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Original Research Article

Comparative Diagnostic Accuracy of Procalcitonin and CRP for the Early Identification of Sepsis in ICU Patients

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Abstract:

Background: Sepsis is a major cause of mortality among critically ill patients, and early detection is essential for improving outcomes. Biomarkers such as procalcitonin (PCT) and C-reactive protein (CRP) are increasingly used for sepsis identification. This study evaluates the diagnostic performance of PCT and CRP in differentiating septic from non-septic ICU patients.

Methods: A cross-sectional analytical study was conducted over one year in a tertiary care hospital, including 184 critically ill ICU patients. Serum PCT and CRP levels were measured within 24 hours of admission. Sepsis was diagnosed using Sepsis-3 criteria, supported by SOFA scoring and culture reports. Data were analyzed using SPSS 26, with $p < 0.05$ considered statistically significant.

Results: Procalcitonin and CRP levels were significantly higher in septic patients compared to non-septic patients ($p < 0.001$). PCT showed superior diagnostic accuracy with an AUC of 0.90, compared to CRP with an AUC of 0.79. Elevated biomarker levels were also associated with increased mortality, with non-survivors exhibiting markedly higher values. PCT demonstrated the strongest correlation with adverse outcomes.

Conclusion: Procalcitonin is a more accurate and reliable biomarker than CRP for early sepsis detection and mortality prediction in critically ill patients.

Keywords: Sepsis, Procalcitonin, C-reactive protein, Biomarkers, ICU, Diagnostic accuracy.

Introduction

Sepsis remains one of the most challenging global health concerns, accounting for millions of deaths each year despite progress in critical care and antimicrobial management [1]. It is now understood as a multifaceted condition triggered by an abnormal and dysregulated immune response to infection, ultimately leading to organ dysfunction. Early recognition is essential because any delay in identifying sepsis or initiating treatment markedly increases mortality, prolongs hospitalization, and escalates healthcare expenditures [2]. The difficulty lies in its often vague and overlapping clinical manifestations, which resemble those seen in trauma, burns, postoperative states, or autoimmune disorders. As a result, depending solely on clinical signs or routine laboratory markers such as fever or white blood cell counts can be insufficient, leading to delayed or missed diagnoses [3]. This challenge has intensified interest in biomarkers that can reflect the underlying inflammatory activity associated with sepsis [4]. Among the many biomarkers investigated over time, CRP and PCT have emerged as the most widely applicable in clinical practice due to their availability, consistency, and well-characterized biological behavior [5].

CRP, first identified in 1930, is an acute-phase reactant synthesized by the liver in response to cytokines such as IL-6, IL-1β, and TNF-α. Its levels can rise dramatically within 24–48 hours of an inflammatory insult, yet its broad responsiveness limits its specificity since elevations occur not only in bacterial infections but also in viral illnesses, autoimmune disorders, trauma, and postoperative recovery [6,7]. Nonetheless, repeated CRP measurements can provide useful prognostic information, especially when levels remain elevated, suggesting ongoing infection or inadequate therapeutic response [8]. Procalcitonin (PCT), conversely, has gained recognition as a more specific marker of bacterial infection. Under normal conditions, its production is minimal, but during systemic bacterial invasion, multiple organs begin synthesizing PCT in response to endotoxins and pro-inflammatory cytokines, leading to a rapid rise within a few hours and a peak within 6–12 hours [9,10]. Higher concentrations often parallel

increasing disease severity, especially in severe sepsis and septic shock [11]. Viral infections typically inhibit PCT production through interferon-gamma, giving it greater specificity for bacterial etiologies. Using CRP and PCT together enhances the accuracy of sepsis diagnosis and helps differentiate it from non-infectious SIRS [12,13]. This study aims to evaluate and compare the diagnostic and prognostic value of PCT and CRP in critically ill patients suspected of sepsis.

Materials and Methods

Study Setting: This cross-sectional analytical study was conducted over a period of one year at a tertiary care hospital.

Sample Size: A total of 184 critically ill patients admitted to the Intensive Care Unit (ICU) were included in the study. Participants were selected through non-probability consecutive sampling, ensuring that all eligible patients during the study period were recruited.

Inclusion Criteria

- Patients aged 18 years and above,
- Individuals admitted to the ICU with a clinical suspicion of infection or sepsis based on systemic inflammatory response indicators, and
- Patients for whom serum procalcitonin (PCT) and C-reactive protein (CRP) measurements were available within the first 24 hours of admission.

