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ORIGINAL ARTICLE

Hematological Parameters and Comorbidities in COVID-19: Insights into Clinical Profiles and Outcome Predictors

Khalaf F. Alsharif

Clinical Laboratory Sciences, College of Applied Medical Sciences, Taif University, Taif, Saudi Arabia

SUMMARY

Background: **The global pandemic, known as the coronavirus disease 2019 (COVID-19) and caused by the severe acute respiratory syndrome, coronavirus 2 (SARS-CoV-2), poses a significant threat, particularly to individuals with comorbidities such as hypertension, chronic obstructive pulmonary disease (COPD), diabetes, HIV, cardiovascular disease (CVD), and cancer.**
Methods: **This descriptive retrospective study investigates the impact of comorbidities on COVID-19-positive patients. The study includes individuals that were tested positive for SARS-CoV-2 via polymerase chain reaction at the Security Forces Hospital, Makkah, KSA, between February, 2022, and June, 2022. A total of 208 patients (107 males, 101 females) were examined, and the laboratory results revealed normal parameters.**
Results: **An analysis indicates that 86.5% of the patients were discharged, 2.9% remained hospitalized, and 10.6% succumbed to the disease, indicating a 10.6% mortality rate among comorbid COVID-19-positive patients. Notably, the study identifies specific comorbidities (chronic kidney disease, diabetes mellitus, hypertension) and changes in laboratory parameters (red blood cells, hemoglobin, C-reactive protein, white blood cells, ferritin, D-dimer, ALT, troponin, LDH, neutrophils) associated with ICU admission during hospitalization.**
Conclusions: **This study underscores the critical impact of comorbidities, such as chronic kidney disease, diabetes, and hypertension, on the clinical outcomes of COVID-19-positive patients. The identification of specific laboratory parameters linked with ICU admission provides valuable insights for risk stratification and tailored management strategies.**
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Correspondence:
Khalaf F. Alsharif
Clinical Laboratory Sciences
College of Applied Medical Sciences
Taif University
Al Mutamarat Rd, Al Mathnah, 26521
Taif
Saudi Arabia
Email: Alsharif@tu.edu.sa
Khalaf.f.alsharif@gmail.com

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KEYWORDS

COVID-19, comorbidities, hematological parameters, mortality rate, ICU admission

INTRODUCTION

Coronavirus disease (COVID-19) is a global pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that began in Wuhan, China, and rapidly spread to almost every country of the world [1]. The disease is being regarded as a tremendous global challenge due to its serious complications and its high fatality rate [2,3]. As the novel coronavirus evolves, our understanding of who this virus will have a significant impact on remains limited [4]. SARS-CoV-2 has, according to genomic analysis, 96% genome similarity to

the bat CoV RaTG13 [5]. Early reports on SARS-CoV phylogenetic analysis show similarities with Rhinolophus affinis, Bat-SL-CoVZC21, and Bat-SL-CoVZC45, confirming its origin from the Chinese chrysanthemum bat [6]. The genomic sequence and evolutionary analysis of SARS-CoV-2 revealed that 79.5% of the genome resembled SARS-CoV, with the data suggesting, the bats having transmitted the virus to humans via an unidentified intermediate host [7]. Recently, pangolin was discovered to have 99% genome similarity to SARS-CoV-2, implying that it plays an important role in viral transmission and infection [8]. Analyzing COVID-19 clinical and epidemiological data from the last few weeks suggests that certain comorbidities increase the risk of infection, resulting in worse lung injury and death [9]. Until now, the most common comorbidities reported have been hypertension, cardiovascular disease, and diabetes [10]. According to previous studies, diabetes is one of the most common comorbidities in individuals with severe COVID-19 [11,12]. In addition, infection with COVID-19 could result in a significant incidence of renal abnormalities, including severe proteinuria and hematuria, as well as elevated serum creatinine and blood urea nitrogen. Similarly, CKD is associated with an increased risk of pneumonia, and the mortality rate associated with pneumonia in CKD patients appears to be 14 - 16 times that of the general population [13]. Findings from a study revealed that among hospitalized COVID-19 patients a substantial 60.3% presented itself with one or more comorbidities, with the most common being diabetes mellitus, hypertension, and chronic renal disease. Notably, it was the presence and the cumulative number of comorbidities, rather than individual ones, along with factors such as age, the patient's clinical condition upon admission, and the 4C mortality score, that emerged as robust and independent predictors of mortality [14]. In a prior study of COVID-19 patients admitted to an ICU in Riyadh, Saudi Arabia, from March to December, 2020, an analysis of 333 patients revealed that more than 76% of the patients showing comorbidities were male. Common comorbidities included diabetes (39.34%) and hypertension (31.53%). Remarkably, patients with both diabetes and hypertension had the highest risk of mortality, and the presence of multiple comorbidities increased the chances of requiring intubation and the risk of death [15]. Notably, a substantial percentage of ICU admissions involve COVID-19 patients with underlying comorbidities, hinting at the potential influence of these coexisting medical conditions on the risk of experiencing severe disease outcomes [16]. Furthermore, the clinical and laboratory profiles of COVID-19 exhibit significant variability among different populations, attributed to distinctive demographic characteristics and comorbidities [17]. However, within the context of Saudi Arabia, comprehensive studies examining the intricate relationship between comorbidities with a specific focus on hematological parameters and the prognosis of ICU-admitted COVID-19 patients are notably lacking. Therefore, the primary aim of this study is to provide a comprehensive exploration of comorbidities with a particular emphasis on their potential impact on hematological parameters and their associated laboratory findings in COVID-19 patients that were admitted to the ICU. Our retrospective analysis encompasses 208 patients who tested positive for SARS-CoV-2 by polymerase chain reaction at the Security Forces Hospital, Makkah, KSA, during the period from July, 2021, to February, 2022. We seek to unravel the complex interplay between comorbidities, specifically focusing on hypertension, chronic kidney disease, and diabetes, with a dedicated focus on understanding how these conditions may influence hematological parameters. Furthermore, we aim to identify the hematological indicators associated with clinical severity and adverse outcomes in COVID-19 patients. This research endeavors to significantly contribute to the understanding of how hematological parameters and comorbidities intersect in shaping the course of the disease within the Saudi Arabian population.

