

# Retrospective Analysis of Outcomes of COVID Patients in a District-Level Hospital: CRP Surveillance and Guiding Management in Severe COVID Patients

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## Abstract

**Background:** Several biomarkers have been explored to predict the severity of various infectious diseases. We aimed to evaluate the outcome of COVID-19 patients and the ability of the C-reactive protein (CRP) to predict the severity of COVID-19 infections.

**Materials and Methods:** A retrospective study on the surveillance of CRP-1 (within 24 h) and CRP-2 (within 48 h) was conducted among 906 patients who were diagnosed with COVID-19 infection via reverse transcription–polymerase chain reaction. The data on demographic characteristics and clinical and laboratory findings were collected from electronic health records. The association between CRP-1 and CRP-2 values and patient characteristics, comorbidity, severity, and outcome was analyzed using Cramer's V test with  $P < 0.05$ , which was considered statistically significant. In addition, the sensitivity and specificity of both CRPs (1 and 2) were also analyzed using receiver operating characteristic (ROC) curves for predicting disease severity in COVID-19 infection.

**Results:** The results suggest that age, clinical severity, CT score severity, and final outcome had a significant association with CRP-1 and CRP-2 values. Increased CRP levels in COVID-19 patients are strongly associated with mortality. Furthermore, the ROC curves showed an area under the curve of 0.75 with an overall sensitivity and specificity of 96.15 and 83.33, respectively.

**Conclusion:** In the present study, CRP levels were found to increase dramatically among COVID-19 patients, and our findings suggest that CRP could be utilized clinically to predict COVID-19 prognosis and severity even before disease progression and the manifestation of clinical symptoms.

**Key words:** Covid 19, Bio marker, C-Reactive protein, Outcomes, Infectious Disease, Cramer's V test

## INTRODUCTION

In December 2019, novel coronavirus emerged in Wuhan City, Hubei Province, China. The coronavirus disease-19 (COVID-19) outbreak is an emerging global health threat across the world.<sup>[1]</sup> As of August 24, 2022, the WHO globally reported 595,219,966 confirmed cases

of COVID-19 and 6,453,458 deaths, in India there are 44,368,195 confirmed cases with 527,452 deaths.<sup>[2]</sup> Many COVID-19 patients exhibit mild symptoms, or sometimes do not exhibit symptoms at all. An emerging challenge is that a small subset of patients with mild or non-severe COVID-19 patients develops into a severe disease course. Therefore, it is important to early identify and give treatment to this subset of patients to reduce the disease severity and improve the outcomes of COVID-19.

The complex pathogenesis of severe acute respiratory syndrome-like cytokine storm, multiorgan disease, and disruption of numerous physiological pathways encompassing fibrinolysis and hemostasis leads to unpredictable clinical progression of the disease,

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which may evolve abruptly and result in critical and life-threatening clinical complications.<sup>[3]</sup> Effective clinical laboratory biomarkers aid in classifying patients according to risk and therefore ensure timely treatment to achieve the desired clinical outcomes. Various inflammatory, biochemical, and hematological biomarkers have been identified in COVID-19 patients, such as procalcitonin, lactate dehydrogenase, urea, liver enzymes, serum amyloid A, cytokines, D-dimer, fibrinogen, ferritin, troponin, creatinine kinase, leukocyte, and platelet counts and lymphocytes.<sup>[2]</sup> C-reactive protein (CRP) is an acute phase that binds to phosphocholine and activates the classical complement pathway of the immune system and regulates phagocytic activity to clear microbes and damaged cells. The normal concentration of CRP in the blood is <10 mg/L; however, it rises rapidly within 48 h from the disease onset and declines abruptly once the infection subsides.<sup>[4-6]</sup> An increase in CRP concentration is associated with acute kidney injury, with an incidence of venous thromboembolism and cardiovascular disease.<sup>[7,8]</sup> Hence, early recognition and timely intervention of COVID-19 are crucial factors for preventing adverse clinical outcomes. Many studies have suggested that CRP can be used as a prognostic biomarker in acute and chronic infections, including malaria, dengue, and hepatitis C.<sup>[9,10]</sup> The current study focused on the outcome of COVID-19 patients and determined the association between CRP levels and disease progression to provide a reference for the clinical management of COVID-19 patients.

