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Risk factors of intensive care admission and mortality in a cohort of 111 Egyptian COVID-19 patients

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ABSTRACT

Background: It is important to understand and identify the different clinical characteristics of COVID-19 patients in order to better understand the disease process and determine the various factors associated with poor prognosis and mortality.

Methods: Data from 111 COVID-19 patients were collected and retrospectively analyzed. The demographics, comorbidities, and laboratory test results of patients admitted to the intensive care unit (ICU) were compared with those admitted to the ward. Additionally, data obtained from patients who were discharged after treatment were compared with those who died at the hospital.

Results: Patients admitted to the ICU were older and presented with significantly higher levels of ferritin, lactate dehydrogenase (LDH), IL-6, c-reactive protein, and procalcitonin than those admitted to the ward. IL-6 level was an independent predictor of ICU admission. Likewise, the non-survivors were significantly older and had higher levels of LDH, d-dimer, IL-6, creatinine, blood urea nitrogen (BUN), and procalcitonin, and a higher prevalence of chronic kidney disease than those who were discharged from the hospital; increased age and high BUN levels were the independent predictors of mortality.

Conclusion: This study identified high IL-6 level as a predictor of ICU admission and older age and high BUN levels as predictors of mortality in patients with COVID-19.

1. Introduction

Coronavirus disease-2019 (COVID-19) was declared a pandemic in March 2020 [1]. It is caused by a positive sense single-stranded RNA coronavirus called SARS-CoV-2 [2] and was first identified in Wuhan, China, in December 2019 [3]. The disease has since spread worldwide, leading to a total of 511,252,681 confirmed cases globally, with the number of deaths reaching 6,238,149 as of 1 May 2022 [4]. In Egypt, the first confirmed case of COVID-19 was reported in February 2020 [5]. Since then, the number of cases has reached 515,645, with more than 24,613 deaths (as of 7 May 2022), according to the Egyptian Ministry of Health [6].

SARS-CoV-2 spreads via respiratory droplets [7]. COVID-19 has a wide variety of clinical presentations ranging from asymptomatic infection to cases of severe respiratory distress and failure, requiring admission to the intensive care unit (ICU) and ventilation. The common symptoms of the disease include fever, cough, malaise, headache, anosmia, ageusia, body aches, and respiratory distress [8]. The leading cause of death in COVID-19 patients is pneumonia, which leads to respiratory failure due to extensive lung injury;

the patient usually suffers from hypoxia followed by features of acute respiratory distress [9].

COVID-19 remains a financial burden to hospitals and health care facilities worldwide [10]. Due to the emergency and severity of the COVID-19 outbreak, several studies have been implemented to help better evaluate the risk factors associated with this disease and understand the factors associated with increased mortality risk. It is also important to clearly understand the general characteristics of COVID-19 patients in different countries. Therefore, the aim of this retrospective study was to evaluate the clinical characteristics, comorbidities, and laboratory findings in COVID-19 patients and determine the risk factors associated with admission to ICU and with mortality.

2. Materials and Methods

2.1. Study subjects and data collection

This retrospective study comprised 111 COVID-19 patients who were confirmed to be positive for SARS-CoV-2 by RT-PCR and admitted to the El-Demerdash Quarantine Hospital in Egypt in the period April-July 2021. Those with a negative RT-PCR result for SARS-

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CoV-2 and pregnant females were excluded from the study. Ethical approval for the study was obtained from the Ethical committee of the Faculty of Medicine, Ain Shams University (ethical approval number FMASU R 17 2022).

Data pertaining to the demographics, presence of comorbidities (prior diagnosis of chronic illness, such as chronic kidney disease, chronic liver disease, cardiac disease, respiratory disease, hypertension, or diabetes), presenting symptoms, ICU admission, and in-hospital mortality were collected. Additional information about the following laboratory parameters was collected: total leucocytic count (TLC), lymphocyte count, hemoglobin level, platelet count and levels of LDH, ferritin, creatinine, blood urea nitrogen (BUN), alanine transaminase (ALT), aspartate transferase (AST), D-dimer, interleukin (IL)-6, and c-reactive protein (CRP). Patients with a procalcitonin level above the reference range were considered positive for the protein.

