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Initial computed tomography features of known inpatient ward versus intensive care admission COVID-19 cases: is there any difference?

Özlem Ünal[1], Ural Koç[2, 3], Erdem Özkan[2], İmran Hasanoğlu[4], Aziz Ahmet Surel[5], Hatice Rahmet Güner[4, 6]

[1]Department of Radiology, Ankara Yıldırım Beyazıt University, Ankara City Hospital, Ankara, Turkey
[2]Department of Radiology, Ankara City Hospital, Ankara, Turkey
[3]General Directorate of Health Services, The Turkish Ministry of Health, Ankara, Turkey
[4]Department of Infectious Diseases, Ankara Yıldırım Beyazıt University, Ankara City Hospital, Ankara, Turkey
[5]Coordinator Head Physician, Ankara City Hospital, Ankara, Turkey
[6]COVID-19 Advisory Committee of the Ministry of Health of Turkey, Ankara, Turkey

ABSTRACT

Objectives: The aim of this study was to evaluate initial computed tomography (CT), basic clinical and demographic features of cases with COVID-19 pneumonia with known inpatient ward and intensive care unit hospitalization.

Methods: A total of 200 cases (103 males, 97 females; age range: 18-92 years) were retrospectively and randomly collected whom were hospitalized and followed up at infectious disease inpatient ward and intensive care unit (ICU). The initial CT findings were interpreted by two radiologists at the same session by consensus.

Results: Cough (61%) and fever (54%) were the main symptoms at the onset presentation. Initial chest CT imaging revealed that 79.5% ground-glass opacities. Bilateral distribution (62.5%), peripheral and central distribution (45.5%), dorsal and ventral involvement (52.5%) were identified in all cases. CT features predominantly were at right and left lower lobes (69.5%, 62.5%; respectively). Cases with known ICU admission had statistically significant differences with inpatient ward admission cases in regards to CT features included mixed GGO and consolidation, bronchial wall thickening, pleural effusion, subpleural band, emphysema, coronary calcification, cardiothoracic ratio, aorta diameter.

Conclusions: Initial CT features may be helpful for foreseeing admission to ICU as in clinical features.

Keywords: COVID-19, CT, ICU, inpatient, features

Coronavirus 2019 disease (COVID-19) was officially named by the World Health Organization (WHO) on 11 February, 2020 after cases of pneumonia unknown etiology was identified in Wuhan, China in December 2019 [1, 2]. The novel coronavirus (2019-nCoV) was isolated by Chinese authorities on 7 January, 2020 [1]. On 11 March, 2020 WHO announced COVID-19 as a pandemia [3], on the other hand The Ministry of Health, Turkey reported first laboratory-confirmed novel coronavirus (2019-nCoV) case on 10 March, 2020 [4]. By May 31, 2020, a total of 163,942 confirmed cases, 2.77% case fatality rate, 648 critical or serious ICU follow-up cases have been reported in Turkey at daily official announcement [4,

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Address for correspondence: Erdem Özkan, MD., Ankara City Hospital, Department of Radiology, Ankara, Turkey. E-mail: erdemozkan5454@gmail.com, Tel (Mobil): +90 538 850 93 50

5].

Reverse transcription-polymerase chain reaction (RT-PCR) is the gold standart diagnostic method for COVID-19, however high false-negative results make managing difficulties in disease course. At this point, radiological methods such as chest x-ray and computed tomography (CT) play important role and are helpful for clinicians in both supporting diagnosis and monitoring the cases even if PCR is negative, but COVID-19 is highly clinically suspected [6, 7]. CT imaging findings of laboratory-confirmed COVID-19 cases in detail from many countries, mainly from China, were to be reported as small or large case sample series [8, 9].

Older adults and cases with concomitant diseases such as hypertension are at a significant risk of severe outcome related to COVID-19 disease [10, 11]. CT has not only pivotal role in the diagnosis, but also has significant role on management of temporal changes of the disease both clinically and radiologically [12]. In this point of view, we hypothesized if there was a difference between initial CT manifestations with known inpatient ward or intensive care unit (ICU) hospitalization history.

In this study, we aimed to evaluate and compare the initial CT, basic clinical and demographic features of laboratory-confirmed sample of 200 COVID-19 cases with known inpatient ward and ICU admission in Ankara City Hospital, Turkey.

METHODS

Turkish Ministry of Health approval was obtained on 21 May, 2020 and local ethics committee approval was received from Ankara City Hospital Ethical Committee, Turkey (approved number: E1/666/2020) on 28 May, 2020. Informed consent was waived due to the retrospective nature of this study.

