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Orjinal Araştırma / Original Article

Chest CT Features of SARS-CoV-2 Pneumonia

SARS-CoV-2 Pnömonisinin Toraks BT Özellikleri

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Abstract

Aim: CT has an important place in diagnosing SARS-CoV-2 due to the RT-PCR test's high false-negative rate and the faster evaluation of CT, although the RT-PCR test is the gold standard. This study aims to understand chest CT features and distributions in patients with SARS-CoV-2 proven by RT-PCR.

Material and Method: This study is retrospective and includes one hundred adult patients with confirmed SARS-CoV-2 infection who admitted to the hospital. The Chest CT findings of these patients were retrospectively recorded. Radiological Society of North America reporting guidelines for SARS-CoV-2 pneumonia was referenced to classify chest CT findings.

Results: In SARS-CoV-2 patients confirmed by RT-PCR, the mean age of 79 pneumonia patients (54.02±16.99) was higher than age of patients without pneumonia (42.47±17.78). Prevalences of ground-glass opacity, consolidation, posterior dominance, bilaterality, peripheral distribution, multifocality, vascular enlargement, pleural effusion, lymphadenopathy, tree-in-bud pattern, halo sign and reverse halo sign were 74.68%, 3.79%, 17.72%, 43.03%, 70.88%, 84.81%, 84.81%, 12.65%, 2.53%, 1.26%, 2.53%, 8.86%, and 3.79%, respectively.

Conclusion: This study's findings indicate that common chest CT findings in SARS-CoV-2 pneumonia are ground glass opacities with multifocal, multilobar, peripheral and bilateral involvement. No significant result was shown in favor of posterior or lower lobe dominance.

Keywords: SARS-CoV-2, coronavirus disease-19, chest computed tomography, pneumonia

Öz

Amaç: SARS-CoV-2'nin tanısında; altın standartın RT-PCR testi olmasına ragmen, RT-PCR testinin yüksek yalancı negatiflik oranı ve toraks BT'nin daha hızlı sonuç vermesi nedeniyle, BT de önemli bir yere sahiptir. Bu çalışmanın amacı RT-PCR ile kanıtlanmış SARS-CoV-2 hastalarında toraks BT özelliklerinin ve dağılımının değerlendirilmesidir.

Gereç ve Yöntem: Bu çalışmaya hastaneye başvuran, SARS-CoV-2 tanısı RT-PCR ile doğrulanan, 100 yetişkin hasta dahil edilmiştir. Bu hastaların toraks BT bulguları retrospektif olarak kaydedilmiştir. BT bulguları, Kuzey Amerika Radyoloji Topluluğu tarafından SARS-CoV-2 için yayınlanan klavuza göre değerlendirilmiştir.

Bulgular: RT-PCR ile doğrulanan 100 SARS-CoV-2 hastasının, 79'unda pnömoni mevcut olup yaş ortalaması (54,02±16,99) iken pnömoni bulgusu olmayan 21 hastanın yaş ortalaması (42,47±17,78) olarak bulunmuştur. Buzlu cam opasitesi, konsolidasyon, posterior ağırlıklı tutulum, bilateral tutulum, periferik dağılım, multifokalite, vasküler genişleme, plevral efüzyon, lenfadenopati, tomurcuk ağaç paterni, halo işareti ve ters halo işareti prevalansları sırasıyla %74,68, %3,79, %17,72, %43,03, %70,88, %84,81, %84,81, %12,65, %2,53, %1,26, %2,53, %8,86 ve %3,79 olarak bulundu.

Sonuç: SARS-CoV-2 pnömonisinde sık görülen göğüs BT bulguları multifokal, multilobar, periferik ve bilateral tutulumlu buzlu cam opasiteleridir. Posterior ya da alt lob hakimiyeti lehine anlamlı sonuç gösterilememiştir.