The patients were divided into two groups based on the site of admission during the hospital stay: those admitted to the ward (n = 38) and those admitted to the ICU (n = 73). Similarly, the patients were divided into two groups based on their survival: those discharged from the hospital (survivors; n = 95) and those who died during admission (non-survivors; n = 16).

The COVID-19 Reporting and Data System (CO-RADS) was used for categorical chest computerized tomography (CT) assessments of the patients. This system uses unenhanced chest CT scans to provide a level of suspicion regarding the degree of pulmonary involvement. Briefly, category CO-RADS 1 implies a very low level of suspicion for pulmonary involvement by COVID-19, CO-RADS 2 implies a low level of suspicion for pulmonary involvement by COVID-19, CO-RADS 3 implies equivocal findings for pulmonary involvement of COVID-19 that can also be found in other viral pneumonias or non-infectious etiologies, CO-RADS 4 implies a high level of suspicion for pulmonary involvement by COVID-19 while CO-RADS 5 implies a very high level of suspicion for pulmonary involvement by COVID-19 based on typical CT findings [11].

2.2. Statistical analysis

Statistical analysis was performed using the Graphpad 8.0 software (Prism, USA). The frequency and percentage were used to describe the categorical data, whereas the quantitative data were presented as median and interquartile range (IQR). Associations between the categorical data were assessed using the Chi-square and Fisher's exact tests, and the Mann–Whitney U test was used to examine the differences in quantitative parameters between the groups in this study. Multivariate analysis was conducted using SPSS

27.0.0 (IBM, Australia) to assess the independent predictors associated with ICU admission and mortality. A p-value of <0.05 was considered statistically significant.

3. Results

The clinical characteristics, demographics, and laboratory as well as CT findings of the 111 COVID-19 patients (males, n = 60 [54.1%]; females, n = 51 [45.9%]; mean age, 60.6 ± 14.6 years) are shown in Table 1. Hypertension was the most common comorbidity (n = 65; 58.6%), followed by diabetes in 53 patients

Table 1. Demographic, clinical, and laboratory data of all patients in the study.

	All patients (n = 111)
Age in years, mean ± SD	60.6 ± 14.6
Gender	
Male	60 (54.1%)
Female	51 (45.9%)
Admission	
Ward	38 (34.2%)
ICU	73 (65.8%)
Outcome	
Discharge	95 (85.6%)
Death	16 (14.4%)
Comorbidities	
Diabetes	53 (47.8%)
Hypertension	65 (58.6%)
Heart disease	29 (26.1%)
Kidney disease	19 (17.1%)
Liver disease	10 (9.1%)
Chest disease	13 (11.7%)
History of stroke	14 (12.6%)
Malignancy	5
Depression	2
Dementia	3
Hypothyroidism	8
BPH	4
Acute kidney injury	6
RA	4
Presentation	
Respiratory	97 (87.4%)
GIT	15 (13.5%)
Ischemia	5 (4.5%)
Acute kidney injury	2 (1.8%)
Persistent fever	3 (2.7%)
Disturbed level of consciousness	6 (5.4%)
TLC ($\times 10^3$/ul)	7.1 (5.3–10)
Lymphocytes ($\times 10^3$/uL)	0.9 (0.7–1.2)
Hemoglobin (gm/dL)	12 (10–13)
Platelets ($\times 10^3$/uL)	217 (146–250)
Ferritin (ng/mL)	610 (277–1113)
LDH (U/L)	302 (201–400)
D-dimer (mg/L)	0.9 (0.5–2)
IL-6 (pg/mL)	33 (10–75.225)
Creatinine (mg/dL)	1.1 (1–1.7)
BUN (mg/dL)	25 (18–34)
AST (U/L)	24.5 (17.25–36)
ALT (U/L)	24 (16–32)
CRP (mg/L)	80 (29–130)
Positive procalcitonin	23 (20.7%)
CO-RADS	
CO-RADS 1	1 (0.9%)
CO-RADS 2	1 (0.9%)
CO-RADS 3	9 (8.1%)
CO-RADS 4	12 (10.8%)
CO-RADS 5	88 (79.3%)

n, number; SD, standard deviationRA:rheumatoid arthritis; BPH:benign prostatic hyperplasia

