Original Article

Comparative Study of Procalcitonin and C-Reactive Protein in Patients with Sepsis

Harsha Virendra Patil, Virendra Chandrashekhar Patil[1]

Departments of Microbiology and [1]Medicine, Krishna Institute of Medical Sciences, Deemed to be University, Karad, Maharashtra, India

Abstract

Background: The early diagnosis and appropriate therapy of sepsis is a challenge in intensive care units in spite of the advances in critical care medicine. **Aim of the study:** The aim is to study and compare procalcitonin (PCT) and C-reactive protein (CRP) levels in patients admitted with the diagnosis of sepsis to the critical care unit. **Materials and Methods:** This was a prospective observational study conducted at the teaching hospital over a period of 1 year. All patients with evidence of sepsis were enrolled for this study and were underwent relevant history, laboratory biochemical and imaging investigations including PCT and CRP levels. **Results:** A total of 64 patients with the diagnosis of sepsis were enrolled in this study. A total of 43 (67.19%) were male and 21 (32.81%) were female. The mean and standard deviation for the Acute Physiology and Chronic Health Evaluation II (APACHE-II) score was 18 (±7), Sepsis-Related Organ Failure Assessment (SOFA) score was 9 (±5), papillary thyroid cancer as 19.07 (±7.02 ng/ml), and CRP was 33.5 (±15.7 mg/l). About 56.25% of patients had PCT in the range of 2–10 ng/ml, 28.13% had >10 ng/ml, and 14.06% had between 0.5 and 1.9 ng/ml. A total of 43 (67.19%) patients had a positive culture for organisms and 21 (32.81%) had sterile with no growth on culture with $P < 0.001$. The mean (20.74 ± 7.13). PCT levels were significantly high in Gram-negative organisms compared to (9.71 ± 0.96). Gram-positive organisms with $P < 0.02$. APACHE-II score, SOFA score, and CRP had a positive correlation with serum PCT levels and negative correlation with creatinine, pH, Glasgow Coma Scale and PaO_2 level. Multivariate analysis revealed that the serum PCT level was better correlated with the variable of sepsis than to CRP ($P < 0.01$). **Conclusion:** The present study concludes that the PCT was statistically significantly correlated with the severity of sepsis, APACHE-II, and SOFA score than CRP. The higher level of PCT was associated with Gram-negative sepsis and mortality.

Keywords: Acute Physiology and Chronic Health Evaluation-II score, C-reactive protein, Gram-negative organism, procalcitonin, sepsis, Sepsis-Related Organ Failure Assessment score

Introduction

Sepsis is a life-threatening and contributing significantly, about one-third to the mortality in intensive care units (ICUs). Devoid of appropriate treatment, sepsis can progress to multiorgan dysfunction and septic shock. Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection.[1] Sepsis is a global health-care problem, characterized by inflammation in response to microbial infection leading to organ dysfunction. Sepsis is defined as systemic inflammatory response syndrome (SIRS) with an infectious process and associated with high morbidity and mortality rates if initial therapy is delayed. Numerous biomarkers (interleukins [IL]-2 and IL-6 and tumor necrosis factor-α), leukotrienes, acute-phase proteins (C-reactive protein [CRP]), and adhesion molecules, have been evaluated with variable results, predicting the severity of sepsis and guiding its management.[2] Recently, procalcitonin (PCT) has been suggested as a novel biomarker that is useful in guiding therapeutic decision making in the management of sepsis. This study was designed to compare the efficacy of PCT and CRP as a diagnostic marker of sepsis and relate these biomarkers with blood culture, parameters, and scores of sepsis in a tertiary care hospital. PCT is an

Access this article online

Quick Response Code:

Website: www.jnsbm.org

DOI: 10.4103/jnsbm.JNSBM_1_20

Address for correspondence: Dr. Virendra Chandrashekhar Patil, Department of Medicine, Krishna Institute of Medical Sciences, Deemed to be University, Malkapur, Karad, Satara, Maharashtra, India.
E-mail: virendracpkimsu@rediffmail.com

Submitted: 01-Jan-2020 **Published:** 22-Jul-2020
Accepted: 26-Feb-2020

How to cite this article: Patil HV, Patil VC. Comparative study of procalcitonin and C-reactive protein in patients with sepsis. J Nat Sc Biol Med 2020;11:93-9.

Table 1: Classification of sepsis according to ACCP/Society of Critical Care Medicine consensus - 1991

Term	Criteria
SIRS	2 out of the 4 following criteria
	Temperature >38°C or <36°C
	Heart rate >90/min
	Hyperventilation evidenced by respiratory rate >20/min or arterial CO_2 <32 mmHg
	WBC count >12,000 cells/μL or lower than 4000 cells/μL
Sepsis	SIRS criteria with presumed or proven infection
Severe sepsis	Sepsis with organ dysfunction
Septic shock	Sepsis with hypotension despite adequate fluid resuscitation

SIRS: Systemic inflammatory response syndrome, WBC: White blood cell

innovative laboratory marker, has been recently proven valuable worldwide in this regard. We hypothesized that PCT and CRP concentrations are different in patients with of sepsis.