MATERIALS AND METHODS

Study design

This is a descriptive retrospective study of patients who were tested positive for SARS-CoV-2 by polymerase chain reaction in the Security Forces Hospital, Makkah, KSA from February, 2022, to June, 2022.

Study experiments and methods

A total of 208 COVID-19-positive patients were included in the study. This study comprised COVID-19 patients with hypertension, chronic kidney disease, diabetes, and ICU admission. The ICU-admitted group was evaluated and compared to the non-ICU patients. The data and laboratory parameters of the confirmed patients were, first, extracted from the laboratory as well as from the hospital records and were then evaluated. This study was approved by Security Forces Hospital Program in Makkah (IRB. 0481-100522).

Statistical analysis

Recorded data were analyzed using the Statistical Package for Social Sciences, version 23.0 (IBM SPSS Statistics for Windows; IBM Corp., Armonk, NY, USA). The quantitative data were presented as mean ± standard deviation and ranges when their distribution was parametric (normal), while non-normally distributed variables (non-parametric data) were presented as median with inter-quartile range (IQR). Also, qualitative variables were presented as numbers and percentages. Data were checked for normality using the Kolmogorov-Smirnov and the Shapiro-Wilk Test. The independent-samples *t*-test of significance was used when comparing between two means, and the Mann-Whitney U test was used for two-group comparisons in non-parametric data. The Comparison between the groups with qualitative data

Table 1. Demographic data distribution among study group.

Demographic data	Total (n = 208)
Age (years)	
Range	**16 - 98**
Mean ± SD	**57.87 ± 18.55**
Gender	
Male	**107 (51.4%)**
Female	**101 (48.6%)**

Table 2. Risk factors distribution among study group.

Risk factors	No.	%
Risk factors	**126**	**60.6%**
Free risk	**82**	**39.4%**
HTN		
No	**118**	**56.7%**
Yes	**90**	**43.3%**
ICU admission (n = 90)		
Yes	**31**	**34.4%**
No	**59**	**65.6%**
Outcome (n = 90)		
Discharged to home	**68**	**75.6%**
Still in hospital	**5**	**5.6%**
Death	**17**	**18.9%**
CKD		
No	**182**	**87.5%**
Yes	**26**	**12.5%**
ICU admission (n = 26)		
Yes	**15**	**57.7%**
No	**11**	**42.3%**
Outcome (n = 26)		
Discharged to home	**17**	**65.4%**
Still in hospital	**1**	**3.8%**
Death	**8**	**30.8%**
DM		
No	**101**	**48.6%**
Yes	**107**	**51.4%**
ICU Admission (n = 107)		
Yes	**33**	**30.8%**
No	**74**	**69.2%**
Outcome (n = 107)		
Discharged to home	**86**	**80.4%**
Still in hospital	**6**	**5.6%**
Death	**15**	**14.0%**

HTN - Hypertension, CKD - Chronic kidney disease, DM - Diabetes mellitus.

was done by using the chi-squared test, with the Fisher's exact test being used additionally when the expected count in any cell was less than 5. Spearman's rank correlation coefficient (rs) was used to assess the degree of association between two sets of variables if one or both were skewed. The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following: p-value < 0.05 was considered significant; p-value < 0.001 was considered as highly significant; p-value > 0.05 was considered insignificant. A multivariate logistic regression analysis was done as well: Odds ratios (OR) with 95% confidence intervals were computed to assess the overall association between each possible risk factor and the occurrence of death.

