ORIGINAL ARTICLE

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Impact of Hiatal Hernia on CT-Severity Scores and Survival of COVID-19 Patients

Hiatal Herninin BT-Şiddet Skorlarına ve COVID-19 Hastalarının Sağkalımına Etkisi

Burcu AKMAN, Ahmet Turan KAYA

Amasya Sabuncuoğlu Şerefeddin Training and Research Hospital, Clinic of Radiology, Amasya, Turkey

ABSTRACT

Aim: We aimed to investigate the impact of hiatal hernia (HH) on computed tomography (CT) findings, CT-severity scores (CT-SS), intensive care unit (ICU) admission, and mortality rates of patients with Coronavirus disease-2019 (COVID-19).

Materials and Methods: Our study was a single-center retrospective analysis of COVID-19 patients admitted to our hospital between July and October 2021. One hundred-forty four of these patients had HH. We also randomly selected 144 COVID-19 patients without HH as the control group. So, the total study population included 288 patients aged ≥18 years. Chest CT scans examined by the radiologist for the presence of HH and CT-SSs were calculated using a visual scoring system.

Results: The presence of HH was statistically associated with COVID-19 Reporting and Data System classification of initial CT ($p=0.002$) and CT-SS ($p<0.001$). Also, HH was statistically associated with ground-glass opacity, pericardial effusion, crazy paving pattern, pleural, bronchial wall thickening and reversed halo sign in CT imaging. Multivariate analysis showed that HH was associated with a higher rate of need for ICU admission [odds ratio (OR): 2.47, $p=0.01$] and mortality (OR: 2.04, $p=0.02$).

Conclusion: The presence of a HH has important implications for the severity of pneumonia and increased ICU admission and mortality in COVID-19 patients.

Keywords: Hiatal hernia, COVID-19, computed tomography, pneumonia

ÖZ

Amaç: Hiatal herninin (HH) Koronavirüs hastalığı-2019 (COVID-19) hastalarının bilgisayarlı tomografi (BT) bulguları, BT-şiddet skorları (BT-ŞS), yoğun bakım ünitesine (YBÜ) yatış ve ölüm oranları üzerindeki etkisini araştırmayı amaçladık.

Gereç ve Yöntem: Çalışmamız Temmuz-Ekim 2021 tarihleri arasında hastanemize başvuran COVID-19 hastalarının tek merkezli retrospektif analiziydi. Bu hastaların 144'ünde HH vardı. Ayrıca kontrol grubu olarak HH'si olmayan 144 COVID-19 hastası rastgele seçildi. Dolayısıyla, toplam çalışma popülasyonu 18 yaş ve üstü 288 hastayı içermekteydi. Toraks BT taramaları, bir radyolog tarafından HH varlığı açısından incelendi ve BT-ŞS'leri, görsel bir puanlama sistemi kullanılarak hesaplandı.

Bulgular: HH varlığı istatistiksel olarak ilk BT'nin COVID-19 Raporlama ve Veri Sistemi sınıflandırması ($p=0,002$) ve BT-ŞS'si ($p<0,001$) ile ilişkiliydi. Ayrıca HH, BT görüntülemede buzlu cam opasitesi, perikardiyal efüzyon, kaldırım taşı paterni, plevral, bronşiyal duvar kalınlaşması ve ters halo işareti ile istatistiksel olarak ilişkiliydi. Çok değişkenli analiz, HH'nin daha yüksek oranda YBÜ'ye yatış [odds oranı (OR): 2,47, $p=0,01$] ve mortalite (OR: 2,04, $p=0,02$) ile ilişkili olduğunu gösterdi.

Sonuç: HH'nin varlığının, COVID-19 hastalarında pnömoninin ciddiyeti ve YBÜ'ye yatış ve mortalite artışı için önemli etkileri vardır.

