# Prospective Study on the Association between Hematologic Tests and Lung Computed Tomography Scans (CT Scan) in Patients with Acute COVID-19 and Non-COVID-19 Pulmonary Infections

**Running Title:** Hematologic Tests and Lung Computed Tomography Scans (CT Scan) in Patients with Acute COVID-19

**Javad Poursamimi[1,2*], Soleyman Saravani[3], Roghayeh Hossein Beigi[4], Sara Rashki Ghalenoo [5],Mehrangiz Ghafari[6], Majid Valizadeh [7]**

[1]Assistant professor of Department Immunology, Faculty of Medicine, Zabol University of Medical Sciences, Zabol, Iran. javadpoursamimi@gmail.com; https://orcid.org/0000-0002-8726-4425

[2]Assistant professor of Department of Laboratory Sciences, School of Paramedical Sciences, Zabol University of Medical Sciences, Zabol, Iran

[3] Ph.D in Medical Education, Department of Community Medicine, School of Medicine, Zabol University of Medical Sciences, Zabol, Iran. saravani_solyman@yahoo.com; https://orcid.org/0000-0001-7239-9872

[4]Assistant Professor of Internal Medicine, Department of Internal Medicine, School of Medicine, Zabol University of Medical Sciences, Zabol, Iran. httpdr.rh.beighy@gmail.com; https://orcid.org/0009-0002-1941-4150

[5] Assistant Professor of Cardiology, Department of Cardiology, Zabol University of Medical, Sciences, Zabol, Iran. dr.s.rashki@gmail.com, https://orcid.org/0000-0002-7638-2290

[6]Assistant Professor of Pathology, Department of Pathology, School of Medicine, Zabol University of Medical Sciences, Zabol, Iran. https://orcid.org/0000-0003-2942-4651

[7] Department of Basic Sciences, School of Medicine, Zabol University of Medical Sciences, Zabol, Iran.valizadehmph@gmail.com, https://orcid.org/0000-0002-7203-5144

*Corresponding Author: Javad Poursamimi, Ph.D. in Medical Immunology,

Department of Immunology, Faculty of Medicine, Zabol University of Medical Sciences, Zabol, Iran, Postal Code: 9861663335, Tel: (+98 54) 32225402, E-mail: poursj1357@zbmu.ac.ir; Javadpoursamimi@gmail.com

**Abstract**

The clinical symptoms of COVID-19 and non-COVID-19 pulmonary infections are very similar. This study aimed to differentiate between these patients by evaluating laboratory criteria and abnormalities in CT scans. The medical records of 200 patients referred to the Amir Hospital in Zabol were analyzed between February 2020 and February 2021. Some of our findings in the COVID-19 group compared to the non-COVID-19 group included an increase in red blood cell counts (RBCs), corpuscular hemoglobin concentration (MCHC), mean hematocrit (HCT), erythrocyte sedimentation rate (ESR), Neutrophil-to-Lymphocyte Ratio (NLR), and Platelet-to-Lymphocyte Ratio (PLR). Additionally, the COVID-19 group had a lower mean corpuscular volume (MCV) of 80 femtoliters (fL) and mean cell hemoglobin (MCH) below 36. The symptoms of pulmonary infection were mostly bilateral in the COVID-19 group, whereas in the non-COVID-19 group, they were predominantly unilateral. 21.6% of patients had 5 to 10 lesions, while 24.7% of the non-COVID-19 group had fewer than 3 lesions. The COVID-19 group showed a distribution of both peripheral and diffuse lesions, whereas the non-COVID-19 group had predominantly peripheral distribution. Linear opacity and ground-glass opacity (GGO) were observed in 10 (6.2%) and 40 (24.7%) individuals in the COVID-19 group, and 13 (8%) and 32 (19.8) individuals in the non-COVID-19 group, respectively. Twenty-one (13%) COVID-19 patients and 16 (9.9%) non-COVID-19 patients exhibited a septal thickening index. Moreover, fine reticular opacity index, crazy paving patterns, and pleural effusion were observed in 6 (3.7%), 19 (11.7%), and 8 (4.9%) of the COVID-19 patients, and 20 (12.3%), 24 (14.8%), and 18 (11.1%) of the non-COVID-19 patients, respectively. Finally, this study concluded that laboratory indices such as MCV, and CT scan findings such as septal thickening are very beneficial for distinguishing between these two groups.

**Keywords:** COVID-19; Diagnosis; Hematologic Tests; Blood Cell Count; Computed Tomography scan (CT scan); Symptoms

## 1. Introduction

The COVID-19 pandemic, caused by the SARS-CoV-2 virus in the 21st century, has been the primary concern of the World Health Organization. Despite efforts to control the disease, multiple instances of infection with new variants and new forms of the disease have underscored the importance of drawing on past experiences in dealing with COVID-19 (1,2). The acute course of COVID-19 varies, ranging from asymptomatic infection to severe respiratory failure. Patients who recover from COVID-19 may experience persistent symptoms and varying degrees of pulmonary abnormalities (3).

