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Original Research Article

Study Of Correlation Of C-Reactive Protein Levels With Appendicitis In Pediatric Age Group Patients

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Abstract

Background: Acute appendicitis is the most common surgical emergency in children. Early differentiation between uncomplicated and complicated appendicitis remains challenging, and inflammatory biomarkers such as C-reactive protein (CRP) may assist in assessing disease severity and guiding management.

Aim: To evaluate the correlation between preoperative serum CRP levels and the severity of appendicitis in pediatric patients.

Materials and Methods: This prospective observational study was conducted at a tertiary care medical college hospital in Western India from January to December 2025. A total of 106 pediatric patients diagnosed with acute appendicitis were included. Clinical evaluation, imaging findings, and laboratory parameters including CRP, total white blood cell (WBC) count, and neutrophil percentage were recorded. Ninety-nine patients underwent appendectomy, while seven were managed conservatively. Histopathological examination was used to classify cases as uncomplicated or complicated appendicitis. Statistical analysis was performed using SPSS version 19, with $p<0.05$ considered significant.

Results: The mean age of patients was 9.85 years, with a male predominance (75.5%). Histopathology revealed uncomplicated appendicitis in 41 (41.4%) patients and complicated appendicitis in 57 (57.6%) patients. The mean WBC count (18.88 ± 14.64 vs. 12.56 ± 3.04 $\times 10^3/mm^3$; p=0.033) and neutrophil percentage (84.96 ± 7.54% vs. 80.68 ± 7.41%; p=0.042) were significantly higher in complicated appendicitis. CRP demonstrated the strongest association with severity, with mean levels of 101.38 ± 68.08 mg/L in complicated cases compared to 22.74 ± 17.80 mg/L in uncomplicated cases ($p<0.001$). CRP values progressively increased from simple inflammation to gangrenous, necrotic, and perforated appendicitis.

Conclusion: Elevated CRP levels strongly correlate with the severity of acute appendicitis in children. CRP, particularly when combined with WBC count and neutrophil percentage, serves as a valuable adjunctive marker for identifying complicated appendicitis and facilitating timely clinical decision-making.

Keywords: Acute appendicitis; C-reactive protein; White blood cell count; Neutrophil percentage; Complicated appendicitis; Inflammatory biomarkers.

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Introduction

Appendicitis is the most common cause of pain abdomen requiring emergency surgery in pediatric patients. [1] Despite the appendix being one of the most extensively investigated organs in surgical practice, a single radiological or laboratory test capable of definitively diagnosing acute appendicitis has yet to be established. The diagnosis traditionally relies on clinical symptoms, routine laboratory parameters, including white blood cell count, neutrophil count, C-reactive protein and USG abdomen.

In recent years, several novel biomarkers—such as procalcitonin, interleukin-6, serum amyloid-A, granulocyte colony-stimulating factor and calprotectin have been proposed to improve diagnostic precision [2-9]. C-reactive protein (CRP) is an acute-phase reactant released into the bloodstream following infection, tissue injury, or

inflammatory processes. Numerous studies have shown that CRP levels rise in proportion to the degree of inflammation. CRP is commonly drawn for the workup of abdominal pain and although nonspecific, is frequently elevated in acute appendicitis [10].

Although the standard treatment for appendicitis is appendectomy, either laparoscopic or open, and it should be performed early to avoid major complications of appendicitis such as perforation of the appendix, gangrenous appendix and peritonitis. However, C-reactive protein (CRP) and other inflammatory markers that we evaluate can be useful in determining the severity of appendicitis in a patient. If CRP levels correlate with a more severe form of appendicitis, it may indicate the need for early surgical intervention. On the other hand, in some cases where CRP levels are relatively low, it raises the question of whether the patient could be managed conservatively and immediate surgery might be deferred. Nevertheless, the final clinical decision ultimately depends on the surgeon's judgment. However, CRP and other biomarkers can serve as valuable adjuncts in assisting clinicians to determine severity, the appropriate timing, stage and mode of treatment in patients with acute appendicitis.

