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COVID-19'un Progresif Aşamasinda Toraks Bilgisayarli Tomografi Bulguları

ChestComputedTomographyFindings in ProgressiveStage of COVID-19

Meral Arifoğlu[1], Nuray Voyvoda[1], Günay Rona[1], Ayse Batırel[2]
1Kartal Doktor Lütfi Kırdar Şehir Hastanesi, Radyoloji Ana Bilim Dalı, İstanbul, Türkiye
2Kartal Doktor Lütfi Kırdar Şehir Hastanesi, Enfeksiyon Hastalıkları Ana Bilim Dalı, İstanbul, Türkiye

ÖZ

GİRİŞ ve AMAÇ: *Bu çalışmanın amacı COVID-19 pnömonisinin radyolojik bulgularındaki zamansal değişiklikleri değerlendirmektir..*

YÖNTEM ve GEREÇLER: *Çalışmaya COVID-19 tanısı almış ve kontrol toraks BT incelemesi olan hastalar dahil edildi. Her iki BT'de de tarama gününe göre evreleme kaydedildi. COVID-19 pnömoni tipleri, BT şiddet skoru ve buzlu cam opasitelerin Hounsfield Ünite (HU) değerleri kaydedildi. Sonuçları karşılaştırmak için paired-sample t test kullanıldı.*

BULGULAR: *Çalışmamıza 37 erkek (48.1%), 40 kadın(51.9%) olmak üzere toplam 77 hasta dahil edildi. İki BT arasındaki ortalama süre 12.64 gündü(min 3-maks 34). Buzlu cam dansitesi, konsolidasyon, crazypavingpatern, fibrotic bant, bronşektazi ve plevral kalınlaşma progresyon evresinde artmış bulgulardı. BT şiddet skoru ve buzlu cam dansitesi yoğunluğu açısından BT'ler arasında istatistiksel olarak anlamlı fark vardı(sırasıyla p=0.0001 ve 0.006). Takipte 54 hastada ilerleme olurken, 15 hastada kısmi/tam gerileme saptandı. Sekiz hastada bulgularda fark yoktu.*

TARTIŞMA ve SONUÇ: *İlerleme, COVID-19 hastalığı semptomlarının başlamasından sonra 2 haftadan fazla sürer. İlerleyen aşamada, buzlu cam dansitesi yoğunluğu ve konsolidasyon alanlarındaki artış ile bronşektazi, crazypavingpatern, plevral kalınlaşma ve fibrotic bant dikkate değer radyolojik bulgulardır.*

Anahtar Kelimeler: : *bilgisayarlı tomografi, pnömoni, viral, koronavirüs, ileri evre, hastalık*

ABSTRACT

INTRODUCTION: *The aim of this study was to evaluate the temporal changes in the radiological findings of COVID-19 pneumonia.*

METHODS: *The study included patients with the diagnosis of COVID-19 and repeat Chest CT examinations. On both CT examinations, staging by the day of scan was recorded. Types of COVID-19 pneumonia, CT severity score, and Hounsfieldunit (HU) values of ground-glassopacity (GGO) were evaluated. The paired-sample t test was used to compare the results.*

RESULTS: *Our study included a total of 77 patients, 37 males (48.1%), 40 females (51.9%). The mean time between the two CTs was 12.64 days (min: 3-max: 34). Consolidation, GGO, crazy-paving pattern, fibrotic band, bronchiectasis, and pleural thickening were findings of increased progression. There was a statistically significant difference between the CTs in terms of CT severity score and GGO density (p=0.0001 and 0.006, respectively). At follow-up, 54 patients had progression, while 15 patients achieved partial/complete regression. Eight patients had no difference in findings.*

DISCUSSION AND CONCLUSION: *Progression lasts more than two weeks after the onset of COVID-19 disease symptoms. In the progressive stage, an increase in the areas of GGO density and consolidation, as well as bronchiectasis, crazy-paving pattern, pleural thickening, and fibrotic band are notable radiological findings.*

Keywords: *computed tomography, pneumonia viral, coronavirus, disease progression*