As of August 18, 2024, the global death toll from the COVID-19 virus had reached 7,060,609, with an additional 46,936 new infections reported in August 2024 (4). In Iran, however, the official statistics on COVID-19 deaths differed from the actual figures. The mortality rate in the country varied by gender, with men experiencing a higher rate than women (326 vs. 264 deaths per 100,000). Additionally, the mortality rate was influenced by age. Geographically, the highest death rates were observed in the central and northwestern provinces of Iran (5).

Developing countries such as Iran have been facing numerous challenges in combating the COVID-19 epidemic. These challenges have been apparent at all stages of preventing, identifying, and treating the disease. For this reason, sometimes, certain regions in southeastern Iran have reported the highest number of COVID-19 cases (6). The symptoms of acute COVID-19 disease are similar to those of other pulmonary infectious diseases. These include fever, fatigue, dry cough, sputum production, sore throat, shortness of breath and headache. In severe cases, pneumonia, edema and respiratory distress can occur. The severity of symptoms depends on factors such as the age of the patients (over 65), cardiovascular diseases, high blood pressure, diabetes, cancer and chronic obstructive pulmonary disease (7). Zabol, located in the southeast of Iran, is one of the most polluted areas in the country in terms of acute pulmonary diseases, particularly those caused by Mycobacterium tuberculosis (8). Exposure to fine dust and soil, which has increased as a result of climate change, has also intensified the severity of pulmonary diseases in this region (9).

Currently, the issue of air pollution caused by climate change has become the most important pressing challenge for residents in these areas. The rise in winds carrying aerosols throughout all seasons of the year has escalated the quantity and severity of pulmonary diseases, leading to a significant increase in hospitalized patients in 2020-2021 (10). It is evident, that using modern techniques to diagnose and differentiate diseases in their early stages can significantly reduce stress for patients of all age groups, especially middle-aged individuals, the elderly (aged 65 and older), and pregnant women. This approach can also help prevent human casualties. CT techniques can be used to diagnose COVID-19 patients and predict the potential development of acute pulmonary conditions like sepsis, acute respiratory distress syndrome (ARDS), pneumonia, and bronchitis (11). In these cases, Ground-Glass Opacity and the appearance of a crazy paving pattern are findings that can be identified through CT imaging techniques and are linked to the interpretation of laboratory indices (12). In this retrospective study, patients were divided into two groups based on whether their acute pulmonary infection was caused by COVID-19 or non-COVID-19. We then compared the laboratory diagnostic indicators and CT imaging of patients in a specific region of southeast Iran.

## 2. Materials and Methods

### 2.1. Study design

This descriptive-analytical study received approval from the Research Committee of Zabol University of Medical Sciences in January 2023. The study examined the records of 200 patients from Amir Hospital in Zabol, Iran, covering the period from February 2020 to February 2021. Among these patients, 60 were diagnosed with acute COVID-19 infection, while 45 had acute non-COVID-19 infections. All patients underwent Computed Tomography (CT) scans of the lungs and had their laboratory indices assessed.

During data collection, patients were grouped based on their symptoms, including cough and fever, along with the results of the Polymerase Chain Reaction (PCR) diagnostic test.

Patients were excluded from the study if they had bacterial infectious diseases, showed normal lung parenchyma on CT scans, had non-infectious parenchymal lesions such as lung cancer, pneumothorax, or pulmonary edema, experienced a delay of more than 7 days between their lung CT and RT-PCR testing (13), were hospitalized for non-pulmonary symptoms, or did not have a lung CT image available.

### 2.2. Laboratory indices and CT Scan

The hematologist carefully reviewed the patients' laboratory indices, which included WBC, Lymphocyte, Neutrophil, Eosinophil, Monocyte, RBC, Hb, HCT, Means Corpuscular Volume (MCV), hemoglobin (MCH), and hemoglobin concentration (MCHC), PLT, NLR, ESR, and CRP.

CT scans of the chest were acquired on 16- to 64-multidector CT scanners (Philips Brilliant 16, Philips Healthcare; GE LightSpeed 16, GE Healthcare; GE VCT LightSpeed 64, GE Healthcare; Somatom Sensation 64, Siemens Healthcare; Somatom AS, Siemens Healthcare; Somatom Spirit, Siemens Healthcare; GE Optima 680, GE Healthcare).

### 2.3. CT-scan images analysis

We used original cross-sectional images for analysis. All images were analyzed by two experienced chest radiologists who were blinded to the clinical details. In cases where their reports were not consistent, the final report was determined by consensus.

In the CT images of patients, indicators include the involvement (unilateral and bilateral), distribution: peripheral, central, or diffuse), linear opacity, ground-glass opacity (GGO), consolidation, interstitial changes (septal thickening, fine reticular opacity, and none), crazy paving pattern and pleural effusion were considered.

### 2.4. Statistical Analysis

The collected data were analyzed using SPSS software version 26. A one-way ANOVA test was employed to compare the means if necessary. A p-value of less than 0.05 was considered statistically significant.