## MATERIALS AND METHODS

A total of 2656 patients were diagnosed with COVID-19 infection via reverse transcription–polymerase chain reaction (RT-PCR) at Thangam Hospital, Namakkal, Tamil Nadu. This retrospective study was conducted among 906 patients who were admitted and met both the inclusion and exclusion criteria. The inclusion criteria included patients above the age of 18 years, confirmed cases of COVID-19 with positive RT-PCR results, and patients who were hospitalized in the study center including those with comorbidities. Exclusion criteria included those patients whose clinical and laboratory data were missing and pregnant women. Ethical clearance was obtained from the institutional ethical committee and prior permission was obtained to access the electronic medical records of COVID-19 patients between July 2020 and February 2022.

### CRP Assessment

A CRP level of 6 mg/L was taken as baseline. CRP levels <6 mg/L were considered normal and CRP levels above 6 mg/L were considered to be abnormal. Abnormal CRP

levels from the entry point were used to assess the severity and progression of the illness and to determine its outcome

### Clinical Severity Categorization

1. Mild: RT-PCR-positive COVID-19 patients with or without mild symptoms such as fever, cough, and sore throat, with mild changes in chest X-ray, and with abnormal respiratory function with SpO<sub>2</sub> >90%
2. Moderate: RT-PCR-positive COVID-19 patients with features of dyspnea or hypoxia, moderate changes in chest X-ray, and abnormal respiratory function with SpO<sub>2</sub> of 75–90%
3. Severe: RT-PCR-positive COVID-19 patients with clinical symptoms of pneumonia, abnormal changes in chest X-ray, and abnormal respiratory function with SpO<sub>2</sub> <75%.

### CT Severity Score

<8 score - Mild  
9–15 - Moderate  
>15 - Severe.

### Statistical Analysis

Python v3.8 was used to perform all the statistical analyses. Pandas, Numpy, Seaborn, Matplotlib, Sklearn, and SciPy packages were used: The correlation study between CRPs (CRP-1 and CRP-2) and the categorical variables was assessed using Cramer's V test with  $P < 0.05$ , which was considered statistically significant. The sensitivity and specificity of both CRP levels (1 and 2) were also analyzed using receiver operating characteristic curves to predict disease severity in COVID-19 patients.

## RESULTS

A total of 906 patients were included in this study. Among 906 patients, 68.1% were male and 31.9% were female. The mean age of patients included in the study was 54.45. Table 1 demonstrates the demographic data (age and sex) of the patients along with median CRP-1 and CRP-2 levels. The results showed a statistically significant association between CRP level and advanced age. As age increases, CRP levels also increase. Further it shows that males have higher CRP levels when compared to females with median CRP-1 (21.01) and CRP-2 (16.61). The results were considered statistically significant [Table 1].

The patients included in the study presented with comorbidities, such as 2.75% chronic kidney disease (CKD), 7.83% coronary heart disease (CAHD), 33.6% hypertension (HTN), 38.07% diabetes mellitus (DM), 3.53% lung disease, and 2.31% malignancy. 23% of patients had normal CRP 1,  $n = 213$ , and 76% of patients had

**Table 1: The demographic data (age and sex) of the patients along with the median CRP-1 and CRP-2 levels**

| S. No. | Patient characteristics | Categories  | Median CRP-1 | IQR    | P-value (Cramer's V) | Median CRP-2 | IQR    | P-value         |
|--------|-------------------------|-------------|--------------|--------|----------------------|--------------|--------|-----------------|
| 1      | Age                     | 18–60 years | 18           | 64.465 | <0.001 (0.1156)      | 17.28        | 44.505 | <0.001 (0.256)  |
|        |                         | >60 years   | 39.57        | 79.065 |                      | 28.87        | 68.335 |                 |
| 2      | Gender                  | Female      | 21.01        | 56.705 | <0.001 (0.1112)      | 16.61        | 40.95  | <0.001 (0.1112) |
|        |                         | Male        | 29.98        | 79.16  |                      | 23           | 59.63  |                 |

CRP: C-reactive protein

abnormal CRP 1,  $n = 693$ . Similarly, 26% of patients had normal CRP-2,  $n = 238$ , and 73% had abnormal CRP-2,  $n = 668$ . About 0.8% were current smokers while 1.5% had a history of smoking.

