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Infectious diseases

Relationship between chest CT scan findings with SOFA score, CRP, comorbidity, and mortality in ICU patients with COVID-19

Mohammad Esmaeil Hejazi[1] | Aida Malek Mahdavi[2] | Zahra Navarbaf[1,3] | Mohammad Kazem Tarzamni[4,5] | Rozhin Moradi[1,3] | Armin Sadeghi[1] | Hamed Valizadeh[1] | Leila Namvar[1]

[1]Tuberculosis and Lung Diseases Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

[2]Connective Tissue Diseases Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

[3]Clinical Research Development Unit, Imam Reza General Hospital, Tabriz University of Medical Sciences, Tabriz, Iran

[4]Medical Radiation Sciences Research Group, Tabriz University of Medical Sciences, Tabriz, Iran

[5]Department of Radiology, Medical School, Tabriz University of Medical Sciences, Tabriz, Iran

Correspondence
Leila Namvar, Tuberculosis and Lung Diseases Research Center, Tabriz University of Medical Sciences, Golgasht St., P.O Box 5166614756, Tabriz, Iran.
Email: leilanamvar3@gmail.com

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Abstract

Objective: This study aimed to investigate the relationship between chest computed tomography (CT) scan findings with sequential organ failure assessment (SOFA) score, C-reactive protein (CRP), comorbidity, and mortality in intensive care unit (ICU) patients with coronavirus disease 19 (COVID-19).

Method: Adult patients (≥18 years old) with COVID-19 who were consecutively admitted to the Imam-Reza Hospital, Tabriz, East-Azerbaijan Province, North-West of Iran between March 2020 and August 2020 were screened and total of 168 patients were included. Demographic, clinical, and mortality data were gathered. Severity of disease was evaluated using the SOFA score system. CRP levels were measured and chest CT scans were performed.

Results: Most of patients had multifocal and bilateral ground glass opacity (GGO) pattern in chest CT scan. There were significant correlations between SOFA score on admission with multifocal and bilateral GGO ($P = .010$ and $P = .011$, respectively). Significant relationships were observed between unilateral and bilateral GGO patterns with CRP ($P = .049$ and $P = .046$, respectively). There was significant relationship between GGO patterns with comorbidities including overweight/obesity, heart failure, cardiovascular diseases, and malignancy ($P < .05$). No significant relationships were observed between chest CT scan results with mortality ($P > .05$).

Conclusion: Multifocal bilateral GGO was the most common pattern. Although chest CT scan characteristics were significantly related with SOFA score, CRP, and comorbidity in ICU patients with COVID-19, a relationship with mortality was not significant.

1 | INTRODUCTION

In December 2019, an outbreak of cases of pneumonia caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was identified in Wuhan, China.[1] The disease has been termed coronavirus disease 19 (COVID-19) and rapidly develops throughout the globe.[1] On March 2020, the World Health Organization (WHO) announced the new coronavirus outbreak to be a pandemic.[2] The clinical severity of COVID-19 varies from asymptomatic to acute respiratory distress syndrome (ARDS) and multiple organ dysfunctions needing respiratory support such as non-invasive ventilation and/or mechanical ventilation and admission to the intensive care unit (ICU).[3] Approximately 20% of the COVID-19 patients develop severe illness after admission to the hospital.[4] Mortality rate ranges from 16-78 percent in critically ill patients with COVID-19.[5] The high Sequential Organ Failure Assessment (SOFA) score on admission can be a significant predictor of developing severe illness in hospital and is considered as a risk factor for COVID-19 mortality.[6-10] Furthermore, underlying diseases such as obesity, diabetes mellitus, chronic respiratory disease, cardiovascular disease, hypertension and cancer have an association with higher risk of mortality.[11,12]

Most patients with COVID-19 present pneumonia thus computed tomography (CT) scanning of the thorax can be a useful tool in screening and diagnosis.[13] Chest CT scan is able to present typical radiological findings of COVID-19 even before the appearance of clinical symptoms.[14-16] Moreover, chest CT scan is a sensitive method in comparison with reverse transcription polymerase chain reaction (RT-PCR) and assists physicians to identify COVID-19 patients who initially had negative RT-PCR results.[14,17] The typical chest CT scan indicates numerous ground glass opacity (GGO) and/or consolidations in a peripheral distribution, which also presents the severity of pulmonary inflammation.[18-20] It has been reported that consolidation and GGO on chest CT scans are more common in non-survivors than survivors.[8,21] In addition, majority of the patients with COVID-19 have bilateral infiltrates on chest CT scans.[11] Due to its availability, chest CT scan may help first-line triage of patients admitting to the hospital.[22] Chest CT scan is also helpful in assessing the severity and progression of disease, monitoring the clinical course as well as assessing the treatment.[23,24] Elevation in consolidative opacities and GGO as well as interstitial septal thickening on chest CT scan is associated with exacerbating pneumonia.[15,25] Chest CT features of COVID-19 pneumonia have been studied mostly in Chinese individuals; however, radiological manifestations should be clarified in other populations and areas around the world that have a quickly increasing number of confirmed cases.