İletişim / Correspondence:
Dr. Meral Arifoğlu
Kartal Doktor Lütfi Kırdar Şehir Hastanesi, Radyoloji Ana Bilim Dalı, İstanbul, Türkiye
E-mail: mirmak80@gmail.com
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INTRODUCTION

SARS-CoV-2, which first emerged in the world in December 2019 and was named by the World Health Organization (WHO) as Coronavirus Disease 2019 (COVID-19), may lead to the clinical picture of pneumonia (1-3). Reverse transcriptase-polymerase chain reaction test (RT-PCR) studied in throat swabs is the gold standard in the diagnosis (4). However, problems with the diagnostic kits and sampling and laboratory analysis errors cause false-negative results, and decrease the reliability of the test (5).

Since it exhibits symptoms of respiratory diseases, chest x-ray and chest computed tomography are used as imaging techniques. However, studies have shown that CT is more sensitive than chest x-ray, and the findings of COVID-19 disease show up on CT before the RT-PCR test becomes positive (6).

Pan et al. divided COVID-19 pneumonia into four stages: early, progressive, peak, and absorption stages, and showed that the radiological findings of the disease differed in these periods (7). According to this classification based on the day of onset of symptoms, the radiological findings increase from day 5 to day 13, while they regress after day 14. However, regression was not found to be so rapid in the study of Wang et al. In patients, the radiological findings may vary by stages, radiological recovery may take longer than 14 days, and the recovery pattern also varies (8).

The aim of this study was to identify the differences in CT findings by stages and evaluate the progression findings in patients with the definitive diagnosis of COVID-19.

MATERIALS AND METHODS

Prior to this study, approval was obtained from our local Ethics Committee (2020/514/176/19) and the Ministry of Health Scientific Research Platform. The requirement for signed written consent was waived in accordance with the Council for International Organizations of Medical Sciences (CIOMS) guidelines.

Patient Selection

CT examinations of adult patients admitted to the infection clinic of our hospital between 11 March 2020 and 30 April 2020 with suspicion of COVID-19 and hospitalized were retrospectively evaluated. The time between the onset of patients' symptoms and CT scan was recorded in days, and staging was performed accordingly.

The study included patients with the definitive diagnosis of COVID-19 and repeat chest CT examinations. Patients who were RT-PCR negative and who had only one CT examination were excluded from the study.

Chest CT Technique

Chest CT examinations were performed in two separate devices: 128-slice Multidetector CT (Philips Ingenuity) and CT scanner (Alexion 16, Toshiba Medical Systems, Japan). Scans were obtained in the supine position on normal breathing. No IV contrast agent was used.

Chest CT Evaluation

DICOM images were evaluated in the EIZO GS520 workstation together by 2 radiologists with 9 and 14 years of experience in the field of thoracic imaging. Evaluations were made in the parenchymal (width 1500 HU; level −700 HU) and mediastinal (width 350 HU; level 40 HU) window settings.

The CT findings of pneumonia were evaluated in four categories based on the study by Simpson et al. typical (Type 1), intermediate (Type 2), atypical (Type 3), and no pneumonia findings (Type 4) (9).

CT severity was evaluated according to the grading system introduced by Chung et al. and the involvement of each lobe was classified as 0%: no involvement (score: 0), 1-25%: minimal (score: 1), 26-50%: mild (score: 2), 51-75%: moderate (score: 3), and 76-100%: severe (score: 4). According to this evaluation, the minimum score was recorded as 0 and the maximum score as 20 (10).

The density of GGO was measured with ROI (Region of interest) and HU by determining the same point on previous and new examinations.

An increase in CT severity score of consolidation and GGO or density of lesion was considered as progression, while a decrease was considered as regression and no change as stable.

Statistics

Percentage, mean and standard deviation were used to evaluate the descriptive findings of the patients. The paired-sample t test was used to compare the repeat examinations of the same patients. A p-value of <0.05 was considered statistically significant.

