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Research Article

Comparative Evaluation of Procalcitonin and C-Reactive Protein as Biomarkers in Suspected Sepsis

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Abstract

Background: Sepsis is a life-threatening condition associated with high morbidity and mortality, particularly in intensive care units. Early diagnosis remains challenging due to non-specific clinical features and delays in blood culture results. Biomarkers such as procalcitonin (PCT) and C-reactive protein (CRP) have emerged as useful tools for early detection and assessment of sepsis severity. **Objective:** To evaluate the diagnostic utility of PCT and CRP in suspected sepsis cases and to correlate these biomarkers with total leucocyte count (TLC), blood culture findings, and severity of sepsis. **Methods:** This retrospective study included 80 adult ICU patients with suspected sepsis at a tertiary care hospital. PCT levels were measured using fluorescence immunoassay, CRP by latex agglutination, and TLC via automated hematology analyzer. Blood cultures were performed using the BACTEC system. Statistical analysis included correlation and significance testing. **Results:** PCT was positive (≥0.5 ng/mL) in 71.2% of patients. Culture positivity was observed in 53.8% of cases, predominantly with gram-negative organisms, especially Escherichia coli. CRP showed a significant positive correlation with PCT at higher levels ($r = 0.640$, $p < 0.00001$), while TLC showed poor correlation. Both PCT and CRP levels increased with sepsis severity. **Conclusion:** PCT, in combination with CRP, serves as a reliable biomarker for diagnosing and assessing the severity of sepsis, whereas TLC has limited utility. A combined biomarker approach improves diagnostic accuracy in clinical practice

Keywords:
Sepsis; Procalcitonin (PCT); C-reactive protein (CRP); Biomarkers; Leukocyte Count

Introduction

Sepsis is a life-threatening condition that contributes significantly to mortality in intensive care units (ICUs),

accounting for approximately one-third of deaths. In the absence of appropriate treatment, sepsis can progress to multi-organ dysfunction and septic shock. It is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection.[1] Sepsis is responsible for substantial morbidity, mortality, and healthcare expenditure worldwide.

Sepsis is often characterized by non-specific clinical features, making early diagnosis challenging. However, early detection and timely intervention significantly improve clinical outcomes.[2] Although blood culture remains the gold standard for the diagnosis of sepsis, delays in obtaining results and the risk of contamination limit its utility in early diagnosis.[3] Therefore, biomarkers such as C-reactive protein (CRP) and procalcitonin (PCT) are increasingly used as surrogate markers for sepsis.[4] Sepsis is a major global healthcare problem characterized by an inflammatory response to microbial infection leading to organ dysfunction. It has also been described as systemic inflammatory response syndrome (SIRS) associated with an infectious process and carries a high risk of morbidity and mortality if treatment is delayed. Several biomarkers—including interleukins (IL-2 and IL-6), tumor necrosis factor-alpha (TNF-α), leukotrienes, acute-phase proteins such as CRP, and adhesion molecules—have been studied for their role in predicting the severity of sepsis and guiding management, though with variable results.[5]

Recently, procalcitonin (PCT) has emerged as a promising biomarker with significant utility in guiding therapeutic decisions in sepsis management. This study was designed to compare the diagnostic efficacy of PCT and CRP as markers of sepsis and to correlate these biomarkers with blood culture findings, clinical parameters, and sepsis severity scores in a tertiary care hospital setting. PCT is a relatively novel laboratory marker that has demonstrated considerable value worldwide in this context.

Total leucocyte count (TLC) and CRP are also commonly used biomarkers of inflammation; however, neither achieves 100% sensitivity. CRP levels tend to rise slowly during bacterial infections, which may result in false-negative results in the early stages of disease.[6] Additionally, CRP may be elevated in viral infections, limiting its ability to distinguish between bacterial and viral etiologies. Various studies have highlighted their roles in inflammatory conditions and infections.[7] The present study was therefore designed to determine PCT levels in patients with suspected sepsis and to evaluate the correlation of PCT with CRP and total leucocyte count (TLC).

Materials and Methods

Study Design and Setting

A retrospective study was conducted in the Departments of Microbiology and Biochemistry at Shri Shankaracharya Institute of Medical Sciences (SSIMS), Bhilai, Chhattisgarh, India. The study was carried out after obtaining approval from the Institutional Scientific Committee and the Institutional Ethics Committee. Written informed consent was obtained from all patients or their legally authorized representatives.