Anahtar Kelimeler: Hiatal herni, COVID-19, bilgisayarlı tomografi, pnömoni

Address for Correspondence: Burcu AKMAN MD, Amasya Sabuncuoğlu Şerefeddin Training and Research Hospital, Clinic of Radiology, Amasya, Turkey
Phone: +90 505 987 02 86 **E-mail:** burcuakman80@gmail.com **ORCID ID:** orcid.org/0000-0002-1067-9008
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INTRODUCTION

The Coronavirus disease-2019 (COVID-19) was first seen in December 2019, in Wuhan and the disease spread rapidly all over the world[1]. The real-time reverse transcriptase-polymerase chain reaction (RT-PCR) is the standard diagnostic method for COVID-19, which is taken from oropharyngeal and nasopharyngeal swab samples[2]. However, the RT-PCR test has high initial false-negative results. Computed tomography (CT) plays a major role in the diagnosis of early-stage disease and follow-up of pneumonia[3]. Bilateral, multiple, generally peripheral and basal localized ground-glass opacities (GGOs) with or without consolidation and bronchovascular thickening are the typical chest CT findings of COVID-19 pneumonia[4].

A hiatal hernia (HH) occurs when the intra-abdominal organs, most commonly the stomach, herniate through the esophageal hiatus into the thorax[5]. Most HHs have no symptoms and are diagnosed incidentally[6]. As a result of increased intra-abdominal pressure, the stomach and other intra-abdominal organs may protrude into the mediastinum[7,8]. Obesity and being elderly are the most important causes of HH[9,10]. Most patients with HH have various nonspecific symptoms resulting from gastroesophageal reflux disease (GERD). Rarely, large HHs can cause atypical symptoms such as shortness of breath and chest pain and uncommon complications such as pulmonary edema and heart failure due to compression of the heart and pulmonary veins by organs protruding into the chest cavity[11]. There are case reports in the literature that show a large HH can cause acute heart failure attacks and acute angina as a result of compression[12-14].

CT is not usually used routinely to diagnose HH, but it can provide useful additional information about the location and type of HH[15,16]. It is often diagnosed incidentally when performing a CT scan for a different indication[17]. The frequency of GER and esophagitis in patients with HH is higher than in the normal population. In clinical studies, HH and concomitant reflux esophagitis have been associated with respiratory symptoms, most commonly asthma[18] and laryngitis[19].

In the literature, there are many studies on comorbidities as risk factors for COVID-19 patients, especially diabetes, hypertension, respiratory and cardiovascular system diseases [20]. However, there is no study investigating the effects of HH as a gastrointestinal comorbidity in COVID-19 patients. Jiang et al.[21] investigated the prevalence of laryngopharyngeal reflux disease (LPRD) in hospitalized COVID-19 patients. They reported that LPRD was common in hospitalized COVID-19 patients and independently increased the risk of serious illness and poor prognosis[21].

In our study, we detected HHs incidentally in non-contrast chest CT of COVID-19 patients and the patients were categorized as the groups with and without HH. The purpose of this study was to look at the association between HH and CT findings, CT-severity scores (CT-SS), ICU admission, and mortality rates in COVID-19 patients.

MATERIALS AND METHODS

The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice and was approved by the Ethical Committee of Amasya University Faculty of Medicine (approval number: 148, date: 4 November 2021). Informed consent was not considered necessary as the study was conducted retrospectively.

Study Population and Data Collection

Our study was a single-center retrospective analysis of a total of 288 patients who applied to the Amasya University Faculty of Medicine Emergency Service and COVID-19 policlinic between July and October 2021. We included only laboratory-confirmed patients who were determined by positive RT-PCR tests. All patients underwent at least one chest CT scan in the radiology department of our hospital. Patients with at least 3 negative RT-PCR tests, pediatric patients, were excluded from the study.

We collected the data for retrospective analysis including demographic characteristics, comorbidities, laboratory findings, length of stay in the hospital, length of stay in ICU and clinical outcomes, and mortality rates from the electronic medical records.

Sample Size

Using the G-power (latest version 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) program, the study sample was determined to be 280 patients, with at least 140 in each group with an effect size of 0.39, α=0.05, and power (1-β)=0.90 using the G-power program. There were two groups: 144 patients with HH and 144 patients without HH (control). We selected randomly 144 COVID-19 patients without HH as the control group.

