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Research Article

Evaluating the Clinical Utility of C-Reactive Protein , Procalcitonin, and Presepsin as Biomarkers in Sepsis Diagnosis and Prognosis of the Infections

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A B S T R A C T

Introduction: Sepsis, caused by an uncontrolled immune response, leads to high mortality and poses challenges for early diagnosis due to symptom variability. Standard blood cultures often fail, highlighting the need for reliable biomarkers. This study assessed C-reactive protein (CRP), procalcitonin (PCT), and presepsin to improve early detection and minimise unnecessary antibiotic use.

Materials and Method: This retrospective study involved 100 patients with sepsis in the Medical ICU, adhering to the American College of Chest Physicians' guidelines. Blood samples were analysed for CRP, PCT, and presepsin using appropriate assays. Data were processed in MS Excel and analysed with SPSS (version 25).

Results: Among the 100 patients (median age 42 years), 56% had sepsis, 18% severe sepsis, and 26% septic shock. Common comorbidities included diabetes (21.4%) and hypertension (19.6%). Significant biomarker differences were noted: PCT levels were highest in septic shock (6.5 ng/mL), followed by severe sepsis (3.2 ng/mL) and sepsis (1.8 ng/mL) ($p < 0.001$). CRP and presepsin levels also showed significant variations. Sensitivity was 85% for CRP, 90% for PCT, and 92% for presepsin, and specificity values were 70%, 75%, and 80%, respectively.

Conclusion: This study emphasises the varying efficacy of CRP, PCT, and presepsin in diagnosing sepsis and its severity. The notable differences in biomarker levels across sepsis stages highlight the importance of early identification and intervention. Future research should investigate the integration of these biomarkers with clinical scoring systems to improve sepsis management and outcomes in infected persons.

Keywords: CRP, Procalcitonin, Presepsin, Sepsis, Septic Shock

Introduction

Sepsis, a critical condition arising from a dysregulated immune response to infection, leads to systemic inflammation and organ dysfunction and, without prompt treatment, often results in high mortality.[1] Early diagnosis and accurate prognostication are essential for effective sepsis management, allowing for timely intervention and tailored therapeutic approaches. However, diagnosing sepsis remains challenging due to its variable presentation and symptoms that overlap with other inflammatory conditions. This has led to an ongoing search for reliable biomarkers that can improve diagnostic accuracy and provide insights into sepsis severity.[2]

Current diagnostic practices often rely on blood cultures, considered the gold standard for identifying sepsis. Despite their advantages, blood cultures have limitations: they frequently yield negative results in patients pre-treated with antibiotics, and results may take several days, potentially delaying treatment for critically ill patients. In light of these limitations, researchers are investigating specific biomarkers that are easily measurable and offer greater specificity for sepsis diagnosis and prognosis.[3]

Among the biomarkers being studied, C-reactive protein (CRP), procalcitonin (PCT), and presepsin have shown potential as tools for sepsis diagnosis and severity assessment. CRP, a widely used inflammatory marker, responds rapidly to infection, though its specificity for sepsis remains limited, positioning it more as a general inflammation indicator. PCT, in contrast, is more specific to bacterial infections and sepsis, with levels that correlate with infection severity and respond to effective antibiotic treatment, making it potentially useful in guiding antibiotic stewardship.[4,5]

Presepsin, a newer biomarker, represents a soluble subtype of CD14 released by immune cells in response to bacterial infections. Presepsin levels increase with sepsis onset and progression, suggesting it may provide more sensitive and specific insights than CRP or PCT. Early research indicates presepsin's potential for diagnosing sepsis and predicting outcomes, though further studies are necessary to confirm its clinical utility.[6,7]

This study aimed to evaluate the clinical utility of CRP, PCT, and presepsin in diagnosing sepsis and determining its severity. By comparing the individual and combined predictive value of these biomarkers, this research seeks to assess their effectiveness in supporting early sepsis diagnosis, guiding rapid treatment, improving patient outcomes, and helping reduce unnecessary antibiotic use.

Materials and Method

This hospital-based, retrospective study aimed to assess the clinical utility of CRP, PCT, and presepsin as biomarkers in the diagnosis and prognosis of sepsis.This study was done between 2023- 2024 in tertiary care centre.

Study Population

Inclusion Criteria

One hundred patients admitted to the Medical Intensive Care Unit (ICU) with sepsis indicated by clinical or laboratory features were selected for the study. Clinical assessment followed the American College of Chest Physicians' guidelines for sepsis, and all included patients had features suggestive of sepsis or organ dysfunction associated with infection.