## 3. Results

### 3.1. Patient demographic data

There were no significant differences in patient distribution based on gender and age. The average age of patients was 50.96 ± 19.90 for COVID-19 and 49.77 ± 18.82 for non-COVID-19. The COVID-19 group consisted of 24 men (40%) with 52.41 ± 4.21 and 36 women (60%) with 50.00 ± 3.27 years. The non-COVID-19 group consisted of 17 men (37.7%) with 54.29 ± 5.02 and 28 women (62.3%) with 47.03±3.28 years.

### 3.2. Patients blood indices

The COVID-19 group (4.81 ± 0.21**)** showed a higher RBC count compared to the non-COVID-19 group **(**4.24 ± 0.16), (P=0.043).

The other indices have been summarized in Table 1 (P>0.05), **Table 1.**

Table 1: The mean ± SD of the hematologic indices were presented.

| Groups | WBC | RBC | Neutrophils | Lymphocytes | PLTs |
|---|---|---|---|---|---|
| COVID-19 | 8.02 ± 3.34 | 4.81 ± 0.81 | 6.72 ± 3.29 | 1.12 ± 0.52 | 218.00 ± 68.06 |
| non-COVID-19 | 9.10 ± 4.05 | 4.24 ± 0.16 | 7.21 ± 3.85 | 1.54 ± 0.85 | 222.60 ± 64.97 |
| P value | - | 0.043 | - | - | - |

The MCV in the COVID-19 group (80.02 ± 1.49) was lower compared to the non-COVID-19 group (85.41 ± 2.23). However, there was no significant difference in the MCV comparison between the groups based on gender (P > 0.05), Table 2. Additionally, the COVID-19 group (25.76 ± 0.67) showed a decrease in MCH compared to the non-COVID-19 group (27.78 ± 1.18) (P=0.043). In contrast, the COVID-19 group (32.43 ± 0.43) showed a higher in the MCHC compared to the non-COVID-19 group (32.33 ± 0.76) (P > 0.05).

In terms of Hb concentration, and HCT, the COVID-19 group (12.38 ± 0.61; 38.39 ± 1.68 ) was slightly higher than the non-COVID-19 group (11.91 ± 0.71; 36.35 ± 1.78), respectively (P > 0.05). (Table 2).

Table 2: The mean ± SD of the blood indices were presented. (Female: F; Male: M)

| Groups | Gender | MCV | MCH | MCHC | PLT | RBC | WBC | Hb | HCT |
|---|---|---|---|---|---|---|---|---|---|
| COVID-19 | M | 79.64 ± 2.34 | 25.74 ± 1.18 | 32.21 ± 0.73 | 207.42 ± 24.21 | 4.95 ± 0.95 | 8.24 ± 0.43 | 12.67 ± 1.02 | 39.12 ± 2.69 |
| | F | 80.41 ± 2.03 | 25.78 ± 0.75 | 32.05 ± 0.51 | 228.57 ± 24.65 | 4.67 ± 0.17 | 7.81 ± 1.81 | 12.11 ± 0.75 | 37.67 ± 2.18 |
| non-COVID-19 | M | 84.34 ± 2.74 | 27.04 ± 1.95 | 31.81 ± 1.58 | 214.28 ± 26.07 | 4.34 ± 0.32 | 10.52 ± 1.81 | 12.02 ± 1.41 | 36.87 ± 3.32 |
| | F | 86.24 ± 3.45 | 28.35 ± 1.53 | 32.73 ± 0.68 | 236.23 ± 23.48 | 4.17 ± 0.17 | 7.98 ± 1.07 | 11.81 ± 0.73 | 35.95 ± 2.02 |

The ESR level in the COVID-19 group (66.00 ± 16.62 ) was higher compared to the non-COVID-19 group (34.67 ± 9.23) (P > 0.05). Furthermore, ESR levels of men, and women in the COVID-19 group were high compared to the non-COVID-19 group (P > 0.05) (Table 3). In terms of CRP, the COVID-19 group (2.07 ± 0.26) was slightly lower compared to the non-COVID-19 group (2.42±0.72) (P>0.05) (data not shown). Additionally, there were no significant differences based on gender (P > 0.05) (Table 3).

Table 3 The mean ± SD of the blood cell ratios (NLR, PLR), ESR, and CRP were presented.

| Groups | Gender | NLR | PLR | ESR | CRP |
|---|---|---|---|---|---|
| COVID-19 | M | 6.19±0.95 | 174.18±18.09 | 78.00±29.00 | 2.00±0.37 |
| | F | 8.16±2.34 | 261.72±38.56 | 54.00±23.00 | 2.14±0.41 |
| non-COVID-19 | M | 8.31±2.78 | 187.74±51.02 | 26.75±10.24 | 2.13±0.26 |
| | F | 4.51±0.76 | 188.31±32.44 | 50.51±16.50 | 2.71±0.18 |

The mean NLR and PLR indices in the COVID-19 group (7.17 ± 1.23), ( 217.95 ± 23.79), were higher than the mean NLR and PLR in the non-COVID-19 group (6.16 ± 1.32), (188.06 ± 27.78), respectively ($P > 0.05$). Additionally, there was no significant difference in the mean NLR and PLR based on gender ($P > 0.05$), **(Table 3)**.

