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CHEST IMAGING

ORIGINAL ARTICLE

Diagnostic performance of low-dose chest CT to detect COVID-19: A Turkish population study

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PURPOSE
We aimed to evaluate the diagnostic performance of low-dose chest computed tomography (CT) in patients under investigation for coronavirus disease 2019 (COVID-19).

METHODS
This retrospective study included 330 patients suspected of having COVID-19 from March 15 to April 16, 2020. We examined 306 patients upon initial presentation using both CT and real-time reverse-transcriptase polymerase-chain-reaction (rRT-PCR). The diagnostic performance of CT was calculated using rRT-PCR as a reference. Clinical and laboratory data, CT characteristics, and lesion distribution were assessed for patients with a confirmed diagnosis via rRT-PCR.

RESULTS
A total of 250 patients were finally diagnosed with COVID-19. Clinical and laboratory findings included myalgia or fatigue (76%), fever (64.8%), dry cough (60.8%), elevated levels of C-reactive protein (86.4%), procalcitonin (62%), and D-dimer (58.2%), increased neutrophil-lymphocyte ratio (NLR) (54.8%), and lymphopenia (34%). Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the initial CT scan were 90.4% (95% IC, 86%–93%), 64.2% (95% IC, 50%–76%), 91.8% (95% IC, 88%–94%), and 60% (95% IC, 49%–69%), respectively. The percentage of patients diagnosed on the initial rRT-PCR test was 51.6% (n=129). Most frequent CT characteristics of COVID-19 in the subgroup of rRT-PCR-positive patients were multiple lesion (97.4%, n=220), followed by bilateral involvement (88.5%, n=200), peripheral distribution (74.3%, n=168), ground-glass opacity (GGO) (69.2%, n=157), subpleural curvilinear opacity (41.6%, n=104), and mixed GGOs (27.6%, n=67).

CONCLUSION
rRT-PCR may produce initial false negative results. For this reason, typical CT findings for COVID-19 should be known especially by radiologists. We suggest that patients with typical CT findings but negative rRT-PCR results should be isolated, and rRT-PCR should be repeated to avoid misdiagnosis.

On December 31, 2019, in Wuhan, Hubei Province, China, a case of viral pneumonia with an unknown cause and the clinical symptoms of fever, cough, and dyspnea was reported to the WHO (1). When patients' lower respiratory tract samples were evaluated, a previously unknown β-cyclotron virus was discovered. Genome analysis of the discovered β-cyclotron virus suggested that it is a new type of *Betacoronavirus* similar to Middle East respiratory syndrome coronavirus (MERS-CoV) and severe acute respiratory syndrome coronavirus (SARS-CoV) (2). This newly discovered virus was named SARS-CoV-2; on February 11, 2020, the WHO officially designated the disease it causes as coronavirus disease 2019 (COVID-19). On January 30, 2020, the World Health Organization (WHO) declared COVID-19 to be an international emergency threatening public health; the illness was declared a pandemic on March 11, 2020 (3). As of May 12, 2020, 4.15 million confirmed cases and 284 000 deaths have been reported worldwide, with an increasing number of cases and deaths drawing attention day by day.

SARS-CoV-2 is an RNA virus belonging to the coronavirus family. Like MERS-CoV and SARS-CoV, it can infect humans and cause a lower respiratory tract infection (4). Wild animals,

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possibly bats, are cited as the source of the virus (3, 5). The most important feature of the virus is that it can be transmitted from human to human through respiratory droplets, contact, and rarely fecal-oral transmission. Studies have reported that COVID-19 cases often have a history of traveling to a region of outbreak or contact with infected individuals. The most common clinical symptoms of the disease are reported as fever, dry cough, shortness of breath, and widespread myalgia (5).

Due to the strong infectious potential of COVID-19, rapid and accurate diagnostic methods are required to detect, isolate, and treat cases as quickly as possible, thereby reducing both the risk of contamination and the mortality rate. Due to the primary involvement of the lower respiratory tract, a chest computed tomography (CT) is strongly recommended for follow-up in suspected and diagnosed cases of COVID-19 (6). Chest radiographs can be used in the mid-to-advanced stages of the disease and to demonstrate the development of acute respiratory distress syndrome (ARDS), but the early diagnostic value of this test is very low (7). The current gold standard for diagnosis is the real-time reverse-transcriptase polymerase-chain-reaction (rRT-PCR) test (8). However, rRT-PCR test results usually require 5 to 6 hours, and rRT-PCR tests have been reported to show false-negative diagnoses during the early stages of the disease. CT provides rapid results and has demonstrated some diagnostic value in the early stages of the disease when an rRT-PCR test is negative (9, 10). This reported high sensitivity of CT can also cause various problems; even completely healthy cases can undergo one or two CT scans to thoroughly rule out a diagnosis of COVID-19. In the later stages of the disease, radiation emitted during a CT scan can pose a risk, especially in infants, children, and young adults. However, new technology and an increase in dose reduction options have made it possible to minimize the radiation dose to 1/8 to 1/9 of the standard dose.