Anahtar Kelimeler: SARS-CoV-2, koronavirüs-19, toraks bilgisayarlı tomografisi, pnömoni

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INTRODUCTION

The severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was the first notice in December 2019 in Wuhan, China. After that, the disease spread worldwide and was named the coronavirus disease 2019 (COVID-19).[1,2] World Health Organization declared this disease as a pandemic.[1,3] Clinical findings of COVID-19 are a spectrum that can range from the common cold to acute respiratory distress syndrome.[4]

The common symptoms of COVID-19 are dry cough, fever, dyspnea, and fatigue. The incubation period is 1-14 days (average five days).[5] The disease is diagnosed by clinical findings, chest computed tomography (CT), and the-real-time-reverse transcription-polymerase chain reaction (RT-PCR).[6] RT-PCR test is the gold standard with specificity is 95%.[7] However, false-negative RT-PCR results were reported even these patients can have abnormal chest CT findings.[8,9] The sensitivity of RT-PCR varies between 42% and 71%, and false-negative results are more common of the disease because the sensitivity of the sampling kit, the timing of the sample collection, and the sample collection method affect the sensitivity of the test.[4,10] What makes chest CT important is that it results faster, and its sensitivity is higher.[4] Some studies have shown that CT has higher sensitivity (86-98%) and a lower false-negative rate than RT-PCR.[10] But the specificity (25%) of CT findings for COVID-19, in contrast to sensitivity, is not high.[11]

The common and typical CT findings of the SARS-CoV-2 disease are ground-glass opacities (GGOs) with peripheral, subpleural, bilateral, multilobar, and basal distribution. Consolidation, crazy-paving pattern, and fibrotic bands are also common. Besides, the halo sign, reverse halo sign, vascular enlargement, and bubble sign are characteristic features of this disease. There are also atypical chest CT findings such as pleural effusion, pleural thickening, bronchiectasis, mediastinal lymphadenopathy (LAP), cavitation, pneumothorax.[12] SARS-CoV-2 CT findings are similar to imaging features of various other disease processes, including drug reaction, inhalation exposure, and other infections.[10] So CT's specificity is not as high as sensitivity in the diagnosis of SARS-CoV-2.[11]

Society of Thoracic Radiology, the American College of Radiology, and the Radiological Society of North America (RSNA) published an expert consensus statement for standardization on reporting chest CT findings related to COVID-19 (SARS-CoV-2) pneumonia. Cases were classified as typical, indeterminate, atypical, or negative for SARS-CoV-2 pneumonia according to the RSNA guidelines.[10]

CT findings for SARS-CoV-2 are essential for early isolating and identifying the patient because the RT-PCR test resulting is slower, and its sensitivity is lower than the chest CT. This study aimed to assess chest CT features and distributions of patients with SARS-CoV-2.

MATERIALS AND METHODS

This study is a retrospective and conducted in a state hospital in Turkey. A hundred patients (n=100) admitted to the hospital and diagnosed SARS-CoV-2 with RT-PCR between 1st-30st June were enrolled in the study. Age under eighteen years and patients with chronic lung disease was the exclusion criteria. Researchers recorded the demographic characteristics and CT findings from the hospital registry system retrospectively. All patients were diagnosed with SARS-CoV-2 using RT-PCR test in the state hospital's microbiology laboratory. The Local Ethics Committee approved the study.

Radiologic Assessment

Two expert radiologists blindly evaluated all CT images and later matched their findings, using the state hospital's local radiology Picture Archiving and Communication Systems (PACS). This study referenced RSNA expert consensus for SARS-CoV-2 to classify CT findings as typical, indeterminate, atypical, or negative. Typical, indeterminate, atypical, or negative CT findings are described in detail in **Table 1**. All CT images were analyzed and recorded in this context. The present study's findings are shown in **Table 2**. Chest CT examinations were conducted with a 16-slice spiral CT scanner (Alexion 16, Toshiba, Japan).

Table 1. Radiological Society of North America Chest CT Classification System for Reporting Covid-19 Pneumonia.[25]

COVID-19 Pneumonia Imaging Classification	CT Findings
Typical appearance	Peripheral, bilateral GGO with or without consolidation or visible intralobular lines (crazy-paving). Multifocal GGO of rounded morphology with or without consolidation or visible intralobular lines (crazy-paving). Reverse halo sign or other findings organizing pneumonia (seen later in disease).
Indeterminate appearance	Absence of typical features and presence of: multifocal, diffuse, perihilar, or unilateral GGO with or without consolidation lacking a specific distribution and are nonrounded or nonperipheral. Few very small GGOs with a nonrounded and nonperipheral distribution.
Atypical appearance	Absence of typical or indeterminate features and presence of: Isolated lobar or segmental consolidation without GGOs. Discrete small nodules (centrilobular, tree-in-bud). Lung cavitation. Smooth interlobular septal thickening with pleural effusion
Negative for pneumonia	No CT features to suggest pneumonia

GGO: Ground glass opacity, CT: Computed tomography

The CT findings were recorded as GGO, consolidation, multifocal, multilobar, bilateral distribution, location of consolidation or GGO, reverse halo sign, halo sign, vascular enlargement (≥3 mm), air-bubble sign, subpleural line, tree-in-bud pattern, air bronchogram, reticular pattern, LAP (defined as lymph node with short-axis >10 mm), pleural and, pericardial effusion, presence of lung cavitation, bronchiectasis.