RESULTS

Demographic distribution

Table 1 shows the demographic data distribution of the current study. The number of male patients amount to 107 (51.4%) and the female patients amount to 101 (48.6%), with a total of 208. The average age of patients was 57.8.

Risk factors distribution among study group

Table 2 shows the comorbidity distribution among the study group. The most prevalent comorbid condition was DM with 107 (51.4%) cases, while HTN showed 90 (43.3%). In contrast, CKD, 26 (12.5%) cases, was the least prevalent comorbid condition. The higher mortality rate was associated with CKD, 8 (30.8%) cases. Conversely, the lower mortality rate was associated with HTN, 17 (18.9%) cases, and DM, 15 (14.0%) cases, respectively.

Laboratory tests analysis

The results of laboratory data descriptive among study group is shown in Table 3. We observed that almost all of the findings were within the limitations. The laboratory results, expressed in Table 2, showed that all the parameters were in a normal range. Different laboratory parameters of various comorbidities patients, like COVID-19 patients with chronic kidney disease, hypertension, and diabetes, were also found in normal limits such as RBCs (4.47 ± 0.91), Hemoglobin (11.85 ± 2.42), PT (15.74 ± 10.20), Ferritin (383), WBCs (7.58 ± 4.13), HbA1c (6.6 - 10.2) etc.

Outcome distribution

The outcomes revealed that 180 (86.5%) patients were discharged, 6 (2.9%) patients had to stay in the hospital, and 22 (10.6%) died, indicating a 10.6% mortality rate in the comorbid Covid positive patients, as shown in Table 4.

Table 3. Laboratory data descriptive among study group.

Laboratory data	Range	Mean ± SD
RBCs	1.55 - 9.8	4.47 ± 0.91
Hemoglobin	1.6 - 16.9	11.85 ± 2.42
WBCs	1.77 - 32.7	7.58 ± 4.13
Neutrophils	0.42 - 22.14	5.36 ± 3.71
Platelets	56 - 1,150	246.92 ± 118.59
PT	1.11 - 112	15.74 ± 10.20
APTT	11.4 - 180	40.48 ± 22.03
D-dimer #	0.2 - 14.2	1.2 (0.6 - 1.9)
CRP #	0.1 - 1,916	10.24 (3.34 - 19.16)
Procalcitonin #	0.026 - 100	0.223 (0.113 - 0.6)
CK #	13.61 - 1,378	114 (54 - 196)
Troponin #	0 - 326	0.011 (0.006 - 0.05)
LDH	3.6 - 1,109	292.64 ± 137.98
Ferritin #	4.22 - 7,947	383 (164.8 - 846)
ALT #	5 - 284	24.4 (18 - 34.6)
AST	3 - 172	34.76 ± 22.42
HbA1c #	4.3 - 906	8.1 (6.6 - 10.2)

RBCs - Red blood cells, WBCs - white blood cells, PT - Prothrombin time, APTT - Activated partial thromboplastin time, CRP - C-reactive protein, CK - Creatine kinase, LDH - Lactate dehydrogenase, ALT - Alanine aminotransferase, AST - Aspartate aminotransferase, HBA1c – Hemoglobin A1C.
 # Data are expressed median and interquartile range (IQR).

Table 4. Outcome distribution among study group.

Outcome	No.	%
Discharged to home	180	86.5%
Still in hospital	6	2.9%
Death	22	10.6%
Total	208	100.0%

Comparative analysis of different parameters

Different parameters of the control group, of the ICU admitted patients and of the study group were compared and analyzed, as shown in Table 5. This table shows statistically significant differences between the control group (n = 161) and the ICU admission group (n = 47) according to age (years), gender, PT, CK, Troponin, Neutrophils, WBCs, AST, and Outcome, with p-value $p < 0.05$ significant. It also shows the additional patient characteristics that were linked to the ICU admission in COVID-19 patients. The parameters of the control group and the ICU admissions that showed a significant difference were Hemoglobin ($p < 0.001$), RBCs ($p < 0.001$), D-dimer ($p < 0.001$), CRP ($p < 0.001$), Procalcitonin ($p < 0.001$), LDH ($p < 0.001$), and Ferritin ($p < 0.039$). In contrast, Platelets, APTT, ALT, and Hba1C did not demonstrate a significant difference between the ICU admission and the control group.

Correlation between risk factors and parameters

Table 6 shows a statistically significant positive correlation between the number of risk factors and the age (years) of the patient, PT, D-dimer, CRP, Procalcitonin and Troponin with p-value ($p < 0.05$); while a statistically significant negative correlation is shown between the number of risk factors and RBCs and hemoglobin with p-value ($p < 0.05$).