In the current study, a percentage of clinically mild, moderate, and severe patients were 28.1%, 31.12%, and 38.19%, respectively. Based on the CO-RADS score, 38.19%, 34.92%, and 27.48% of cases were severe, moderate, and mild, respectively. A total of 77.48% of the patients had a  $SpO_2 > 90$ , 20% had a  $SpO_2$  of 75–90 and 1.76 had  $< 75$ . Furthermore, 60.26% of the patients were administered remdesivir, 80.13% were administered steroids, and 2.64% were administered tocilizumab for treatment [Table 2].

Of total patients included in the current study, 39.5% of the patients required oxygen supplement. 7.17% needed high-flow nasal oxygen. 60.26% of the patients were given remdesivir for treatment. 80.13% were given steroids and 2.64% were given tocilizumab. Patients who required oxygen supplement, remdesivir, steroids, tocilizumab, and high-flow nasal oxygen had a significant association with CRP-1 and CRP-2 levels [Table 3].

Table 4 depicts the correlation between clinical severity and CRP-1 and CRP-2 levels in COVID-19 patients. The median CRP-1 for patients who experienced mild clinical severity was 5.63. The median CRP-1 for patients who experienced moderate clinical severity was 23.73. The median CRP-1 for patients who experienced severe clinical severity was 64.1. Similarly, 3.79 was the median CRP-2 for patients with mild clinical severity. The median CRP-2 for patients who experienced moderate clinical severity was 18.485. The median CRP-2 for patients who experienced severe clinical severity was 46.51. The results were statistically significant and suggested that as the clinical severity increased, the disease progressed with an elevation of both CRP-1 and CRP-2 levels. This infers that there was an increase in CRP levels in severe cases than in mild and moderate cases, suggesting that the CRP level may be a biomarker of disease severity and progression in patients with COVID-19.

Table 4 also depicts the correlation of CT score with CRP in COVID-19 patients. The median CRP-1 with mild, moderate, and severe CT scores was 4.98, 22.78,

**Table 2: The percentages of various categorical variables in the study**

| Variable                | Category | Frequency | Percent |
|-------------------------|----------|-----------|---------|
| CT scan (CO-RADS score) | Severe   | 346       | 38.2    |
|                         | Moderate | 311       | 34.3    |
|                         | Mild     | 249       | 27.5    |
| Clinical severity       | Severe   | 369       | 40.7    |
|                         | Moderate | 282       | 31.1    |
|                         | Mild     | 255       | 28.2    |
| CRP-1                   | Abnormal | 693       | 76.5    |
|                         | Normal   | 213       | 23.5    |
| CRP-2                   | Abnormal | 668       | 73.7    |
|                         | Normal   | 238       | 26.3    |
| Current smoker          | Y        | 7         | 0.8     |
|                         | N        | 899       | 99.2    |
| Past smoker             | Y        | 14        | 1.5     |
|                         | N        | 892       | 98.5    |
| CAHD                    | Y-Yes    | 835       | 92.2    |
|                         | N-No     | 71        | 7.8     |
| CKD (Y/N)               | N        | 881       | 97.2    |
|                         | Y        | 25        | 2.8     |
| HTN (Y/N)               | Y        | 601       | 66.3    |
|                         | N        | 305       | 33.7    |
| DM (Y/N)                | N        | 561       | 61.9    |
|                         | Y        | 345       | 38.1    |
| Lung disease (Y/N)      | N        | 874       | 96.5    |
|                         | Y        | 32        | 3.5     |
| Malignancy              | N        | 885       | 97.7    |
|                         | Y        | 21        | 2.3     |

CKD: Chronic kidney disease, CAHD: Coronary heart disease, DM: Diabetes mellitus, HTN: Hypertension

and 64.9, respectively. Similarly, the median CRP-2 with mild, moderate, and severe CT scores was 4.15, 19.29, and 45.71, respectively. The results were statistically significant and suggested that as the CT score increases, the disease is progressed and documented with an increase in CRP levels [Table 4].

