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Research Article

Serum Procalcitonin and C - reactive protein as Predictors of Severity and Outcomes in Pediatric Sepsis. A Cross-Sectional Clinical Study

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ABSTRACT

Background: Sepsis in children is a major cause of morbidity and mortality globally, especially in low- and middle-income countries where its early detection is challenging. Serum procalcitonin (PCT) and C-reactive protein (CRP) are now being used to determine disease severity and outcomes.

Aim: The aim of this study is to determine the diagnostic value of serum procalcitonin and C-reactive protein in the assessment of disease severity and prognosis of children with sepsis.

Methods: A cross-sectional study was conducted at Ghurki Trust Teaching Hospital, Lahore, Pakistan, from June 2023 to June 2025. One hundred children (1 month to 12 years) with sepsis were included. On admission, serum concentrations of PCT and CRP were determined. The severity of the disease and the outcome (recovery without complications, recovery with complications, and death) were used to categorise patients. Data were analysed with SPSS software version 26 (p-value < 0.05).

Results: Both biomarkers demonstrated significantly higher values in patients with severe sepsis compared to those with non-severe disease (PCT: 9.12 ± 2.36 vs 3.28 ± 1.21 ng/mL; CRP: 88.67 ± 17.54 vs 44.92 ± 13.18 mg/L; $p<0.001$). The highest levels were found in the group of patients who died (PCT: 11.02 ± 2.87 ng/mL; CRP: 94.67 ± 18.33 mg/L). Procalcitonin levels greater than 5 ng/mL were significantly associated with mortality (OR = 3.92, $p<0.001$), while a CRP level greater than 60 mg/L was significantly associated with complications (OR = 2.76, $p=0.003$).

Conclusion: Serum procalcitonin is a good predictor of severity and mortality, whereas C-reactive protein is more related to complications. The integration of these biomarkers may help to predict the risk of complications and guide management strategies in children with sepsis.

Keywords: Pediatric Sepsis, Procalcitonin, C-Reactive Protein, Biomarkers, Severity, Mortality, Inflammation.

INTRODUCTION

Sepsis in children is a serious and potentially life-threatening condition that occurs when the immune response to an infection goes into overdrive, resulting in excessive inflammation, cell injury, and varying degrees of organ dysfunction[1]. It continues to be a common cause of illness and death in children, particularly in low- and middle-income countries where early recognition and access to complicated health care are limited. Although there are advances in pediatric intensive care and antibiotics, early identification of severity remains a challenge because of the non-specific symptoms and rapid course of disease often observed in children[2].

The pathway to sepsis in children is intricate and comprises a balance of pro- and anti-inflammatory responses. After infection, the immune response by the host results in the release of inflammatory cytokines, which in turn cause endothelial dysfunction and changes in microvascular blood flow. This can lead to systemic inflammatory response syndrome, septic shock, and multiple organ dysfunction if not identified early. Given the dynamic nature of this process and its variability among patients, clinical signs and symptoms alone may not be enough to make early, accurate

predictions about the severity of illness and its outcome[4,5].

Over the past few years, there has been a growing interest in using laboratory biomarkers to guide clinical practice. In particular, serum procalcitonin and C-reactive protein have proven useful markers of inflammation. Procalcitonin, a precursor of the hormone calcitonin, is normally present in low concentrations in the blood but is elevated in bacterial infections. Its early rise after infection onset and high specificity for bacterial infections allow it to be used to gauge the severity of infection and disease course[6,7].

C-reactive protein (CRP), on the other hand, is an acute-phase protein produced by the liver in response to pro-inflammatory cytokines, such as interleukin-6. While not specific like procalcitonin and potentially elevated during various inflammatory processes, CRP is a marker of the magnitude of the inflammatory response and has been extensively used to assess disease severity and predict complications[8,9].

