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Evaluation of Computed Tomography and PCR Results of Patients Admitted to Pandemic Hospital in Terms of COVID-19

Pandemi Hastanesine Başvuran Hastaların Bilgisayarlı Tomografi ve PCR Sonuçlarının COVID-19 Açısından Değerlendirilmesi

Gulay Macin[1], Salih Macin[2], Ugur Arslan[2]

[1]Beyhekim Training and Research Hospital, Department of Radiology, Konya, Turkey
[2]Selçuk University Faculty of Medicine, Department of Medical Microbiology, Konya, Turkey

Abstract

Aim: COVID-19 is an infectious disease that primarily affects the respiratory system and spreads rapidly. In addition to reverse transcription-polymerase chain reaction (RT-PCR), which is the primary diagnostic method in the COVID-19 pandemic, Computed Tomography (CT) method is also used. The aim of this study is to evaluate the appearance and distribution of abnormal parenchymal findings with thorax CT in patients diagnosed with COVID-19 by RT-PCR method and to evaluate the relationship between the severity of lung infection and the clinical course of the disease in these patients.

Materials and Methods: Patients (n:613) with a preliminary diagnosis of COVID-19 who applied to Selçuk University Training and Research Hospital were evaluated retrospectively between December 2020 and February 2021. Nasopharyngeal samples were studied for COVID-19 with RT-PCR by Selçuk University Medical Faculty Microbiology Laboratory. Thoracic CT images of 361 patients with positive COVID-19 PCR tests were examined for the presence of COVID-19 pneumonia. The clinical course of patients with COVID-19 pneumonia was evaluated.

Results: RT-PCR results was positive in 361 (58.9%) of 613 patients. While 243 (67.3%) of the PCR positive patients had signs of pneumonia, 118 (32.7%) of them had normal lung parenchyma. There was consolidation in 22% of the patients, and ground glass with consolidation in 20%. Thirty four patients (14%) had crazy-paving pattern and 19 (7.8%) patients had reverse halo appearance. A significant relationship was found between the severity of lung infection involvement and the clinical course of the disease.

Conclusion: A comprehensive understanding of diagnostic imaging features is essential for effective patient management and treatment.

Keywords: COVID-19, Computed Tomography, PCR

Öz

Amaç: COVID-19, öncelikle solunum sistemini etkileyen ve hızla yayılan bulaşıcı bir hastalıktır. COVID-19 pandemisinde primer tanı yöntemi olan ters transkripsiyon-polimeraz zincir reaksiyonu (RT-PCR) yanısıra bilgisayarlı tomografi (BT) yöntemi de kullanılmaktadır. Bu çalışmanın amacı, RT-PCR yöntemi ile COVID-19 tanısı konulan hastaların toraks BT ile anormal parankimal bulguların görünüm ve dağılımını ve akciğer enfeksiyonun şiddeti ile hastalığın klinik seyri arasındaki ilişkiyi değerlendirmektir.

Gereç ve Yöntem: Aralık 2020 ile Şubat 2021 tarihleri arasında Selçuk Üniversitesi Eğitim ve Araştırma Hastanesi'ne COVID-19 ön tanısı ile başvuran hastalar (n:613) retrospektif olarak değerlendirildi. Nazofaringeal sürüntü örnekleri Selçuk Üniversitesi Tıp Fakültesi Mikrobiyoloji Laboratuvarında RT-PCR ile COVID-19 açısından çalışıldı. COVID-19 PCR testi pozitif olan 361 hastanın toraks BT görüntüleri COVID-19 pnömonisi açısından incelendi. COVID-19 pnomonisi olan hastaların klinik seyirleri değerlendirildi.

Bulgular: RT-PCR testi 613 hastanın 361'inde (%58.9) pozitifti. RT-PCR testi pozitif olan hastaların 243'ünde (%67.3) pnömoni bulguları varken, 118'inde (%32.7) akciğer parankimi normaldi. Covid-19 hastalarının akciğer bulgularının büyük bir kısmını (%90) buzlu cam görüntüsü oluşturuyordu. Hastaların %22'sinde konsolidasyon, %20 'sinde buzlu cam ile konsolidasyon birlikteliği vardı. Hastaların 34'ünde (%14) çılgın döşeme paterni ve 19'unda (%7.8) ters halo görünümü vardı. Akciğer enfeksiyonu tutulumunun şiddeti ile hastalığın klinik seyri arasında anlamlı ilişki bulundu.

