

Original Article

Evaluation of the Diagnostic Importance of Laboratory Markers in Older Patients with COVID 19: A New Index for Investigating Severity of Diseases

Arezoo Afkhami¹, Paniz Balmeh², Mahya Yargholi³, Mahforouzalsadat Marashi⁴, Zohreh Salehnassaj⁵, Narges Ansari^{1*} 

¹Department of Internal Medicine, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

²Department of Pediatrics, Mazandaran University of Medical Sciences, Mazandaran, Iran

³Department of Radiology, Baqiyatallah University of Medical Sciences, Tehran, Iran

⁴Department of Infectious Disease and Tropical Medicine, School of Medicine, Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran

⁵Center for Health Related Social and Behavioral Sciences Research, Shahroud University of Medical Sciences, Shahroud, Iran

Article history:

Received: June 10, 2025

Accepted: November 29, 2025

ePublished: August 29, 2026

***Corresponding author:**

Narges Ansari,

Email: Ansari_narges58@yahoo.com



Abstract

Introduction: Coronavirus disease 2019 (COVID-19) can cause significant changes in serum biomarkers. C-reactive protein (CRP) and albumin (Alb) are proteins that can serve as potential markers of systemic inflammation. This study aimed to investigate CRP levels and the CRP/Alb ratio among hospitalized patients with COVID-19.

Methods: This cross-sectional analytical study was conducted among 114 patients with COVID-19 who were admitted to Al-Zahra Hospital in Isfahan, Iran, between 2021 and 2022. After checking the inclusion and exclusion criteria, demographic variables such as age, sex, and education level were collected, along with clinical data, including the number of days since symptom onset, length of hospitalization, initial oxygen saturation, severity of lung involvement, CRP, albumin, and the CRP/Alb ratio. Data were analyzed using SPSS version 20.

Results: The mean age of participants in this study was 60.36±16.37 years, with 63% being men. The mean first-day CRP level was 55.59±33.81. The mean CRP/Alb ratio in all patients was 17.31±11.60. In the group with severe lung involvement, the mean CRP/Alb ratio and Alb level were 22.99±11.27 and 3.14±0.46, respectively. Patients with severe lung involvement exhibited significant clinical and statistical differences in CRP/Alb ratio and albumin and CRP levels compared with those with mild or moderate lung involvement ($P<0.05$). Receiver operating characteristic curve analysis showed that baseline CRP/Alb ratio had a moderate predictive performance for 28-day mortality (AUC: 0.72, 95% CI: 0.587-0.853).

Conclusion: The results showed that the CRP/Alb ratio can be a useful prognostic marker in patients with COVID-19. Further studies are needed to evaluate the prognostic value of this index in patients with COVID-19 and other diseases.

Keywords: C-reactive protein, Albumin, COVID-19

Please cite this article as follows: Afkhami A, Balmeh P, Yargholi M, Marashi M, Salehnassaj Z, Ansari N. Evaluation of the diagnostic importance of laboratory markers in older patients with Covid 19: a new index for investigating severity of diseases. Avicenna J Aging Healthc 2025;3(1):7-13. doi:10.34172/ajah.4040

Introduction

The outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) began in 2019 and was named Coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO) in early 2020. Although the disease was initially believed to have originated from animal-to-human transmission in a seafood and wild-animal market, it soon became clear that COVID-19 can be transmitted from person to person. The main cause of death is usually due to complications involving multiple

organs, including pneumonia (1-4).

COVID-19 is a highly contagious viral infection that can easily be transmitted from person to person. The virus likely enters human respiratory epithelial cells through interaction between its surface proteins and angiotensin-converting enzyme 2 (ACE-2) receptors on human cells. The number of COVID-19 cases has spread rapidly worldwide and has been recognized as a global pandemic (1, 2, 5-7).

Patients with COVID-19 present with a range of



different initial symptoms, the most common of which are fever, myalgia, fatigue, and dry cough. In fact, patients with COVID-19 are more likely to develop respiratory symptoms, such as dry cough and shortness of breath. This disease can affect the lungs with manifestations ranging from mild to severe, similar to those of other respiratory viral diseases (7-12). Most patients recover without serious complications; however, patients with underlying conditions, such as diabetes, hypertension, heart disease, and obesity, may experience more severe disease. Several days after the onset of the disease, some patients may develop severe shortness of breath and hypoxia, which can rapidly progress to acute respiratory distress syndrome (ARDS) or organ failure due to the severity of the disease. Currently, various vaccines are being tested and administered in different parts of the world, and prevention and widespread vaccination seem to be the best approaches (1, 8-12).