Statistical Analyses

Data were analyzed with statistical software (SPSS statistical package, version 20.0; IBM Corp.). Categorical variables were displayed as counts and percentages, and continuous variables were shown as mean±standard deviation. The groups were tested with Kolmogorov-Smirnov to test the normality. One Way ANOVA and Tukey tests were used for numeric data. $p<0.05$ was considered statistically significant.

Table 2. SARS-CoV-2 Pneumonia Chest Computed Tomography findings.

Chest CT findings	n	%
Bilateral	56	70.88
Unilateral	23	29.11
Peripheral	67	84.81
Central	2	2.53
Lower	43	54.43
Upper	4	5.06
Posterior	34	43.03
Anterior	7	8.86
Multilobar	59	74.68
Multifocal	67	84.81
Consolidation	3	3.79
GGO + Consolidation	14	17.72
GGO	59	74.68
Vascular Enlargement	10	12.65
Crazy Paving	11	13.92
Subpleural Line	9	11.39
Halo	7	8.86
Reticular Pattern	7	8.86
Air Bronchogram	6	7.59
Reverse Halo	3	3.79
Air Bubble	2	2.53
Pleural Effusion	2	2.53
Tree-in-Bud	2	2.53
Bronchectasis	1	1.26
LAP	1	1.26
Pericardial Effusion	0	0
Cavitation	0	0

GGO: Ground glass opacity, LAP: Lymphadenopathy

RESULTS

Of the 100 patients participating in the study, 43 (43%) were male, and 57 (57%) were female, and the mean age was 51.60±17.71 years. 21 (%21) of the patients had no signs of pneumonia in CT, and 79 (%79) patients had positive CT findings. The mean age of 21 patients without pneumonia was 42.47±17.78 and the mean age of 79 patients with pneumonia was 54.02±16.99. These findings show that age and pneumonia rate positively correlates (p: 0.007).

54 (68.35%) of the 79 patients with pneumonia had typical (**Figure 1** and **2**), 18 (22.78%) had indeterminate (**Figure 3**), and 7 (8.80%) had atypical (**Figure 4**) CT findings for SARS-CoV-2 pneumonia. 59 (74.68%) patients had GGO (**Figure 1, 2** and **3**), 3 (3.79%) patients had consolidation, and 14 (17.72%) patients had GGO + consolidation (**Figure 1**) on chest CT . Fifty-six patients (70.88%) had bilateral lung lesions, and 23 patients (29.11%) had unilateral lung lesions. Lower lobe involvement was more prominent in 43 patients (54.43%) and upper lobe involvement in 4 patients (5.06%). 67 (84.81%) of CT findings of the patients with pneumonia have peripherally, 2 (2.53%) centrally distributed, and the remaining 10 patients had peripheral and central distribution. 34 (43.03%) of CT findings of the patients with pneumonia has posterior dominance, 7 (8.86%) anterior dominance and 38 (48%) patients had no anterior/posterior dominancy. Only one patient had LAP, two patients had pleural effusion, and two patients had the tree-in-bud pattern (**Figure 4**). Pericardial effusion or lung cavitation was not observed in any patient. The features of CT findings and rates are given in **Table 2**.

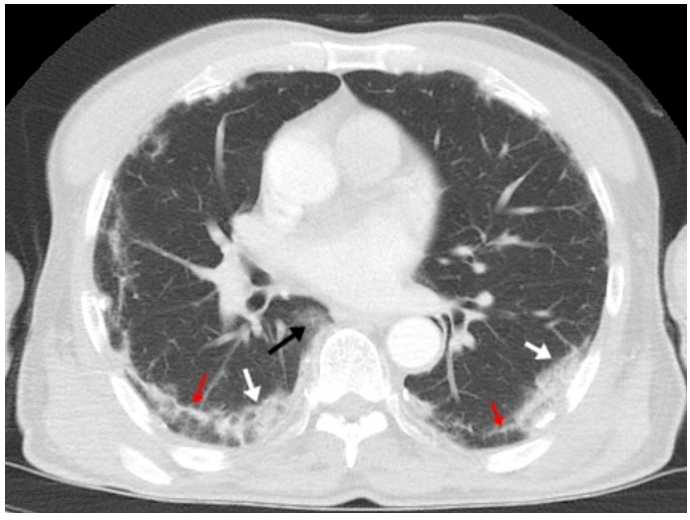

Figure 1. Axial chest CT image shows subpleural line (red arrow), multifocal-peripheral ground-glass opacities (black arrow), and consolidation (white arrow)-typical appearance for SARS-COV-2.

