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Clinical, Laboratory, and Chest CT Features of Dead versus Recovered Coronavirus Disease 2019 (COVID-19) Patients: A Multicenter Study

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Abstract

Background: The current study was carried out to analyze the clinical, laboratory, and computed tomography (CT) findings obtained from both groups of patients, i.e., those who died or recovered from coronavirus disease 2019 (COVID-19).

Methods: This cross-sectional multicenter study was conducted on 71 adult patients with COVID-19 who had been discharged or died. Demographic, clinical, laboratory, and CT features were obtained from electronic medical records and compared between deceased and survived patients.

Results: Seventy-one patients (40 men, 31 women, 23–98 years) were included in the study. The mean age of deceased patients (70.77±17.36 years) was significantly higher than recovered ones (49.68±16.25 years) ($P<0.001$). Cough and neurological signs (a lateralizing sign of focal neurological insult) were shown to be significantly different between survived and non-survived groups ($P=0.008$ and $P<0.001$, respectively). Leukocytosis was present in 15 (41.7%) patients who died and 5 (14.3%) patients who were discharged ($P=0.01$). Hemoglobin and O_2 saturation were significantly lower in patients who died than in recovered ones ($P<0.001$ and $P=0.001$, respectively). A significantly higher level of CRP was found in deceased infected patients compared to recovered ones ($P=0.001$). Crazy-paving pattern and consolidation were significantly higher in patients who died than in recovered subjects ($P<0.001$).

Conclusion: Patients' manifestations on admission, such as older age, cough, leukocytosis, low levels of hemoglobin and O_2 saturation, as well as the occurrence of crazy-paving patterns and consolidation, were predictive of poor outcomes.

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Introduction

Coronavirus disease 2019 (COVID-19), which was generated from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections, was spread worldwide.[1-3] Given the vast clinical spectrum of SARS-CoV-2 infection, including asymptomatic pneumonia, mild upper respiratory tract involvement, severe viral infection, and even respiratory failure and death, hospitalization of many patients with pneumonia around the world is inevitable.[4]

According to the established evidence, the severe acute respiratory syndrome is substantially associated with COVID-19. An approximate 80%

genome sequence homology between SARS-CoV-2 and SARS-CoV, and an approximate 96% identical similarity between SARS-CoV-2 in terms of whole-genome sequence and a bat coronavirus were reported.[5] SARS-CoV-2 is less lethal but more transmissible than SARS-CoV.[6] For researchers seeking to investigate radiological, clinical, and laboratory findings, COVID-19 has become a popular topic. Many radiologic findings about chest computed tomography (CT) and chest X-ray have revealed bilateral ground-glass opacity (GGO) with or without peripheral lung consolidation.[7, 8] Therefore, it is imperative for clinicians to immediately identify clinical laboratory predictors of disease progression towards severe/critical form in order to classify risks and differentiate severe conditions from the mild/moderate form of COVID-19.

Although only mild symptoms are witnessed in a considerable rate of infected subjects, multi-organ failure, pneumonia, or even death can develop in some cases. Nevertheless, it is not yet identified what the clinical characteristics of dead patients are.[9] Accordingly, we conducted research with a focus on clinical characteristics, laboratory features, and the radiological findings of the dead and discharged COVID-19 cases to compare these features among patients with different clinical outcomes, thereby presenting evidence for the risk stratification and making a contribution to the improvement of the clinical practice and reduced fatality.

Methods

Patients and Study Design

In this cross-sectional and multi-center study, COVID-19-diagnosed patients were screened according to WHO interim guidance. Then, the patients who died or were discharged were included in our study.

