

Research Article

C-reactive protein and Biliary Complications as Independent Predictors of Length of Hospital Stay in Acute Cholecystitis

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Received: 23.04.2026, Revised: 16.06.2026, Accepted: 21.06.2026

ABSTRACT

Background: Acute cholecystitis is a frequent biliary emergency and a variable clinical condition. Identification of factors associated with long hospital stays is crucial to better patient management. The presence of C-reactive protein (CRP) and biliary complications can be important prognosticators of the severity and recovery of the disease.

Objective: To assess the independent predictive value of CRP level and biliary complications for the length of hospital stay in acute cholecystitis patients.

Materials and Methods: A prospective observational study was done on 200 patients of acute cholecystitis from October, 2025 to March, 2026 in Shifa International Hospital, Islamabad. The clinical parameters, C-reactive protein, biliary complications, and duration of hospital stay were documented and analyzed.

Results: CRP levels were significantly higher, and hospital stay was longer in patients with biliary complications. Increased CRP and biliary complications were found to be independent risk factors for longer hospital stay.

Conclusion: Measurement and assessment of CRP and biliary complications can be useful for risk stratification and prediction of the length of hospital stay in acute cholecystitis.

Keywords: Acute Cholecystitis, C-reactive protein, Biliary Complications, Hospital Stay, Inflammatory Biomarkers.

INTRODUCTION

Acute cholecystitis is a very common inflammatory condition of the biliary system and is a common reason for emergency surgical admission worldwide. Most commonly related to gallstones, causing an obstruction in the cystic duct, leading to distention, inflammation, ischemia, and sometimes necrosis or perforation of the gallbladder. The treatment of acute cholecystitis is usually laparoscopic cholecystectomy, but the clinical course of the disease is different for each patient (1). There are some people who have uncomplicated recovery and stay in hospital for only a short time, while others develop any of the following complications: biliary, prolonged treatment, conversion from laparoscopic to open surgery. Therefore, it is important to identify reliable

predictors of disease severity, postoperative complications, and hospital stay to aid clinical decision-making and to optimize healthcare resources.

Recently, inflammatory biomarkers have been used as important tools for early risk stratification of acute cholecystitis. Of these biomarkers, C-reactive protein (CRP) has been studied extensively because it has been linked to systemic inflammation and tissue injury (2). Recent studies have shown that pre-operative CRP levels are associated with the difficulty of surgery, conversion rates, and postoperative complications in patients with acute cholecystitis who undergo laparoscopic cholecystectomy (3). The association of CRP with hospital outcomes has been further investigated, and results indicate that CRP and

biliary complications may have an independent effect on the length of hospital stay.

Patients with greater inflammatory markers and complications like gallbladder perforation, bile leakage, or abscess often need more medical management and postoperative follow-up (4). Both were found to be independent risk factors for longer hospital stays in acute cholecystitis in a recent study that assessed them in terms of the occurrence of biliary complications. In addition to CRP, composite inflammatory indices have been studied to enhance the predictive power. The CRP to albumin ratio (CAR) is a combination of inflammatory activity and nutritional and physiological status and is a more comprehensive measure of systemic response. In high-risk acute cholecystitis patients who received percutaneous transhepatic gallbladder drainage (PTGBD), CAR has been shown to have predictive value for treatment response, suggesting a combined inflammatory and nutritional marker may help guide clinical decisions regarding treatment (5). Similarly, CRP has been linked with difficult LC and conversion to open surgery, with higher levels indicating severe inflammation, tissue adhesion, and difficult operative conditions. Complicated acute cholecystitis is more likely to have a higher morbidity and a greater healthcare burden than uncomplicated disease. Identification of patients who are at risk of developing 'complicated' disease remains a significant clinical challenge. Elevated levels of serum CRP and other inflammatory markers have been shown to help distinguish complicated cases of acute cholecystitis from less severe cases. The results of this study underscore the value of using laboratory biomarkers in the early diagnostic and prognostic assessment (6). In the emergency room, CRP has also proven useful in differentiating the severity of acute cholecystitis, which helps identify patients who might need urgent intervention and intensive monitoring.