Sonuç: Etkin hasta yönetimi ve tedavisi için tanısal görüntüleme özelliklerinin kapsamlı bir şekilde anlaşılması şarttır.

Anahtar Kelimeler: COVID-19, Bilgisayarlı tomografi, PCR

Corresponding *(İletişim)*: Salih Maçin, Selçuk University Faculty of Medicine, Department of Medical Microbiology, Konya, Turkey
E-mail *(E-posta)*: salihmacin@hotmail.com
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INTRODUCTION

A new type of coronavirus, called severe acute respiratory syndrome Coronavirus-2 (SARS-CoV-2), was isolated from lower respiratory tract samples by the International Virus Taxonomy Committee.[1] The disease was named the new coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO) on February 11, 2020.[2] Since COVID-19 spread rapidly all over the world, it was declared as a pandemic by WHO.[3] Clinical findings in people infected with COVID-19 range from an asymptomatic course to severe pneumonia requiring mechanical ventilation. The most common symptoms of COVID-19 disease have been defined as fever, dry cough, shortness of breath, muscle pain, loss of taste and smell, diarrhea, and vomiting.[4,5]

Rapid diagnosis is needed because the symptoms of COVID-19 are not specific to the disease and the disease can rapidly progress to severe pneumonia and even cause death.[6] Because of the high contagiousness of COVID-19, it is important to detect the disease early and isolate the infected person from the healthy population. For the definitive diagnosis of COVID-19, the SARS-CoV-2 reverse transcription-polymerase chain reaction (RT-PCR) test must be positive from the nasopharyngeal and throat swab samples. RT-PCR test is considered the gold standard in the diagnosis of COVID-19. RT-PCR sensitivity has been reported between 30% and 60% in the first test due to difficulties in sampling, processing, and kit performance.[7] In cases where RT-PCR is false negative, imaging methods have gained importance for the diagnosis of rate. Chest radiography has played an important role in the clinical follow-up of COVID-19 patients, especially intensive care patients. During the pandemic process, Computed Tomography (CT) has been accepted as the most valid imaging method because its sensitivity in showing COVID-19 pneumonia is 98%.[8]

In suspicious cases, CT imaging has gained great importance in terms of making a diagnosis before the RT-PCR test and reducing the risk of transmission by early isolation of the infected person.[9] Currently, thoracic CT has been accepted as one of the main tools for screening, primary diagnosis and evaluation of disease severity.[10] The aim of this study is to evaluate the appearance and distribution of abnormal parenchymal findings from thorax CT images of patients diagnosed with COVID-19 by RT-PCR and to evaluate the relationship between the severity of lung infection and the clinical course of the disease in these patients.

MATERIAL AND METHOD

It is a retrospective study evaluating patients who applied to Selçuk University Training and Research Hospital between December 2020 and February 2021 due to COVID-19. Samples taken from patients with suspected COVID-19 were evaluated by Selçuk University Medical Faculty, Medical Microbiology Laboratory and patients who were found to be RT-PCR positive were included in the study. Pulmonary parenchymal findings of patients with positive RT-PCR test were evaluated in terms of COVID-19 in thorax CT taken at Selçuk Unviersity Training and Research Hospital.

Nasopharyngeal swab samples taken with dacron swaps from patients with suspected COVID-19 were sent to Selçuk University Medical Faculty Hospital Medical Microbiology Laboratory with transfer tubes containing 2 ml VNAT (Viral Nucleic Acid Buffer). After the samples were vortexed, the RT-PCR step took place. BioSpeedy® Direct RT-qPCR SARS-CoV-2 (Bioeksen R&D Technologies Ltd., Istanbul, Turkey) kit was used for RT-PCR. After PCR, RT-qPCR was performed on LightCycler96 (Roche, Switzerland) instrument in accordance with the manufacturer's instructions. Samples that formed a logarithmic curve at the end of the study were accepted as positive (cq<38).

