Intensive Care Medicine

LETTER TO THE EDITOR Un-edited accepted proof

Admission chest CT score predicts 5-day outcome in patients with COVID-19

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Author's contributions

Each author has participated sufficiently in the work to take public responsibility for the content, including a substantial contribution to conception and design, execution, or analysis and interpretation of data.

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Dear Editor,

Since December 2019, COVID-19 has rapidly spread and 2 804 796 cases, including 193 710 deaths, have been reported worldwide as of April 26, 2020 [1]. While most patients have mild symptoms and recover without treatment, some patients may develop dyspnea, requiring oxygen therapy, or rapidly deteriorate into respiratory or multi-organ failure, requiring mechanical ventilation and intensive care unit monitoring [2]. Early identification of patients at risk of rapid worsening may help management of COVID-19 patients in emergency departments. CT is largely used for diagnosis of COVID-19, in addition to RT-PCR, and typically shows bilateral peripheral ground glass opacities with occasional consolidations [3]. The extent of lung lesions is correlated with disease severity [4]. However, data about the prognostic value of CT in COVID-19 are scarce [5]. We assessed an admission CT score for predicting the 5-day outcome in COVID-19 patients.

Patients with RT-PCR confirmed COVID-19 who underwent CT from March 1 to March 20, 2020 at our institution were retrospectively enrolled. All CTs were independently scored by two radiologists blinded to clinical data. The CT score (range: 0-25) was defined as the sum of lung involvement (0: 0%, 1: <5%, 2: 5-25%, 3: 25-50%, 4: 50-75%, 5: >75%) of each lobe, **including ground glass opacity, crazy paving and consolidation** (Figure 1 and Supplementary Materials 1). Poor 5-day outcome was defined as need for mechanical ventilation or death within 5 days of the CT. Baseline characteristics were compared between patients with poor and good 5-day outcome (Supplementary Materials 2). **The optimal cutoff CT score for discriminating patients with poor and good outcome was determined using ROC curve (Supplementary Materials 3) and maximizing the Youden index.** To identify predictors for poor 5-day outcome, baseline characteristics with p-value<0.10 were entered into multivariate logistic regression (Supplementary Materials 4). Inter-observer reliability for CT score was assessed. Institutional review board approval was obtained and patient consent was waived.

142 COVID-19 patients were enrolled, of whom 12 (8.5%) required mechanical ventilation and 8 (5.6%) died within 5 days of the CT **(Supplementary Materials 5).** Patients with poor 5-day outcome had higher median CT scores (15; interquartile range 13-20) than other patients (8; 5-11, p<0.001). The optimal CT score to predict poor 5-day outcome was ≥13 (sensitivity 80.0%, specificity 85.2%, AUC 0.853). On multivariate analysis, CT score ≥13 was related to poor 5-day outcome (odds ratio 44.243, 95% CI 8.609-227.365, p<0.001). Inter-observer reliability was excellent (intraclass correlation coefficient 0.976, 95% CI 0.966-0.983).

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We found that the admission CT score was an independent predictor for 5-day outcome of COVID-19 patients. Our results are consistent with those of Colombi et al. [5] who showed that well aerated lung quantification predicted intensive care unit admission or death. Interestingly, the CT score is simple, reproducible and readily available in daily practice with no need of post-processing software. It may help select patients at risk of rapid deterioration who should require high-level monitoring. **External validation of our non-replicated single-center results and comparison of CT score with X-ray or ultrasound-based scores are needed.**

