Research Article (Araştırma Makalesi)

Initial Screening Chest Computed Tomography Findings of Patients Who Were Admitted to Fırat University Hospital with Pre-diagnosis of Coronavirus Disease 2019 (COVID-19)

Fırat Üniversitesi Hastanesine Başvuran Koronavirüs Hastalığı-2019 (Covid-19) Ön Tanılı Hastaların İlk Bakı Toraks Bilgisayarlı Tomografi Bulguları

Serpil AGLAMIS[1], Yesim EROGLU[1]

[1] Firat University, Faculty of Medicine, Department of Radiology, Elazig, Turkey

Özet

Amaç: COVID-19 ön tanısı ile toraks bilgisayarlı tomografi (BT) incelemesi yapılan hastaların ilk bakıdaki radyolojik bulgularını değerlendirmektir.

Gereç ve Yöntemler: COVID-19 ön tanılı 90 hastanın ilk bakı toraks BT incelemesinin görüntüleme verileri retrospektif analiz için toplandı. Hastaların demografik özellikleri, semptomları ve ek hastalıkları kaydedildi. İlk bakı toraks BT incelemesinin görüntüleme bulguları ve takip BT görüntülemesi yapılan hastaların takip BT bulguları analiz edildi.

Bulgular: COVID-19 ön tanılı hastaların ilk toraks BT bulgularında buzlu cam dansiteleri (%59), konsolidasyon (%34), kaldırım taşı manzarası (%5), hava bronkogramı (%18), vasküler genişleme (%6), bronşektazi-bronş duvar kalınlaşması (%7), air bubble (%7), subplevral çizgi (%10), plevral kalınlaşma-plevral sıvı (%8), halo işareti (%5), düzensiz kenarlı nodül (%9) ve ters halo işareti (%4) mevcuttu. Takip BT görüntülerinde dikkat çeken bulgular progresyon evresinde yeni konsolidasyon alanlarının ortaya çıkması, buzlu cam dansitelerinin konsolidasyona dönüşmesi, bilateral plevral effüzyon, traksiyon bronşektazileri ve hiler lenfadenopati gelişmesiydi. Regresyona uğrayan olgularda ise ilk BT görüntülemesinde izlediğimiz konsolidasyonun buzlu cam dansitelerine dönüştüğü görüldü.

Sonuç: COVID-19 ön tanılı hastaların ilk bakı toraks BT görüntülemelerinde en sık izlenen bulgu buzlu cam dansiteleriydi. Progresyon evresinde, ilk bakıda izlenen buzlu cam dansiteleri veya konsolidasyon alanlarında artış, bilateral plevral effüzyon, traksiyon bronşektazileri ve hiler lenfadenopatiler izlendi.

Anahtar kelimeler: Buzlu cam dansiteleri, COVID-19, Konsolidasyon, Toraks bilgisayarlı tomografisi

Abstract

Objective: To evaluate radiological findings on initial screening of the patients who had chest computed tomography (CT) with the pre-diagnosis of coronavirus disease-2019 (COVID-19).

Material and Methods: Chest CT images of 90 patients with a pre-diagnosis of COVID-19 were retrospectively analyzed. Demographic characteristics, symptoms, and comorbid conditions of the patients were recorded. The chest CT findings on initial screening and follow-up were analyzed.

Results: The chest CT findings on the initial screening of the patients with a pre-diagnosis of COVID-19 included ground-glass opacities (GGOs) (59%), consolidation (34%), crazy-paving pattern (5%), air bronchogram (18%), vascular dilation (6%), bronchiectasis-bronchial wall thickening (7%), air bubble (7%), subpleural line (10%), halo sign (5%), nodule with irregular borders (9%) and reverse halo sign (%4). The predominant findings in the follow-up CT images included newly developing consolidations in the progression stage, GGOs converting to consolidations, bilateral pleural effusion, traction bronchiectasis, and hilar lymphadenopathy. In the regressed cases, it was observed that the consolidation we observed in the first CT imaging turned into GGOs.

Conclusion: Ground-glass opacities were the most common finding in initial screening thorax CT scans of patients with pre-diagnosis of COVID-19. An increase in the ground-glass densities or consolidation areas identified upon initial examination, bilateral pleural effusion, traction bronchiectasis, and hilar lymphadenopathies were observed in the progression stage

Keywords: Chest computed tomography, Consolidation, COVID-19, Ground-glass opacities

Yazışma Adresi: Serpil AĞLAMIŞ, Fırat Üniversitesi Tıp Fakültesi Radyoloji Ana bilim Dalı, 23100, Elazığ, Türkiye
Telefon: +905305017468
Email: drserpil23@yahoo.com.tr
ORCID No (Sırasıyla): 0000-0002-1857-4606, 0000-0003-3636-4810
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INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a contagious and potentially fatal disease caused by a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (1). The disease is primarily characterized by pulmonary inflammation (2,3). Clinical manifestations vary from asymptomatic cases to life-threatening conditions. The main clinical findings include fever, fatigue, and cough; additionally, dyspnea may develop approximately one week after these symptoms. Critical cases may progress to respiratory distress syndrome, septic shock, and even death (4).

A definite diagnosis is based on a real-time reverse transcription-polymerase chain reaction (RT-PCR) test of oro-pharyngeal and nasopharyngeal swabs, broncho-alveolar lavage, or tracheal aspirate (5). Chest computed tomography (CT) is the most valuable imaging method that plays a role in early diagnosis, early quarantine, and the follow-up of treatment. Computed tomography is a superior imaging method for revealing pneumonia findings radiologically. The most common radiological findings in COVID-19 include bilateral, multi-lobar, and peripheral ground-glass opacities (GGOs) mainly in medial and inferior zones, consolidations, and crazy-paving patterns (6). The chest CT findings may vary depending on the stage and the severity of the disease (7-9).