(47.8%) and heart disease in 29 patients (26.1%). Respiratory symptoms were the most common presenting symptoms (n = 97; 87.4%), followed by gastrointestinal (GIT) symptoms in 15 patients (13.5%). Of the 111 patients, 73 (65.8%) required ICU admission during their hospital stay. A total of 95 patients (85.6%) were discharged, and 16 patients died during admission (14.4%). Most patients (n = 88; 79.3%) presented with chest CT findings consistent with CO-RADS 5. The chest CT findings of 12 (10.8%) and 9 (8.1%) patients were consistent with CO-RADS 4 and 3, respectively, whereas CO-RADS 2 and 1 were identified in 1 patient each.

Different demographic, clinical and laboratory parameters were compared between patients admitted to the ward and patients admitted to the ICU as shown in Table 2. Patients admitted to the ICU (n = 73; mean age, 62.4 years) were significantly (p = 0.037) older than those admitted to the ward (n = 38; mean age, 57.3 years). A higher number of males were observed among those admitted to the ICU compared to those

in the ward (58.9% vs. 44.7%), statistical significance not withstanding. Neither smoking nor any of the pre-existing comorbidities showed any association with ICU admission.

Patients admitted to the ICU had significantly higher levels of ferritin than those in the ward (median, 750 ng/mL vs. 305 ng/mL). Likewise, significantly higher levels of LDH (327 U/L vs. 209 U/L), IL-6 (59 pg/mL vs. 11.5 pg/mL), and CRP (94 mg/L vs. 45 mg/L) were observed among those admitted to the ICU. A higher proportion of ICU patients were procalcitonin positive compared to those in the ward (20/73; 27.4% vs. 3/38; 7.9%). No significant differences in the TLC, lymphocyte count, hemoglobin levels, platelet count, and levels of d-dimer, creatinine, BUN, AST, and ALT were observed between the two groups of patients.

Patients were divided into two groups according to survival. Data was compared between survivors and non-survivors (Table 3). The mean age of the patients in the non-survivor group (n = 16; 65.8 years) was significantly (p = 0.025) higher than that observed among those who were discharged from the hospital (n = 95; 59.8 years). Although the male gender was

Table 2. Comparisons between patients admitted to the ward and the ICU.

