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SERUM PROCALCITONIN LEVELS AND BACTERIOLOGICAL PROFILE IN PATIENTS WITH SEPSIS AT A TERTIARY CARE CENTRE

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ABSTRACT

Background

Sepsis remains a leading cause of morbidity and mortality worldwide, requiring early diagnosis and prompt initiation of appropriate antimicrobial therapy. Procalcitonin has emerged as a

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promising biomarker for bacterial sepsis; however, its correlation with bacteriological findings varies across clinical settings.

Objectives

To evaluate serum procalcitonin levels in patients with sepsis and to analyze their association with blood culture positivity and the bacteriological profile.

Materials and Methods

This observational study was conducted at a tertiary care centre and included 100 clinically diagnosed sepsis patients. Serum procalcitonin levels were measured at admission using standard immunoassay techniques. Blood samples were collected for culture and identification of bacterial pathogens using conventional microbiological methods. Data were analyzed to assess the relationship between procalcitonin levels, culture results, and type of bacterial infection.

Results

Elevated serum procalcitonin levels (>0.5 ng/mL) were observed in 82% of patients, with 46% showing markedly high levels (>10 ng/mL). Blood cultures were positive in 62% of cases. Gram-negative bacteria were the predominant isolates (66.1%), with *Escherichia coli* and *Klebsiella pneumoniae* being the most common pathogens. Gram-positive organisms accounted for 33.9% of isolates, predominantly *Staphylococcus aureus* and *Enterococcus* species. Mean serum procalcitonin levels were significantly higher in culture-positive patients compared to culture-negative patients. Furthermore, Gram-negative sepsis was associated with higher procalcitonin levels than Gram-positive infections.

Conclusion

Serum procalcitonin is a valuable biomarker for the diagnosis of bacterial sepsis and shows a strong correlation with blood culture positivity. Higher procalcitonin levels are particularly

associated with Gram-negative bacterial infections. Procalcitonin may serve as a useful adjunct to microbiological investigations for early diagnosis and risk stratification in sepsis.

Keywords

Sepsis; Procalcitonin; Blood culture; Gram-negative bacteria; Biomarker

INTRODUCTION

Sepsis is a life-threatening organ dysfunction caused by a dysregulated host response to infection and remains a major global health challenge despite advances in critical care medicine [1]. It accounts for significant morbidity, mortality, prolonged hospital stay, and increased healthcare expenditure worldwide. Recent estimates suggest that sepsis affects millions of individuals annually, with a disproportionately higher burden in low- and middle-income countries due to delayed diagnosis, limited resources, and rising antimicrobial resistance [2,3]. Early recognition and timely initiation of appropriate therapy are crucial determinants of patient outcomes in sepsis.

The clinical presentation of sepsis is often heterogeneous and non-specific, ranging from mild systemic inflammatory response to severe septic shock with multi-organ dysfunction [4]. Conventional diagnostic approaches rely on clinical assessment, laboratory parameters such as leukocyte count and C-reactive protein (CRP), and microbiological culture results. However, these methods have several limitations. Blood cultures, although considered the gold standard for identifying the causative pathogen, have low sensitivity, are time-consuming, and may be affected by prior antibiotic administration [5,6]. As a result, there is a growing interest in identifying reliable biomarkers that can aid in the early diagnosis, severity assessment, and prognostication of sepsis.

The host immune response in sepsis is complex and involves activation of both pro-inflammatory and anti-inflammatory pathways [7]. Excessive release of cytokines, endotoxins, and inflammatory mediators leads to endothelial dysfunction, microcirculatory impairment, and ultimately organ failure [8]. Afaq N stated that Gram positive organisms was the most common isolate.Biomarkers reflecting this inflammatory cascade have been extensively studied to

improve diagnostic accuracy and guide therapeutic decisions [9]. Among these, procalcitonin (PCT) has gained significant attention due to its relative specificity for bacterial infections.

Procalcitonin is a 116-amino-acid precursor of the hormone calcitonin and is normally produced by the C-cells of the thyroid gland, with negligible serum levels in healthy individuals [10]. During bacterial infections, procalcitonin synthesis is markedly upregulated in various extrathyroidal tissues, including the liver, lungs, and mononuclear cells, under the influence of bacterial endotoxins and pro-inflammatory cytokines such as interleukin-6 and tumor necrosis factor-α [11,12]. In contrast, viral infections tend to suppress procalcitonin production through interferon-γ, making it a useful marker for distinguishing bacterial from non-bacterial causes of systemic inflammation [13].

