

Evaluation of spleen volume in thoracic computed tomography in patients with COVID-19 pneumonia

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ABSTRACT

Objectives: There is not enough data on the effect of COVID-19 on spleen volume in patients with COVID-19. Our aim was to compare the spleen volume of the COVID-19 patients with the control group.

Material and Method: 214 Patients (121 men, 93 women) who have a diagnosis of COVID-19 who have thorax CT were included in the study. In the patient group, there was evidence of viral pneumonia on thoracic CT or PCR was positive, all of them were patients who received treatment for Covid. The control group consisted of 185 patients (106 men, 79 women). Interobserver agreement was calculated. Analysis of the receiver operating characteristic (ROC) curve was used to identify a spleen volume cutoff value at which the accuracy for COVID-19 diagnosis was maximised.

Results: The mean spleen volume of the patient group was found to be 260 (range, 96.3-565, SD: 82.5) which was statistically significantly higher than the control group which was 220 (range, 125.9-331.9, SD: 34.5) ($p < 0.05$). Excellent agreement was found between two blind observers and between intraobserver spleen volume measurements. In our study, the spleen volume for the diagnosis of COVID-19 pneumonia was 208.4 (AUC 0.639; 95% CI 0.584-0.695), sensitivity and specificity were 69.6% and 66.7%, respectively.

Conclusions: Quantitative evaluation of spleen volume can give an idea about the Covid diagnosis. Spleen volume is higher in Covid group than control group.

Keywords: Coronavirus disease, COVID-19, computed tomography, splenomegaly

INTRODUCTION

Novel coronavirus disease 2019 (COVID-19) is an infectious disease that first appeared in Wuhan province, People's Republic of China (1). In the following process, this disease spread all over the world and was declared as a pandemic by the World Health Organization (WHO) (2). Although the gold standard for diagnosis is the real-time reverse transcription polymerase chain reaction (RT-PCR) test, thorax computed tomography (CT) examination stands out as a very important modality, especially in patients with clinical symptoms and negative results of the test (3). The spleen is the largest organ of the reticuloendothelial system. Increased spleen size (splenomegaly) is an important clinical finding especially for liver diseases and various diseases

such as immune system, hematopoietic system, portal hypertension, splenic vein thrombosis and lymphoma. Therefore, it seems necessary to properly evaluate the size of the spleen, both in order to initiate a diagnostic process and to make appropriate treatment decisions and to follow the treatment response in certain cases (4,5). Radiological imaging methods are widely used in the evaluation of spleen volume (6-9). In this study, it was aimed to measure the spleen size in thoracic CT of patients who were examined with non-contrast thorax CT with suspected COVID-19 and taking Covid treatment, to calculate the spleen volume and to evaluate the relationship between spleen volume and COVID-19.

MATERIAL AND METHOD

Patient Population

Our study was approved by the Ümraniye Training and Research Hospital Ethics Committee (protocol number: B.10.1.TKH.4.34.H.GP.0.01). Patients who were examined with non-contrast thorax CT due to the suspicion of COVID-19 at the Haydarpaşa Sultan Abdulhamidhan Training and Research Hospital Radiology Department between April 4 and May 26 were retrospectively screened. Of the 360 patients found, 214 with radiological findings of infection or positive PCR were included in the study. 145 patients were excluded from the study. Of these 145 patients removed, 11 were not eligible for evaluation due to low image quality and 132 because the CT sections passing through the upper abdomen did not completely contain the spleen. Two patients were not included in the study due to their history of splenectomy. The control group consisted of 185 patients. All of them were patients who underwent thoracic CT for other reasons other than infection in 2019. In the patient group, there was evidence of viral pneumonia on thoracic CT or PCR was positive, all of them were patients who received treatment for Covid.