Cases

A total of 1,800 cases with laboratory-confirmed COVID-19, 5500 highly clinically suspected cases who were admitted to Ankara City Hospital in Turkey from March 11, 2020 to May 31, 2020. As a sample 200 laboratory-confirmed COVID-19 cases were retrospectively and randomly collected who were hospitalized and followed up at infectious disease inpatient ward and ICU. The study included 103 males and 97 females with a median age of 45 years (range, 18-92). The basic demographic, clinical and radiological data including gender, age, exposure history, onset symptoms, underlying diseases, CT features were screened, interpreted and analyzed. The study sample had at least one positive results of RT-PCR with nasopharyngeal swab testing and chest CT examination in their electronic health records. Chest CT examinations and admissions were at the same day for study sample. Flow chart of the study was shown in Fig. 1.

Imaging Technique

The chest CT examinations were acquired by using 128-slice Revolution Evo CT (GE Healthcare) scanners in the supine position at full inspiration from lung apices to the inferior level of the costophrenic angle. The acquisition parameters were as follows: 100 or 120 kVp; 80-400 mAs; 1.375, pitch; 0.625 reconstruction interval; 0.5 seconds (sec) rotation time. Slice thickness was 1.25 mm. Automatic exposure control system (ASiR, GE, Healthcare) regulated the tube current. All chest CT examinations were obtained without intravenous contrast material.

Imaging Interpretation

The chest CT examinations were reviewed at the picture archiving and communication systems (PACS) by two radiologist blinded to the radiology report and clinic data at the same session by consensus. The conventional lung and mediastinal window settings were used by radiologists (window width: 1500 hounsfield unit (HU), window level: -600 to -700 HU; window width: 350-450 hounsfield unit (HU), window level: 40-50 HU, respectively). Multiplanar reconstruction (MPR) techniques were also used at the image interpretation sessions.

The chest CT features were interpreted in the view of presence of CT features, number of lung lobes involved, frequency of lung lobe involvement, lesion distribution by side (bilateral or unilateral), anterior-posterior localisation (ventral, dorsal or both), transverse localisation (central, peripheral or both) and scattering (focal, multifocal or diffuse), lesion characteristics and other findings. We evaluated lesion characteristics defined in previous studies and in accordance with glossary of Fleischner Society [13-16]. We measured main pulmonary artery and aorta di-