Several studies have demonstrated that serum procalcitonin levels rise early in the course of bacterial sepsis, often within 4–6 hours of infection, and correlate with disease severity [14,15]. Higher procalcitonin concentrations have been associated with severe sepsis, septic shock, and increased mortality [16]. Compared to traditional inflammatory markers such as CRP and erythrocyte sedimentation rate, procalcitonin exhibits faster kinetics and better specificity for bacterial infections [17]. These properties make it a valuable tool not only for diagnosis but also for monitoring treatment response and guiding antibiotic stewardship [18].

Despite its advantages, the interpretation of procalcitonin levels can be influenced by several factors, including the type of infecting organism [19]. Evidence suggests that Gram-negative bacterial infections are associated with significantly higher procalcitonin levels compared to Gram-positive infections, likely due to the potent endotoxin-mediated inflammatory response triggered by lipopolysaccharides [20,21]. Understanding this relationship is particularly important in regions with a high prevalence of multidrug-resistant Gram-negative organisms.

The bacteriological profile of sepsis varies widely depending on geographic location, hospital setting, and patient population [22]. In recent years, Gram-negative bacteria such as *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii* have emerged as predominant causes of sepsis in many tertiary care centers [23,24]. At the same time,

Gram-positive organisms including *Staphylococcus aureus* and *Enterococcus* species continue to play a significant role, particularly in hospital-acquired and device-associated infections [25].

The rising incidence of antimicrobial resistance further complicates the management of sepsis and underscores the need for early and accurate identification of bacterial etiology [26]. Empirical broad-spectrum antibiotic therapy, although lifesaving, contributes to resistance if used indiscriminately [27]. Biomarkers such as procalcitonin may help clinicians stratify patients, predict bacterial involvement, and rationalize antibiotic use while awaiting definitive culture results [28].

Several studies have evaluated the diagnostic and prognostic utility of procalcitonin in sepsis; however, results have been inconsistent due to variations in study design, patient populations, and microbiological patterns [29,30]. Moreover, limited data are available from developing countries where the burden of sepsis and prevalence of Gram-negative infections are particularly high [31]. Establishing the relationship between serum procalcitonin levels and bacteriological findings in such settings is essential for optimizing sepsis management strategies.

Therefore, the present study was undertaken to evaluate serum procalcitonin levels in patients with sepsis and to analyze their correlation with blood culture positivity and the bacteriological profile. Understanding this association may enhance early diagnostic accuracy, support clinical decision-making, and contribute to improved outcomes in patients with sepsis [32].

MATERIAL AND METHODS

This was a **hospital-based observational study** conducted in the Department of Microbiology in collaboration with the Department of Medicine and Biochemistry of a tertiary care centre. The study was carried out over a period of **24 months i.e, August 2023 to August 2025**

A total of **100 patients** clinically diagnosed with sepsis and admitted to medical wards and ICUs during the study period were enrolled. Sepsis was defined according to the **Sepsis-3 criteria**, which includes suspected or documented infection associated with acute organ dysfunction.

The study included **100 consecutive patients** fulfilling the eligibility criteria. All eligible patients during the study period were included using a **convenience sampling method**.

Inclusion Criteria

Patients were included in the study if they fulfilled the following criteria:

1. Patients aged **≥18 years**
2. Clinically suspected or confirmed cases of **sepsis** based on Sepsis-3 criteria
3. Patients presenting with signs of systemic infection such as fever or hypothermia, tachycardia, tachypnea, hypotension, or altered sensorium
4. Patients in whom **blood samples for procalcitonin estimation and blood culture** could be obtained at the time of admission
5. Patients or legally authorized representatives who provided **informed consent**

Exclusion Criteria

Patients were excluded from the study if they met any of the following conditions:

1. Patients with **viral infections**, parasitic infections, or fungal infections without evidence of bacterial sepsis
2. Patients who had received **prolonged antibiotic therapy (>48 hours)** prior to hospital admission
3. Patients with **major trauma, burns, or recent major surgery**, as these conditions may elevate procalcitonin levels independently
4. Patients with **chronic inflammatory or autoimmune diseases**
5. Patients with **malignancy**, especially medullary thyroid carcinoma or small cell lung carcinoma
6. Patients with **end-stage renal disease** on dialysis
7. Pregnant women
8. Patients unwilling to participate in the study