	Ward admission (n = 38)	ICU admission (n = 73)	p-value
Age in years, mean ± SD	57.3 ± 14.8	62.4 ± 14.2	**0.037***
Gender			
Male	17 (44.7%)	43 (58.9%)	0.155
Female	21 (55.3%)	30 (41.1%)	
Smoking			
Smoker	7 (18.4)	17 (23.3%)	
Ex-smoker	4 (10.5%)	13 (17.8%)	0.422
Non-smoker	27 (71.1%)	43 (58.9%)	
Comorbidities			
Diabetes	21 (55.3)	32 (43.8)	0.253
Hypertension	21 (55.3%)	44 (60.3%)	0.611
kidney disease	6 (15.8%)	13 (17.8%)	0.789
Liver disease	5 (13.2%)	5 (6.8%)	0.271
Heart disease	7 (18.4%)	22 (30.1%)	0.183
Chest disease	5 (13.2%)	8 (10.0%)	0.733
History of stroke	5 (13.2%)	9 (12.3%)	0.901
TLC (×10³/ul)	6.6 (4.39–8.3)	7.7 (5.2–10.5)	0.074
Lymphocytes (×10³/uL)	0.9 (0.6–1.0)	0.9 (0.7–1.3)	0.412
Hemoglobin (gm/dL)	12(10.2–13.3)	12(9.9–13)	0.988
Platelets (×10³/uL)	195(148–237)	218(144–268)	0.259
Ferritin (ng/mL)	305(169–689)	750(419–1184)	**<0.001***
LDH (U/L)	209(160–392)	327(245–434)	**0.002***
D-dimer (mg/L)	0.75(0.5–1.5)	0.9(0.6–2.2)	0.143
IL-6 (pg/mL)	11.5(5.3–30)	59(20–85.3)	**<0.001***
Creatinine (mg/dL)	1.1(0.9–1.7)	1.1(1.0–1.8)	0.453
BUN (mg/dL)	20(16–33)	26(18–38)	0.064
AST (U/L)	22(16–34)	26(19–39)	0.103
ALT (U/L)	22(16–29)	25(17–35)	0.089
CRP (mg/L)	45(15.7–97.3)	94(37.5–150)	**0.004***
Positive procalcitonin	3 (7.9%)	20 (27.4%)	**0.025***
CO-RADS			
CO-RADS 1,2,3	6	5	
CO-RADS 4	4	8	0.325
CO-RADS 5	28	60	

*: p < 0.05.

Table 3. Comparisons between the survivors and non-survivors.

	Survivors (n = 95)	Non-survivors (n = 16)	p-value
Age in years, mean ± SD	59.8 ± 13.7	65.8 ± 18.9	**0.025***
Gender			
Male	50 (52.6%)	10 (62.5%)	0.463
Female	45 (47.4%)	6 (37.5%)	
Smoking			
Smoker	20 (21.1%)	4 (25%)	
Ex-smoker	13 (13.6%)	4 (25%)	0.417
Non-smoker	62 (65.3%)	8 (50%)	
Comorbidities			
Diabetes	45 (47.4%)	8 (50%)	0.845
Hypertension	56 (58.9%)	9 (56.3%)	0.839
Kidney disease	13 (13.7%)	6 (37.5%)	**0.019***
Liver disease	8 (8.4%)	2 (12.5%)	0.635
Heart disease	22 (23.2%)	7 (43.8%)	0.082
Chest disease	12 (12.6%)	1 (6.3%)	0.688
Stroke	12 (12.6%)	2 (12.5%)	0.999
TLC (×10³/ul)	7 (5.0–9.9)	7.7 (6.1–12.3)	0.145
Lymphocytes (×10³/uL)	0.9(0.7–1.2)	0.9(0.6–1.4)	0.919
Hemoglobin (gm/dL)	12.0(10.3–13.0)	11.7(9.1–13)	0.491
Platelets (×10³/uL)	219(150–250)	173(106–264)	0.183
Ferritin (ng/mL)	610(269–1038)	633(363–1838)	0.292
LDH (U/L)	287(192–400)	409(346–575)	**0.002***
D-dimer (mg/L)	0.8(0.5–1.8)	1.3(0.8–2.5)	**0.029***
IL-6 (pg/mL)	26.5(9.0–70.0)	48.6(33.0–89.6)	**0.026***
Creatinine (mg/dL)	1.1(1.0–1.4)	1.8(1.2–2.4)	**0.011***
BUN (mg/dL)	21.0(17.0–33.0)	34(30–53)	**0.001***
AST (U/L)	23(17–32)	32(24–43)	0.076
ALT (U/L)	24(16–32)	24(15–35)	>0.999
CRP (mg/L)	66(27–126)	100.5(38.5–132.3)	0.273
Positive procalcitonin	16 (16.8%)	7 (43.8%)	**0.014***
CO-RADS			
CO-RADS 1,2,3	9	2	
CO-RADS 4	12	0	0.316
CO-RADS 5	74	14	

*: p < 0.05.

Table 4. Univariate and multivariate analyses for factors associated with ICU admission.