Materials and Methods

Aim of the study

To study and compare PCT and CRP levels in patients admitted with the diagnosis of sepsis to the critical care unit. All patients admitted to medical ICU with evidence of sepsis were enrolled for this study and were underwent relevant history, laboratory biochemical, and imaging investigations. This was a time-bound study for 1 year.

Study design

This was a prospective observational and noninterventional study conducted at the teaching hospital.

Inclusion criteria

All consecutive patients with evidence of sepsis with age ≥18 years were enrolled for this study.

Study settings

This study was conducted over a period of 1 year (January 2018–December 2018) in Krishna Institute of Medical Sciences a tertiary care teaching hospital. This study was conducted in KIMS Hospital over a period of 1 year (January 2018–December 2018). The Institutional Ethical Committee approval was taken (protocol number: 055/2018–2019). The informed and written consent was taken from patients before enrolling for the study. A total of 64 patients were included in this study satisfying the inclusion criteria. The American College of Chest Physician's (ACCP) criterion for the diagnosis of sepsis (≥2 of the following) (a) temperature >38°C/<36°C, (b) heart rate >90 bpm (c) respiratory rate >20 breaths/min or $paCO_2$ <32 mm Hg, and (d) white blood cell (WBC) count >12,000 cells/mm^3 or <4000 cells/mm^3 or >10% immature (band) forms. Patients were diagnosed and classified into the following four groups, namely using criteria for SIRS, sepsis, severe sepsis, and septic shock based on the 1991 ACCP/Society of Critical Care Medicine consensus conference [Table 1].[3]

Sepsis was clinically defined as a diagnosed infection and at least two of four SIRS criteria which include: (a) body temperature >38°C or <36°C, (b) heart rate >90 beats/min, (c) respiratory rate >20 breaths/min or an arterial partial pressure of carbon dioxide <4.3 kPa (32 mmHg), (d) white blood cell count >12,000 or <4000/mm^3, or the presence of >10% immature neutrophils.[1] The infection was defined based on infection sites, clinical features, clinical microbiology, and imaging tests. The Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sepsis-related Organ Failure Assessment (SOFA) scores were calculated using data from the first 24 h after admission. We also recorded the ICU and hospital length of stay. The patients were subsequently followed till discharge or death.[2]

Measurement of C-reactive protein, procalcitonin, and laboratory parameters

Within 12 h after ICU admission, 10 mL of blood was sampled for complete blood count, PCT, CRP, blood culture, renal function test, liver function test, and required investigations. PCT rapid quantitative test is a fluorescence immunoassay used to measure serum PCT level. To study the values of PCT obtained, they were divided into four groups based on the severity of sepsis, thus helping in diagnosing sepsis patients.[4] (PCT >10 ng/ml: Severe bacterial sepsis or septic shock, PCT 2–10 ng/ml: Severe systemic inflammatory response, most likely due to sepsis, PCT 0.5–1.9 ng/ml: SIRS; a systemic infection cannot be excluded and PCT <0.5 ng/ml: Local bacterial infection possible; sepsis unlikely). CRP concentrations were measured in a serum sample using a turbidimetric immunoassay test. Blood cultures were done by the automated BacT/Alert BioMerieux system with strict aseptic precautions.

Statistical analysis

Data were analyzed for mean, percentage, standard deviation, Chi-square test, multiple correlation, and multivariate analysis by using the Statistical Package for the Social Sciences-21 (SPSS) for Windows (SPSS, Chicago, IL, USA).

Results

A total of 64 patients with the diagnosis of sepsis were enrolled in this study. Total 43 (67.19%) were male and 21 (32.81%) were female, with a male:female ratio being 2:1 ($P < 0.05$).

The mean and standard deviation for was APACHE-II score was 18 (±7), SOFA score was 9 (±5), papillary thyroid cancer (PTC) was 19.07 (±7.02 ng/ml), and CRP was 33.5 (±15.7 mg/l) [Table 2].

About 56.25% of patients had PCT in the range of 2–10 ng/ml, 28.13% had >10 ng/ml, and 14.06% had between 0.5 and 1.9 ng/ml ($P < 0.05$) [Table 3].

A total of 43 (67.19%) patients had a positive culture for organisms and 21 (32.81%) had sterile with no growth on culture with $P < 0.001$. The mean (20.74 ± 7.13). PCT levels were significantly high in Gram-negative organisms (Klebsiella, *Pseudomonas*

aeruginosa, *Acinetobacter baumannii*, *Escherichia coli*) compared to (9.71 ± 0.96) Gram-positive organisms (*Staphylococcus aureus* and coagulase-positive staphylococci [COPS]) with $P < 0.02$. The mean CRP level was not significantly differ among the organism ($P < 0.23$) [Table 4] [Graph 1].

A total of 16 (37.21%) samples from blood, 15 (34.88%) from sputum, 11 (25.58%) from urine and 1 (2.33%) from stool were positive for bacterial growth in the present study with predominance of blood and sputum positivity on culture ($P < 0.05$) [Table 5 and Graph 2].

Of total 43 culture-positive samples 25.6% were *A. baumannii*, 34.88% were *E. coli*, 11.6% were *P. aeruginosa*, 9.3% were *Klebsiella* spp., 11.6% were *S. aureus* 4.65% were COPS and 2.33% were *C.* albicans [Table 6].