Parenchymal involvement of patients with COVID-19 lung involvement was evaluated as right, left and both lungs from thorax CT images. A severity score was calculated by adapting the scoring made by HYF Yong et al. The involvement score of 0% was scored as zero, the involvement score of less than 5%, the score as 1, the 5-25% involvement score as 2, the 25-50% involvement score as 3, the 50-75% involvement score as 4, and the more than 75% involvement score as 5. The sum of the scores will provide a semi-quantitative assessment for general lung involvement. (Maximum CT score for both lungs was 25). Scoring determined for lung involvement was divided into groups as lung infection severity. The total lung involvement score in the right and left lungs is grouped as 0-5 (Mild), 6-10 (Mild-Moderate), 11-15 (Moderate), 16-20 (Moderate-Severe) and 21-25 (Severe) lung infection.

In addition, patients with lung infections were grouped as outpatients, those who were treated in the hospital ward and intensive care unit, and those who were dead. COVID-19 lung involvement was evaluated in terms of the most common ground glass pattern (GGO), cobblestone view (interlobular and intralobular septal thickening with GGO), consolidation (homogeneous opacification). In addition, secondary findings such as linear opacity (linear, curvilinear opacity or subpleural reticulation), pleural and pericardial effusion, nodule, reverse halo, and lymph node with a short axis greater than 1 cm were also evaluated. The presence of pulmonary lesions were grouped as peripheral (outer 1/3 of the lung parenchyma) and central (inner 2/3 of the lung parenchyma) and diffuse (peripheral and central). Involvement of pulmonary lesions was noted as single lobe, unilateral multilobe and bilateral multilob.

Our study was approved by the Ethics Committee of the Faculty of Medicine, Non-Interventional Clinical Research Ethics Committee of Selçuk University in 24.02.2021, with the decision of the ethics committee numbered 2021/96.

Statistical Analysis

All statistical analyzes were carried out with the help of IBM SPSS 21.0 package program. Before statistical analysis, the normal distribution compliance of the semi-quantitative scoring used to determine the degree of lung involvement was checked with the Shapiro Wilk normality test. Scoring findings were given as mean ± standard deviation, and findings related to other radiological parameters used in the study were given as frequency (n) and percentage (%). Comparison of the involvement scores of the patients in the lower and upper lobes of the lungs was compared using an independent sample t-test. In statistical tests, the significance level was taken as 5%. Data are described as number, percentages (95% confidence intervals). Confidence intervals were calculated by Clopper-Pearson method. p-value was calculated using Chi-square proportion test.

RESULTS

613 patients who applied to Selçuk University Training and Research Hospital were evaluated retrospectively. While 361 (58.9%) of the RT-PCR 613 patients were positive, 252 (41.1%) patients were negative. The lung parenchyma was normal in 118 (32.7%) while there were abnormal findings in the lung parenchyma in 243 of the PCR positive patients (67.3%). While 57 (22.6%) of 252 patients with negative RT-PCR test had abnormal findings in the lung parenchyma, 195 (77.4%) had normal lung parenchyma (**Table 1**). Thoracic CT sensitivity 67.3% (95% CI 62-72%), specificity 77.4% (95% CI 71-82%), positive predictive value 81% (95% CI 77-84), and negative predictive value 62% (95% CI 58-66%) were detected.

Table 1. Evaluation of lung involvement with RT-PCR in patients admitted to the hospital (n = 613)

	Lung involvement positive N(%)	Lung involvement negative N(%)	Total
RT-PCR (+)	243 (67.3)	118 (32.7)	361
RT-PCR (-)	57 (22.6)	195 (77.4)	252

Abnormal findings were found in the lung parenchyma in 243 (67.3%) of 361 patients with positive RT -PCR test. The distribution of lung parenchymal findings of RT-PCR positive COVID-19 patients (n = 243) with lung involvement is shown in **Table 2**. Right and left lung involvement rates were very similar and there was no significant difference ($p < 0.05$). Although the bilateral lower lobe involvement percentage was higher, there was no significant difference between the upper and lower lobe involvement rates ($p < 0.05$).