The study was carried out following the *Declaration of Helsinki* and obtained the approval of the Ethics Committee of Shiraz University of Medical Sciences, Shiraz, Iran (IR.SUMS.REC.1399.120). In this study, all confirmed COVID-19 cases admitted from March 1 to May 30 at the isolation ward of Faghihi, Ali Asghar, and Namazi Hospitals of Shiraz University of Medical Sciences, Shiraz, Iran, were included in the study. They were placed in hospitals that were equipped for hospitalizing severe COVID-19 patients. The criteria for discharge were: 1) two negative throat swab specimens collected 24 h apart for tests of 2019-nCoV; 2) resolved COVID-19 symptoms; 3) normal body temperature for three consecutive days; and 4) significantly improved COVID-19 chest CT findings. The ethics committee waived the informed consent form since we used the existing samples collected during routine medical care and there was no additional risk to the patient.

Data Collection

SARS-CoV-2 nucleic acid was checked in all patients to confirm the virus infection by real-time reverse-transcription polymerase chain reaction (RT-PCR). In addition, a chest CT was performed to diagnose the infection. The clinical manifestations, laboratory features, and radiological assessments were collected based on chest CT extracted from medical records. Two experienced clinicians reviewed the data. Moreover, the samples were collected from different centers and sent to the central laboratory to analyze the samples.

CT Scanning Protocol, Image Viewing, and Evaluation

Two radiologists with over five years of experience in chest imaging independently investigated all CT images. In case of disagreements, an agreement was reached through discussion. A third radiologist with more than 25 years of lung imaging experience checked all CT findings to confirm them. All patients underwent scanning with the scanners described elsewhere.[10] The dominant patterns on CT images were divided into three main categories: bronchial, lung, and pleural changes. Each main category has been divided into subcategories. For example, pulmonary changes have been classified into seven subcategories, which have been described elsewhere.[10]

Statistical Analysis

The SPSS Statistics 23.0 software (SPSS Inc., Chicago, Illinois, USA) was used for the statistical data analysis. The normality distribution of the data was assessed using the Kolmogorov-Smirnov test. In addition, continuous variables were presented as mean±standard deviation (SD) and were analyzed using the independent sample t-test and the Mann-Whitney U test. Finally, categorical variables were represented by counts and percentages and assessed using the $\chi 2$ test or Fisher's exact test as necessary. A value of $P<0.05$ was considered statistically significant.

Results

Table 1 presents the results of the comparison between clinical and laboratory characteristics of deceased and discharged patients from three hospitals, comprised of 71 COVID-19 confirmed cases who received hospitalization at Faghihi, Ali Asghar, and Namazee hospitals, Shiraz, Iran, before January 31, 2020. Thirty-six patients died during hospitalization and the rest were discharged. The patients' mean age was 60.85±19.80, ranging from 23 to 98 years, and most patients were male (40 men and 31 women). It is also notable that the deceased patients (70.77±17.36) were older than the discharged ones

Table 1: Comparison of clinical and laboratory features between deceased and discharged patients with COVID-19