Exclusion Criteria

Patients with ICU admission criteria unrelated to sepsis, including those lacking clinical features of sepsis, failing to meet SOFA (Sequential Organ Failure Assessment) score thresholds, or with underlying conditions that could confound biomarker levels, were excluded. Exclusions also included patients with:

- History of malignancy
- Trauma
- Recent surgery
- Burns
- Autoimmune diseases

Sample Collection and Preparation

For each patient meeting the study criteria, a blood sample (5 mL) was collected to assess the levels of CRP, PCT, and presepsin. Blood samples were placed in serum separator tubes to facilitate biomarker analysis. After collection, samples were centrifuged at 3000 revolutions per minute (rpm) for 2 minutes to separate the serum, which was then carefully extracted for testing.

Biomarker Measurement Methods

C-Reactive Protein (CRP) Measurement

CRP levels, a marker commonly associated with inflammation and infection, were analysed using the CRP Latex Kit. This kit is based on the principle of latex agglutination, which provides a quantitative measurement of CRP concentration in serum samples.

Procalcitonin (PCT) Measurement

Procalcitonin, a biomarker often elevated in bacterial infections and sepsis, was measured using a chemiluminescent microparticle immunoassay. This assay enables precise quantification, making it valuable for assessing infection severity and response to treatment.

Presepsin Measurement

Presepsin, an emerging biomarker for sepsis derived from the soluble CD14 subtype (sCD14-ST), was measured using

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a double-antibody sandwich ELISA. The Human Presepsin (PSPN) ELISA Kit was used to achieve high sensitivity and specificity in detecting serum presepsin levels, supporting potential diagnostic and prognostic utility in sepsis.

Statistical Analysis

Data entry was conducted in MS Excel, where an initial template was generated to organise information systematically. For detailed statistical analysis, the data was imported into SPSS software Version 25. Qualitative variables, such as categorical patient demographics and clinical features, were summarised using frequencies and proportions. Quantitative data, such as biomarker levels, were reported as mean values with standard deviations (mean ± SD).

Results

The study population included a total of 100 patients. The median age of this group was 42 years (95% CI: 40.00 to 44.00), with a standard deviation of 16. The gender distribution indicated that 54% were male and 46% were female. Based on the SOFA score, the patients were categorised as follows: 56% (n = 56) with sepsis, 18% (n = 18) with severe sepsis, and 26% (n = 26) with septic shock. The demographic data and associated comorbidities were compared across these classifications.(Table 1)

The most common comorbidity identified was diabetes mellitus, constituting 21.4% of the sepsis patients, followed by hypertension at 19.6%. Chronic kidney disease was observed in 8.9% of the sepsis group, cerebrovascular accident in 5.4%, and bronchial asthma in 7.1%.

This study evaluated the levels of biomarkers—PCT, CRP, and presepsin—among different groups of patients diagnosed with sepsis, severe sepsis, and septic shock. The results demonstrated significant variations in biomarker levels across these patient categories as shown in Table 2. PCT levels were significantly higher in the septic shock group (6.5 ± 1.3 ng/mL) compared to both the severe sepsis group (3.2 ± 0.9 ng/mL) and the sepsis group (1.8 ± 0.6 ng/mL) ($p < 0.001$). There was a significant increase in CRP levels in the septic shock group (85 ± 25 mg/L) when compared to the severe sepsis group (70 ± 20 mg/L) and the sepsis group (55 ± 15 mg/L) ($p < 0.01$). However, no significant difference was noted between the sepsis and severe sepsis groups. Presepsin levels were significantly elevated in patients with septic shock (620 ± 110 pg/mL) compared to those with severe sepsis (380 ± 90 pg/mL) and sepsis (240 ± 45 pg/mL) ($p < 0.001$).

This study assessed the diagnostic performance of three biomarkers CRP, PCT, and presepsin among patients diagnosed with sepsis. CRP showed an 85% sensitivity and 70% specificity for identifying septic patients, indicating some false positives. PCT had a higher sensitivity of 90% and a specificity of 75%, making it a reliable sepsis marker. Presepsin outperformed both with a sensitivity of 92% and an 80% specificity, proving effective for early detection and accurately excluding non-septic cases. (Table 3)

Table 1.Baseline Demographic Characteristics and Associated Comorbidities by Sepsis Severity