Clinical data have shown that certain laboratory indicators can be used to assess disease severity. C-reactive protein (CRP) is an acute-phase protein and one of the most important indicators used in medical science. It is widely used in various diseases, especially acute inflammatory diseases, mainly due to its relatively low cost. Given the prevalence of COVID-19, identifying more accurate indicators is increasingly necessary (8-12). In addition, albumin is one of the most important indicators of the patient's nutritional status. Low albumin levels can adversely affect the body's immune system. The ratio of CRP to Alb (CRP/Alb) has also been investigated in several diseases and has been used as an effective indicator in clinical medicine.

CRP is an inflammatory marker and, along with albumin, can serve as an inexpensive and available marker for monitoring patients. Some studies have shown that these indices can be useful for monitoring the status of patients with inflammatory and infectious diseases (1, 2). It has also been used as an indicator for determining the prognosis of some cancers. Recently, some studies have recommended using this indicator for COVID-19, but few studies have been conducted in this area. Therefore, this study can help to better understand this novel indicator in patients with COVID-19 (13-19, 20-27).

The use of laboratory indices, due to their availability and low cost, can be useful for monitoring patients and following up on their clinical status. Given the above and the need to identify better indicators for this disease, this study aimed to investigate the levels of CRP and albumin and the CRP/Alb ratio in hospitalized patients with COVID-19 at Alzahra Hospital, Isfahan, Iran, during 2021-2022.

Materials and Methods

This cross-sectional study was conducted on 114 patients with COVID-19 who referred to Al-Zahra Hospital in Isfahan in 2021-2022. COVID-19 diagnosis was confirmed through reverse transcription-polymerase chain reaction (RT-PCR) tests and imaging findings. We examined the

medical records, laboratory results, nursing reports, and lung high-resolution computed tomography (CT) scans of all patients who had confirmed COVID-19 infection. The patients were admitted to the hospital between January 2021 and February 2022. Data collection forms were used to collect epidemiological, clinical, laboratory, radiological, and treatment data from medical records. To ensure accuracy, two researchers independently reviewed the data collection forms.

Exclusion criteria included rheumatologic diseases, cancer in the past six months, lack of necessary data, infectious diseases in the two weeks prior to hospitalization, and treatment with drugs effective on CRP (celecoxib, fenofibrate, niacin, vitamin E, Non-steroidal anti-inflammatory drugs (NSAIDs), anti-rheumatic drugs, and so on) in the two weeks before hospitalization.

Method

Collected variables included demographic characteristics (age, sex, and education level) and clinical data (the number of days since symptom onset, length of hospital stay, medical history, initial oxygen saturation, severity of lung involvement on CT scan, and smoking status. Laboratory data included blood CRP levels, blood albumin levels, CRP/Alb ratio, and CRP levels on days 1, 3, and 5. The severity of lung involvement was determined as mild, moderate, or severe by an experienced internal medicine specialist. Patients were subsequently divided into mild, moderate, and severe groups based on the degree of pulmonary involvement. Pulmonary involvement was assessed based on CT scan.

Statistical Analyses

Data were analyzed using parametric or nonparametric statistical tests in SPSS software (version 20.0). Quantitative data were expressed as mean $\pm$ standard deviation (SD) for normally distributed data, while qualitative data were reported as frequencies, medians, interquartile ranges, and percentages. In all analyses, a P -value < 0.05 was considered statistically significant.

Ethical Considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki. Patient demographic information was kept confidential, and the study protocol was approved by the Ethics Committee of Isfahan University of Medical Sciences (Ethics code: IR.MUI.MED.REC.1401.111).

Results

The mean age of participants in this study was 60.36 ± 16.37 years, with 75 men and 44 women (Tables 1 and 2, Figure 1). Upon admission, the initial oxygen saturation among patients without oxygen was $86.28 \pm 3.49\%$, and the mean length of hospital stay was 10.72 ± 9.41 days.

The mean CRP level on day 1 was 55.59 ± 33.81 mg/L, which subsequently decreased on day 3 (35.87 ± 33.10 mg/L) and day 5 (30.85 ± 32.95 mg/L) of hospitalization.

