SD	2.28±0.75
Middle lobe	
No	12 (12.0)
Yes	88 (88.0)
Score	
Mean±SD	1.82±0.81
Right lower lobe	
No	6 (6.0)
Yes	94 (94.0)
Score	
Mean±SD	3.04±1.37
Left upper lobe	
No	12 (12.0)
Yes	88 (88.0)
Score	
Mean±SD	2.50±1.11
Left lower lobe	
No	6 (6.0)
Yes	94 (94.0)
Score	
Mean±SD	3.66±1.17
Total score	
Mean±SD	11.92±3.14
Severity	
Mild	9 (9.0)
Moderate	85 (85.0)
Severe	6 (6.0)

Table 3 Relation between severity of lung affection and oxygen saturation

Variables	O_2 saturation [*n* (%)]		Test value	*P*
	Normal	Decreased		
Severity				
Mild (9 cases)	6 (20.7)	3 (4.2)		
Moderate (85 cases)	22 (75.9)	63 (88.7)	9.74	0.045*
Severe (6 cases)	1 (3.4)	5 (7.1)		
Total	29 (100.0)	71 (100.0)		

*Statistically significant. χ^2 test.

the prevalence of severe COVID-19 in hospitalized patients ranged from 15 to 26%, and these patients were with severe chest CT findings and laboratory data [13,14].

Conversely, there is increasing evidence that the combined sensitivity of the nose and throat swabs may be inadequate when performed at a single point in time. This also depends on the technical characteristics of the test and the sampling method [15]. The relatively long turnaround time for viral load testing and the insensitivity of a single RT-PCR test in nasal and throat swab specimens also do not rapidly identify large numbers of SARS-CoV2 patients [16].

Noncontrast high-resolution chest CT has a central and important part, especially in the early identification of illness in cases with false-negative RT-PCR results and the treatment and detection of disease progression. In addition, radiological results can be used to determine the degree of the illness, greatly assisting physicians in their clinical decisions and ensuring effective therapy [11,17].

This prospective descriptive study was conducted on 100 patients with COVID-19 infection confirmed by RT-PCR. These patients underwent O_2 assessment by pulse oximetry, chest CT, and laboratory tests. In our study, we revealed that the mean age of patients was 50.82 years. Male to female ratio was 1.08: 1. This was in agreement with the study by Saeed *et al*. [18], who enrolled 902 patients with a mean age was 44.0 ± 11.0 years (85% males, 15% females) to investigate the correlation between chest CT-severity scores and the symptoms of COVID-19 pneumonia in adult patients. However, the study by Francone *et al*. [16] enrolled 103 patients with a mean age of 63 ± 15 years (64% males and 36% females).

The semiquantitative scoring system was previously demonstrated by Wang *et al*. [13] and Zhou *et al*. [19]

Table 4 Distribution of maximum oxygen requirement in the studied patients

Severity	Maximum O_2 requirement [*n* (%)]					Test value	*P*
	Facemask	HFNC/BIPAP	Intubation	Nasal cannula	Nonrebreather mask		
At admission							
Mild (9 cases)	3 (8.6)	0	0	6 (15)	0		
Moderate (85 cases)	32 (91.4)	5 (100)	10 (62.5)	34 (85)	4 (100)	21.377	0.001*
Severe (6 cases)	0	0	6 (37.5)	0	0		
After 3 weeks							
Mild	0	0	0	3 (23)	0		
Moderate	17 (100)	4 (100)	2 (50)	10 (77)	5 (100)	10.703	0.030*
Severe (2 cases remain, rest died)	0	0	2 (50)	0	0		
After 6 weeks							
Mild	0	0	0	0	0		
Moderate	19 (100)	3 (100)	0	8 (100)	4 (100)	–	–
Severe	0	0	0	0	0		

BIPAP, bi-level positive airway pressure; HFNC, high-flow nasal cannula. *Statistically significant. $\chi 2$ test.

using the system previously reported for the degree of ARDS on lung CT scans to assess the degree of involvement of the lung parenchyma [20]. Simply, the right lung is categorized into three parts: upper lobe, middle lobe, and lower lobe. The left lung was categorized into two parts, the upper and the lower lobes. Each lobe of the lung was evaluated in terms of the percentage of involvement on a scale of 0–5.