Given the distinct advantages and disadvantages of each of these biomarkers, their joint analysis may offer a more holistic assessment of disease burden. Combining both procalcitonin and C-reactive protein could improve the capacity to distinguish among the levels of severity, predict clinical outcomes, and help initiate appropriate treatment[10].

The current study aims to examine the associations between serum procalcitonin and C-reactive protein levels and disease severity and outcomes in children with sepsis. It also seeks to explore their relationship with complications and death, in an effort to enhance early risk stratification and guide therapeutic decision-making in children[11].

MATERIALS AND METHODS

A hospital-based cross-sectional study was conducted in the Department of Paediatrics at Ghurki Trust Teaching Hospital, Lahore, Pakistan, over two years from June 2023 to June 2025. Using a non-probability consecutive sampling method, 100 children with sepsis were recruited.

It included children between 1 month and 12 years of age with clinical signs and symptoms of sepsis. This included fever, tachycardia, changes in consciousness, and signs of systemic inflammatory response, in association with laboratory or microbiological evidence of infection. Sepsis was diagnosed as per established criteria in children, which includes the presence of systemic inflammatory response syndrome along with suspected or proven infection. To reduce confounding factors on inflammatory markers, patients with congenital or acquired immune deficiency, chronic inflammatory conditions, cancer, or chronic immunosuppressive drug use were excluded.

After obtaining parental or guardians' consent, baseline demographic and clinical data, including age, sex, presenting symptoms and signs, and medical history, were documented. During admission, blood samples were drawn aseptically for the measurement of serum procalcitonin (PCT) and C-reactive protein (CRP) levels. The levels of procalcitonin were measured using a quantitative immunoassay, while CRP was measured by a highly sensitive nephelometric assay. Laboratory tests were conducted in the institutional laboratory.

Clinical assessment allowed patients to be classified into two groups: non-severe sepsis and severe sepsis or septic shock. This was based on the presence of organ dysfunction, hemodynamic instability, and the need for intensive care. The outcomes of the patients were tracked during hospital stays and were grouped into three groups: full recovery, recovery with complications (respiratory, kidney, or brain dysfunction), and death.

Data were collected and analysed using the Statistical Package for Social Sciences (SPSS) version 26. Continuous variables were presented as means ± standard deviations, and categorical variables as frequencies and percentages. The independent sample t-test was used for comparing continuous variables, and the chi-square test for categorical variables. Logistic regression analysis was used to examine the association between serum procalcitonin and C-reactive protein levels with disease severity and mortality. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study examined 100 children with sepsis. The average age of patients was 5.1 ± 2.8 years. Among them, 56% were male, and 44% were female. According to the clinical classification, 58 patients (58%) were classified as non-severe sepsis, while 42 patients (42%) were classified as severe sepsis or septic shock. Procalcitonin and C-reactive protein concentrations in serum were significantly elevated in patients with severe disease as compared to those with non-severe disease.

The average procalcitonin level in the severe sepsis group was 9.12 ± 2.36 ng/mL, which was significantly higher than the level in the non-severe sepsis group (3.28 ± 1.21 ng/mL), with a p-value of <0.001. The same trend was observed for C-reactive protein, with significantly higher values found in patients with severe sepsis (88.67 ± 17.54 mg/L) as compared to those with non-severe sepsis (44.92 ± 13.18 mg/L), with again a statistically highly significant difference (p<0.001). These results suggest a strong correlation between the elevation of these biomarkers and the severity of sepsis in children, as shown in Table 1.