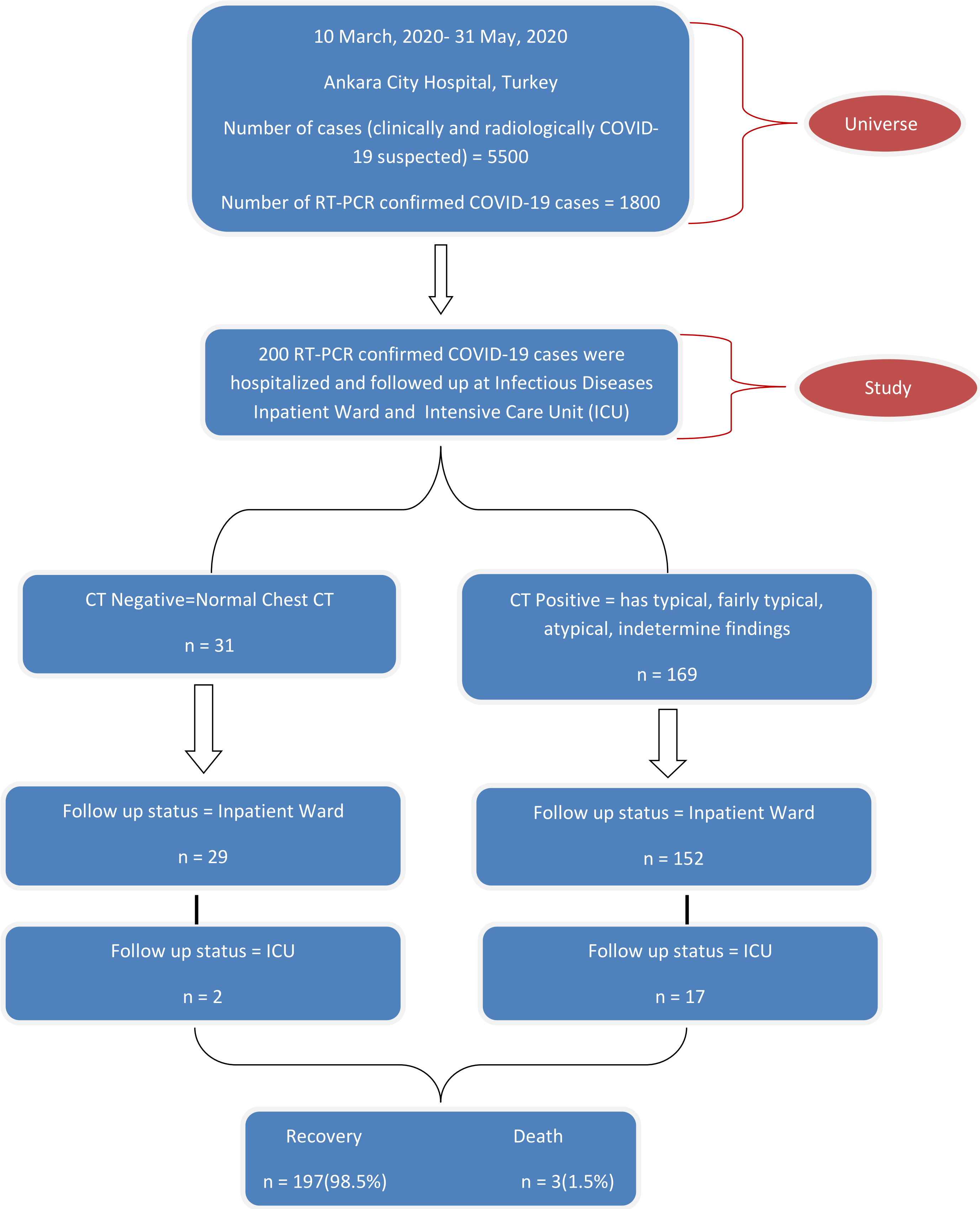

Fig. 1. **Flow chart of the study.**

Table 1. Basic demographic and clinical features

Features	All Cases (n = 200)
Sex	
Male	103 (51.5)
Female	97 (48.5)
Age (years)	
Median	45
Range	18-92
Age group (years)	
18-29	31 (15.5)
30-39	47 (23.5)
40-49	39 (19.5)
50-59	33 (16.5)
60-69	20 (10)
> 69	30 (15)
Exposure history	
Exposure	98 (49)
No exposure	102 (51)
Onset symptoms[a]	
Time since symptoms onset (day)	3 (0-10)
Cough	122 (61)
Fever	108 (54)
Dyspne	59 (29.5)
Myalgia	55 (27.5)
Malasie/Debility	57 (28.5)
Headache	33 (16.5)
Anosmia	20 (10)
Loss of taste	11 (5.5)
Diarrhea	9 (4.5)
Chest Pain	5 (2.5)
Back pain	2 (1)
No symptoms	39 (19.5)
Underlying disease[b]	
Hypertension	45 (22.5)
Coronary artery disease	36 (18)
Diabetes	25 (12.5)
Chronic obstructive pulmonary disease	15 (7.5)
Others (Asthma,CKD[c], PAD[d], Alzeimer)	5 (2.5)
None	142 (71)

Note-Except for age and time since symptoms onset (median with minimum-maximum range) data are numbers with percentage in parentheses.
[a,b]Some cases had more than one symptoms and underlying disease.
[c,d]Chronic kidney disease, peripheral artery disease

ameters at the level of the bifurcation of the main pulmonary artery in the transverse plan. Cardiothoracic ratio assessed as maximum diameter of heart divided by maximum thoracic diameter in the axial CT images of chest. Coronary calcifications, scoliosis and kyphosis were interpreted via MPR images as present or absent.

Statistical Analysis

Categorical and nominal datas were presented as numbers and percentages, numeric datas as medians with minimum-maximum range. Comparison of categoric and nominal datas was evaluated by chi-square or Fisher exact test, on the other hand numeric datas by Mann Whitney U test between inpatient ward and ICU admission cases. *P* value < 0.05 was accepted as statistically significant. SPPS for Windows software package (version 21.0, SPSS Inc.) was used for statistical analysis.

RESULTS

Demographic and Clinical Features

A total of 200 cases were included in this study. Our group of cases consisted of 103 (51.5%) males, 97 (49.5%) females, with an age range of 18-92 (median age, 45 years). 41.5% of total cases were older than 50 years. The time between onset of symptoms and hospital presentation ranged from 0 to 10 days (median, 3 days). 49% (n = 98) of total cases had an exposure history to patients with laboratory confirmed COVID-19. Common onset symptoms were cough (61%) and fewer (54%). Thirty-nine cases had no symptoms. The basic demographic and clinical features are given in Table 1.