The mean CRP level at admission was significantly higher in patients with severe lung involvement (68.07 ± 29.07 mg/L) compared to those with moderate (54.75 ± 36.56 mg/L) and mild lung involvement (35.36 ± 26.05 mg/L). This difference between the severe and mild lung-involvement groups was statistically significant ($P < 0.05$),

Table 1. Demographics and Baseline Characteristics of Patients Infected with COVID-19

Variables	Number	Minimum	Maximum	Mean $\pm$ SD
Age (years)	114	30.00	103.00	60.36 ± 16.37
Oxygen Saturation (%)	112	72.00	94.00	86.28 ± 3.49
Days From Symptom Onset	101	5.00	50.00	17.19 ± 9.74
Hospitalization Duration (Days)	101	1.00	70.00	10.72 ± 9.41
Creatinine	116	0.30	3.70	1.20 ± 0.55
GFR (mL/min)	108	30	128	69.7 ± 40.9
Albumin(g/dl)	110	2.00	4.20	3.37 ± 0.45
White Blood Cells	108	2300.00	17800.00	7491.66 ± 3313.04
Neutrophils (%)	94	5.00	95.00	76.12 ± 14.70
Lymphocytes (%)	105	1.00	85.00	16.72 ± 14.23
ESR	113	2.00	102.00	48.17 ± 25.92
CRP Day 1	117	1.00	111.00	55.59 ± 33.81
CRP Day 3	88	1	124	35.87 ± 33.10
CRP Day 5	57	1	122	30.85 ± 32.95
CRP/Alb Ratio	110	0.24	55.50	17.31 ± 11.60

Note. SD: Standard deviation; CRP: C-reactive protein; GFR: Glomerular filtration rate; Alb: Albumin; ESR: Erythrocyte sedimentation rate.

as illustrated in Table 3. The mean albumin was 3.37 ± 0.45 among all patients.

The proportion of smokers was higher among patients with severe lung involvement (32%) compared to those with moderate involvement (28%) or mild involvement (10%). The mean CRP/Alb ratio among all patients was 17.31 ± 11.60 . In patients with severe lung involvement, the mean CRP/Alb ratio was 22.99 ± 11.27 , compared with 11.87 ± 16.24 and 10.11 ± 7.79 in patients with moderate and mild lung involvement, respectively. Patients with severe lung involvement had significantly higher CRP/Alb ratios than the other two groups, both clinically and statistically ($P < 0.05$), as depicted in Table 3. Receiver operating characteristic curve analysis showed that the baseline CRP/Alb ratio was a moderate predictor of 28-day mortality (AUC: 0.72, 95% CI: 0.587-0.853).

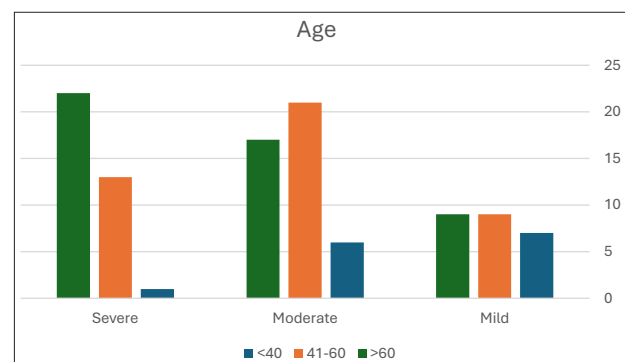


Figure 1. Age Distribution of Patients With COVID-19 Based on Severity of Lung Disease. Note. COVID-19: Coronavirus disease 2019

Table 2. Demographics and Baseline Characteristics of Patients Infected With COVID-19 According to Severity

Variables		Severity, N = 114 (%)			
		Mild	Moderate	Severe	Total
Sex	Male	16 (14.03)	26 (22.80)	23 (20.20)	65
	Female	13 (11.40)	20 (17.54)	16 (14.03)	49
Age (Years)	-	54.12 ± 16.64	57.75 ± 15.82	66 ± 13.75	-
Education	Elementary	6 (5.26)	6 (5.26)	6 (5.26)	18
	Middle School	4 (3.50)	10 (8.77)	12 (10.52)	26
	High school	10 (8.77)	9 (7.89)	7 (6.14)	26
	University	15 (13.20)	19 (16.66)	10 (8.77)	44
Ischemic Heart Disease	Yes	4 (21.05)	8 (42.10)	7 (36.84)	19
Diabetes Mellitus	Yes	1 (4.7)	12 (57.14)	8 (38.09)	21
Hypertension	Yes	6 (20.00)	14 (46.66)	10 (33.33)	30
Dyslipidemia	Yes	2 (11.76)	10 (58.82)	5 (29.41)	17
Remdesivir	Yes	21 (25.92)	34 (41.97)	26 (32.09)	81
Dexamethasone	Yes	26 (26.53)	44 (44.89)	38 (38.77)	98
PTE	Yes	0	2 (40.00)	3 (60.00)	5
DVT	Yes	0	0	0	0
Death	Yes	0	0	9 (100)	9
ESR	-	45.96 ± 28.8	48.78 ± 25.35	52.55 ± 22.9	48.82 ± 25.7
Albumin*(g/dL)	-	3.57 ± 0.41	3.41 ± 0.42	3.14 ± 0.46	3.36 ± 0.46
GFR (mL/min)	-	79.50 ± 17.62	79.04 ± 57.59	53.93 ± 22.367	69.64 ± 41.44