Table 5 depicts the correlation of patient outcome and CRP-1 and CRP-2 levels. 89% of the patients were alive and healthy, 3.4% of the patients were alive but morbid, and 7.6% were dead. Furthermore, the median CRP-1 and CRP-2 in alive patients were 21.42 and 18.67, respectively. Similarly, the median CRP-1 and CRP-2 in dead patients were 73.07 and 68.5, respectively. This infers that CRP concentrations remain high in expired patients; therefore, CRP could be a promising biomarker for assessing mortality [Table 5].

**Table 3: The treatment modality and median CRP-1 and CRP-2 levels**

| Variable                     | Category | Frequency | Percent   | Median CRP-1 | Median CRP-2 | P-value         |
|------------------------------|----------|-----------|-----------|--------------|--------------|-----------------|
| Oxygen requirement (Y/N)     | N        | 548       | 0.604857  | 10.93        | 10.545       | <0.001 (0.1012) |
|                              | Y        | 358       | 0.395143  | 63.82        | 45.865       |                 |
| Remdesivir (Y/N)             | Y        | 546       | 0.602649  | 37.93        | 28.79        | <0.001 (0.1077) |
|                              | N        | 360       | 0.397351  | 11.37        | 11.085       |                 |
| Steroids (Y/N)               | Y        | 726       | 0.801325  | 37.02        | 27.39        | <0.001 (0.1178) |
|                              | N        | 180       | 0.198675  | 5.705        | 4.745        |                 |
| Tocilizumab (Y/N)            | N        | 882       | 0.97351   | 24.73        | 20.7         | 0.024 (0.983)   |
|                              | Y        | 24        | 0.0264901 | 80.52        | 29.49        |                 |
| High-flow nasal oxygen (Y/N) | N        | 841       | 0.928256  | 20.83        | 18.34        | <0.001 (0.980)  |
|                              | Y        | 65        | 0.0717439 | 73.07        | 70.02        |                 |

CRP: C-reactive protein

**Table 4: Correlation of clinical severity and CT score with CRP-1 and CRP-2 levels in COVID-19 patients**

| S. No. | Patient characteristics | Categories | Median CRP-1 | IQR    | P-value        | Median CRP-2 | IQR   | P-value        |
|--------|-------------------------|------------|--------------|--------|----------------|--------------|-------|----------------|
| 1      | Clinical severity       | Mild       | 5.63         | 11.9   | <0.001 (0.942) | 3.79         | 10.23 | <0.001 (0.863) |
|        |                         | Moderate   | 23.735       | 54.67  |                |              |       |                |
|        |                         | Severe     | 64.12        | 89.14  |                |              |       |                |
| 2      | CT score severity       | Mild       | 4.98         | 9.43   | <0.001 (0.952) | 4.15         | 10.82 | <0.001 (0.878) |
|        |                         | Moderate   | 22.78        | 54.67  |                |              |       |                |
|        |                         | Severe     | 64.96        | 88.465 |                |              |       |                |

CRP: C-reactive protein

**Table 5: Correlation of patient outcome and CRP-1 and CRP-2 levels**

| S. No. | Outcome         | Frequency | Percentage | Median CRP-1 | IQR   | P-value         | Median CRP-2 | IQR    | P-value         |
|--------|-----------------|-----------|------------|--------------|-------|-----------------|--------------|--------|-----------------|
| 1      | AH              | 806       | 89%        |              |       |                 |              |        |                 |
| 2      | D-Dead          | 69        | 3.4%       |              |       |                 |              |        |                 |
| 3      | Am-Alive morbid | 31        | 7.6%       |              |       |                 |              |        |                 |
| 4      | ALIVE           | 837       | 92.3%      | 21.42        | 66.91 | <0.001 (0.1300) | 18.67        | 46.41  | <0.001 (0.1265) |
| 5      | DIED            | 69        | 7.6%       | 73.07        | 78.87 |                 | 68.5         | 81.685 | <0.001 (0.1265) |

AH: Alive healthy, CRP: C-reactive protein

Table 6 depicts the association between median CRP levels in patients who are dead while having the comorbidities. The results showed a significant association between CRP-1 and CRP-2 levels in patients who died while having the comorbidities [Table 6].