Aims & Objectives: To evaluate the association between preoperative serum CRP levels and the severity of appendicitis in pediatric patients.

Material and Methods

This prospective observational study was conducted at a tertiary care medical college hospital in Western India from January 2025 to December 2025. A total of 106 pediatric patients diagnosed with acute appendicitis in the Department of Pediatric Surgery were included in the study. Out of 106 patients 99 were operated and 7 patients were managed with conservatively. The diagnosis of acute appendicitis was made based on clinical assessment supported by ultrasonography and, when required computed tomography. Preoperative laboratory parameters including C-reactive protein (CRP), total white blood cell (WBC) count, and neutrophil percentage were recorded for all patients.

All resected samples were subjected to histopathological examination to confirm the diagnosis and to categorize the cases as uncomplicated or complicated appendicitis. The collected data were compiled, reviewed and analyzed using Microsoft Excel. The association between inflammatory markers and the severity of appendicitis was evaluated.

Statistical Analysis: The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2019) and then exported to data editor page of SPSS version 19 (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were described as means and standard deviations or median and interquartile range based on their distribution. Qualitative variables were presented as count and percentages. For all tests, confidence level and level of significance were set at 95% and 5% respectively.

Results

A total of 106 pediatric patients with a clinical diagnosis of acute appendicitis were included in the study.

The age of patients ranged from 3 years to 14 years, with a mean age of 9.85 ± SD years (Table 1). There were 80 males (75.5%) and 26 females (24.5%), showing a clear male predominance with a male-to-female ratio of approximately 3.1:1 in our pediatric age group patients.

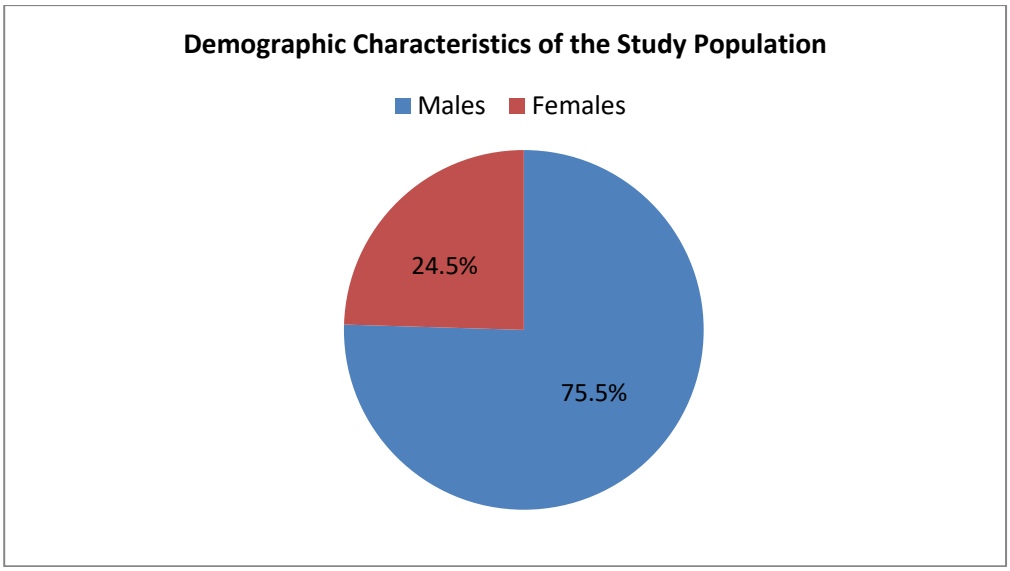

Figure 1: Demographic Characteristics of the Study Population

All patients presented with abdominal pain of varying severity. Pain intensity was categorized as mild, moderate or severe based on clinical assessment. Severe abdominal pain was observed in the majority of patients (~55–60%) followed by moderate pain (~25–30%) and mild pain (~15 20%). Severe pain was more frequently associated with longer duration of symptoms and accompanying systemic feature. Vomiting was present in most patients. The duration of vomiting ranged from 1 to 7 days, with the majority experiencing vomiting for 2–5 episodes. Patients with severe pain tended to have a longer duration of vomiting. Fever was documented in a significant proportion of patients. Most cases had mild-grade fever, while a smaller number presented with moderate fever. Fever duration commonly ranged from 2 to 7 days. The presence of fever was more frequently associated with severe pain and prolonged vomiting.