Laboratory Procedures

RT-PCR for Severe acute respiratory syndrome-Coronavirus-2 was performed on the oropharyngeal and nasopharyngeal swab specimens of all patients according to World Health Organization interim guidelines. RT-PCR tests were repeated in patients with a high clinical and radiologic suspicion of COVID-19 when the initial PCR test was negative. The laboratory tests obtained within 1 day from the performance of thorax CT at the patient's admission, including complete blood count, serum biochemistry parameters, inflammatory markers such as C-reactive protein (CRP), creatine kinase, and lactate dehydrogenase level, erythrocyte sedimentation rate (ESR) and ferritin, were recorded from the hospital records.

Computed Tomography Protocol

All non-contrast chest CT scans of the study patients were performed in a supine position using the multidetector CT scanners 128-slice GE Healthcare Revolution EVO CT (GE Medical Systems; Milwaukee, WI). The following acquisition and reconstruction parameters were used: Tube potential was 120 kV; tube current ranged from 100 to 450 mA; beam pitch was 1.375; beam collimation was 64 mm×0.625 mm; gantry rotation was 0.4 seconds; acquisition direction was craniocaudal; reconstruction kernel was standard; slice thickness and section overlap was 0.625 mm. The chest CT scans were evaluated at 1500 WW and 450 WL for the lung window and 400 WW and 40 WL for the mediastinal window. The non-contrast chest CT was obtained in one breath-hold. Multiplanar reconstruction images (axial, coronal, and sagittal images) were used for diagnosing HH.

Image Analysis

A radiologist with more than 15 years of experience in chest CT imaging retrospectively analyzed the CT images in a standard clinical picture archiving and diagnostic system Workstation, blinded to the clinical and laboratory data. A semi-quantitative 25 Point CT-SS system, which was previously used in the literature, was used to visually calculate the involvement of each pulmonary lobe[22]. It was calculated as follows: 0 no involvement; 5% involvement; 25% involvement; 26-49% involvement; 50-75% involvement; and >75% involvement. The total CT-SS was then calculated by adding the CT scores of the five lobes, which ranged from 0 (none) to 25 (maximum).

The imaging findings of chest CTs and COVID-19 Reporting and Data System (CO-RADS) classification of the initial CTs were analyzed. With the CO-RADS classification, the evaluation of thorax CT scans of patients with COVID-19 was standardized and classified between 1 (very low) and 5 (very high) for suspected COVID-19 pneumonia[23].

CT scans were also evaluated for HH using axial, coronal images, and sagittal images with mediastinal window settings. The lower parts of the posterior mediastinum were examined for the presence of HH in thorax CTs using 3D post-processing images. We defined the CT findings for HHs as soft tissue fullness adjacent to the esophagus, the definition of rugal folds of the stomach, above the esophageal hiatus, a lobulated or asymmetrical enteral shape, or a mixture of these findings. HH was considered present if the gastroesophageal junction was displaced approximately 2 cm or more above the esophageal hiatus[24,25].

Firstly, we draw a line through the anterior and posterior parts of the esophageal hiatus on the sagittal planes to determine how much the gastroesophageal junction migrated above the diaphragm. Then, a vertical line from the hiatus line to the gastroesophageal junction was drawn and the distance was measured (Figure 1).

