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Biological profile and risk factors of mortality in COVID-19 patients at Adlucem hospital in Banka-Bafang, Cameroon: a cross-sectional study

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Abstract

Background Despite availability of preventive vaccine and global control of the SARS-CoV-19 transmission, continuous emergence of new strains coupled with the increase spread of Mpox poses significant public health threats. Identification of simple factors for stratification and prognostics of hospitalized patients is crucial for management of these patients in limited resource settings. The aim of this study was to assess the biological profile of severe hospitalized COVID-19 patients in Cameroon and identify risk factors for mortality.

Methods A prospective, cross-sectional, analytical study was conducted of a cohort of COVID-19 patients admitted and managed at the Adlucem hospital in Banka-Bafang, Haut-Nkam Department, West Cameroon Region, from 2021 to 2022. The clinical characteristics and biological parameters of patients with COVID-19 were evaluated.

Results Of the 259 cases of COVID-19 included in the study, 68 cases (26.3%) died. The majority of patients who died were over 70 years of age. Key factors predictive of mortality in these patients were leukocytosis (OR = 2.035; 95%CI: 1.161–3.567; $p = 0.013$), thrombocytosis (OR = 4.286; 95%CI: 1.152–15.950; $p = 0.030$), hypokalemia (OR = 2.400; 95%CI: 1.143–5.042; $p = 0.021$), hyponatremia (OR = 2.292; 95%CI: 1.185–4.431; $p = 0.014$) and hypochloremia (OR = 2.644; 95%CI: 1.188–5.882; $p = 0.017$).

Conclusion Age, electrolyte imbalance and thrombocytosis were predictive of death in COVID-19 patients in this cohort. Thus, a biological work-up should be considered for risk stratification to ensure efficient management of COVID-19 patients on a case-by-case basis in resource limited settings like Cameroon.

Clinical trial number Not applicable.

Keywords COVID-19, Death, Biological profile, Risk factors, Cameroon

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Introduction

The SARS-CoV-2 virus, responsible for COVID-19, continues to circulate throughout the world. The World Health Organisation (WHO) estimates that more than 776 million cases have been recorded and that almost 7.1 million people have died; more than 4,000 deaths have been reported in the last 28 days, despite the existence of a vaccine and measures to control the spread [1]. COVID-19 presents clinically with a wide spectrum of symptoms, ranging from no symptom, isolated pneumopathy to multi-system involvement with potentially fatal complications, thus sometimes misleading characteristics [2]. The acute inflammatory effects of COVID-19 range from mild to severe clinical, biological and radiological manifestations reaching multiple organ systems besides the lungs. Although the case was reported in Egypt in February 2020, the first two waves progressed rather slowly in Africa than other continents [3]. Within three months with spread across most African, mostly imported from Europe and America and not from China where the virus originated [4]. Data on associated complications are important to inform management strategies but remain scarce in Africa due to limited reporting. In Cameroon, the first cases of the COVID-19 were reported on March 06, 2020. By March 30, 2020, three weeks later, (the country had recorded 142 confirmed cases of COVID-19 and 2 related deaths [5]. This exponential growth in reported infections prompted the Cameroon government, through its Ministry of Public Health, to set out a series of public health measures to limit the spread of the virus in accordance with WHO recommendations [6]. These measures included regular handwashing, social distancing, and banning gatherings of more than fifty people nationwide, and instituted screening at points of entry into Cameroon active case finding and isolation of suspected cases.

A lower number of confirmed cases and associated deaths were reported in African countries, compared to European countries [7]. The differences in observed mortality across Africa compared to other continents (Asia, the Americas and Europe) are potentially associated with the younger population structure in Africa, the lower epidemiology of comorbidities known to increase risk of COVID-19 severity and symptoms presentation does not exclude limited capacity for diagnosis [8]. To date, several studies have reported an overview of the evolution of the disease in Cameroon, vulnerability to the severity of COVID-19 and access to healthcare, and its potential socio-economic consequences [9–13]. However, no study has presented the specific biological profile of COVID-19 in Cameroonian patients. Knowledge of the biological factors associated with the development of severe disease will inform accurate patient stratification and resource allocations for management of COVID-19 cases in Cameroon. The aim of this study was therefore to describe the biological profiles of COVID19 patients diagnosed at the Adlucem hospital in Banka-Bafang, West Region in Cameroon and identify risk factors for death in patients to optimize management and improve public health.