The primary method for controlling COVID-19 is early diagnosis, rapid isolation, and early treatment. A real-time reverse transcription protein chain reaction (RT-PCR) is the standard method for the detection of the nucleic acid of the virus. However, the test may initially yield negative results or false-negative results. A 4-8 day interval may be seen between the initial negative test and the positive PCR (9,10). Abnormal or specific findings on the initial chest CT were suggested to be of the utmost importance in early diagnosis (11). The aim of the present study is to evaluate the radiological findings on the initial screening in patients who were subject to a chest CT with pre-diagnosis of COVID-19.

MATERIALS AND METHODS

This retrospective study was approved by the Fırat University Ethics Committee (2020/07-08). Throughout the research, the Helsinki Declaration was adhered to. Patients with previous lung surgery or recent biopsy, patients with primary or metastatic thoracic malignancy, and patients with a history of trauma were excluded from the study. A total of 90 patients who were subject to chest CT imaging at our hospital were included in the study. The demographic characteristics, symptoms, and co-morbid conditions of the patients were recorded.

The computed tomography analyses were done by using a 64 channel multi-detector CT scanner (Philips, İncisive CT). All the images were obtained when the patient was in a supine position by using 70-120 kVp tube voltage, 60-120 mAs tube current, 0.8 mm section thickness parameters, and without injecting the contrast medium.

Image Analysis

All the CT images were evaluated at the work stations in our department by two radiologists with 8 (YE) and 12 (SA) years of experience respectively. The images were evaluated with regard to the presence of ground-glass opacities and consolidation, and the distribution of these findings (bilateral, unilateral, anterior, posterior location, peripheral and/or central involvement), which involved the lobes of the lung (superior, medial, inferior lobes) were recorded. The crazy-paving pattern, air bronchogram, vascular dilation, bronchial changes, air bubble, sub-pleural line, pleural thickening, pleural effusion, halo sign, reverse halo sign, nodules, lymphadenopathy (LAP), pericardial effusion, fibrosis, and other radiological findings were also recorded. The radiological changes detected in the 7 patients who were subject to a control CT were evaluated.

Statistical Analysis

Data were expressed as counts (n) and percentages (%). Statistical analysis was performed with the SPSS (Statistical Package for the Social Sciences) software (version 25, IBM).

RESULTS

A total of 90 patients who were hospitalized due to COVID-19 were included in the study. Of these patients, 52 (58%) were male and 38 (42%) were female, and the mean age was 52±10 years (range 19-87). A fever (45/90, 50%) and cough (55/90, 61%) were the most common symptoms followed by dyspnea (31/90, 34%), myalgia or fatigue (11/90, 12%), a mild headache (4/90, 5%) and diarrhea (4/90, 5%), abdominal pain (4/90, 5%) and sore throat (4/90, 5%). Of 90 patients, 21 (23%) had diabetes, hypertension, chronic liver disease, chronic obstructive pulmonary disease, and heart disease. The demographic and clinical characteristics of the patients are presented in **Table 1**.

Table 1. Demographic and clinical characteristics of the patients		
Characteristics	**n**	**%**
Gender		
Female	38	42
Male	52	58
Age		
Range	18-89	
Mean	52	
Symptoms		
Fever	45	50
Cough	55	61
Dyspnea	31	34
Myalgia/Fatigue	11	12
Headache	4	5
Sore throat	4	5
Abdominal pain	4	5
Diarrhea	4	5

The chest CT findings on the initial screening of the patients with a pre-diagnosis of COVID-19 included GGO (53/90, 59%), consolidation (31/90, 34%), crazy-paving pattern (4/90, 5%), air bronchogram (16/90, 18%), vascular dilation (5/90, 6%), bronchiectasis-bronchial wall thickening (6/90, 7%), air bubble (6/90, 7%), subpleural line (9/90, 10%), halo sign (4/90, 5%), nodule with irregular borders (8/90, 9%) and reverse halo sign (3/90, 4%) (**Figures 1-6**). Initial CT findings of 90 patients are presented in **Table 2**.

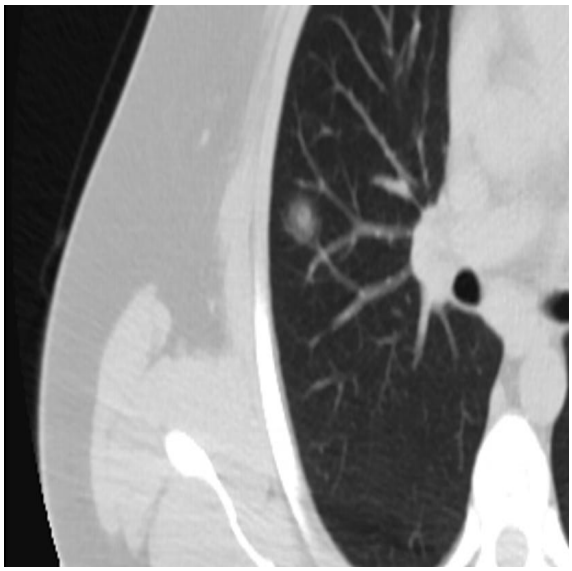

Figure 1. Halo sign was observed in the opacity located in superior lobe of the right lung in a 38-year old patient

Table 2. Initial CT findings of 90 patients		
CT finding	**n**	**%**
Ground-glass opacity	53	59
Consolidation	31	34
Crazy-paving pattern	4	5
Air bronchogram	16	18
Vascular dilation	5	6
Bronchiectasis-bronchial wall thickening	6	7
Air bubble	6	7
Subpleural line	9	10
Halo sign	4	5
Nodule with irregular borders	8	9
Reverse halo sign	3	4