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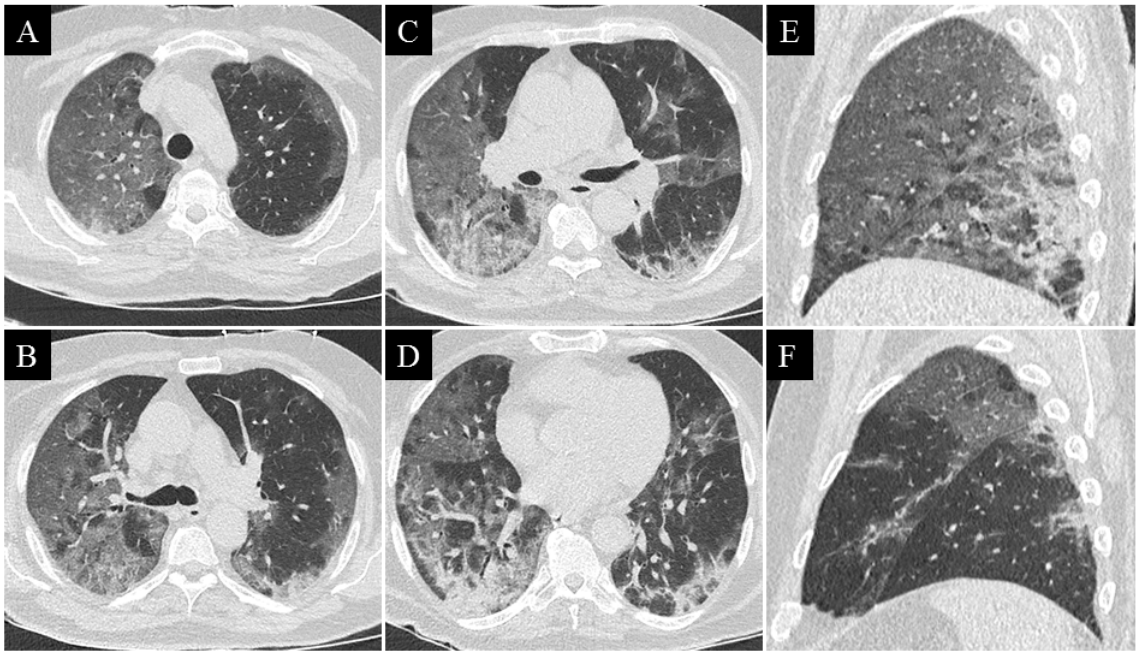
Figure 1: Axial and sagittal CT images from a 63-year old man presenting at emergency room for severe COVID-19 at day 12 after symptom onset.



Axial (A to D), right (E) and left (F) sagittal selected CT images showed extensive, bilateral and asymmetric ground glass opacities involving almost the entire right lung, with small consolidation in the right lower lobe. Left lung involvement was less severe. The lobe score was 5 (>75%) for right upper lobe, 5 (>75%) for right middle lobe, 5 (>75%) for right lower lobe, 3 (25-50%) for left upper lobe and 2 (5-25%) for left lower lobe. The total CT score for this patient was 20. The patient presented respiratory failure requiring mechanical ventilation 1 day after this scan.

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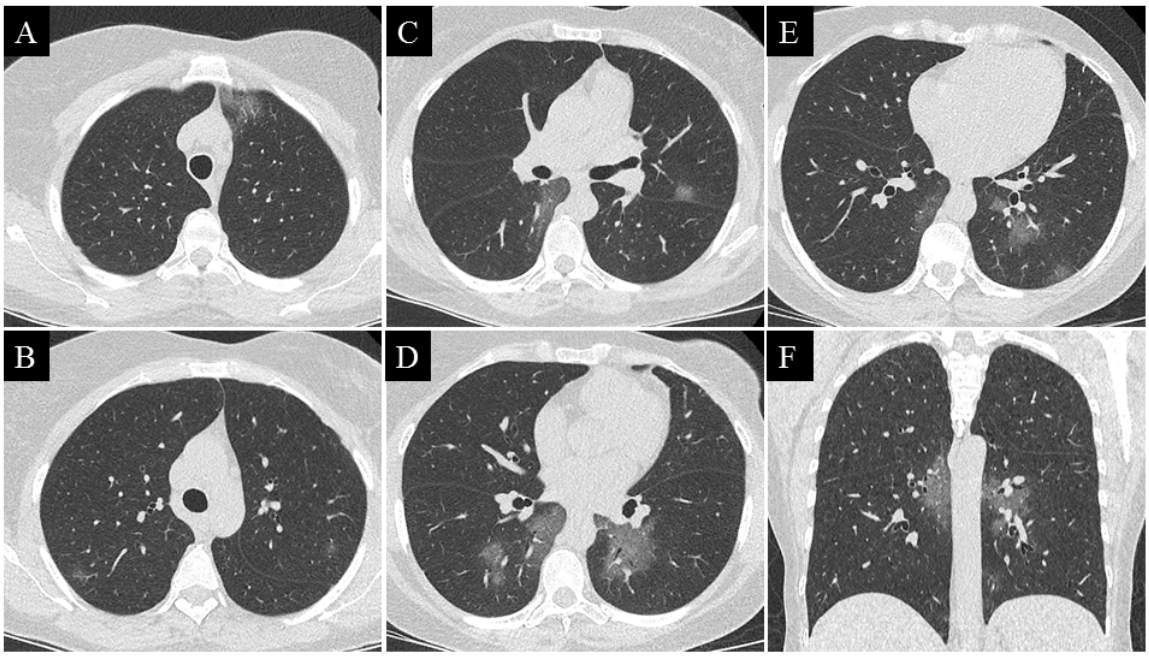
Supplementary Materials 1: Axial and coronal CT images from a 62-year old woman presenting at emergency room for moderate COVID-19 at day 7 after symptom onset.