Technical Data

All patients were imaged in the supine position on 320 detector CT (Aquilion-ONE, Toshiba Medical Systems, Otawara, Japan). All images were obtained at 5 mm slice thickness in the lung window in the standard dose protocol. Standard protocol (120 kVp, auto-mA — maximal 350 mA) was used for thoracic CT scans. CT images were acquired at the end of the inspirium

for a single breath-hold period. 1.25 mm collimation, 400 milliseconds (msec) rotation, 1.35 pitch, 120 kV in X-ray tube and 400–480 milliamper/second (mAs), section thickness; 1.25 mm and reconstruction interval; Parameters of 2.5 mm were used. Field of view (FOV) was adjusted according to the size of the patient and a 512x512 matrix was used.

Evaluation of Images

Spleen index measurements in thoracic CT of the patients included in the study were made by two radiologists with 8 years and 9 years of professional experience. Both radiologists measured the spleen size unaware of each other's results. After both radiologists made the measurements separately, the 1st radiologist made all measurements again 15 days later. Measurements were made using picture archiving and communication system (PACS).

Spleen Volume Calculation

The methodology in the study by Kucybała et al. (10) was used to calculate the spleen volume. First of all in axial section (**Figure 1a**), maximal length (L)—the longest dimension between poles of the spleen, the thickness (T) at the level of the hilum was obtained by measuring the distance between the inner and outer contours of the spleen. After that, the maximum height (H) of the spleen was measured by measuring the distance between the upper and lower pole of the spleen in coronal reformatted sections (**Figure 1b**). Spleen volume was calculated using the formula of “ $30 + 0.58 (L \times T \times H)$ ” and the range of 110-340 mL was accepted as the normal range, while the value above 340 ml was evaluated as splenomegaly (10) (**Figure 2**).