Main points

- Low-dose chest CT has high sensitivity (90.4%), but lower specificity (64.2%) for COVID-19.
- Bilaterally and multilobar GGOs and/or consolidation in the periphery of the lungs are the primary CT characteristics of COVID-19.
- rRT-PCR may produce initial false-negative results; therefore patients with typical CT findings but negative rRT-PCR results should be isolated, and rRT-PCR should be repeated.

The purpose of the present study was to evaluate diagnostic performance of low-dose chest CT in patients under investigation for COVID-19.

Methods

Study population and design

This retrospective study was approved by the Institutional Ethics Committee (IRB protocol number: 2020/49) and the requirement for informed consent was waived. Of 330 patients who presented at the hospital's COVID-19 outpatient clinic from March 15 to April 16, 2020 were evaluated. During admission, white blood cell counts (WBC), neutrophil, lymphocyte, platelet counts, neutrophil/lymphocyte ratio (NLR), C-reactive protein (CRP), procalcitonin, and D-dimer levels were recorded. Inclusion criteria were presence of at least two of the following clinical manifestations: fever >38°C, lower respiratory tract infection symptoms suggesting COVID-19, or normal or decreased lymphocyte count and elevated CRP levels; and evaluation by both chest CT imaging and rRT-PCR test at admission. Patients who presented severe CT motion artifacts and those who did not undergo rRT-PCR testing for COVID-19 were excluded. Low-dose chest CT imaging was performed on 330 patients. Based on the exclusion criteria, 3 patients with severe artifacts in CT images and 21 patients who did not undergo rRT-PCR test for COVID-19 were excluded from the study. For the final diagnosis, a positive first or repeated rRT-PCR test was accepted. COVID-19 was detected in 250 of 306 cases included in the study. The inclusion and exclusion criteria and the details of patient enrollment in the study are shown in the flowchart (Fig. 1).

Image acquisition

All CT examinations were conducted with a 16-slice spiral CT scanner (Emotion 16, Siemens Healthineers). The scanning range was from the apex to the base of the lung. Acquisitions were performed during a deep inspiration, breath-hold, without contrast administration. We implemented a low-dose scanning protocol with the following parameters: tube voltage, 80 kVp; tube current, 35–50 mA; rotation time, 0.75 s; pitch, 1.5; slice thickness, 3 mm; and detector width, 1.5 mm. In addition to the above-mentioned reduction dose strategy, we used iterative reconstruction algorithms. The dose length product and effective dose were 20.4 mGy.cm and 0.2856 mSv, compared with 260 mGy.cm and 3.64 mSv in a standard dose protocol.

Image interpretation

All CT scans were independently reviewed and evaluated by three board-certified radiologists who had 7, 8, and 8 years of experience in chest imaging, respectively. Disagreements in readers interpretation were settled by consensus agreement. CT scans for all cases were evaluated for the following features: presence of ground-glass opacity (GGO), mixed GGO (GGO and consolidation), consolidation, distribution and number of lobes and segment affected by GGO and/or consolidation, air bronchograms, centrilobular nodules, subpleural linear opacity, reverse halo sign, tree-in-bud sign, crazy-paving and/or reticular pattern, bronchial dilatation and/or cystic change, vascular enlargement (>3 mm), pleural effusion, and lymphadenopathy (defined as lymph node size of >10 mm in short-axis dimension). CT findings were defined in accordance with Fleischner Society guidelines (11). GGO was defined as a hazy increase in lung attenuation on lung window CT images, not obscuring the bronchial and vascular margins. Consolidation was defined as high-density patchy opacities with obscuration of margins of vessels and airway walls, inside which air bronchogram could be observed. The distribution of GGO and/or consolidation was classified as follows: central (predominantly in the inner two-thirds of the lung), peripheral (predominantly in the outer third of the lung), and diffuse (indications in multiple lung segments).