APACHE-II score, SOFA score, CRP and serum creatinine had positive correlation with serum PCT levels and negative correlation with creatinine, pH, Glasgow Coma Scale (GCS), and PaO_2 level [Graph 2a and b].

Of the total 64 patients with Sepsis 9 (14.06%) succumbed during treatment with mean high mean PCT 35 (±7.9) and mean CRP of 23.5 (±9.4). The mean of PCT was significantly higher than the mean of CRP in patients with mortality with $P < 0.001$. Multivariate analysis revealed that the serum PCT level was better correlated with the variable of sepsis compared to CRP after controlling age and gender ($P < 0.01$).

Table 2: Mean (±standard deviation) of numerical values

Variables	Mean (±SD)	Variables	Mean (±SD)
Age	57.39 (±16.10)	Na^+	130.26 (±19.22)
Temperature	100.56 (±2.89)	K^+	4.55 (±1.44)
HR	135.01 (±24.89)	Creatinine	1.66 (±0.51)
RR	34.85 (±8.55)	WBC	7891 (±1137)
MAP	63.10 (±17.58)	GCS	9.22 (±4.66)
PaO_2	89.22 (±59.49)	PCT (ng/ml)	19.07 (±7.02)
pH	7.28 (±0.20)	CRP (mg/l)	33.5 (±15.7)
APACHE-II score	18 (±7)	SOFA	9 (±5)

SD: Standard deviation, PCT: Procalcitonin, CRP: C-reactive protein, WBC: White blood cell, SOFA: Sepsis-related organ failure assessment, APACHE II: Acute physiology and chronic health evaluation II, GCS: Glasgow coma scale, MAP: Mean arterial pressure, HR: Heart rate, RR: Respiratory rate

Table 3: Frequency distribution of procalcitonin according to levels (n=64)

PCT levels (ng/ml)	*n* (%)
PCT >10	18 (28.13)
PCT 2-10	36 (56.25)
PCT 0.5-1.9	9 (14.06)
PCT <0.5	1 (1.56)

PCT: Procalcitonin

Discussion

Blood culture is considered as the gold standard for the confirmation of bacteraemia and subsequently test the antimicrobial sensitivity, but the delayed process of bacterial culture delays the diagnosis of sepsis. PCT is an amino acid polypeptide precursor for the hormone calcitonin. It was first identified in 1975 and first linked to infectious disease in 1983 when increased serum levels of immune-reactive calcitonin were described in patients with staphylococcal toxic shock syndrome. High serum PCT levels in sepsis that the current research on PCT in bacterial disease accelerated. PCT offers favorable kinetics for a biomarker. The PCT as a biomarker proved successfully its clinical usefulness in determining the presence of sepsis. It clearly showed the significance of the early diagnosis of bacterial infected sepsis. The serum concentration of PCT, CRP, IL-6, and lactate was elevated according to the severity of illness. Along with PCT, other (including, CRP, IL) biomarkers are used in the diagnosis of sepsis. Compared to CRP, PCT has better diagnostic and prognostic value and will clearly distinguish viral and bacterial infection. The serum PCT level rises rapidly in sepsis than CRP levels and peaks within a very short time, the level of PCT returns to normal range faster than CRP which makes it a better biomarker for sepsis. Several studies mentioned the advantages of the PCT as a biomarker for sepsis. We compared our results with various studies from India and overseas.[5] Recently, PCT has been suggested as a novel biomarker that may be useful in guiding therapeutic decision-making in the management of sepsis. In the present study, a total of 64 patients with the diagnosis of sepsis were enrolled in this study. A total of 67.19% were male and 32.81% were female. In the present study, total 56.25% of patients had PCT in the range of 2–10 ng/ml, 28.13% had >10 ng/ml, and 14.06% had between 0.5 and 1.9 ng/ml in a patient with sepsis. Forty-six trials evaluating the efficacy of PCT concentrations 39 trials yielding positive results in diagnosing sepsis.[2] The peak PCT concentrations occur early after injury in both patients with sepsis and with multiple organ dysfunction syndrome (MODS) and mortality in patients with abdominal sepsis ($P < 0.01$).[2] Hu *et al*. observed that PCT and CRP are useful markers and should be used to evaluate serious bacterial infections with a fever of unknown origin.[6] Similarly, in the present study,

Table 4: Cultures of various samples with their positivity regarding organism growth

