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The Value of Using Procalcitonin Instead of CRP as A Biomarker of Sepsis in Hospitalized Patients in Al-Ahrar Teaching Hospital

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ABSTRACT

Background: Sepsis remains a major cause of morbidity and mortality in hospitalized patients, particularly in intensive care units (ICUs). Defined as a life-threatening organ dysfunction caused by a dysregulated host response to infection, early recognition and prompt treatment are critical to improving outcomes. In resource-constrained hospitals**,** accurate and timely diagnosis is especially vital to guide antibiotic stewardship and reduce unnecessary healthcare costs. Procalcitonin, the precursor of the hormone calcitonin, is produced in response to bacterial endotoxins and pro-inflammatory cytokines. Unlike CRP, PCT is more specific to bacterial infections and less influenced by viral infections or sterile inflammation.

Objectives: Based on blood culture results, this study aimed to evaluate the diagnostic utility of PCT and CRP as early indicators of infection in terms of their capacity to forecast sepsis, intending to assess the benefits of routinely diagnosing sepsis in low-resource hospitals using PCT rather than CRP.

Patients and Methods: In one hundred hospitalized patients suspected to have sepsis, PCT levels were compared to CRP levels in relation to results of blood culture.

Results: 15% of hospitalized patients with suspected sepsis had a positive blood culture. Compared to CRP, which had sensitivity, specificity, positive predictive value, negative predictive value, and area under the curve of 18.5%, 89.1%, 66.6%, 48.2%, and 0.640, respectively, PCT had these values at 33.3%, 98.3%, 93.3%, 67%, and 0.854.

Conclusion: PCT is found to be superior to CRP in terms of accuracy and specificity, and more reliable marker in identification of sepsis in hospitalized patient.

Keywords: Sepsis, PCT, CRP, Hospitalized patients.

INTRODUCTION

Sepsis, a life-threatening condition associated with organ dysfunction due to an irregular response to infection, it is related to high rates of morbidity, mortality, and health service costs [(1)].

Patients with sepsis have symptoms of tachypnea, tachycardia, fever, and elevated WBC count [(2)].

Early diagnosis of patients with sepsis must be taken seriously to reduce comorbidities, acute comorbid illness, the length, and the cost of hospitalization itself [(3)]. Hence, there has been always a rising interest in providing evidence-based tools to diagnose and manage septic patients in hospitals and evaluate the accuracy of these tools [(4)]. A non-specific acute phase reactant, C-reactive protein (CRP) can increase 10,000-fold in reaction to severe illness, sepsis, or tissue injury. CRP has a role in getting rid microorganisms and necrotic tissue by actuating cytotoxic cascades [(5)]. In routine practice, CRP is commonly used as a diagnostic tool for infection, as a marker for disease severity, also in the evaluation of the therapeutic effect of antibiotic therapy [(6)].

Procalcitonin (PCT) is the prohormone of calcitonin, secreted by several types of cells from many organs in the proinflammatory process, especially bacterial infection [(7)].

A clinically significant bacterial infection that requires antibiotic treatment is indicated by a PCT value more than 0.1 ng/mL. If its concentration gets more than 0.5 ng/mL, severe sepsis or septic shock should be considered [(8)].

Based on blood culture results, this study aimed to evaluate the diagnostic utility of PCT and CRP as early indicators of infection in terms of their capacity to forecast sepsis, intending to assess the benefits of routinely diagnosing sepsis in low-resource hospitals using PCT rather than CRP.

PATIENTS AND METHODS

Our study was performed during the period from October 2024 to February 2025 in Clinical Pathology Department, Al-Ahrar Teaching Hospital, Zagazig, Egypt. This study included one hundred hospitalized patients suspected to have sepsis, at the first day of signs and symptoms of sepsis their procalcitonin and C-reactive protein level was measured and blood culture was done. Comparing the results of procalcitonin and CRP in relation to the blood culture result, and calculating specificity and sensitivity of each test was also done.