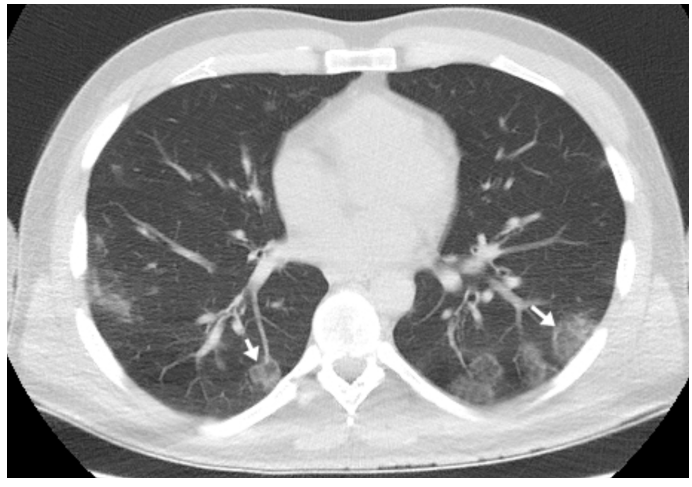

Figure 2. Axial CT image shows peripheral ground-glass opacities with the reverse-halo sign (white arrow). Typical appearance for SARS-COV-2.

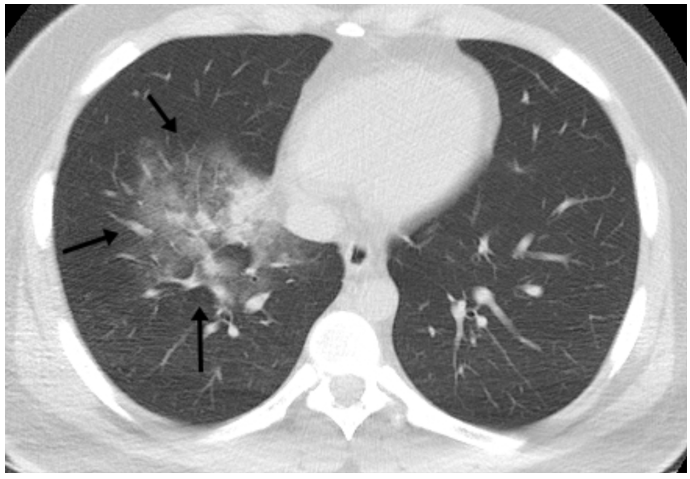

Figure 3. Axial CT image shows central-unilobar ground-glass opacities (black arrow). Indeterminate appearance for SARS-COV-2.

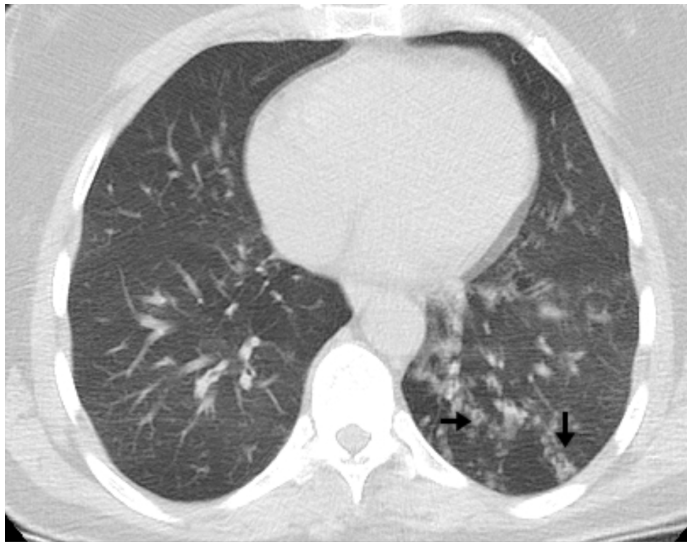

Figure 4. Axial chest CT image shows tree-in-bud pattern (black arrow)-atypical appearance for SARS-COV-2

