Original article

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# Diagnostic accuracy of presepsin and C-reactive protein in the early stages of neonatal sepsis: A prospective study

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## ABSTRACT

***Introduction.*** Neonatal sepsis is a common complication in the neonatal intensive care unit (NICU). Biomarkers have certain limitations, and recent studies suggest that presepsin (PSEP) could be used for early diagnosis.

***Objective.*** To determine the early diagnostic accuracy of PSEP in newborns with suspected sepsis and to compare it with C-reactive protein (CRP).

***Population and methods.*** A prospective, cross-sectional study of newborns with suspected early- or late-onset sepsis. We defined confirmed sepsis as a positive blood culture or cerebrospinal fluid culture and excluded patients with congenital anomalies, those currently receiving antibiotic treatment, and those for whom parental informed consent was not obtained. ROC curves were plotted for PSEP and CRP.

***Results.*** A total of 150 suspected sepsis events in 122 newborns were included. The median gestational age was 32 weeks (IQR 29-37) and the median birth weight was 1530 grams (IQR 990-2705). The incidence of confirmed sepsis was 12% (95% CI, 7.3-18.3), and the median PSEP was 511 pg/mL (IQR, 392-785), with no statistically significant differences among confirmed sepsis, clinical sepsis, and no sepsis. The ROC curve for PSEP in confirmed sepsis was 0.62 (95% CI 0.48-0.76) and 0.77 (95%CI 0.68-0.86) for CRP. The optimal cutoff value for PSEP was 447 pg/mL and 14.8 mg/dL for CRP.

***Conclusion.*** The diagnostic accuracy of PSEP is low in the early stages of sepsis.

***Keywords:*** *presepsin; C-reactive protein; neonatal sepsis; preterm infant; biomarkers.*

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## INTRODUCTION

Neonatal sepsis is one of the leading causes of death and neurological impairment in newborns admitted to the NICU, especially those with very low birth weight (VLBW).[1,2] Early diagnosis is challenging because the signs and symptoms are nonspecific, leading to inappropriate antibiotic use.[3] The gold standard for diagnosis is blood culture, despite its limitations, such as the time to a positive result, sample volume, and contamination. Currently, C-reactive protein (CRP) is the most widely used biomarker despite its low sensitivity in the early stages of sepsis, its variation with gestational age (GA), and its elevation in non-infectious conditions (neonatal asphyxia, intraventricular hemorrhage, and postoperative states).[4] The systemic inflammatory response that occurs in newborns triggers a disruption of homeostasis with a potentially disproportionate systemic effect; therefore, the search for a sensitive and specific marker of sepsis remains a challenge.

Presepsin (PSEP) is a low-molecular-weight peptide (soluble CD14 subtype) released when it detaches from the membrane of monocytes and macrophages following bacterial stimulation. Studies in adults demonstrated high sensitivity (Sn) and specificity (Sp), along with a higher area under the curve (AUC) than CRP, suggesting that it could be an early and reliable biomarker of sepsis.[5,6] Some studies define PSEP as an accurate biomarker in newborns, independent of gestational age, and most compared healthy newborns with sick ones.[7-9] Over the past decade, some studies have found that PSEP has some discriminatory power, as well as greater accuracy in identifying septic newborns at higher risk of rapid clinical deterioration.[10-12]

A multicenter study published in 2025 compared baseline PSEP values (at birth, with no signs of sepsis) with subsequent sepsis event values in newborns between 35 and 39 weeks' gestation; statistically significant differences were also observed.[13]

The primary objective of this study was to determine the early diagnostic accuracy of PSEP in term and preterm newborns with suspected early- or late-onset sepsis. The secondary objective was to compare it with CRP.

## POPULATION AND METHODS

A single-center cross-sectional study that prospectively included all term and preterm newborns admitted to the NICU with suspected sepsis from September 2016 until the target sample size was reached in August 2018.

The exclusion criteria were major congenital anomalies, congenital TORCH infections, fetal hydrops, genetic syndromes, ongoing antibiotic treatment, lost samples, and the absence or refusal of informed consent from both parents.