Abnormal parenchymal findings observed in 243 of RT-PCR positive COVID-19 patients were evaluated as primary and secondary findings and summarized in **Table 3**. The majority of the lung findings of COVID-19 patients were ground glass (GGO). Pericardial effusion was not detected in any patient.

Table 2. Distribution of lung parenchymal findings of RT-PCR positive COVID-19 patients (n = 243) with lung involvement

	N (%)
Right lung	234 (96.3)
Left lung	229 (94.2)
Bilateral lung	221 (90.9)
Single lobe	23 (9.4)
Single sided multilob	217 (89.3)
Bilateral multilob	184 (75.7)
Peripheral	234 (96.3)
Central	136 (56)
Peripheral and central	134 (55.1)
Right lung upper lobe	174 (71.6)
Right lung middle lobe	191 (78.6)
Right lung lower lobe	225 (92.6)
Left lung upper lobe	207 (85.2)
Left lung lower lobe	214 (88.1)
Upper lobe involvement	223 (91.8)
Lower lon involvement	233 (95.9)

Table 3. Characteristics and distribution of parenchymal findings of Covid-19 patients with lung involvement (n:243)

COVID-19 primary findings	N (%)
Ground glass (GGO)	233 (95.9)
Consolidation	54 (22.2)
Ground glass + consolidation	49 (20.2)
Crazy paving	34 (14)
Secondary findings	
Linear opacity	61 (25.1)
Reverse halo	19 (7.8)
Nodule	32 (13.2)
Pleural effusion	9 (3.7)
Mediastinal lymph node	25 (10.3)
Pericardial effusion	0

The distribution of lung parenchymal involvement according to lobes and scores is shown in **Tables 4** and **5**. In lung parenchymal involvement scoring, 3 and above (≥ 25-50%) involvement rate was evaluated as high score; Scores below 3 are considered as low scores. While high score was higher in upper lobes, low score was observed more in lower lobes. The difference between them is statistically significant ($p < .001$). The mean lung involvement score was higher in the left lung compared to the right lung. The mean score in the right lung was highest in the lower lobe; It was mostly detected in the upper lobe of the left lung.

Table 4: Distribution of lung parenchymal involvement by lobes and scores

	Score 0 (%)	Score 1 (%)	Score 2 (%)	Score 3 (%)	Score 4 (%)	Score 5 (%)	Mean±SD
Right lung upper lobe	28.3	46.9	14.8	5.7	3.2	0.8	1.11±1.04
Right lung middle lobe	21.3	49	18.5	4.5	4.5	1.2	1.25±1.06
Right lung lower lobe	7.4	41.9	27.5	9.8	4.1	9	1.37±1.05
Left lung upper lobe	14.8	53.4	19.3	6.1	4.9	1.2	1.88±1.34
Left lung lower lobe	11.9	46.9	20.9	9.4	2.4	8.2	1.68±1.34

Table 5. Lung parenchymal involvement scoring and statistical comparison (n:243)

	Score <3 (Low Score) N (%)	Score ≥3 (High Score) N (%)	P value
Right lung upper lobe	24 (9.9)	219 (90.1)	<.001
Right lung middle lobe	25 (10.3)	218 (89.7)	<.001
Right lung lower lobe	56 (23)	187 (77)	<.001
Left lung upper lobe	30 (12.4)	213 (87.6)	<.001
Left lung lower lobe	49 (20.2)	194 (79.8)	<.001

Scoring determined for lung involvement was divided into groups as lung infection severity. The total lung involvement score in the right and left lung was grouped as 0-5 Mild, 6-10 Mild-Moderate, 11-15 Moderate, 16-20 Medium-Severe and 21-25 Severe lung infection. In addition, patients with lung infections were grouped as outpatients, those treated in the hospital ward and intensive care unit, and those who were dead. A significant relationship was found between the severity of lung infection involvement and the clinical course of the disease. While 58.3% of the patients with mild lung infection were treated on an outpatient basis; 80.9% of the patients with mild-moderate lung infections were treated in the service at the hospital. While none of the patients with moderate and severe lung infections were on an outpatient basis, 36% were found to be dead, 9% were treated in the intensive care unit and the rest in the service. There was a significant relationship between the course of the disease and age, and as the age increased, the treatment and ex rates in the intensive care unit increased. While the average age of the outpatients was 47; The average age of those treated in the intensive care unit and the patients who died was 69 years old. There was no significant relationship between the severity of lung infection and age.