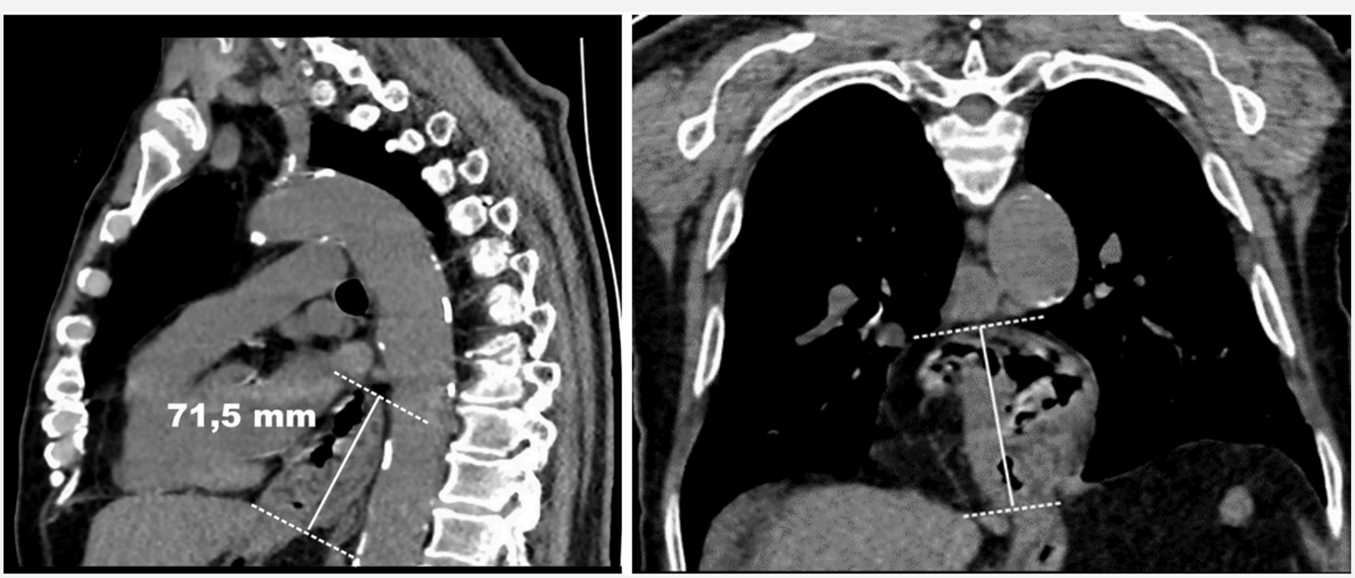

Figure 1. Sagittal (a) and coronal (b) computed tomography scan of a 75-year-old male patient with a hiatal hernia. The length of the hernia was measured (straight line) from the level of the esophageal hiatus (dashed line) to the upper direction of the contour change (dashed line)

Statistical Analysis

Using IBM Statistical Package for the Social Sciences statistics for Windows, version 22.0, statistical analyses were carried out. Descriptive statistics of patients' demographics and laboratory results, total CT scores, and mortality rates were reported as frequency rates, percentages, and mean or median values. Using the Kolmogorov-Smirnov, the variables' conformity to the normal distribution was evaluated. For comparing continuous variables with and without HH, the Mann-Whitney U test was employed for variables with non-normal distribution and Student's t-test for variables with normal distribution. The chi-square test was used instead of the comparison of categorical variables according to the presence of HH. To identify independent risk variables for ICU admission and death of COVID-19 patients, multivariate logistic regression was performed. Statistics were determined significant at $p<0.05$.

RESULTS

Demographic Features

The study population included 288 patients with a mean age of 65±13.9 years; 156 (54.2%) were male. In the group of HH, 79 (54.9%) patients were male with a mean age of 71±11.3 years. Hiatal hernia was statistically associated with older age ($p<0.001$). No significant differences were found between HH and gender. Also, we found no significant difference between gender and mortality (p=0.896). However, there was a statistical association between the male gender with high ICU admission (p=0.02).

The most common comorbidities of the study population were hypertension (HT) (143/288; 49.7%) and diabetes mellitus (96/288; 33.3%). There was no significant difference between HH and comorbidities.

In addition, when we correlated HH with laboratory findings, statistical associations were found between HH and elevated serum inflammatory markers such as CRP, ESR, increased neutrophil, decreased lymphocyte percentage, and multiple abnormal laboratory findings shown in Table 1.

The patients' median length of stay in the hospital was 13 days, while the median length of stay at the ICU was 10 days. While there was a significant relationship between HH and the length of stay in the ICU (p=0.015), there was no significant relationship between the length of stay in the non-ICU (p=0.221) (Table 1).

Of all 288 patients, 29 (10.1%) patients were treated as outpatients. Of all inpatients, 66/259 (25.48%) patients were treated in ICU. Of the patients with HH, 48/66 (72.7%) patients were treated in ICU. 84/288 (29.2%) patients died in the total study population, and 61/84 (72.6%) patients died in the group with HH (Figure 2).

We found a particularly strong association between HH and mortality rates ($p<0.001$) and the need for ICU treatment ($p<0.001$) (Table 2).