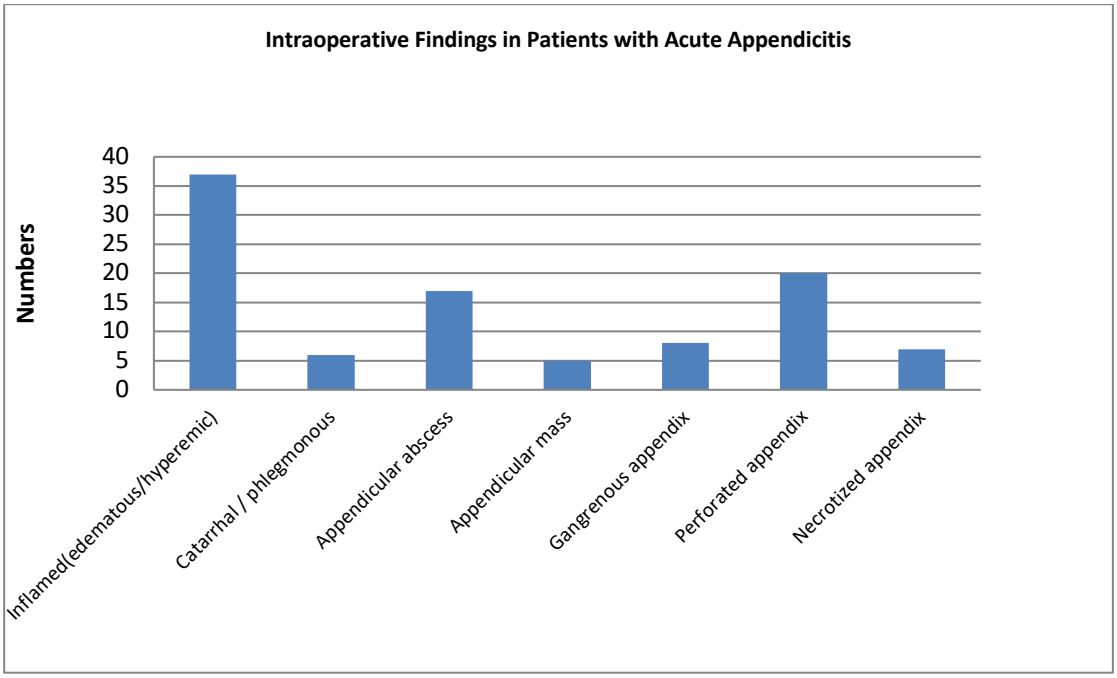

Figure 2: Intraoperative Findings in Patients with Acute Appendicitis

Among the 99 pediatric patients who were operated, the most common intra operative finding was an inflamed (edematous/hyperemic) appendix, observed in 37 patients (37.37%). Perforated appendix was noted in 20 patients (20.20%), followed by appendicular abscess in 17 patients (17.17%).

Gangrenous appendix was present in 8 patients (8.08%), while necrotized appendix was found in 7 patients (7.07%). Catarrhal/phlegmonous appendicitis was observed in 6 patients (6.06%), and appendicular mass was identified in 5 patients (5.05%).

These findings indicate that a substantial proportion of patients presented with complicated appendicitis, including perforation, abscess formation, gangrene, and necrosis. Additionally, seven patients were managed conservatively.