		Total		Deceased		Discharged		P value
		N	Mean (SD)/ percentage	N	Mean (SD)/ percentage	N	Mean (SD)/ percentage	
Age, year		68	60.85 (19.80)	36	70.77 (17.36)	32	49.68 (16.25)	<0.001
Sex	Male	40	56.3%	20	28.2%	20	28.2%	0.893
	Female	31	43.7%	16	22.5%	15	21.1%	
Hospital duration, days		66	7.50 (4.47)	35	6.65 (3.95)	31	8.45 (4.88)	0.104
Time from illness onset to hospital admission, days		42	5.45 (3.62)	25	5.40 (4.06)	17	5.52 (2.98)	0.911
ICU duration, days		17	6.05 (4.45)	11	5.63 (4.27)	6	6.83 (5.07)	0.612
ICU admission	Yes	17	25.8%	11	16.7%	6	9.1%	0.263
	No	49	74.2%	24	36.4%	25	37.9%	
Temperature °C		64	37.09 (0.78)	33	37.01 (0.69)	31	37.18 (0.86)	0.392
Fever	Yes	18	28.1%	8	12.5%	10	15.6%	0.476
	No	46	71.9%	25	39.1%	21	32.8%	
Cough	Yes	45	63.4%	18	25.4%	27	38.0%	0.008
	No	20	28.2%	16	22.5%	4	5.6%	
Sore throat	Yes	8	11.3%	5	7.0%	3	4.2%	0.308
	No	58	81.7%	30	42.3%	28	39.4%	
Dyspnea	Yes	55	77.5%	28	39.4%	27	38.0%	0.585
	No	10	14.1%	6	8.5%	4	5.6%	
Myalgia	Yes	17	23.9%	9	12.7%	8	11.3%	0.363
	No	49	69.0%	26	36.6%	23	32.4%	
Fatigue	Yes	6	8.5%	3	4.2%	3	4.2%	0.358
	No	60	84.5%	32	45.1%	28	39.4%	
Diarrhea	Yes	8	11.3%	3	4.2%	5	7.0%	0.234
	No	58	81.7%	32	45.1%	26	36.6%	
Neurological sign	Yes	13	18.3%	13	18.3%	0	0.0%	<0.001
	No	53	74.6%	22	31.0%	31	43.7%	
O_2 Saturation, %		65	89.46 (8.57)	35	86.51 (9.90)	30	92.90 (4.96)	0.001
Leukocyte count, $\times 10^9$/L		64	8.50 (6.67)	33	11.01 (7.83)	31	5.82 (3.70)	0.003
Leukopenia		12	37.5%	5	15.6%	7	21.9%	0.059
Leukocytosis		20	62.6%	15	46.9%	5	15.6%	
Lymphocyte ratio		58	19.68 (13.15)	29	15.41 (14.26)	29	23.96 (10.54)	0.012
CRP, mg/L		50	49.22 (41.02)	24	70.37 (49.02)	26	29.69 (16.14)	0.001
ESR, mm/h		29	46.21 (24.90)	14	43.00 (25.59)	15	49.20 (24.74)	0.513
Hemoglobin, g/L		64	12.70 (2.68)	33	11.18 (2.66)	31	14.32 (1.51)	<0.001
AST, U/L		36	112.00 (387.54)	16	206.18 (576.96)	20	36.65 (20.10)	0.258
LDH, U/L		31	1049.55 (2141.50)	17	1460.65 (2857.69)	14	550.36 (206.96)	0.245
Antiviral therapy	Yes	62	87.3%	31	43.7%	31	43.7%	0.553
	No	4	5.6%	3	4.2%	1	1.4%	
Antibacterial therapy	Yes	67	94.4%	35	49.3%	32	45.1%	0.290
	No	0	0%	0	0%	0	0%	

COVID-19: Coronavirus disease; N: Number; SD: Standard deviation; ICU: Intensive care unit; CRP: C-reactive protein; ESR: Erythrocyte sedimentation rate; AST: Aspartate aminotransferase; LDH: Lactate dehydrogenase. A P value less than 0.05 was considered significant.

(49.68±16.25) (P<0.001). The most prevalent symptoms at the time of patients' hospital admission were dyspnea (77.5%), followed by cough (63.4%). Of all the clinical manifestations, cough and neurological signs (the lateralizing sign of focal neurological insult) were shown to be significantly different between the two groups (P=0.008 and P<0.001, respectively). Notably, all the dead patients showed neurological signs; however, the remaining 43.7% who did not show neurological signs were discharged. Furthermore, the two groups did not differ substantially in terms of the symptoms like sore throat, dyspnea, myalgia, fatigue, and diarrhea (Table 1).