The multivariate analysis suggested that HH was related to a higher rate of ICU admission [odds ratio (OR): 2.47, 95% confidence interval (CI): 1.24-4.93, p=0.01] and mortality (OR: 2.04, 95% CI: 1.05-3.96, p=0.02) (Table 3, 4). There was a significant relationship between mortality with older age (OR: 1.07, 95% CI: 1.03-1.10, $p<0.001$), hiatal hernia (OR: 2.04, 95% CI: 1.05-3.96, p=0.02) and chronic heart disease (OR: 3.38, 95% CI: 1.15-9.97, p=0.02) shown in Table 3.

The Results of Computed Tomography Images

The median CT-SS of total patients was 10 (0-25). The median CT-SS was 12.5 in the group with HH and the median CT-SS was 8 in the group without HH. There was a statistically significant association between HH with CO-RADS classification of the initial CT imaging (p=0.002) and CT-SS ($p<0.001$).

In addition, HH was statistically associated with GGOs (p=0.003), pericardial effusion, crazy paving pattern, reticular pattern, linear opacity, intra-interlobular septal thickening, pleural, bronchial wall thickening ($p<0.001$), and reversed halo sign (p=0.002) in the CT imaging (Table 2).

DISCUSSION

In this retrospective analysis, we evaluated the association between the presence of hiatal hernia in CT-SS, ICU admission, and mortality rates of patients with COVID-19. According to our study presence of HH was associated with increased mortality and ICU admission rates in COVID-19 patients. Also, our results showed that the COVID-19 patients with HH had higher CT-SS and severe pneumonia CT findings.

The association of many respiratory diseases with HH and GERD has been reported in the literature. In patients with idiopathic pulmonary fibrosis, Tossier et al.[26] found a relationship between the presence of HH and an increased risk of mortality from respiratory causes. They also investigated the presence or absence of HH in coronal and sagittal images of chest CT scans. We also defined HH in the non-contrast chest CT imaging of COVID-19 patients incidentally. The association of hospitalization for reflux esophagitis with hospitalization for numerous upper respiratory and lung diseases was reported. The most common association was seen with sinusitis, laryngitis, pharyngitis, chronic bronchitis, bronchiectasis, asthma, pneumonia, and pulmonary fibrosis[27]. Since HH is associated with reflux esophagitis, it has been reported to be associated with respiratory conditions in various studies[28,29] but it has some limitations in terms of cause and effect.

Table 1. Comparison of age, CT-severity score, laboratory findings and length of stay in hospital or ICU according to the presence of hiatal hernia

	Hiatal hernia	n	Mean	Standard deviation	95% confidence interval for mean		Minimum	Maximum	p value
					Lower bound	Upper bound			
Age[a]	Y	144	58.86	13.60	56.62	61.10	24	93	**<0.001**
	V	144	71.23	11.37	69.36	73.10	39	94	
	T	288	65.05	13.96	63.43	66.66	24	94	
CT-severity score	Y	144	8.38	7.02	7.23	9.54	0	25	**<0.001**
	V	144	12.75	8.17	11.40	14.09	0	25	
	T	288	10.56	7.91	9.65	11.48	0	25	
Neutrophil percentage (40.1-67)[a]	Y	144	69.78	13.58	67.55	72.02	8.13	97.2	**0.025**
	V	144	73.31	12.94	71.18	75.44	34.6	96.6	
	T	288	71.55	13.36	70	73.1	8.13	97.2	
Lymphocyte percentage (23.6-48)[a]	Y	144	20.68	10.16	19	22.35	0.13	68.5	**0.036**
	V	144	18.44	10.60	16.69	20.18	2.30	54.1	
	T	288	19.56	10.42	18.35	20.77	0.13	68.5	
LDH (135-225; U/L)	Y	140	307.65	149.99	282.58	332.71	121	1422	**0.037**
	V	144	343.93	162.94	317.09	370.77	140	1167	
	T	284	326.04	157.46	307.65	344.43	121	1422	
CRP (0-5; mg/L)	Y	144	54.09	64.18	43.51	64.66	0.1	347	**0.05**
	V	144	65.14	61.77	54.97	75.32	0.06	304.19	
	T	288	59.618	63.12	52.29	66.93	0.06	347	
Ferritin (22-322; ug/L)	Y	142	322.95	459.97	246.64	399.26	5.2	3500	0.933
	V	142	353.81	566.26	259.86	447.75	5.5	4892.5	
	T	284	338.38	515.1	278.2	398.556	5.2	4892.5	
ESR (0-30; mm/H)	Y	142	48.09	27.71	43.49	52.68	6	118	**0.003**
	V	142	57.746	28.06	53.091	62.4	11	139	
	T	284	52.91	28.25	49.61	56.2	6	139	
Fibrinogen (200-400; mg/dL)	Y	138	495.17	154.35	469.18	521.15	30.7	975	**0.001**
	V	142	541.67	138.05	518.77	564.57	222	901	
	T	280	518.75	147.9	501.35	536.15	30.7	975	
D-dimer (0-0.5; µg/mL)	Y	142	1.02	1.94	0.7	1.3483	0.02	15.2	**<0.001**
	V	141	2.04	5.28	1.16	2.92	0.15	46.6	
	T	283	1.53	4	1.06	2	0.02	46.6	
BUN (16.6-48.5; mg/dL)	Y	143	39.33	28.37	34.64	44.02	13	267	**<0.001**
	V	143	45.61	24.74	41.52	49.70	17	171	
	T	286	42.47	26.76	39.36	45.59	13	267	
Length of stay in hospital	Y	124	15.37	11.68	13.29	17.45	1	59	0.221
	V	134	15.53	8.921	14.01	17.05	2	42	
	T	258	15.45	10.32	14.19	16.72	1	59	
Length of stay in ICU	Y	18	19.00	12.40	12.83	25.17	0	53	**0.015**
	V	49	11.82	8.31	9.43	14.20	0	33	
		67	13.75	10.01	11,30	16.19	0	53	