Initial CT Features

Thirty-one cases (15.5%) had normal CT without any findings. Five lobes involvement were identified 38.5% (n = 77) of total cases. Right and left lower lobes were more likely to be involved (69.5% versus 62.5%). Lesion distribution characteristics in lung parenchyma are given in Table 2. Typical features such as ground-glass opacities (GGOs) (79.5%), round-shaped lesions (44%) and vascular enlargement (38%) were presented on the CT images in most of the cases (Figs. 2 and 3). Reversed halo sign and crazy-paving

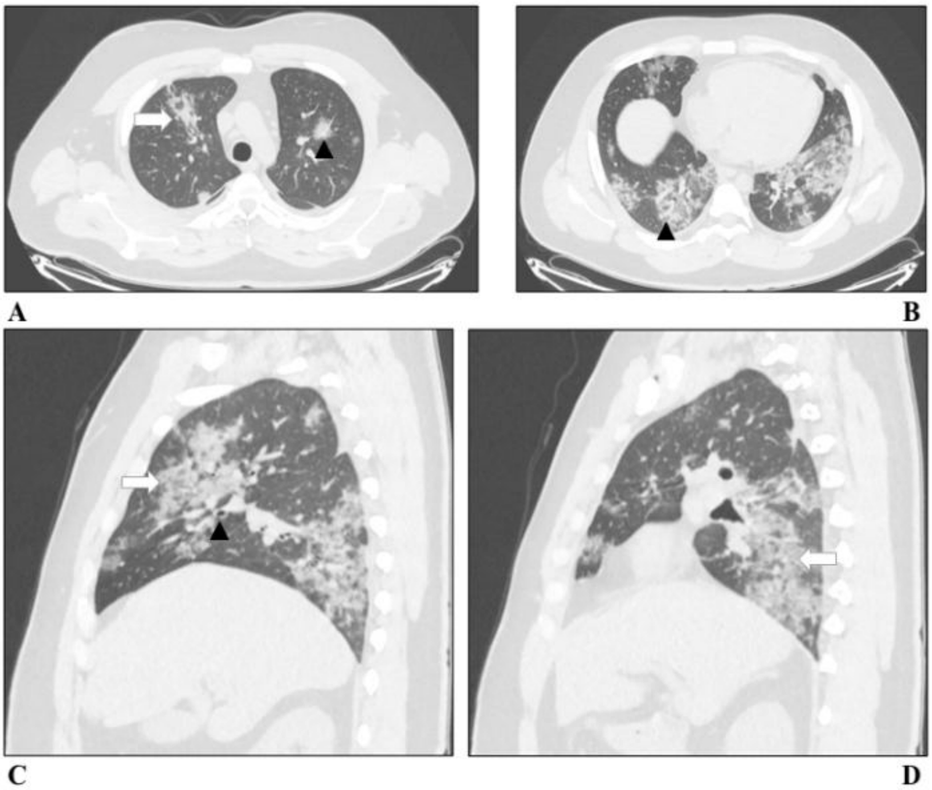

Fig. 2. **(A-D) A 55-year-old man with coronavirus disease (COVID-19). Patient had onset symptoms of fever, cough and dyspnea. CT was performed on day of admission. CT images show bilateral multifocal ground-glass opacities (GGOs) and GGOs with superimposed consolidations (white arrows: A, C and D). Vascular enlargements and bronchial wall thickenings (black arrowheads: A, B, C) are also present.**