### 3.3. CT-scan findings

The involvement in the lungs of the 52 patients in the COVID-19 group were bilateral and 8 patients were unilateral. In contrast, there were 2 patients with bilateral lesions and 43 patients with unilateral lesions in the non-COVID-19 group ($P = 0.00$). Additionally, there was no significant difference in the involvement analysis based on gender ($P > 0.05$).

The lesion count was analyzed across four categories: fewer than 3, between 3 and 5, between 5 and 10, and over 10. In the COVID-19 group, 37% of participants exhibited lesions, compared to 15.2% in the non-COVID-19 group. Tables 4.

Table 4: The lesion count across four categories was displayed.

| **Lesion count** | | **Less of 3** | **Between 3 to 5** | **Between 5 to 10** | **Over 10** | **Total** |
|---|---|---|---|---|---|---|
| **COVID-19** | Female | 4(50%) | 6(75%) | 22 (62.8%) | 4(44.5%) | 36(60%) |
| | Male | 4(50%) | 2(25%) | 13(37.1%) | 5(55.5) | 24(40%) |
| | Total | 8(100%) | 8(100%) | 35(100%) | 9(100%) | 60 (100%) |
| **non-COVID-19** | Female | 7(50%) | 2(100%) | - | - | 9(56.3%) |
| | Male | 7(50%) | - | - | - | 7(43.7%) |
| | Total | 14(100%) | 2(100%) | - | - | 16 (100%) |

The analysis of distribution in three statuses - Central, Peripheral, and Diffuse- in the COVID-19 group compared to the non-COVID-19 group showed a significant difference ($P = 0.00$).

In the COVID-19 and non-COVID-19 groups, there were one (0.6%) and 2 (1.2%) individuals classified as Central, 40 (24.7%) and 42 (25.9%) as Peripheral, and 19 (11.7%) and one (0.6%) individual as Diffuse, respectively.

The highest rate of distribution was related to the Peripheral status in both groups.

GGO was observed in 40 (24.7%) and 32 (19.8%) individuals in the COVID-19 and in the non-COVID-19 group, respectively ($P > 0.05$). Twenty (12.3%), and 13 (8%) individuals were negative in the COVID-19, and the non-

COVID-19 groups, respectively (P > 0.05). However, examination of GGO showed a significant increase compared to age (P = 0.028) (Figure. 1a).

Linear opacity was observed in the 10 (6.2%), and 13 (8%) individuals in the COVID-19 and the non-COVID-19 groups, respectively (P > 0.05). Fifty (30.9%), and 32 (19.8%) individuals from the COVID-19 and the non-COVID-19 groups were negative, respectively (P > 0.05) (Figure. 1b).

The consolidation index was observed in 18 (11.1%), and 14 (8.6%) individuals in the COVID-19 and the non-COVID-19 groups, respectively (P > 0.05). Forty-two (25.9%), and 31(19.1%) individuals from the COVID-19 and non-COVID-19 groups were negative, respectively (P > 0.05) (Figure. 1c).

Interstitial changes in the three subsections included septal thickening, fine reticular opacity, and none revealed that 21 (13%), and 16 (9.9%) individuals in the COVID-19 and non-COVID-19 groups had a septal thickening, respectively (P = 0.038). Additionally, 6 (3.7%), and 20 (12.3%) individuals in the COVID-19 and non-COVID-19 groups had a fine reticular opacity, respectively (P = 0.038). The remaining participants, consisting of 33 (20.4%), and 9 (5.6%) individuals in the COVID-19 and non-COVID-19 groups were negative, respectively (P = 0.038) (Figure. 1d).

The crazy paving pattern structure was observed in 19 (11.7%), and 24 (14.8%) individuals in the COVID-19 and non-COVID-19 groups, respectively (P = 0.025). Conversely, 41 (25.3%), and 21 (13%) individuals in the COVID-19 group and non-COVID-19 groups were negative, respectively (P = 0.025) (Figure. 1e).

Pleural effusion was observed in 8 (4.9%), and 18 (11.1%) individuals in the COVID-19 and non-COVID-19 groups, respectively (P = 0.002). Conversely, 52 (32.1%), and 27 (16.7%) individuals in the COVID-19 and non-COVID-19 groups were negative, respectively (P = 0.002) (Figure. 1f).