[a]Independent samples test was used.

Mann-Whitney U test was used.

A: Absent, P: Present, T: Total, CT: Computed tomography, ICU: Intensive care unit, LDH: Lactate dehydrogenase, CRP: C-reactive protein, BUN: Blood urea nitrogen

Figure 2. An 86-year-old man with confirmed Coronavirus disease-2019. His initial computed tomography (CT)-severity scores was calculated as 12. Axial (a) and coronal (b) lung window of unenhanced chest CT scans show bilateral ground-glass opacities with interlobular and intralobular septal thickening (crazy-paving pattern) with hiatal hernia. The coronal (c) mediastinal window of CT shows a part of the stomach sliding up into the chest through the hiatus. The patient died after being treated in the intensive care unit for 5 days

Table 2. Comparison of demographic parameters and chest CT findings according to the presence of hiatal hernia

		Hiatal hernia		Total	p value*
		A n (%)	P n (%)		
Gender	Male	77 (49.4%)	79 (50.6%)	156	0.813
	Female	67 (50.8%)	65 (49.2%)	132	
Mortality or surviving	Alive	121 (59.3%)	83 (40.7%)	204	**<0.001**
	Death	23 (27.4%)	61 (72.6%)	84	
ICU	ICU	18 (27.3%)	48 (72.7%)	66	**<0.001**
	Non-ICU	126 (56.8%)	96 (43.2%)	222	
GGOs	A	35 (68.6)	16 (31.4)	51	**0.003**
	P	109 (46)	128 (54)	237	
Consolidation	A	107 (53.8)	92 (46.2)	199	0.056
	P	37 (41.6)	52 (58.4)	89	
Crazy paving pattern	A	103 (61.3)	65 (38.7)	168	**<0.001**
	P	41 (34.2)	79 (65.8)	120	
Reticular pattern	A	64 (86.5)	10 (13.5)	74	**<0.001**
	P	80 (37.4)	134 (62.6)	214	
Intralobular septal thickening	A	91 (67.3)	55 (36.7)	146	**<0.001**
	P	53 (37.3)	89 (62.7)	142	
Interlobular septal thickening	A	54 (83.1)	11 (16.9)	65	**<0.001**
	P	90 (40.4)	133 (59.6)	223	
Linear opacities	A	36 (78.3)	10 (21.7)	46	**<0.001**
	P	108 (44.6)	134 (55.4)	242	
Adjacent pleural thickening	A	83 (64.3)	46 (35.7)	129	**<0.001**
	P	61 (38.4)	98 (61.6)	159	
Vascular thickening	A	39 (67.4)	15 (32.6)	54	**<0.001**
	P	105 (44.9)	129 (55.1)	234	
Bronchial wall thickening	A	58 (57.6)	28 (42.4)	86	**<0.001**
	P	86 (42.6)	116 (57.4)	202	

