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Research Article

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RELATIONSHIP BETWEEN THE CHEST CT CHARACTERISTICS AND CLINICAL OUTCOMES OF COVID-19 PATIENTS BY AGE GROUPS

COVID-19 HASTALARINDA YAŞ GRUPLARINA GÖRE TORAKS BT BULGULARI VE KLİNİK SONLANIM ARASINDAKİ İLİŞKİ

Selçuk Parlak[1], Muhammed Said Beşler[1], Utku Eren Özkaya[1]
Esra Çıvgın[1], Ebru Şengül Parlak[2]

[1]Ankara City Hospital, Department of Radiology, Ankara
[2]Ankara City Hospital, Department of Chest Diseases, Ankara

Yazışma Adresi / Correspondence:
Uzm. Dr. Selçuk Parlak (e-mail: selcukparlakdr@gmail.com)

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Ankara Yıldırım Beyazıt University Faculty of Medicine
Department of Family Medicine

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Öz

Amaç: COVID-19 hastalarında yaşın, toraks bilgisayarlı tomografi (BT) bulguları ve hastalık şiddeti üzerindeki etkisini analiz etmek.

Materyal ve Metot: Çalışma, 1 Nisan 2020-1 Haziran 2020 tarihleri arasındaki 367 COVID-19 hastasının toraks BT görüntülerini içeriyordu. Hastalar dört yaş grubuna ayrıldı: Grup A (≤19 yaş), grup B (20-39 yaş), grup C (40-59 yaş) ve grup D (≥60 yaş). BT'de lateralite, tutulan loblar, lezyon sayısı, lezyon tipleri ve lezyon dağılımı değerlendirildi ve karşılaştırıldı.

Bulgular: Çalışma popülasyonu 367 hastadan (210 erkek, 157 kadın, ortalama yaş 47.50, aralık 12-92 yaş) oluşmaktaydı. Yaş grupları arasında cinsiyet farkı yoktu. Tüm yaş gruplarında en sık görülen BT bulgusu buzlu cam opasitesiydi. Lezyon sayısının da daha fazla olduğu yaşlı hastalarda konsolidasyonlar, kaldırım taşı manzarası ve hava bronkogramları daha yaygındı. Yaşlı hastalarda üst loblar ve sağ orta lob daha sık etkilenmişti. Grup A ve B'de mortalite saptanmazken, grup C ve D'de yoğun bakım ihtiyacı ve ölüm oranları daha yüksekti. ROC eğrisi analizi, kötü prognoz açısından 55 yaşın optimal kesim değeri olduğunu ortaya koydu.

Sonuç: COVID-19 hastalarının toraks BT bulguları yaşa göre değişiklik göstermektedir. Bilateral, multiple ve yaygın infiltrasyonlar, konsolidasyon, hava bronkogramı, kaldırım taşı manzarası ile üst lobların tutulumu ve ileri yaş kötü prognoz işareti olarak düşünülmelidir.

Anahtar Kelimeler: COVID-19, multidedektör bilgisayarlı tomografi, yaşlı, pnömoni

Abstract

Objectives: To analyze the effect of age on chest computed tomography (CT) features and disease severity in COVID-19.

Materials and Methods: The study included the chest CT images of 367 patients with COVID-19 between April 1, 2020, and June 1, 2020. The patients were divided into four age groups: Group A (≤19 years), group B (20-39 years), Group C (40-59 years), and Group D (≥60 years). On chest CT, laterality, involved lobes, number of lesions, lesion types, and lesion distribution were evaluated and compared.

Results: The study population consisted of 367 patients (210 male and 157 female, mean age 47.50 years, range 12-92 years). There was no significant gender difference between the age groups. The most common CT finding in all age groups was ground-glass opacity. Consolidations, crazy-paving patterns, and air bronchograms were more common in elderly patients, in which the number of lesions was also higher. The upper lobes and the right middle lobe were affected more frequently in elderly patients. While no mortality was found in groups A and B, the rates of intensive care admission and mortality were higher in groups C and D. The ROC curve analysis revealed that 55 years of age was the optimal cut-off value to predict a worse outcome.