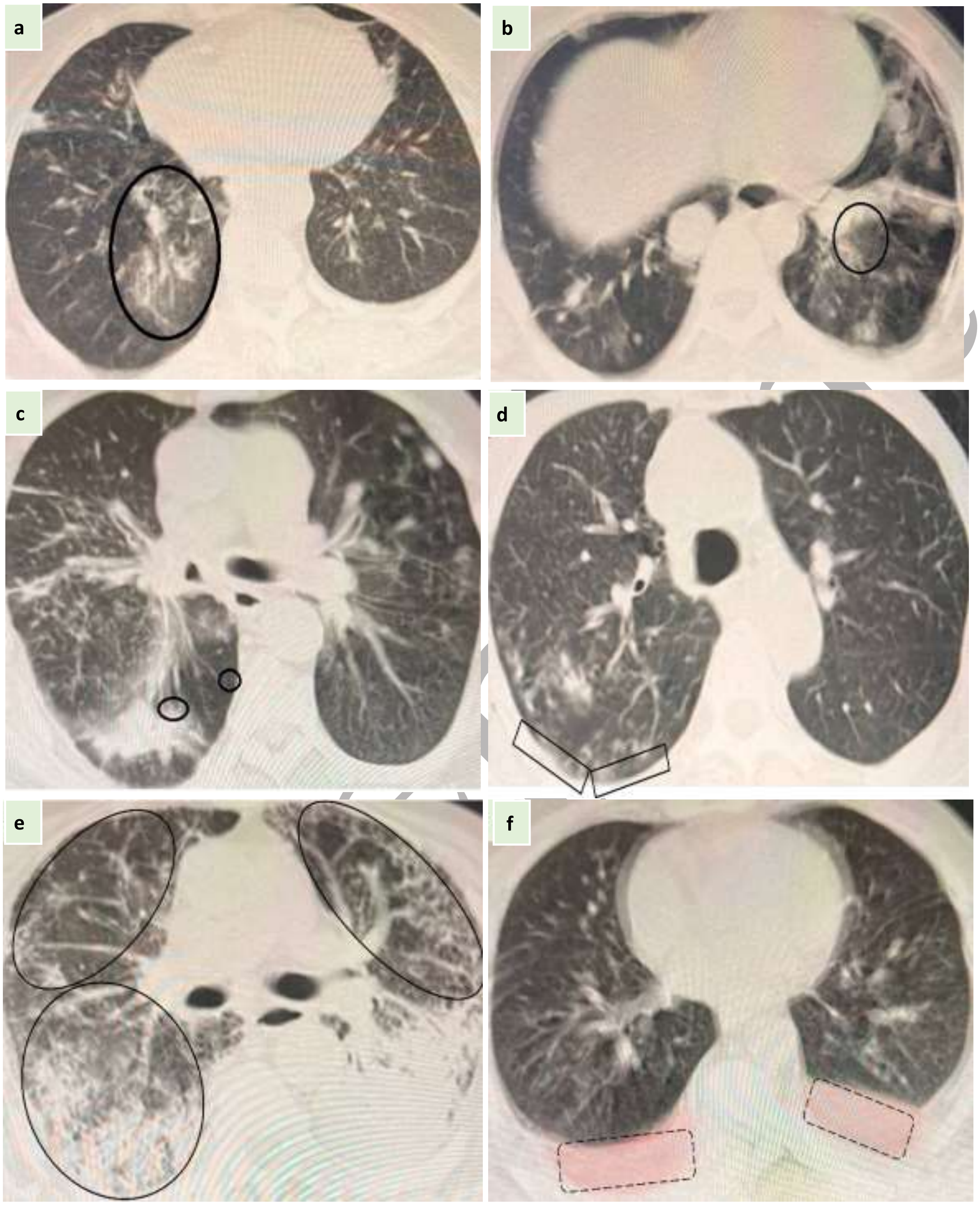


Figure 1: The histopathological changes of Lung in CT scan images of COVID-19 infection. **a)** Ground-glass opacity (GGO), **b)** Linear opacity, **c)** Consolidation, **d)** Interstitial changes (septal thickening, and fine reticular opacity), **e)** The crazy paving pattern structure, **f)** Pleural effusion

### 3.4. Correlations

The analysis of the correlation between the laboratory indices and CT imaging in both groups showed that only plural effusion-NLR (correlation coefficient: -0.515, P value: 0.041) in the non-COVID-19 group, crazy paving pattern-lymphocyte counts (-0.566, 0.035) in the COVID-19 group, consolidation-MCHC (-0.505, 0.046) in the non-COVID-19 group, and involvement -lymphocyte counts (0.660, 0.010) in the COVID-19 group were significant.

## 4. Discussion

The descriptive-analytical study evaluated laboratory indices such as RBC counts and histopathological indices of the lungs, such as GGO by CT scans. Due to the unique geographical location of the Zabol area in Iran, as well as the lack of suitable vegetation and recent climate changes, there has been a noticeable increase in the number of patients with acute pulmonary infections in local hospitals (14). The records were classified into two groups: COVID-19 and non-COVID-19, based on PCR testing. In 2020, Li et al. conducted a study that closely resembles the current research. They used RT-PCR tests to differentiate patients with COVID-19 pulmonary infections from those with non-COVID-19 pulmonary infections (13).

### 4.1. Findings from biochemical analysis

The RBC counts were within the normal range. However, there was a significant increase in the COVID-19 group compared to the non-COVID-19 group (P = 0.043). In the COVID-19 group, there was a significant decrease in men's MCV index to less than 80, which was significantly different compared to the non-COVID-19 group (P = 0.034). Additionally, the MCH index for men and women in the COVID-19 group was less than 36. There was a significant decrease in the MCH index in the COVID-19 group compared to the non-COVID-19 group (P = 0.043). Furthermore, the mean MCHC index in the COVID-19 group was higher than in the non-COVID-19 group ($P>0.05$). There were no significant differences within the group comparison based on gender.