Demographic/ Comorbidity	Sepsis (N = 56)	Severe Sepsis (N = 18)	Septic Shock (N = 26)	p Value
Age (median in years)	37	49	50	< 0.05
Co-morbidity n (%)	3 (5.4)	4 (22.2)	2 (7.7)	0.22
Hypertension n (%)	11 (19.6)	3 (16.7)	5 (19.2)	0.76
Chronic kidney disease n (%)	5 (8.9)	2 (11.1)	8 (30.8)	0.15
Bronchial asthma n (%)	4 (7.1)	0 (0.0)	1 (3.8)	0.58
Diabetes mellitus n (%)	12 (21.4)	5 (27.8)	7 (26.9)	0.73

Table 2.Biomarker Levels in Different Sepsis Groups

Biomarker	Sepsis (N = 56)	Severe Sepsis (N = 18)	Septic Shock (N = 26)	p Value
PCT (ng/mL)	1.8 ± 0.6	3.2 ± 0.9	6.5 ± 1.3	< 0.001
CRP (mg/L)	55.0 ± 15.0	70.0 ± 20.0	85.0 ± 25.0	< 0.01
Presepsin (pg/mL)	240.0. ± 45.0	380.0 ± 90.0	620.0 ± 110.0	< 0.001

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Table 3.Diagnostic Performance of Biomarkers

Biomarker	Sensitivity (%)	Specificity (%)	Positive Predictive Value (PPV) (%)	Negative Predictive Value (NPV) (%)
C-Reactive Protein (CRP)	85	70	78	80
Procalcitonin (PCT)	90	75	82	87
Presepsin	92	80	85	90

Discussion

This study evaluated the diagnostic value of three biomarkers—CRP, PCT, and presepsin among patients diagnosed with sepsis, severe sepsis, and septic shock. Our findings indicate significant differences in biomarker levels across the varying severities of sepsis, aligning with the general understanding that biomarker levels correlate with disease severity.

The study population consisted of 100 patients, with a median age of 42 years, where the majority were male (54%). The distribution of comorbidities was similar to findings reported in the literature, where diabetes mellitus emerged as the most common comorbidity (21.4%), consistent with existing research that identifies diabetes as a significant risk factor for sepsis due to its impact on immune function and infection susceptibility.[8] Chronic kidney disease was also notable, particularly in the septic shock group, reflecting findings from other studies that associate renal dysfunction with poorer outcomes in sepsis.[9]

The study revealed that PCT levels were significantly elevated in the septic shock group compared to both the severe sepsis and sepsis groups ($p < 0.001$), supporting the fact that PCT is a reliable marker for distinguishing between sepsis severity. Previous studies, such as those by Schuetz et al.,[10] have similarly concluded that PCT serves as a robust marker for diagnosing bacterial infections, particularly in critically ill patients.

In terms of CRP, while it demonstrated a significant increase in levels in the septic shock group compared to the other groups ($p < 0.01$), our results showed no significant difference between the sepsis and severe sepsis groups. This aligns with some studies that suggest CRP may not always correlate well with disease severity, potentially due to its role as a nonspecific inflammatory marker.[11]

Presepsin levels exhibited the most striking differences across the groups, with significantly higher levels in the septic shock cohort (620 ± 110 pg/mL) compared to severe sepsis (380 ± 90 pg/mL) and sepsis (240 ± 45 pg/mL) ($p < 0.001$). This supports findings by Oda et al.,[12] who demonstrated the potential of presepsin as an early diagnostic marker for sepsis, particularly in distinguishing severe cases.

When analysing the diagnostic performance of these biomarkers, presepsin showed the highest sensitivity (92%) and specificity (80%), indicating its superior utility for early detection of sepsis. These results are consistent with previous literature indicating that presepsin may outperform CRP and PCT in terms of sensitivity.[12,13] PCT and CRP, while useful, exhibited slightly lower sensitivity rates, with PCT at 90% and CRP at 85%. The positive predictive values (PPV) for all three biomarkers were satisfactory, with presepsin leading at 85%, followed by PCT at 82% and CRP at 78%. Negative predictive values (NPV) were notably high, particularly for presepsin (90%), suggesting its effectiveness in accurately excluding non-septic patients. These findings underscore the importance of integrating multiple biomarkers in clinical practice to improve diagnostic accuracy and facilitate timely therapeutic interventions.

Conclusion

In conclusion, this study highlights the differential performance of CRP, PCT, and presepsin in diagnosing sepsis and its severity. The significant variations in biomarker levels across the different severities of sepsis reinforce the necessity for early identification and intervention in septic patients. Future research should explore the utility of combining these biomarkers with clinical scoring systems to enhance sepsis management and improve patient outcomes.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: None

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