Table 1: Histopathological Examination (HPE) Findings

Histopathological Finding	Type	Number (n)	Percentage (%)
1.Normal appendix		2	02.02
2.Uncomplicated Appendicitis			
	Inflamed (edematous/hyperemic)	35	35.35
	Catarrhal / phlegmonous	6	06.06
3.Complicated Appendicitis			
	Gangrenous appendix	25	25.25
	Perforated appendix	20	20.20
	Necrotic appendix	12	12.12
Total		99	100

Histopathological examination demonstrated normal appendiceal histology in 2 (2.02%) patients. Uncomplicated appendicitis was identified in 41 (41.41%) cases, including inflamed (edematous/ hyperemic) appendices in 35 (35.35%) and catarrhal/phlegmonous appendicitis in 6 (6.06%) cases. Complicated appendicitis was present in 57 (57.57%) patients, of whom 25 (25.25%) had gangrenous appendicitis, 20 (20.20%) had perforated appendicitis and 12 (12.12%) had necrotic appendicitis.

These findings indicate a predominance of complicated appendicitis in the study cohort.

Table 2: Comparison of Inflammatory Markers between Uncomplicated and Complicated Appendicitis

Parameter	Uncomplicated (n=50)	Complicated (n=56)	p-value
WBC($\times10^3$/mm^3)	12.56 ± 3.04	18.88 ± 14.64	0.033
Neutrophils (%)	80.68 ± 7.41	84.96 ± 7.54	0.042
CRP (mg/L)	22.74 ± 17.80	101.38 ± 68.08	<0.001

Values expressed as Mean ± Standard Deviation.

Inflammatory markers were compared between uncomplicated (including those who were managed conservatively) and complicated appendicitis groups. The mean white blood cell (WBC) count in the uncomplicated appendicitis group was 12.56 ± 3.04 $\times10^3$/mm^3, whereas the complicated appendicitis group had a significantly higher mean WBC count of 18.88 ± 14.64 $\times10^3$/mm^3 (p=0.033). Similarly, the mean neutrophil percentage was higher in complicated appendicitis (84.96 ± 7.54%) compared to uncomplicated appendicitis (80.68±7.41%) (p=0.042). The C-reactive protein (CRP) level showed the most pronounced difference between the two groups. Patients with uncomplicated appendicitis had a mean CRP level of 22.74 ± 17.80 mg/L, whereas patients with complicated appendicitis had markedly elevated CRP levels with a mean value of 101.38 ± 68.08 mg/L, demonstrating a highly significant difference ($p < 0.001$).

Table 3: CRP Levels According to Severity of Appendicitis

Severity	Mean CRP (mg/L)
Inflamed appendix	18.6
Grossly inflamed appendix(Catarrhal/ phlegmonous)	27.3
Gangrenous appendix	94.1
Necrotised appendix	113.8
Perforated appendix	96.5

Relationship between C-reactive protein (CRP) and the severity of appendicitis: Analysis of CRP levels according to intra-operative severity demonstrated a progressive increase with worsening pathology. Patients with simple inflamed appendix had relatively low CRP levels, while gangrenous, necrotized, and perforated appendicitis were associated with markedly elevated CRP values. The highest CRP levels were observed in cases with necrotized appendix and perforated appendix associated with pus collection, indicating a strong association between CRP elevation and disease severity.

Overall, these findings suggest that CRP is a strong biochemical marker for predicting complicated appendicitis, with higher values correlating with increasing severity of appendiceal inflammation.

Discussion

Acute appendicitis is one of the most common surgical emergencies in children and remains a significant cause of acute abdominal pain requiring operative intervention. Early identification of complicated appendicitis is crucial, as delayed diagnosis may lead to serious complications such as gangrene, perforation, intra-abdominal abscess, and increased postoperative morbidity. In addition to clinical evaluation and imaging, laboratory inflammatory markers play an important role in supporting the diagnosis. Among these, white blood cell (WBC) count, neutrophil percentage, and C-reactive protein (CRP) are commonly used indicators of systemic inflammation and may also help in predicting the severity and progression of appendiceal disease. In the present study, inflammatory markers were found to be significantly higher in patients with complicated appendicitis compared to those with uncomplicated disease. Both the mean WBC count and neutrophil percentage were elevated in the complicated appendicitis group. However, CRP levels demonstrated the most marked difference between the two groups. These findings indicate that the systemic inflammatory response intensifies as the disease progresses from simple appendiceal inflammation to more advanced stages such as gangrene, necrosis, and perforation.