In line with our study, a study by Marchi et al. in 2022 showed a strong correlation between the severity of clinical symptoms in COVID-19 patients and a decrease in peripheral RBC counts. They found that assessing the morphology of RBCs is essential and can aid in improving the patients' condition. The study also revealed that RBCs tend to become microcytic during viral infections (15).

However, our findings showed that the RBC counts were higher in the COVID-19 group compared to the non-COVID-19 group, even though they were within the normal range. On the other hand, the average MCV index for men in the COVID-19 group was less than 80 fL. This suggests that the morphology of the RBCs in the COVID-19 group is likely microcytic.

The microcytic morphology of RBCs had not been evaluated in the hospitals of Zabol City. Some studies have shown a close relationship between a decrease in MCV to under 80 fL with a hereditary origin and the occurrence of heterozygous α or β thalassemia. These patients often do not exhibit clinical symptoms of anemia, and their RBC morphology is likely to be microcytic hypochromic (16).

The average total HCT in the COVID-19 group was slightly higher the non-COVID-19 group ($P > 0.05$). It's important to note that the HCT formula calculates the ratio of RBCs to the total volume of blood. It's possible that COVID-19 patients may have experienced a loss of plasma volume, leading to a falsely elevated HCT level. In this direction, Asan et al. (2021) evaluated the HCT index in COVID-19 patients with mild or severe symptoms. They found that the average HCT levels in patients with severe symptoms were lower than those in patients with mild symptoms (17).

The use of HCT in monitoring the condition of COVID-19 patients is crucial due to its close relationship with peripheral blood viscosity. Several studies have indicated a significant increase in the peripheral blood viscosity of COVID-19 patients. Moreover, changes in viscosity have been linked to conditions such as myocardial infarction (MI), venous thrombosis, and venous thromboembolism (18). Increased blood viscosity in pulmonary viral infections may lead to defects in microcirculation and hemodynamics, highlighting the importance of considering blood viscosity in such cases (19).

The mean ESR, PLR, and NLR in the COVID-19 group were insignificantly higher than in the non-COVID-19 group. In line with this, a study by Li et al. in 2024 discovered a direct correlation between the severity of symptoms in patients with lower pulmonary viral infections and an elevated ESR. Furthermore, they reported that an increase in WBC, PCT, and CRP levels could also be beneficial in predicting the prognosis of this patient group (20). In addition to the ESR and CRP, Asan et al. identified high levels of the NLR as characteristic features of acute viral infections, particularly in patients with severe COVID-19 symptoms, which aligns with our findings. However, they observed a decrease in the PLR in these patients compared to those with mild symptoms (17).

### 4.2. Findings from CT-scans analysis

In this study, the pathological characteristics such as unilateral and bilateral lung involvement were considered to assess symptom severity and predict disease prognosis.

In our study, there were 52 (32.1%) individuals with bilateral involvement, and 8 (4.9%) individuals with unilateral in the COVID-19 group. However, there were 2 (1.2%) individuals with bilateral involvement and 43 (26.5%) with unilateral involvement in the non-COVID-19 group ($P = 0.00$). A study conducted by Wu et al. in 2020 showed that out of 130 patients with acute COVID-19 infection who had CT images, only 14 patients had unilateral involvement and 116 patients had bilateral involvement (21).

In our study, the highest number of lesion was observed in the COVID-19 group, ranging between 5-10 lesions, in the female population. However, the number of lesion in the non-COVID-19 group was less than 3 lesions, in both sexes. In Wu et al's study, out of a total of 130 COVID-19 patients, 9 patients had single lesions and 113 patients had multiple lesions (21).

In our study, the distribution of central, peripheral, and diffuse patterns differed between the COVID-19 group and the non-COVID-19 group ($P = 0.00$). Within the COVID-19 group, 0.6% showed central distribution, 24.7% showed peripheral distribution, and 11.7% individuals showed diffuse distribution. In contrast, the non-COVID-19 group had 1.2% central distribution, 25.9% peripheral distribution, and 0.6% individual diffuse distribution. The highest distribution rate was observed in the peripheral pattern in both groups. In relation to this, a study by Li et al in 2020 examined the location, size of lesions, and distribution in the CT images of COVID-19 patients. They found that a peripheral distribution increased the risk of pulmonary infection by 13.5 times compared to the diffuse form. Additionally, lesions larger than 10 cm were associated with COVID-19 pulmonary infection (13).

Linear opacity was only observed in 6.2% of individuals in the COVID-19 group (P>0.05). However, in 2020, Liang et al. did not observe linear opacity characteristics in patients with COVID-19 infection specifically. They acknowledged that linear opacity occurs along with consolidation and GGO in the patients. Additionally, they found a significant relationship between the severity of the disease symptoms and the presence of these findings (22).

The GGOs appeared in 24.7% of COVID-19 and 19.8% of individuals in non-COVID-19 groups. Further analysis revealed a significant increase in the occurrence of these lesions with age.