Statistical analysis

Data were analyzed with statistical software (SPSS statistical package, version 25.0; IBM Corp.). Kolmogorov-Smirnov tests were applied to check the normality of variables. Continuous data with normal distribution were expressed as mean ± standard deviation (SD), non-normally distributed data were expressed as median (interquartile range), and categorical variables were presented as numbers (percentages). The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV)

Table 1. Laboratory findings of patients with COVID-19

Laboratory parameters	
Lymphocyte count (×10⁶/L) (n=250)	1.42 (0.3–3.99)
Neutrophil count (×10⁶/L) (n=250)	6.1 (1.34–25.24)
Platelet count (×10⁹/L) (n=250), mean±SD	233.4±88
C-reactive protein level (mg/L) (n=250)	70.1 (0.26–568.20)
NLR (n=250)	5.7 (0.80–32.31)
Procalcitonin level (ng/mL) (n=120)	0.61 (0.02–26.99)
D-dimer (ng/mL) (n=181)	1324.1 (150–8444)

Data are presented as median (interquartile range), except for platelet count.
NLR, neutrophil/lymphocyte ratio.

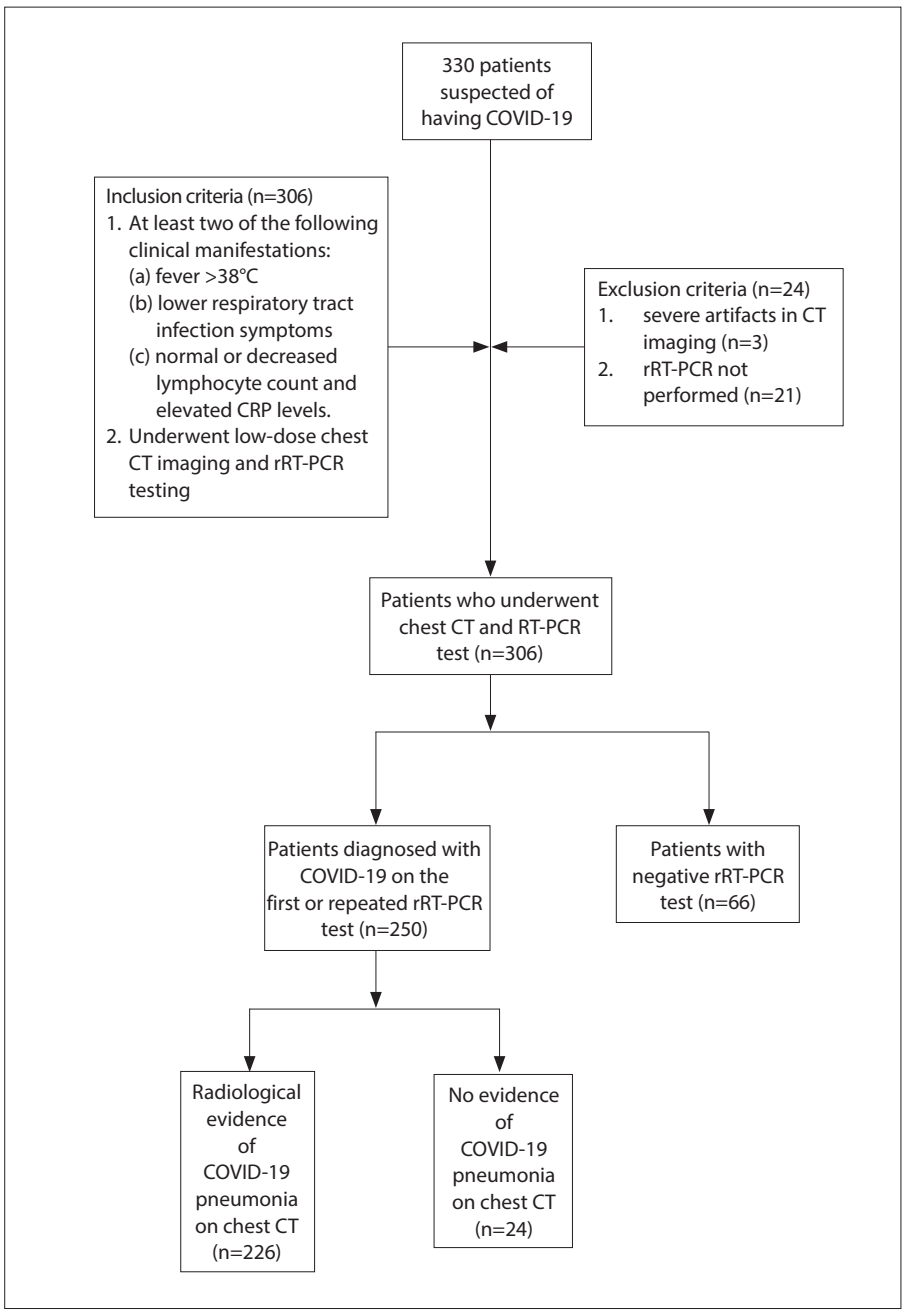

Figure 1. Flowchart for patient inclusion in the study.