Materials and methods

Study design and framework

This study was a part of a research project entitled "COVID-19 and cardio metabolic syndrome in Cameroon which started in December 2021 and ended in March 2023. The project used cross-sectional (at the admission for biological parameters) and prospective (follow-up of 15 months for survivors). Data presented in this publication are biological parameters of each patient at the admission and some parameters of the hospitalization. This study was conducted at the Adlucem hospital in Banka-Bafang, Haut-Nkam Division, West Cameroon region, located between latitude 5° 9' 5" north and longitude 10° 10' 60" east. This hospital was one of the Special Care Centers for the diagnosis of COVID-19 and management of COVID patients approved by the health authorities and was under the technical and clinical supervision of the Bafoussam Regional hospital, West Region of Cameroun. It is also one of the most frequently visited hospitals in the Bafang health district (60% of the consultations), will focus on patients managed for severe COVID-19 in a dedicated departmental management Centre set up during the pandemic.

Study population and inclusion of participants

The study population included all individuals, irrespective of age or sex, who received a consultation at Adlucem hospital in Banka-Bafang for signs or symptoms suggestive of SARS-CoV-2 infection during the study period. Two nasopharyngeal samples were taken from each patient using swabs. One swab was used for rapid diagnosis using the Accu-Tell ® COVID-19 antigen cassette, which is a rapid chromatographic immunoassay for the qualitative detection of SARS-CoV-2 antigen. The second swabs was used to confirm the diagnosis at the regional hospital of Bafoussam by RT-PCR (reverse transcription polymerase chain reaction) using the AmpliQuick® SARS-CoV-2 PCR Kit, which enables detection of 2 SARS-CoV-2 viral genes (the RdRp gene and the E gene) and a human control gene (the RNaseP gene). The lowest cycle threshold (Ct) value was determined for each gene after RT-PCR analysis and was used for statistical analysis. The RT-PCR result was positive when a specific SARS-CoV-2 gene was amplified with less than 33 cycles. The RT-PCR result was negative in the absence of SARS-CoV-2 gene amplification.

A convenient sampling approach was used whereby all patients with a confirmed laboratory positive test for SARS-Cov-2 infection diagnosed by a qualitative reverse transcriptase polymerase chain reaction (RT-PCR) test performed on nasopharyngeal swab samples was included in the study. After sampling, 300 participants were selected for the study. Subjects confirmed positive for SARS-Cov-2 infection and attending Bafang district hospital with missing clinical records and relevant laboratory tests were excluded from the study as illustrated in the Fig. 1 below.

Data collection and study variables

Medical records were reviewed to collect demographic and clinical characteristics (age, sex, history of chronic illness and lifestyle, clinical signs on admission). Biological data including haemogram, biochemical markers (C-reactive protein (CRP), blood glucose and ionograms in particular) of COVID-19 patients managed at the Adlucem hospital, Banka-Bafang.

Collection of biological data and applied definitions

Biological parameters of interest included hemoglobin, red blood cells, white blood cells, platelets, CRP, total cholesterol, triglycerides, HDL-cholesterol (HDL-c), LDL-cholesterol (LDL-c), glucose, glycated hemoglobin, aspartate amino transferase (ASAT), alanine amino transferase (ALAT), urea, creatinine, sodium, potassium and chlorine. Fasting blood glucose was assessed by the Glucose Oxidase-Peroxidase (GOP-POD) method. Total cholesterol, plasma triglycerides, HDL-c, LDL-c, AST, ALT, urea, serum creatinine were assessed enzymatically and colorimetrically using ChronoLab kits (Traversia Prat de la Riba 34 B 08849 Sant Climent de Llobregat Barcelona, Spain). The full blood count was performed using a Sysmex poch-100i (USA) automatic analyzer and red blood cell count (RBC), white blood cell count (WBC), platelets (PLQ) counts and total hemoglobin (Hb) were determined.