While GGO was observed in 52% out of 46 patients under 50 years, it was observed in 66% of 44 patients above 50 years of age. Of the GGOs, 17 were unilateral and 36 were bilateral. They were located in the inferior lobe in 46, the medial lobe in 27 and the superior lobe in 30; the peripheral in 41, the central in 23; the anterior in 32 and the posterior in 39; 13 were focal and 40 were multi-focal (**Table 3**). According to these results, the GGO's were located in the peripheral posterior and inferior lobes, and the multifocal was more suggestive. Consolidation was observed in 41% of the patients under 50 years and 27% of the patients over 50 years. Of them, 24 were in the inferior lobe, 7 in the medial lobe and 12 in the superior lobe; 23 were peripheral, 16 were central; 13 were in the anterior, 22 were in the posterior; 15 were focal, and 16 were multifocal (**Table 3**). According to these results, the consolidations located in the inferior lobe were more suggestive.

Table 3. Anatomic location of ground-glass opacity and consolidation findings in the initial CT				
	Ground-glass opacity	**%**	**Consolidation**	**%**
Bilateral	36	68	14	45
Unilateral	17	32	17	55
Inferior lobe	46	45	24	56
Medial lobe	27	26	7	16
Superior lobe	30	29	12	28
Peripheral	41	64	23	59
Central	23	36	16	41
Anterior	32	45	13	37
Posterior	39	55	22	63
Focal	13	25	15	48
Multifocal	40	75	16	52

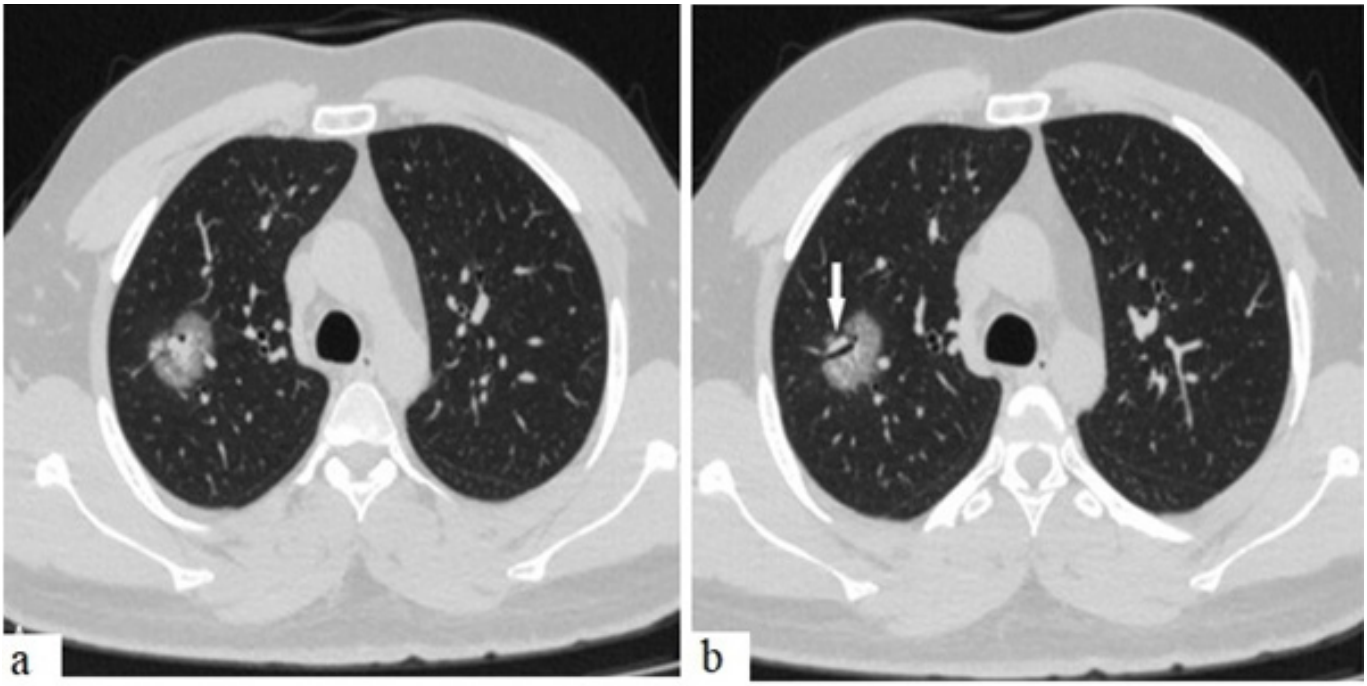

Figure 2. A 30-year-old male patient was admitted with fever. a. Focal GGO with halo sign-consolidation was observed in superior lobe of the right lung. b. Vascular dilation and bronchiectasis were observed in this field.