Exclusion Criteria

- Patients who had been on antibiotic therapy for more than 48 hours before ICU admission,
- Those diagnosed with chronic inflammatory or autoimmune disorders,
- Patients with advanced hepatic failure or who had undergone major surgery within the previous week, and

Data Collection: Prior to data collection, approval was obtained from the institutional ethics committee. Due to the critical status of the participant's, informed consent was obtained from the attendants or legally authorized representatives. Comprehensive clinical information—including demographic details, presenting illness, comorbidities, vital parameters, and indicators of organ dysfunction—was documented using a structured proforma. Blood samples were collected within 24 hours of ICU admission. Serum PCT levels were estimated using an automated immunoassay based on electrochemiluminescence, while CRP levels were measured through a high-sensitivity immunoturbidimetric method. Sepsis was diagnosed according to the Sepsis-3 definition, characterized by life-threatening organ dysfunction associated with infection, reflected by a rise of ≥2 points in the SOFA score. Additional investigations, including blood cultures and other microbial tests (urine, sputum, wound swabs), were performed to confirm infectious etiology.

Data Analysis: Statistical analysis was carried out using SPSS version 26. Continuous variables, such as age, PCT, and CRP values, were expressed as mean ± standard deviation, whereas categorical variables like gender, infection source, and sepsis status were presented as frequencies and percentages. Between-group comparisons of continuous variables were performed using the independent-sample t-test, and associations between categorical variables were assessed using the chi-square test. A p-value <0.05 was considered statistically significant.

Results

The demographic characteristics show that septic patients tended to be older and had a slightly higher proportion of hypertension, diabetes, smoking, and chronic kidney disease compared to the non-septic group. Males formed the majority in both groups. These comorbidities, particularly hypertension and chronic kidney disease, were more prevalent among septic patients, reflecting their higher vulnerability to severe infections (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics (N = 184)

Variable	Total (N=184)	Septic Group (N=127)	Non-Septic Group (N=57)
Age (years), mean ± SD	59.8 ± 14.0	62.0 ± 13.6	55.0 ± 13.1
Gender — Male, n (%)	112 (60.8%)	75 (59.1%)	37 (64.9%)
Hypertension, n (%)	122 (66.3%)	88 (69.2%)	34 (59.6%)
Diabetes mellitus, n (%)	110 (59.8%)	77 (60.6%)	33 (57.9%)
Smoking history, n (%)	53 (28.8%)	40 (31.4%)	13 (22.8%)
Chronic kidney disease, n (%)	57 (31.0%)	43 (33.9%)	14 (22.8%)

Procalcitonin levels were markedly higher in the septic group compared to the non-septic group, showing a significant difference and reinforcing its utility as a bacterial infection marker. CRP values also demonstrated a statistically meaningful elevation in septic patients. Both biomarkers, therefore, showed strong discriminatory ability in distinguishing septic from non-septic critically ill patients (Table 2).

Table 2: Serum Procalcitonin and CRP Levels in Septic and Non-Septic Groups (N = 184)

Marker	Total (N=184)	Septic Group (N=127)	Non-Septic Group (N=57)	p-value
Procalcitonin (ng/mL), mean ± SD	5.3 ± 3.0	7.7 ± 4.4	2.2 ± 1.0	<0.001
C-Reactive Protein (mg/L), mean ± SD	97.5 ± 44.8	112.2 ± 52.1	76.5 ± 31.5	<0.001