Diagnostic criteria were defined as follows: anemia was defined as a hemoglobin level below 12 g/dL [14], hyperleukocytosis as a leukocyte count above 11×10^3 /mm, polycythemia as a red blood cell count above 4.5×10^3 /mm^3 and thrombocytosis as a platelet count above 450×10^3 /mm^3 [15]. A C-reactive protein (CRP) level above 12 mg/L was considered high [16]. Potassium levels below 3.3 mmol/L and above 5.1 mmol/L defined hypokalemia and hyperkalemia respectively [17]. Similarly, sodium levels below 135 mmol/L and above 145 mmol/L corresponded to hyponatremia and hypernatremia respectively [18]. Chlorides below 95 mmol/L and above 105 mmol/L corresponded to hypochloremia and hyperchloremia respectively [19]. Finally, hepatic function was assessed by ALAT levels above 50 IU/L and ASAT above 40 IU/L [20]. Elevated blood uremia was considered for urea levels above 0.43 g/L [21] and hypercreatinemia was diagnosed by blood creatinine levels above 14 mg/L and 11 mg/dL for men and women respectively [22].

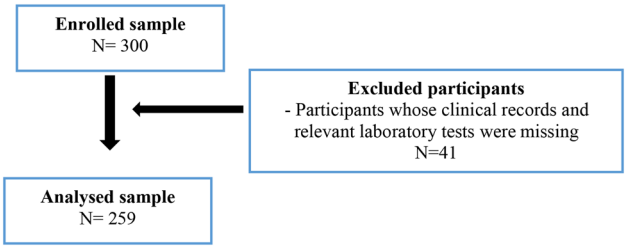

Fig. 1 Flow chart of sample selection

Statistical analysis

Statistical analyses were performed using SPSS version 25.0 for Windows (SPSS, Inc., IBM Corporation, Chicago, USA). Quantitative data were expressed as mean ± standard error, while qualitative data were expressed as frequencies (%). The Student's t test was used to compare means, while the chi-square test or Fisher's exact test was used to compare proportions. Logistic regression was used to identify risk factors associated with the death. The effect of potential confounding factors was adjusted for in the logistic regression model in multivariate analysis. Statistical significance was retained for a p-value < 0.05.

Results

Sociodemographic and clinical characteristics of COVID-19 patients

During the study period, 259 patients were confirmed positive for Covid-19 with more men [62.2% (161/259)] than women [37.8% (98/259)]. The hospitalization rate for men (64.4%) was higher than for those who succumbed to the disease (55.9%). Among women, the number of deaths was higher than the number of living (hospitalized) patients (44.1% vs. 35.6%). More than half of patients aged 70 years and over died compared 28.8% still hospitalized for COVID ($p = 0.002$) as of the time of data collection. Vomiting, abdominal pain, dyspnea, fever were the most significantly reported symptoms among the COVID patients who demised compared to all hospitalized patients ($p < 0.05$) (Table 1).

Anthropometric, hematological and ionic characteristics of COVID-19 patients

The results of anthropometric, hematological and ionic characteristics of COVID-19 patients are reported in Table 2 below. Mean weight (76.10 ± 9.66 kg vs. 73.28 ± 10.19 kg, $p = 0.049$) and body mass index (26.40 ± 2.93 kg/m^2 vs. 25.22 ± 3.55 kg/m^2, $P = 0.014$) were significantly higher in deceased patients than in those

Table 1 Clinical symptoms characteristics of COVID-19 patients

Variables	Death		
	No	Yes	p value
Sex			
Women	35.6 (68)	44.1 (30)	0.214
Men	64.4 (123)	55.9 (38)	
Age (years)			
18–29 years	13.1 (25)	7.4 (5)	0.002
30–49 years	19.9 (38)	20.6 (14)	
50–69 years	38.2 (73)	19.1 (13)	
≥ 70 years	28.8 (55)	52.9 (36)	
Vomiting			
Yes	3.7 (7)	14.7 (10)	0.002
No	96.3 (184)	85.3 (58)	
Abdominal pain			
Yes	2.1 (4)	19.1 (13)	< 0.0001
No	97.9 (187)	80.9 (55)	
Cough			
Yes	85.9 (164)	77.9 (53)	0.128
No	14.1 (27)	22.1 (15)	
Fever			
Yes	74.3 (142)	39.7 (27)	< 0.0001
No	25.7 (49)	60.3 (41)	
Headache			
Yes	32.1 (61)	25.4 (17)	0.303
No	67.9 (129)	74.6 (50)	
Dyspnea			
Yes	48.9 (93)	64.2 (43)	0.032
No	51.1 (97)	35.8 (24)	
Asthenia			
Yes	60.2 (115)	57.4 (39)	0.680
No	39.8 (76)	42.6 (29)	
Anorexia			
Yes	22.5 (43)	20.6 (14)	0.742
No	77.5 (148)	79.4 (54)	
Nasal discharge			
Yes	2.6 (5)	4.4 (3)	0.463
No	97.4 (186)	95.6 (65)	
Diarrhea			
Yes	8.4 (16)	8.8 (6)	0.910
No	91.6 (175)	91.2 (62)	