Table 1: Comparison of Serum Procalcitonin and CRP Levels According to Disease Severity

Variable	Non-Severe Sepsis (n=58)	Severe Sepsis (n=42)	p-value
Procalcitonin (ng/mL)	3.28 ± 1.21	9.12 ± 2.36	<0.001
C-Reactive Protein (mg/L)	44.92 ± 13.18	88.67 ± 17.54	<0.001

In terms of clinical outcomes, most children (70%) recovered without complications, 20% suffered clinical complications during their hospital stay, and 10% died. There was a gradual rise in both procalcitonin and C-reactive protein levels as the clinical status of the patients worsened. The lowest average procalcitonin concentration was found in patients with complete recovery (4.12 ± 1.38 ng/mL). Conversely, higher values were observed in those with complications (7.26 ± 2.11 ng/mL), and the highest levels were observed in those who died (11.02 ± 2.87 ng/mL). This trend was also observed with C-reactive protein, with higher values in patients with poor outcomes, demonstrating greater inflammatory response in complicated cases and deaths. These data are detailed in Table 2.

Table 2: Serum Procalcitonin and CRP Levels According to Clinical Outcomes

Outcome	Number of Patients (n)	PCT (ng/mL)	CRP (mg/L)
Recovery without complications	70	4.12 ± 1.38	49.83 ± 14.26
Recovery with complications	20	7.26 ± 2.11	76.45 ± 15.92
Mortality	10	11.02 ± 2.87	94.67 ± 18.33

Further evaluation based on predefined biomarker thresholds demonstrated a significant predictive relationship with clinical outcomes. Elevated procalcitonin levels (above 5 ng/mL) were significantly associated with increased mortality, while higher C-reactive protein (above 60 mg/L) was predictive of complications. These results were supported by multivariate logistic regression. Procalcitonin levels were independently associated with death (OR = 3.92, 95% CI: 1.85-8.31, p<0.001). On the other hand, elevated CRP levels were independently linked to the development of complications (OR = 2.76, 95% CI: 1.33-5.74, p=0.003). These findings underline the different, yet complementary, predictive value of these two biomarkers in predicting clinical outcomes, as shown in Table 3.

Table 3: Logistic Regression Analysis of Predictors of Outcomes

Variable	Outcome	Odds Ratio (OR)	95% CI	p-value
PCT >5 ng/mL	Mortality	3.92	1.85–8.31	<0.001
CRP >60 mg/L	Complications	2.76	1.33–5.74	0.003

To provide a comparison of the biomarker concentrations with clinical outcomes, a bar graph was generated. This shows the gradual rise in concentrations of PCT and CRP in patients who recovered, who had complications, and those who died, suggesting their strong association with clinical outcomes (Figure 1).