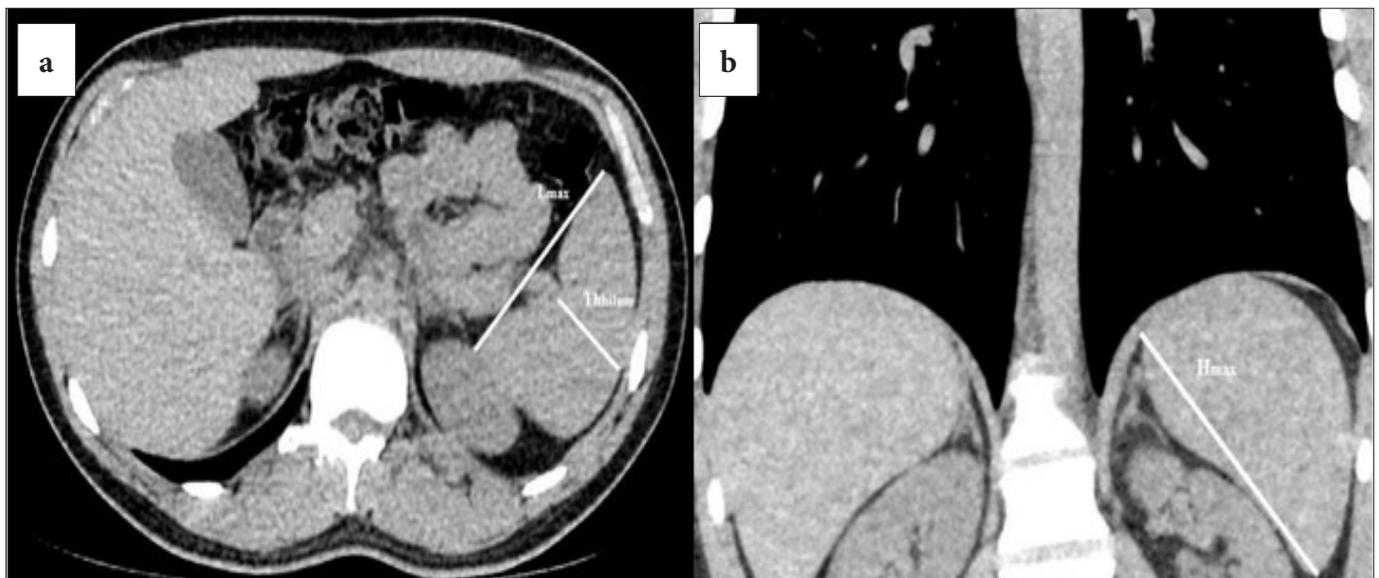


Figure 1. The method for calculating spleen volume on CT. First of all in axial section (**a**), maximal length (L)—the longest dimension between poles of the spleen, the thickness (T) at the level of the hilum was obtained by measuring the distance between the inner and outer contours of the spleen. After that, the maximum height (H) of the spleen was measured by measuring the distance between the upper and lower pole of the spleen in coronal reformatted sections (**b**).