Table 2. Distribution of the affected lobes on low-dose chest CT for confirmed COVID-19 patients

Affected lobe	n/N (%)
Right upper lobe	100/226 (44.2)
Right middle lobe	142/226 (62.8)
Right lower lobe	158/226 (69.9)
Left upper lobe	132/226 (58.4)
Left lower lobe	169/226 (74.7)

for diagnosing COVID-19 are reported with 95% confidence interval (95% CI), using rRT-PCR as reference.

Results

A total of 306 patients underwent low-dose chest CT and rRT-PCR, including 159 males (51%) and 147 females (49%), with mean age of 60±18 years (range, 18–97 years). A total of 250 patients (81%) had confirmation of COVID-19; the number of patients diagnosed on the first, second, and third rRT-PCR tests were 129 (51.6%), 92 (36%), and 29 (11%), respectively.

In the 250 patients with confirmed COVID-19, clinical symptoms were as follows: fever (162/250, 64%), myalgia or fatigue (190/250, 76%), dry cough (152/250, 60%), shortness of breath (20/250, 8%). Median hospitalization days of patients were 5.7 days (range, 1–30 days). Laboratory results are summarized in Table 1. Increased CRP (216/250, 86%), D-dimer (106/182, 58%), NLR (137/250, 54%), procalcitonin level (78/124, 62%), and lymphopenia (85/250, %34) usually accompanied symptoms of COVID-19.

Of the 250 patients who underwent low-dose chest CT on admission, 226 (90.4%) showed radiographic evidence of COVID-19. The overall sensitivity, specificity, PPV, and NPV of initial CT were 90.4% (range, 86%–93.7%), 64.2% (50.3%–76.6%), 91.8% (88.8%–94.1%), and 60% (49.4%–69.7%), respectively. A total of 200 patients (88.5%) had bilateral lung lesions, and 26 patients (11.5%) had unilateral lung lesions. Except for 6 patients (2.6%) with a single lesion, the majority of patients had multiple CT abnormalities. The mean number of affected lobes and segments were 3 and 7, respectively. The distribution of the affected lobes in the 226 patients with confirmed COVID-19 is summarized in Table 2.

Among 226 COVID-19 patients, 173 (69.2%) had GGOs (Figs. 2, 3a), 69 (27.6%) had mixed GGO, 67 (26.8%) had only consol-

Table 3. Distribution of the CT findings by age groups (decades)

	Age groups (years)							
	18–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100
GGO	32 (18.4)	45 (26)	37 (21.3)	23 (13.2)	16 (9.2)	11 (6.3)	8 (4.6)	1 (0.5)
Mixed GGO	5 (7.2)	7 (10.1)	12 (17.3)	12 (17.3)	19 (27.5)	12 (17.3)	2 (2.8)	0 (0)
Only consolidation	3 (4.4)	7 (10.4)	10 (14.9)	18 (26.8)	21 (31.3)	9 (13.4)	6 (8.9)	3 (4.4)
Air bronchograms	0 (0)	3 (9)	3 (9)	8 (24.2)	12 (36.3)	3 (9)	2 (6)	1 (3)
Centrilobular nodules	0 (0)	2 (8.6)	2 (8.6)	7 (30.4)	10 (43.4)	1 (4.3)	1 (4.3)	0 (0)
Subpleural curvilinear opacity	14 (13.4)	13 (12.5)	22 (21.1)	26 (25)	18 (17.3)	7 (6.7)	2 (1.9)	2 (1.9)
Crazy-paving pattern	2 (5.4)	3 (8.1)	3 (8.1)	6 (16.2)	14 (37.8)	7 (18.9)	1 (2.7)	1 (2.7)
Reversed halo sign	0	2 (10.5)	3 (15.7)	3 (15.7)	5 (26.3)	4 (21)	2 (10.5)	0
Reticular pattern	4 (7.1)	5 (8.9)	9 (16)	13 (23.2)	14 (25)	8 (14.2)	2 (3.5)	1 (1.7)
Bronchial dilatation	2 (4.7)	4 (9.5)	7 (16.6)	11 (16.1)	12 (28.5)	2 (4.7)	2 (4.7)	2 (4.7)
Vascular enlargement	3 (8.5)	3 (8.5)	4 (11.4)	10 (28.5)	10 (28.5)	2 (5.7)	1 (2.8)	2 (5.7)
Cystic changes	0	0	2 (16.6)	3 (25)	4 (33.3)	2 (16.6)	1 (8.3)	0
Tree-in-bud sign	0	1 (6.2)	2 (12.5)	3 (18.7)	6 (37.5)	3 (18.7)	1 (6.2)	0
Pleural effusion	0	0	3 (17.6)	3 (17.6)	6 (35.2)	2 (11.7)	1 (5.8)	2 (11.7)
Lymphadenopathy	0	0	0	0	1 (50)	0	0	1 (50)