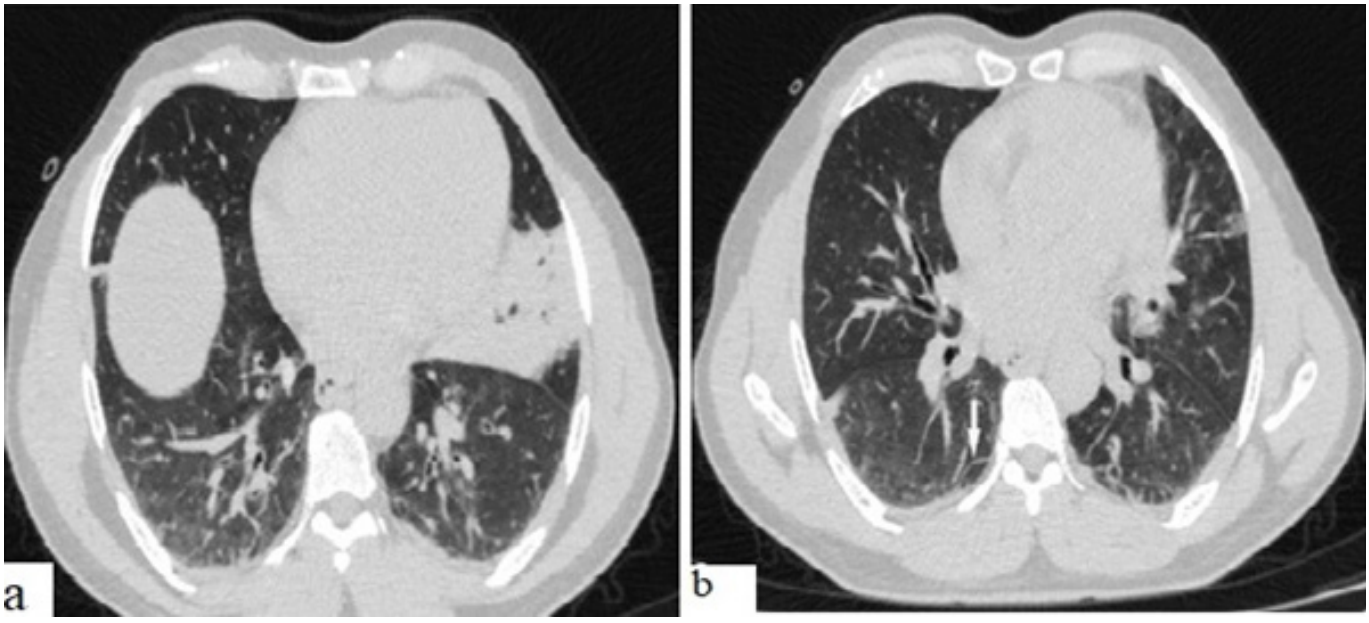

Figure 3. A 44-year-old patient was admitted with fever and fatigue. **a.** Consolidation with air bronchogram was detected in lingular segment of the left lung. **b.** Subpleural line (arrow) was present in inferior lobe of the right lung.

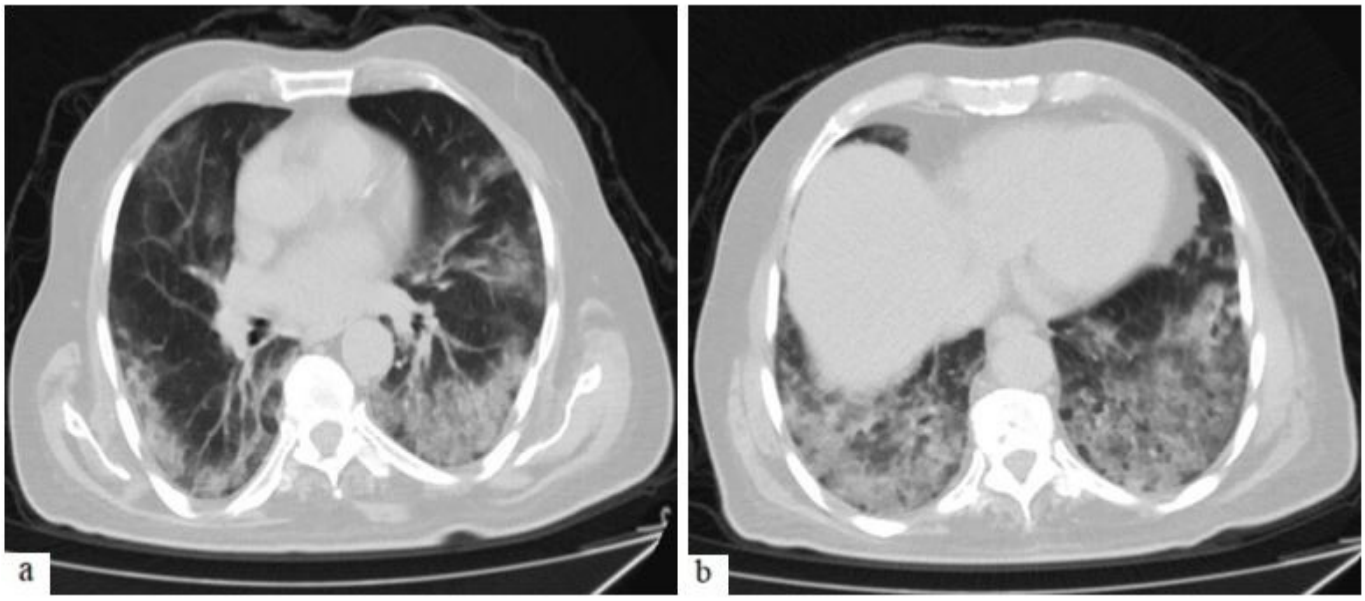

Figure 4. A 76-year-old patient was admitted with cough. **a.** Multi-lobar GGOs in bilateral lungs, predominantly in inferior lobes and periphery. **b.** Millimetric cystic images consistent with air bubble were observed in inferior lobes of the left lung.