In the present study, total leukocyte count (WBC), neutrophil percentage, and C-reactive protein

(CRP) were evaluated as markers of severity in pediatric acute appendicitis. We observed that mean WBC was significantly higher in complicated appendicitis compared to uncomplicated cases ($18.88 \pm 14.64 \times 10^3/mm^3$ vs $12.56 \pm 3.04 \times 10^3/mm^3$; $p = 0.033$), suggesting an association between leukocytosis and increasing inflammatory severity. However, Mazhar et al. [11] reported no statistically significant difference in WBC between uncomplicated and complicated appendicitis. This discrepancy may be attributed to differences in sample size, patient characteristics, timing of presentation, and variability in disease severity. Delayed presentation in our cohort may have contributed to higher WBC levels in complicated cases. Furthermore, the wide standard deviation observed in the complicated group reflects heterogeneity in disease progression.

Neutrophil percentage was also significantly elevated in complicated appendicitis ($84.96 \pm 7.54\%$) compared to uncomplicated cases ($80.68 \pm 7.41\%$; $p = 0.042$), indicating a more intense acute inflammatory response. This finding is consistent with Grönroos, [14] who demonstrated that neutrophilia correlates with the severity of appendiceal inflammation. CRP emerged as the most reliable marker in the present study, with significantly higher levels in complicated appendicitis (101.38 ± 68.08 mg/L) compared to uncomplicated cases (22.74 ± 17.80 mg/L; $p < 0.001$). Additionally, CRP levels increased progressively with worsening intraoperative findings, with the highest values observed in gangrenous, necrotised, and perforated appendicitis. These findings are in agreement with Mazhar et al., [11] who also reported significantly elevated CRP levels in complicated cases, as well as with studies by Yu et al. [15] and Xharra et al., [16] demonstrating a strong association between CRP and advanced appendiceal disease.

Although WBC and neutrophil count are useful indicators of inflammation, their specificity is limited when used independently. Andersson [12] and Sack et al. [13] have reported that leukocytosis may be present in a wide range of inflammatory conditions, thereby reducing its predictive value for appendiceal perforation or severity. In contrast, CRP, as an acute-phase reactant, reflects the magnitude of tissue inflammation and necrosis more accurately.

Importantly, the combined use of WBC, neutrophil percentage, and CRP improves diagnostic accuracy and enhances the ability to differentiate between uncomplicated and complicated appendicitis. Similar observations have been reported by Kwan and Nager, [17] who demonstrated that combining these inflammatory markers significantly improves diagnostic performance in pediatric appendicitis.

Conclusion

The present study demonstrates that inflammatory biomarkers are significantly associated with the severity of acute appendicitis. Patients with complicated appendicitis showed significantly higher white blood cell counts, neutrophil percentages and C-reactive protein (CRP) levels compared with those having uncomplicated appendicitis.

Although WBC count and neutrophil percentage also demonstrated significant associations with appendiceal inflammation, their predictive value appears to be enhanced when used in combination with CRP levels.

Therefore, routine assessment of CRP, WBC and neutrophil percentage can provide useful adjunctive information in the early diagnosis and severity assessment of acute appendicitis. These markers may help clinicians identify complicated cases earlier, facilitate timely surgical intervention and potentially reduce morbidity associated with delayed treatment.

However, laboratory findings should always be interpreted in conjunction with clinical evaluation, imaging studies and operative findings to ensure accurate diagnosis and optimal patient management.

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