SARS-CoV-2 infection is a multifaceted disease; therefore a reliable and appropriate biomarker is required to show changes in pattern of lung involvement and predict the severity of COVID-19 pneumonia. C-reactive protein (CRP) can be useful in the early diagnosis of pneumonia,[26] and patients with severe pneumonia had high CRP concentrations. Recently, studies have indicated that CRP has a positive association with severe dengue infection.[27,28] Changes in CRP have been demonstrated in COVID-19 patients, but little is known about its correlation with disease severity.[29,30] According to the research in COVID-19 patients, CRP concentration increased as the disease progressed and positive correlation was observed between CRP concentration with lung lesion and disease severity.[31] Furthermore, serum high-sensitivity CRP concentration and CT scores have a good consistency, and their combination can effectively evaluate disease progression and therapeutic effects.[32]

Since Iran has the largest number of approved COVID-19 cases in Asia after China and to the best of our knowledge, there is no study investigating the relationship between chest CT scan characteristics with SOFA score, CRP, comorbidity, and mortality in Iranian COVID-19 patients, current study designed to assess the chest CT scan features in ICU patients with COVID-19 and to find whether there is a relationship between the chest CT scan features with SOFA score, CRP, comorbidity, and mortality.

What's known

Chest CT scan can be a useful tool in screening and diagnosis and is able to present typical radiological findings of COVID-19 even before the appearance of clinical symptoms. Chest CT scan is also helpful in assessing the severity and progression of disease, monitoring the clinical course as well as assessing the treatment.

What's new

Multifocal bilateral GGO was the most common pattern in chest CT scan. There were significant correlations between SOFA score on admission with multifocal and bilateral GGO. Significant relationships were observed between unilateral and bilateral GGO patterns with CRP. There was significant relationship between GGO patterns with comorbidities including overweight/obesity, heart failure, cardiovascular diseases, and malignancy. No significant relationships were observed between chest CT scan results with mortality.

2 | METHODS

2.1 | Study patients

Adult patients (≥18 years old) with COVID-19 according to the WHO interim guidance[33] who were consecutively admitted to the Imam-Reza Medical Research and Training Hospital, Tabriz, East-Azerbaijan Province, North-West of Iran between March 2020 and August 2020 were screened and total of 168 ICU patients diagnosed by PCR COVID-19 positive and typical CT scan pattern in PCR negative patients were included in this research. Imam-Reza Medical Research and Training Hospital is the main in Tabriz city, East-Azerbaijan Province, which is one of the high-risk regions in the North-West of Iran. This hospital is affiliated to the Tabriz University of Medical Sciences, Tabriz, Iran. The research protocol was confirmed by the Institutional Review Board and Medical Ethics Committee of Tabriz University of Medical Sciences (ethics code: IR.TBZMED.REC.1399.016). Written informed consents were collected from the patients or their families.

2.2 | Data collection

Demographic and clinical characteristics were gathered using a data collection form. The demographic data including age, sex, and smoking; comorbidities including hypertension, diabetes, chronic respiratory disease, coronary artery disease, heart failure, cardiovascular disease, chronic renal failure, malignancy, rheumatologic disease, and chronic liver disease; clinical symptoms including cough, fever, dyspnea, myalgia, fatigue, hemoptysis, chill, headache, sore throat, anorexia, nausea/vomiting, anosmia, taste loss, and diarrhea; vital signs including blood pressure, respiratory rate, heart rate, blood O_2 saturation, and body temperature as well as mortality (survived or died) were gathered. The SOFA score system was used to determine severity of disease with higher scores reflecting more severe illness.[34] Blood samples were also collected on admission and CRP levels were measured by immunoturbidimetry method. Due to wide variation in CRP level, we classified it into three categories: 1+: <10 mg/dL, 2+: 10-50 mg/dL, and 3+: >50 mg/dL.[35] The date of disease onset was ascertained as the day when the first symptom was appeared.

2.3 | Chest CT scan

Chest CT scans were conducted by a multi-detector CT scanner 16 slice (Siemens, Munich, Germany) with detailed parameters as below: tube voltage, 120 kV; tube current, standard (60-120 mAs); slice thickness, 1-1.5 mm; reconstruction interval, 1-1.5 mm. The CT scans were conducted beginning from the apex to the lowest part of the lungs in a deep inspiration. Patients were supine in the CT scanner with arms above their head. An expert radiologist (Dr Mohammad Kazem Tarzamni, Professor of Radiology with 25 year experience) analyzed and interpreted the CT scans. Pattern of lung involvement in chest CT scan of COVID-19 patients was divided into 8 categories: Unifocal GGO, Multifocal GGO, Unilateral GGO, Bilateral GGO, Unifocal Consolidation, Multifocal Consolidation, Unilateral Consolidation, and Bilateral Consolidation.