still hospitalized. The mean serum creatinine concentrations were significantly higher in deceased patients than in patients still in hospitalized at the time of the study (16.77 ± 1.14 g/L vs. 12.88 ± 0.41 g/L) ($p < 0.05$). Analysis of electrolyte homeostasis found the mean serum potassium concentrations to be significantly lower for patients who died compared to those who survived still in hospitalize (3.55 ± 0.11 mmol/L vs. 3.85 ± 0.06 mmol/L) ($p < 0.05$). The mean white blood cell count was also significantly higher in deceased patients compared to the survived (12.32 ± 1.19 g/L vs. 10.01 ± 0.45 g/L) ($p < 0.05$).

Table 2 Anthropometric, hematological and ionic characteristics of COVID-19 patients

Variables	Death		
	No	Yes	p value
Clinical characteristics			
SBP (mmHg)	135.03 ± 28.86	140.86 ± 29.85	0.095
DBP (mmHg)	74.73 ± 11.41	76.73 ± 14.78	0.254
Anthropometric characteristics			
Weight (Kg)	73.28 ± 10.19	76.10 ± 9.66	0.049
BMI (Kg/m^2)	25.22 ± 3.55	26.40 ± 2.93	0.014
Blood count			
White blood cells (g/L)	10.01 ± 0.45	12.32 ± 1.19	0.027
Red blood cells (g/L)	4.14 ± 0.21	4.13 ± 0.15	0.073
platelets (g/L)	228.91 ± 6.19	254.10 ± 17.21	0.085
Hemoglobin (g/dL)	11.42 ± 0.13	11.59 ± 0.16	0.465
Biochemicals characteristics			
CRP (mg/L)	57.93 ± 3.15	58.58 ± 6.04	0.919
Total Cholesterol (g/L)	1.88 ± 0.05	1.92 ± 0.07	0.672
Triglycerides (g/L)	1.22 ± 0.05	1.26 ± 0.09	0.738
HDL-cholesterol (g/L)	0.45 ± 0.01	0.50 ± 0.03	0.154
LDL-cholesterol (g/L)	1.25 ± 0.04	1.20 ± 0.04	0.418
H1ABc	6.99 ± 0.16	7.47 ± 0.18	0.065
Glucose (g/L)	1.42 ± 0.07	1.57 ± 1.19	0.379
AST (UI/L)	48.27 ± 5.40	61.76 ± 22.71	0.386
ALT (UI/L)	46.28 ± 3.42	47.00 ± 6.04	0.926
Urea (g/L)	0.38 ± 0.02	0.44 ± 0.03	0.220
Creatinine (g/L)	12.88 ± 0.41	16.77 ± 1.14	0.004
Ionics characteristics			
Potassium (mmol/L)	3.85 ± 0.06	3.55 ± 0.11	0.010
Sodium (mmol/L)	136.71 ± 1.48	131.44 ± 3.25	0.092
Chlorine (mmol/L)	91.16 ± 2.45	85.19 ± 2.01	0.121

AST: aspartate aminotransferase; ALT: alinine aminotransferase; HDL: high density lipoprotein; LDL: low density lipoprotein; CRP: C-reactive protein; BMI: Body mass index

Main biological abnormalities observed in COVID-19 patients

An analysis of biological abnormalities in patients with covid-19 is presented in Table 3 below. This study found more overweight in the group that survived still admitted in hospital than those who died (41.1% vs. 27.9%; $p = 0.05$), but more obese people in the group that demised. There was Electrolyte imbalance with in the patients who demised having higher hypochloremia (86.2% vs. 70.0%) than the survived group, followed by hyponatremia (35.4% vs. 19.3%) and hypokalemia (26.2% vs. 12.9%), than in hospitalized patients ($p < 0.05$). Over 57.4% of the demised patients had leukocytosis, compared with 39.8% of those who survived hospitalized ($p < 0.05$). In addition, thrombocytosis was observed in 8.8% of patients who died compared to only 2.1% of survivor's still hospitalized ($p < 0.05$).