DISCUSSION

COVID-19 is an infectious disease that primarily affects the respiratory system, starting in China and causing a pandemic by spreading all over the world. Early diagnosis methods play an important role in controlling the disease.[11] RT-PCR and thorax CT imaging has been accepted as the most important diagnostic methods. Although RT-PCR is the gold standard, radiological imaging methods have gained importance because of its false negative results. Thorax CT has become the prominent diagnostic method in COVID-19 due to its high sensitivity in showing abnormal changes in the lung parenchyma in the early period.[12,13]

In the study conducted by T.Ai et al.[14] on 1014 patients, the sensitivity of thorax CT in demonstrating COVID-19 infection was found to be 97% and specificity 25% by reference to RT-PCR. In our study, thorax CT sensitivity was found lower and specificity was higher. More than 80% of patients with negative RT-PCR tests had typical CT signs. On the one hand, because of the overlap of CT imaging features between COVID-19 and other viral pneumonia, false positive cases of COVID-19 can be identified by chest CT.

T.Ai et al.[14] in 90% of 888 patients, Chung et al.[12] in 76% of 21 patients, a review study of 919 patients,[15] 87.5% of bilateral lung involvement was demonstrated. Bilateral lung involvement was 61.2% in our study, and bilateral lung involvement was less than other studies. In addition, no significant difference was reported between the rates of right and left lung involvement in the studies performed, and similarly, no significant difference was found between the two lung involvement rates in our study.[16,17]

Song et al.[18] reported single lobe involvement 8% and five lobe involvement 39%; Liu et al.[19] reported a single lobe involvement rate as 8% and five lobe involvement rate as 43%, Chung et al.[12] reported a five-lobe involvement rate as 38%. In our study, the single lobe involvement rate was 9.4% and the five lobe involvement rate was 35%, which is similar to other studies. Peripheral location rate was reported by Han et al.[20] 90% of 108 patients, Song et al.[18] reported 84%, and 76% in a review study[15] of 919 patients. Since the blood and lymph flow is more intense in the peripheral area, the inflammatory response to the virus is most common in these areas. Lesions in thoracic CT imaging are often thought to be secondary to this hypothesis with peripheral localization.[20] In our study, central and peripheral-central (mixed) involvement was similar, and no difference was observed.

Han et al. detected ground glass in 80% of 108 patients, ground glass and consolidation in 41%, and crazy paving stone pattern in 40%.[20] W. Zhao et al.[22] found the ground glass frequency 86.1% and consolidation frequency 43.6%; Wu et al.[21] reported the ground glass ratio as 53.2% and the consolidation rate and ground glass ratio together as 46.2%. T.Ai et al.[14] detected ground glass in 46% and consolidation in 50% of 888 patients. Similar to other studies, the rate of ground glass was found to be higher in our study. Consolidation and consolidation-ground glass association was less determined.

Table 6. Comparison of the severity and clinical course of lung parenchymal involvement

Score	Lung Involvement Severity	N (%)	Outpatient Treatment N (%)	Treatment in the Ward N (%)	Intensive care N (%)	Ex N (%)	P
							<.001
0-5	Mild	110 (45)	63 (58.3)	42 (8.9)	2 (1.9)	1 (0.9)	
6-10	Mild-Moderate	89 (36.6)	12 (13.5)	72 (80.9)	1 (1.1)	4 (4.5)	
11-15	Moderate	22 (9)	2 (9.1)	17 (77.3)	1 (4.5)	2 (9.1)	
16-20	Medium-Severe	13 (5.3)	0 (0)	9 (69.2)	0 (0)	4 (30.8)	
21-25	Severe	9 (3.7)	0 (0)	3 (33.3)	2 (22.2)	4 (44.4)	