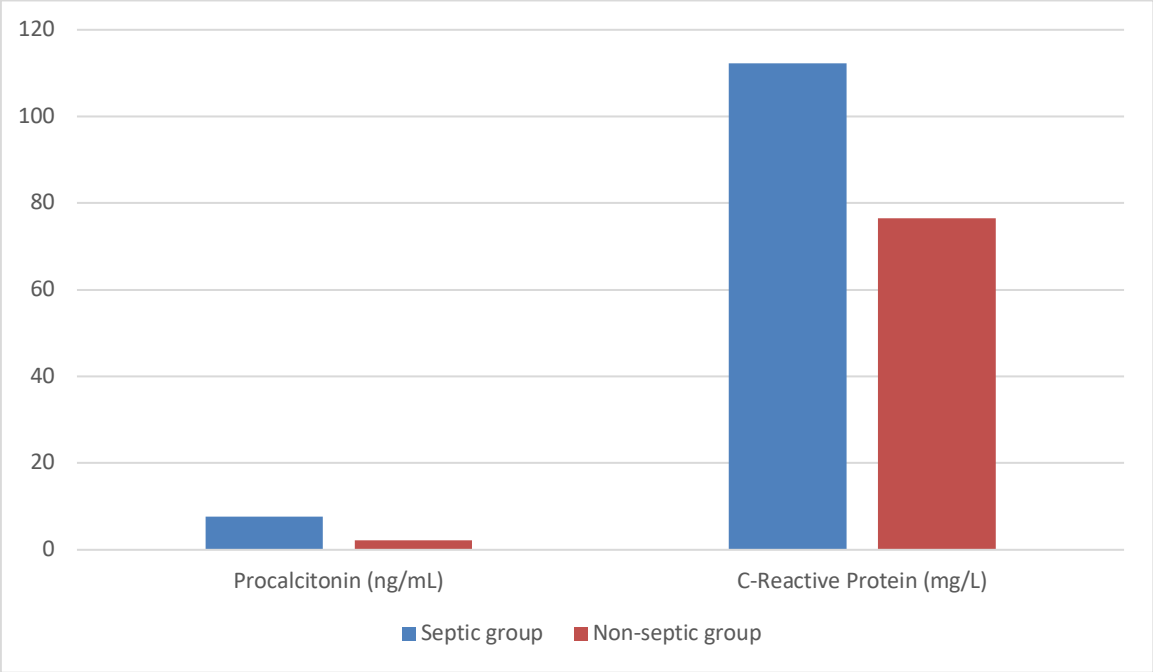

Figure 1: Serum Procalcitonin and CRP Levels in Septic and Non-Septic Groups

Procalcitonin demonstrated superior diagnostic accuracy, reflected in higher sensitivity, specificity, predictive values, and AUC compared to CRP. Its AUC nearing 0.90 indicates excellent ability to differentiate septic from non-septic patients, whereas CRP showed moderate diagnostic performance. These findings highlight procalcitonin as a more reliable biomarker for early sepsis identification (Table 3).

Table 3: Diagnostic Accuracy of Procalcitonin and CRP

Marker	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC (95% CI)
Procalcitonin	86.5	80.5	91.0	76.0	0.90 (0.86–0.93)
C-Reactive Protein	79.5	70.1	84.2	64.1	0.79 (0.74–0.83)

Non-survivors had significantly higher procalcitonin and CRP levels compared to survivors, with PCT showing the strongest association with mortality. This suggests that elevated biomarker levels, particularly procalcitonin, correlate with worse outcomes and may help identify patients at higher risk of deterioration (Table 4).

Table 4: Mortality and Biomarker Levels

Marker	Survivors (N=160)	Non-Survivors (N=24)	p-value
Procalcitonin (ng/mL), mean ± SD	4.8 ± 2.9	8.5 ± 4.8	<0.001
C-Reactive Protein (mg/L), mean ± SD	95.5 ± 42.8	124.0 ± 55.0	0.014

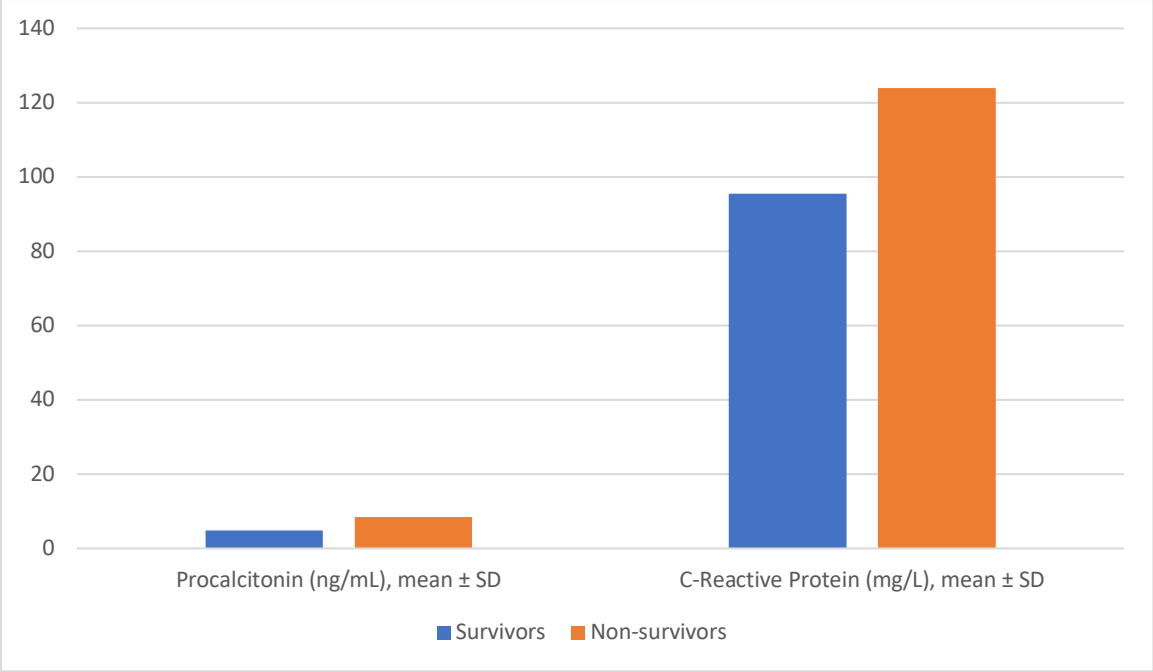

Figure 2: Correlation between biomarkers and mortality.