Figure 1 represents the receiver operating characteristic (ROC) curves of CRP-1 and CRP-2 for predicting the disease severity in COVID-19 patients. Analysis of the ROC curve illustrated an area under the curve 0.75 with overall sensitivity and specificity of 96.15 and 83.33, respectively [Table 5]. The biomarker indicated a high diagnostic value for assessing the clinical severity. The sensitivity and specificity of CRP-1 were 94.23% and 46.79%, respectively. Similarly, the sensitivity and specificity of CRP-2 were 92.3% and 55.04%, respectively [Table 7].

## DISCUSSION

The current retrospective study evaluated the outcome of 906 COVID-19 patients and the association between CRP and COVID-19 infection. Among the 906 patients,

68.1% were male and 31.9% were female. The mean age of patients included in the study was 54.45. The patients included in the current study presented with comorbidities such as 2.75% CKD, 7.83% with CAHD, 33.6% HTN, 38.07% with DM, 3.53% with lung disease, and malignancy 2.31%.

CRP is an acute-phase protein synthesized by the liver and increases during inflammatory responses. Studies<sup>[11,12]</sup> have shown that CRP levels are increased in viral and bacterial infections. Many studies have suggested that CRP can be used as a prognostic biomarker for acute and chronic infections. Data published in recent studies suggest that severe COVID-19 patients have higher CRP levels than non-severe COVID-19 patients.<sup>[13-17]</sup> CRP levels in COVID-19 patients can effectively predict disease severity, outcomes, prognosis, and mortality. In the current study out of 906 patients, the median CRP-1 for patients who experienced mild clinical severity was 5.63. The median CRP-1 for patients who experienced moderate clinical severity was 23.73. The median CRP-1 for patients who experienced severe clinical severity was 64.1. Similarly,

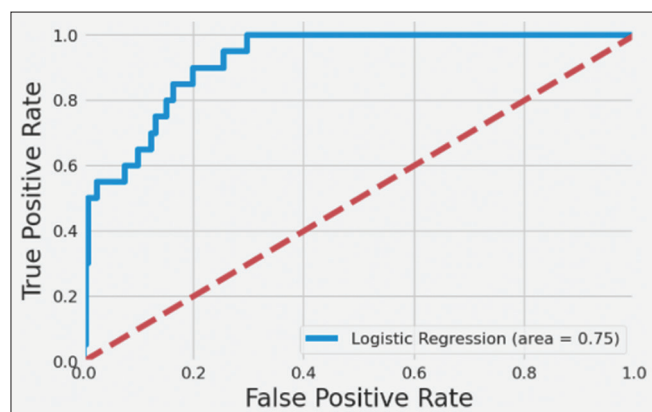
**Table 6: Association between median CRP levels in patients who are dead while having the comorbidities**

| Comorbidity  | Cat | Median CRP-1 (dead) | IQR    | P-value (Cramer's V) | Median CRP-2 (dead) | IQR    | P-value (Cramer's V) |
|--------------|-----|---------------------|--------|----------------------|---------------------|--------|----------------------|
| DM           | Y   | 94.95               | 113.45 | <0.001 (0.96)        | 71.985              | 84.73  | <0.001 (0.93)        |
|              | N   | 64.12               | 67.65  |                      | 51.93               | 75.43  |                      |
| CKD          | Y   | 57.78               | 103.02 | <0.001 (0.92)        | 62.99               | 85.6   | <0.001 (0.91)        |
|              | N   | 73.07               | 85.59  |                      | 68.5                | 80.11  |                      |
| CAHD         | Y   | 81.7                | 97.945 | <0.001 (0.90)        | 86.995              | 92.025 | <0.001 (0.80)        |
|              | N   | 70.76               | 77.95  |                      | 66.97               | 79.34  |                      |
| HTN          | Y   | 73.185              | 91.89  | <0.001 (0.89)        | 68.445              | 87.085 | <0.001 (0.83)        |
|              | N   | 70.76               | 76.54  |                      | 68.5                | 76.57  |                      |
| Lung disease | Y   | 6.53                | NA     | <0.001 (0.82)        | 26.67               | NA     | <0.001 (0.92)        |
|              | N   | 73.68               | 77.38  |                      | 69.21               | 79.77  |                      |
| Malignancy   | Y   | 52.76               | NA     | <0.001 (0.96)        | 41.61               | NA     | <0.001 (0.96)        |
|              | N   | 73.185              | 80.04  |                      | 69.97               | 83.26  |                      |