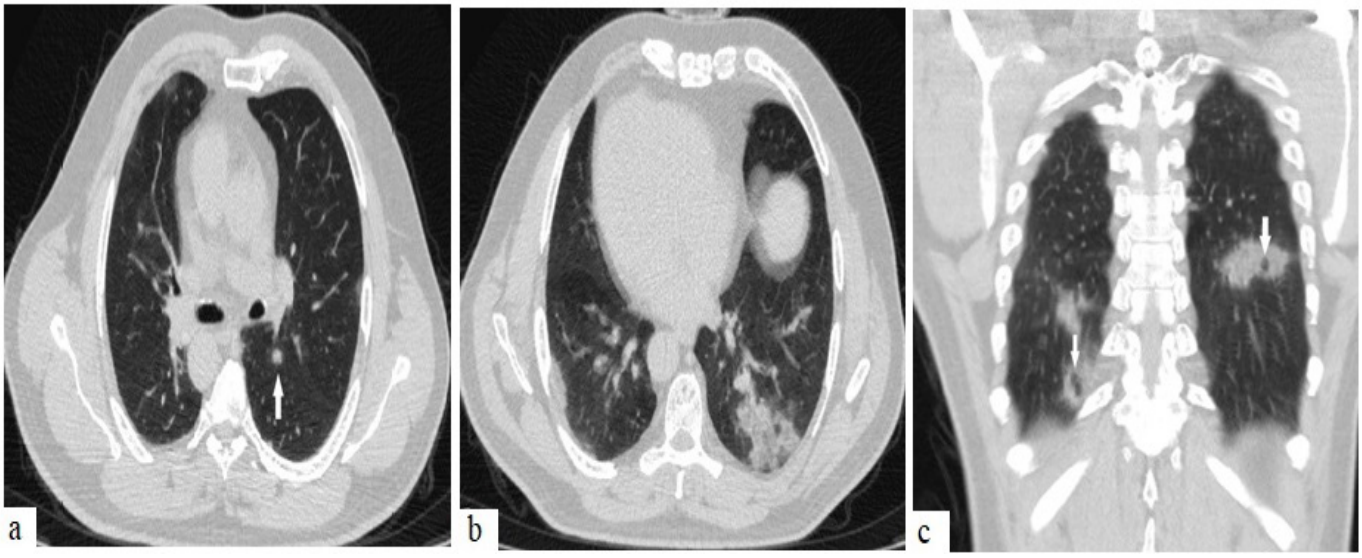

Figure 5. A 48-year-old patient was admitted with headache and fatigue. **a.** Nodular opacity with mildly irregular borders (arrow) was observed in inferior lobe of the left lung. **b, c.** Air bubbles (arrows) were observed within consolidation fields in bilateral lungs.

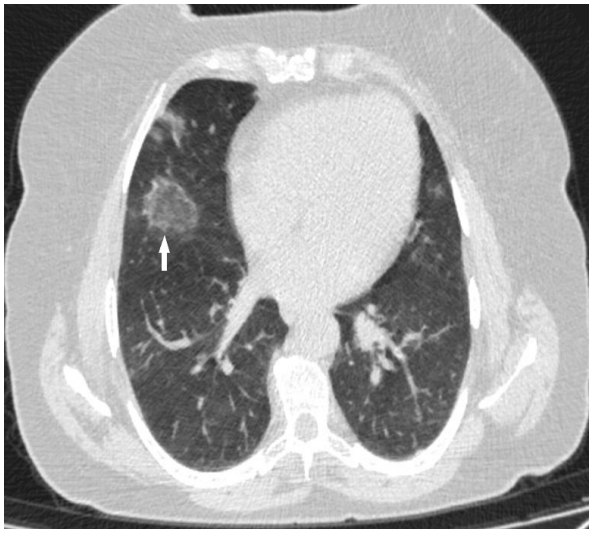

Figure 6. Reverse halo sign (arrow) was observed in medial lobe of the right lung in a 60-year-old female patient who was admitted with cough and dyspnea.

The follow-up CT was performed on day 7 and thereafter in 7 patients who were hospitalized with a pre-diagnosis of COVID-19. The initial and follow-up CT findings are listed in **Table 4**.

Progression was detected in 4 out of 7 patients (57%) (**Figures 7-10**).

The findings suggestive for progression included the conversion of the GGO to consolidation, an increase in the intensity of consolidation, pleural effusion, and hilar LAP. The regression findings included the conversion of the consolidation to GGO and the complete disappearance of the initial GGO and consolidation fields. Follow-up imaging was available for only one of the patients with chronic disease. Progression was observed in the patient diagnosed with hypertension and diabetes (patient 1), the imaging findings of whom are presented in **Table 4**.

DISCUSSION

Real-time RT-PCR is the standard method for the detection of the nucleic acid of SARS-CoV-2. However, the test may initially yield negative or false negative results. The time of the sample collection, the insufficiency of material in the sample and the quality of the kit can lead to erroneous results in RT-PCR tests. Studies have reported false negatives in the initial RT-PCR results of patients with COVID-19 infection (12-14). These false-negative findings cannot be ignored in symptomatic persons with suspected COVID-19 infection. CT has played an important role in the diagnosis and treatment of COVID-19 patients (15,16).The computed tomography findings were proven to be diagnostic in many cases with false-negative RT-PCR results. The early diagnosis of COVID-19 that led to a pandemic is of importance for enabling isolation and controlling the spread of the disease. Therefore, it is essential to comprehensively understand the typical and atypical radiological features of COVID-19 and radiological findings according to the stages of the disease (13,14). Chest CT findings may vary depending on the stage and severity of the disease (17).