	Univariate (ICU admission)			Multivariate (ICU admission)		
	p-value	Odds ratio	95% CI	p-value	Odds ratio	95% CI
Age in years >64	0.003*	3.518	1.516–8.165	0.058	2.864	0.965–8.498
Ferritin >502 ng/mL	<0.001*	5.742	2.440–13.512	0.214	2.055	0.659–6.411
LDH >200 U/L	<0.001*	8.125	3.076–21.464	0.109	2.817	0.794–10.001
IL-6 > 38 pg/mL	<0.001*	10.664	3.674–30.949	0.016*	4.688	1.340–16.397
CRP >76 mg/L	<0.001*	3.945	1.694–9.184	0.358	1.726	0.540–5.518
Positive procalcitonin	0.028*	4.267	1.172–15.532	0.133	3.209	0.701–14.683

*: $p < 0.05$.
CI, confidence interval.

more prevalent among the non-survivors (62.5% vs. 52.6%), no significant statistical association was observed between gender and survival. The prevalence of chronic kidney diseases was significantly (p = 0.019) higher among the non-survivors (6/16; 37.5%) compared to the survivors (13/95; 13.7%). No significant differences in smoking habit or presence of the other comorbidities were observed between the two groups of patients.

LDH levels were significantly higher among the non-survivors (median, 409 U/L vs. 287 U/L). Similarly, the non-survivors presented with significantly higher levels of d-dimer (1.3 mg/L vs. 0.8 mg/L), IL-6 (48.6 pg/mL vs. 26.5 pg/mL), creatinine (1.8 mg/dL vs. 1.1 mg/dL), and BUN (34 mg/dL vs. 21 mg/dL) compared to the survivors. A higher proportion of non-survivors were positive for procalcitonin (7/16; 43.8%) compared to survivors (16/95; 16.8%). Meanwhile, no differences in TLC, lymphocyte count, hemoglobin levels, platelet count, and levels of ferritin, AST, and ALT were observed between the two groups.

Multivariable analysis was performed to identify the patient characteristics associated with ICU admission (Table 4). Although univariate analysis revealed an association with age (>64 years; odds ratio [OR], 3.518), ferritin level (>502 ng/mL; OR, 5.742), LDH level (>200 U/L; OR, 8.125), IL-6 level (>38 pg/mL; OR, 10.664), CRP level (>76 mg/L; OR, 3.945), and a positive procalcitonin result (OR, 4.267), only an IL-6 level of >38 pg/mL was found to be independently associated with ICU admission in the multivariate analysis. Additionally, multivariable analysis was performed to identify the risk factors associated with mortality (Table 5). Univariate analysis revealed an association with age (>69 years; OR, 4.423), presence of chronic

kidney disease (OR, 3.738), LDH (>327 U/L; OR, 7.775), D-dimer level (>1 mg/L; OR, 4.133), IL-6 level (>19 pg/mL; OR, 10.882), creatinine level (>1.1 mg/dL; OR, 5.958), BUN level (>26 mg/dL; OR, 25.714), and a positive procalcitonin result (OR, 4.687); however, only age (>69 years) and a BUN level of >26 mg/dL were independently associated with death in the multivariate analysis (OR = 4.989 and 18.558, respectively). IL-6 was not included in the multivariate analysis because only one patient from the non-survivor group had an IL-6 level of <19 pg/mL.

4. Discussion

The identification and recognition of different risk factors that might be associated with ICU admission and mortality in patients with COVID-19 may allow for the early recognition of those at high risk of deterioration and death; additionally, adequate intervention can be performed to manage these cases on time.

The prognosis and clinical course of COVID-19 are highly unpredictable. Several studies are being conducted to investigate the possible prognostic characteristics that can be used to identify patients who require immediate medical care and to evaluate the associations between these characteristics and mortality. In the current study, we investigated the association between factors affecting ICU admission and mortality in COVID-19 patients. Patients admitted to the ICU and those from the non-survivor group were older than those admitted to the ward and from the survivor group, respectively. Age was associated with both ICU admission and mortality in the univariate analysis. Furthermore, age (>69 years) was associated with mortality in the multivariate analysis. Regarding

Table 5. Univariate and multivariate analyses for factors associated with mortality.