GGO, ground-glass opacity.

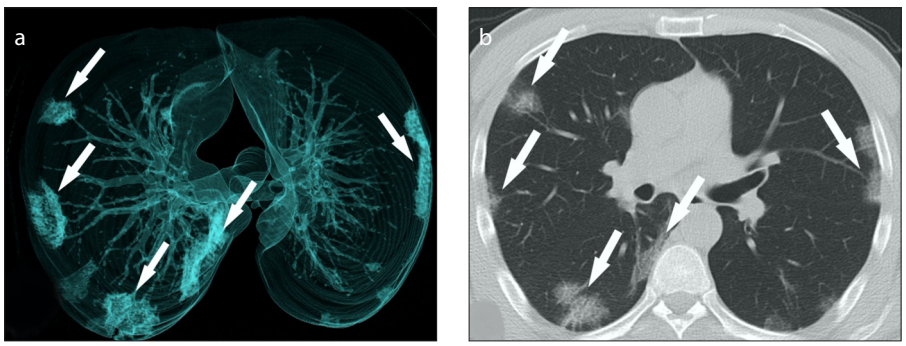

Figure 2. a, b. A 34-year-old man with COVID-19 pneumonia presenting with fever and dry cough. Laboratory examination revealed elevated CRP levels and lymphopenia. 3D volume-rendered **(a)** and axial **(b)** low-dose chest CT images show multifocal, peripheral, patchy ground-glass opacities (GGOs) *(arrows)*.

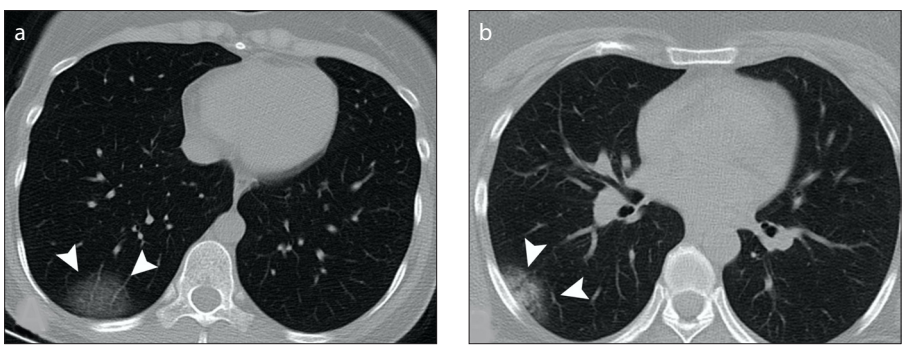

Figure 3. a, b. Axial low-dose chest CT image **(a)** of a 42-year-old female COVID-19 patient presenting with headache and fatigue for 3 days shows pure GGO in the right lobe subpleural area *(arrowheads)*. Axial low-dose chest CT image **(b)** of a 55-year-old female COVID-19 patient presenting with fever and dry cough for 4 days shows consolidation in the right lobe subpleural area *(arrowheads)*.

idation (Fig. 3b), 168 (74.3%) had peripheral distribution, 52 (23%) had diffuse distribution, 6 (2.7%) had central distribution, 33 (13.2%) had air bronchograms, 23 (9.2%) had centrilobular nodules, 104 (41.6%) had subpleural curvilinear opacity (Fig. 4a), 37 (14.8%) had a crazy-paving pattern (Fig. 4b), 19 (7.6%) had reversed halo sign (Fig. 4c), 56 (22.4%) had a reticular pattern, 42 (16.8%) had bronchial dilatation (Fig. 5a), 35 (14%) had vascular enlargement (Fig. 5b), 12 (4.8%) had cystic changes (Fig. 5c), 16 (5.9%) had tree-in-bud sign, 17 (6.8%) had pleural effusion, and 2 (0.8%) had lymphadenopathy. The distribution of the CT findings by decades of age is presented in Table 3.