Sixty-seven (94.4%) and sixty-two (87.3%) patients received antivirals (lopinavir/ritonavir) and antibiotics, respectively (Table 2). The mean time from the illness onset to hospital admission was 5.45±3.62 days. Besides, the hospitalization lasted 6.65±3.95 and 8.45±4.88 days for the dead and discharged infected patients, respectively. Of all the patients, 25.8% were admitted to ICU (16.7% died), while the remaining 74.2% were not. Most patients had comorbidities, of which hypertension and diabetes mellitus were the most common, followed by heart disease. Most of those who died (30/36, 83.3%) had underlying diseases, the

Table 2: Comparison of chest CT features between deceased and discharged patients with COVID-19

		Total		Deceased		Discharged		P value
		N	Mean (SD)/ percentage	N	Mean (SD)/ percentage	N	Mean (SD)/ percentage	
Upper lobe		71	5.63 (6.97)	36	7.14 (8.12)	35	4.09 (5.23)	0.064
Middle lobe		71	8.25 (6.66)	36	10.83 (6.81)	35	5.60 (5.41)	0.001
Lower lobe		71	10.20 (7.97)	36	13.72 (7.98)	35	6.57 (6.20)	<0.001
Pattern Score		71	24.17 (19.14)	36	31.81 (19.42)	35	16.31 (15.52)	<0.001
Right upper lobe	Yes	53	74.6%	28	39.4%	25	35.2%	0.539
	No	18	25.4%	8	11.3%	10	14.1%	
Right middle lobe	Yes	54	76.1%	28	39.4%	26	36.6%	0.730
	No	17	23.9%	8	11.3%	9	12.7%	
Right lower lobe	Yes	63	88.7%	35	49.3%	28	39.4%	0.022
	No	8	11.3%	1	1.4%	7	9.9%	
Left upper lobe	Yes	54	76.1%	30	42.3%	24	33.8%	0.145
	No	17	23.9%	6	8.5%	11	15.5%	
Left lower lobe	Yes	61	85.9%	33	46.5%	28	39.4%	0.158
	No	10	14.1%	3	4.2%	7	9.9%	
Ground glass opacity	Yes	69	97.2%	36	50.7%	33	46.5%	0.146
	No	2	2.8%	0	0.0%	2	2.8%	
Lymphadenopathy	Yes	15	21.1%	1	1.4%	14	19.7%	<0.001
	No	56	78.9%	35	49.3%	21	29.6%	
Pleural effusion	Yes	24	33.8%	15	21.1%	9	12.7%	0.155
	No	47	66.2%	21	29.6%	26	36.6%	
Crazy paving	Yes	11	15.5%	11	15.5%	0	0.0%	<0.001
	No	60	84.5%	25	35.2%	35	49.3%	
Reverse halo	Yes	2	2.8%	0	0.0%	2	2.8%	0.146
	No	69	97.2%	36	50.7%	33	46.5%	
Reticular opacity	Yes	5	7.0%	4	5.6%	1	1.4%	0.174
	No	66	93.0%	32	45.1%	34	47.9%	
Consolidation	Yes	28	39.4%	26	36.6%	2	2.8%	<0.001
	No	43	60.6%	10	14.1%	33	46.5%	
Tree in bud	Yes	1	1.4%	1	1.4%	0	0.0%	0.321
	No	70	98.6%	35	49.3%	35	49.3%	
Centrilobular nodule	Yes	1	1.4%	1	1.4%	0	0.0%	0.321
	No	70	98.6%	35	49.3%	35	49.3%	
Cavitation	Yes	1	1.4%	1	1.4%	0	0.0%	0.321
	No	70	98.6%	35	49.3%	35	49.3%	
Solid nodules	Yes	3	4.2%	2	2.8%	1	1.4%	0.572
	No	68	95.8%	34	47.9%	34	47.9%	
Air bronchogram	Yes	14	19.7%	10	14.1%	4	5.6%	0.083
	No	57	80.3%	26	36.6%	31	43.7%	
Distribution	Peripheral	30	42.3%	16	22.5%	14	19.7%	0.257
	Peribron-chovascular	5	7.0%	4	5.6%	1	1.4%	
	Diffuse	34	47.9%	16	22.5%	18	25.4%	
Bilateral	Bilateral	60	84.5%	33	46.5%	27	38.0%	0.166
	Unilateral	9	12.7%	3	4.2%	6	8.5%	