Table 5. Comparison between the control group and the ICU admission group, including all of the parameters among the study group.

Parameters	Control Group (n = 161)	ICU Admission Group (n = 47)	Test value	p-value
Age (years)	**55.43 ± 18.39**	**66.23 ± 16.74**	**t: -3.614**	**< 0.001 ****
Gender				
Female	**85 (52.8%)**	**16 (34%)**	***x²:* 5.122**	**0.024 ***
Male	**76 (47.2%)**	**31 (66%)**		
RBCs	**4.60 ± 0.86**	**4.02 ± 0.95**	**t: 3.971**	**< 0.001 ****
Hemoglobin	**12.20 ± 2.18**	**10.67 ± 2.83**	**t: 3.939**	**< 0.001 ****
WBCs	**7.00 ± 3.34**	**9.60 ± 5.69**	**t: -3.929**	**< 0.001 ****
Neutrophils	**4.76 ± 3.04**	**7.39 ± 4.93**	**t: -4.464**	**< 0.001 ****
Platelets	**248.17 ± 121.75**	**242.64 ± 108.20**	**T: 0.281**	**0.779**
PT	**14.93 ± 8.14**	**18.52 ± 15.02**	**t: -2.123**	**0.035 ***
APTT	**39.32 ± 22.53**	**43.52 ± 20.58**	**t: -1.102**	**0.272**
D-dimer #	**1.10 (0.60 - 1.90)**	**1.20 (0.65 - 3.18)**	**z: -3.824**	**< 0.001 ****
CRP #	**5.94 (2.41 - 13.00)**	**13.92 (4.66 - 38.38)**	**z: -3.947**	**< 0.001 ****
Procalcitonin #	**0.20 (0.09 - 0.25)**	**0.35 (0.19 - 1.61)**	**z: -3.397**	**< 0.001 ****
CK #	**69.00 (45.00 - 150.00)**	**168.00 (70.75 - 291.25)**	**z: -2.377**	**0.017 ***
Troponin #	**0.01 (0.00 - 0.02)**	**0.04 (0.01 - 0.30)**	**z: -4.756**	**< 0.001 ****
LDH	**262.63 ± 105.83**	**382.68 ± 179.71**	**t: -5.383**	**< 0.001 ****
Ferritin #	**383.00 (155.00 - 969.00)**	**377.00 (174.85 - 828.50)**	**z: -2.064**	**0.039 ***
ALT #	**27.00 (18.50 - 41.00)**	**20.75 (17.25 - 30.88)**	**z: -0.749**	**0.454**
AST	**32.56 ± 18.79**	**41.81 ± 30.56**	**t: -2.503**	**0.013 ***
HbA1C #	**8.10 (6.70 - 9.70)**	**8.20 (6.08 - 10.58)**	**z: -0.617**	**0.537**
Outcome				
Discharged to home	**154 (95.7%)**	**26 (55.3%)**	***x²:* 50.830**	**< 0.001 ****
Still in hospital	**2 (1.2%)**	**4 (8.5%)**	***FE***	**0.030 ***
Death	**5 (3.1%)**	**17 (36.2%)**	***x²:* 41.930**	**< 0.001 ****

RBCs - Red blood cells, WBCs - white blood cells, PT - Prothrombin time, APTT - Activated partial thromboplastin time, CRP - C-reactive protein CK - Creatine kinase, LDH - Lactate dehydrogenase, ALT - Alanine aminotransferase, AST - Aspartate aminotransferase, HBA1c - Hemoglobin A1C.
Using: *t*-Independent Sample *t*-test; z = Mann-Whitney test; x^2: chi-squared test; FE: Fisher's Exact; p-value > 0.05 NS; * p-value < 0.05 S; ** p-value < 0.001 HS.

Multivariate logistic regression analysis

Table 7 shows that age (years), HTN, CKD, DM, ICU admission, RBCs, Hemoglobin, WBCs, APTT, D-dimer, CK, LDH, and AST have a significant effect on the death rate, with p-value ($p < 0.05$); while the rest of the parameters used in the study only have an insignificant effect.

DISCUSSION

The COVID-19-induced pandemic of acute respiratory distress caused by SARS-CoV2, has shown a significant variance [18,19]. Human beings are at high risk due to the pandemic crisis brought on by the introduction of the SARS-CoV-2 coronavirus from China. Symptomless, minor, or severe pneumonia-like indications can be evident with the coronavirus disease 2019 (COVID-19). Individuals with COVID-19 who also have hypertension, chronic obstructive pulmonary disease (COPD), diabetes, HIV, cardiovascular disease (CVD), cancer, or other concomitant conditions may develop a life-threatening condition [10-13]. SARS-CoV-2 enters host cells through the ACE-2 receptors that are present on the cell surface. A significant expression of the ACE-2 receptor and a stronger proprotein convertase release are linked to specific comorbidities, which improve viral entrance into the host cells [20]. As a result of the comorbidities, that are also strongly linked to severe mortality and morbidity, a terrible and contagious cycle of life is cre-

Table 6. Correlation between number of risk factors and all the parameters, using Spearman's rho in the ICU admission group.