A total of 80 patients were included in the study. The sample size was calculated based on the prevalence of suspected sepsis cases in the hospital using the Yamane equation. Data were collected from adult patients aged more than 18 years who were admitted to the Intensive Care Unit (ICU) and fulfilled the American College of Chest Physicians (ACCP) criteria for the diagnosis of sepsis.

Inclusion Criteria

Patients were included if they had a suspected or proven source of infection along with two or more of the following clinical features:

- Temperature >38°C (100.4°F) or <36°C (96.8°F)
- Heart rate >90 beats per minute
- Respiratory rate >20 breaths per minute or $PaCO_2$ <32 mmHg
- White blood cell (WBC) count >12,000/mm³ or <4,000/mm³, or >10% band forms

Exclusion Criteria

Patients with cardiogenic shock, recent major surgery, severe trauma, severe burns, small cell lung carcinoma, or medullary carcinoma of the thyroid were excluded from the study, as procalcitonin (PCT) levels may be non-specifically elevated in these conditions.

Measurement of PCT, CRP, and Other Laboratory Parameters

- Procalcitonin levels were measured using a fluorescence immunoassay (FIA) meter (Finecare) with a rapid quantitative test. A PCT value of >0.5 ng/mL was considered significant, as per the manufacturer's instructions.
- C-reactive protein (CRP) levels were measured using a latex agglutination test. Total leucocyte count (TLC) was determined using an automated hematology analyzer.
- Blood cultures were performed using the automated BACTEC BD system under strict aseptic conditions.

Table 1: Grouping of sepsis based on PCT values

PCT (ng/ml)		Interpretation
<0.5		Local bacterial infection
0.5-1.9		Systemic infection cannot be excluded
2-10		Sepsis
>10	Severe bacterial sepsis or septic shock	

Statistical Analysis

Data were analyzed using both descriptive and inferential statistical methods. Descriptive statistics included mean, percentage, standard deviation, and range. Inferential statistics included correlation analysis, Z-test, and Chi-square test. A p-value of <0.05 was considered statistically significant.

Results

The study included 80 patients, comprising 44 (55%) males and 36 (45%) females. The mean age of the study population was 52.9 years. Patients were categorized into four groups based on procalcitonin (PCT) levels and severity of sepsis. A PCT value of ≥0.5 ng/mL was considered positive for sepsis. PCT was positive in 57 patients. The minimum PCT value observed was 0.1 ng/mL, while the maximum was 100 ng/mL, with a mean value of 12.73 ng/mL.

Table 2: Distribution of Procalcitonin Levels

PCT (ng/mL)	<0.5	0.5–1.9	2–10	>10
No. of Samples (%)	23 (28.8%)	17 (21.3%)	18 (22.5%)	22 (27.5%)
Mean ± SD	0.26 ± 0.08	1.19 ± 0.24	4.74 ± 0.79	41.8 ± 2.7

Table 3: Culture Characteristics, Isolate Distribution, and Biomarker Comparison (n = 80)

S. No.	Parameter	Category/Organism	Number (n)	Percentage (%)	Mean PCT (ng/mL)
1	Culture Result	Culture Positive	43	53.8	—
		No Growth	37	46.2	—
2	Sample Type (n = 43)	Urine	16	37.2	—
		Sputum	9	20.9	—
		Pus	7	16.3	—
		Blood	6	13.9	—
		Multiple Samples	5	11.6	—
3	Gram Stain (n = 43)	Gram Negative	35	81.4	11.2
		Gram Positive	8	18.6	16.1
4	Common Organisms	Escherichia coli	25	58.1	—
		Klebsiella pneumoniae	8	18.6	—
		Pseudomonas aeruginosa	3	6.9	—

Out of 80 cases, 43 (53.8%) were culture-positive, while 37 (46.2%) showed no growth. Among the 43 isolates, the majority were obtained from urine (37.2%), followed by sputum (20.9%), pus (16.3%), blood (13.9%), and multiple samples (11.6%). Gram-negative organisms predominated (81.4%), while gram-positive organisms accounted for 18.6% of isolates. The most common pathogen identified was Escherichia coli (58.1%), followed by Klebsiella pneumoniae (18.6%) and Pseudomonas aeruginosa (6.9%). The mean PCT level in gram-negative infections (11.9 ng/mL) was lower compared to gram-positive infections (16.2 ng/mL); however, this difference was not statistically significant.