RESULTS

There were 1289 patients admitted to the infection clinic of our hospital and hospitalized. Of these, 905 were excluded from the study because of being RT-PCR negative and 307 because of having only one CT examination. Our study included a total of 77 patients, 37 males (48.1%) and 40 females (51.9%), with a mean age of 50.17 years (min: 23 - max: 77). All patients had undergone a second chest CT scan, while 16 of the patients had undergone a third CT scan. The mean time between the first and second CT examinations was 12.64 days (min: 3-max: 34).

Staging, types of COVID-19 pneumonia, CT severity score and GGO HU values on the first and second CT examinations by the day of CT scan were shown in Table 1.

Table 1. Comparison of the first and second CTs

First CT	Second CT		
Temporal CTChanges 1	Early stage		67
	Progressive stage		8
23			
	Peak stage		2
19			
	Absorption stage		0
34			
Pneumonia Types	Type 1	32	49
	Type 2	18	14
	Type 3	8	4
	Type 4	19	0
CT Severity Score 7.39±5.38	P=0.0001		3.87±3.64
GGO HU values (n:72) 541.73±217.11	P=0.006 -440.7± 235.57		-

CT: Computed tomography; GGO: Ground glass opacity; HU: Hounsfield Unit; p<0.05 is statistically significant

There was a statistically significant difference between the first and second CT examinations in terms of CT severity score and density of GGO (p=0.0001 and 0.006, respectively) (Table 1).

The CT findings (GGO density, consolidation, crazy paving pattern, fibrotic band, bronchiectasis, reversed halo sign, air bubble, pleural thickening, pleural effusion, mosaic attenuation) of the first and second CT examinations were shown in Table 2 (Figure 1-5).

Table 2. Comparison of the radiological findings on the first and second CTs

CT Findings	First CT	Second CT
GGO	58	64
Consolidation	28	40
Crazy Paving	16	26
Fibrotic Density	18	52
Bronchiectasis	13	34
Reverse Halo Sign	7	6
Air Bubble Sign	3	3
Pleural Thickening	2	27
Pleural Effusion	1	7
Mosaic attenuation	6	9
Lymphadenopathy	3	1
Atelectasis	12	10

CT: Computed tomography; GGO: Ground glass opacity

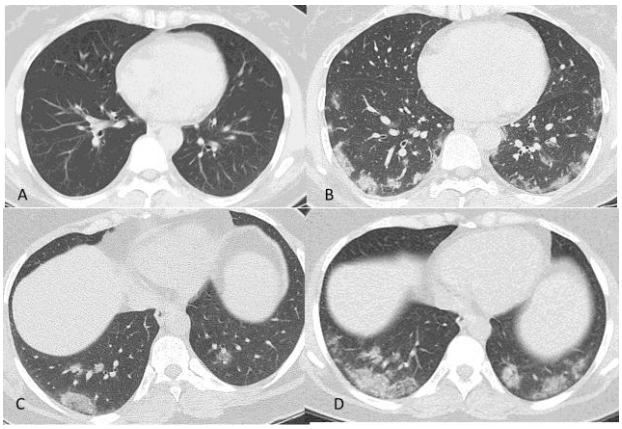

Figure 1. *A 50-year-old female patient who presented with shortness of breath had no COVID-19 pneumonia findings on the axial slices of the non-enhanced chest CT (A) performed on the day of onset of symptoms, while the CT of the same patient performed after 11 days showed peripheral consolidation area located in the lower lobes of both lungs and round GGO density (B) in the middle lobe of the right lung and the lingular segments of the left lung. A 44-year-old female patient who presented with malaise had consolidation areas located in the lower lobe of the right lung and GGO density in the lower lobe of the left lung (C) on the chest CT performed on the day of onset of symptoms, while the 6-day CT of the same patient showed an increase in consolidations visualized in the lower lobe of the right lung, and the GGO density in the lower lobe of the left lung turned into consolidation with air bronchogram (D).*