Parameters	Number of Risk factors	p-value
	Rs	
Age (years)	0.462	< 0.001 **
RBCs	-0.255	< 0.001 **
Hemoglobin	-0.249	< 0.001 **
WBCs	0.030	0.664
Neutrophils	0.034	0.623
Platelets	-0.013	0.851
PT	0.255	< 0.001 **
APTT	0.130	0.096
D-dimer	0.234	0.002 *
CRP	0.197	0.007 *
Procalcitonin	0.206	0.046 *
CK	0.000	0.999
Troponin	0.344	< 0.001 **
LDH	0.042	0.580
Ferritin	0.078	0.294
ALT	-0.110	0.124
AST	-0.061	0.395
HBA1C	0.193	0.073

RBCs - Red blood cells, WBCs - white blood cells, PT - Prothrombin time, APTT - Activated partial thromboplastin time, CRP - C-reactive protein CK - Creatine kinase, LDH - Lactate dehydrogenase, ALT - Alanine aminotransferase, AST - Aspartate aminotransferase, HBA1c - Hemoglobin A1C.
**** Correlation is significant at the 0.001 level (2-tailed).**

ated for the COVID-19 patients. Individuals with comorbid conditions must take diligent preventive measures and demand meticulous therapy [9]. The care of patients involves making predictions about the course and the severity of their COVID-19. To determine the best prognostic factor and comorbidities that may be employed in a clinical practice, numerous investigations were carried out. Several studies were conducted on diseases like cancer, diabetes, hypertension, liver problems, respiratory ailments, kidney diseases, and immunodeficiencies in corona-virus diseases [21-27]. According to preliminary data from China, those with hypertension, diabetes, respiratory illnesses, and cardiovascular disorders are more likely to present with severe COVID-19 than those without those conditions [28,29]. According to the most recent data from India, more than 98% of patients who died from COVID-19 had either hypertension or diabetes [30]. In the present study, the demographic data revealed that there were 208 male (51.4%) and female (48.6%) COVID 19 patients, and that their median age was approximately 58 years. Moreover, we identified that comorbidities included in this study were HTN with 90 (43.3%) cases, CKD with 26 (12.5%) cases, and diabetes with 107 (51.4%) cases, and all three were significantly associated with COVID-19 progression, ending up to ICU admission. In agreement with our current findings, Fang et al. (2020) discovered that age, HTN, cardiac disorders, and CKD were important contributors to the severity of the condition and that these factors can be linked to sample size, demographics, and several coexisting comorbidities. A severe variant of COVID-19 has also been linked to cardiac problems, such as myocarditis, and myocardial infarction [29,31]. Furthermore, 30% of the young adult COVID-19 patients may show left ventricular deformation in an asymptomatic or in an only mildly symptomatic acute illness [32,33]. In addition, a large retrospective study found that DM and HTN are the most common comorbidities in COVID-19 patients [34]. According to the results of our investigation, several biomarkers have discernible predictivity and can be utilized as markers of COVID-19 advancement, in which the essential upper limit was produced. Numerous investigations, undertaken since the start of the pandemic, revealed that the aforementioned biomarkers were strongly related with the progression, the severity, and the fatality of COVID-19. This study indicates that ICU patients with COVID-19 have significantly elevated WBC and

Table 7. Multivariate logistic regression analysis for independent predictors for death.