Note. COVID-19: Coronavirus disease 2019; SD: Standard deviation; PTE: Pulmonary thromboembolism; DVT: Deep vein thrombosis; ESR: Erythrocyte sedimentation rate; GFR: Glomerular filtration rate.

Table 3. Demographics and Baseline Characteristics of Patients Infected With COVID-19 According to CRP and CRP/Alb Levels

Variables	CRP/Alb					CRP				
	N	Mean	SD	Minimum	Maximum	N	Mean	SD	Minimum	Maximum
Age (years)										
<40	12	15.94	8.67	2.75	26.86	15	55.20	29.74	11.00	94.00
41-60	42	16.05	11.00	0.25	38.85	44	52.88	33.42	1.00	107.00
>60	50	18.70	13.02	0.24	55.50	52	57.37	36.12	1.00	111.00
Total	104	17.31	11.78	0.24	55.50	111	55.30	34.04	1.00	111.00
Sex										
Male	70	17.59	12.05	0.24	55.50	72	55.48	34.02	1.00	122.00
Female	40	16.82	10.88	0.24	55.50	45	55.76	33.86	1.00	111.00
Education Level										
Elementary	14	19.3662	13.69	0.30	41.82	16	56.37	34.49	1.00	94.00
Mid School	27	19.37	13.41	0.27	55.50	28	58.76	36.43	1.00	111.00
High school	21	17.70	10.73	0.24	31.71	22	58.09	36.34	1.00	111.00
University	38	15.60	10.68	0.25	38.85	41	52.75	32.26	1.00	101.00
Total	100	17.59	11.86	0.24	55.50	107	55.96	34.17	1.00	111.00
Oxygen Saturation (%)										
<80	7	18.42	18.19	0.28	41.82	7	45.47	40.89	1.00	92.00
80-85	29	18.09	10.77	0.25	33.57	30	54.72	34.14	1.00	111.00
>85	67	16.56	11.66	0.24	55.50	72	54.27	33.81	1.00	111.00
Disease Severity										
Mild	23	10.11 [£]	7.79	0.25	28.00	25	35.36 ^ª	26.05	1.00	91.00
Moderate	41	16.24 [¥]	11.87	0.24	41.82	43	54.75	36.56	1.00	107.00
Severe	36	22.99 ^{¥, £}	11.27	0.32	55.50	38	68.07 ^ª	29.07	1.00	111.00
Total	105	17.12	11.80	0.24	55.50	111	54.86	34.20	1.00	111.00
Days from Symptom Onset										
<10	29	15.20	10.04	0.24	32.50	30	54.76	34.23	1.00	111.00
10-15	23	16.39	11.64	0.27	33.57	25	55.36	36.54	1.00	108.00
>15	41	18.87	12.85	0.32	55.50	44	54.93	33.12	1.00	111.00
Hospitalization Duration (Days)										
<10	56	14.99	10.71	.24	33.57	60	52.42	35.01	1.00	111.00
10-15	21	19.47	10.87	.32	36.25	21	59.57	32.15	1.00	107.00
>15	16	21.43	14.89	1.58	55.50	18	58.22	33.62	6.00	111.00
PTE										
Yes	6	23.48	11.05	2.25	34.67	6	81.33	36.46	9.00	108.00
GFR										
<30	12	21.14	16.27	0.27	41.82	12	58.00	44.18	1.00	111.00
30-44	7	14.62	11.74	0.24	27.00	7	47.75	37.13	1.00	85.00
45-59	14	21.15	14.82	0.32	55.50	17	64.00	35.05	1.00	111.00
60-90	52	15.62	10.08	0.28	38.85	55	52.30	31.48	1.00	104.00
90-00	16	15.74	10.04	0.25	28.00	16	52.12	34.10	1.00	94.00
Remdesivir										
Yes	79	17.24	11.18	0.24	55.5	84	56.32	33.29	1	111