Table 4. Initial and follow-up CT findings of 7 patients

Patient	Initial CT findings	CT findings on days ≥7
Patient 1	Peripheral GGOs predominantly in bilateral inferior lobes of the lung, interlobular septal thickening	7th day: Progression of GGOs in inferior lobe of the left lung to focal consolidation, traction bronchiectasis, bilateral pleural effusion
Patient 2	Bulla and bleb, calcific nodule	12th day: Bulla and bleb, calcific nodule
Patient 3	GGOs and consolidations predominantly peripheral and bilateral	7th day: Increase in GGOs and newly developing GGOs and consolidations
Patient 4	Normal CT findings	7th day: Bilateral peripheral patchy GGOs and focal consolidations in a few fields
Patient 5	Multiple focal GGOs and consolidations in bilateral lungs	13th day: Complete regression of the radiological findings
Patient 6	Patchy GGOs and consolidations predominantly in bilateral lungs and inferior lobes	12th day: Right hilar LAP, progression of GGOs to consolidation and newly developing consolidation fields
Patient 7	Peripheral GGOs and consolidations predominantly in bilateral lungs	12th day: Regression of consolidation fields to GGOs

GGO: Ground-Glass Opacity, CT: Computed Tomography, LAP: Lymphadenopathy

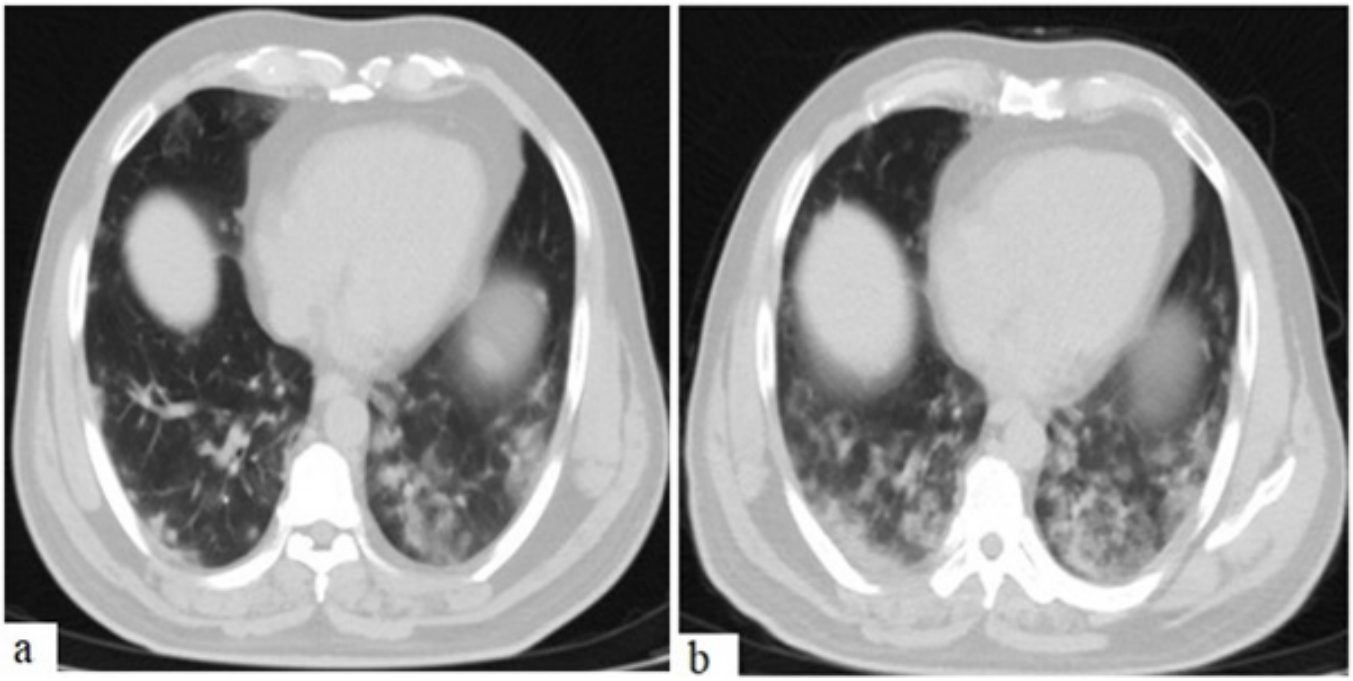

Figure 7. A 50-year-old male patient was admitted with cough and dyspnea. **a.** Initial chest CT revealed bilateral peripheral multilobar GGOs and consolidations. **b.** Progression was detected in GGOs and consolidations on follow-up chest CT obtained on day 7.