Jin et al.[23] found secondary findings such as bronchial wall thickening, pleural effusions, lymphadenopathy, and ground glass-surrounded pulmonary nodules in approximately 7% of patients. In our study, 25 (10%) patients had mediastinal lymph nodes, 19 (7.8%) patients had reverse halo, 32 (13%) patients had nodules, and 9 (3.7%) patients had pleural effusion. Secondary findings were detected low. In some studies,[15,24] differences in ground glass and consolidative opacity ratios were found to be statistically significant between age groups (p <0.001). In our study, no significant relationship was found between age and the pattern of ground glass, consolidation, ground glass-consolidation, and crazy paving lung involvement. While Song et al. Commonly reported secondary findings in elderly patients, no significant relationship was found between these findings and age in our study.[18]

There are not many studies evaluating pulmonary parenchymal involvement by scoring in the literature. In this study, a semi-quantitative scoring method was used to assess the amount of lung opacification of 5 lobes and the COVID-19 burden. In our study, the mean lung involvement score was higher in the left lung than in the right lung. R. Yang et al.[25] did not find a significant difference between left and right lung scores. In our study, while 3 or more (≥ 25-50%) involvement rate was evaluated as a high score in the scoring of lung parenchymal involvement; scores below 3 are considered as low scores. R. Yang et al. used a different scoring method than our study. However, they found lower lobe scores higher than middle-upper lobe scores in both patients with low and high scores. In our study, while the high score was higher in the upper lobes, the low score was observed more in the lower lobes. The difference between them was statistically significant (p <.001).

Among the secondary findings, only a relationship was observed between pleural effusion and moderate to moderate-severe lung infection, but no significant relationship was observed between other secondary findings and the severity of lung infection. While R.Yang et al.[25] detected pleural effusion in seven cases and lymphadenopathy in two cases in the severe group, they did not detect pleural effusion and lymphadenopathy in the mild group.

Ground glass pattern was the most common in patients with low and high scores. Patients with pure consolidation with ground glass and consolidation were mostly high scored patients. The crazy paving pattern was more common in high scoring patients than in low scoring patients. Li K et al.[26] compared the chest CT findings of patients with severe and mild COVID-19 pneumonia and reported that the consolidation rate was 88% in patients with severe disease and 53.4% in patients with milder symptoms. Similarly, in our study, more consolidation was observed in patients with high scores than in patients with low scores.

There was no relationship between the ground glass pattern and the course of the disease. Patients with consolidation (15%) compared to patients without (4%) consolidation with ground glass (11%), those with a crazy-paving pattern (21%) compared to those without (4%), compared to those without (4%) It was thought that the ex rate increased. There was no significant relationship between pulmonary involvement patterns and those treated in the intensive care unit, suggesting that patients with consolidation, consolidation and ground glass, crazy-paving pattern had a worse prognosis than those without.

CONCLUSION

While there are abnormal findings in the lung at the time of diagnosis in the majority of RT-PCR positive patients; there were also patients who were negative for RT-PCR but showed typical findings for covid pneumonia in the lung. In the cases of COVID-19, a largely ground-glass pattern with peripheral localization was observed on CT. While ground glass pattern was observed in patients with low and high scores, consolidation on ground glass, pure consolidation, and crazy cobblestone view were observed more in patients with high scores. While the high score was higher in the upper lobes, the lower score was higher in the lower lobes. Among the secondary findings, a relationship was observed between pleural effusion and the severity of infection. A significant relationship was found between the severity of lung infection involvement and the clinical course of the disease. While none of the patients with moderate and severe lung infections were on an outpatient basis, one third of them died and the rest were treated in the intensive care unit and the ward. A significant relationship was found between the course of the disease and age, and as age increased, treatment and ex rates in the intensive care unit increased.

A comprehensive understanding of diagnostic imaging features is essential for effective patient management and treatment. In the patient population suspected of COVID-19, typical imaging findings of COVID-19 should be interpreted with caution. In addition, this study provides a simple semi-quantitative method to assess the severity of COVID-19 on initial chest CT images. Thus, the course of the disease can contribute to patient management.

This study had some limitations. While evaluating the thorax CT sensitivity and specificity, the interpretation was made according to the first RT-PCR and thorax CT images.

ETHICAL DECLARATIONS

Ethics Committee Approval: Our study was approved by the Ethics Committee of the Faculty of Medicine, Non-Interventional Clinical Research Ethics Committee of Selçuk University in 24.02.2021, with the decision of the ethics committee numbered 2021/96.

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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