Note. CRP: C-reactive protein; Alb: Albumin; CRP/Alb: C-reactive protein-to-albumin ratio; SD: Standard deviation; PTE: Pulmonary thromboembolism; GFR: Glomerular filtration rate; £: Significant difference ($P<0.05$); ¥: Significant difference ($P<0.05$); ª: Significant difference ($P<0.05$).

Discussion

Coronavirus disease spread rapidly worldwide in 2020. The clinical manifestations of the disease include difficulty breathing, fever, cough, and fatigue, which in some cases can lead to serious complications. To identify predictors

of severe complications in patients with COVID-19, many studies have investigated various inflammatory markers and the immune system's response to viral infection (1-4, 22-25).

One marker of interest in this area is the CRP/Alb ratio.

CRP is an inflammatory protein produced by the liver that increases rapidly during systemic inflammation in the body, whereas albumin is a serum protein produced by the liver that reflects the body's nutritional status. Overall, the findings of the present study showed that patients with more severe lung involvement exhibited significantly higher CRP/Alb ratios than those with milder involvement, suggesting that the CRP/Alb ratio may serve as a reliable indicator of inflammatory severity in COVID-19.

High CRP levels at the time of hospital admission, along with advanced age, have been reported as key factors associated with the progression of COVID-19. Additionally, a direct correlation has been observed between CRP levels at admission and the extent of lung damage, highlighting its utility as an indicator of disease severity. CRP is a protein produced by the liver that has been shown in numerous studies to act as an early indicator of infection and inflammation. Its serum concentration increases rapidly within about 6 hours of the onset of illness. When the inflammatory process comes to an end, and the patient begins to recover, CRP levels decrease. Therefore, monitoring CRP concentration is a suitable indicator for assessing disease severity (22-25).

The relationship between blood oxygen saturation and CRP levels in COVID-19 patients has also been investigated in some studies. Generally, studies exploring this relationship indicate that an increase in CRP levels is associated with a decrease in blood oxygen levels, and vice versa. However, more accurate clinical studies are needed to diagnose patients at risk of serious complications. Consistent with literature findings, patients with lower blood oxygen levels have higher CRP levels (21-24).

Studies have also shown that patients with elevated CRP levels face a higher risk of COVID-19-related mortality. Additionally, an increase in CRP levels over time indicates disease progression and the development of severe complications, such as pulmonary injury and heart attacks. The results of the present study support these observations. However, it should be noted that the CRP level represents only one of several indicators used to monitor the clinical status of COVID-19 patients and must be examined in conjunction with other clinical findings (20-24).

Patients with COVID-19 frequently experience a decrease in albumin levels. Albumin is an essential protein in the body that plays a key role in maintaining blood pressure, transporting hormones and drugs, and maintaining the acid-base balance. According to various studies, approximately 65% of hospitalized COVID-19 patients experience a decrease in albumin levels. Patients with low albumin levels are at a significantly higher risk of mortality. One study showed that patients with albumin levels less than 3.5 g/dL have higher mortality rates. Therefore, physicians need to pay sufficient attention to the albumin levels of COVID-19 patients during their course of treatment (22-24).

Under inflammatory conditions, pro-inflammatory

cytokines can reduce serum albumin levels by decreasing its synthesis through interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF- α) or by increasing its breakdown. Low serum albumin levels have been associated with long-term postoperative complications in colorectal cancer patients and increased short- and long-term mortality in hospitalized patients. In COVID-19 patients, low serum albumin levels serve as a strong predictor of poor prognosis (27-32).

Based on available literature and the findings of the present study, integrating CRP and albumin levels into a single index may enhance the clinical management of hospitalized COVID-19 patients within the first 24 hours of admission. This index is considered a valuable indicator in this field and has been used in some studies of other diseases, showing promising results in predicting disease severity, mortality, and prognosis. One of the primary advantages of this method is its simplicity of calculation. Additionally, measuring both albumin and CRP levels is inexpensive and available in many laboratory settings. The concept of combining albumin and CRP was proposed in 2009, and subsequent studies demonstrated its prognostic and predictive value for mortality in patients admitted to the intensive care unit (ICU) and those with liver cancer (29-33).