Conclusion: The CT findings of COVID-19 patients vary in different age groups. Bilateral, multiple and diffuse infiltrations, consolidation, air bronchogram, and crazy-paving patterns, upper lobe involvement, and older age should be considered as an indicator for worse outcomes.

Keywords: COVID-19, multidetector computed tomography, elderly, pneumonia.

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Introduction

Coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first reported in Wuhan, China in December 2019.[1,2] The disease rapidly spread to other cities in China and the entire world.[3] The World Health Organization (WHO) declared the increasingly spreading disease as a global pandemic on March 11, 2020.[4] As of October 4, the number of confirmed cases reported by WHO was 34,804,348, and the number of deaths 1,030,738.[5]

The virus is transmitted through large droplets scattered in the environment during coughing and sneezing. The common symptoms are fever, cough, sore throat, headache, fatigue, and dyspnea. COVID-19 may be asymptomatic in mild cases, while severe cases can progress to pneumonia, acute respiratory distress syndrome, and multi-organ dysfunction.[2,6]

The real-time reverse transcription-polymerase chain reaction (RT-PCR) test is the reference standard in the diagnosis of COVID-19.[6,7] However, the sensitivity of RT-PCR is not very high, and false-negative results in repeated tests cause difficulties in diagnosis and delays in treatment.[7] Computed tomography (CT) can detect lung lesions at a high sensitivity rate; therefore, it is a useful tool, especially in cases with high clinical suspicion and negative RT-PCR tests in the early stage.[7,8] The common chest high-resolution CT (HRCT) findings of COVID-19 include ground-glass opacity (GGO), GGO with interlobular septal thickening (crazy-paving pattern), and consolidation, particularly in the lower lobes with a peripheral or posterior distribution. Pleural effusion, pericardial effusion, lymphadenopathy, cavitation, halo sign, and pneumothorax can also be seen, albeit rarely.[8]

It has been reported in the literature that COVID-19 has a severe clinical manifestation with higher mortality in the elderly compared to young patients.[9,10] The aim of this study was to compare COVID-19 patients according to age groups in terms of clinical and chest HRCT findings.

Materials and Methods

This retrospective study was approved by the ethics committee of our hospital (approval number: E1-20-1277) and the Republic of Turkey Ministry of Health COVID-19 Scientific Research Committee. Data were collected between April 1st, 2020, and June 1st, 2020, from a total of 367 patients with PCR-confirmed COVID-19. All consecutive patients within the stated time interval were included in the study except for eight chest CT imaging with prominent respiratory motion artifacts. Chest CT images were not analyzed if the patients had no positive PCR test. For all patients, the PCR test and chest CT were performed on the same day. HRCT was performed using a 128-slice multidetector scanner (GE Revolution EVO 128 Slice CT Scanner, GE Medical Systems, Milwaukee, WI, USA) reserved only for COVID-19-suspected cases. All scans were performed without

intravenous contrast media with the patient in the supine position during end-inspiration. The following technical parameters were used: tube voltage 100 kV, tube current 90-300 mAs, spiral pitch factor 0.98, collimation width 0.625, and slice thickness 1.3 mm with a sharp reconstruction kernel. The chest HRCT images were evaluated using the Picture Archiving and Communication System (PACS).

The patients were divided into four groups according to age: Group A (≤19 years), Group B (20-39 years), group C (40-59 years), and Group D (≥60 years). Two senior radiologists experienced in chest CT imaging evaluated the images and classified the HRCT findings by consensus. After a detailed analysis and evaluation of the images, the CT features included (i) laterality, (ii) involved lobes, (iii) peripheral, central or diffuse involvement, (iv) number of lesions (single or multiple), (v) lesion types (GGO, consolidation, interlobular septal thickening, crazy-paving pattern, air bronchogram, linear opacity, adjacent pleural thickening, pleural effusion, halo sign, pericardial effusion, bronchial dilatation, vascular enlargement, atelectasis, lymphadenopathy, acinar nodules, and mosaic perfusion). The peripheral zone was defined as the outer one-third region of the lung, and the central zone as the inner two-thirds region. If both the peripheral and central zones were affected, the term 'diffuse involvement' was used.