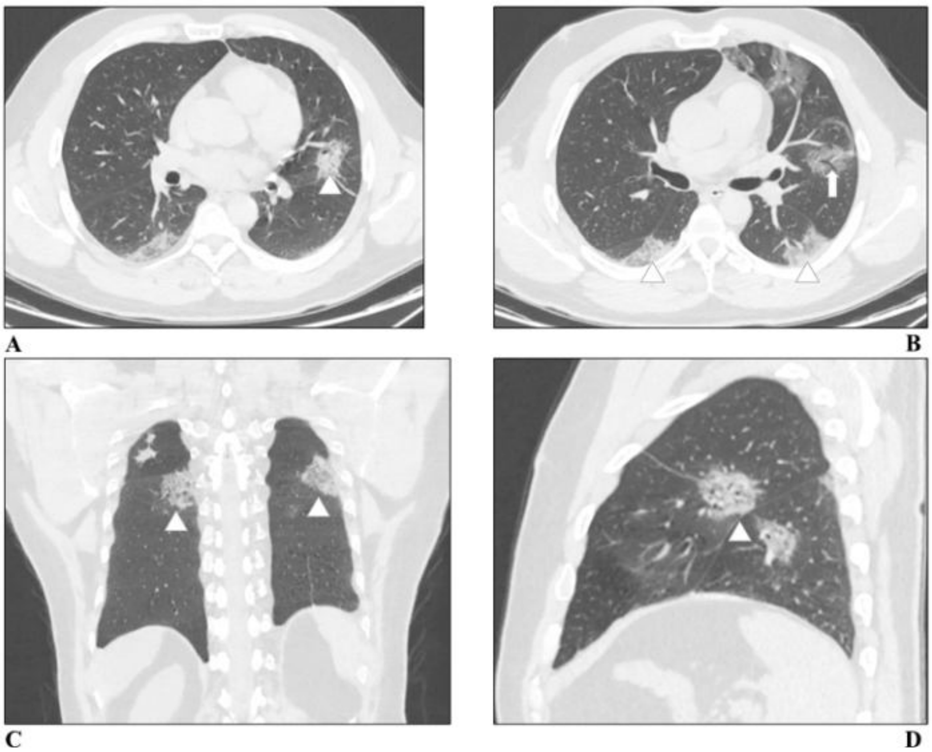

Fig. 3. **(A-D) A 45-year-old man with cough. Axial (A and B), coronal (C) and sagittal (D) CT images show bilateral multiple ground-glass opacities (GGOs) and consolidations with thickened intralobular and interlobular septum (white arrowheads: A, C and D). Air bronchogram sign is also present (white arrow: B).**

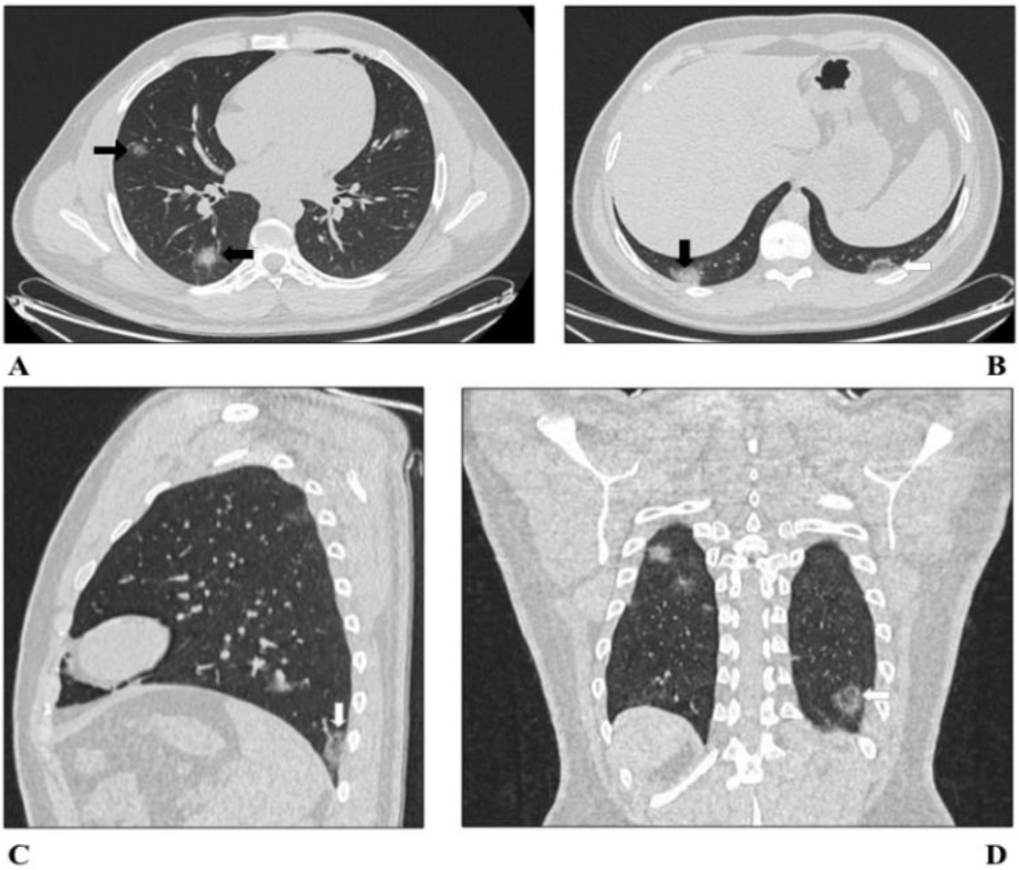

Fig. 4. **(A-D) A 38-year-old man with laboratory confirmed coronavirus disease (COVID-19). Patient presented with fever and cough for two days. CT was performed on day of admission. Axial CT images show peripheral round-shaped ground-glass opacities(GGOs) (black arrows: A and B). Reverse halo sign is also present in axial, sagittal and coronal images (white arrows: B, C and D).**