Table 4: Distribution of CRP and TLC Levels with Reference to PCT Values

S. No.	PCT (ng/mL)	No. of Samples	CRP (mg/L) Mean ± SD	TLC (cells/mm³) Mean ± SD
1	<0.5	25	10.2 ± 0.82	10,703.3 ± 483.4
2	0.5–1.9	17	13.8 ± 1.8	12,602 ± 2023.6
3	2–10	17	14.4 ± 1.9	14,288.5 ± 1219.03
4	>10	21	21.7 ± 3.8	12,610.8 ± 2024.4

CRP and TLC levels were analyzed across the four PCT groups. The CRP values ranged from 6 mg/L to 92 mg/L, while TLC ranged from 4,320 to 39,100 cells/mm³.

Table 5: Correlation of PCT with CRP and TLC

PCT Range	Parameter	CRP (r-value)	TLC (r-value)
>0.5	Correlation coefficient	-0.14583	-0.00829
	P-value	0.290857	0.551734
0.5–2	Correlation coefficient	0.06641	-0.1087
	P-value	0.672258	0.4906

PCT Range	Parameter	CRP (r-value)	TLC (r-value)
2–10	Correlation coefficient	0.31985	0.1571
	P-value	0.036571	0.314376
>10	Correlation coefficient	0.64044	-0.1521
	P-value	0.00001	0.297131
Overall	Correlation coefficient	0.252	-0.021
	P-value	0.001	0.7748

CRP demonstrated a progressive increase in correlation with rising PCT levels. At lower PCT ranges (>0.5 and 0.5–2 ng/mL), the correlation was weak and not statistically significant. In the 2–10 ng/mL range, a moderate positive and statistically significant correlation was observed ($r = 0.31985$, $p < 0.05$). This correlation became strong and highly significant at PCT levels >10 ng/mL ($r = 0.64044$, $p < 0.00001$). Overall, CRP showed a significant positive correlation with PCT ($r = 0.252$, $p = 0.001$).

In contrast, TLC showed poor, inconsistent, and statistically non-significant correlations across all PCT ranges, suggesting that CRP is a more reliable marker than TLC for assessing the severity of sepsis.

Discussion

Procalcitonin (PCT) is widely used as both a diagnostic and prognostic biomarker in various clinical conditions, particularly bacterial sepsis. It also serves as an indicator of disease severity, and PCT clearance has been utilized to assess patient recovery from sepsis.[8]

In the present study, the mean age of the study population was 55 years. Approximately 21.3% of patients had PCT levels in the range of 0.5–1.9 ng/mL, 22.5% in the range of 2–10 ng/mL, and 27.5% had levels >10 ng/mL. A similar distribution has been reported in studies conducted globally. A study from the United States reported a higher incidence of sepsis in patients aged above 57 years,[9] while an epidemiological study from India reported a mean age of 58.17 years in patients with severe sepsis.[10]

In the current study, 43 (53.8%) patients had positive blood cultures, while 37 (46.2%) had sterile cultures, with a statistically significant difference ($p < 0.05$). Among culture-positive cases, the most common isolate was Escherichia coli (54.21%), followed by Klebsiella pneumoniae (19.28%) and Pseudomonas aeruginosa (6.02%).

In our study, PCT levels were higher in gram-positive infections (16.1 ng/mL) compared to gram-negative infections (11.2 ng/mL); however, this difference was not statistically significant. The mean CRP and total leucocyte count (TLC) levels also did not differ significantly between different organisms. Similar to our findings, Tanrıverdi et al. reported that PCT was superior to CRP in predicting bacterial infections in patients with acute exacerbation of chronic obstructive pulmonary disease.[11] In contrast, Titova et al. observed that PCT had comparable accuracy to CRP and white blood cell count in predicting pneumonia in such patients.[12]

In the present study, patients with septic shock demonstrated significantly higher PCT and CRP levels compared to those with sepsis, with strong statistical significance ($p < 0.0001$).

Comparable findings were reported by Lipinska-Gediga et al.[13] Additionally, a study from Maharashtra showed that PCT had a stronger correlation with sepsis severity compared to CRP.[14] Nargis et al. also reported that both PCT and CRP levels were significantly elevated in sepsis, severe sepsis, and septic shock ($p < 0.01$), with PCT demonstrating superior diagnostic performance over CRP.[15]

Correlation analysis in the present study revealed that CRP had a positive and statistically significant correlation with PCT, particularly in higher PCT ranges and in patients with severe sepsis and septic shock ($p < 0.05$ and $p < 0.00001$, respectively). In contrast, TLC showed a weak and inconsistent negative correlation with PCT, which was not statistically significant. These findings suggest that CRP, when used in conjunction with PCT, is a better predictor of sepsis severity compared to TLC.[16] Similar observations were made by Menka et al., who concluded that CRP and PCT are useful predictors of sepsis, whereas white blood cell counts do not show a reliable correlation.[17] The limitations of the present study include a relatively small sample size and its retrospective design. Additionally, other promising biomarkers such as presepsin and serum lactate were not evaluated.