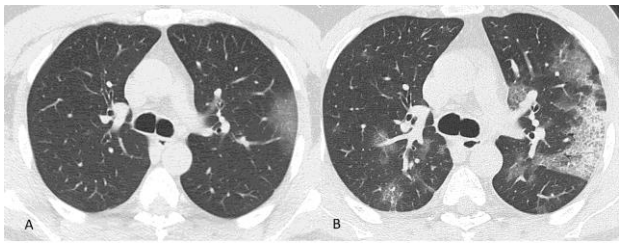

Figure 2. *A 38-year-old male patient who presented with cough and malaise had peripheral and central GGO density on the CT examination performed on the day of onset of symptoms (A). The CT of the same patient performed on day 11 showed an increase in the GGO density, crazy-paving pattern, and consolidation visualized in the left lung, as well as central, peribronchovascular, peripheral GGO density and subpleural fibrotic bands in the right lung (B).*

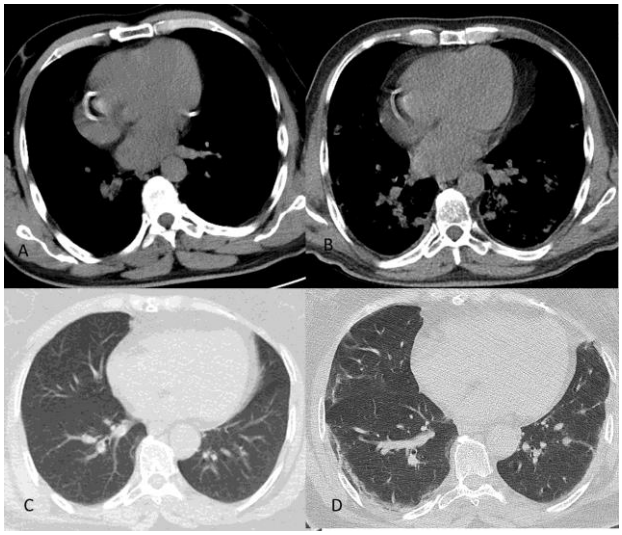

Figure 3. *A 59-year-old male patient who presented with cough and fever had normal pleural thickness on the costal surfaces of the lower lobes of both lungs in the mediastinal window on the chest CT performed 7 days after the onset of symptoms (A), while the CT of the same patient performed after 9 days showed consolidation areas in the lower lobes of both lungs and costal pleural thickening in the lower lobes of both lungs (B). A 61-year-old female patient with a history of asymptomatic contact at the time of admission had no COVID-19 finding on the admission CT (C), while the CT of the same patient performed on day 7 due to developing shortness of breathing during the follow-up revealed subpleural curvilinear fibrotic bands and pleural thickening in both lungs.*

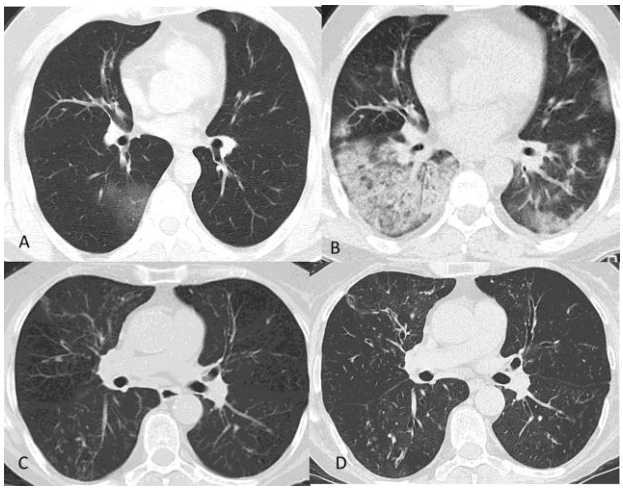

Figure 4. A 41-year-old male patient who presented with fever had a subpleural GGO density on the chest CT performed 1 day after the onset of symptoms (A). The CT of the same patient performed after 8 days showed diffuse consolidation and GGOs in both lungs, more significantly in the right lower lobe (B). A 71-year-old female patient who presented with fever and joint pain had peribronchovascular GGOs density in both lungs and bronchiectasis in the upper lobe of the left lung on the chest CT performed 3 days after the onset of symptoms (C). While the CT of the same patient performed 8 days after the first CT showed no significant difference in the GGOs density in both lungs, and there was an increase in the bronchiectatic changes in both lungs, more significantly in the right lung (D).