Statistical Analysis

Statistical analysis was performed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). In descriptive statistics, normal distribution was determined by one-sample Kolmogorov-Smirnov test, and continuous variables that were not normally distributed were expressed as median (minimum-maximum) values, while categorical variables were presented as numbers and percentages. The Kruskal-Wallis test was used to compare the variables between the groups. The differences between the categorical variables were calculated by the chi-square test. A receiver operating characteristic (ROC) curve was applied to obtain the optimum cut-off value of age in predicting severe disease. A p-value of < 0.05 was considered statistically significant.

Results

The study population consisted of 367 patients (210 male and 157 female, mean age 47.50 years, range 12-92 years). There was no significant gender difference in age groups. The most common CT finding in all age groups was GGO without a statistically significant difference (Figure 1). Consolidation, air bronchogram, crazy-paving pattern, and pleural effusion were statistically more common in elderly patients ($p < 0.05$) (Table 1) (Figure 2). No air bronchogram, crazy-paving pattern, linear opacity, pleural effusion, or thickening was detected in group A (Figure 3). Pleural effusion was a rare finding of COVID-19 and was not detected in group A or B. In group A, while the number of cases with unilateral involvement was higher than those with bilateral involvement cases, the bilateral feature of the lesions increased with age reaching 86.70% in group D ($p <$

0.001). Lesions of both the upper lobes and right middle lobe were more common in patients in groups C and D than in patients in groups A and B ($p < 0.001$). Most of the lesions in younger patients (groups A and B) were located in the peripheral zone. There was no significant difference in central zone involvement between the age groups, but the cases involving both the peripheral and the central zones were more common in groups C and D than in groups A and B ($p < 0.001$). Solitary lung lesions were also more common in group A. The number of lesions increased with age, and especially in group D, the majority of the patients had multiple lesions (92.20%). There was no intensive care required for any patient in group A. In group B, only three (2.50 %) patients were treated in the intensive care unit (ICU), and they were also discharged with healing. In group D, 38 (42.20%) patients were admitted to ICU. There were no deaths in groups A and B (Table 1). The ROC curve analysis revealed that 55 years was the optimal cut-off age value to predict ICU requirement (area under the curve: 0.841, 95% confidence interval: 0.783-0.898, $p< 0.001$). The sensitivity and specificity values were 72.20% and 74.80%, respectively (Figure 4).

Figure 1. Ground glass opacities (arrows), the most common imaging finding in COVID-19.

Figure 2. Axial chest CT of a 77-year-old male showing bilateral consolidations (arrow) containing air bronchograms (open arrow) posteriorly and crazy-paving pattern (arrowhead) predominantly in the anterior regions.

Figure 3. Axial chest CT of a 19-year-old female patient showing two ground-glass opacities (arrows) with subpleural distribution in the lower lobe of the right lung.

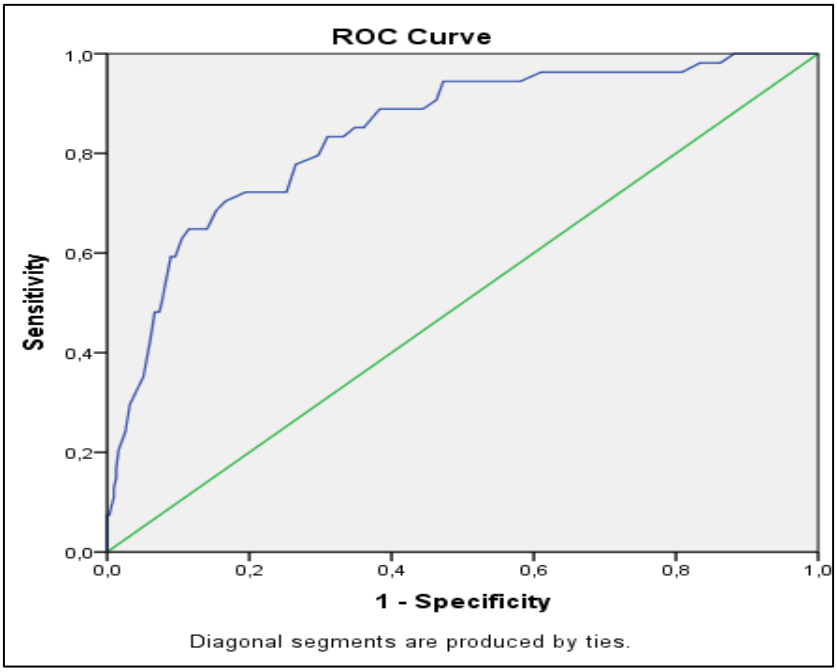

Figure 4. Receiver operating characteristic (ROC) curve analysis for age in the prediction of intensive care requirement. Area under the curve: 0.841 (95% confidence interval: 0.783-0.898, $p < 0.001$).