CT: Computed tomography; COVID-19: Coronavirus disease; N: Number; SD: Standard deviation. P value less than 0.05 was considered as significant.

most common of which was diabetes (13/36, 36%), followed by heart diseases (12/36, 33%), hypertension (11/36, 30%), kidney diseases (6/36, 16%), cancers (6/36, 16%), strokes (4/36, 11%), and non-COVID-19 infection (3/36, 8%). Among the underlying diseases, cardiovascular disease (CVD) and kidney disease were found to be significantly higher in non-survived patients (10 (27.8%) and 6 (16.7%), respectively) compared to recovered patients (1 (2.9%) and 0 (0.0%)) (P=0.004 and P=0.012, respectively).

20 (62.6%) and 12 (37.5%) patients showed leukocytosis and leukopenia, respectively. Moreover, those who died of COVID-19 infection had higher leukocyte count and CRP level (P=0.003 and P=0.001, respectively) compared with the survived patients. Yet, compared to the discharged patients, the patients who died had significantly lower lymphocytes ratio and hemoglobin (Hb) (P=0.012 and P=<0.001, respectively). Moreover, no significant differences were found in terms of erythrocyte sedimentation

rate (ESR) (P=0.513), aspartate aminotransferase (AST) (P=0.258), and lactate dehydrogenase (LDH) (P=0.245) levels between the dead and survived groups.

The mean number of lesions seen in different lung lobes for the deceased and discharged groups were 24.17±19.14, 31.81±19.42, and 16.31±15.52 (P=<0.001), respectively. Additionally, it is worth noting that the number of lesions in the middle and lower lobes in the deceased group (10.83±6.81, 13.72±7.98, respectively) was significantly higher than that of the discharged group (5.60±5.41, 6.57±6.20, respectively) (P=0.001 and P<0.001, respectively). Likewise, the number of lesions in the upper lobe was higher (close to the significant level, P=0.064) in the deceased group (7.14±8.12) than in the discharged group (4.09±5.23). 35 patients in the deceased group had lesions in the right lower lobe, while only one in this group did not have any lesions in the right lower lobe.

The statistical incidence of GGO did not show a significant difference between the two studied groups (P=0.146). Also, the two groups did not differ regarding pleural effusion, reticular opacity, and solid nodules (P=0.155, P=0.174, and P=0.572, respectively). Nonetheless, CT results revealed that 78.9% (56 patients) of all patients did not have lymphadenopathy (15 patients have lymphadenopathy) and that only 1.4% of the dead patients had lymphadenopathy. In addition, the results showed that all the patients who had a crazy-paving pattern died, while 35.2% of the deceased group did not have such a pattern. Likewise, out of 28 patients who showed consolidation, 26 died and only two were discharged.

Discussion

As clinical and radiological results play a crucial role in diagnosing and treating COVID-19 patients, this study was performed to elucidate the clinical and radiological determining factors in the recovery or death of COVID-19-infected patients. In the present study, all patients were classified into two categories, the discharged and deceased patient groups. Ultimately, findings exhibited that cough manifestations were more widely witnessed in the deceased group, along with lower O_2 saturation, Hb, neutrophil to lymphocyte ratio (NLR), higher age, WBC count, and CRP compared to the recovered group. In addition, cardiovascular and kidney diseases comorbidities were more prevalent among dead subjects than survived patients. Moreover, crazy-paving pattern and consolidation incidence were significantly higher in the deceased COVID-19 patients compared to the discharged ones. GGO was also the most frequent CT finding among all the COVID-19-infected patients in the study.