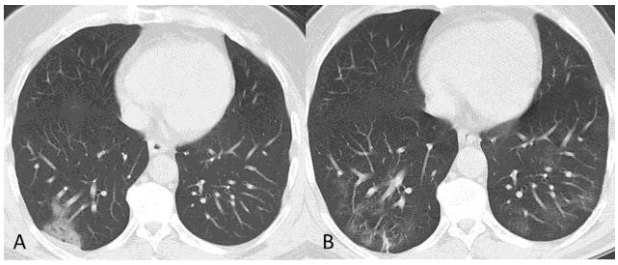

Figure 5. *A 50-year-old male patient who presented with cough and fever had a peripheral consolidation area in the lower lobe of the right lung on the chest CT performed 2 days after the onset of symptoms (A). The CT of the same patient performed 30 days after the first CT showed regression in the consolidation visualized in the right lung, and a fibrotic band at this level. In addition, areas of obliterated GGO density, which were not visualized on the first CT, were noted in the lower lobes of both lungs (B).*

Depending on the increase in the findings of the second CT examination, 54 patients were considered to have progressive disease. The findings of 15 patients were partially/completely regressed. On the other hand, 8 patients had no difference in findings.

Sixteen patients had a third CT examination. The mean time between the first and third CT was 19 days (min: 11- max: 30). Of these patients, 3 had progression and 12 had regression on CT, while the CT examination of 1 patient was considered stable.

The need for intensive care unit developed in 4 patients with progressed CT findings and 2 patients with regressed CT findings . All 77 patients were discharged with full recovery.

DISCUSSION

Chest CT is commonly used for the diagnosis of COVID-19 disease and its sensitivity and specificity have been reported as 60%–98% and 25%–53%, respectively (11-14). A study on COVID-19 patients found that findings of COVID-19 disease appeared on CT 3 days before the RT-PCR test became positive (15). For this reason, CT has gained importance in early diagnosis and repeat CT scans have been used in daily practice.

In their study, Pan et al. reported the mean time between the two CT examinations as 4 days and detected progressive radiological findings in the first three stages from the onset of symptoms and regression in the absorption stage (7). In our study, it was found that this progression continued after day 14. This difference may be due to the fact that our patient group in the study consisted of hospitalized patients.

The characteristic radiological findings of COVID-19 disease are GGO density and consolidation (16). The new-onset GGO or consolidation can be seen in the progressive stage of the disease (7-8). The common findings in our study were GGO and consolidation. Other CT findings included crazy-paving pattern, fibrotic band, and reversed halo sign. Unlike other studies, crazy paving pattern was a finding, which was observed in both stage 1 and stage 4 and increased in the progression stage (7,16). As a different finding in our study, fibrotic bands were not only seen in the regression stage but also in all stages (17). Current studies have not described bronchiectasis as a typical finding. However, the fact that bronchiectasis was observed in all stages and increased in the progressive stage in our study was notable (8,16).

Pleural thickening and pleural effusion were more common in the absorption stage. Pleural thickening was most frequently detected in the posterobasal segments of the lower lobe. This may be because these segments are the most commonly involved sites by the disease (18).

In the progressive patients, there was an increase in the number and volume of involved segments of the lungs, and measurable density differences were detected on CT examinations due to the increase in the rate of consolidation. Density measurement in the progression evaluation of the lesions may contribute to the visual evaluation.

Our limitations are the short interval between two CTs and a small sample size. There is a need for long-term studies to evaluate the findings of late sequel. Since there was no mortality, the relation of CT findings with mortality could not be evaluated. When the initial CT and control CT were compared, no CT findings that might clue the progression were found.

In conclusion, the radiological findings progress in the first two weeks after the onset of symptoms of COVID-19 disease. In the progressive stage, many findings such as GGO density, predominantly consolidation, are identified. It takes more than 14 days for these findings to regress. Control CT should only be scanned for patients who are clinically needed.

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