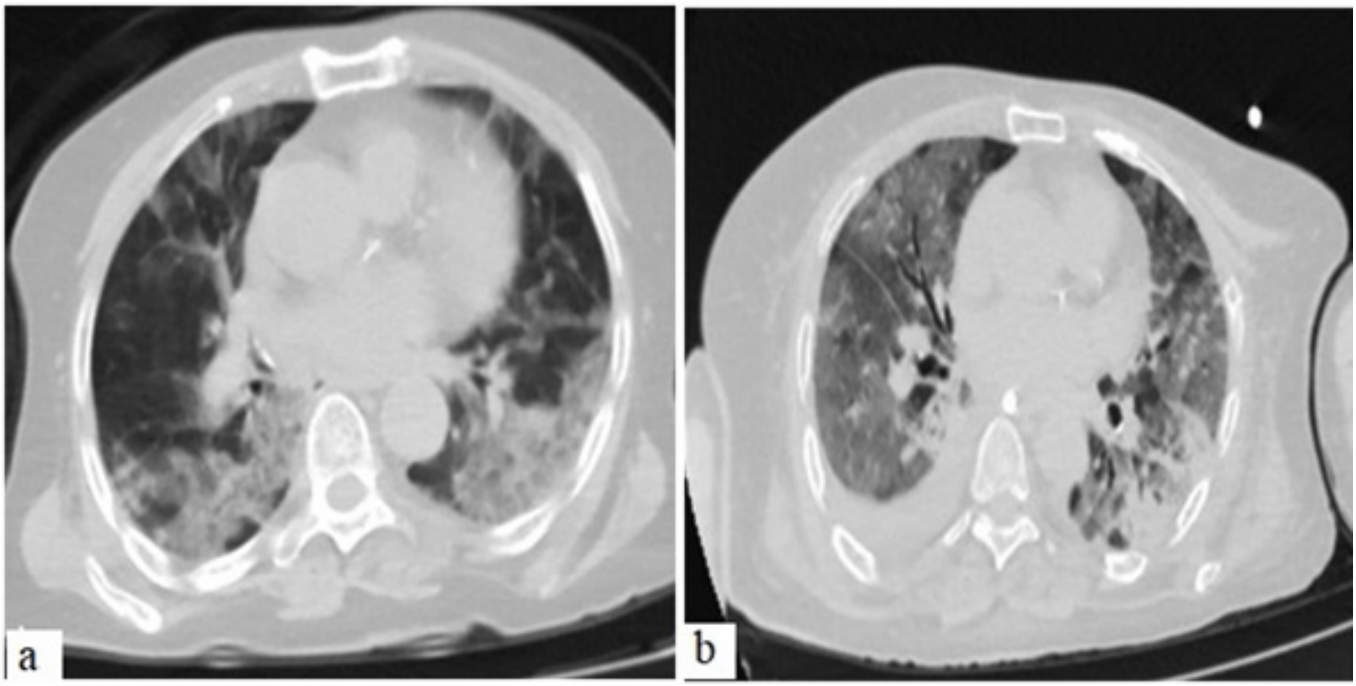

Figure 8. A 81-year-old female patient was admitted with fatigue. **a.** Initial chest CT revealed bilateral peripheral multi-lobar GGOs. **b.** Diffuse GGO in bilateral lungs, focal consolidation fields in the left lung and newly developing pleural fluid and bronchiectasis in the right were observed on follow-up chest CT obtained on day 7.

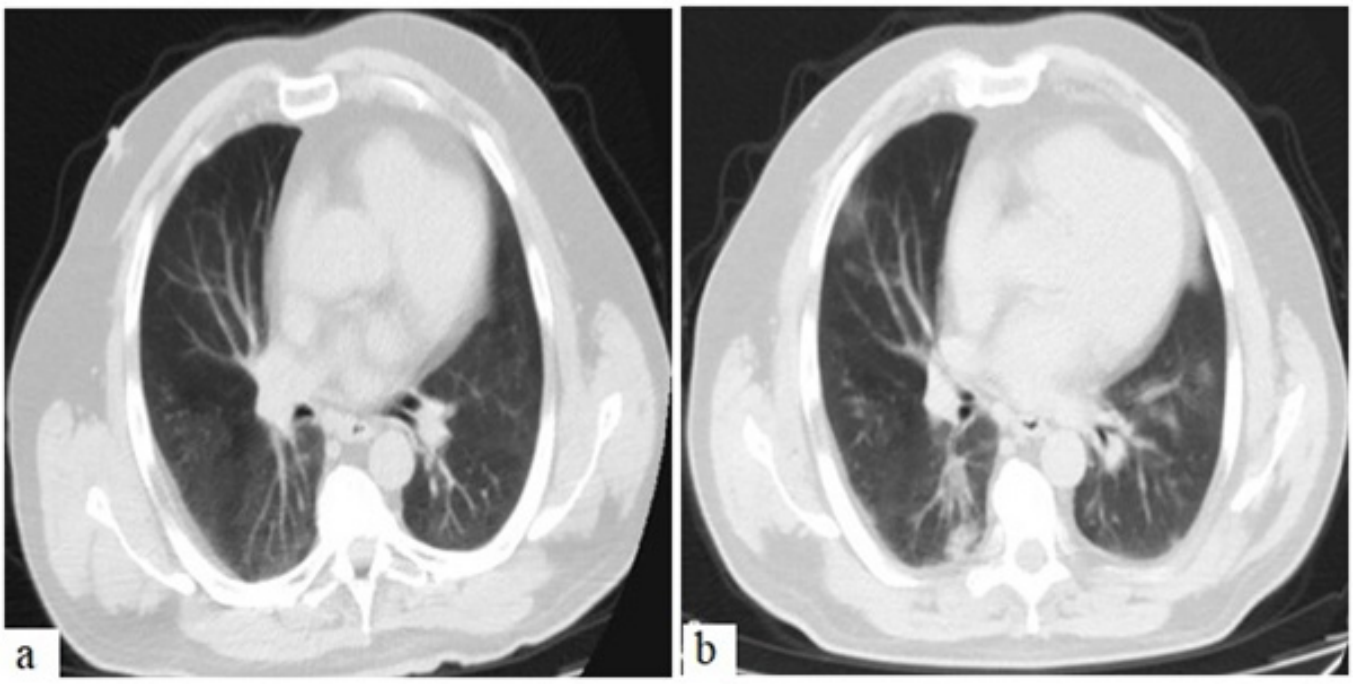

Figure 9. A 55-year-old male patient was admitted with cough and dyspnea. **a.** Initial chest CT revealed normal radiological findings. **b.** A few newly developing peripheral GGOs and consolidations were observed on follow-up chest CT obtained on day 7.