Discussion

Sepsis continues to be a major contributor to critical illness–related deaths, making its timely identification essential for improving clinical outcomes. The present study evaluated the role of serum procalcitonin (PCT) and C-reactive protein (CRP) as early diagnostic markers of sepsis in critically ill patients admitted to a tertiary care ICU. Our findings indicate that both biomarkers were significantly elevated in the septic group compared with non-septic patients, with PCT demonstrating a clearer diagnostic advantage. This aligns with previous literature emphasizing the superior specificity of PCT for bacterial infections relative to CRP, which functions primarily as a nonspecific inflammatory marker [14]. In our study population, mean PCT levels were notably higher in septic patients (7.7 ± 4.4 ng/mL) than in those without sepsis (2.2 ± 1.0 ng/mL), and the marker showed strong diagnostic accuracy with a sensitivity of 86.5% and specificity of 80.5%. These results parallel earlier evidence by Nauclér et al. (2016) and Schuetz et al. (2017), who demonstrated that PCT rises rapidly following the onset of bacterial infection and performs reliably in distinguishing systemic infection from other inflammatory states. The rapid elevation of PCT and its correlation with the clinical progression of sepsis support its utility as a frontline diagnostic tool compared with traditional markers such as CRP, which may be elevated regardless of infection status [15].

CRP, although widely used, lacks the specificity required to conclusively differentiate between bacterial and non-bacterial causes of inflammation. In our cohort, septic patients exhibited higher CRP concentrations (112.2 ± 52.1 mg/L) compared with non-septic individuals (76.5 ± 31.5 mg/L); however, its diagnostic performance (AUC = 0.79) was less robust than that of PCT. This is consistent with earlier studies highlighting that while CRP is sensitive to inflammatory activity, it is influenced by a wide range of non-infectious conditions, including autoimmune disorders, trauma, and viral infections [17–19]. As a result, CRP alone may not provide sufficient discriminatory capability during the early evaluation of suspected sepsis. Nonetheless, the upward trend of CRP among septic individuals suggests that it remains useful for monitoring systemic inflammation over time.

The relationship between biomarker levels and sepsis severity was evident in our study. Patients with mild sepsis demonstrated comparatively lower PCT (approximately 4.1 ± 2.2 ng/mL) and CRP (about 97 ± 46 mg/L) levels, whereas those with severe sepsis had substantially elevated values (PCT: 11.2 ± 5.1 ng/mL; CRP: 136 ± 59 mg/L). These gradients support prior observations linking higher biomarker concentrations with increasing disease severity, organ dysfunction, and poorer clinical trajectories [20]. Thus, both PCT and CRP can serve as adjunctive markers not only in the initial diagnosis but also in tracking disease progression and therapeutic response in critically ill patients.

Mortality analysis also revealed a clear association between elevated biomarker levels and adverse outcomes. Non-survivors exhibited substantially higher PCT (8.5 ± 4.8 ng/mL) and CRP (124.0 ± 55.0 mg/L) compared to survivors, reinforcing the prognostic significance of these inflammatory markers. These findings correspond with previous

reports identifying raised PCT levels as an indicator of increased mortality risk in septic patients [21]. Collectively, the results of this study confirm that while both CRP and PCT are valuable in assessing systemic inflammation, PCT remains the more precise and clinically informative biomarker for early detection, severity stratification, and prognosis in sepsis.

Conclusion

This study demonstrates that serum procalcitonin and C-reactive protein are valuable biomarkers for the early identification of sepsis in critically ill patients, with procalcitonin showing superior diagnostic accuracy, stronger discriminatory power, and a closer association with mortality than CRP. Elevated levels of both markers were significantly correlated with sepsis and adverse outcomes, indicating their potential role not only in early diagnosis but also in risk stratification. Given its higher sensitivity, specificity, and predictive values, procalcitonin emerges as a more reliable tool for distinguishing septic from non-septic patients, thereby aiding in timely clinical decision-making and improving patient management in the ICU setting.

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