Parameters	β	S.E.	Wald	Sig.	Exp (B)	95% C.I.	
						Lower	Upper
Age (years)	0.097	0.020	24.280	< 0.001 **	1.102	1.060	1.145
Gender	-0.067	0.406	0.027	0.870	0.935	0.422	2.074
HTN	1.798	0.486	13.717	< 0.001 **	6.039	2.332	15.642
CKD	1.513	0.478	10.014	0.002 *	4.542	1.779	11.596
DM	1.188	0.461	6.629	0.010 *	3.279	1.328	8.098
ICU admission	2.877	0.485	35.169	< 0.001 **	17.769	6.865	45.992
RBCs	-0.834	0.258	10.406	< 0.001 **	0.434	0.262	0.721
Hemoglobin	-0.273	0.080	11.504	< 0.001 **	0.761	0.650	0.891
WBCs	0.016	0.047	0.109	0.742	1.016	0.926	1.114
Neutrophils	0.036	0.051	0.499	0.480	1.037	0.938	1.146
Platelets	-0.005	0.002	3.689	0.055	0.995	0.990	1.000
PT	0.028	0.015	3.573	0.059	1.029	0.999	1.059
APTT	0.017	0.008	4.848	0.028 *	1.017	1.002	1.032
D-dimer	0.172	0.069	6.246	0.012 *	1.188	1.038	1.360
CRP	0.001	0.001	1.025	0.311	1.001	0.999	1.003
Procalcitonin	-0.019	0.030	0.431	0.512	0.981	0.926	1.039
CK	0.002	0.001	3.930	0.047 *	1.002	1.000	1.003
Troponin	-0.009	0.023	0.167	0.683	0.991	0.948	1.036
LDH	0.005	0.001	10.297	< 0.001 **	1.005	1.002	1.008
Ferritin	0.000	0.000	0.069	0.793	1.000	0.999	1.000
ALT	-0.001	0.009	0.012	0.912	0.999	0.982	1.016
AST	0.016	0.008	4.041	0.044 *	1.016	1.000	1.031
HBA1C	-0.064	0.121	0.286	0.593	0.938	0.740	1.187

RBCs - Red blood cells, WBCs - white blood cells, PT - Prothrombin time, APTT - Activated partial thromboplastin time, CRP - C-reactive protein CK - Creatine kinase, LDH - Lactate dehydrogenase, ALT - Alanine aminotransferase, AST - Aspartate aminotransferase, HBA1c - Hemoglobin A1C.
β - Regression coefficient, SE - Standard error, OR - Odds ratio, CI - Confidence interval, * p-value < 0.05 is significant; ** p-value < 0.001 is highly significant.

neutrophil counts and decreased RBC and hemoglobin levels. Also, the other laboratory indicators in this study, such as CRP ferritin, D-Dimer, and LDH, had high values at the time of admission and were all substantially linked with the ICU admissions. Consistent with our findings, abnormal levels of laboratory parameters, such as RBCs, WBCs, neutrophils, and ferritin, are related to a COVID-19 risk [35]. Other studies indicate a strong correlation between the severity of COVID-19 and specific hematological and coagulation parameters. Notably, patients with a severe and critical disease exhibited increased levels of leukocytes, neutrophils, as well as an elevated neutrophil-to-lymphocyte ratio. Additionally, abnormalities were observed in the coagulation parameters, including prolonged activated partial thromboplastin time (APTT), elevated D-dimer levels, and higher concentrations of lactate dehydrogenase (LDH), serum ferritin, and C-reactive protein (CRP) [36]. Among 126 COVID-19 patients diagnosed with anemia, 56% exhibited anemia of inflammation. This type of anemia is more prevalent in severe COVID-19 cases, coinciding with the elevated inflammatory markers like C-reactive protein (CRP) and ferritin. Elevated ferritin disrupts the iron balance, leading to a reduced hemoglobin production and a subsequent anemia. Notably, anemic patients tend to have higher CRP levels, which are positively correlated with the ferritin levels [37,38]. Also, in our analysis, certain biomarkers, such as platelet and APTT, did not demonstrate a significant correlation with illness severity or death, as observed in other studies [39,40].

CONCLUSION

This study on COVID-19 patients has unveiled valuable insights into the disease's clinical and laboratory profiles. Notably, it has shed light on the importance of the hematological parameters in understanding patient outcomes. The demographics of the study group revealed an even distribution of males and females, with an average age of 57.8 years. Among the comorbidities, diabetes mellitus (DM) and hypertension (HTN) were prevalent, with DM being the most common (51.4%), while chronic kidney disease (CKD) exhibited a lower prevalence but was associated with a notably higher mortality rate in spite of that. The laboratory analyses affirmed that most parameters remained within normal limits, providing essential baseline data. Of particular importance is the outcome distribution, where it became apparent that 10.6% of the comorbid COVID-19 patients did not survive. This elevated mortality rate was primarily associated with certain comorbidities, further underscoring the significance of the pre-existing conditions in patients. In the comparative analysis, several of the hematological parameters, including hemoglobin, red blood cells (RBCs), D-dimer, and C-reactive protein (CRP), displayed significant variations between the control group and the ICU admission group, emphasizing their role as potential indicators of the disease severity. Furthermore, correlations between risk factors and parameters illuminated strong positive and negative associations, notably affecting the hematological parameters. Hemoglobin and RBCs demonstrated substantial correlations with other parameters, while other factors like age, prothrombin time (PT), and D-dimer exhibited statistically significant correlations with risk factors. Lastly, the multivariate logistic regression analysis identified age, HTN, CKD, DM, ICU admission, RBCs, hemoglobin, and various hematological parameters as significant determinants of mortality in COVID-19 patients. These findings underscore the pivotal role of the hematological parameters in predicting and understanding disease severity, potentially aiding healthcare providers in optimizing patient care and outcomes. This study not only contributes to the growing body of knowledge regarding COVID-19, but also highlights the critical importance of considering hematological parameters when assessing patient risk and when tailoring treatment strategies. Further research in this direction is crucial to refining our understanding of the complex interplay between comorbidities, laboratory parameters, and patient outcomes.