Table 3 Main biological abnormalities observed in COVID-19 patients

Abnormality	Death		
	No	Yes	p value
	% (n)	% (n)	
Anthropometric abnormality			
Overweight	41.1 (79)	27.9 (19)	0.05
Obesity	6.8 (13)	8.8 (6)	0.146
Biochemical abnormality			
Total hypercholesterolemia	77.0 (67)	70.0 (35)	0.365
Hypertriglyceridemia	36.8 (32)	34.0 (17)	0.744
Hypocholesterolemia HDL	36.8 (32)	30.0 (15)	0.421
Hypercholesterolemia LDL	26.4 (23)	28.0 (14)	0.843
High CRP	91.6 (175)	88.2 (60)	0.408
Hyper creatinemia	28.9 (55)	26.5 (18)	0.697
High urea	22.1 (42)	30.9 (21)	0.148
Hypokalemia	12.9 (18)	26.2 (17)	0.019
Hyponatremia	19.3 (27)	35.4 (23)	0.044
hypochloremia	70.0 (98)	86.2 (56)	0.042
Blood count			
High white blood cells	39.8 (76)	57.4 (39)	0.028
High red blood cells	4.2 (8)	2.9 (2)	0.076
High platelets	2.1 (4)	8.8 (6)	0.013
Low hemoglobin	62.3 (119)	52.9 (36)	0.175

HDL: high density lipoprotein; LDL: low density lipoprotein; CRP: C-reactive protein

Biological predictors of death in COVID-19 patients in the study population

Bivariate analyses identified several risk factors associated with death in COVID patients. Leukocytosis (OR = 2.035; 95%CI: 1.161–3.567; $p = 0.013$), thrombocytosis (OR = 4.286; 95%CI: 1.152–15.950; $p = 0.030$), hypokalemia (OR = 2.400; 95%CI: 1.143–5.042; $p = 0.021$), hyponatremia (OR = 2.292; 95%CI: 1.185–4.431; $p = 0.014$) and hypochloremia (OR = 2.644; 95%CI: 1.188–5.882; $p = 0.017$) were determined to be independent predictors of death in COVID-19. Furthermore, after adjustment for sex and age, overweight (AOR = 1.877; 95%CI: 1.017–3.477; $p = 0.044$) also emerged as a significant risk factor for dying of COVID-19 (Table 4).

Table 4 Biological predictors of death in COVID-19 patients in the study population

Variables	OR (95% CI)	p value	AOR (95% CI)	p value
Overweight	1.819 (0.995–3.324)	0.052	1.877 (1.017–3.477)	0.044
Total hypercholesterolemia	0.697 (0.318–1.526)	0.366	0.669 (0.300-1.489)	0.324
Hypertriglyceridemia	0.885 (0.427–1.837)	0.744	0.879 (0.416–1.857)	0.735
Hypocholesterolemia HDL	0.737 (0.350–1.552)	0.422	0.770 (0.360–1.648)	0.501
Hypercholesterolemia LDL	1.082 (0.496–2.360)	0843	1.167 (0.526–2.590)	0.705
High CRP	0.686 (0.279–1.683)	0.410	0.678 (0.271–1.695)	0.405
Hyper creatinemia	0.884 (0.474–1.648)	0.697	0.800 (0.421–1.522)	0.497
High urea	1.574 (0.849–2.921)	0.150	1.390 (0.734–2.632)	0.313
High white blood cells	2.035 (1.161–3.567)	0.013	1.940 (1.093–3.442)	0.023
High red blood cells	0.686 (0.142–3.312)	0.639	0.762 (0.152–3.823)	0.741
High platelets	4.524 (1.236–16.557	0.023	4.286 (1.152–15.950)	0.030
Hypokalemia	2.400 (1.143–5.042)	0.021	2.600 (1.213–5.576)	0.014
Hyponatremia	2.292 (1.185–4.431)	0.014	2.144 (1.092–4.207)	0.027
Hypochloremia	2.667 (1.209–5.883)	0.015	2.644 (1.188–5.882)	0.017