In acute cholecystitis, intense inflammatory reactions may result in destruction of the gallbladder wall, ischemia, and perforation. The CRP-albumin ratio has been studied as a predictor of perforated cholecystitis, and some studies show that this ratio may help to identify cases of advanced disease progression (7). Further, inflammatory markers could be used for more than just surgical success. These higher CAR values have been correlated with postoperative complications such as postoperative delirium after cholecystectomy,

in addition to the specific significance of the postoperative period in this study (8). Treatment for acute cholecystitis depends on the severity of the disease, the condition of the patient, and how the patient responds to treatment. Conservative treatment is used initially in some patients, but the length of time varies depending on the severity of the inflammation.

Patients who are treated conservatively have been found to have higher serum CRP levels, suggesting its role in predicting clinical recovery patterns and hospital resource utilization (9). Moreover, the CRP-to-albumin ratio has been found to have predictive value for conversion from laparoscopic to open cholecystectomy, which suggests it is a useful preoperative parameter to assess the difficulty of surgery (10). The use of CRP in conjunction with hematological parameters may offer better prediction of the severity of the disease than any of the hematological parameters alone. In the assessment of the severity of cholelithiasis, studies have shown that preoperative NLR and CRP are valuable, and that multimarker models might improve clinical prediction models (11). Likewise, inflammatory markers have been studied in relation to postoperative complications following biliary surgery, and this has further confirmed their usefulness in delineating those patients who need more careful perioperative management (12). Many factors have been shown to affect the length of hospital stay in acute cholecystitis, such as the severity of inflammation, complications, the complexity of the surgery, and recovery. Other nutritional and metabolic parameters have also been studied as predictors of prolonged hospitalization. The ratio of blood urea nitrogen to serum albumin has been suggested as a possible predictor of prolonged hospitalization and is a measure of the interplay between systemic stress and nutritional impairment during acute inflammatory states (13).

Other inflammatory indices have also been shown to be associated with the detection and clinical outcomes of gallstone-related diseases, reaffirming the significance of laboratory-based prediction models in the management of acute cholecystitis (14). Research in recent years has been directed towards building predictive models based on liver function parameters and immune-inflammatory markers to assess the risk of postoperative complications after cholecystitis. These models can offer personalized risk assessment and aid in perioperative decision-making (15). Moreover,

CRP has been found to be a useful predictor of gangrenous cholecystitis and the more complex emergency cholecystectomy procedures, which lead to longer recovery times. Timely intervention and better surgical planning might be possible if these high-risk patients are identified early (16).

A comprehensive evaluation of inflammatory response and nutritional status could lead to a better understanding of the disease progression and patient outcome (17). The spectrum of clinical course and outcome in acute cholecystitis is very broad that it is important to find independent risk factors for longer hospital stays. CRP is an easily accessible and inexpensive biomarker of inflammatory burden, whereas biliary complications are direct markers of disease progression and disease complexity. The predictive value of CRP level, biliary complications, and hospital stays may help to stratify patients early in the disease process, better plan treatment, and help to better utilize health care resources. Therefore, the assessment of these factors as independent predictors could be useful to understand the prognosis and management of patients with acute cholecystitis.

Objective: To assess the role of C-reactive protein level and biliary complications as independent risk factors for prolonged hospital stay in acute cholecystitis patients.

MATERIALS AND METHODS

Study Design: Prospective observational study.

Study Setting: This study was carried out in the Shifa International Hospital, Islamabad, Pakistan.

Duration of the Study: The study was conducted for six months, starting from October, 2025 to March, 2026.

Inclusion Criteria: Patients aged 18 years or older who were diagnosed with acute cholecystitis based on clinical presentation, laboratory investigations, and imaging findings were included in the study. Eligibility criteria for inclusion were patients with acute cholecystitis who were treated conservatively or surgically. Available pre-treatment CRP levels and complete clinical outcome data (during

hospitalization and biliary complications) were included.