Sample Collection and Laboratory Methods

Procalcitonin Estimation

Venous blood samples (3–5 mL) were collected aseptically from all enrolled patients at the time of admission before initiation of antibiotic therapy. Serum procalcitonin levels were measured using a **quantitative immunoassay method** as per the manufacturer's instructions. Procalcitonin values were interpreted as follows:

- <0.5 ng/mL: Low probability of bacterial infection
- 0.5–2.0 ng/mL: Possible bacterial infection
- 2.0–10.0 ng/mL: High probability of sepsis
- 10.0 ng/mL: Severe bacterial sepsis or septic shock

Blood Culture and Bacteriological Identification

Blood samples for culture were collected aseptically before antibiotic administration. Approximately **8–10 mL of blood** was inoculated into blood culture bottles and incubated using standard microbiological techniques. Positive cultures were processed further for identification of bacterial isolates using **conventional biochemical methods**. Bacterial isolates were categorized into **Gram-negative and Gram-positive organisms** based on Gram staining and biochemical reactions.

Data Collection

Demographic details, clinical features, laboratory parameters, blood culture results, and procalcitonin levels were recorded using a predesigned proforma. All patient data were anonymized to maintain confidentiality.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using appropriate statistical software. Continuous variables were expressed as **mean ± standard deviation**, while categorical variables were expressed as **frequencies and percentages**. Comparison of procalcitonin levels between

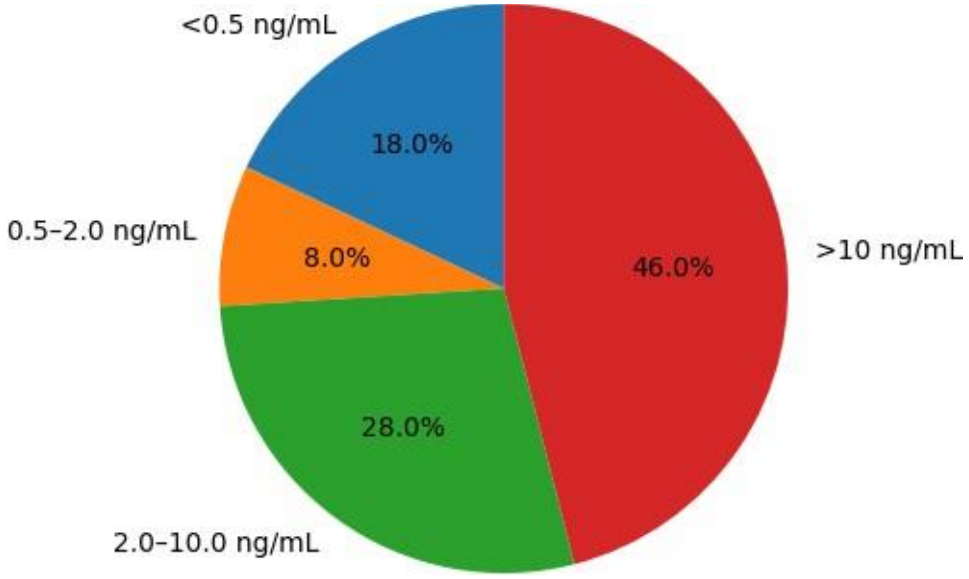
culture-positive and culture-negative groups and between Gram-negative and Gram-positive infections was performed using appropriate statistical tests. A **p-value <0.05** was considered statistically significant.

RESULTS

It was observed that the distribution of serum procalcitonin levels among sepsis patients at the time of admission. Elevated procalcitonin levels (>0.5 ng/mL) were observed in the majority of patients (82%), indicating a strong association with bacterial sepsis. Nearly half of the patients (46%) demonstrated markedly raised procalcitonin levels exceeding 10 ng/mL, reflecting severe systemic infection. Moderate elevation (2–10 ng/mL) was seen in 28% of cases, while only 18% of patients had procalcitonin levels within the normal range (<0.5 ng/mL), suggesting a lower probability of bacterial etiology in these individuals.

Table 1. Distribution of Serum Procalcitonin Levels in Sepsis Patients (n = 100)

Serum Procalcitonin Level (ng/mL)	Number of Patients	Percentage (%)
< 0.5	18	18.0
0.5 – <2.0	8	8.0
2.0 – 10.0	28	28.0
> 10.0	46	46.0
Total	**100**	**100**



Graph 1: Distribution of Serum Procalcitonin Levels in Sepsis Patients

Table 2. Blood Culture Positivity Among Sepsis Patients

Blood Culture Status	Number of Patients	Percentage (%)
Culture Positive	62	62.0
Culture Negative	38	38.0
Total	**100**	**100**

Table 2 shows the blood culture results among patients with sepsis. Blood cultures were positive in 62% of cases, confirming bacterial infection in a significant proportion of patients. However, 38% of patients were culture negative, which may be attributed to prior antibiotic administration, low-level bacteremia, or infections caused by fastidious organisms. Despite culture negativity, several of these patients exhibited elevated procalcitonin levels, highlighting the usefulness of procalcitonin as an adjunct diagnostic marker in sepsis.