2.4 | Statistical analysis

Statistical analysis was carried out by SPSS 16.0 software (SPSS, Chicago, IL). The normal distribution of variables was assessed using the Kolmogorov-Smirnov test. Categorical variables were presented as number with percentage. Continuous variables were expressed as mean ±SD or median (interquartile range), as appropriate. Comparisons between groups were made by Chi-square test, Independent sample t-test, or Mann-Whitney U test, as appropriate. Correlations between variables were determined by Spearman correlation analysis. P <.05 was defined statistically significant.

3 | RESULTS

Total of 168 ICU patients with COVID-19 were studied. Baseline characteristics of patients are presented in Table 1.

As presented in Table 2, most of patients who had multifocal and bilateral GGO pattern on chest CT scans had SOFA scores <5 on admission (day 1). Significant relationships were only observed between the SOFA score classification on admission (day 1) with multifocal and bilateral GGO (P = .016 and P = .044, respectively).

TABLE 1 Baseline characteristics of COVID-19 patients

Characteristics	All patients (n = 168)
Age (year)	62.65 ± 17.34
Sex	
Male	102 (61)
Female	66 (39)
Smoking	24 (15)
SOFA score	5.14 ± 3.39
CRP	
1+	43 (26)
2+	38 (23)
3+	36 (21)
High	11 (7)
Comorbidity	
Overweight/Obesity	81 (79)
Hypertension	76 (47)
Diabetes	40 (25)
Coronary artery disease	22 (14)
Chronic respiratory disease	20 (12)
Chronic renal failure	17 (11)
Heart failure	15 (9)
Cardiovascular disease	13 (8)
Malignancy	10 (6)
Rheumatologic disease	5 (3)
Chronic liver disease	3 (2)
Clinical symptoms	
Dyspnea	127 (76)
Cough	91 (54)
Myalgia	48 (29)
Fever (temperature ≥37.3°C)	47 (28)
Fatigue	45 (27)
Chill	35 (21)
Anorexia	18 (11)
Headache	17 (10)
Nausea/Vomiting	17 (10)
Sore throat	15 (9)
Anosmia	14 (8)
Taste loss	13 (8)
Diarrhea	6 (4)
Hemoptysis	6 (4)
Vital signs	
Systolic blood pressure (mmHg)	121.91 ± 19.21
Diastolic blood pressure (mmHg)	73.11 ± 13.95
Respiratory rate (breaths/min)	25.10 ± 7.35
Heart rate (beats/min)	96.06 ± 17.12
Blood O_2 saturation (%)	83.43 ± 11.49

(Continues)

TABLE 1 (Continued)

Characteristics	All patients (n = 168)
Body temperature (°C)	37.27 ± 0.75
Chest CT scan	
Unifocal GGO	
Yes	8 (5)
No	160 (95)
Multifocal GGO	
Yes	98 (58)
No	70 (42)
Unilateral GGO	
Yes	6 (4)
No	162 (96)
Bilateral GGO	
Yes	100 (60)
No	68 (40)
Unifocal Consolidation	
Yes	4 (2)
No	164 (98)
Multifocal Consolidation	
Yes	55 (33)
No	113 (67)
Unilateral Consolidation	
Yes	4 (2)
No	164 (98)
Bilateral Consolidation	
Yes	60 (36)
No	108 (64)
Multifocal Bilateral GGO	
Yes	54 (32)
No	114 (68)
Multifocal Bilateral Consolidation	
Yes	18 (11)
No	150 (89)
Multifocal Bilateral GGO Consolidation	
Yes	42 (25)
No	126 (75)

Note: Continuous variables were reported as mean ±SD or median (IQR) while categorical variables were expressed as frequency (percentage).
Abbreviations: COVID-19, Coronavirus disease 19; CRP, C-reactive protein; CT, Computed tomography; GGO, ground glass opacity; SOFA, Sequential Organ Failure Assessment.

Table 3 presents correlations between chest CT scan with SOFA scores on admission (day 1) and on day 5 in study patients. According to Table 3, there were only significant correlations between SOFA score on admission (day 1) with multifocal and bilateral GGO ($P = .010$ and $P = .011$, respectively). In addition, there were significant correlations between SOFA scores on admission (day 1) and on day 5 with multifocal bilateral GGO ($P = .035$ and $P = .044$, respectively).