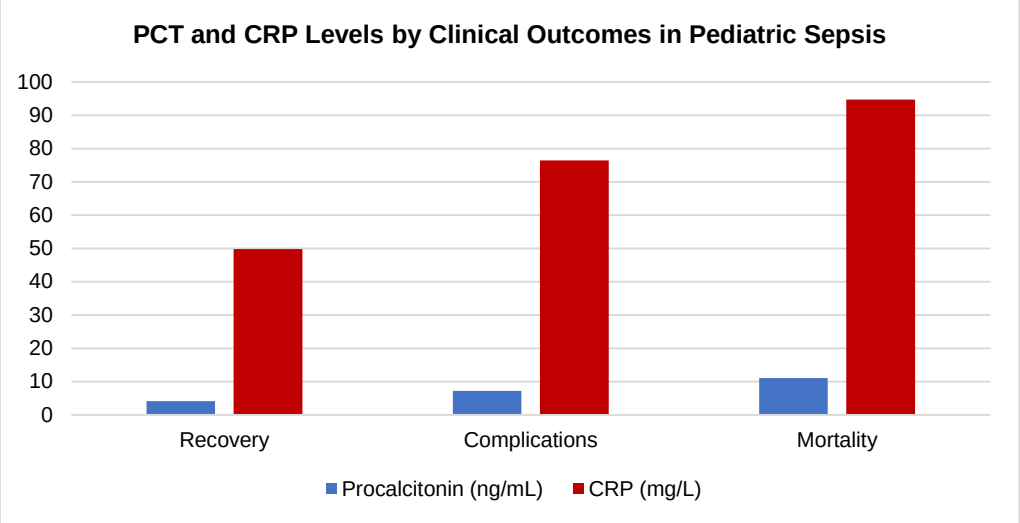

Figure 1: Mean Serum Procalcitonin and CRP Levels Across Clinical Outcome Groups

The graphical representation further supports the statistical findings, demonstrating that both biomarkers increase proportionally with disease severity and poor outcomes. Notably, procalcitonin shows a higher rise in mortality and confirms its ability to predict mortality, while CRP is associated with systemic inflammation and is more associated with complications. Taken together, these findings clearly demonstrate the importance of early measurement of these biomarkers for the treatment of sepsis and the prediction of patient outcomes.

DISCUSSION

The results of the current study underline the value of using procalcitonin and C-reactive protein concentrations for the assessment of disease severity and prediction of clinical outcomes in children with sepsis[7]. The two biomarkers showed a distinct positive trend as disease severity increased, with much higher concentrations among children with severe disease and those who died. By contrast, lower levels were observed in those with less severe disease or in those who survived[8].

These findings highlight the value of including biomarker measurements in clinical assessments, as they offer objective evidence to support early identification of patients at risk. The strong association between high levels of the biomarkers and poor outcomes indicates that procalcitonin and C-reactive protein can be used for risk assessment and prognosis in children with sepsis[9,10].

Procalcitonin was a good indicator of severity/mortality. Its elevated levels in severe sepsis and non-survivors demonstrate its significant association with systemic bacterial infection and the degree of host inflammatory response[11]. This is because the response of PCT to bacterial endotoxins and pro-inflammatory cytokines is swift and provides a more dynamic reflection of disease severity than other markers. The significant association of PCT concentrations exceeding the established cut-off with the risk of death in this study further suggests its utility as an independent predictor, rendering it a useful early marker of critically ill children[12].

C-reactive protein (CRP) was also found to be strongly associated with the severity of disease, although not as specific as PCT[13]. CRP was associated with complications in particular and, as such, it may be a more suitable marker of the inflammatory process and subsequent tissue damage, rather than a predictor of short-term death. Its gradual rise and slow decline in inflammation make it a good biomarker for monitoring disease course and response to therapy. CRP is widely accessible and is an inexpensive marker, especially in low-resource settings[14].

An important finding of this study is that PCT and CRP are complementary. While PCT was a better predictor of death, CRP was useful in predicting inflammatory complications[15]. Using these two markers increases the information about the patient and enables clinicians to stratify between different degrees of severity and predict poor outcomes. Using these two markers together can inform the decision-making regarding intensive care unit admission, escalation of care, or requiring closer monitoring[16].

Our findings are consistent with other published studies that show PCT is a more specific marker for bacterial infection and CRP is a non-specific

marker for inflammation[17]. However, this study adds to the evidence base by looking at children in a developing country, where the earlier the diagnosis, the better. This study shows the practicality of using these biomarkers in clinical practice and the value of early treatment[18].

This study has some limitation; the cross-sectional design of the study does not allow assessment of changes in these biomarkers[19]. This may provide more information regarding disease progression and response to treatment. Also, the single-center study with a limited sample size may limit the generalizability of the findings. It is recommended that larger sample sizes, longitudinal data, and multi-center studies are required to validate these findings[20].

CONCLUSION

Procalcitonin and C-reactive protein (CRP) can predict the severity, complications, and death of septic children. The use of PCT and CRP can be used together to risk-stratify at an early point, to facilitate decision-making and treatment. The inclusion of the use of these markers in the protocol may reduce the morbidity and mortality of pediatric sepsis.

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Author Contributions

Conceptualization: TM, KZ
Methodology: MIY, LZ
Data Collection: ZN, GA
Statistical Analysis: MIY
Manuscript Writing: TM, KZ
Critical Review and Final Approval: All authors

Conflict of Interest

The authors declare no conflict of interest.

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