In fact, studies suggest that an elevated CRP/Alb ratio is significantly associated with a higher risk of mortality in COVID-19 patients. In other words, an increase in the CRP/Alb ratio indicates a state of severe inflammation, which increases the risk of mortality in COVID-19 patients. Therefore, assessing the CRP/Alb ratio at admission may serve as a useful tool for predicting mortality risk in hospitalized COVID-19 patients (22-30).

Consistent with prior literature, an increase in CRP/Alb ratio in COVID-19 patients is associated with a higher risk of serious complications, such as cardiovascular, respiratory, and renal diseases. For example, a study evaluating 144 patients with COVID-19 showed that the CRP/Alb ratio was higher in patients with serious cardiovascular and respiratory complications. Similarly, another study of 200 COVID-19 patients confirmed that the CRP/Alb ratio was higher in patients at a high risk of mortality. Based on these studies, the CRP/Alb ratio can serve as a valuable predictor for the risk of serious complications in COVID-19 patients. This indicator can help physicians identify patients at risk of serious complications, thereby facilitating timely and appropriate treatment. However, further accurate studies are needed to establish a more precise and stable diagnosis of the risk of serious complications in COVID-19 patients (24-33).

In another study, the results demonstrated that elevated levels of CRP, lymphocytes, neutrophil aspartate aminotransferase, ferritin, and prothrombin time were significantly higher in patients with a longer period of hospitalization compared to other patients (20).

Limitations and Suggestions

Every study has inherent limitations. First, this study was

conducted in a single center, which may potentially limit the generalizability of the findings to other populations with varying demographics. Second, there were incomplete patient records. It is suggested that future studies evaluate newer indices and assess their combination with available indices, such as the erythrocyte sedimentation rate, CRP, and white blood cell count, based on available laboratory tests. Additionally, these indices can be investigated in a wider range of inflammatory diseases in future studies. Finally, the treatments administered to patients may affect their indices and clinical outcomes; therefore, these potential confounding effects should be considered in the data analysis.

Conclusion

The results of this study suggest that the CRP/Alb ratio may serve as a valuable indicator in patients with COVID-19 and can play an important role in monitoring disease status and the recovery process of patients. However, it should be noted that CRP levels and the CRP/Alb ratio are only part of the indicators used to assess the condition of COVID-19 patients and should therefore be investigated along with other clinical findings.

Acknowledgements

The authors would like to acknowledge the staff of Al-Zahra Hospital (Isfahan, Iran) for their support and cooperation.

Authors' Contribution

Conceptualization: Narjes Ansari

Data Curation: Arezoo Afkhami

Formal Analysis: Narjes Ansari

Funding Acquisition: Narjes Ansari

Investigation: Arezoo Afkhami

Methodology: Narjes Ansari

Project Administration: Narjes Ansari

Resources: Narjes Ansari

Software: Narjes Ansari

Supervision: Narjes Ansari

Validation: Narjes Ansari

Visualization: Narjes Ansari

Writing—Original Draft: Arezoo Afkhami, Paniz Balme, Mahya Yargholi Mahforouzsadat Marashi

Writing—Review & Editing: Narjes Ansari

Competing Interests

The authors declare no competing interests.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethical Approval

This study was approved by the Ethics Committee of Isfahan University of Medical Sciences (Ethical Approval Code: IR.MUI.MED.REC.1401.111).

Funding

None.