After reviewing the medical history of the participants, patients with hypertension, diabetes mellitus, inflammatory disease, cardiovascular disease, cancers, strokes were excluded.

History including: age, gender, smoking, personal habits, was also obtained.

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Blood samples of patients was collected as follow:

1. **Serum sample:**

Three milliliters of venous blood were drawn into plain tubes, let to stand at room temperature for fifteen minutes, and then centrifuged for five minutes at 3000 rpm in order to extract the serum.

The same serum sample was used to assess the PCT and CRP values using sandwich immunoassay with the VITROS system (Ortho-Clinical Diagnostics, USA) and enzyme-linked fluorescence assay with the VIDAS system (bioMerieux Co., Lyon, France), respectively.

2. **Blood culture:**

2 samples from each patient were taken from different sites, skin was meticulously prepared prior to venipuncture to prevent contamination of the specimen. Specimen was taken before the start of antimicrobial therapy. To ensure accurate test results, the right amount of blood must be extracted into each blood culture bottle based on the bottle's size. The bottle, which contained a broth medium that supports bacterial growth, was incubated in a standard incubator and checked every day for indications of growth by subculturing on chocolate MacConkey agar.

Ethical approval:

All the participant gave their informed consent. The General Organization of Teaching Hospitals and Institutes' Ethical Committee gave its approval to the study (IRB number HAH00047-16/10/2024). The Declaration of Helsinki was followed when conducting the study.

Statistical analysis

SPSS version 16 was used to analyze the data. Mean values and their standard deviation as well as median values were computed for all continuous results. Frequency and percentage were computed for categorical parameters. P value < 0.05 was considered significant.

RESULTS

Table 1 displays the sampled population's distribution by PCT categories. As a function of PCT level, CRP values rose from Group 1 to Group 5, and the group differences were statistically significant (P < 0.05). Group 1 has procalcitonin levels < 0.05 ng/mL, Group 2 has levels 0.05-0.49 ng/mL, Group 3 has levels 0.5-1.99 ng/mL, Group 4 has levels 2-9.99 ng/mL, and Group 5 has levels > 10 ng/mL (Table 1 and Fig. 1).

Table 1: Distribution of sample population in accordance with the categorized groups of procalcitonin level

Groups	Total (n)	Results of Blood Culture (n)				CRP (mg/dl)	
		Negative	Negative rate	Positive	Positive rate	Mean ± SD	Median
1	6	6	100	0	0	7.8±4.5	8
2	42	41	97.6	1	2.4	8.8±3.7	8
3	23	18	78.3	5	21.7	11.8±4.0	10
4	15	11	73.3	4	26.7	10.3±4.5	11
5	14	9	64.3	5	35.7	13.8±5.1	14
Total	100	85	85	15	15	10.4±4.5	10

SD: Standard deviation.