The current results revealed that regarding the distribution of abnormalities of COVID-19 pneumonia of each lobe, the disease involvement was mainly in the inferior lobes of both lungs. In agreement with our findings, the results by Francone *et al.* [16] revealed that the disease involvement was mainly in the lower lobes. However, our study was not in agreement with the study by Högström *et al*. [21], who reported that the posterior segment of the upper lobes (66%), the superior segment of the lower lobes (77%), the lateral basal segments of the lower lobes (left, 77%; right, 68%), and the posterior basal segments of the lower lobes (left, 79%; right, 81%) are the most frequently involved sites.

Regarding the distribution of O_2 requirements in these patients, the study by Saeed *et al*. [18] reported that 646 (71%) patients did not require any O_2 support. The remaining 256 patients required O_2 supplements as follows: 126 (14%) patients required nasal cannula, 32 (3.5%) patients required facemask, 15 (1%) patients required nonrebreather mask, 21 (2%) patients required a BiPAP or HFNC, and 62 (7%) patients need intubation, out of which 32 (51%) patients were eventually extubated. However, in our study, severe diseased patients were intubated and died within 6 weeks, and intubated moderate cases (10 cases) were either discharged when improved in the first 3 weeks (eight cases) or died when their treatment prolonged more than 3 weeks (two cases).

Wang *et al*. [22] reported that most patients required O_2 therapy and a minority of the patients needed invasive ventilation or even extracorporeal membrane oxygenation. In the ICU group, four (11%) patients received high-flow O_2 and 16 (44%) received noninvasive ventilation. Invasive mechanical ventilation was required in 17 (47.2%) patients, four of whom received extracorporeal membrane oxygenation as rescue therapy.

In agreement with our results about CT scores, the study by Saeed *et al*. [18] concluded that the severity of CT correlates well with the symptoms and complications of COVID-19. They also have a significant correlation ($P < 0.05$) between CT-severity score and male sex, elevated inflammatory indicators, peak O_2 supply, length of hospital stay, intubation need, and clinical prognosis. Based on our findings, the results by Francone *et al*. [16] revealed that CT score was significantly lower in the mild category than in the severe and significant categories, confirming a high correlation between imaging findings and clinical stage. They reported no statistical significance between the severe and significant categories ($P = 0.7921$).

In support of our findings, Zhang *et al*. [23] revealed that the chest CT score of cases with COVID-19 is correlated with the severity of the inflammation.

Moreover, Feng *et al*. [24] showed that CT-severity scores on admission were significant predictors for progression in patients with moderate COVID-19 pneumonia.

The study by Yang *et al*. [25] concluded that the CT-severity score can be used for assessing the severity of COVID-19 with 83% sensitivity and 94% specificity.

The study by Feng *et al.* [24] also supports our results as they revealed that using this CT-severity score correctly detects the severity of lung pneumonia and concludes the illness prognosis is good in cases with moderate COVID-19 pneumonia at hospital entry early within 14 days.

Of 148 patients included in a study conducted by Aziz-Ahari *et al*. [26], 93 patients recovered, whereas 55 patients died. The best CT score cutoff for discriminating patients based on the severity of disease was 12.5, with 68.3% sensitivity and 72.7% specificity. In addition, with a cutoff of CT score of 15.5, sensitivities of 51.6% and specificities of 72.6% were observed for intubation.

Conclusion

CTSS helps to detect patients at risk and the prognosis in cases with COVID-19 lung inflammations. The CT results are greatly correlated with disease symptoms and test parameters. There was a statistically significant increase in CT score in cases with decreased O_2 saturation compared with those with normal O_2 saturation. Therefore, our study greatly supports the use of chest CT in cases with COVID-19 lung inflammations.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

References

1 Tcheutchoua DN, Tankeu AT, Angong DL, Agoons BB, Nguemnang NY, Djeunga HC, Kamgno J. Unexpected low burden of coronavirus disease 2019 (COVID-19) in sub-Saharan Africa region despite disastrous predictions: reasons and perspectives. Pan Afr Med J 2020; **37**:352.

2 Corman VM, Landt O, Kaiser M, Molenkamp R, Meijer A, Chu DK, *et al*. Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR. Eurosurveillance 2020; **25**:200–245.

3 Panno S, Ruiz-Ruiz S, Caruso AG, Alfaro-Fernandez A, San Ambrosio MI, Davino S. Real-time reverse transcription polymerase chain reaction development for rapid detection of Tomato brown rugose fruit virus and comparison with other techniques. Peer J 2019; **7**:79–128.

4 Liu J, Yu H, Zhang S. The indispensable role of chest CT in the detection of coronavirus disease 2019 (COVID-19). Eur J Nucl Med Mol Imag 2020; **47**:1638–1639.