Discussion

In this retrospective study, CT findings consistent with COVID-19 were found in 226 (90.4%) of 250 confirmed COVID-19 patients. The overall sensitivity, specificity, PPV, and NPV of initial CT for COVID-19 pneumonia were 90.4%, 64.2%, 91.8%, and 60%, respectively. Our results are similar to the findings reported in the literature, and initially revealed that chest CT was superior to the rRT-PCR test.

COVID-19 is a new disease which is caused by a *Betacoronavirus* with potentially far-reaching public health ramifications. So far, respiratory droplets and direct contact have been identified as the main transmission routes. The incubation period of the disease is usually 4–7 days, but no longer than 14 days, and patients develop clinical symptoms after the incubation period (12). The diameter of the virus particle is very small, about 60–140 nm, so it easily reaches

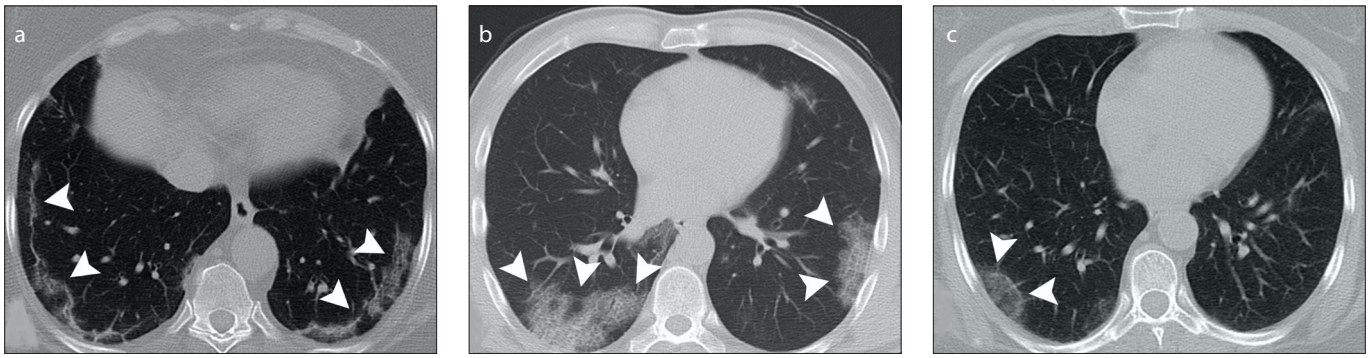

Figure 4. a–c. Axial low-dose chest CT image **(a)** of a 51- year-old female COVID-19 patient presenting with fever and dry cough for 3 days shows subpleural curvilinear lines *(arrowheads)* in the bilateral lower lobes. Axial low-dose chest CT image **(b)** of a 41-year-old male COVID-19 patient presenting with fever, cough, and fatigue for 5 days demonstrates a crazy-paving pattern in the bilateral lower lobes *(arrowheads)*. Axial low-dose chest CT image **(c)** of a 46-year-old female COVID-19 patient presenting with fever, dry cough, and myalgia for 3 days shows a peripherally placed reversed halo sign *(arrowheads)* in the right lower lobe.