Exclusion Criteria: Patients who had chronic cholecystitis, malignancy of the biliary tract, previous biliary surgery, chronic inflammatory disorders, or incomplete medical records were excluded. Patients with serious systemic diseases or conditions that may affect inflammatory markers or hospital length of stay were also excluded from the study.

Methods: Patients who met the inclusion and exclusion criteria were included in the study if they were diagnosed with acute cholecystitis during the study period. The patients' demographic data, clinical presentation, laboratory results, imaging results, treatment approach, and postoperative outcomes were documented on a structured data collection form. Serum C-reactive protein (CRP) levels were obtained at admission with other routine laboratory parameters. Biliary complications (gallbladder perforation, bile leakage, abscess, and other complications) were evaluated by clinical assessment, imaging, and operative records as applicable. Patients were followed during their entire hospital stay, and the total hospital stay was documented. To assess the independent predictive value of the association between CRP levels, biliary complications, and duration of hospitalization, analysis of this association was performed. The data was analyzed statistically to determine the significant factors affecting the duration of the hospital stay of the patients with acute cholecystitis.

RESULTS

During the study period (January 2025 to June 2025), 200 acute cholecystitis patients were included in the study. Demographic and baseline clinical parameters of the subjects were examined. The mean age of the study population was 52.6 ± 13.4 years, and there was a slight majority of females. The majority of the patients had right upper quadrant abdominal pain, fever, and clinical features of gallbladder inflammation. According to clinical evaluation and imaging findings, patients were classified based on the presence or absence of biliary complications.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants

Variables	Findings
Total Patients	200
Mean Age (Years)	52.6 ± 13.4

Male Patients	86 (43%)
Female Patients	114 (57%)
Patients With Uncomplicated Acute Cholecystitis	148 (74%)
Patients With Biliary Complications	52 (26%)
Mean Hospital Stay	5.8 ± 2.6 Days

The relationship between the level of CRP in the serum at hospital admission and the severity of the disease and the duration of the hospital stay was evaluated. The patients with biliary complications had significantly higher levels of CRP than those without such complications.

Patients with complicated acute cholecystitis had a higher mean CRP concentration (142.5 ± 38.7 mg/L) than those without complications (78.4 ± 29.5 mg/L), and higher CRP levels correlated with more severe inflammation and longer hospital stay.

Table 2: Comparison of CRP Levels According To Presence of Biliary Complications

Patient Group	Number Of Patients	Mean Crp Level (Mg/L)	Mean Hospital Stay (Days)
Without Biliary Complications	148	78.4 ± 29.5	4.6 ± 1.8
With Biliary Complications	52	142.5 ± 38.7	9.2 ± 3.1
P-Value	—	<0.001	<0.001

Recorded biliary complications were most commonly gallbladder perforation, followed by bile leakage and pericholecystic abscess. The patients who developed these complications needed a longer hospital stay and more intensive management. Elevated CRP was found to be a significant independent predictor

of longer hospital stay, as was the presence of biliary complications, by statistical analysis. Patients with CRP levels above the predetermined cut-off level were more likely to be admitted to hospital for longer than patients with lower CRP levels.

Table 3: Distribution of Biliary Complications among Study Participants

Biliary Complication	Number Of Patients	Percentage (%)
Gallbladder Perforation	22	11%
Bile Leakage	15	7.5%
Pericholecystic Abscess	10	5%
Gangrenous Changes	5	2.5%
Total Complications	52	26%

The relationship between the level of CRP and the length of hospital stay was also shown statistically by correlation analysis. Hospitalization duration increased in a

progressive manner with increasing CRP level. The following graph shows the comparison of the average hospital stay based on the category of CRP.