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Table 1. Comparison of HRCT findings and prognosis of COVID-19 in different age groups.

	Age group				p
	≤19 years	20-39 years	40-59 years	≥60 years	
Number of patients	12 (3.20%)	122 (33.20%)	143 (38.90%)	90 (24.50%)	
Gender					
Female	6 (50%)	47 (38.50%)	58 (40.60%)	46 (51.10%)	0.163
Male	6 (50%)	75 (61.50%)	85 (59.40%)	44 (48.90%)	
Lesion side					
Unilateral	8 (66.70%)	54 (44.30%)	27 (18.90%)	12 (13.30%)	**<0.001**
Bilateral	4 (33.30%)	68 (55.70%)	116 (81.10%)	78 (86.70%)	
Lesion location					
Right upper lobe	4 (33.30%)	49 (40.20%)	96 (67.10%)	78 (86.70%)	**<0.001**
Right middle lobe	-	51 (41.80%)	98 (68.50%)	74 (82.20%)	**<0.001**
Right lower lobe	5 (41.70%)	94 (77%)	117 (81.80%)	74 (82.20%)	**0.028**
Left upper lobe	4 (33.30%)	45 (36.90%)	98 (68.50%)	72 (80%)	**<0.001**
Left lower lobe	4 (33.30%)	35 (28.70%)	89 (62.20%)	63 (70%)	**<0.001**
Lesion location					
Peripheral	10 (83.30%)	90 (73.80%)	76 (53.10%)	43 (47.80%)	**<0.001**
Central	1 (8.30%)	8 (6.60%)	5 (3.50%)	-	
Diffuse	1 (8.30%)	24 (19.70%)	62 (43.40%)	47 (52.20%)	
Lesion number					
Solitary	7 (58.30%)	42 (34.40%)	28 (19.60%)	7 (7.80%)	**<0.001**
Multiple	5 (41.70%)	80 (65.60%)	115 (80.40%)	83 (92.20%)	
Pulmonary lesions					
Ground glass opacity	12 (100%)	115 (94.30%)	136 (95.10%)	86 (95.60%)	0.941
Consolidation	2 (16.70%)	35 (28.70%)	47 (33.10%)	43 (47.80%)	**0.002**
Air bronchogram	-	15 (12.30%)	20 (14%)	18 (20%)	**0.047**
Pleural effusion	-	-	2 (1.40%)	10 (11.10%)	**<0.001**
Linear opacity	-	7 (5.70%)	22 (15.40%)	30 (33.30%)	**<0.001**
Crazy-paving pattern	-	17 (13.90%)	36 (25.20%)	35 (38.90%)	**<0.001**
Pleural thickening	-	21 (17.20%)	33 (23.10%)	20 (22.20%)	0.106
Halo sign	2 (16.70%)	3 (2.50%)	2 (1.40%)	2 (2.20%)	0.140
Pericardial effusion	-	1 (0.80%)	2 (1.40%)	2 (2.20%)	0.338
Bronchial dilatation	-	1 (0.80%)	-	-	0.306
Vascular enlargement	-	4 (3.30%)	7 (4.90%)	9 (10%)	**0.025**
Atelectasis	1 (8.30%)	2 (1.60%)	3 (2.10%)	5 (5.60%)	0.323
Lymphadenopathy	-	-	-	3 (3.30%)	**0.016**
Acinar nodules	-	1 (0.80%)	2 (1.40%)	-	0.705
Mosaic perfusion	-	-	1 (0.70%)	-	0.854
Hospitalization					
ICU	-	3 (2.50%)	13 (9.10%)	38 (42.20%)	**<0.001**
Non-ICU	12 (100%)	119 (97.50%)	130 (90.90%)	52 (57.80%)	
Mortality/surviving					
Mortality	-	-	5 (3.50%)	15 (16.70%)	**<0.001**
Surviving	12 (100%)	122 (100%)	138 (96.50%)	75 (83.30%)	