Axial (A to E) and coronal (F) selected CT images showed bilateral and multifocal subpleural ground glass opacities. The lobe score was 1 (<5%) for right upper lobe, 0 (0%) for right middle lobe, 2 (5-25%) for right lower lobe, 1 (<5%) for left upper lobe and 2 (5-25%) for left lower lobe. The total CT score for this patient was 6. The patient was discharged from hospital 2 days after admission.

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Supplementary Materials 2: Baseline clinical characteristics and 5-day outcomes of COVID-19 patients

Characteristics	Poor outcome (n=20)	Good outcome (n=122)	p value
Age	73.6 (58.8-85.9)	61.4 (52.9-76.1)	0.019
Male, n(%)	16 (80)	70 (57.4)	0.082
Comorbidities			
COPD, n(%)	3 (15)	4 (3.3)	0.058
Diabetes, n(%)	6 (30)	27 (22.1)	0.409
Hypertension, n(%)	8 (40)	55 (45.1)	0.809
Coronary heart disease, n(%)	5 (25)	14 (11.5)	0.148
Cerebrovascular disease, n(%)	4 (20)	7 (5.7)	0.05
Hepatitis B infection, n(%)	0	4 (3.3)	1
Malignancy, n(%)	0	16 (13.1)	0.128
Chronic renal disease, n(%)	4 (20)	14 (11.5)	0.285
Immunodeficiency, n(%)	1 (5)	12 (9.8)	0.694
Onset-to-CT time, days	7 (5-9)	5 (3-9)	0.373
Temperature, °C	37.4 (36.8-38.2)	37.5 (36.9-38.2)	0.592
Respiratory rate, times/min	22 (17-26)	20 (16-24)	0.133
Oxygen saturation, %	93(89-96)	97 (95-98)	<0.001
Disease severity			0.005
Moderate, n(%)	6 (30)	80 (65.6)	
Severe, n(%)	14 (70)	42 (34.4)	
CT score	15 (13-20)	8 (5-11)	<0.001

Unless specified, numbers are median (interquartile range).
Poor outcome was defined as need for mechanical ventilation or death within 5 days of the CT. Good outcome was considered when the patient was still alive 5 days after the CT with no need of mechanical ventilation.
COPD, chronic obstructive pulmonary disease.