The significance of the GGO findings for diagnosing COVID-19 infection is highlighted in Wang et al.'s 2020 study. They identified the distribution of bilateral GGO in the posterior and peripheral lungs, with or without consolidation, as the primary characteristic of COVID-19 infection (23). In a study conducted by Elmokadem et al. in 2021, they used GGO to distinguish between COVID-19 and non-COVID-19 pulmonary infections. They found that CT scans can accurately differentiate between GGO caused by COVID-19 and GGO caused by non-COVID-19 conditions with a diagnostic accuracy ranging from 59% to 77.2% (24).

Only 18 and and 14 individuals in the COVID-19 and non-COVID-19 groups respectively, showed consolidation lesions in CT images (P>0.05). Concerning this, Yu et al. study in 2021 revealed a significant direct relationship between the size of consolidation lesions and age in COVID-19 patients (12).

The interstitial changes in the COVID-19 group were significantly different compared to the non-COVID-19 group. There was a notable difference in septal thickening and fine reticular opacity between the two groups. Specifically, 21 individuals in COVID-19 and 16 in non-COVID-19 groups exhibited septal thickening. Additionally, 6 individuals with COVID-19 and 20 with non-COVID-19 with significant differences displayed fine reticular opacity. In relation to this, a study by Barbosa et al. in 2020, uncovered a significant increase in interlobular septal thickening and the severity of symptoms in COVID-19 patients. Additionally, a reduction in oxygen saturation was linked to septal thickening, diffuse distribution, and pleural effusion (25).

The crazy paving pattern was also observed in 19, and 24 individuals in the COVID-19 and non-COVID-19 groups, respectively (P<0.05). Baeis et al. 2020 found a significant difference between hospitalized and outpatient COVID-19 cases regarding the crazy-paving pattern. They also noted that the crazy-paving pattern is linked to the inflammatory phase of the disease, making it a valuable tool for predicting symptom severity (26).

The CT scans of 8, and 18 individuals in the COVID-19 and non-COVID-19 groups showed the presence of pleural effusion (P<0.05). Li et al. also discovered that the absence of pleural effusion in the CT of COVID-19 patients was linked to a 3.5-fold increase in symptoms of pulmonary infections. We also observed an increase in pleural effusion in the non-COVID-19 group (13).

The correlation analysis showed that only plural effusion-NLR in the non-COVID-19 group, crazy paving pattern-lymphocyte counts in the COVID-19 group, consolidation-MCHC in the non-COVID-19 group, and involvement-lymphocyte counts in the COVID-19 group were significant.

Our study revealed that the COVID-19 group had low RBC counts and MCV, as well as high HCT, ESR, NLR, and PLR compared to the non-COVID-19 group. Additionally, the COVID-19 group showed bilateral involvement, a higher number of lesions, peripheral and diffuse distribution, increased GGO, more consolidation, and predominant septal thickening. On the other hand, the non-COVID-19 group exhibited a higher prevalence of crazy paving patterns and pleural effusion. These findings proved to be very useful in identifying and distinguishing between these two groups of patients.

**Acknowledgment**

I am grateful to the staff of the Amir Hospital of Zabol for generously giving their time and expertise. Additionally, I gratefully acknowledge funding from the Research Council of Zabol University of Medical Sciences in Zabol, Iran.

**Author Contributions**

Study concept and design: J P. Analysis and interpretation of data: J P, and S S. Drafting of the manuscript: J P. Critical revision of the manuscript for important intellectual content: J P, S S, R HB, S RGH, and M V. Statistical analysis: J P.

**Ethics**

The ethics committee of Zabol University of Medical Sciences, Zabol, Iran, granted the research ethics code number IR.ZBMU.REC.1401.130.

**Conflict of interest**

The authors declared no conflict of interest.

**Funding**

This study received financial support from the research council of Zabol University of Medical Sciences.

**Data availability statement**

The data will be available upon request to the corresponding author.

**References**

1. Kosidło JW, Wolszczak-Biedrzycka B, Dymicka-Piekarska V, Dorf J, Matowicka-Karna J. Clinical

Significance and Diagnostic Utility of NLR, LMR, PLR and SII in the Course of COVID-19: A Literature Review. J Inflamm Res. 2023;16:539–62.

2. Motamed N. An Overview of Future Development Methods of Infectious Bronchitis Vaccines. Iran J Vet Med. 2000;18(1):1–2.

3. Solomon JJ, Heyman B, Ko JP, Condos R, Lynch DA. CT of post-acute lung complications of COVID-19. Radiology. 2021;301(2):E383–95.

4. World Health Organization. Bulletin of the World Health Organization. Vol. 102, ProQuest. 2024. p. 9.

5. Ebrahimoghli R, Abbasi-Ghahramanloo A, Moradi-As lE, Adham D. The COVID-19 pandemic's true death toll in Iran after two years: an interrupted time series analysis of weekly all-cause mortality data. BMC Public Health. 2023;23(1):442–51.