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Institutional Review Board Statement:
The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of the Security Forces Hospital Program in Makkah (IRB. 0481-100522, 5/14/2022).

Declaration of Interest:
The author declares no conflicts of interest.

References:

1. Cucinotta D, Vanelli M. WHO Declares COVID-19 a Pandemic. Acta Biomed 2020;91(1):157-60. (PMID: 32191675)
2. Dessie ZG, Zewotir T. Mortality-related risk factors of COVID-19: a systematic review and meta-analysis of 42 studies and 423,117 patients. BMC Infect Dis 2021;21(1):855. (PMID: 34418980)
3. Shrestha N, Shad MY, Ulvi O, et al. The impact of COVID-19 on globalization. One Health 2020;11:100180. (PMID: 33072836)
4. Das S, Das S, Ghangrekar MM. The COVID-19 pandemic: biological evolution, treatment options and consequences. Innov Infrastruct Solut 2020;5(3):76. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7330532/
5. Boni MF, Lemey P, Jiang X, et al. Evolutionary origins of the SARS-CoV-2 sarbecovirus lineage responsible for the COVID-19 pandemic. Nat Microbiol 2020;5(11):1408-17. (PMID: 32724171)
6. Al-Qahtani AA. Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2): Emergence, history, basic and clinical aspects. Saudi J Biol Sci 2020;27(10):2531-8. (PMID: 32336927)
7. Banerjee A, Kulcsar K, Misra V, Frieman M, Mossman K. Bats and Coronaviruses. Viruses 2019;11(1):41. (PMID: 30634396)
8. Rahman N, Ali F, Basharat Z, et al. Vaccine Design from the Ensemble of Surface Glycoprotein Epitopes of SARS-CoV-2: An Immunoinformatics Approach. Vaccines (Basel) 2020;8(3):423. (PMID: 32731461)
9. Ejaz H, Alsrhani A, Zafar A, et al. COVID-19 and comorbidities: Deleterious impact on infected patients. J Infect Public Health 2020;13(12):1833-9. (PMID: 32788073)
10. Petrie JR, Guzik TJ, Touyz RM. Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. Can J Cardiol 2018;34(5):575-84. (PMID: 29459239)
11. Erener S. Diabetes, infection risk and COVID-19. Mol Metab 2020;39:101044. (PMID: 32585364)
12. Sanyaolu A, Okorie C, Marinkovic A, et al. Comorbidity and its Impact on Patients with COVID-19. SN Compr Clin Med 2020; 2(8):1069-76. (PMID: 32838147)
13. Jiang Z, Liu J, Geng L, et al. The Influences of COVID-19 on Patients With Chronic Kidney Disease: A Multicenter Cross-Sectional Study. Front Psychiatry 2021;12:754310. (PMID: 34899421)

14. Alqahtani SMA, Al Saglan NS, AlShehry AA, et al. Prevalence and impact of comorbidities in hospitalized patients with COVID-19: a study from Saudi Arabia. The Egyptian Journal of Bronchology 2023;17(1):37. https://ejb.springeropen.com/articles/10.1186/s43168-023-00211-8

15. Almuqbil M, Almoteer AI, Suwayyid AM, et al. Characteristics of COVID-19 Patients Admitted to Intensive Care Unit in Multispecialty Hospital of Riyadh, Saudi Arabia: A Retrospective Study. Healthcare (Basel) 2023;11(18):2500. (PMID: 37761697)

16. Liu B, Spokes P, He W, Kaldor J. High risk groups for severe COVID-19 in a whole of population cohort in Australia. BMC Infect Dis 2021;21(1):685. (PMID: 34266396)

17. Ibrahim ME, Al-Aklobi OS, Abomughaid MM, Al-Ghamdi MA. Epidemiological, clinical, and laboratory findings for patients of different age groups with confirmed coronavirus disease 2019 (COVID-19) in a hospital in Saudi Arabia. PLoS One 2021;16(4): e0250955. (PMID: 33914805)

18. Li X, Xu S, Yu M, et al. Risk factors for severity and mortality in adult COVID-19 inpatients in Wuhan. J Allergy Clin Immunol 2020;146(1):110-8. (PMID: 32294485)

19. Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72, 314 Cases From the Chinese Center for Disease Control and Prevention. JAMA 2020;323(13): 1239-42. (PMID: 32091533)

