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Analysis of Early Hematological Indicators in Hospitalized Patients Infected with COVID-19

Chao Fang, Hongmei Zhao, Simin Ren, Nuan Xiao

The COVID-19 outbreak in 2019 has had a massive and profound impact on the entire world. It not only poses a serious threat to human health but also has caused significant economic disruption. As the COVID-19 virus continues to mutate, the symptoms of those infected have become increasingly atypical.

The diagnosis of COVID-19 mainly relies on viral nucleic acid testing and chest CT scans. However, early nucleic acid tests may not always yield positive results, and chest CT scans may not show typical signs.

Therefore, it is necessary to combine various factors to assist in diagnosis. During the large-scale outbreak of COVID-19, it was observed in clinical practice that COVID-19 patients exhibit characteristic blood test results. This article will analyze the hematological characteristics of COVID-19 in order to better serve the clinical work.

1 Data and Methods

1.1 General Information

The study collected data from patients hospitalized with COVID-19 infection at Hebei University Affiliated Hospital between December 2022 and January 2023, including a total of 101 cases. All included patients tested positive for COVID-19 nucleic acid and exhibited radiological features of viral pneumonia. The hematological indicators collected were the first laboratory test results upon admission. Patients with a history of malignant tumors, acute coronary syndrome, acute cerebrovascular disease, or chronic liver and kidney insufficiency were excluded from the study.

1.2 Hematological Indicators

The hematological indicators mainly include white blood cells (WBC), neutrophils (N), lymphocytes (L), C-reactive protein (CRP), serum amyloid A (SAA), procalcitonin (PCT), serum creatinine (Scr), gamma-glutamyl transferase (γ -GT), alanine aminotransferase (ALT), aspartate aminotransferase (AST), creatine kinase-MB (CK-MB), troponin I (cTnI), serum potassium (K^+), serum sodium (Na^+), serum chloride (Cl^-), D-dimer (D-D), partial pressure of oxygen (PO_2), and partial pressure of carbon dioxide (PCO_2).

1.3 Statistical Analysis

SPSS 22.0 software was used for data statistics and analysis. The number and proportion of elevated, normal, and decreased cases for each hematological indicator were calculated. Measurement data are presented as mean ± standard deviation ($\bar{x} \pm s$). Comparison of indicators between severe and non severe groups using independent sample t-test, Pearson correlation analysis was used to examine the relationships between the indicators. A P-value of less than 0.05 was considered statistically significant.

2 Results

2.1 General Characteristics

A total of 101 patient records were included for analysis, comprising 50 males (49.5%) and 51 females (50.5%), with a male-to-female ratio of 0.98: 1. The gender ratio showed no statistically significant difference ($P > 0.05$). The average age was 73.61 ± 12.29 years. The patients were divided into severe and non-severe groups, with 7 cases (6.93%) classified as severe and 94 cases (93.07%) classified as non-severe.

2.2 Differences in Indicators between Severe and Non-Severe Patients

Among severe and non-severe patients, the WBC and neutrophil (N) counts were significantly higher in severe patients, while a certain proportion of patients showed a decrease in lymphocyte (L) counts. The increases in CRP and SAA were positively correlated with the severity of infection. Serum creatinine (Scr) was mostly normal, Abnormal individuals account for a small proportion. The proportion of elevated CK-MB was higher in severe patients compared to non-severe patients. In terms of electrolytes, potassium (K^+), sodium (Na^+), and chloride (Cl^-) showed a decreasing trend, with significant reductions in Na+ and Cl-. D-dimer (D-D) was notably elevated in COVID-19 patients. Among the indicators compared between the severe and non-severe groups, the difference in PO_2 was statistically significant ($P < 0.01$), while the other indicators showed no significant statistical differences (all $P > 0.05$), as shown in Table 1.

Table 1 Biochemical Indicators by Group

Indicators	Severe Group ($\bar{x}\pm s$)	Non-Severe Group($\bar{x}\pm s$)	P-value
WBC($x10^9$/L)	8.94±4.50	7.65±3.81	0.396
N($x10^9$/L)	7.32±4.07	6.72±8.46	0.854
L($x10^9$/L)	0.99±0.46	1.25±1.22	0.589
CRP(mg/L)	54.74±27.03	50.13±66.54	0.856
SAA(mg/L)	434.09±247.16	405.80±668.07	0.912
SCr(umol/L)	59.00±27.96	72.00±36.85	0.364
GGT(U/L)	63.00±86.93	47.73±47.03	0.441
ALT(U/L)	29.86±24.14	27.14±30.05	0.816
AST(U/L)	23.00±12.43	27.45±21.77	0.596
CKMB(ng/ml)	2.07±2.10	1.53±1.53	0.380
K^+(mmol/L)	4.11±0.40	4.12±0.59	0.987
Na^+(mmol/L)	138.57±6.73	136.54±14.02	0.706
Cl^-(mmol/L)	103.00±6.90	102.77±5.74	0.918
D-D(ng/ml)	775.43±1256.68	567.89±735.44	0.497
PO_2(mmHg)	55.43±3.21	97.00±28.94	＜0.001
PCO_2(mmHg)	38.86±10.92	38.77±7.33	0.975