Table 4 shows relationship between chest CT scan and mortality with CRP in study patients. According to Table 4, most patients with GGO patterns on chest CT scans had CRP 1+. Significant relationships were observed between unilateral and bilateral GGO patterns on chest CT scans with CRP ($P = .049$ and $P = .046$, respectively).

As demonstrated in Table 5, significant relationships were observed between unifocal, unilateral, and bilateral GGO patterns on chest CT scans with overweight/obesity ($P = .006$, $P = .045$, and $P = .034$, respectively). Furthermore, significant relationships were observed between multifocal and bilateral GGO patterns on chest CT scans with heart failure ($P = .001$ and $P = .001$, respectively). In addition, there were significant relationships between unifocal, multifocal, unilateral, and bilateral GGO patterns on chest CT scans with cardiovascular diseases ($P = .041$, $P = .005$, $P = .027$ and $P = .003$, respectively). Significant relationships were also observed between unifocal and unilateral GGO patterns on chest CT scans with malignancy ($P = .012$ and $P = .006$, respectively). Significant relationship was also observed between multifocal bilateral GGO pattern with cardiovascular diseases ($P = .041$).

According to Table 6, no significant relationships were observed between chest CT scan results with mortality ($P > .05$).

4 | DISCUSSION

To the best of our knowledge, this is the first study to assess the relationship between chest CT scan findings with SOFA score, CRP, comorbidity, and mortality in ICU patients with COVID-19 in East-Azerbaijan Province, which is one of the high-risk regions in the North-West of Iran. Consistent with previous studies,[18-20,36-44] our research indicated that multifocal and bilateral GGO were the most common patterns on chest CT scans. Furthermore, multifocal and bilateral consolidation were more prevalent than unifocal and unilateral consolidation patterns. A GGO pattern has been suggested to be a very common feature in COVID-19 pneumonia as 100% of individuals whose diagnosis was affirmed by RT-PCR had this feature.[38] Also, there was no significant difference in the CT scan features between subjects with confirmed COVID-19 who needed admission and subjects who were discharged.[38] Since a GGO pattern can be present in different phases of the disease,[45-47] thereby being the most common radiologic feature. The appearance of GGO can be attributable to COVID-19 pathophysiology. The SARS-CoV-2 virus invades the pulmonary interstitium at the end of the lobular bronchioles and spreads to the distal end. The lesion emanates in the secondary pulmonary lobule, appearing as a round ground-glass appearance on CT and then expands to become as confluent GGO.[48] A GGO pattern can cause partial filling of the alveoli that is related with the viral infections pathogenesis.[49] It has been reported that GGO with or without consolidation are major characteristics of the COVID-19. These characteristics are highly indicative of acute interstitial pneumonia of the disease and are consistent with its histopathological

TABLE 2 Relationship between chest CT scan and SOFA scores in study patients

	SOFA score on Day 1			*P*-value*	SOFA score on Day 5			*P*-value*
Chest CT scan	<5	5-10	>10		<5	5-10	>10	
Unifocal GGO				.625				.655
Yes	3 (38)	5 (63)	0 (0)		1 (25.0)	3 (75.0)	0 (0)	
No	78 (49)	75 (47)	7 (4)		27 (36)	41 (54)	8 (10)	
Multifocal GGO				**.016**				.564
Yes	54 (55)	42 (43)	2 (2)		18 (40)	23 (51)	4 (9)	
No	27 (39)	38 (54)	5 (7)		10 (29)	21 (60)	4 (11)	
Unilateral GGO				.501				.872
Yes	1 (20)	5 (80)	0 (0)		1 (33)	3 (67)	0 (0)	
No	80 (50)	75 (46)	7 (4)		27 (36)	41 (54)	8 (10)	
Bilateral GGO				**.044**				.465
Yes	55 (55)	43 (43)	2 (2)		19 (40)	24 (51)	4 (9)	
No	26 (38)	37 (55)	5 (7)		9 (27)	20 (61)	4 (12)	
Unifocal Consolidation				.095				.822
Yes	2 (50)	1 (25)	1 (25)		1 (33)	2 (67)	0 (0)	
No	79 (48)	79 (48)	6 (4)		27 (35)	42 (55)	8 (10)	
Multifocal Consolidation				.370				.643
Yes	26 (47)	25 (46)	4 (7)		9 (29)	19 (61)	3 (10)	
No	55 (49)	55 (49)	3 (3)		19 (39)	25 (51)	5 (10)	
Unilateral Consolidation				.095				.822
Yes	2 (50)	1 (25)	1 (25)		1 (33)	2 (67)	0 (0)	
No	79 (48)	79 (48)	6 (4)		27 (35)	42 (55)	8 (10)	
Bilateral Consolidation				.481				.934
Yes	28 (47)	28 (47)	4 (6)		12 (33)	20 (56)	4 (11)	
No	53 (49)	52 (48)	3 (3)		16 (36)	24 (55)	4 (9)	
Multifocal Bilateral GGO				.077				.215
Yes	31 (57)	23 (43)	0 (0)		11 (50)	9 (41)	2 (9)	
No	50 (44)	57 (50)	7 (6)		17 (30)	35 (60)	6 (10)	
Multifocal Bilateral Consolidation				.172				.766
Yes	6 (33)	10 (56)	2 (11)		4 (31)	7 (54)	2 (15)	
No	75 (50)	70 (47)	5 (3)		24 (36)	37 (55)	6 (9)	
Multifocal Bilateral GGO				.773				.799
Consolidation								
Yes	22 (52)	18 (43)	2 (5)		7 (30)	14 (61)	2 (9)	
No	59 (47)	62 (49)	5 (4)		21 (37)	30 (53)	6 (10)	