Table 2. Continued					
Bronchiectasis	A	95 (63.8)	54 (36.2)	149	**<0.001**
	P	49 (35.3)	90 (63.7)	139	
Reversed halo	A	111 (56.3)	86 (43.7)	197	**0.002**
	P	33 (36.3)	58 (63.7)	91	
Halo present	A	85 (52.8)	76 (47.2)	161	0.285
	P	59 (46.5)	68 (53.5)	127	
Tree- in-bud sign	A	139 (53.3)	119 (46.7)	205	**0.002**
	P	8 (24.2)	25 (75.8)	33	
Pericardial effusion	A	136 (54.4)	114 (45.6)	250	**<0.001**
	P	8 (21.1)	30 (78.9)	38	
Pleural effusion	A	130 (52.0)	120 (48.0)	250	0.082
	P	14 (36.8)	24 (63.2)	38	
Mediastinal lymph node enlargement	A	123 56.7)	94 (43.3)	217	**<0.001**
	P	21 (29.6)	50 (70.4)	71	

*All p-values of reports comparisons were analyzed by the chi-square test.

±p-values of reports were analyzed by logistic regression.

A: Absent, P: Present, ICU: Intensive care unit, GGOs: Ground-glass opacities, CT: Computed tomography

Table 3. Univariate and multivariate analysis of mortality

Mortality								
	Univariate				Multivariate			
	p value	OR	95% CI		p value	OR	95% CI	
			Lower	Upper			Lower	Upper
Age	**<0.001**	0.921	0.898	0.945	**<0.001**	**1.07**	1.038	1.103
CT-severity score	**0.004**	0.954	0.923	0.985	0.29	1.022	0.982	1.064
CRP	**0.014**	0.995	0.991	0.999	0.169	1.003	0.999	1.008
Lymphocyte count	**0.036**	1.486	1.026	2.154	0.801	0.946	0.615	1.456
Hiatal hernia	**<0.001**	0.259	0.148	0.451	**0.035**	**2.041**	1.051	3.963
Chronic heart disease	**0.001**	0.223	0.089	0.56	**0.027**	**3.388**	1.151	9.971
Hypertension	**<0.001**	0.372	0.218	0.633	0.406	1.335	0.675	2.639
Cerebrovascular disease	**0.02**	0.296	0.106	0.824	0.102	2.74	0.818	9.183
Hyperlipidemia	**0.017**	0.509	0.292	0.888	0.458	1.313	0.639	2.695

Hosmer and Lemeshow test=0.917.

CI: Confidence interval, CRP: C-reactive protein, CT: Computed tomography, OR: Odds ratio

The high risk of hospitalization for respiratory disease after hospitalization for reflux disease supports the causal effect of reflux in respiratory diseases. These respiratory symptoms associated with HH may occur as a result of acid refluxing into the airway due to microaspiration of acid in the esophagus causing vagal-mediated neurogenic reflex and airway contraction[30]. And also, Ruhl et al.[31] reported that hospitalization due to HH and reflux esophagitis increases the risk of hospitalization due to many respiratory diseases. For this reason, patients with respiratory diseases that are resistant to treatment or whose etiology cannot be determined should be evaluated in terms of HH and reflux esophagitis and necessary treatment plans should be applied. Also, in our study, HH was statistically associated with multiple abnormal CT findings including GGOs, pericardial effusion, crazy paving pattern, reticular pattern, linear opacity, intra-interlobular septal thickening, pleural and bronchial wall thickening and reversed halo sign in the CT imaging. In this study, it was observed that in COVID-19 patients with HH, the pulmonary findings and the prognosis may be worse and should be considered in the treatment of these patients.