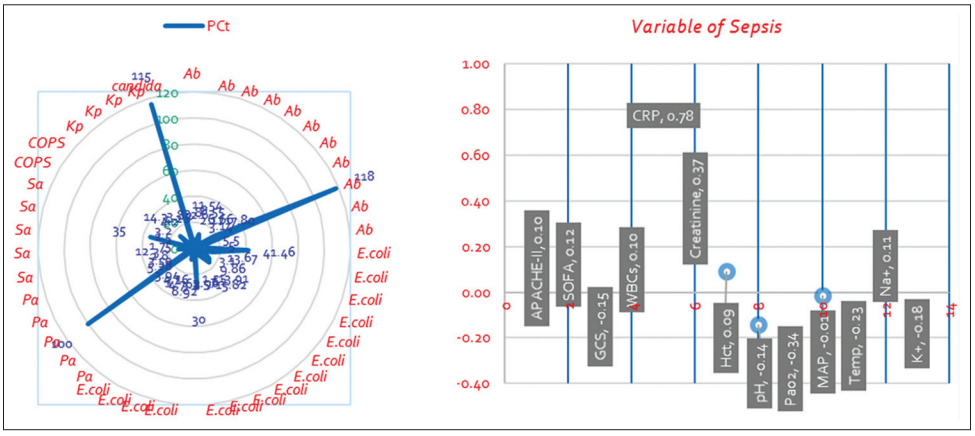
	Culture (%)	Mean PCT level	Mean CRP level	Organism	Mean PCT	Organism	Mean PCT	Organism	Mean PCT
Sterile	21.00 (32.81)	9.75 (±4.91)	18.56 (±7.9)	*Ab*	16.79	*Pa*	23.5	*Sa*	10.67
Positive	43.00 (67.19)	25.79 (±7.57)	39.5 (± 13.9)	*E. coli*	10.87	*Kp*	31.81	*COPS*	8.75

PCT: Procalcitonin, CRP: C-reactive protein, *Ab*: *Acinetobacter baumannii*, *Sa*: *Staphylococcus aureus*, *Kp*: *Klebsiella pneumonia*, *E. coli*: *Escherichia coli*, *Pa*: *Pseudomonas aeruginosa*, COPS: Coagulase-positive staphylococci

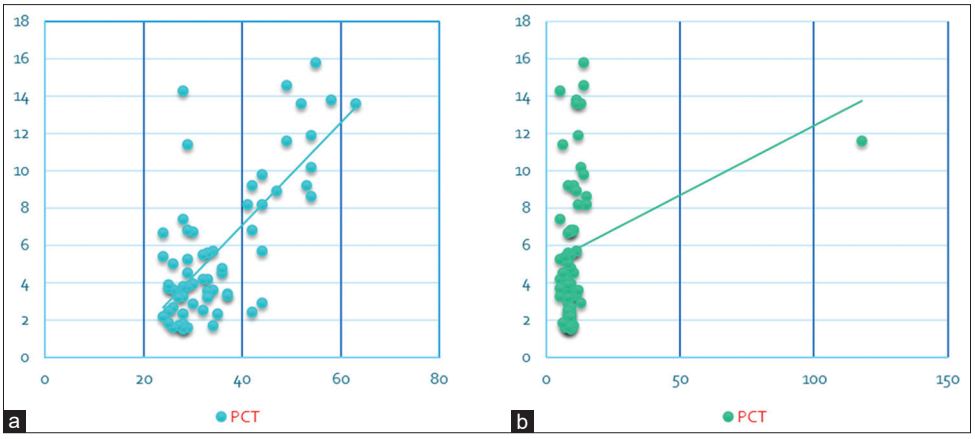
Table 5: Organism isolated from clinical sample with their procalcitonin levels

Sample	Organism	PCT	Diagnosis	Sample	Organism	PCT	Diagnosis	Sample	Organism	PCT	Diagnosis
Blood	*Ab*	3.8	Sepsis	Urine	*E. coli*	30	UTI	Blood	*Sa*	1.5	Sepsis
Sputum	*Ab*	2.6	VAP	Blood	*E. coli*	3.2	Sepsis	Blood	*COPS*	3.2	Sepsis
Sputum	*Ab*	11.54	VAP	Blood	*E. coli*	8.92	Sepsis	Sputum	*COPS*	14.3	VAP
Sputum	*Ab*	8.55	VAP	Ascitic fluid	*E. coli*	4.76	Sepsis	Sputum	*Kp*	4.2	CAP
Urine	*Ab*	2.12	UTI	Ett	*E. coli*	3.16	VAP	Sputum	*Kp*	4.2	VAP
Sputum	*Ab*	6.66	VAP	Sputum	*Pa*	4.7	VAP	Blood	*Kp*	3.85	Sepsis
Urine	*Ab*	3.14	UTI	Sputum	*Pa*	3.94	VAP	Sputum	*Kp*	115	VAP
Sputum	*Ab*	17.80	VAP	Urine	*Pa*	100	UTI	Blood	*Candida*	2	Sepsis
Blood	*Ab*	118	Sepsis	Sputum	*Pa*	5.28	VAP	Urine	*E. coli*	9.86	UTI
Blood	*Ab*	5.5	Sepsis	Blood	*Pa*	3.59	Sepsis	Urine	*E. coli*	13.91	UTI
Blood	*Ab*	5	Sepsis	Sputum	*Sa*	2.8	CAP	Urine	*E. coli*	15.82	UTI
Urine	*E. coli*	41.46	UTI	Sputum	*Sa*	12.3	VAP	Urine	*E. coli*	7.2	UTI
Ascitic fluid	*E. coli*	13.67	Sepsis	Sputum	*Sa*	1.75	VAP	Blood	*E. coli*	1.5	Sepsis
Urine	*E. coli*	3.1	UTI	Blood	*Sa*	35	Sepsis	Stool	*E. coli*	3.96	Age
Urine	*E. coli*	2.5	UTI								