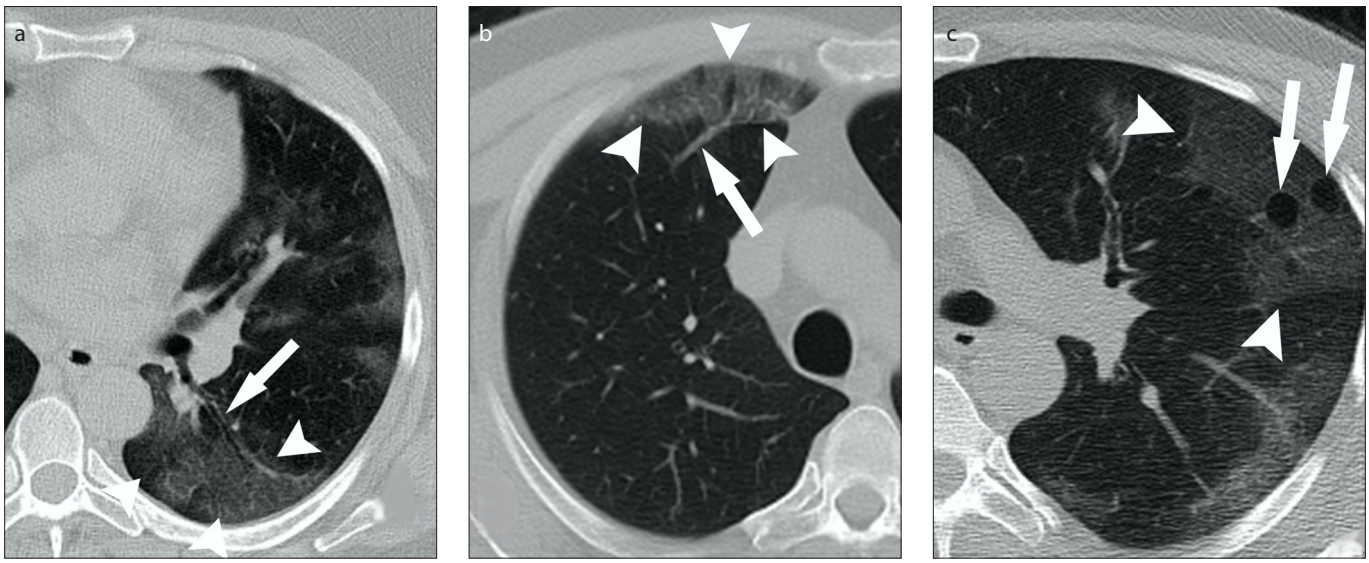

Figure 5. a–c. Axial low-dose chest CT image **(a)** of a 44-year-old female COVID-19 patient presenting with fever and sore throat for 2 days shows multifocal, peripherally placed patchy GGO in the left lung *(arrowhead)* and enlarged bronchus *(arrow)*. Axial low-dose chest CT image **(b)** of a 55-year-old male COVID-19 patient presenting with headache and myalgia for 3 days shows GGO area *(arrowheads)* in the right middle lobe with vascular enlargement *(arrow)*. Axial low-dose chest CT image **(c)** of a 51-year-old male COVID-19 patient presenting with fever, sore throat, and myalgia shows a peripheral GGO *(arrowheads)* with cystic changes *(arrows)* in the upper left lobe.

the terminal lung structures, such as alveolar septum, alveolar wall, and interlobular septum, causing extensive edema and lymphocyte infiltration in the lung interstitium (13). Therefore, chest imaging, especially chest CT, plays an important role in the initial diagnosis and follow-up of the disease. Published clinical guidelines strongly recommended chest CT for patients suspected of having COVID-19 (6). The rRT-PCR test is considered the gold standard test for the diagnosis of COVID-19, but in some cases it can yield a false negative result. A number of cases with false negative rRT-PCR results have been reported in the early stages of the disease, possibly due to inadequate viral material in the sample or technical problems during nucleic acid extraction (8, 10). In cases with typical clinical manifestations, even if the rRT-PCR test is negative, chest CT can be a valuable test because it can show the characteristic features of the disease (14, 15). Because initial negative rRT-PCR results should be suspected as false, we recommend isolating patients with typical imaging findings on chest CT and performing repeat rRT-PCR testing to prevent misdiagnosis.

Although rRT-PCR is accepted as the gold standard, in our study, the test initially gave positive results in 126 of 250 patients, and sensitivity was found to be 51.6%. In another study with 167 patients, Xie et al. (10) reported 5 patients with initially negative rRT-PCR test results who had typical CT findings of COVID-19 (10). On the other hand, in our study, 24 of 250 patients with confirmed disease on repeated rRT-PCR test had normal chest CT findings. Chung et al. (14) reported that 3 out of 21 patients diagnosed with COVID-19 by repeated rRT-PCR test had normal chest CT findings. In the current study, bilateral lung involvement was more common than unilateral involvement (88.5% and 11.5%, respectively). Only 6 patients (2.6%) had a single lesion; in general, there were multiple lesions. The number of affected lobes and segments were 3 and 7, respectively, and the most affected lobes were left lower, right lower, and right middle lobes (74.7%, 69.9%, and 62.8%, re-

spectively). When the distribution of lesions was evaluated, peripheral distribution was found to be more frequent than central and diffuse distribution (74.3%, 23%, and 2.7%, respectively). The most frequent chest CT findings were GGOs (69.2%), followed by mixed GGOs (27.6%), and consolidation (26.8%). While GGOs were more common in young patients, mixed GGOs and consolidations were more common in elderly patients. Common findings included subpleural curvilinear opacity (41.6%), reticular pattern (22.4%), bronchial dilatation (16.8%), crazy-paving pattern (14.8%), vascular enlargement (14%), and air bronchograms (13.2%). All patients with air bronchograms had consolidations. Patients with a reticular pattern or crazy-paving pattern were more likely to stay in the hospital and need intensive care than other patients. Rarer findings included centrilobular nodules (9.2%), reversed halo sign (7.6%), pleural effusion (6.8%), tree-in-bud sign (5.9%), cystic changes (4.8%), and lymphadenopathy (0.8%). The development of pleural effusion is an indication that the disease is at an advanced stage and is frequently seen in patients who needed intensive care.