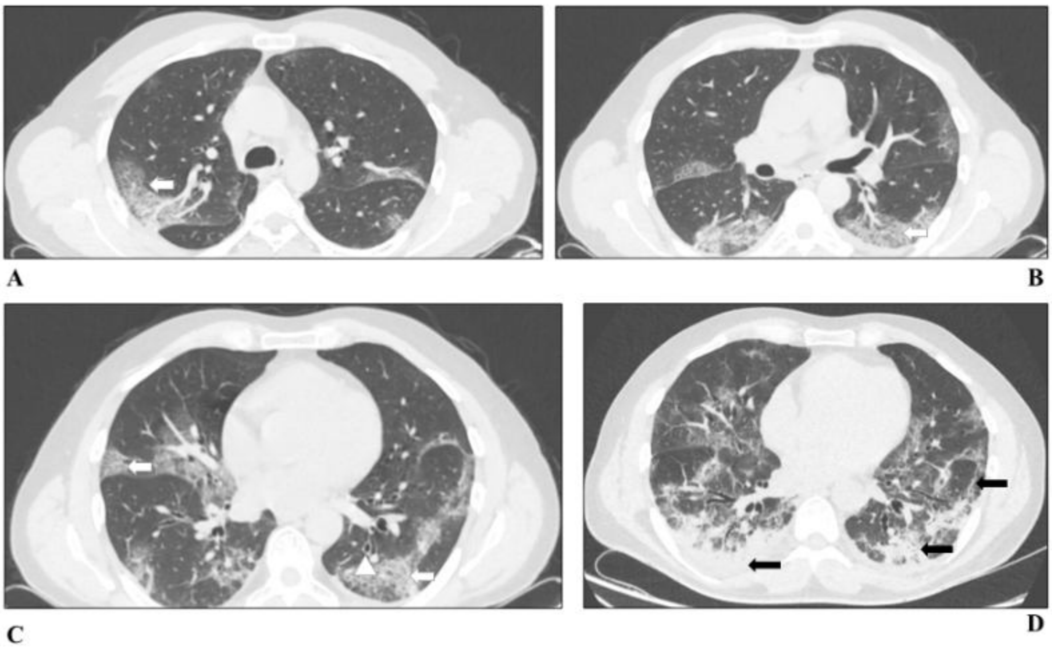

Fig. 5. **(A-D) A 60-year-old man with dry cough, dyspnea and fatigue. CT was performed on day of admission (A, B and C) and 10 days later (D). Axial CT scans show interlobular septal thickening in a crazy paving pattern (white arrows: A, B and C) and bronchial wall thickening (white arrowhead: C), while consolidations and subpleural curvilinear bands occur10 days later (black arrows: D).**