2.3 The number and proportion of cases for each indicator in the severe and non-severe groups

The WBC and neutrophil counts were significantly higher in severe patients compared to non-severe patients (57% vs. 23%; 57% vs. 38%). The changes in lymphocyte counts mainly manifested as normal or decreased levels, with no significant difference in the proportion of decreases between severe and non-severe patients (29% vs. 31%). Although the average lymphocyte count was lower in severe patients, this difference was not statistically significant ($P > 0.05$). Both CRP and SAA levels

were elevated in both groups, with a significantly higher proportion in the severe group compared to the non-severe group (86% vs. 80%; 57% vs. 38%).

The proportion of cases with decreased Scr was higher in severe patients than in non-severe patients (43% vs. 11%). GGT levels were elevated in similar proportions in both groups (29% vs. 31%). The proportions of patients with elevated ALT and AST were similar in both groups (14% vs. 15%). CKMB elevation was more pronounced in the severe group compared to the non-severe group (14% vs. 3%). A significant proportion of patients in both groups showed decreases in Na+ and Cl- levels (43% vs. 33%; 14% vs. 11%), while changes in K+ levels were not significant. D-dimer levels were elevated in varying proportions in both groups (43% vs. 62%). as shown in Table 2 and Table 3.

Table 2 Number and Proportion of Indicators in Severe Patients

Indicators	Number of Elevated Cases (%)	Number of Normal Cases (%)	Number of Decreased Cases (%)
WBC(x10^9/L)	4(57%)	2(29%)	1(14%)
N(x10^9/L)	4(57%)	2(29%)	1(14%)
L(x10^9/L)	1(14%)	4(57%)	2(29%)
CRP(mg/L)	6(86%)	1(14%)	0
SAA(mg/L)	6(86%)	1(14%)	0
SCr(umol/L)	0	4(57%)	3(43%)
GGT(U/L)	2(29%)	5(71%)	0
ALT(U/L)	1(14%)	6(86%)	0
AST(U/L)	1(14%)	5(71%)	1(14%)
CKMB(ng/ml)	1(14%)	5(71%)	1(14%)
K^+(mmol/L)	0	5(71%)	0
Na^+(mmol/L)	1(14%)	3(43%)	3(43%)
Cl^-(mmol/L)	1(14%)	5(71%)	1(14%)
D-D(ng/ml)	3(43%)	4(57%)	0
PO_2(mmHg)	0	7(100%)	0
PCO_2(mmHg)	1(14%)	4(57%)	2(29%)

Table 3 Number and Proportion of Indicators in Non-Severe Patients

Indicators	Number of Elevated Cases (%)	Number of Normal Cases (%)	Number of Decreased Cases (%)
WBC(x10^9/L)	23(24%)	63(67%)	8(9%)
N(x10^9/L)	36(38%)	54(58%)	4(4%)
L(x10^9/L)	0	65(69%)	29(31%)
CRP(mg/L)	75(80%)	19(20%)	0
SAA(mg/L)	74(79%)	20(21%)	0
SCr(umol/L)	10(11%)	74(78%)	10(11%)
GGT(U/L)	29(31%)	65(69%)	0
ALT(U/L)	13(14%)	84(86%)	0
AST(U/L)	14(15%)	77(82%)	3(3%)
CKMB(ng/ml)	3(3%)	71(76%)	20(21%)
K^+(mmol/L)	2(2%)	84(89%)	10(11%)
Na^+(mmol/L)	3(3%)	60(64%)	31(33%)
Cl^-(mmol/L)	7(7%)	77(82%)	11(11%)
D-D(ng/ml)	58(62%)	36(38%)	0
PO_2(mmHg)	23(25%)	35(37%)	36(38%)
PCO_2(mmHg)	8(8%)	62(66%)	24(26%)

2.4 Correlation Analysis of Various Hematological Indicators

Correlation analysis of the included hematological indicators shows that WBC is significantly positively correlated with N, CRP, and SAA, and also significantly positively correlated with Scr and D-dimer. Higher levels of WBC, N, CRP, and SAA are associated with more severe inflammation, greater risk of kidney damage, and increased risk of thrombosis. CRP is significantly positively correlated with SAA and also significantly positively correlated with Scr. More severe inflammation is associated with greater kidney damage. SAA is significantly positively correlated with Scr and significantly negatively correlated with Cl-. Higher levels of SAA are associated with more severe inflammation and a greater decrease in Cl-. Scr is significantly positively correlated with K+, meaning higher creatinine levels are associated with increased blood potassium. GGT is significantly positively correlated with ALT and AST, and ALT is significantly positively correlated with AST, as shown in Table 4.