PCT: Procalcitonin, VAP: Ventilator-associated pneumonia, UTI: Urinary tract infection, *E. coli*: *Escherichia coli*, *Ab*: *Acinetobacter baumannii*, *Pa*: *Pseudomonas aeruginosa*, *Sa*: *Staphylococcus aureus*, *Kp*: *Klebsiella pneumoniae*, COPS: Coagulase-positive staphylococci



Graph 1: Relation of procalcitonin with bacteria associated with sepsis and correlation of procalcitonin with variables of Sepsis



Graph 2: (a and b) Correlation of procalcitonin with Acute Physiology and Chronic Health Evaluation-II score and Sepsis-Related Organ Failure Assessment score

67.19% of patients had a positive culture for organisms and 32.81% had sterile with $P < 0.001$. In the present study of total 43 culture-positive samples 25.6% were *A. baumannii*, 34.88% were *E. coli*, 11.6% were *P. aeruginosa*, 9.3% were *Klebsiella* spp., 11.6% were *S. aureus* 4.65% were COPS and 2.33% were *Candida albicans* with the significantly high

Table 6: Distribution of culture positivity for bacterial growth

	Ab (%)	*E. coli* (%)	*Pa* (%)	*COPS* (%)	*Sa* (%)	*Kp* (%)	*Candida* (%)	Total (%)
Blood	4 (25)	5 (31.25)	1 (6.25)	1 (6.25)	3 (18.8)	1 (6.25)	1 (6.25)	16 (37.21)
Sputum	5 (33.3)	1 (6.66)	3 (20)	1 (6.66)	2 (13.3)	3 (20)	0 (0)	15 (34.88)
Urine	2 (18.2)	8 (72.72)	1 (9.09)	0 (0)	0 (0)	0 (0)	0 (0)	11 (25.58)
Stool	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.33)
Total	11 (25.6)	15 (34.88)	5 (11.6)	2 (4.65)	5 (11.6)	4 (9.3)	1 (2.33)	43 (100)

E. coli: *Escherichia coli*, *Ab*: *Acinetobacter baumannii*, *Pa*: *Pseudomonas aeruginosa*, *Sa*: *Staphylococcus aureus*, *Kp*: *Klebsiella pneumoniae*, COPS: Coagulase-positive staphylococci

level of PCT and CRP. Similarly, Tang *et al.* stated that both PCT and CRP are helpful in detecting pneumonia caused by different types of infection.[7] Tanrıverdi *et al*. concluded that the PCT was better than CRP for predicting a bacterial infection; these findings are similar to the present study ($P < 0.01$).[8] Titova *et al*. quoted that the PCT had about the same accuracy as CRP and WBC in predicting pneumonia in patients hospitalized with acute exacerbations of chronic obstructive pulmonary disease.[9] In the present study, PCT levels were significantly high (20.74 ± 7.13) in Gram-negative organisms compared to (9.71 ± 0.96) Gram-positive organisms ($P < 0.02$). The mean CRP level was not significantly differ among the organism ($P < 0.23$). In the current study in multivariate analysis revealed that the serum PCT level was better correlated with the variable of sepsis compared to CRP after controlling age and gender ($P < 0.01$). Similarly, Nargis *et al*. quoted that the serum PCT and CR*P* values in cases with sepsis, severe sepsis and septic shock were significantly higher ($P < 0.01$) and PCT was found to be superior to CRP in the identification and to assess the severity of sepsis.[10] Sharma and Duggal in their study quoted that the PCT along with CRP, is a better diagnostic tool for sepsis.[11] Tian *et al*. found that PCT levels were valuable in discriminating sepsis from SIRS and determining sepsis severity in critically ill patients. We observed APACHE-II score, SOFA score, CRP and serum creatinine had a positive correlation with serum PCT levels and negative correlation with creatinine, pH, GCS, and PaO_2 level.[12] Castelli *et al*. reported that the maximum PCT concentrations were found at higher score levels (SOFA score >12) compared to CRP.[13] Similarly, Qin *et al*. reported that the PCT, CRP, and SOFA score in the combination of them has higher evaluation value in patients with sepsis.[14] Wang and Chen found that compared with CRP, PCT was more significantly correlated with the APACHE II score and SOFA score. PCT can be a better indicator for the evaluation of the degree of sepsis.[15] Ocakli *et al*. quoted, PCT may be a better marker for therapeutic decisions in advanced chronic inflammatory diseases.[16] Mustafić *et al.* stated that there was a significant correlation between PCT and SOFA, and APACHE II score in nonsurviving septic patients indicates that PTC combined with clinical score could be useful for assessing the severity of infection, these findings are similar to the present study.[17] Huang *et al*. found positive statistical correlation between PCT and SOFA score ($r = 0.979$, $P < 0.05$), similar to the present study ($r = 0.12$). PCT was a useful marker for the diagnosis of infectious SIRS after the cardiac operation as compared with WBC and CRP.[18] In the present study, 14.06% of patients with sepsis succumbed during treatment with mean high mean PCT 35 (±7.9) and mean CRP of 23.5 (±9.4). The mean of PCT was significantly higher than the mean of CRP in patients with mortality with $P < 0.001$. In the present study in multivariate analysis revealed that the serum PCT level was better correlated with the variable of sepsis compared to CRP ($P < 0.01$). Castelli *et al*. reported that PCT and CRP may be useful together with bacteriological data in sepsis diagnosis. PCT and SOFA closer correlate with the infection severity; PCT is the better parameter to estimate severity, prognosis or further course of the disease; these findings are similar to the present study.[19] Wang *et al*. observed that the prognostic value of PCT is better than that of CRP and CPIS score for evaluation of community-acquired pneumonia (CAP).[20] Liu *et al*. reported that the detection of PCT in combination with high-sensitivity (hs)-CRP facilitates the early diagnosis of pneumonia and sepsis.[21] Guo *et al*. stated that the dynamic CRP and PCT changes may potentially be used in the future to predict the prognosis of hospitalized patients with CAP.[22] Luzzani *et al*. stated that the PCT is a better marker of sepsis with organ dysfunction than CRP.[23] Zhang *et al*. quoted that hs-CRP is not inferior to PCT in the diagnosis of sepsis and septic shock.[24] Ruan *et al*., in their meta-analysis study, quoted that the combination of PCT and CRP improves the accuracy of the diagnosis of sepsis.[25] Sinha *et al*. quoted that the PCT ≥2 ng/ml had a statistically significant correlation with the sepsis ($P < 0.0001$).[26] Nasimfar *et al*. stated that the serum PCT level can be measured as a marker of bacterial infections with CRP, erythrocyte sedimentation rate and WBC count.[27] Pravin Charles *et al*. quoted that the PCT with CRP and other tests for the septic screen can aid in better diagnosis of sepsis.[28] Imran Siddiqui *et al*. reported that in comparison to PCT and CRP, high plasma lactic acid levels are associated with the development of all-cause MODS and worse outcome in critically ill patients [Table 7].[29]