Table 2. Other chest CT features and measurements

Findings	All Cases (n = 200)	Cases followed-up inpatient ward (n = 181)	Cases with ICU admission (n = 19)	*p value*
Age (years)	45 (18-92)	43 (18-92)	72 (36-92)	**< 0.001**
Sex				0.705
Male	103 (51.5)	94 (51.9)	9 (47.4)	
Female	97 (48.5)	87 (48.1)	10 (52.6)	
Underlying disease	58 (29)	39 (21.5)	19 (100)	**< 0.001**
Without CT findings (%)	31 (15.5)	29 (16)	2 (10.5)	0.744
Time since symptoms onset (day)	3 (0-10)	3 (0-10)	0 (0-8)	**0.006**
Imaging Findings				
Number of lobes involved				0.520
1	38 (19)	33 (18.2)	5 (26.3)	
2	21 (10.5)	18 (9.9)	2 (10.5)	
3	12 (6)	12 (6.6)	1 (5.3)	
4	21 (10.5)	19 (10.5)	2 (10.5)	
5	77 (38.5)	70 (38.7)	7 (36.8)	
Frequency of lobe involvement				
Right upper lobe	108 (54)	99 (54.7)	9 (47.3)	0.542
Left upper lobe	107 (53.5)	99 (54.7)	8 (42.1)	0.295
Middle lobe	104 (52)	95 (52.5)	9 (47.3)	0.671
Right lower lobe	139 (69.5)	127 (70.2)	12 (63.1)	0.528
Left lower lobe	125 (62.5)	113 (62.4)	12 (63.1)	0.950
Lung region distribution				0.564
Bilateral	125 (62.5)	111 (61.3)	14 (73.7)	
Unilateral	44 (22)	41 (22.7)	3 (15.8)	
Transverse distribution				0.483
Central	4 (2)	3 (1.7)	1 (5.3)	
Peripheral	74 (37)	67 (37.0)	7 (36.8)	
Peripheral and central	91 (45.5)	82 (45.3)	9 (47.4)	
Anterior-posterior distribution				0.618
Ventral	12 (6)	11 (6.1)	1 (5.3)	
Dorsal	52 (26)	45 (24.9)	7 (36.8)	
Ventral and dorsal	105 (52.5)	96 (53.0)	9 (47.4)	
Scattered distribution				**0.019**
Focal	38 (19)	32 (17.7)	4 (21.1)	
Multifocal	115 (57.5)	108 (59.7)	9 (47.4)	
Diffuse	16 (8)	12 (6.6)	4 (21.1)	
Round-shaped lesions	88 (44)	82 (45.3)	6 (31.6)	0.144
Ground-glass opacities	159 (79.5)	146 (80.7)	13 (68.4)	**0.010**
Consolidation	60 (30)	52 (28.7)	8 (42.1)	0.294
Mixed ground-glass opacities and consolidation	57 (28.5)	49 (27.1)	8 (42.1)	**< 0.001**
Reticulation	59 (29.5)	52 (28.7)	7 (36.8)	0.568
Centrilobular nodules	17 (8.5)	14 (7.7)	3 (15.7)	0.385
Crazy-paving pattern	43 (21.5)	39 (21.5)	4 (21.1)	0.848
Air bronchogram sign	27 (13.5)	24 (13.3)	3 (15.7)	0.738
Bronchiectasis	15 (7.5)	12 (6.6)	3 (15.7)	0.179
Bronchial wall thickening	17 (8.5)	11 (6.1)	6 (31.6)	**0.003**
Reversed halo sign	15 (7.5)	15 (8.3)	0 (0)	0.368
Halo sign	26 (13)	26 (14.4)	0 (0)	0.078
Subpleural bands	17 (8.5)	11 (6.1)	6 (31.6)	**0.003**
Vascular enlargement	76 (38)	68 (37.6)	8 (42.1)	0.697
Pleural effusion	5 (2.5)	0 (0)	5 (26.3)	**< 0.001**
Pleural thickening	7 (3.5)	5 (2.8)	2 (10.5)	0.148
Mediastinal lymphadenopathy	40 (20)	32 (17.7)	7 (36.8)	0.073
Pericardial effusion	11 (5.5)	8 (4.4)	3 (15.7)	0.084
Cavitation	0 (0)	0 (0)	0 (0)	
Pneumothorax	0 (0)	0 (0)	0 (0)	
Empyhsema	33 (16.5)	26 (14.4)	7 (36.8)	**0.021**
Coronary calcification	55 (27.5)	44 (24.3)	11 (57.9)	**0.002**
Scoliosis	47 (23.5)	37 (20.4)	10 (52.6)	**0.004**
Kyphosis	57 (28.5)	43 (23.8)	14 (73.7)	**< 0.001**
Main pulmonary artery diameter (mm)	26.5 (18-43)	26 (18-43)	28 (20-34)	0.352
Aorta diameter (mm)	31 (21-45)	31 (21-43)	34 (25-45)	**0.006**
Cardiothoracic ratio	0.45 (0.23-0.66)	0.45 (0.23-0.66)	0.52 (0.43-0.63)	**< 0.001**

Note-Except for age, main pulmonary artery, ascending aorta diameter and cardiothoracic ratio (median with minimum-maximum range) data are numbers with percentage in parentheses.

patern were identified 7.5% (n = 15) and 21.5% (n = 43) of total cases, respectively (Figs. 4 and 5). Other chest CT features and measurements are demonstrated in Table 2.

Comparison of Basic Demographic-Clinical and Initial CT Features with Known Inpatient Ward and ICU Admission Cases

Cases with known ICU admission were older than known inpatient ward admission ($p < 0.001$). All of the cases known ICU admission had comorbid diseases. There were statistically significant difference the time between onset of symptoms and hospital presentation ($p = 0.006$). Regarding to lobe number and frequency of lobe involvement, no significant difference were found between two groups. The anterior-posterior, transverse, lung side distributions had no significant difference, on the other hand in regards to scattered distribution diffuse patern was higher frequency (21.1%) in known ICU admission cases. GGOs' were commonly presented in known inpatient ward admission cases ($P = 0.01$), however mixed GGO and consolidations were identified in known ICU admission cases ($p < 0.001$). Other statistically significant and non-significant features and measurements are shown in Table 2.