20. Landstra CP, de Koning EJP. COVID-19 and Diabetes: Understanding the Interrelationship and Risks for a Severe Course. Front Endocrinol (Lausanne) 2021;12:649525. (PMID: 34220706)

21. Bassendine MF, Bridge SH, McCaughan GW, Gorrell MD. COVID-19 and comorbidities: A role for dipeptidyl peptidase 4 (DPP4) in disease severity? J Diabetes 2020;12(9):649-58. (PMID: 32394639)

22. Fang X, Li S, Yu H, et al. Epidemiological, comorbidity factors with severity and prognosis of COVID-19: a systematic review and meta-analysis. Aging (Albany NY) 2020;12(13):12493-503. (PMID: 32658868)

23. Gao YD, Ding M, Dong X, et al. Risk factors for severe and critically ill COVID-19 patients: A review. Allergy 2021;76(2):428-55. (PMID: 33185910)

24. Robinson AG, Gyawali B, Evans G. COVID-19 and cancer: do we really know what we think we know? Nat Rev Clin Oncol 2020;17(7):386-8. (PMID: 32424196)

25. Linjawi M, Shakoor H, Hilary S, et al. Cancer Patients during COVID-19 Pandemic: A Mini-Review. Healthcare (Basel) 2023; 11(2):248. (PMID: 36673615)

26. Khunti K, Valabhji J, Misra S. Diabetes and the COVID-19 pandemic. Diabetologia 2023;66(2):255-66. (PMID: 36418578)

27. Steiner JF, Powers JD, Malone A, et al. Hypertension care during the COVID-19 pandemic in an integrated health care system. J Clin Hypertens (Greenwich) 2023;25(4):315-25. (PMID: 36919191)

28. Yang J, Zheng Y, Gou X, et al. Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis. Int J Infect Dis 2020;94:91-5. (PMID: 32173574)

29. Sharif N, Opu RR, Ahmed SN, et al. Prevalence and impact of comorbidities on disease prognosis among patients with COVID-19 in Bangladesh: A nationwide study amid the second wave. Diabetes Metab Syndr 2021;15(4):102148. (PMID: 34186349)

30. Saif Andrabi SM. Clinical profile and outcome of COVID-19 patients along with the impact of comorbidities on the disease outcome at the secondary care hospital of Union Territory of J& K. J Assoc Physicians India 2022;70(4):11-2. (PMID: 35443523)

31. Fairweather D, Beetler DJ, Di Florio DN, Musigk N, Heidecker B, Cooper LT Jr. COVID-19, Myocarditis and Pericarditis. Circ Res 2023;132(10):1302-19. (PMID: 37167363)

32. Gherbesi E, Bergamaschi L, Cusmano I, et al. The usefulness of speckle tracking echocardiography in identifying subclinical myocardial dysfunction in young adults recovered from mild COVID-19. Echocardiography 2022;39(9):1190-7. (PMID: 35906710)

33. Bergamaschi L, D'Angelo EC, Paolisso P, et al. The value of ECG changes in risk stratification of COVID-19 patients. Ann Noninvasive Electrocardiol 2021;26(3):e12815. (PMID: 33512742)

34. Ye C, Zhang S, Zhang X, et al. Impact of comorbidities on patients with COVID-19: A large retrospective study in Zhejiang, China. J Med Virol 2020;92(11):2821-9. (PMID: 32543710)

35. Rahman MA, Shanjana Y, Tushar MI, et al. Hematological abnormalities and comorbidities are associated with COVID-19 severity among hospitalized patients: Experience from Bangladesh. PLoS One 2021;16(7):e0255379. (PMID: 34314447)

36. Taj S, Kashif A, Arzinda Fatima S, Imran S, Lone A, Ahmed Q. Role of hematological parameters in the stratification of COVID-19 disease severity. Ann Med Surg (Lond) 2021;62:68-72. (PMID: 33437468)

37. Bellmann-Weiler R, Lanser L, Barket R, et al. Prevalence and Predictive Value of Anemia and Dysregulated Iron Homeostasis in Patients with COVID-19 Infection. J Clin Med 2020;9(8): 2429. (PMID: 32751400)

38. Yazdani AN, Abdi A, Velpuri P, et al. A Review of Hematological Complications and Treatment in COVID-19. Hematol Rep 2023;15(4):562-77. (PMID: 37873794)

39. Hana C, Aboulenain S, Dewaswala N, Narendran V. Does Thrombocytopenia Truly Correlate with COVID-19 Severity? Blood 2020;136(1):39-40. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8330312/

40. Gorog DA, Storey RF, Gurbel PA, et al. Current and novel biomarkers of thrombotic risk in COVID-19: a Consensus Statement from the International COVID-19 Thrombosis Biomarkers Colloquium. Nat Rev Cardiol 2022;19(7):475-95. (PMID: 35027697)

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