In a similar study, Huang et al. (9) showed that bilateral lung involvement was present in 98% of cases with confirmed COVID-19. In another study, Chung et al. (14) described the CT manifestations of COVID-19 in 21 patients and reported bilateral lung involvement in 76% of them. In the same study, more than half of the patients showed isolated GGO, while 29% showed mixed GGOs. A crazy-paving pattern was seen in 19% of the patients. Song et al. (16), in their study of 51 confirmed COVID-19 patients, identified most frequent CT findings as isolated GGOs, subpleural curvilinear opacity, and mixed GGOs. Air bronchograms were reported in 80% of these patients (16). In two other major studies on 138 and 99 confirmed cases, respectively, GGO and consolidation were the most frequently reported imaging features (17, 18). Several studies show that pleural effusion, pericardial effusion, lymphadenopathy, cavitation, halo sign, and pneumothorax are among the least common, or rarely reported, findings (12, 16). In our study, CT findings were similar to those in the literature.

Pan et al. (7) evaluated the temporal course of CT changes in confirmed COVID-19 cases and showed that in the early stages, the dominant finding was GGO and a small number of affected lobes (7). They reported that the intensification of the crazy-paving pattern, the increase in the number of affected lobes, and the emergence of consolidation showed advanced disease. In a study of confirmed COVID-19 cases, Song et al. (16) reported GGOs in 77% and consolidation in 23% of those younger than 50 years old. However, in patients older than 50 years old, GGO was reported in 55% and consolidation in 45%. They claimed that, as the age increased, consolidation was more common than GGO (16). Atypical findings (centrilobular nodules, reversed halo sign, pleural effusion, tree-in-bud sign, cystic changes, and lymphadenopathy) have been reported more frequently in elderly patients (6, 19). In our study, as in the literature, the appearance of the crazy-paving pattern and the emergence of consolidation were associated with poor prognosis, and the incidence of consolidation versus GGO was higher in elderly patients.

In our study, the symptoms of confirmed COVID-19 patients at the admission stage were very diverse—the most common clinical symptom was fever, followed by myalgia, fatigue, and dry cough. In agreement with our study, very different clinical symptoms have been reported in the literature. Low-grade fever and dry cough are among the most frequent clinical symptoms reported (20, 21). The most common laboratory changes in COVID-19 patients were elevated CRP, D-dimer, procalcitonin levels, NLR, and lymphopenia. Similarly, laboratory changes were reported in the literature (5, 14, 17). However, these clinical symptoms and laboratory parameters present no specific findings for COVID-19 and are changes that can occur in many viral infections.

Although the imaging method strongly recommended in the diagnosis of COVID-19 is CT, it is necessary to pay attention to the radiation caused by CT. Particularly in infants, children, and young adults, repeated CT scanning can cause unnecessary radiation. In our study, we minimized the radiation dose using low-dose CT techniques and reduced it to 1/8 to 1/9 of the standard dose.

Our study had several limitations. First, because COVID-19 is a novel disease and lacks serial and long-term CT data, we could only perform a retrospective evaluation on the existing information. Second, we only evaluated the CTs of patients at the initial admission stage. We did not evaluate the follow-up CT scanning. We think that follow-up CT scanning should also be evaluated to assess the course of the entire disease. Finally, the rRT-PCR test was performed only for COVID-19. No tests were performed for other viruses that can cause pneumonia. Testing for other viruses would also be helpful in evaluating the sensitivity and specificity of the identified imaging findings for COVID-19.

In conclusion, our study shows that low-dose CT is highly effective in detecting pulmonary parenchymal abnormalities in COVID-19 patients. Peripherally located, multiple GGOs can be identified as the most characteristic CT finding of COVID-19. In addition, although the rRT-PCR is accepted as the gold-standard method of testing, it should be kept in mind that it may show a negative result in the initial period and, if positive imaging findings are detected, the patients should be isolated and the rRT-PCR test should be repeated.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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