OR: odds ratio; ORa: odds ratio adjusted for sex and age; HDL: high density lipoprotein; LDL: low density lipoprotein; CRP: C-reactive protein

Discussion

This study aimed to describe the biological profile of COVID-19 patients in hospital that was central to the diagnosis and management of COVID-19 at a health district in Bafang in the West region of Cameroon and to identify risk factors for dying of COVID-19. COVID-19 severity and mortality was higher in older patients than those who survived (72% vs. 67%), with the over 70 years old patients (52.1%) seeing a significantly higher mortality than any other age group. These results are similar to those of other African studies, notably in Kinshasa in the Democratic Republic of Congo, highlighting the impact of advanced age on COVID-19-related mortality [23] and an association of higher age with disease severity [2] explained by the aging immune system, which renders the elderly more vulnerable to severe complications of the disease. Indeed, Nlandu et al. [24] and Pan et al. [25] also suggested that immunosenescence is characterized by reduced production of native T and B cells and dysfunction of innate immune cells, which could explain the greater vulnerability of the elderly to COVID-19. This altered immune response particularly favors viral

persistence and a deregulated inflammatory response, leading to a cytokine storm.

The symptoms most observed in patients who demised were vomiting, abdominal pain, dyspnea and fever. However, the frequency of these signs were low compared with those observed by Mandina et al. [26] in Kinshasa, Democratic Republic of Congo, and Chen et al. [27] in China. Whether this is associated with the consumption of traditional medicinal products informally reported in the Cameroonian population is not known.

Analysis of the biological abnormalities observed in deceased COVID-19 patients and those still in hospital showed that electrolyte disorders (hypokalemia (26.2), hyponatremia (35.4%) and hypochloremia (86.2%)); leukocytosis (57.4%) and thrombocytosis (8.8%) were significantly more prevalent in deceased patients ($p < 0.05$).

Previous studies by Ksantini [28] and Daoui [29] showed that 76% and 84.56% of patients presented with severe forms of COVID-19 in Marakech and Agadir. While a Moroccan study found leukocytosis in patients with severe COVID-19, a study at the CHU Hedi Chaker-Sfax in Tunisia found it elevated in only 35.4% of such cases [2]. Similarly, leukocytosis was found to be an independent risk factor for mortality in these COVID-19 patients in Cameroon (OR = 1.940, 95% CI: 1.093–3.442, $p = 0.023$). Mohebbi et al. [30] and Zhu et al. [31] also showed that patients with higher WBC counts faced a significantly higher risk of dying of COVID-19 patients in Shiraz, Iran and Wu Han province, China respectively. The increase in white blood cells correlates with an increase in neutrophils, which release reactive oxygen species capable of destroying normal or foreign cells, thus reducing the number of lymphocytes needed to fight infectious diseases [32, 33]. Thrombocytosis was found in 8.8% of our patients, slightly higher than the 6.8% found by Chabati et al. [34]; and is associated with an elevated mortality risk in COVID-19 patients (OR = 4.286, 95% CI: 1.152–15.950, $p = 0.030$). The high risk of mortality in COVID-19 patients with thrombocytosis observed here is not well documented in the literature. COVID-19 patients are more prone to thrombocytopenia [35]. However, it has been established that COVID-19 patients with thrombocytosis had longer hospital stays and poorer outcomes [36]. Previous studies also noted that in severe cases of COVID-19, platelet counts increased significantly due to the cytokine storm. However, the underlying mechanisms remain unclear [37].