A body of evidence has shown conflicting laboratory features in patients with COVID-19.[11] In this study, the dead COVID-19-infected patients demonstrated a significant leukocytosis and lymphopenia occurrence,, which coincides with those of other studies on COVID-19 patients. Previous studies consider leukocytosis as a risk factor in dead patients;[8, 12] however, others reported a significant decrease in the WBC counts or lack of any significant relationship between the severe and mild groups.[13, 14] Decreased lymphocyte count in patients with COVID-19 may be due to activation of T lymphocytes, accelerated cell cycle, exhaustion, and apoptosis of these lymphocytes. Also, the decrease in T regulatory cells that play an anti-inflammatory role during lymphopenia results in increased inflammation and disease progression.[15] T lymphocyte reduction can worsen the status of the disease.[16] In addition, Yao et al. suggested that lymphocyte-recruited lungs are among the reasons their blood count is lower.[17]

On the contrary, both the observed decreased lymphocytes and the increased number of leukocytes observed in the study's deceased group indicate an increase in leukocyte indices other than lymphocytes like neutrophils and monocyte in these patients. An increase in the number of neutrophils and neutrophil to lymphocyte ratio (NLR) has been observed in several studies.[18, 19] NLR is used as a biomarker to detect the severity of bacterial diseases[20] and Sun et al. demonstrated that NLR can determine the severity of the COVID-19 disease in patients.[18] In line with our study, Sun et al. also showed that the count of hemoglobin in the severe group is lower than that of the mild group.[18] Coronavirus can affect heme metabolism and hemoglobin break-down,[21] leading to hypoxia in COVID-19 patients and reduced oxygen-carrying capacity. It also suggests Hb functions as a predicting factor in the severity of COVID-19 infection. Subsequently, lower O_2 saturation was seen in the deceased patients compared to the discharged ones. Likewise, as we expected, the levels of CRP, used as a common inflammatory marker in the diagnosis of infectious diseases, were significantly higher in deceased patients than in the discharged ones. Given the association of CRP with disease severity and mortality in various studies, CRP have been suggested as a predictor marker in the severity of COVID-19.[22] Interestingly, though not significant, the ESR rate was at a lower level in the deceased patients than in the discharged patients. As one of the risk factors for death in various diseases and marker of disease severity in conditions, such as cancer and infection, LDH levels are also associated with the severity of pulmonary damage in COVID-19.[8, 23] Although the levels of LDH and AST were higher in the deceased group compared to the survived COVID-19 infected patients, they were not significant. AST is one of the factors which is indicative of liver function, and as its level in our study was not significantly higher in the deceased group, it can be said that the liver tissue may not be the main target of the virus and AST level is not useful in distinguishing the survived from non-survived COVID-19 pneumonia cases. Nevertheless, to clarify this association, more liver function tests are required.

According to the findings of the recent studies,[10, 24, 25] CT features such as different degrees of GGOs with/without crazy-paving signs, architectural distortion in a peripheral distribution, and multifocal organizing pneumonia were common in nearly all the patients with COVID-19.[26] In the present study, the most typical imaging features were GGO (97.2%), consolidation (39.4%), pleural effusion (33.8%), and crazy-paving pattern (15.5%) for both groups of COVID-19 pneumonia. The deceased COVID-19 patients were shown to have a significantly higher prevalence of crazy-paving patterns and consolidation than the survived patients. It suggests that inflammatory exudation fills alveoli, indicating that the virus circulates the respiratory epithelium; as a result, bronchitis is necrotized and alveolar damage is diffused.[27, 28] Also, consolidation might indicate further infiltration of the parenchyma. Moreover, there was no significant difference between the deceased and discharged COVID-19-infected patients regarding GGO prevalence.