IL-6 and IL-10 performance better than CRP and PCT in identifying patients with high-risk febrile illness. Standard blood culture techniques require time with results typically not available for at least 24–48 h, highlighting the need for rapid diagnosis and risk stratification where biomarkers could be of use. PCT has been investigated as the biomarker that holds the most assure for bloodstream infections in recent research.[32] Serological tests are indispensable in the diagnosis of early infection. At present, only PCT and CRP are commonly used

Table 7: Comparison of various studies with present study

Author and years	Study design	Study population	Conclusion
Hu *et al*. (2017)[6]	Systematic review and meta-analysis		PCT and CRP are useful markers and should be used to evaluate SBIs with FUO
Tanrıverdi *et al*. (2015)[8]	Cross-sectional study	*n*=77	PCT was better than CRP and the N/L ratio for predicting a bacterial infection in hospitalized patients with AECOPD
Titova *et al*. (2019)[9]	Prospective observational study	*n*=113	PCT had about the same accuracy as CRP and WBC in predicting pneumonia
Nargis *et al*. (2014)[10]	Cross-sectional	*n*=73	PCT is found to be superior to CRP in terms of accuracy in identification and to assess the severity of sepsis
Sharma and Duggal (2019)[11]	Cross-sectional study	*n*=80	The PCT along with CRP is a better diagnostic tool for sepsis
Qin *et al*. (2019)[14]	Retrospective study	*n*=265	PCT, CRP and SOFA score has higher evaluation value patients with sepsis
Wang and Chen (2015)[15]	Retrospective study	*n*=201	Compared with CRP, PCT was more significantly correlated with APACHE II score and SOFA score
Huang *et al*. (2012)[18]	Prospective case control study	*n*=72	Positive statistical correlation was found between PCT and SOFA score (r=0.979, P<0.05) PCT
Castelli *et al*. (2006)[19]	Cross-sectional study	*n*=255	PCT and CRP with bacteriological data helps in sepsis diagnosis; PCT and SOFA correlate with the infection severity
Liu *et al*. (2018)[21]	Prospective study	*n*=220	The detection of PCT in combination with hs-CRP facilitates the early diagnosis of pneumonia and sepsis
Wang *et al*. (2019)[20]	Prospective study	*n*=214	The prognostic value of PCT and sTREM-1 is better than that of CRP and CPIS
Guo *et al*. (2018)[22]	Cross-sectional	*n*=350	Serum serial CRP and PCT levels had moderate predictive value for hospitalized CAP prognosis
Luzzani *et al*. (2003)[23]	Prospective study	*n*=70	PCT is a better marker of sepsis than CRP
Zhang H *et al*. (2017)[24]	Prospective study	*n*=70	CRP is at par to PCT in the diagnosis of sepsis and septic shock
Sinha *et al*. (2011)[26]	Prospective study	*n*=40	PCT ≥2 ng/ml had statistically significant correlation with the presence of sepsis (P<0.0001)
Nasimfar *et al*. (2018)[27]	Prospective case-control study	*n*=45/45	PCT level in conjunction with CRP, ESR, and WBC count can be considered a diagnostic marker of bacterial infections
Pravin Charles *et al*. (2018)[28]	Prospective cross-sectional study	*n*=75	PCT in conjunction with CRP and other tests for septic screen can aid in better diagnosis of sepsis
Hohn *et al*. (2013)[30]	Retrospective study	*n*=141	PCT-protocol was associated with a reduced duration of antibiotic therapy in septic ICU patients without compromising clinical or economical outcomes
Verlinden *et al*. (2019)[31]	Prospective study	*n*=66	CRP has better than PCT discriminatory power between aetiologies of fever with neutropenia
Present study	Prospective observational	*n*=64	Proportionate increased level of serum procalcitoinin and CRP with better correlation of PCT levels and APACHE-II and SOFA scores. The parameters of sepsis, organ dysfunction and mortality were correlated with the increased level of serum PCT level