References

- Yuan Y, Jiao B, Qu L, Yang D, Liu R. The development of COVID-19 treatment. *Front Immunol* 2023;14:1125246. doi:10.3389/fimmu.2023.1125246
- Otter JA, Donskey C, Yezli S, Douthwaite S, Goldenberg SD, Weber DJ. Transmission of SARS and MERS coronaviruses and influenza virus in healthcare settings: the possible role of dry surface contamination. *J Hosp Infect* 2016;92(3):235-50. doi:10.1016/j.jhin.2015.08.027
- Zhou P, Yang XL, Wang XG, Hu B, Zhang L, Zhang W, et al. A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature* 2020;579(7798):270-3. doi:10.1038/s41586-020-2012-7
- World Health Organization (WHO). WHO Director-General's Remarks at the Media Briefing on 2019-nCoV on 11 February 2020. Geneva: WHO; 2020. Available from: <https://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020>. Accessed February 12, 2020.
- CDC COVID-19 Response Team. Geographic differences in COVID-19 cases, deaths, and incidence - United States, February 12-April 7, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69(15):465-71. doi:10.15585/mmwr.mm6915e4
- Panda S, Nanda R, Tripathy PK, Mangaraj M. Immuno-inflammatory predictors of disease severity in COVID-19: a systematic review and meta-analysis. *J Family Med Prim Care* 2021;10(3):1102-16. doi:10.4103/jfmpc.jfmpc_2196_20
- Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 2020;395(10229):1054-62. doi:10.1016/s0140-6736(20)30566-3
- Wang L. C-reactive protein levels in the early stage of COVID-19. *Med Mal Infect* 2020;50(4):332-4. doi:10.1016/j.medmal.2020.03.007
- Sadeghi-Haddad-Zavareh M, Bayani M, Shokri M, Ebrahimpour S, Babazadeh A, Mehraeen R, et al. C-reactive protein as a prognostic indicator in COVID-19 patients. *Interdiscip Perspect Infect Dis* 2021;2021:5557582. doi:10.1155/2021/5557582
- Wang G, Wu C, Zhang Q, Wu F, Yu B, Lv J, et al. C-reactive protein level may predict the risk of COVID-19 aggravation. *Open Forum Infect Dis* 2020;7(5):ofaa153. doi:10.1093/ofid/ofaa153
- Li K, Wu J, Wu F, Guo D, Chen L, Fang Z, et al. The clinical and chest CT features associated with severe and critical COVID-19 pneumonia. *Invest Radiol* 2020;55(6):327-31. doi:10.1097/rli.0000000000000672
- Chen W, Zheng KI, Liu S, Yan Z, Xu C, Qiao Z. Plasma CRP level is positively associated with the severity of COVID-19. *Ann Clin Microbiol Antimicrob* 2020;19(1):18. doi:10.1186/s12941-020-00362-2
- Duzenli T, Ketenci M, Akyol T, Koseoglu H, Tanoglu A, Kaplan M, et al. Predictive factors of complications and 30-day mortality in patients undergoing percutaneous endoscopic gastrostomy: the utility of C-reactive protein to albumin ratio. *Acta Gastroenterol Belg* 2021;84(2):283-8. doi:10.51821/84.2.283
- Erdöl MA, Gayretli Yayla K. Relationship between c-reactive protein to albumin ratio and coronary artery calcium score and CAD-RADS scores with coronary computed tomography angiography. *Turk J Med Sci* 2021;51(5):2674-82. doi:10.3906/sag-2103-104
- Xu H, Hu L, Wei X, Niu J, Gao Y, He J, et al. The predictive value of preoperative high-sensitive C-reactive protein/albumin ratio in systemic inflammatory response syndrome after percutaneous nephrolithotomy. *J Endourol* 2019;33(1):1-8. doi:10.1089/end.2018.0632
- Hwang JC, Jiang MY, Lu YH, Wang CT. Precedent fluctuation of serum hs-CRP to albumin ratios and mortality risk of clinically stable hemodialysis patients. *PLoS One* 2015;10(3):e0120266. doi:10.1371/journal.pone.0120266
- Socha MW, Malinowski B, Puk O, Wartęga M, Bernard P,