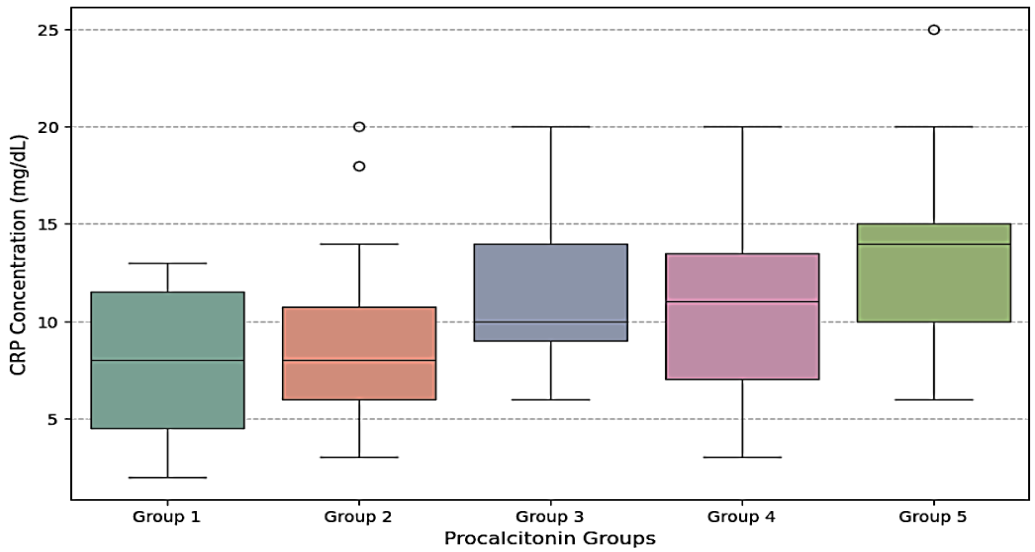


Fig. 1: Boxplot illustrates the CRP concentration levels (in mg/dL) for five procalcitonin groups, highlighting differences in central tendency, variability, and distribution.

Out of the 85 blood culture findings, 15 were positive and the rest were negative. The positive and negative blood culture groups had median PCT values of 7 and 0.3 ng/ml (Fig. 2) and median CRP values of 11 and 10 mg/dl (Fig. 3). The positive blood culture group had greater levels of both PCT and CRP than the negative group, although the difference was only statistically significant for PCT ($P < 0.01$) and not for CRP ($P = 0.07$).

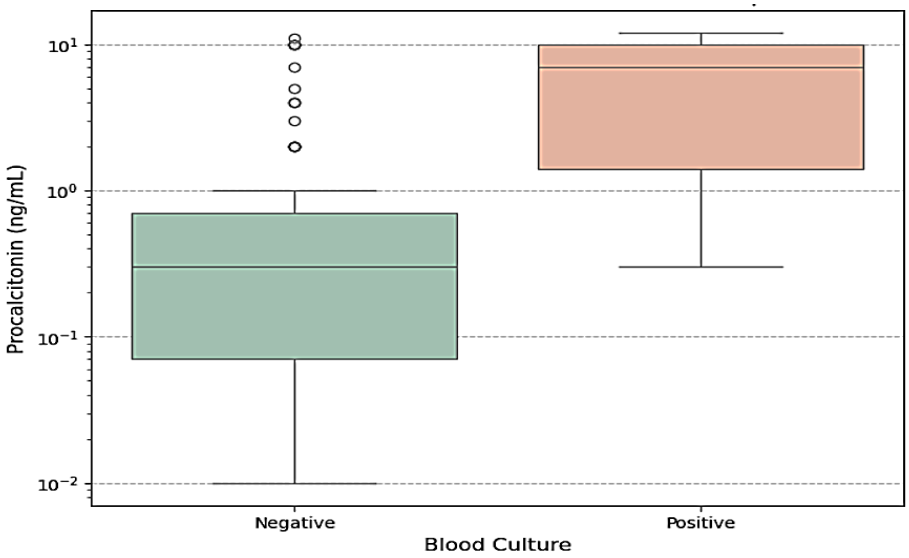


Fig. 2: Boxplot compares procalcitonin levels (ng/mL) in two blood culture groups: Negative and Positive.