Note: Bold values are statistically significant ($P < .05$).
Data were expressed as frequency (percentage).
Abbreviations: CT, Computed tomography; GGO, ground glass opacity; SOFA. Sequential Organ Failure Assessment.
$P < .05$ was considered significant.
*P values indicate comparison between groups (Chi-square).

results that COVID-19 pneumonia involves both parenchyma and interstitial lung tissue.[50] In addition, GGO and consolidation are more common in patients who needed ICU admission. These findings indicate that chest CT scan can be a helpful risk stratification tool for admitted patients, and via applying a simple procedure for scoring the abnormal results in each location, radiologists can give critical information about at-risk patients who need ICU admission. Moreover, the chest CT scan can predict the prognosis of patients.[51] Based on our study, a GGO pattern was more valuable than a consolidation pattern in predicting the prognosis of COVID-19 patients which was in line with Lin et al[52] who indicated the value of the CT scan in diagnosis and evaluation of COVID-19. Additional studies are

TABLE 3 Correlation between chest CT scan and SOFA scores in study patients

Chest CT scan	SOFA score on Day 1 (n = 168)		SOFA score on Day 5 (n = 80)	
	r	*P*-value*	r	*P*-value*
Unifocal GGO	0.008	.917	0.075	.509
Multifocal GGO	0.199	**.010**	0.196	.082
Unilateral GGO	0.088	.256	0.095	.404
Bilateral GGO	0.196	**.011**	0.196	.082
Unifocal Consolidation	0.004	.963	0.059	.605
Multifocal Consolidation	0.039	.620	0.170	.132
Unilateral Consolidation	0.004	.963	0.059	.605
Bilateral Consolidation	0.035	.656	0.112	.325
Multifocal Bilateral GGO	0.162	**.035**	0.226	**.044**
Multifocal Bilateral Consolidation	0.127	.102	0.192	.088
Multifocal Bilateral GGO Consolidation	0.056	.467	0.008	.941

Note: $P < .05$ was considered significant.

Abbreviations: CT, Computed tomography; GGO, ground glass opacity; SOFA, Sequential Organ Failure Assessment.

*Spearman rank correlation coefficient.

warranted to completely understand the prognostic power of this finding in patients with COVID-19.

Our study preliminarily demonstrated a significant correlation between chest CT scan features including multifocal and bilateral GGO patterns with SOFA score on admission (day 1). In addition, significant correlations were noticed between multifocal bilateral GGO with SOFA scores on admission (day 1) and on day 5. These findings indicate that in more severe disease, more abnormalities can be observed on chest CT scan. The SOFA score is an important index to reflect the state and degree of multiple organ dysfunctions[11] and can predict the severity and outcome of the disease.[53,54] In a study by Francone et al,[55] CT score was significantly higher in critical and severe patients than in mild stage subjects which was consistent with our research. In addition, Shen et al[56] found that CT imaging was helpful in classifying disease severity as a larger proportion of scans from critically ill patients presented bilateral lung involvement compared with mild cases. In another study on COVID-19 patients, higher CT scores had a significant relationship with more severe disease.[57] Wu et al[40] also suggested that chest CT scan could be used to assess the severity of the disease and had a considerable function in clinical practice. Therefore, it seems that CT is the main procedure to determine the severity of the disease and can be used to identify disease progression. The main benefit of the CT scan is that the test is available immediately and results are accessible directly after scanning. This benefit depends on the accessibility of a CT scan, personnel and a well-designed approach to perform these scans.