Consolidation occurs when pathological fluids, cells, or tissues replace alveolar air, characterized by the increased pulmonary parenchymal density, resulting in concealing airway walls and margins of underlying vessels.[29] Moreover, COVID-19 patients usually show patchy, multifocal, or segmental consolidation disseminated in subpleural areas or across the bronchovascular bundles with a 2-64% occurrence rate.[8] Additionally, it has been considered that consolidation is an indicator of disease progression. According to Song et al., patients with longer time intervals between the time of symptom onset and CT scan, or those older than 50 years of age, showed more consolidative lesions;[30] this can function as an alert to manage and distinguish the severe/critical patients from the non-severe ones more effectively. Consolidations were more common in the death group than in the survival group. It was also found that the dead group showed more occurrence of consolidations than the survival group.

The results yielded from CT may have a close similarity to viscous secretions, which flow slowly through the pulmonary alveoli described in the autopsy report.[31] This event indicates acute respiratory distress syndrome (ARDS), which is recognized as an acute, diffuse, inflammatory lung injury. It leads to an extended alveolar-capillary permeability and acts as a strong predictor of mortality, displaying the severity. The findings of studies conducted on SARS have shown that a crazy-paving pattern is likely the product of alveolar edema and interstitial inflammation in acute lung injury.[32, 33] About 15.5% of cases in the dead group showed a crazy-paving appearance, reflecting interstitial lesions, thickened intralobular, and interlobular septae.

The recently conducted studies reported that 36% of COVID-19 patients showed a crazy-paving pattern.[34] Likewise, the crazy-paving pattern, coupled with diffuse GGO and consolidation, can represent COVID-19 turning into the progressive or peak stage.[35] It is noteworthy that lymphadenopathy was observed in 4-8% of COVID-19-diagnosed patients.[36] Also, lymphadenopathy was considered a significant risk factor for severe/acute COVID-19 pneumonia.[34] However, tree-in-bud sign and centrilobular nodule were only seen in one of the deceased COVID-19-infected patients, which was in line with the previously published studies.[7, 37, 38] Moreover, Chan et al.[39] and Cheng et al.[40] studies did not report lymphadenopathy in COVID-19 patients, which was in line with our findings, reporting in just one deceased patient.

As SARS-CoV involves an angiotensin-converting enzyme (ACE) that helps spread alveolar damage, it causes direct lung injury,[27] accounting for pathologic mechanism of GGO and consolidation, along with the swift alterations in CT findings. The findings of the present study are in line with the trend, according to which the crazy-paving pattern or consolidation on chest imaging should persuade the radiologist to think of COVID-19 as a potential diagnosis and to predict the severity of disease.[41]

The right lower lobe of the lung's bronchus was indicated to be straighter and steeper than the lung's other bronchial branches, suggesting that the virus is more prone to penetrate the branches of the right inferior lobar bronchus and cause infection in the early stage of the disease.[42] Given the degree of the disease's involvement, it was revealed that the disease distribution was mainly dispersed peripherally (subpleural) and most of both survived and non-survived patients manifested bilateral involvement in the initial chest CT.

It is noteworthy that this study has some limitations. First, given its retrospective design, only some laboratory tests were done on patients. Therefore, their role in predicting hospital deaths could be underestimated. However, the results of the current study allow an early assessment of the imaging characteristics of COVID-19. Last but not least, the interpretation of our results might be limited due to the influence of the sample size. However, by including all the adult patients in the three designated COVID-19 hospitals, we expect our study population to represent the cases diagnosed and treated in Shiraz, Iran.

Conclusion

As far as the authors' knowledge is concerned, this is the first and most inclusive study conducted on patients with COVID-19 experiencing a certain consequence of the disease in the south of Iran. This study identified several predictors and diagnostic factors for the mortality of COVID-19-confirmed patients. It was found that advanced age, cough, decreased oxygen saturation, more pre-existing concomitant diseases, neurological signs, elevated CRP, decreased Hb and NLR, GGO, crazy-paving pattern, and consolidation at the admission time were among the factors that predict the death of patients with COVID-19 pneumonia. Therefore, close monitoring and timely treatment should be performed for elderly patients at high risk.

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Conflict of interest*:* None declared.

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