DISCUSSION

The purpose of this study was to analyzed initial CT features of patient with known hospitalization in ICU and inpatient ward. An outstanding feature of this study is not only comprehensively evaluated initial CT features but also assessed differences in CT findings between known ICU and inpatient ward admission.

Meta-analyses and systematic reviews revealed that gender and age range varied between different sample sizes, countries [14, 17]. In our study cohort, cases were predominantly male and median age was 45. Most of the cases were under the age of 60 could be related to the statement of curfew restriction for people over the age 65. In their review and meta-analysis of 1115 patients, Won *et al*. [18] showed that fever and cough were the main clinical characteristics. We found that the similar clinical characteristics, on the other hand anosmia, loss of taste, diarrhea, chest pain and back pain were less frequently seen. 19.5% of our cases with no symptoms were recurited from filiation method.

In the current study, bilateral, multifocal, periferal and dorsal dominant, five lobes involvement with a lower lobe predominance especially right was the most common lesion localizations. GGOs, round-shaped lesions, vascular enlargement were the main CT features. These findings are in agreement with previous systematic reviews and meta-analyses [14, 16-18]. The typical findings suggesting that progression including consolidation, mixed GGOs and consolidation, crazy-paving patern, reversed halo sign were found less frequently. On the other hand, of our cases, %15.5 had normal CT in their initial imaging. These results may be related to accession of cases to healthcare in the early period and filiation method. In our cases, median day for hospital presentation after the symptoms were started, was 3. The atypical and fairly typical findings, such as bronciectasis, air-brochogram sign, bronchial wall thickening, halo sign, subpleural bands, pleural thickening, pleural effusion, pericardial effusion, centrilobular nodules and lymphadenopathy were also seen but less commonly compatible with previous literature [19]. Cavitation and pneumothorax cases with COVID-19 were rarely reported in literature [20, 21]. These two rare findings were not seen in our cases.

In their study, Meng *et al*. [22] reported that main CT feature was GGOs in asymptomatic cases with COVID-19. Our results suggested that same initial CT findings especially cases known inpatient wards admission. However, CT features of diffuse distribution, mixed GGOs and consolidation were statistically significant initial CT finding in known ICU admission cases than known inpatient wards admission. Pure consolidation was higher at initial CTs with known ICU cases, but it was not statistically significant than with known inpatient ward admission. Subpleural bands or lines which may be associated to pulmonary edema or fibrosis and bronchial wall thickening which usually related to inflammation of airways [23], we found these findings higher in their initial CTs with known ICU admission cases. Pleural effusion indicating severity were observed higher in cases with known ICU admission. Other findings, such as pericardial effusion and mediastinal lymphadenopathy suggesting severity [24] showed higher frequencies in their initial CTs with known ICU admission cases, but it was not statistically significant.

Older age and comorbidities are major risk factors leading to poor prognosis for patients with COVID-19 [25, 26]. In accordance with these factors, in our cohort known ICU admission cases had older median age and underlying diseases which were statistically significant than with known inpatient ward admission. These cases showed early hospital presentation. Moreover, these group of cases had significant findings in regard to CT features such as emphysema, coronary calcifications, scoliosis, kyposis, aorta diameter and cardiothoracic ratio which were also related to age and underlying diseases. We should give attention these findings at image interperations.

Limitations

Our study has some limitations. Firstly, we did not evaluate laboratory findings. Secondly, we only interpreted the initial CTs, not follow-up CTs. Liu *et al*. [27] revealed that CT quantification of lesion might early predict the progression and severity. Our study was based on predominantly qualitative CT features. Therefore lastly, visual assessments might cause under- or over-estimation some of CT features.

CONCLUSION

Initial chest CT imaging features may give an idea whether patients may need intensive care admission in the COVID-19 course like demographic features such as elderly or clinical features such as having hypertension history.

Authors' Contribution

Study Conception: ÖÜ, UK, EÖ, İH, AAS, HRG; Study Design: ÖÜ, UK, EÖ, İH, AAS, HRG; Supervision: ÖÜ, UK, EÖ, İH, AAS, HRG; Funding: N/A; Materials: ÖÜ, UK, EÖ, İH; Data Collection and/or Processing: ÖÜ, UK, EÖ, İH; Statistical Analysis and/or Data Interpretation: ÖÜ, UK, EÖ, HRG; Literature Review: ÖÜ, UK, HRG; Manuscript Preparation: ÖÜ, UK, EÖ, İH, AAS and Critical Review: İH, AAS, HRG.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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