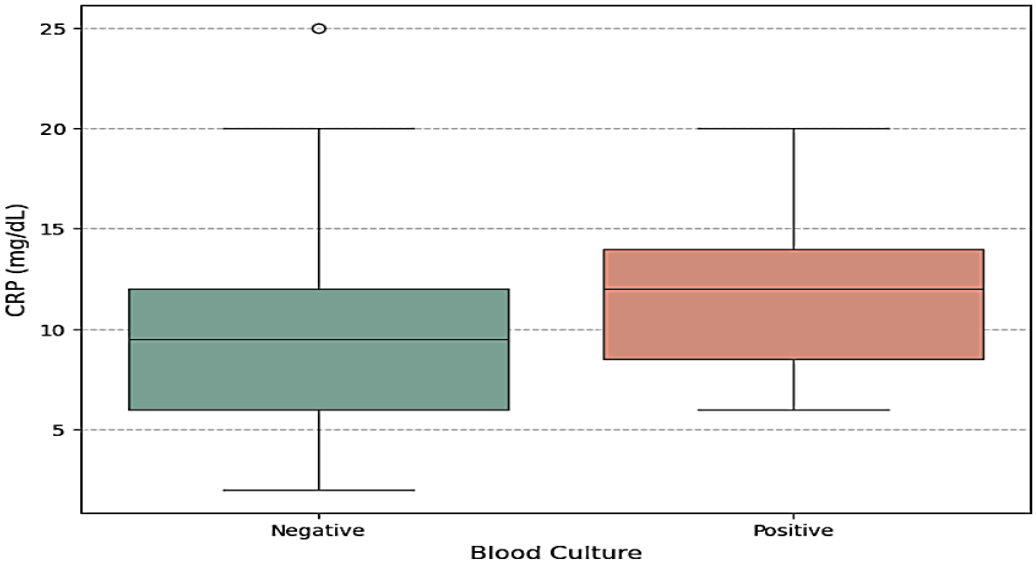


Fig. 3: Boxplot compares C-reactive protein (CRP) levels (mg/dL) between two blood culture statuses: Negative and Positive.

The AUC of PCT was higher than that of CRP, according to a ROC curve analysis used to evaluate the predictive value of PCT and CRP for sepsis ($P < 0.01$, Fig. 4 and table 2).

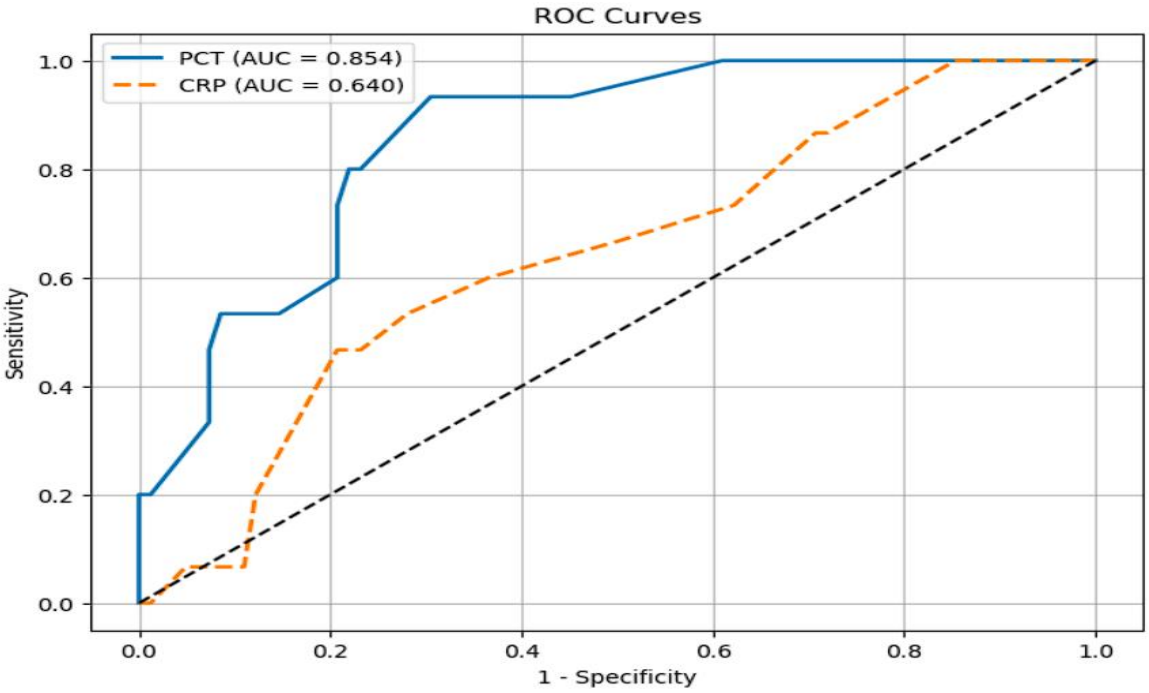
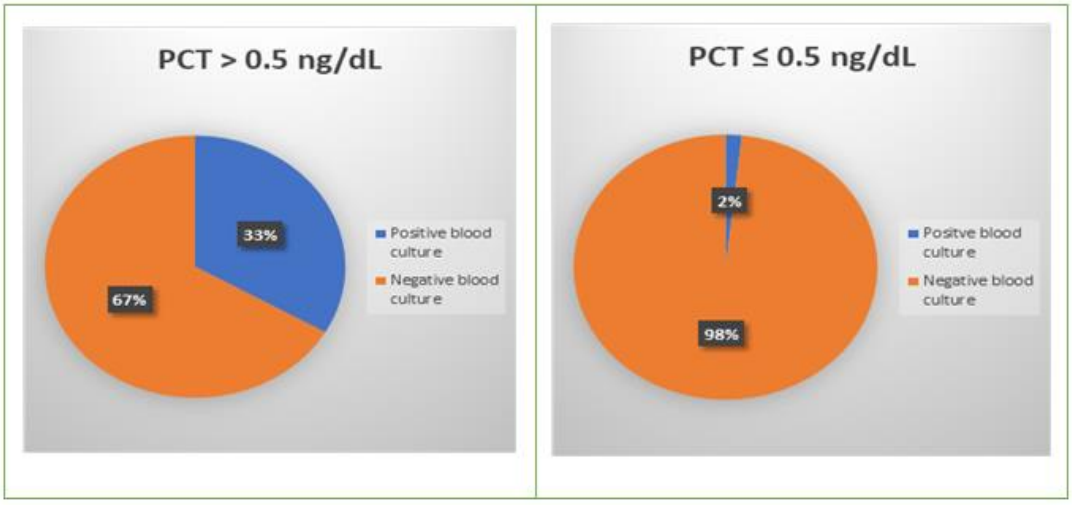