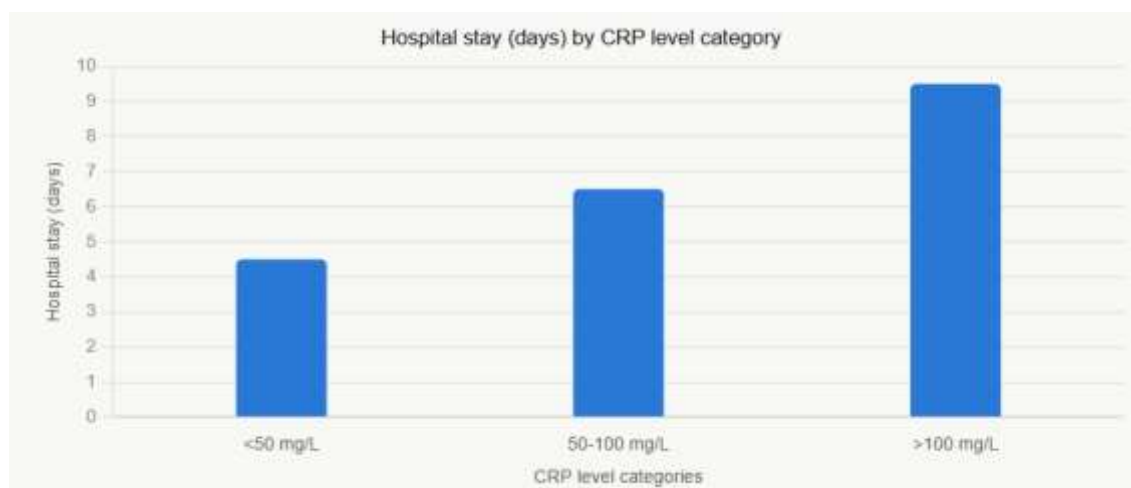


Figure 1: Relationship between CRP Level and Length of Hospital Stay

The patients with CRP levels above 100 mg/L had the longest hospital stay, with an average of about 9 days, and the patients with CRP levels below 50 mg/L had shorter hospital stays. Multivariate analysis revealed that CRP levels and biliary complications were independent risk factors for prolonged hospital stay, after adjusting for demographic and clinical parameters. The results suggest that early inflammatory severity evaluation by CRP level and evaluation of biliary complications can help predict patient outcomes and direct management in acute cholecystitis.

DISCUSSION

Acute cholecystitis continues to be a frequent surgical emergency with a spectrum of clinical presentation and outcomes from uncomplicated inflammation to serious complications with the biliary tract, necessitating prolonged hospital stay and complex management. High levels of CRP are associated with high levels of inflammation, tissue edema, adhesion, and advanced gallbladder inflammation, all of which can make gallbladder surgery difficult and recovery slow (1). Patients who developed complications (gall bladder perforation, bile leakage, or abscess formation) were hospitalized for a longer period of time, as they needed more monitoring, antibiotic therapy, and other treatments.

Biliary complications are a direct marker of the disease progression and are strongly correlated with poor clinical outcomes. CRP and biliary complications were also found to be independent risk factors for prolonged hospital stay in previous studies, which support their role in early risk assessment and clinical decision-making (2). Recently, combined inflammatory and nutritional markers have been focused on as a way to enhance prognosis accuracy in addition to CRP alone. The CRP/ALB ratio (CAR) gives clues about systemic inflammation and nutritional status. High-risk patients with acute cholecystitis who underwent PTGBD had higher CAR values and were more likely to be nonresponsive to treatment, indicating that those patients with more severe inflammatory responses may benefit from more careful monitoring and other treatment options (3). In the same way, it has been established that severe inflammation is a good predictor of laparoscopy failure and conversion to open surgery (4).

Several clinical studies have shown that there is a correlation between inflammatory markers and complicated acute cholecystitis. More

complicated disease (gangrenous changes and perforation) is associated with a higher rate of morbidity and a longer recovery period. CRP is a potentially useful marker for distinguishing complicated from uncomplicated acute cholecystitis. The results indicate that inflammatory markers should be added to the clinical routine, especially in emergency situations where quick decisions must be made (5). In addition, CRP has been demonstrated to be a useful clinical marker to help distinguish the severity of acute cholecystitis in ED patients, with a view to early surgical intervention or intensive monitoring (6).