DISCUSSION

This study evaluating the chest CT features and distribution of patients with SARS-CoV-2 shows that the pneumonia formation of SARS-CoV-2 increases with age. The average age of patients with pneumonia (54.02±16.99 years) was higher than the average age of patients without pneumonia (42.47±17.78), which shows that the rate of SARS-CoV-2 developing pneumonia increases as the patient's age increases ($p< 0.05$). In this study, the higher rate of female patients (57%) and the higher average age of patients with pneumonia (54.02±16.99) were similar to the studies in the literature. In the study of Çinkooğlu et al.[1] the proportion of female patients was 53%, and the mean age of patients with pneumonia was 51.0±15.8. Melendi et al. also found that the average age of patients with pneumonia was higher than the average age of patients without pneumonia (34 vs. 50).[13] On the other hand, lung involvement percentage was just 4% in the early-stage (0–3 days).[14] In this study, we do not know whether this mean age difference is real or related to the early stage of the disease, since the patients were not followed up and the stage of disease during CT scan was not known. This is one of the limitations of our study.

Chest CT has demonstrated about 56–98% sensitivity in detecting SARS-CoV-2 at initial presentation, although RT-PCR has a sensitivity as low as 42–71% for helping detect SARS-CoV-2.[10,15] Although its high sensitivity for the diagnosis of SARS-CoV-2, the specificity of chest CT is low (25%), as noted in a report of 1014 patients in the screening population.[11,16] However, for infectious disease control, sensitivity was more critical than specificity.[8] On the other hand, radiologists in the United States and China distinguished SARS-CoV-2 from other viral pneumonia at chest CT in recent studies.[15] Although GGO was more frequent in patients with SARS-CoV-2, consolidations were more frequent in patients with non-COVID-19 viral pneumonia; both infections were usually bilaterally involving multiple lobes.[17] SARS-CoV-2 pneumonia's CT features like GGO, peripheral distribution, reverse halo sign, vascular enlargement, and reticular opacity were more common than non-COVID-19 viral pneumonia.[15] In non-COVID-19 viral pneumonia, the involvement pattern was peripheral and central, while in SARS-CoV-2, mainly peripheral and posterior, was involved.[17]

This study indicates that GGOs with multifocal, multilobar, peripheral, and bilateral involvement are common chest CT findings in SARS-CoV-2 pneumonia. There was just 54.43% lower lobe dominance and 43.03%posterior dominance in this study. Adams et al. prepared a meta-analysis from 28 publications (a total of 3466 patients) and calculated pooled prevalence about SARS-CoV-2 chest CT findings. Normal chest CT imaging findings prevalence was 10.6% in COVID-19. Prevalences of posterior dominance, GGO, bilateral abnormalities, vascular enlargement, multifocality, peripheral distribution, pleural effusion, LAP, tree-in-bud pattern, central lesion distribution and cavitation were 90.0%, 81.0%, 75.8% , 72.9%, 63.2%, 59%, 5.2%, 5.1%, 4.1%, 3.6% and 0.7%, respectively.[9] In the other studies at literature; the major chest CT abnormalities for SARS-CoV-2 observed were consolidation 2-69%, GGO 34-98%, multifocal 42-63%, peripheral 50-87%, bilateral 75-90%, reticulation 1-59%, crazy-paving 14-34% and 17-56% negative CT findings.[6,11,18-24]

Current studies about CT findings of SARS-CoV-2 in the presence of secondary diseases such as superinfections and aspiration are limited. But recent research shows that more than 20% of patients with SARS-CoV-2 may have co-infections. In this study, the rate of patients with atypical CT findings was 7%, and we do not know if SARS-CoV-2 or other infections caused these findings.[25]

The present study had several limitations. Main limitations are that the research did not include patients with false-negative RT-PCR results, and there was no clinical information about the patients. The disease stage of the patients in the during of CT examination was unknown and their follow-up could not be done. Other limitations are that it is a retrospective study, and the number of patients is low.

CONCLUSION

SARS-CoV-2 is an infection seen with multiple peripheral GGO or GGO+ consolidation, regardless of anterior/posterior dominance and lower lobe/upper lobe dominance in CT.

ETHICAL DECLARATIONS

Ethics Committee Approval: Tokat Gaziosmanpaşa University Ethics Committee approved the study with the number 20-KAEK-225 in 27.08.2020.

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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