Conclusion

Procalcitonin, in combination with CRP, serves as a more reliable diagnostic tool for sepsis. However, their correlation with TLC remains poor. Given the absence of a single ideal biomarker, this study emphasizes the importance of using a combination of biomarkers for the accurate diagnosis and assessment of sepsis.

References

1. Kim MHH, Choi JHH. An Update on Sepsis Biomarkers. Infection & Chemotherapy. 2020;52(1):1–18.
2. Bagshaw SM, Bellomo R. Early diagnosis of acute kidney injury. Current Opinion in Critical Care. 2007;13(6):638–644.
3. Chung TP, Laramie JM, Province M, Cobb JP. Functional genomics of critical illness and injury. Critical Care Medicine. 2002;30(Suppl.):S51–S57.
4. Castelli GP, Pognani C, Meisner M, Stuani A, Bellomi D, Sgarbi L. Procalcitonin and C reactive protein during systemic inflammatory response syndrome, sepsis and organ dysfunction. Crit Care. 2004;8(4):R234–R242.
5. Bagshaw SM, Bellomo R. Early diagnosis of acute kidney injury. Current Opinion in Critical Care. 2007;13(6):638–644.
6. Hofer N, Zacharias E, Müller W, Resch B. An Update on the Use of C-Reactive Protein in Early-Onset Neonatal Sepsis: Current Insights and New Tasks. Neonatology. 2012;102(1):25–36.
7. Azzini AM, Dorizzi RM, Sette P, Vecchi M, Coledan I, Righi E, et al. A 2020 review on the role of procalcitonin in different clinical settings: an update conducted with the tools of the Evidence Based Laboratory Medicine. Annals of Translational Medicine. 2020;8(9):610–627.
8. Mehanic S, Baljic R. The Importance of Serum Procalcitonin in Diagnosis and Treatment of Serious Bacterial Infections and Sepsis. Materia Socio Medica. 2013;25(4):277–281.
9. Epidemiology of Sepsis in the United States from 1979 through 2000. New England Journal of Medicine. 2003;348(16):1546–1554.
10. Todi S, Chatterjee S, Bhattacharyya M. Epidemiology of severe sepsis in India. Critical Care. 2007;11(Suppl 2):S25–S26.

11. Tanrıverdi H, Örnek T, Erboy F, Altınsoy B, Uygur F, Atalay F, et al. Comparison of diagnostic values of procalcitonin, C-reactive protein and blood neutrophil/lymphocyte ratio levels in predicting bacterial infection in hospitalized patients with acute exacerbations of COPD. Wiener klinische Wochenschrift. 2015;127(19-20):756–763.
12. Titova E, Christensen A, Henriksen AH, Steinshamn S, Åsberg A. Comparison of procalcitonin, C-reactive protein, white blood cell count and clinical status in diagnosing pneumonia in patients hospitalized with acute exacerbations of COPD: A prospective observational study. Chronic Respiratory Disease. 2019;16:147997231876976.
13. Lipi□ska-Gediga M, Mierzchała-Pasierb M, zyna Durek G. Procalcitonin kinetics – prognostic and diagnostic significance in septic patients. Archives of Medical Science. 2016;12(1):112–119.
14. Patil HV, Patil VC. Comparative Study of Procalcitonin and C-Reactive Protein in Patients with Sepsis. J Nat Sc Biol Med. 2020;11(2):93–102.
15. Nargis W, Ibrahim M, Ahamed BU. Procalcitonin versus C-reactive protein: Usefulness as biomarker of sepsis in ICU patient. International Journal of Critical Illness and Injury Science. 2014;4(3):195– 199.
16. Sharma S, Duggal N. Role of procalcitonin, Il- 6 and C- reactive protein in suspected cases of sepsis. Indian Journal of Pathology and Microbiology. 2019;62(4):578–581.
17. Menka K, Tanu R, Gn G, S R. C Reactive and Procalcitonin Correlation with WBC Counts in Culture Positive Patients of Sepsis. Med J Clin Trials Case Stud. 2019;3:1–6