In patients with hiatal hernia, pulmonary edema or heart failure may occur as a result of compression of the heart and pulmonary vessels by organs protruding into the chest cavity[11]. In our study, consistent with the literature, 78.9% (30/38; p<0.001) of patients with pericardial effusion had HH, which was statistically significant. Also, the effect of acid reflux into the airway can increase respiratory symptoms and

Table 4. Univariate and multivariate analysis of ICU admission

ICU admission	Univariate				Multivariate			
	p value	OR	95% CI		p value	OR	95% CI	
			Lower	Upper			Lower	Upper
Age	**<0.001**	1.045	1.022	1.069	0.124	1.022	0.994	1.051
CT-severity score	**0.002**	1.057	1.021	1.095	0.253	1.025	0.983	1.068
CRP	**0.028**	1.005	1	1.009	0.269	1.003	0.998	1.008
Lymphocyte count	**0.053**	0.668	0.444	1.006	0.719	0.918	0.576	1.464
Gender	**0.021**	0.509	0.286	0.905	0.073	0.545	0.281	1.059
Hiatal hernia	**<0.001**	3.5	1.915	6.398	**0.01**	2.478	1.245	4.931
Chronic heart disease	**0.092**	2.218	0.877	5.606	0.536	1.392	0.488	3.967
Hypertension	**0.005**	2.281	1.288	4.038	0.218	1.55	0.772	3.112
Cerebrovascular diseases	**0.049**	2.808	1.003	7.857	0.275	1.933	0.593	6.309
Hyperlipidemia	**0.031**	1.916	1.061	3.46	0.332	1.425	0.696	2.918

Hosmer and Lemeshow test=0.233.

CI: Confidence interval, CRP: C-reactive protein, CT: Computed tomography, OR: Odds ratio, ICU: Intensive care unit

complications. In addition, HH reduced total lung capacity and vital capacity as well as gas trapping leading to restrictive lung disease symptoms. Restrictive lung disease may also develop as a result of a HH due to pulmonary fibrosis induced by gastric reflux[32]. In the current study, 75% (21/28; p=0.005) of patients with pulmonary fibrosis had HH, which was statistically significant. These reasons may explain the high rates of ICU admission and mortality of patients with HH in our study.

The most prevalent comorbidities among COVID-19 patients, according to the literature, were hypertension and diabetes, cardiovascular disorders, and respiratory system diseases[20]. However, there are few studies about the effect of digestive system diseases on the prognosis of COVID-19 patients. Jiang et al.[21] investigated the impacts of LPRD on COVID-19 patients who were hospitalized. They reported that LPRD was common in hospitalized COVID-19 patients and was independently related to the risk of serious or critical infection. Since the incidence of LPRD was higher in patients with HH, mortality and ICU admission were also significantly higher in patients with HH in our study.

To our knowledge, this is the first study to investigate the association between hiatal hernia, CT-SS, and death rates in COVID-19 patients. Our results showed a significant relationship between hiatal hernia and high CT-SS, ICU admission and mortality. Our study contributed to the literature with its results and emphasized the importance of the presence of HH in patients with COVID-19. If there is a filling defect in the inferior mediastinum in the X-rays of COVID-19 patients, HH should be considered and thorax CT should be performed. Also, when evaluating thorax CT of COVID-19 patients, coronal and sagittal images should be examined in terms of hiatal hernia. In addition, the echocardiographic examination is recommended for the evaluation of cardiac and pulmonary venous system compression with large HH.

Study Limitations

The current study has some limitations. The first limitation is that our study was a single-center retrospective analysis. Therefore, a multicenter study with a large sample size is needed for more validation. Second, since our study was retrospective, patients could not be evaluated for GERD. Third, we evaluated the initial chest CT images of the patients. We did not use follow-up CTs, so we cannot review late-period CT finding changes.

CONCLUSION

We found that the presence of a hiatal hernia has important implications for the severity of pneumonia and increased ICU admission and mortality in COVID-19 patients. Therefore, when evaluating chest CT scans of COVID-19 patients, the investigation in terms of hiatal hernia should also be made for the prognosis and treatment planning of the patient.

Ethics

Ethics Committee Approval: The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice and was approved by the Ethical Committee of Amasya University Faculty of Medicine (approval number: 148, date: 4 November 2021).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: A.T.K., Design: B.A., Data Collection or Processing: A.T.K., B.A., Analysis or Interpretation: A.T.K., B.A., Literature Search: B.A., Writing: B.A.

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