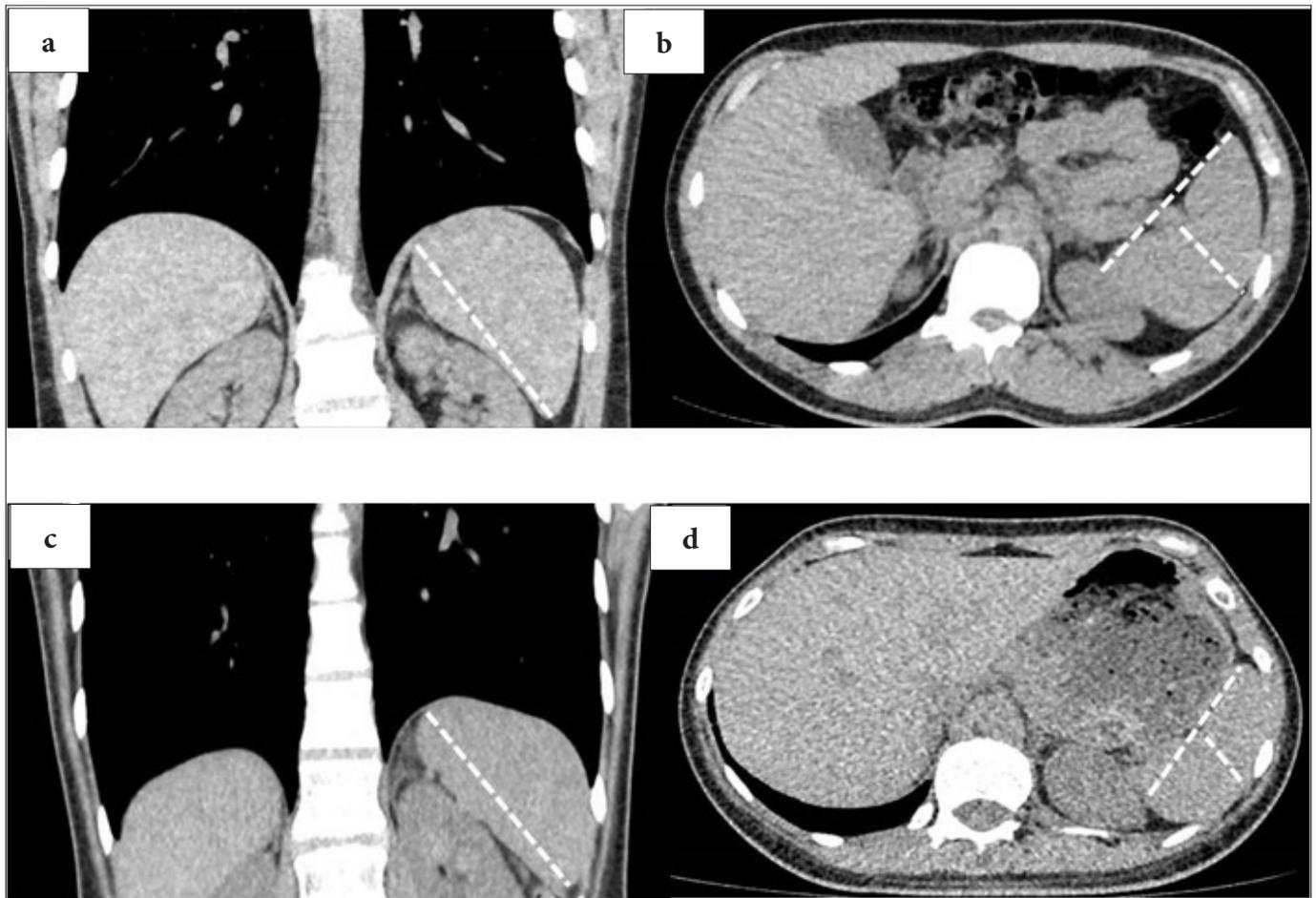


Figure 2. Spleen size in Covid-positive patient Hmax: 123mm Lmax: 98mm Th: 50mm, Volum: 349mm³ (a-b), covid negative control group Hmax: 111mm Lmax: 94mm Th: 36mm Volum 218mm³ (c-d) in CT examination.

Statistical Analysis

Statistical Package for Social Science (SPSS, version 20.0) package program was used for statistical data analysis while evaluating the findings obtained in the study. Descriptive statistical methods were used while evaluating the study data. The results were evaluated at the 95% confidence interval and the significance level at $p < 0.05$. The data were evaluated using the Kolmogorov-Smirnov test, which showed a normal distribution. Comparison of the control group and the patient group by gender was calculated using the Chi-square test, and the comparison of BMI and spleen volume was calculated using the Mann Whitney U test. In the measurements, the intraclass correlation coefficient (ICC) was used to show inter-observer and intra-observer agreement. A ICC value greater than 0.80 indicates a perfect agreement. Correlations between variables were evaluated using the Pearson correlation coefficient.

RESULTS

Two hundred and fourteen Covid patients (121 men, 93 women) and 185 controls (106 men, 79 women) were included in this study. The mean age was 50.6

years (range, 18-86 years) for the patient group and 52.4 years (range, 21-79) for the control group. Body mass index was calculated as 26.8 (range, 20-30) in the patient group and 26.6 (range, 19.9-30) in the control group. In the Mann Whitney U test, no difference was found between age and BMI values, which are variables that can affect spleen size in the patient group and the control group. The mean spleen volume of the patient group was 260 (range, 96.3-565, SD: 82.5), and the mean spleen volume of the control group was 220 (range, 125.9-331.9, SD: 34.5). Comparing the two groups with the Mann Whitney U test, the mean of the patient group was found to be statistically significantly higher than the control group ($p < 0.05$) (Table 1). Interobserver variability results are shown in (Table 2). Excellent agreement was found between two blind observers and between intraobserver spleen volume measurements. In our study, spleen volume for diagnosis of COVID-19 pneumonia was 208.4 (AUC 0.639; 95% CI 0.584-0.695), sensitivity and specificity were 69.6% and 66.7%, respectively shows the ROC curve plotted for splenic volume values (Figure 2).

Table 1. Mean spleen volumes for Covid patients and the control group			
	Covid patients (n=214)	Control Group (n=185)	P value
Spleen volume (mean±SD)	260±82.5	220±34.5	<0.05*

*Statistical comparison between groups with Mann Whitney U test

Table 2. Interobserver variability for spleen volume measurements			
	Observer 1 (mean±SD)	Observer 2 (mean±SD)	ICC intraclass correlation coefficient
Spleen volume (n=399)	241.58±67.7	241.76±67.1	0.993 (0.992-0.994)