Table 3. Distribution of Bacterial Isolates in Culture-Positive Sepsis (n = 62)

Type of Organism	Number of Isolates	Percentage (%)
Gram-negative bacteria	41	66.1
Gram-positive bacteria	21	33.9
Total	**62**	**100**

Table 3 illustrates the overall distribution of bacterial isolates obtained from culture-positive sepsis cases. Gram-negative organisms were predominant, accounting for 66.1% of the isolates, while Gram-positive bacteria constituted 33.9%. This predominance of Gram-negative pathogens underscores their major role in the etiology of sepsis in the present study and aligns with trends reported from tertiary care centers in developing countries.

Table 4. Spectrum of Gram-Negative Bacterial Isolates (n = 41)

Organism	Number of Isolates	Percentage (%)
Escherichia coli	15	24.2
Klebsiella pneumoniae	12	19.4
Pseudomonas aeruginosa	8	12.9
Acinetobacter baumannii	6	9.6
Total	**41**	**66.1***

*Percentage calculated out of total culture-positive cases (n = 62)

Table 4 presents the spectrum of Gram-negative bacterial isolates among culture-positive patients. *Escherichia coli* emerged as the most common Gram-negative pathogen (24.2%), followed by *Klebsiella pneumoniae* (19.4%). Other important pathogens included *Pseudomonas aeruginosa* (12.9%) and *Acinetobacter baumannii* (9.6%). The presence of these multidrug-resistant organisms highlights the clinical severity and therapeutic challenges associated with Gram-negative sepsis.

Table 5. Spectrum of Gram-Positive Bacterial Isolates (n = 21)

Organism	Number of Isolates	Percentage (%)
Staphylococcus aureus	13	21.0
Enterococcus species	8	12.9
Total	**21**	**33.9***

*Percentage calculated out of total culture-positive cases (n = 62)

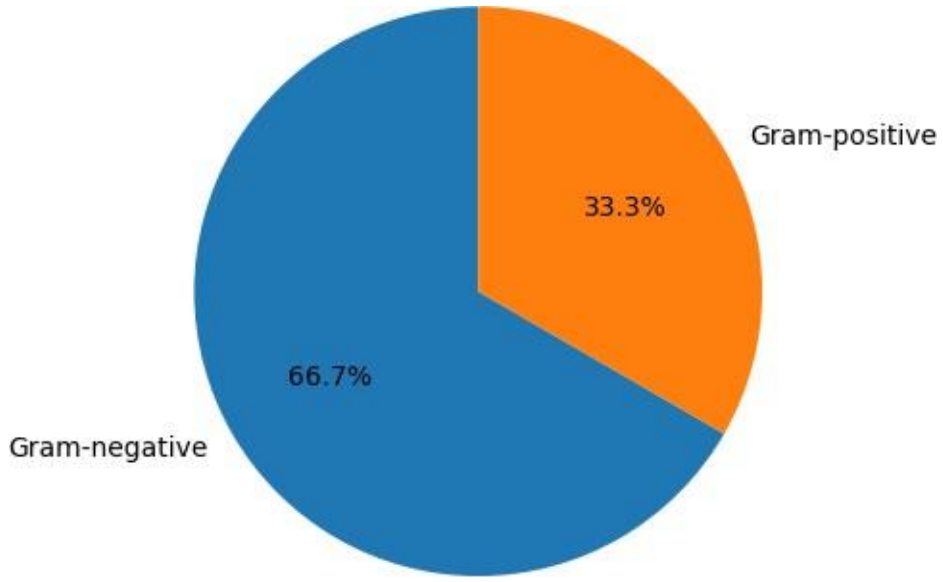
Table 5 demonstrates the distribution of Gram-positive bacterial isolates. *Staphylococcus aureus*, including methicillin-resistant strains, was the predominant Gram-positive organism, accounting for 21.0% of culture-positive cases. *Enterococcus* species contributed to 12.9% of infections. These findings emphasize the continued importance of Gram-positive cocci as significant causative agents of sepsis, particularly in hospital-acquired infections.