Increased inflammatory parameters, such as CRP were reported in COVID-19.[31,44,55,58-60] CRP is a non-specific acute-phase protein as well as a sensitive biomarker of inflammation, infection, and tissue destruction.[61] Increased CRP concentrations may reflect the extent of inflammation or extensive tissue damage and are usually noticed in viral pneumonia.[62,63] According to our study, there was a significant relationship between chest CT scan features including unilateral and bilateral GGO patterns with serum CRP. Our research was consistent with Zhu et al[64] who indicated that chest CT scan results significantly positively correlated with CRP concentrations. Furthermore, Zhang et al[44] and Xiong et al[65] reported that CRP had a significant positive correlation with the severity of pneumonia assessed on CT scan. Francone et al[55] indicated a statistically significant correlation between CT score and CRP which was in line with our study. Moreover, Tan et al[60] stated a positive correlation between CRP with CT scores which was similar to present study. Chen et al[66] also found a positive correlation between plasma CRP level and CT grading. Furthermore, it has been reported that serum CRP concentration and CT scores have a good consistency, and their combination can effectively evaluate disease progression and therapeutic effects.[32]

Our study preliminarily demonstrated significant relationships between chest CT scan features including GGO patterns with comorbidities, such as overweight/obesity, heart failure, cardiovascular diseases, and malignancy. To our surprise, this research did not reveal significant relationship between chest CT scan features with preexisting hypertension and diabetes mellitus. There are limited reports about the relationship between chest CT scan manifestations and comorbidities. Our study was supported by Liu et al[67] who reported that preexisting chronic diseases were correlated with the higher disease severity and increased admittance to ICU. However, another study conducted by Asai et al[68] did not find any correlation between the underlying diseases and radiological characteristics which was in contrast with our study. This discrepancy might be due to differences in sample size and characteristics of studied patients. The sample size included in

TABLE 4 Relationship between chest CT scan and C-reactive protein in study patients (n = 168)

Chest CT scan	C-reactive protein 1+	2+	3+	High	*P*-value*
Unifocal GGO					.722
Yes	3 (38)	1 (13)	1 (13)	1 (13)	
No	37 (23)	37 (23)	33 (21)	10 (6)	
Multifocal GGO					.063
Yes	26 (27)	20 (20)	14 (14)	5 (5)	
No	14 (20)	18 (26)	20 (29)	6 (9)	
Unilateral GGO					**.049**
Yes	2 (40)	1 (20)	1 (20)	1 (20)	
No	38 (24)	37 (23)	33 (20)	10 (6)	
Bilateral GGO					**.046**
Yes	26 (26)	20 (20)	14 (14)	6 (6)	
No	14 (21)	18 (27)	20 (29)	5 (7)	
Unifocal Consolidation					.386
Yes	2 (50)	1 (25)	0 (0)	1 (25)	
No	38 (23)	37 (23)	34 (21)	10 (6)	
Multifocal Consolidation					.233
Yes	10 (18)	16 (29)	8 (15)	2 (4)	
No	30 (27)	22 (20)	26 (23)	9 (8)	
Unilateral Consolidation					.386
Yes	2 (50)	1 (25)	0 (0)	1 (25)	
No	38 (23)	37 (23)	34 (21)	10 (6)	
Bilateral Consolidation					.094
Yes	10 (17)	19 (32)	8 (13)	3 (5)	
No	30 (28)	19 (18)	26 (24)	8 (7)	
Multifocal Bilateral GGO					.095
Yes	19 (35)	7 (13)	9 (17)	3 (6)	
No	21 (18)	31 (27)	25 (22)	8 (7)	
Multifocal Bilateral Consolidation					.118
Yes	2 (11)	8 (44)	5 (28)	0 (0)	
No	38 (25)	30 (20)	29 (19)	11 (7)	
Multifocal Bilateral GGO Consolidation					.113
Yes	7 (17)	11 (26)	4 (10)	3 (7)	
No	33 (26)	27 (21)	30 (24)	8 (6)	
Mortality					.556
Survived	26 (26)	22 (22)	21 (21)	8 (8)	
Died	16 (21)	16 (21)	15 (20)	4 (5)	

Note: Data were expressed as frequency (percentage).

Abbreviations: CT, Computed tomography; GGO, ground glass opacity.

$P < .05$ was considered significant.