6. Shakibnia P, Ahmadi RH, Fallah F, Ebrahimzadeh F, Dosari AS, Mojtahedi A, et al. Iran as the Center of challenges in the Middle East for the Outbreak of COVID-19 Delta Variant. Iran Red Crescent Med J. 2021;23(11):e1394.

7. Rothan HA BS. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. J Autoimmun. 2020;109(February):102433.

8. Khazaei HA, Rezaei N, Bagheri GR, Dankoub MA, Shahryari K, Tahai A, et al. Epidemiology of tuberculosis in the southeastern Iran. Eur J Epidemiol. 2005;20:879–83.

9. Shahsavani A, Tobías A, Querol X, Stafoggia M, Abdolshahnejad M, Mayvaneh F, et al. Short-term effects of particulate matter during desert and non-desert dust days on mortality in Iran. Environ Int. 2020;134:105299.

10. Akrami R, Hemmatjou S, Sheervalilou R, Shahraki O, Ghaznavi H. Investigating the Association between COVID-19 Prognosis and Demographic and Clinical Features, Underlying Diseases, and Drug and Supplement Use in Patients Hospitalized in Zabol, Iran: A Single-Center Retrospective Study. Infect Epidemiol Microbiol. 2023;9(2):167-78.

11. Suganya D, Kalpana R. Prognosticating various acute covid lung disorders from COVID-19 patient using chest CT Images. Eng Appl Artif Intell. 2023;119(105820):1–15.

12. Yu Q, Wang Y, Huang S, Liu S, Zhou Z, Zhang S, et al. Multicenter cohort study demonstrates more consolidation in upper lungs on initial CT increases the risk of adverse clinical outcome in COVID-19 patients. Theranostics. 2020;10(12):5641-48.

13. Li X, Fang X, Bian Y, Lu J. Comparison of chest CT findings between COVID-19 pneumonia and other types of viral pneumonia: a two-center retrospective study. Eur Radiol. 2020;30(10):5470–8.

14. Khaniabadi YO, Fanelli R, De Marco A, Daryanoosh SM, Kloog I, Hopke PK, et al. Hospital admissions in Iran for cardiovascular and respiratory diseases attributed to the Middle Eastern Dust storms. Environ Sci Pollut Res. 2017;24:16860–8.

15. Marchi G, Bozzini C, Bertolone L, Dima F, Busti F, Castagna A, et al. Red Blood Cell Morphologic Abnormalities in Patients Hospitalized for COVID-19. Front Physiol. 2022;13:932013.

16. Brancaleoni V, Di Pierro E, Motta I, Cappellini M.D. Laboratory diagnosis of thalassemia. Int J Lab Hematol. 2016;38(Suppl. 1):32-40.

17. Asan A, Üstündağ Y, Koca N, Şimşek A, Sayan HE, Parildar H, et al. Do initial hematologic indices predict the severity of covid-19 patients? Turkish J Med Sci. 2021;51(1):39–44.

18. Joob B, Wiwanitkit V. Blood viscosity of COVID-19 patient: a preliminary report. Am J Blood Res [Internet]. 2021;11(1):93–5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/33796395%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC8010604

19. Bogomol'tsev BP DA. Clinical implications of impaired microcirculation and hemodynamics in acute respiratory viral infections and their pharmacological correction. Klin Med (Mosk). 2003;81(5):9–15.

20. Li N, Jia Y, Feng J, Chang H, Li S. Changes in the levels of WBC count, PCT, CRP and ESR in Patients with acute Community-acquired Lower Respiratory tract infections and their diagnostic value. Pakistan J Med Sci. 2024;40(3):405-9.

21. Wu J, Pan J, Teng D, Xu X, Feng J, Chen YC. Interpretation of CT signs of 2019 novel coronavirus (COVID-19) pneumonia. Eur Radiol. 2020;30(10):5455–62.

22. Liang T, Liu Z, Wu CC, Jin C, Zhao H, Wang Y, et al. Evolution of CT findings in patients with mild COVID-19 pneumonia. Eur Radiol. 2020;30:4865–73.

23. Wang D, Hu B, Hu Ch, Zhu F, Al. LX et. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. Jama. 2020;323(11):1061-9.

24. Elmokadem AH, Bayoumi D, Abo-Hedibah SA, El-Morsy A. Diagnostic performance of chest CT in differDiagnostic performance of chest CT in differentiating COVID-19 from other causes of ground-glass opacitiesentiating COVID-19 from other causes of ground-glass opacities. Egypt J Radiol Nucl Med. 2021;52(1):1–10.

25. Barbosa CS, Chaves GW, de Oliveira CV, Bachion GH, Chi CK, Cerri GG, et al. COVID-19 pneumonia in the emergency department: correlation of initial chest CT findings with short-term outcome. Emerg Radiol. 2020;27(6):691-9.

26. Baeis MG, Mozafari A, Movaseghi F, Yadollahzadeh M, Sohrabi A, Afsharpad M, et al. The Crazy-Paving

Pattern in Chest CT Imaging of COVID-19 Patients: An Alarming Sign for Hospitalization. Iran J Radiol. 2021;18(2):e113286.