PCT: Procalcitonin, CRP: C-reactive protein, SBIs: Serious bacterial infections, FUO: Fever of unknown origin, N/L: Neutrophil/lymphocyte, AECOPD: Acute exacerbations of chronic obstructive pulmonary disease, WBC: White blood cell, SOFA: Sepsis-related organ failure assessment, APACHE II: Acute physiology and chronic health evaluation II, hs-CRP: High-sensitivity-CRP, TREM 1: Triggering receptor expressed on myeloid cells-1, CPIS: Clinical pulmonary infection score, CAP: Community acquired pneumonia, ESR: Erythrocyte sedimentation rate, ICU: Intensive care unit

in clinical practice. Recently, serum amyloid A1 (SAA1) and heparin-binding protein (HBP) have been shown to be new biomarkers because SAA1 is highly sensitive and specific for viral infections, and HBP is predictive for septic shock.[33] The present study support the majority of the research conducted in India and overseas in regard to the utility of PCT in sepsis.

Conclusion

The present study revealed that the severity of sepsis was correlated with the proportionate increased level of serum procalcitonin and CRP as well, with better correlation was found between the PCT levels and APACHE-II and SOFA scores. The parameters of sepsis, organ dysfunction, and mortality were significantly correlated with the serum PCT level. Patients with mortality in the present population had significantly high levels of PCT levels compared to CRP. To conclude it was obvious from the present study that the serum procalcitonin will help in the diagnosis, management, and prognosis of the disease in a patient with sepsis which can be complimented by other parameters of sepsis including SOFA score and CRP.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Shankar-Hari M, Phillips GS, Levy ML, Seymour CW, Liu VX, Deutschman CS, *et al*. Developing a New Definition and Assessing New Clinical Criteria for Septic Shock: For the Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). JAMA 2016;315:775-87.
2. Sridharan P, Chamberlain RS. The efficacy of procalcitonin as a biomarker in the management of sepsis: Slaying dragons or tilting at windmills? Surg Infect (Larchmt) 2013;14:489-511.
3. Bone RC, Sibbald WJ, Sprung CL. The ACCP-SCCM consensus conference on sepsis and organ failure. Chest 1992;101:1481-3.
4. Harbarth S, Holeckova K, Froidevaux C, Pittet D, Ricou B, Grau GE, *et al*. Diagnostic value of procalcitonin, interleukin-6, and interleukin-8 in critically ill patients admitted with suspected sepsis. Am J Respir Crit Care Med 2001;164:396-402.
5. Nelson GE, Mave V, Gupta A. Biomarkers for sepsis: a review with special attention to India. Biomed Res Int 2014;2014:264351.
6. Hu L, Shi Q, Shi M, Liu R, Wang C. Diagnostic value of PCT and CRP for detecting serious bacterial infections in patients with fever of unknown origin: A systematic review and meta-analysis. Appl Immunohistochem Mol Morphol 2017;25:e61-e69.
7. Tang JH, Gao DP, Zou PF. Comparison of serum PCT and CRP levels in patients infected by different pathogenic microorganisms: A systematic review and meta-analysis. Braz J Med Biol Res 2018;51:e6783.
8. 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. Wien Klin Wochenschr 2015;127:756-63.
9. 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. Chron Respir Dis 2018;16:1-9.
10. Nargis W, Ibrahim M, Ahamed BU. Procalcitonin versus C-reactive protein: Usefulness as biomarker of sepsis in ICU patient. Int J Crit Illn Inj Sci 2014;4:195-9.
11. Sharma S, Duggal N. Role of procalcitonin, IL-6 and C- reactive protein in suspected cases of sepsis. Indian J Pathol Microbiol 2019;62:578-81.
12. Tian G, Pan SY, Ma G, Liao W, Su QG, Gu BC, *et al*. Serum levels of procalcitonin as a biomarker for differentiating between sepsis and systemic inflammatory response syndrome in the neurological intensive care unit. J Clin Neurosci 2014;21:1153-8.
13. 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:R234-42.
14. Qin X, Guo Q, Liu Y, Zhu D, Li J, Zheng D, *et al*. Prognostic value of procalcitonin and C-reactive protein combined with sequential organ failure assessment score in elderly patients with sepsis induced by pulmonary infection. Zhonghua Wei Zhong Bing Ji Jiu Yi Xue 2019;31:562-5.
15. Wang S, Chen D. The correlation between procalcitonin, C-reactive protein and severity scores in patients with sepsis and their value in assessment of prognosis. Zhonghua Wei Zhong Bing Ji Jiu Yi Xue 2015;27:97-101.