CRP: C-reactive protein, CKD: Chronic kidney disease, CAHD: Coronary heart disease, DM: Diabetes mellitus, HTN: Hypertension

**Table 7: The sensitivity and specificity**

| Results                   | Percentage |
|---------------------------|------------|
| Sensitivity               | 96.15      |
| Specificity               | 83.33      |
| Positive likelihood ratio | 5.769      |
| Negative likelihood ratio | 0.04615    |



**Figure 1: The receiver operating characteristic curves of C-reactive protein-1 and C-reactive protein-2**

3.79 was the median CRP-2 for patients with mild clinical severity. The median CRP-2 level in patients with moderate clinical severity was 18.485. 46.51 was the median CRP-2 for patients who experienced severe clinical severity. The results were statistically significant and suggested that as the clinical severity increased, the disease progressed with an elevation of both CRP-1 and CRP-2 levels. This infers that there was an increase in CRP levels in severe cases than in mild and moderate cases, suggesting that the CRP levels in COVID-19 patients can effectively predict disease severity and prognosis. This further helps in step-up or step-down interventions in critical care setting.

The current study correlated the CT scores with CRP levels in COVID-19 patients. The median CRP-1 with mild, moderate, and severe CT scores was 4.98, 22.78,

and 64.9, respectively. Similarly, the median CRP-2 with mild, moderate, and severe CT scores was 4.15, 19.29, and 45.71, respectively. The results were statistically significant and suggested that as the CT score increased, the disease progressed and was documented with an increase in CRP levels. Furthermore, this suggests the usefulness of the CT severity score in triaging the cases. Several studies have documented similar observation.<sup>[18-20]</sup>

Of total patients included in the current study, 39.5% of the patients required oxygen supplement. 7.17% needed high-flow nasal oxygen. 60.26% of the patients were given remdesivir for treatment. 80.13% were given steroids and 2.64% were given tocilizumab. The current study documented higher CRP levels in severe cases requiring oxygen and high-flow nasal oxygen supplement. This suggests that the CRP level may be used as a potential biomarker in assessing the COVID-19 prognosis.

The current study correlated patient outcomes with CRP-1 and CRP-2 levels. Of patients, 89% were alive and healthy, 3.4% were alive but morbid, and 7.6% had died. The median CRP-1 and CRP-2 levels in alive patients were 21.42 and 18.67, respectively. Similarly, the median CRP-1 and CRP-2 in dead patients were 73.07 and 68.5, respectively. Furthermore, a significant association was found between CRP-1 and CRP-2 levels patients who died while having the comorbidities. This infers that CRP concentrations remain high in expired patients as compared to alive patients which indicate that an increase in CRP level is strongly associated with the prognosis of COVID-19 which must be employed within the clinical practice to guide COVID-19 disease severity and predictable marker in assessing mortality rate.

The overall sensitivity and specificity of CRP were 96.15 and 83.33, respectively. The biomarker indicated a high diagnostic value for assessing the clinical severity. The sensitivity and specificity of CRP-1 were 94.23% and 46.79%, respectively. Similarly, the sensitivity

and specificity of CRP-2 were 92.3% and 55.04%, respectively.