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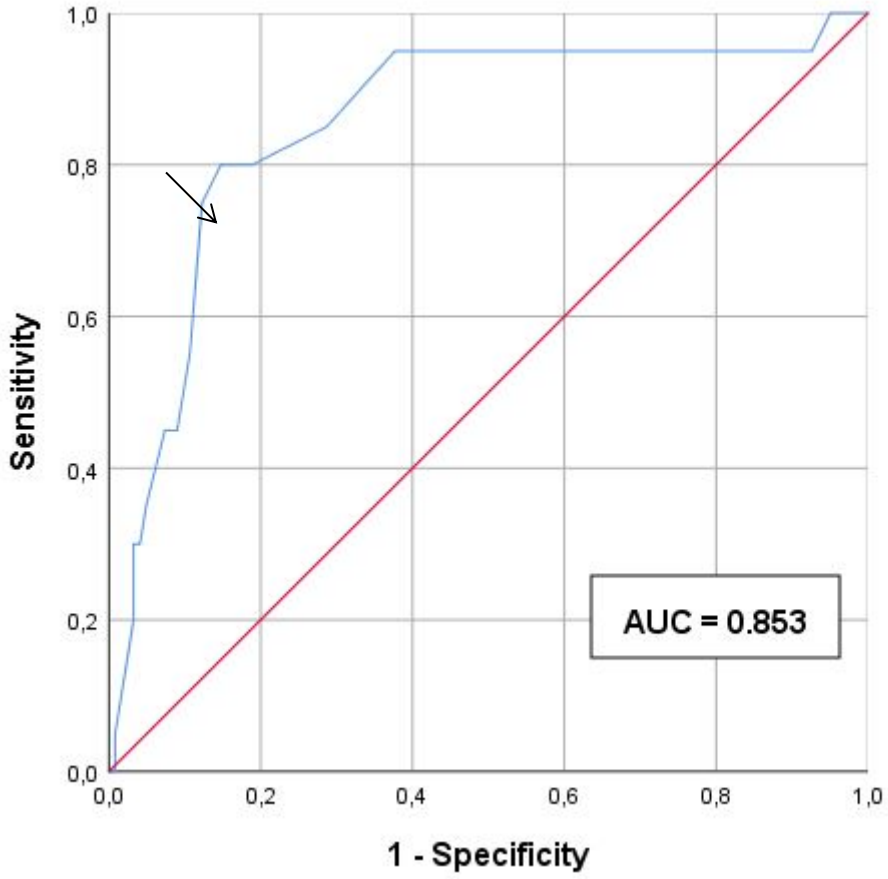
Supplementary Materials 3: Receiver operating characteristic curve of CT score for predicting poor 5-day outcome



The optimal cutoff CT score (arrow) to predict poor 5-day outcome was ≥13, with a sensitivity of 80.0% and a specificity of 85.2%.
AUC, area under the receiver operating characteristic curve.

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Supplementary Materials 4: Factors associated with poor 5-day outcome in multivariate analysis

Characteristics	OR (95%CI)	p value
Age	1.039 (0.997-1.083)	0.069
Male	4.432 (0.922-21.314)	0.063
COPD	8.805 (0.697-111.229)	0.093
Cerebrovascular disease	9.840 (1.263-76.676)	0.029
CT score≥13	44.243 (8.609-227.365)	<0.001

COPD, chronic obstructive pulmonary disease.

Supplementary Materials 5: Characteristics of patients with poor 5-day outcome (n=20)

Patient	Age	Sex	Comorbidity (number)	Disease severity	Onset-to-CT time (days)	CT score	CT-to-ventilation time (days)	CT-to-death time (days)
1	89	F	2	moderate	1	1	-	4
2	86	M	2	severe	6	10	-	5
3	87	M	3	severe	3	10	-	3
4	72	M	0	severe	7	11	4	-
5	75	F	2	moderate	9	13	4	-
6	82	M	2	severe	10	14	-	5
7	49	M	1	moderate	7	14	0	-
8	43	M	2	moderate	8	14	2	-
9	83	M	3	severe	16	14	-	3
10	52	M	1	moderate	7	15	2	-
11	85	M	0	severe	8	15	-	4
12	69	F	4	severe	11	17	3	-
13	77	M	1	severe	3	17	0	-
14	69	M	0	severe	8	18	1	-
15	51	M	1	severe	7	20	2	-
16	63	M	0	severe	12	20	1	-
17	71	M	2	severe	7	21	1	-
18	87	F	3	moderate	3	21	-	3
19	97	M	2	severe	5	21	-	2
20	57	M	0	severe	6	22	1	-

Poor 5-day outcome was defined as need for mechanical ventilation or death within 5 days of the CT. Comorbidities included chronic obstructive pulmonary disease, diabetes, hypertension, coronary heart disease, cerebrovascular disease, hepatitis B infection, malignancy, chronic renal disease, and immunodeficiency. The total number of comorbidities per patient was summed up.
F, female; M, male.

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