Figure 4: Procalcitonin (PCT) and C-reactive protein (CRP) receiver operating characteristic curves for sepsis prediction.

Table 2: Procalcitonin (PCT) and C-reactive protein (CRP) receiver operating characteristic curves for sepsis prediction.

	AUC	Standard deviation	Approximate 95% confidence interval	
			lower	upper
PCT	0.854	3.559	- 4.8	9.1
CRP	0.640	4.515	1.4	19.1

Using a PCT cut-off value of 0.5 ng/dL, we undertook PCT analysis and subsequently stratified our population into two groups: patients with PCT values ≤0.5 ng/dL and patients with PCT values >0.5 ng/dL (Fig. 5). Consequently, 58 patients (58%) had a PCT value ≤0.5 ng/dL and 42 patients (42%) had a value >0.5 ng/dL. Upon closer examination of these data, we found that 57 (98%) of the patients with PCT values ≤0.5 ng/dL had a negative blood culture, whereas only 1 (2%) had a positive one; of the patients with PCT values >0.5 ng/dL, 14 (33%) had a positive blood culture and 28 (67%) had a negative one.



A **B**

Fig 5: (**A**) blood culture stratification for patients with PCT ≤0.5 ng/dL; (B) blood culture stratification for patients with PCT >0.5 ng/dL.

As indicated in table 3, PCT demonstrated higher levels of accuracy (71%) with greater specificity and sensitivity (98.3%, 33.3%), positive and negative predictive values (93.3%, 67%), and both the positive and negative likelihood ratios (0.34, 0.33) when compared to CRP levels ≥ 10 mg/dl in this study.