	Univariate (Mortality)			Multivariate (Mortality)		
	p-value	Odds ratio	95% CI	p-value	Odds ratio	95% CI
Age in years >69	0.009*	4.423	1.460–13.395	0.041*	4.989	1.067–23.333
Kidney disease	0.027*	3.738	1.161–12.037	0.379	0.432	0.066–2.803
LDH >327 U/L	0.002*	7.775	2.069–29.209	0.073	4.572	0.868–24.074
D-dimer >1 mg/L	0.015*	4.133	1.324–12.903	0.218	2.651	0.563–12.484
IL-6 > 19 pg/mL	0.024*	10.882	1.376–86.070	–	–	–
Creatinine >1.1 mg/dL	0.008*	5.958	1.592–22.300	0.935	0.911	0.099–8.374
BUN >26 mg/dL	0.002*	25.714	3.255–203.114	0.026*	18.558	1.420–242.584
Positive procalcitonin	0.010*	4.687	1.443–15.232	0.096	3.912	0.785–19.487

*: $p < 0.05$.

COVID-19 patients, increased age has been reported to be associated with admission to ICU [12] and mortality in studies in Italy [13,14] China[] and New York [15]. Aging causes various biological changes in the immune system (called immunosenescence), wherein the immune response and immune cells are affected, resulting in a decline in their functions, altered immune response, and weakened ability to combat various infections [16].

Among the different comorbidities investigated in the present study, none was associated with ICU admission; alternatively, the presence of chronic kidney disease was significantly higher among the non-survivors compared to the survivors and was associated with mortality in the univariate analysis. Furthermore, the levels of BUN and creatinine were significantly higher in the non-survivors. A BUN level of >26 mg/dL was associated with mortality in the univariate and multivariate analyses. Novelli et al. reported a higher prevalence of chronic kidney disease among non-survivors compared to survivors in a study conducted in Italy; the non-survivors showed higher blood urea levels, which was considered as an independent marker of mortality [17]. Similarly, Grasselli et al. [13] reported a higher frequency of chronic kidney disease in non-survivors, and Han et al. demonstrated an association between urea levels and the severity of COVID-19 [18].

Several laboratory parameters were analyzed in the current study. Patients admitted to the ICU had higher ferritin levels than those admitted to the ward. A recent study from New York City reported higher ferritin levels in COVID-19 patients admitted to the ICU [19]. Ferritin levels were found to be associated with the degree of lung involvement in COVID-19 patients, where levels greater than the 25th percentile were associated with the involvement of all five pulmonary lobes, septal thickening, and mediastinal lymph node enlargement [20]. Ferritin is an iron storage protein, and its expression is post-transcriptionally regulated by the level of iron in the body. High levels of intracellular iron increase the expression of ferritin, whereas iron deficiency results in a decreased expression. Additionally, ferritin is an acute-phase protein; hence, circulating levels of this protein can increase the incidence of inflammatory conditions and infection [21]. Cytokine storm and hemophagocytic lymphohistiocytosis are the two main factors suggested to cause an increase in ferritin levels in patients with COVID-19 [22].

Similar to the findings reported by Wang et al. [12] and Zhao et al. [19], higher levels of LDH were detected in ICU patients and non-survivors when compared to those in the ward and the survivors, respectively, in the current study. Elevated LDH is a reflection of tissue destruction and is considered to be an indicator of cell damage, such as in the case of pneumonia induced by infection with SARS-CoV-2 [23]. Several studies have reported high LDH levels in COVID-19 patients; Wu et al. [24] reported that the occurrence of ARDS in COVID-19 patients was associated with high LDH levels. In another study, Xiong et al. [25] revealed correlations between the LDH level and the severity of the lung abnormality quantified on the initial CT. Zhou et al. [26] identified LDH level as a predictor of ARDS in COVID-19 patients with fever.