**P* values indicate comparison between groups (Chi-square).

present study was larger than Asai et al[68] research and the results may be more convincing. It has been reported that comorbidities lead to an impaired body function and weakened immune system, thereby causing individuals to be more vulnerable to the coronavirus. Chronic diseases share several common features with infectious disorders and their complications, such as endothelial dysfunction, the pro-inflammatory state, and alterations in the innate immune response.[69-71] More investigations

TABLE 5 Relationship between chest CT scan and comorbidities in study patients

	Overweight/ Obesity			Hypertension			Diabetes			Heart failure			CVD			Malignancy		
Chest CT scan	Yes	No	P*	Yes	No	P*	Yes	No	P*	Yes	No	P*	Yes	No	P*	Yes	No	P*
Unifocal GGO			**.006**			.584			.509			.639			**.041**			**.012**
Yes	1 (25)	3 (75)		3 (37)	5 (63)		1 (14)	6 (86)		1 (14)	6 (86)		2 (29)	5 (71)		2 (29)	5 (71)	
No	80 (82)	18 (18)		73 (47)	81 (53)		39 (25)	115 (75)		14 (9)	141 (91)		11 (7)	144 (93)		8 (5)	147 (95)	
Multifocal GGO			.059			.871			.737			**.001**			**.005**			.993
Yes	53 (86)	9 (14)		45 (46)	52 (54)		25 (26)	72 (74)		3 (3)	94 (97)		3 (3)	94 (97)		6 (6)	91 (94)	
No	28 (70)	12 (30)		31 (48)	34 (52)		15 (23)	49 (77)		12 (18)	53 (82)		10 (15)	55 (85)		4 (6)	61 (94)	
Unilateral GGO			**.045**			.608			.620			.728			**.027**			**.006**
Yes	1 (33)	2 (67)		2 (40)	4 (60)		2 (40)	4 (60)		0 (0)	6 (100)		2 (40)	4 (60)		2 (40)	4 (60)	
No	80 (81)	19 (19)		74 (47)	82 (53)		38 (25)	117 (75)		15 (10)	141 (90)		11 (7)	145 (93)		8 (5)	148 (95)	
Bilateral GGO			**.034**			.430			.823			**.001**			**.003**			.941
Yes	55 (86)	9 (14)		44 (44)	55 (56)		24 (24)	75 (76)		3 (3)	96 (97)		3 (3)	96 (97)		6 (6)	93 (94)	
No	26 (68)	12 (32)		32 (51)	31 (49)		16 (26)	46 (74)		12 (19)	51 (81)		10 (16)	53 (84)		4 (6)	59 (94)	
Unifocal Consolidation			0.2			0.6			0.7			0.5			0.6			.654
Yes	1 (50)	1 (50)	99	1 (33)	2 (67)	34	1 (33)	2 (67)	31	0 (0)	3 (100)	77	0 (0)	3 (100)	06	0 (0)	3 (100)	
No	80 (80)	20 (20)		75 (47)	84 (53)		39 (25)	119 (75)		15 (9)	144 (91)		13 (8)	146 (92)		10 (6)	149 (94)	
Multifocal Consolidation			.0			.11			.1			.2			.1			.817
Yes	28 (90)	3 (10)	72	30 (56)	24 (44)	9	17 (32)	37 (68)	66	3 (6)	51 (94)	50	2 (4)	52 (96)	52	3 (6)	51 (94)	
No	53 (75)	18 (25)		46 (43)	62 (57)		33 (22)	84 (78)		12 (11)	96 (89)		11 (10)	97 (90)		7 (6)	101 (94)	
Unilateral Consolidation			.299			.634			.731			.577			.606			.654
Yes	1 (50)	1 (50)		1 (33)	2 (67)		1 (33)	2 (67)		0 (0)	3 (100)		0 (0)	3 (100)		0 (0)	3 (100)	
No	80 (80)	20 (20)		75 (47)	84 (53)		39 (25)	119 (75)		15 (9)	144 (91)		13 (8)	146 (92)		10 (6)	149 (94)	
Bilateral Consolidation			0.119			0.116			0.173			0.180			0.109			.693
Yes	30 (88)	4 (12)		32 (55)	26 (45)		18 (31)	40 (69)		3 (5)	55 (95)		2 (3)	56 (97)		3 (5)	55 (95)	
No	51 (75)	17 (25)		44 (42)	60 (58)		22 (21)	81 (79)		12 (12)	92 (88)		11 (11)	93 (89)		7 (7)	97 (93)	

(Continues)

TABLE 5 (Continued)

Chest CT scan	Overweight/ Obesity			Hypertension			Diabetes			Heart failure			CVD			Malignancy		
	Yes	No	P*	Yes	No	P*	Yes	No	P*	Yes	No	P*	Yes	No	P*	Yes	No	P*
Multifocal Bilateral GGO			.065			.148			.584			.085			**.041**			.817
Yes	33 (89)	4 (11)		21 (39)	33 (61)		12 (22)	42 (78)		2 (4)	52 (96)		1 (2)12	53 (98)		3 (6)	51 (94)	
No	48 (74)	17 (26)		55 (51)	53 (49)		28 (26)	79 (74)		13 (12)	95 (88)		(11)	96 (89)		7 (6)	101 (94)	
Multifocal Bilateral Consolidation			.110			.188			.217			.638			.213			.280
Yes	9 (100)	0 (0)		10 (63)	6 (37)		6 (37)	10 (63)		2 (12)	14 (88)		0 (0)	16 (100)		0 (0)	16 (100)	
No	72 (77)	21 (23)		66 (45)	80 (55)		34 (23)	111 (77)		13 (9)	133 (91)		13 (9)	133 (91)		10 (7)	136 (93)	
Multifocal Bilateral GGO Consolidation			.933			.409			.516			.074			.366			.762
Yes	20 (80)	5 (20)		22 (52)	20 (48)		12 (29)	30 (71)		1 (2)	41 (98)		2 (5)	40 (95)		3 (7)	39 (93)	
No	61 (79)	16 (21)		54 (45)	66 (55)		28 (24)	91 (76)		14 (12)	106 (88)		11 (9)	109 (91)		7 (6)	113 (94)	