Table 3: Comparison the PCT and CRP validity tests for diagnosing any potential sepsis

Validity tests	High possibilities of sepsis (%)	
	PCT	CRP
Sensitivity	33.3	18.5
Specificity	98.3	89.1
(+) ve LR	0.34	0.21
(−) ve LR	0.33	0.2
PPV	93.3	66.6
NPV	67	48.2
Accuracy	71	51

(+): Positive likelihood ratio, or LR, (-): Negative likelihood ratio, or LR, PCT: Procalcitonin, CRP: C-reactive protein, PPV: Positive predictive value, NPV: Negative predictive value.

DISCUSSION

More prompt care may be possible if hospitalized patients who are at risk of sepsis are identified early. Because infection symptoms might be vague or attenuated, choosing decisions based on them is frequently subjective. Therefore, it is still difficult to identify sepsis or infection in hospitalized patients, and trustworthy biomarkers are required for this purpose. However, sepsis cannot always be confirmed by currently available clinical and biochemical indicators as leukocyte count and erythrocyte sedimentation rate (ESR). Furthermore, confirming data of microbiological research are not always readily available. Bacterial infection is known to be indicated by biomarkers like PCT and CRP [(9)].

The study's findings showed that among hospitalized patients, increases in PCT levels were directly correlated with increases in the CRP value. Group 5, which had the highest PCT levels, had greater CRP levels than Group 1, which had the lowest PCT levels. Furthermore, the PCT and CRP values of the positive blood culture group were higher than those of the negative blood culture group. These results demonstrate how important it is to combine biochemical information from biomarkers with clinical state in order to detect sepsis. Additionally, the observed increases in PCT and CRP levels imply that these biomarkers have therapeutic value for predicting sepsis.

One of the best biomarkers for identifying infections and sepsis is PCT [(10)]. Our study's PCT's AUC was higher than CRP's (0.854, 0.640), suggesting that PCT is a more accurate measure for the diagnosis and detection of sepsis. The current study indicated that serum PCT values above 5 ng/ml were highly suggestive of sepsis, with sensitivity (33.3%), specificity (98.3%), and predictive value, compared to CRP level ≥ 10 mg/dl that show a sensitivity of (18.5%) and a specificity of (89.1%). This is consistent with the accuracy of determining PCT and CRP levels for the diagnosis of bacterial infections was assessed by a meta-analysis that included published studies that assessed these markers for the identification of bacterial infections in hospitalized patients. The sensitivity of the PCT level was higher (88% vs. 75%). and more specific (81% vs. 67%) than CRP level showing how effective PCT is as an infection marker [(11)]. For example, individuals with severe bacterial infections had elevated serum PCT, while those without sepsis had undetectable serum PCT [(10)]. CRP levels ≥ 10 mg/dl in hospitalized patients was found to be highly predictive of sepsis [(12)], even if it was unable to predict the severity or outcome of the condition. Due to the brief duration of elevated serum levels and the time it takes for a reaction to occur, CRP is also insufficient for prompt diagnosis and prognosis [(13,14)].

There are not many studies that show PCT performs worse than CRP for diagnosing sepsis [(15-17)]. On the other hand, the bulk of research has shown that procalcitonin is a more accurate indicator of the severity, prognosis, or future course of sepsis [(18-20)].

To sum up, PCT is a specific, better indicator, and dependable sepsis biomarker than CRP in hospitalized patients and could be a helpful prognostic factor.

LIMITATIONS

There were certain restrictions on our investigation. First off, biases in selection and observation may have existed due to the single-center nature of the study. For example, the diverse nature of patient blood samples may have led to more ambiguous results. Second, the avoidance of daily serial PCT monitoring may have improved its efficacy as a sepsis follow-up measure. It is important to consider the effects of the disease's progression.

RECOMMENDATIONS

In a clinical setting, accurate PCT level evaluation can improve hospitalized patients' treatment by enabling timely diagnosis and avoiding potentially unnecessary medication.

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• Conflicts of interest: The authors reported no conflicts of interest.

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