Table 6. Comparison of Serum Procalcitonin Levels With Culture Status

Culture Status	Mean Procalcitonin (ng/mL)	Standard Deviation
Culture Positive	9.8	± 4.6
Culture Negative	2.4	± 1.2

Table 7. Serum Procalcitonin Levels According to Type of Bacterial Infection

Type of Infection	Mean Procalcitonin (ng/mL)	Standard Deviation
Gram-negative	11.2	± 4.8
Gram-positive	5.6	± 2.3



Graph 2: Serum Procalcitonin Levels According to Type of Bacterial Infection

It was noted that the compares serum procalcitonin levels between culture-positive and culture-negative sepsis patients. The mean procalcitonin level was markedly higher in culture-positive patients (9.8 ± 4.6 ng/mL) compared to culture-negative patients (2.4 ± 1.2 ng/mL). This difference suggests that elevated procalcitonin levels correlate strongly with confirmed bacterial infection and may assist in differentiating true bacterial sepsis from non-bacterial inflammatory conditions.

It illustrates the relationship between serum procalcitonin levels and the type of bacterial infection. Patients with Gram-negative sepsis exhibited significantly higher mean procalcitonin levels (11.2 ± 4.8 ng/mL) compared to those with Gram-positive infections (5.6 ± 2.3 ng/mL). This finding supports the observation that Gram-negative infections elicit a stronger procalcitonin response, possibly due to endotoxin-mediated inflammatory pathways.

DISCUSSION

Sepsis remains a major cause of morbidity and mortality worldwide despite advances in diagnostic modalities and antimicrobial therapy [1,2]. Early identification of bacterial sepsis and prompt initiation of appropriate treatment are critical determinants of patient outcomes [3,4]. In this context, biomarkers that can reliably differentiate bacterial sepsis from non-bacterial inflammatory conditions and predict disease severity are of immense clinical value. The present study evaluated serum procalcitonin levels in patients with sepsis and analyzed their correlation with blood culture positivity and bacteriological profile, providing important insights into the diagnostic utility of procalcitonin in a tertiary care setting.

In the present study, elevated serum procalcitonin levels (>0.5 ng/mL) were observed in the majority of patients, with nearly half demonstrating markedly high levels (>10 ng/mL). This finding reinforces the role of procalcitonin as a sensitive biomarker for bacterial sepsis, as originally described by Assicot et al. and supported by multiple subsequent studies [5–8]. Procalcitonin levels are known to rise rapidly in response to bacterial endotoxins and pro-inflammatory cytokines, reflecting the intensity of the systemic inflammatory response [9–12].

A key observation in the present study was the significantly higher mean procalcitonin levels in culture-positive patients compared to culture-negative patients. Similar observations have been reported in several studies, highlighting the strong association between elevated procalcitonin levels and confirmed bacterial infection [13–15]. Culture-negative sepsis is a recognized clinical entity and may occur due to prior antibiotic exposure, low bacterial load, intermittent bacteremia, or fastidious organisms [16]. In such cases, elevated procalcitonin levels may indicate ongoing bacterial infection despite negative culture results, emphasizing its role as an adjunct diagnostic marker [17].

The blood culture positivity rate observed in the present study was comparable to rates reported from other tertiary care hospitals [18,19]. Gram-negative bacteria were the predominant isolates, accounting for approximately two-thirds of culture-positive cases. This finding is consistent with recent reports indicating a shift toward Gram-negative predominance in sepsis, particularly in developing countries [20–22]. The frequent isolation of *Escherichia coli* and *Klebsiella*

pneumoniae in the present study may be attributed to urinary tract, gastrointestinal, and intra-abdominal sources of infection, which are common portals of entry in sepsis [23].

The isolation of non-fermenting Gram-negative bacilli such as *Pseudomonas aeruginosa* and *Acinetobacter baumannii* is particularly concerning, as these organisms are commonly associated with hospital-acquired infections and exhibit high levels of antimicrobial resistance [24–26]. Their presence underscores the growing challenge of managing sepsis in tertiary care settings and highlights the importance of infection control measures and antimicrobial stewardship programs [27].

Gram-positive organisms accounted for approximately one-third of isolates in the present study, with *Staphylococcus aureus* being the most common pathogen, followed by *Enterococcus* species. These findings are consistent with previous studies demonstrating the continued significance of Gram-positive cocci in bloodstream infections and sepsis, particularly in device-associated and nosocomial infections [28,29].