Electrolyte imbalance in the form of hyponatremia, hypokalemia and hypochloremia were more prevalent in patients who died from COVID-19, with the risk of death up to 2 times higher than in patients with normal natremia/hypernatremia. The elevated risk is attributed to the syndrome of inappropriate secretion of antidiuretic hormone secretion (SIADH), frequently seen in hyponatremic patients suffering from acute respiratory distress syndrome [38]. This is similar to earlier study that found of hyponatremia, accompanied by neurological complications (encephalopathy, cerebral edema and convulsions) which can have serious consequences, including death [39]. As for hypokalemia, the high prevalence and high risk of death observed in COVID-19 patients could be explained by the hyperactivation of the renin angiotensin aldosterone system (RAAS) in COVID-19 patients, which promotes potassium excretion in the urine [40]. In addition, the gastrointestinal symptoms (diarrhea, vomiting) observed in patients suffering from COVID-19 could also be evoked. These symptoms may result from the loss of potassium from the gastrointestinal tract [41]. The results observed in this study are in contrast to those of Ramanandafy et al. [42] who showed no significant difference for hypokalemia and hyponatremia in patients with severe forms of COVID-19 compared to patients with mild forms in Madagascar. When it came to hypochloremia, we observed a high frequency in deceased COVID-19 patients and a three times higher mortality risk than in patients with normal/hyperchloremia. These results (hyponatremia, hypokalemia and hypochloremia) are similar to those of Wu et al. [43], who observed a high risk of long-term hospitalization for COVID-19 patients with these electrolyte disorders. Indeed, the longer the duration of hospitalization, the higher the risk of death.

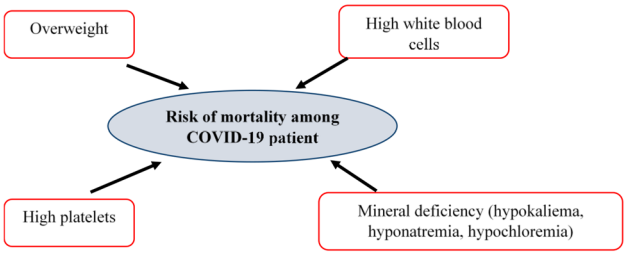

Fig. 2 Factors that may contribute to mortality in COVID-19 patients

Conclusion

This study highlights critical hematological and biochemical factors associated with mortality in Cameroonian patients with COVID-19, including leukocytosis, thrombocytosis and electrolyte imbalances (hypokalemia, hyponatremia and hypochloremia). These results highlight the unique biological profile of COVID-19 in Cameroon, suggesting the need for tailored therapeutic strategies to address these specificities and improve patient outcomes. At the end of this work, we summarize the factors associated with mortality in covid 19 patients in the form of a diagram (Fig. 2).

Abbreviations

COVID-19	Coronavirus Disease 2019
Mpox	Monkey pox

CI	Confidence interval
SPSS	Statistical Package for the Social Sciences
SARS-CoV-19	Severe Acute Respiratory Syndrome coronavirus 19
WHO	World Health Organization
RAAS	Renin Angiotensin Aldosterone System
HDL	High Density Lipoprotein
LDL	Low Density Lipoprotein
CRP	C - Reactive Protein
BMI	Body Mass Index
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
H1ABc	Glycated Hemoglobin
AST	Aspartate aminotransferase
ALT	Alanine aminotransferase

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Author contributions
Conceptualization: BMAA and JLN; Investigation: BMAA, DYEE, OMHR, BM, DP, ANJ; Writing-original draft preparation: BRTT, BMAA, LSN; Writing-review and editing: BMAA, ENL, BRTT and LK; Analyzed the data: BRTT, VPH and LJNM; Supervision: ENL, BB and JLN. All authors critically revised the manuscript for important intellectual content. All authors approved the final manuscript and agreed to the published version of the manuscript.

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Data availability
The data sets generated during and/or analyzed during the current study are available from the corresponding authors on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Regional Ethics Committee for Human Health Research of the Western Region of the Ministry of Public Health of Cameroon under number 853/28/08/2024/CE/CRERSH-OU/VP. The collection was authorized by the authorities of the Ad Lucem Hospital in Banka-Bafang. Informed consent was obtained from all participants, who were previously informed of the nature, objectives, potential risks and expected benefits of the research. Participants were fully informed of their right to withdraw from the interview or not participate. Confidentiality measures were put in place, including the allocation of unique codes to each participant. All methods were conducted in accordance with ethical standards, as outlined in the Declaration of Helsinki. To mitigate the risk of COVID-19 transmission, social distancing measures were implemented and participants were provided with necessary protective equipment, such as face masks and hand sanitizer.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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