5 Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N, *et al*. Chest CT findings in coronavirus disease-19 (COVID-19): relationship to duration of infection. Radiology 2020; **295**:200–463.

6 Li W, Cui H, Li K, Fang Y, Li S. Chest computed tomography in children with COVID-19 respiratory infection. Pediatr Radiol 2020; **50**:796–799.

7 Salehi S, Abedi A, Balakrishnan S, Gholamrezanezhad A. Coronavirus disease (COVID-19): a systematic review of imaging fndings in 919 patients. Am J Roentgenol 2020; **215**:87–93.

8 Wang W, Gao R, Zheng Y, Jiang L. COVID-19 with spontaneous pneumothorax, pneumomediastinum and subcutaneous emphysema. J Travel Med 2020; **27**:49–62.

9 Ye Z, Zhang Y, Wang Y, Huang Z, Song B. Chest CT manifestations of new coronavirus disease (COVID-19) (2020): a pictorial review. Eur Radiol 2020; **30**:4381–4389.

10 Ali TF, Tawab MA, ElHariri MA. CT chest of COVID-19 patients: what should a radiologist know? Egypt J Radiol Nucl Med 2020; **51**:1–6.

11 Pan F, Ye T, Sun P, Gui S, Liang B, Li L, *et al*. Time course of lung changes at chest CT during recovery from coronavirus disease 2019 (COVID-19). Radiology 2020; **295**:715–721.

12 Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, *et al*. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020; **395**:497–506.

13 Wang Y, Dong C, Hu Y, Li C, Ren Q, Zhang X, *et al*. Temporal changes of CT findings in 90 patients with COVID-19 pneumonia: a longitudinal study. Radiology 2020; **296**:55–64.

14 Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, *et al*. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med 2020; **382**:1708–1720.

15 Han H, Luo Q, Mo F, Long L, Zheng W. SARS-CoV-2 RNA more readily detected in induced sputum than in throat swabs of convalescent COVID-19 patients. Lancet Infect Dis 2020; **20**:655–656.

16 Francone M, Iafrate F, Masci GM, Coco S, Cilia F, Manganaro L, *et al*. Chest CT score in COVID-19 patients: correlation with disease severity and short-term prognosis. Eur Radiol 2020; **30**:6808–6817.

17 Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, Tao Q, Sun Z, *et al*. Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. Radiology 2020; **296**:32–40.

18 Saeed GA, Gaba W, Shah A, Al Helali AA, Raidullah E, Al Ali AB, *et al*. Correlation between chest CT severity scores and the clinical parameters of adult patients with COVID-19 pneumonia. Radiol Res Pract 2021; **2021**:20–21.

19 Zhou S, Wang Y, Zhu T, Xia L. CT features of coronavirus disease 2019 (COVID-19) pneumonia in 62 patients in Wuhan, China. Am J Roentgenol 2020; **214**:1287–1294.

20 Ooi GC, Khong PL, Müller NL, Yiu WC, Zhou LJ, Ho JC, *et al*. Severe acute respiratory syndrome: temporal lung changes at thin-section CT in 30 patients. Radiology 2004; **230**:836–844.

21 Högström H, NIlsson BE, WIllner S. Correction with growth following diaphyseal forearm fracture. Acta Orthop Scand 1976; **47**:299–303.

22 Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, *et al*. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. JAMA 2020; **323**:1061–1069.

23 Zhang J, Meng G, Li W, Shi B, Dong H, Su Z, *et al*. Relationship of chest CT score with clinical characteristics of 108 patients hospitalized with COVID-19 in Wuhan, China. Respir Res 2020; **21**:1–11.

24 Feng Z, Yu Q, Yao S, Luo L, Zhou W, Mao X, *et al*. Early prediction of disease progression in COVID-19 pneumonia patients with chest CT and clinical characteristics. Nat Commun 2020; **11**:1–9.

25 Yang R, Li X, Liu H, Zhen Y, Zhang X, Xiong Q, *et al*. Chest CT severity score: an imaging tool for assessing severe COVID-19. Radiology 2020; **2**:200–247.

26 Aziz-Ahari A, Keyhanian M, Mamishi S, Mahmoudi S, Bastani E, Asadi F, Khaleghi M. Chest CT severity score: assessment of COVID-19 severity and short-term prognosis in hospitalized Iranian patients. Wien Med Wochenschr 2022; **172**:77–83.