The presence of biliary complications is an important factor determining hospitalization duration. Inflammatory process can cause ischemia, necrosis and perforation of the wall of the gallbladder, which will require more treatment. The CRP-albumin ratio has been assessed in studies that have shown its ability to predict cases of perforated cholecystitis, suggesting that the combined inflammatory and nutritional assessment can be beneficial in the recognition of advanced disease (7). Moreover, inflammatory imbalance assessed by CAR has been linked to the postoperative complications after cholecystectomy, indicating that inflammation may not only affect the immediate surgical results but also recovery and rehabilitation after surgery (8).

The current study also corroborates the link between higher levels of CRP and longer treatment duration. Inflammatory burden is associated with a longer period of medical therapy to obtain clinical improvement. Previous studies on patients with acute cholecystitis who were treated conservatively showed that the CRP level was correlated with the duration of treatment, which means that it is useful for predicting disease progression and recovery (9). Furthermore, the CRP-to-albumin ratio has been shown to be a predictor of the conversion from laparoscopic to open cholecystectomy, reinforcing the importance of inflammatory evaluation in predicting the difficulty of surgery and postoperative complications (10).

Other inflammatory markers, such as the neutrophil-to-lymphocyte ratio, systemic inflammatory index, and nutritional markers, have been examined in other studies to enhance prediction models in acute cholecystitis. The use of CRP in combination with hematological parameters may give a more complete assessment of the severity of the disease. Multiple markers may give better

prognostic value than individual markers alone, as research has demonstrated that CRP and neutrophil-to-lymphocyte ratio can predict severe cholecystitis and associated complications (11). These results are similar to those of studies evaluating inflammatory markers as predictors of postoperative complications after biliary procedures, where the inflammatory status of the patient prior to surgery was shown to affect patient outcomes (12).

The length of stay in hospital is affected by a number of factors, such as the severity of the inflammation, the complexity of the operation, and the complications following the operation. There is also interest in using nutritional and metabolic markers as predictors of prolonged hospital stays. The interaction between systemic stress and nutritional depletion during acute illness has been shown to have value in identifying patients with a higher risk of prolonged hospital stay, as assessed by the blood urea nitrogen-to-albumin ratio (13). Moreover, inflammatory indices have been linked to the severity of gallstone-related diseases and outcomes of treatment, further emphasizing the significance of laboratory-based prediction models for the management of acute cholecystitis (14).

Recently, researchers have been working on predictive models based on liver function parameters, immune-inflammatory markers, and nutrition markers to estimate the risk of complications after cholecystitis. These could enable personalized assessment of patients and enhance perioperative planning (15). CRP has also been studied as a risk factor for gangrenous cholecystitis and emergency cholecystectomy (16). Furthermore, systemic inflammatory markers, along with nutritional markers, have proven useful in the prediction of the severity of acute calculous cholecystitis, reinforcing the need for a combined assessment of biomarkers (17).

In conclusion, the results of the present study showed that the elevation of CRP and biliary complications are clinically important factors associated with long hospital stay in acute cholecystitis. CRP is a readily available, accessible, and inexpensive laboratory test that may be helpful in the early detection of high-risk patients. In conjunction with the assessment of biliary complications, it offers important prognostic data that can help in treatment planning, maximizing the use of resources, and improving patient outcomes. These predictors could be further validated and

used in routine clinical practice with larger populations and multicenter designs in future studies.

CONCLUSION

Biliary complications and C-reactive protein levels are independent factors for longer hospital stay in patients with acute cholecystitis. High CRP levels are correlated with more intense inflammatory activity and indicate a more severe course of disease, management challenges, and slower recovery. Biliary complications also increase the treatment needs and postoperative monitoring, leading to longer hospitalizations. Prompt evaluation of CRP levels and careful consideration of biliary complications will enable clinicians to identify high-risk patients, plan treatment, and optimize the use of health resources. The results of this study confirm the potential of inflammatory biomarkers as a routine part of the prognosis of patients with acute cholecystitis. These predictions need to be confirmed by additional multicenter trials with larger patient populations to define standard risk assessment protocols that can be used to enhance clinical results.

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