Table 4 Correlation Analysis of Various Hematological Indicators

	WBC	N	L	CRP	SAA	Scr	GGT	ALT	AST	CKMB	K^+	Na^+	Cl^-	DD	PO_2	PCO_2
WBC	1															
N	.392**	1														
L	0.122	0.000	1													
CRP	.339**	0.147	-0.158	1												
SAA	.322**	0.131	-0.143	.859**	1											
Scr	.217*	0.068	-0.091	.222*	.208*	1										
GGT	0.025	-0.030	0.000	0.107	0.072	0.131	1									
ALT	-0.061	-0.060	-0.063	-0.016	-0.061	-0.016	.688**	1								
AST	-0.031	-0.060	-0.044	-0.064	-0.028	0.014	.490**	.854**	1							
CKMB	0.145	0.043	-0.052	0.016	0.096	0.137	0.002	0.087	0.170	1						
K^+	0.138	0.166	0.002	0.118	0.114	.440**	0.186	0.095	0.038	-0.028	1					
Na^+	0.046	0.028	-0.084	-0.015	-0.064	0.034	-0.009	-0.134	-.315**	-0.071	-0.037	1				
Cl^-	0.008	0.043	0.016	-0.141	-.210*	0.066	0.099	0.102	0.067	-0.168	-0.187	.234*	1			
DD	.247*	0.103	-0.056	0.111	0.119	0.190	-0.073	0.011	0.025	0.103	0.173	0.042	0.065	1		
PO_2	-0.107	-0.094	0.193	0.009	-0.003	0.117	0.124	0.134	0.097	-0.126	.291**	-0.111	-.253*	-0.108	1	
PCO_2	-0.170	-0.162	0.015	-.248*	-.284**	-0.109	-0.007	0.040	0.035	0.019	-0.077	0.117	-0.114	-0.059	-0.116	1

* indicates a correlation at the 0.05 level; ** indicates a correlation at the 0.01 level.

3 Discussion

This study shows a positive correlation between creatinine and blood potassium. The reason for this is that in patients with renal failure, glomerular and tubular dysfunction leads to impaired potassium excretion, which often results in elevated potassium levels.

COVID-19 infection causes myocardial damage, leading to elevated levels of cardiac enzymes in patients with COVID-19. Severe patients experience more significant myocardial damage compared to non-severe patients, suggesting that COVID-19 infection can result in myocardial injury. This study found a higher proportion of elevated CKMB in the severe group compared to the non-severe group, which is consistent with a 2022 domestic meta-analysis on CKMB and LDH related to myocardial injury in different types of COVID-19 patients [1].

This study observed elevated levels of GGT, ALT, and AST in both severe and non-severe patients, with a higher proportion of elevated GGT. Research has confirmed that the novel coronavirus primarily enters cells via ACE2, leading to damage in the body. ACE2 is expressed with higher specificity in biliary epithelial cells than in liver cells, being 20 times more prevalent, suggesting that COVID-19 infection may lead to damage to the biliary epithelial cells. GGT is mainly present in liver

cells and biliary epithelial cells and primarily reflects biliary damage and cholestasis. ALT is predominantly found in liver cells, followed by the kidneys, heart, and muscles, while AST is mainly distributed in myocardial cells, followed by the liver and skeletal muscles. Therefore, the impact of COVID-19 on GGT is higher than on ALT and AST [2].

In this study, inflammatory indicators WBC, CRP, and SAA were positively correlated with D-dimer. The more severe the infection, the higher the D-dimer levels and the greater the blood hypercoagulability. SAA was negatively correlated with Na+ and Cl- , indicating that with more severe viral infection, Na+ and Cl- levels are more likely to decrease. The reason for this is that the COVID-19 virus infects the host by binding to the angiotensin-converting enzyme 2 (ACE2) receptor. Since ACE2 receptors are widely present in the kidneys and gastrointestinal tract, viral-induced damage to these organs can lead to acute kidney injury and gastrointestinal disorders. Common complications of kidney and gastrointestinal involvement in COVID-19 include fluid and electrolyte imbalances, often manifesting as hyponatremia, hypernatremia, hypokalemia, hypocalcemia, hypochloremia, hypervolemia, and hypovolemia [3]. If not treated promptly, these imbalances can lead to severe consequences and even be life-threatening. Fluid and electrolyte disturbances are more common in severe patients.

In summary, this study analyzes the relationships among various indicators based on the general hematological characteristics of COVID-19 patients. Indicators that may appear independent are actually closely related. Infection can cause multi-system damage in the body, with elevated inflammatory markers accompanying abnormalities in liver and kidney function, blood hypercoagulability, and fluid-electrolyte imbalances. It is crucial to monitor these indicators and intervene promptly in COVID-19 patients. By understanding these hematological features, it is possible to estimate the likelihood of COVID-19 infection even before a diagnosis is confirmed and to assess disease progression in confirmed COVID-19 patients. This provides valuable insights for clinical diagnosis and treatment strategies.

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About the Author

Chao Fang, Master, Attending physician,Geriatrics and General Practice.