CRP is an acute inflammatory protein synthesized mainly by hepatocytes but can also be synthesized by other cell types. The levels of CRP increase during inflammatory conditions and infections [27]. The present study revealed significantly higher CRP levels in ICU patients when compared to those in the ward. Similar results have been reported by Zhao et al. [19] and Bannaga et al. [28], wherein higher levels of CRP were observed in ICU patients compared to ward patients. According to Han et al. [18], CRP levels were associated with disease severity in COVID-19 patients. Furthermore, Akdogan et al. [29] reported higher CRP levels in severe COVID-19 patients compared to the non-severe patients. Similar to LDH, CRP was found to be associated with the occurrence of ARDS [24] and the degree of lung involvement quantified on initial CT [25] in COVID-19 patients.

D-dimer is the smallest fibrin degradation product in the blood circulation [30]. Therefore, it is considered as a laboratory biomarker that reflects the activation of coagulation and fibrinolysis. D-dimer is commonly used to rule out venous thromboembolism owing to its sensitivity [31]. Our results show increased levels of d-dimer among non-survivors compared to survivors. Higher d-dimer levels among non-survivors have also been reported by Zhou et al. [14], Zhao et al. [19] and Poudel et al. [32]. Moreover, according to Ayed et al. [33], d-dimer is a predictive factor associated with mortality. A meta-analysis study revealed that high levels of d-dimer are associated with higher risks of both mortality and disease severity [34].

Procalcitonin is generally synthesized by parafollicular thyroid cells and is mainly induced by endotoxins; therefore, it is considered as a marker of sepsis in clinical practice. Endotoxins indirectly induce the production of procalcitonin by inducing the production of inflammatory cytokines [35]. However, these inflammatory cytokines are reported to be increased during COVID-19 infection, resulting in a cytokine storm. Thus, elevated levels of procalcitonin in COVID-19 might directly result from the cytokine storm that can occur during COVID-19 or could be due to a secondary bacterial infection [36]. In the present study, procalcitonin positivity was significantly higher among the non-survivors and in patients admitted to the ICU. Zhao et al. [19] also reported higher procalcitonin levels in non-survivors and in patients admitted to ICU. Moreover, Wang et al. [12] reported higher

proportion of patients with positive procalcitonin among ICU patients compared to ward patients. Furthermore, Zhou et al. [14] and Ayed et al. [33] reported higher procalcitonin levels in non-survivors with a procalcitonin level of >0.2 ng/mL being an independent predictor of mortality.

Several studies have focused on the cytokine storm that occurs during COVID-19. The levels of multiple cytokines (IL-6, GM-CSF, TNF, interferons, and IL-18) are reported to rise during the storm among which IL-6 was the most prominent to show high levels. In fact, IL-6 receptor antagonist (tocilizumab) is currently used in COVID-19 patients who exhibit cytokine storm [37]. In the present study, significantly higher levels of IL-6 were observed in ICU patients and non-survivors. IL-6 was associated with ICU admission in the univariate and multivariate analyses and mortality in the univariate analysis. Herold et al. [38] reported an association between elevated IL-6 levels and the need for mechanical ventilation. According to Lavillegrand et al. [39], high IL-6 levels are associated with adverse clinical outcomes and death in critically ill COVID-19 patients. A recent meta-analysis found that higher levels of IL-6 are associated with increased risks of complicated COVID-19 and death [40].

As a newly emerging infectious disease, it is important to identify and understand the different clinical characteristics of COVID-19 patients to help better understand the disease process and the various factors associated with poor prognosis and mortality.

In conclusion, in the studied patients, high IL-6 level was an independent predictor of ICU admission, while both older age and high BUN level were found to be independent predictors of mortality.

Disclosure statement

None to declare.

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