## CONCLUSION AND LIMITATION

CRP levels increase during inflammatory responses, and measurement of CRP alone is the most practical tool to monitor disease outcomes in COVID-19 patients. Limitations of the current study include that it is a retrospective study and assessed only CRP-1 (within 24 h) and CRP-2 (within 48 h). Therefore, to confirm our findings, a large multicenter clinical study should be conducted with multiple CRP level measurements measured at different treatment times.

## REFERENCES

- Lai CC, Shih TP, Ko WC, Tang HJ, Hsueh PR. Severe acute respiratory syndrome coronavirus 2 (COVID-19) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. *Int J Antimicrob Agents* 2020;55:105924.
- WHO COVID-19 Dashboard. Geneva: World Health Organization; 2020. Available from: <https://covid19.who.int> [Last accessed on 2022 Aug 24].
- Fazal M. C-Reactive protein a promising Biomarker of COVID-19 Severity. *Korean J Clin Lab Sci* 2021;53:201-7.
- Marnell L, Mold C, Du Clos TW. C-reactive protein: Ligands, receptors, and role in inflammation. *Clin Immunol* 2005;117:104-11.
- Young B, Gleeson M, Cripps AW. C-reactive protein: A critical review. *Pathology* 1991;23:118-24.
- Pepys MB, Hirschfield GM. C-reactive protein: A critical update. *J Clin Invest* 2003;111:1805-12.
- Murashima M, Nishimoto M, Kokubu M, Hamano T, Matsui M, Eriguchi M, *et al.* Inflammation as a predictor of acute kidney injury and mediator of higher mortality after acute kidney injury in non-cardiac surgery. *Sci Rep* 2019;9:20260.
- Patil S, Gondhali G, Acharya A. Serial CRP (C-reactive protein) monitoring in COVID-19 Pneumonia for the assessment of severity, ventilatory support requirement and predicting early lung fibrosis. *J Med* 2022;23:112-20.
- Bhardwaj N, Ahmed MZ, Sharma S, Nayak A, Anvikar AR, Pande V. C-reactive protein as a prognostic marker of *Plasmodium falciparum* malaria severity. *J Vector Borne Dis* 2019;56:122-6.
- Vuong NL, Le Duyen HT, Lam PK, Tam DT, Vinh Chau NV, Van Kinh N, *et al.* C-reactive protein as a potential biomarker for disease progression in dengue: A multi-country observational study. *BMC Med* 2020;18:35.
- Coster D, Wasserman A, Fisher E, Rogowski O, Zeltser D, Shapira I, *et al.* Using the kinetics of C-reactive protein response to improve the differential diagnosis between acute bacterial and viral infections. *Infection* 2020;48:241-8.
- Ten Oever J, Tromp M, Bleeker-Rovers CP, Joosten LA, Netea MG, Pickkers P, *et al.* Combination of biomarkers for the discrimination between bacterial and viral lower respiratory tract infections. *J Infect* 2012;65:490-5.
- 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.
- Shang W, Dong J, Ren Y, Tian M, Li W, Hu J, *et al.* The value of clinical parameters in predicting the severity of COVID-19. *J Med Virol* 2020;92:2188-92.
- Liu SL, Wang SY, Sun YF, Jia QY, Yang CL, Cai PJ, *et al.* Expressions of SAA, CRP, and FERR in different severities of COVID-19. *Eur Rev Med Pharmacol Sci* 2020;24:11386-94.
- Bergantini L, Bargagli E, D'Alessandro M, Refini RM, Cameli P, Galasso L, *et al.* Prognostic bioindicators in severe COVID-19 patients. *Cytokine* 2021;141:155455.
- Xue G, Gan X, Wu Z, Xie D, Xiong Y, Hua L, *et al.* Novel serological biomarkers for inflammation in predicting disease severity in patients with COVID-19. *Int Immunopharmacol* 2020;89:107065.
- Wang L. C-reactive protein levels in the early stage of COVID-19. *Méd Mal Infect* 2020;50:332-4.
- Lonsane A, Chopra RK, Jayamani M. Late Breaking Abstract - Correlation of CT severity score and Inflammatory markers to predict the disease severity in COVID 19 patients *Europ Respir J* 2021;58:A819.
- 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;395:497-506.

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