*Linear by linear association, ICU: intensive care unit

Discussion

COVID-19, which has been transmitted to millions of people worldwide, can affect all age groups. Studies have shown that the disease is milder in the pediatric age group. On the contrary, in studies conducted in different age groups, it has been reported that the disease is more severe and mortality is higher among the elderly.[11,12]

In this study, the common chest CT findings were defined and detailed in terms of the level of lesions, lung lobe distribution, and diffusivity, and they were then compared between different age groups. GGO was the most common manifestation in all age groups. Consolidations, crazy-paving patterns, and air bronchograms were more common in elderly groups. There was no patient with the crazy-paving pattern or air bronchograms in group A. Song et al. stratified their patients into two age groups (≤50 years and >50 years) and reported a significant rate of consolidation in the older group that also tended to have more areas of lung involvement.[13] Similarly, Chen et al. observed that the crazy-paving pattern and air bronchograms were common in the elderly groups.[11] However, unlike our study, the authors found no difference between the age groups in terms of the consolidation. There was no sign of air bronchogram in any of the lesions in the youngest group, which is consistent with our study findings. In another study, it was reported that both the upper lobes and the right middle lobe were affected more frequently in elderly patients.[12] This is in agreement with the lobar distribution observed in our study and suggests that the lower lobes are frequently involved in the general population, while the upper lobes are involved as the age increases. In the literature, bilaterality, both peripheral and central involvement, and multiple lesions are all described to be more common in elderly groups. It has also been suggested that older patients with multiple comorbidities are more likely to have impaired body function and weakened immune systems, and thus are more susceptible to alveolar damage and inflammatory exudates caused by COVID-19.[11,12] These findings are evidence that in elderly patients, COVID-19 has a greater and broader effect on the lungs. Involvement of larger areas is associated with the disease severity.

From the existing data, it is clear that the disease is more severe in the elderly. The need for intensive care and the mortality rate is higher in this patient population.[9,14] In a study by Chen et al., the mortality of older patients was significantly higher than that of younger patients (34.50% vs. 4.70%, $p < 0.001$).[14] In another study conducted with 301 confirmed COVID-19 cases, the optimal cut-off value of age for differentiating between progression and no progression was found to be 50 years.[15] In the current study, the optimal cut-off value was calculated as 55 years in the prediction of intensive care requirement. In our study, only three patients in groups A and B were admitted to ICU, and there was no mortality in these groups. Thirteen (9.10%) patients in group C and 38 (42.20%) in group D were admitted to ICU. Among these patients, five in group C and 15 in group D died. When the findings were evaluated together, bilateral and larger involvement, crazy-paving pattern, consolidation, and accompanying pleural effusion were indicators for worse outcomes in elderly patients.

Limitations

There were some limitations to this study. The number of patients in group A was less compared to the other groups, which may have affected the results. In addition, the admission time of the patients to the hospital did not coincide with the onset of symptoms for all patients. While some patients presented to the hospital on the first symptomatic day, others presented on the following days. This may have caused differences in chest CT findings. Ground glass appearances can be caused by other conditions such as heart failure, pulmonary edema. However, in the current study, there were only a few patients with pleural effusion indicating fluid overload. Thromboembolic complications could not be evaluated since all acquisitions were performed without contrast media. Lastly, this study did not include the evaluation of smoking history, which may also be an important risk factor for the development and course of infection in elderly patients.

In conclusion, chest CT is an important tool for the diagnosis, treatment management, and follow-up of COVID-19-infected patients. Elderly people are more susceptible to the virus, and they also have higher rates of intensive care requirement and mortality rates. Bilateral, multiple, and diffuse infiltrations in the form of consolidation, air bronchogram, and crazy-paving pattern involving upper lobes in patients older than 55 years should be considered as indicators of poor prognosis. The treatment plan may need to be revised in these patients.

Conflict of interest

The authors declare that there is no conflict of interest.

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