- Nowaczyk M, et al. C-reactive protein as a diagnostic and prognostic factor of endometrial cancer. *Crit Rev Oncol Hematol* 2021;164:103419. doi:[10.1016/j.critrevonc.2021.103419](https://doi.org/10.1016/j.critrevonc.2021.103419)
18. Liu X, Guo X, Zhang Z. Preoperative serum hypersensitive-C-reactive-protein (hs-CRP) to albumin ratio predicts survival in patients with luminal B subtype breast cancer. *Onco Targets Ther* 2021;14:4137-48. doi:[10.2147/ott.S320111](https://doi.org/10.2147/ott.S320111)
 19. Feketea GM, Vlacha V. The diagnostic significance of usual biochemical parameters in coronavirus disease 19 (COVID-19): albumin to globulin ratio and CRP to albumin ratio. *Front Med (Lausanne)* 2020;7:566591. doi:[10.3389/fmed.2020.566591](https://doi.org/10.3389/fmed.2020.566591)
 20. Karakoyun I, Colak A, Turken M, Altin Z, Arslan FD, Iyilikci V, et al. Diagnostic utility of C-reactive protein to albumin ratio as an early warning sign in hospitalized severe COVID-19 patients. *Int Immunopharmacol* 2021;91:107285. doi:[10.1016/j.intimp.2020.107285](https://doi.org/10.1016/j.intimp.2020.107285)
 21. Uzum Y, Turkkan E. Predictivity of CRP, albumin, and CRP to albumin ratio on the development of intensive care requirement, mortality, and disease severity in COVID-19. *Cureus* 2023;15(1):e33600. doi:[10.7759/cureus.33600](https://doi.org/10.7759/cureus.33600)
 22. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020;395(10223):497-506. doi:[10.1016/s0140-6736\(20\)30183-5](https://doi.org/10.1016/s0140-6736(20)30183-5)
 23. Liu Y, Yang Y, Zhang C, Huang F, Wang F, Yuan J, et al. Clinical and biochemical indexes from 2019-nCoV infected patients linked to viral loads and lung injury. *Sci China Life Sci* 2020;63(3):364-74. doi:[10.1007/s11427-020-1643-8](https://doi.org/10.1007/s11427-020-1643-8)
 24. Lippi G, Plebani M, Henry BM. Thrombocytopenia is associated with severe coronavirus disease 2019 (COVID-19) infections: a meta-analysis. *Clin Chim Acta* 2020;506:145-8. doi:[10.1016/j.cca.2020.03.022](https://doi.org/10.1016/j.cca.2020.03.022)
 25. Zhang L, Yan X, Fan Q, Liu H, Liu X, Liu Z, et al. D-dimer levels on admission to predict in-hospital mortality in patients with COVID-19. *J Thromb Haemost* 2020;18(6):1324-9. doi:[10.1111/jth.14859](https://doi.org/10.1111/jth.14859)
 26. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med* 2020;382(18):1708-20. doi:[10.1056/NEJMoa2002032](https://doi.org/10.1056/NEJMoa2002032)
 27. Huang I, Lim MA, Pranata R. Diabetes mellitus is associated with increased mortality and severity of disease in COVID-19 pneumonia - a systematic review, meta-analysis, and meta-regression. *Diabetes Metab Syndr* 2020;14(4):395-403. doi:[10.1016/j.dsx.2020.04.018](https://doi.org/10.1016/j.dsx.2020.04.018)
 28. Henry BM, de Oliveira MH, Benoit S, Plebani M, Lippi G. Hematologic, biochemical and immune biomarker abnormalities associated with severe illness and mortality in coronavirus disease 2019 (COVID-19): a meta-analysis. *Clin Chim Lab Med* 2020;58(7):1021-8. doi:[10.1515/cclm-2020-0369](https://doi.org/10.1515/cclm-2020-0369)
 29. Lippi G, Plebani M. Procalcitonin in patients with severe coronavirus disease 2019 (COVID-19): a meta-analysis. *Clin Chim Acta* 2020;505:190-1. doi:[10.1016/j.cca.2020.03.004](https://doi.org/10.1016/j.cca.2020.03.004)
 30. Fairclough E, Cairns E, Hamilton J, Kelly C. Evaluation of a modified early warning system for acute medical admissions and comparison with C-reactive protein/albumin ratio as a predictor of patient outcome. *Clin Med (Lond)* 2009;9(1):30-3. doi:[10.7861/clinmedicine.9-1-30](https://doi.org/10.7861/clinmedicine.9-1-30)
 31. Ranzani OT, Zampieri FG, Forte DN, Azevedo LC, Park M. C-reactive protein/albumin ratio predicts 90-day mortality of septic patients. *PLoS One* 2013;8(3):e59321. doi:[10.1371/journal.pone.0059321](https://doi.org/10.1371/journal.pone.0059321)
 32. Edalatkhah A, Samadi Khorshidi F, Mohammadi H, Hassannejad R, Jafari F, Lame M, et al. Risk factors, clinical, and laboratory characteristics of patients with a diagnosis of COVID-19. *J Emerg Pract Trauma* 2022;8(2):115-21. doi:[10.34172/jept.2022.13](https://doi.org/10.34172/jept.2022.13)
 33. Kinoshita A, Onoda H, Imai N, Iwaku A, Oishi M, Tanaka K, et al. The C-reactive protein/albumin ratio, a novel inflammation-based prognostic score, predicts outcomes in patients with hepatocellular carcinoma. *Ann Surg Oncol* 2015;22(3):803-10. doi:[10.1245/s10434-014-4048-0](https://doi.org/10.1245/s10434-014-4048-0)