ICC: Intraclass Correlation Coefficients; SD: standard deviation

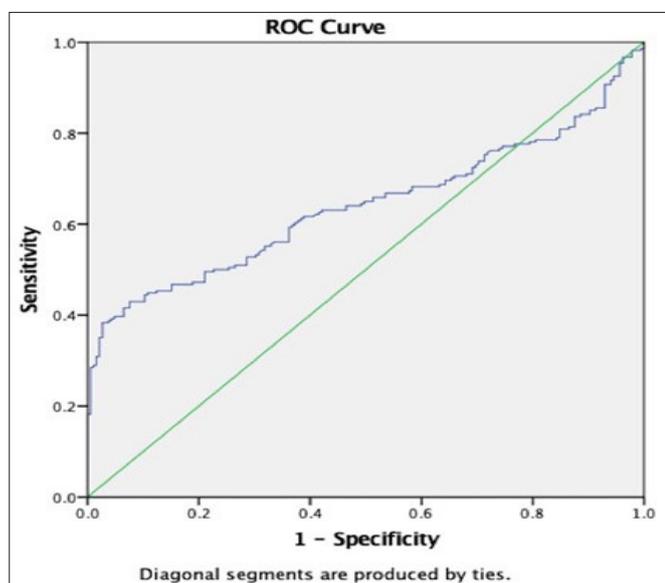


Figure 3. ROC curve for COVID-19 pneumonia diagnosis based on spleen volumes

DISCUSSION

The clinical features of COVID-19 range from asymptomatic to acute respiratory distress syndrome and multi-organ dysfunction. Common clinical features include fever (but not all), cough, sore throat, headache, fatigue, headache, myalgia, and shortness of breath. Conjunctivitis has also been described. Therefore, it cannot be distinguished from other respiratory infections. Sometimes at the end of the first week, the disease can progress to pneumonia, respiratory failure and death. The disease affects many systems (11,12). When we look at the blood tests, the white cell count is usually normal or low. There may be lymphopenia; Lymphocyte count less than 1000 has been associated with severe disease. The platelet count is usually normal or slightly low (13). The spleen may be one of the organs directly attacked by the virus in some patients who die from COVID-19. T and B lymphocytes in the spleen are reduced to varying

degrees, lymphoid follicles are reduced, and the number of NK cells does not change significantly. Pathological changes of the spleen may be related to the direct attack of the virus and the immune system attacking its own tissues. The literature shows that although other imaging techniques such as ultrasonography (14,15) or magnetic resonance imaging (MRI) can be used, CT detects the varying splenic volume with the highest sensitivity and specificity (16). Additionally, a number of studies have demonstrated the significant accuracy of CT in the evaluation of the spleen in both pediatric and adult populations (17,18). We also used CT in our study. Because of the suspicion of Covid pneumonia thoracic CT was already performed, an additional scan was not performed for spleen so no additional dose was given. In our study, we showed that the spleen volume increased statistically significantly in patients diagnosed with Covid, but the average did not exceed the limit of splenomegaly. Xu et al. (13) studied the pathological changes of the spleen in post-mortem COVID-19 patients and analyzed the relationship between the weakened immune system and splenic lesions. They showed that the cell composition of the spleen was decreased in histopathological examinations. Since the Covid pandemic is very new, there is not enough data in the literature on the relationship between Covid infection and spleen volume. While calculating spleen volume, agreement between observers was excellent which shows that the volume measurements based on CT is highly reproducible.

There were some limitations in our study. Although patients with known infections, hematological diseases, infiltrative diseases, and diseases of the spleen that may enlarge the spleen were excluded from the study, patients were not tested for these diseases. Therefore, other reasons that may cause splenomegaly may still be in the study. Another limitation was the small number of patients.

It would be useful to re-evaluate the spleen volumes after a certain period of time in order to determine the change in spleen volume over time. Randomized controlled studies with larger patient groups are needed to demonstrate the effect of infection on splenic volume in COVID-19 patients.

ETHICAL DECLARATIONS

Ethics Committee Approval: The research was approved by Ümraniye Training and Research Hospital Ethics Committee (protocol number: B.10.1.TKH.4.34.H.GP.0.01).

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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