16. Ocakli B, Tuncay E, Gungor S, Sertbas M, Adiguzel N, Irmak I, *et al*. Inflammatory markers in patients using domiciliary non-invasive mechanical ventilation: C reactive protein, procalcitonin, neutrophil lymphocyte ratio. Front Public Health 2018;6:245.
17. Mustafić S, Brkić S, Prnjavorac B, Sinanović A, Porobić Jahić H, Salkić S. Diagnostic and prognostic value of procalcitonin in patients with sepsis. Med Glas (Zenica) 2018;15:93-100.
18. Huang WP, Jiang WQ, Hu B, Ye H, Zeng HK. Significance of serum procalcitonin levels in the evaluation of severity and prognosis of patients with systemic inflammatory response syndrome. Zhongguo Wei Zhong Bing Ji Jiu Yi Xue 2012;24:294-7.
19. Castelli GP, Pognani C, Cita M, Stuani A, Sgarbi L, Paladini R. Procalcitonin, C-reactive protein, white blood cells and SOFA score in ICU: Diagnosis and monitoring of sepsis. Minerva Anestesiol 2006;72:69-80.
20. Wang Y, Zhang S, Li L, Xie J. The usefulness of serum procalcitonin, C-reactive protein, soluble triggering receptor expressed on myeloid cells 1 and Clinical Pulmonary Infection Score for evaluation of severity and prognosis of community-acquired pneumonia in elderly patients. Arch Gerontol Geriatr 2019;80:53-7.
21. Liu GB, Cui XQ, Wang ZB, Wen L, Duan HL. Detection of serum procalcitonin and hypersensitive C-reactive protein in patients with pneumonia and sepsis. J Biol Regul Homeost Agents 2018;32:1165-9.
22. Guo S, Mao X, Liang M. The moderate predictive value of serial serum CRP and PCT levels for the prognosis of hospitalized community-acquired pneumonia. Respir Res 2018;19:193.
23. Luzzani A, Polati E, Dorizzi R, Rungatscher A, Pavan R, Merlini A. Comparison of procalcitonin and C-reactive protein as markers of sepsis. Crit Care Med 2003;31:1737-41.
24. Zhang H, Wang X, Zhang Q, Xia Y, Liu D. Comparison of procalcitonin and high-sensitivity C-reactive protein for the diagnosis of sepsis and septic shock in the oldest old patients. BMC Geriatr 2017;17:173.
25. Ruan L, Chen GY, Liu Z, Zhao Y, Xu GY, Li SF, *et al*. The combination of procalcitonin and C-reactive protein or presepsin alone improves the accuracy of diagnosis of neonatal sepsis: A meta-analysis and systematic review. Crit Care 2018;22:316.
26. Sinha M, Desai S, Mantri S, Kulkarni A. Procalcitonin as an adjunctive biomarker in sepsis. Indian J Anaesth 2011;55:266-70.
27. Nasimfar A, Sadeghi E, Karamyyar M, Manesh LJ. Comparison of serum procalcitonin level with erythrocytes sedimentation rate, C-reactive protein, white blood cell count, and blood culture in the diagnosis of bacterial infections in patients hospitalized in Motahhari Hospital of Urmia (2016). J Adv Pharm Technol Res 2018;9:147-52.
28. Pravin Charles MV, Kalaivani R, Venkatesh S, Kali A, Seetha KS. Evaluation of procalcitonin as a diagnostic marker in neonatal sepsis. Indian J Pathol Microbiol 2018;61:81-4.
29. Siddiqui I, Jafri L, Abbas Q, Raheem A, Haque AU. Relationship of serum procalcitonin, C-reactive protein, and lactic acid to organ failure and outcome in critically ill pediatric population. Indian J Crit Care Med 2018;22:91-5.
30. Hohn A, Schroeder S, Gehrt A, Bernhardt K, Bein B, Wegscheider K, *et al*. Procalcitonin-guided algorithm to reduce length of antibiotic therapy in patients with severe sepsis and septic shock. BMC Infect Dis 2013;13:158.
31. Verlinden A, De Vroey V, Goossens H, Roelant E, Van De Velde AL, Berneman ZN, *et al*. Comparison of the Power of Procalcitonin and C-Reactive Protein to Discriminate between Different Aetiologies of Fever in Prolonged Profound Neutropenia: A Single-Centre Prospective Observational Study. Mediterr J Hematol Infect Dis 2019;11:e2019023.
32. Xu XJ, Luo ZB, Xia T, Song H, Yang SL, Xu WQ, *et al*. Comparison of interleukin-6, interleukin-10, procalcitonin and C-reactive protein in identifying high-risk febrile illness in pediatric cancer patients: A prospective observational study. Cytokine 2019;116:1-6.
33. Niu T, Liu Y, Zhu F, Ma J, Gao J. Time-resolved fluorescent immunoassay-based combined detection of procalcitonin, C-reactive protein, heparin binding protein, and serum amyloid A1 to improve the diagnostic accuracy of early infection. J Clin Lab Anal 2019;33:e22694.