Note: Bold values are statistically significant ($P < .05$).

Data were expressed as frequency (percentage).

Abbreviations: CT, Computed tomography; CVD, Cardiovascular disease; GGO, ground glass opacity.

$P < .05$ was considered significant.

*P values indicate comparison between groups (Chi-square).

TABLE 6 Relationship between chest CT scan and mortality in study patients (n = 168)

Chest CT scan	Mortality: Survived (n = 94)	Died (n = 74)	P-value*
Unifocal GGO			.281
Yes	3 (37)	5 (63)	
No	91 (57)	69 (43)	
Multifocal GGO			.713
Yes	56 (57)	42 (43)	
No	38 (54)	32 (46)	
Unilateral GGO			.400
Yes	2 (40)	4 (60)	
No	92 (57)	70 (43)	
Bilateral GGO			.988
Yes	56 (56)	44 (44)	
No	38 (56)	30 (44)	
Unifocal Consolidation			.437
Yes	3 (75)	1 (25)	
No	91 (55)	73 (45)	
Multifocal Consolidation			.114
Yes	26 (47)	29 (53)	
No	68 (60)	45 (40)	
Unilateral Consolidation			.437
Yes	3 (75)	1 (25)	
No	91 (56)	73 (45)	
Bilateral Consolidation			.138
Yes	29 (48)	31 (52)	
No	65 (60)	43 (40)	
Multifocal Bilateral GGO			.111
Yes	35 (65)	19 (35)	
No	59 (52)	55 (48)	
Multifocal Bilateral Consolidation			.123
Yes	7 (39)	11 (61)	
No	87 (58)	63 (42)	
Multifocal Bilateral GGO Consolidation			.370
Yes	21 (50)	21 (50)	
No	73 (58)	53 (42)	

Note: Data were expressed as frequency (percentage).
Abbreviations: CT, Computed tomography; GGO, ground glass opacity.
$P < .05$ was considered significant.
**P* values indicate comparison between groups (Chi-square).

are warranted to evaluate the nature and extent of coexistence between COVID-19 and chronic diseases.

Based on our study, multifocal and bilateral GGO patterns on chest CT scans were more common in survived patients than in death patients, whereas multifocal and bilateral consolidation patterns were more common in death patients than in survived patients. Recent investigations by Zhou et al[8] and Yuan et al[36] showed consolidation and bilateral infiltration were more frequent in patients who died from COVID-19 than patients who survived which was in line with our research. Li et al[72] also reported that consolidations on CT images were more common in death patients than in survived patients which was consistent with our study. Furthermore, another study in COVID-19 adults reported that presence of consolidation pattern was more common in non-survivors compared to survivors.[73] The relation between CT findings and mortality are not completely understood. Present research did not show any significant relationships between chest CT scan results with mortality. Our research was consistent with Asai et al[68] who also indicated no significant association between CT findings with mortality. However, Raoufi et al[74] showed a significant correlation between chest CT scan characteristics and mortality of COVID-19 cases which was in contrast with our study. Furthermore, Hu et al[21] reported that chest CT findings were worsening in patients who died from COVID-19.

This study had some limitations including a single-center study and having small sample size. Thus, additional large-scale multicenter studies would be helpful. Furthermore, we did not follow-up these patients who survived and correlated their chest CT or clinical findings with outcomes. Lastly, no autopsy was conducted in the deceased patients.

5 | CONCLUSION

In conclusion, multifocal bilateral GGO was the most common pattern on chest CT scans. Furthermore, multifocal bilateral consolidation was more prevalent than unifocal unilateral consolidation pattern. Although chest CT scan characteristics were significantly related with SOFA score, CRP, and comorbidity in ICU patients with COVID-19, a relationship with mortality was not significant.

CONFLICT OF INTEREST

The authors declared that they have no conflicts of interests.

DATA AVAILABILITY STATEMENT

Data available on request from the authors. The data that support the findings of this study are available from the corresponding author upon reasonable request.

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