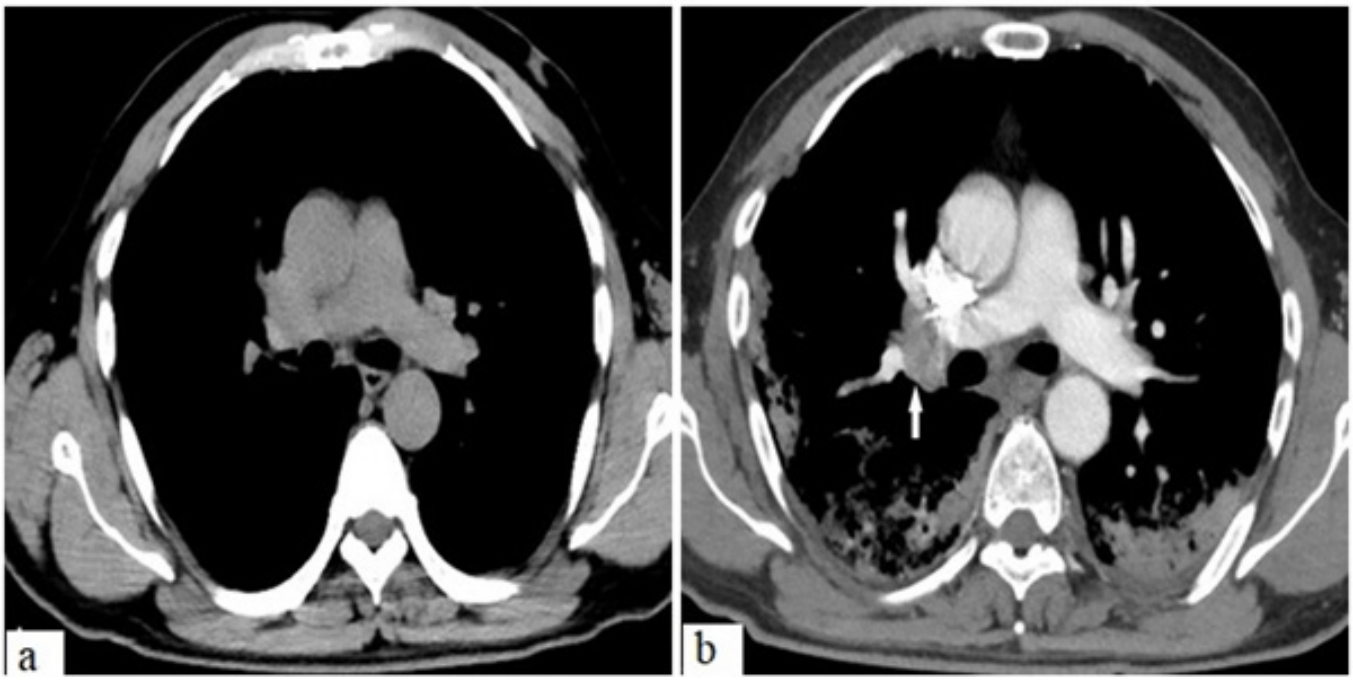

Figure 10. A 55-year-old male patient was admitted with high fever. **a.** Right hilus was in normal appearance in the initial chest CT. **b.** Lymphadenopathy (arrow) was observed in the right hilus in control chest CT obtained on day 12.

Studies have reported chest CT to produce typical imaging features in almost all patients with COVID-19 (18-21). The typical findings on chest CT images of individuals with COVID-19 include peripherally localized and bilateral multifocal patchy GGOs, interlobular septal thickening, vascular enlargement and consolidation. In COVID-19, the involvement of the lower lobes is more common than the upper and middle lobes. Aside from peripheral distribution and multilobar involvement, posterior involvement is also an important feature of lesion distribution (15,22-24). In this study, the most common CT findings were GGOs. They were mostly located bilaterally, peripheral, in the inferior lobes, and in the posterior. Lung lesions in early COVID-19 are usually localized, and manifest mostly as patchy or segmental GGOs confined to the subpleural or peribronchovascular regions of one or both lungs. The consolidation finding emerges in the patients who have symptoms for five days or longer. In advanced stages, CT findings may be compatible with other types of viral pneumonia (10,25).

The predominant findings in the follow-up CT images included newly developing consolidations in the progression stage, the GGOs converting to consolidations, the bilateral pleural effusion, the traction bronchiectasis, and the hilar LAPs. In the cases where there was developed regression, the initial radiological finding was the consolidations converting to GGOs. Atypical findings, including subpleural bullae, blebs and calcific nodules, were observed on the initial CT images of one of our follow-up patients. The findings were stable on a follow-up CT performed on day 12. A previous study reported the possibility of the development of subpleural bullae and blebs in severe COVID-19 disease (26). Due to the mild clinical course of our patient, we believed that the findings identified on CT may have been present before the COVID-19 infection.

There were pulmonary nodules in eight of our patients. Pleural effusion was observed on day 7 in one of our follow-up patients, and hilar LAP on day 12 in another patient. Mediastinal LAP, pleural effusion, cavitation and pulmonary nodules have been identified as uncommon findings of COVID-19 (26). It has been reported that CT findings such as consolidation, interlobular septal thickening, crazy-paving pattern, traction bronchiectasis, reticulation, lymphadenopathy and pleural effusion are more common in severe cases when compared to common COVID-19 findings (9,27,28).

The present study has two limitations. First, we did not have sufficient knowledge about symptom durations. Second, we could obtain follow-up CT images in only 7 patients.

The COVID-19 disease may emerge with different imaging findings, most commonly GGOs and consolidations. Given the important role of CT in the early diagnosis of COVID-19, radiologists should analyse the CT findings sufficiently.

Conflict of Interest and Financial Status: Our study has not been financed by an institution and institution. In this study, there is no conflict of interest among the authors on any subject.

Author Contribution: All authors contributed equally to the article.

Ethical Statement: This retrospective study was approved by the Fırat University Ethics Committee (2020/07-08).

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