One of the most important findings of the present study was the significantly higher serum procalcitonin levels observed in Gram-negative sepsis compared to Gram-positive infections. This observation has been reported by several investigators and is attributed to the potent endotoxin-mediated inflammatory response induced by lipopolysaccharides present in the outer membrane of Gram-negative bacteria [16,18,30]. Endotoxins strongly stimulate the release of cytokines such as tumor necrosis factor-α and interleukin-6, leading to marked upregulation of procalcitonin synthesis [10,11].

The association between higher procalcitonin levels and Gram-negative infections suggests that procalcitonin may provide indirect clues regarding the type of infecting organism. This has important clinical implications, as early recognition of Gram-negative sepsis may guide empirical antibiotic therapy while awaiting culture results [19,21]. Elevated procalcitonin levels at admission may prompt clinicians to initiate timely broad-spectrum antimicrobial coverage, thereby improving patient outcomes [31].

In addition to its diagnostic role, procalcitonin has been increasingly used to guide antibiotic stewardship. Several randomized trials and meta-analyses have demonstrated that procalcitonin-

guided therapy can reduce unnecessary antibiotic exposure without adversely affecting patient outcomes [10,11,18]. Although serial procalcitonin measurements were not evaluated in the present study, the strong correlation between baseline procalcitonin levels and bacteriological findings supports its potential utility in monitoring response to therapy.

Despite its advantages, procalcitonin is not a standalone diagnostic tool. Elevated levels may be observed in non-infectious conditions such as major trauma, burns, and certain malignancies [9,12]. To minimize these confounding factors, such conditions were excluded from the present study. Blood culture remains essential for definitive pathogen identification and antimicrobial susceptibility testing, which are crucial for targeted therapy and containment of antimicrobial resistance [26,27].

The findings of the present study are particularly relevant in resource-limited settings where delays in culture results often hinder early diagnosis and appropriate management of sepsis [22,23]. Procalcitonin, as a rapid and reliable biomarker, can aid in early diagnosis, risk stratification, and rational antibiotic use, thereby improving patient outcomes and reducing the burden of antimicrobial resistance [24,31].

However, the present study has certain limitations. Being a single-center study, the findings may not be generalizable to all healthcare settings. The sample size was limited, and outcomes such as mortality, length of hospital stay, and serial procalcitonin trends were not evaluated. Future multicenter studies with larger sample sizes and inclusion of serial procalcitonin measurements are required to further validate these findings [32].

In conclusion, the present study demonstrates that serum procalcitonin is a valuable biomarker in the diagnosis of bacterial sepsis and shows a strong correlation with blood culture positivity and bacterial etiology. Higher procalcitonin levels are particularly associated with Gram-negative infections. When used alongside clinical assessment and microbiological investigations, procalcitonin can enhance early diagnosis, guide empirical therapy, and support antibiotic stewardship in patients with sepsis.

CONCLUSION

The present study highlights the significant role of serum procalcitonin as a reliable biomarker in the diagnosis of bacterial sepsis. Elevated procalcitonin levels were observed in the majority of sepsis patients and showed a strong correlation with blood culture positivity, reinforcing its diagnostic value. Patients with culture-positive sepsis exhibited significantly higher procalcitonin levels compared to culture-negative cases, emphasizing its usefulness as an adjunct tool in identifying true bacterial infections.

The bacteriological profile of sepsis in this study was dominated by Gram-negative organisms, particularly *Escherichia coli* and *Klebsiella pneumoniae*. Importantly, Gram-negative infections were associated with significantly higher serum procalcitonin levels than Gram-positive infections, suggesting that procalcitonin may also provide indirect insight into the underlying bacterial etiology.

Overall, serum procalcitonin, when used in conjunction with clinical assessment and microbiological investigations, can enhance early diagnosis, aid in risk stratification, and support timely initiation of appropriate empirical antibiotic therapy. Incorporation of procalcitonin into routine sepsis evaluation may improve patient management and contribute to more rational antibiotic use, especially in resource-limited healthcare settings.

Limitations

- Single-center study, limiting generalizability
- Relatively small sample size
- Serial procalcitonin levels not assessed
- Clinical outcomes (mortality, length of stay) not evaluated
- Prior antibiotic use may have affected blood culture results

DECLARATIONS:

Conflicts of interest: There is no any conflict of interest associated with this study

Consent to participate: There is consent to participate.

Consent for publication: There is consent for the publication of this paper.

Authors' contributions: Author equally contributed the work.

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