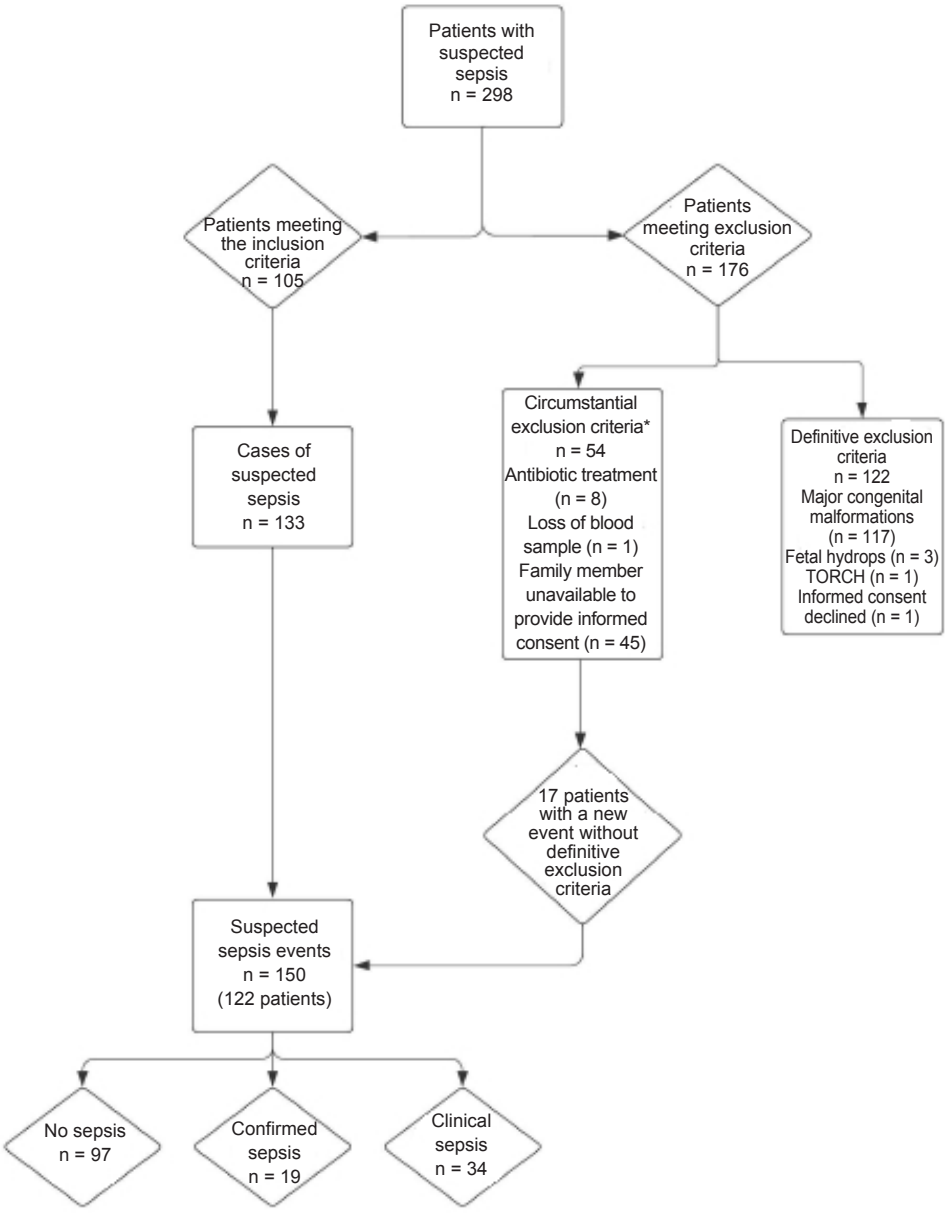
Systemic infection was defined as the presence of one or more of the following signs and symptoms of systemic inflammatory response syndrome (SIRS): hypo- or hyperthermia (<36.5 °C or >38 °C), frequent episodes of apnea or bradycardia (>3 episodes/hour), worsening of respiratory symptoms, sustained and unexplained tachycardia (>160 beats per minute), hypotension, lethargy, inability to tolerate food, metabolic acidosis (pH <7.20), hyper- or hypoglycemia, mottled appearance. Confirmed sepsis was defined as SIRS and a positive blood and/or cerebrospinal fluid culture; clinical sepsis was defined as a clinical picture of systemic infection, laboratory findings consistent with sepsis, and negative cultures after 7 days of antibiotic treatment.

Early sepsis was defined as occurring within the first 72 hours of life, and late sepsis as occurring thereafter. In cases of suspected early sepsis, the following factors were considered: a history of premature and prolonged (>18 hours) rupture of membranes (PROM), chorioamnionitis, and spontaneous onset of preterm labor. Confirmed coagulase-negative staphylococcal (CNS) sepsis was defined in collaboration with the Infectious Diseases Committee by evaluating each patient, given that this microorganism remains the most prevalent in our unit. Urinary tract infection (UTI) was defined as a positive urine culture for a microorganism with a count >100 000 colony-forming units per milliliter (CFU/mL) obtained via urethral catheterization.

### Procedures

Blood samples were collected at the time of the medical evaluation (time 0) before starting antibiotic treatment. Venous or arterial blood samples were collected for blood cultures (1 ml), white blood cell count, platelets (0.5 ml in an EDTA tube), and CRP (0.5 ml from a heparinized syringe). Samples for PSEP testing were separated from the EDTA tube (0.2 ml), centrifuged, and stored refrigerated at -70 °C until analyzed using PATHFAST Presepsin (LSI Medience Corporation, Japan; Mitsubishi Chemical Europe GmbH, Willstätterstr 30, 40549

**Figure 1. Patients flowchart**




**Circumstantial exclusion criteria refer to a suspected sepsis event in which patients could not be included, but could have been included in another event, given the absence of definitive exclusion criteria.*

Düsseldorf, Germany).

Those who performed the analyses remained unaware of the results, which were not made available to the neonatologists.

## Statistical analysis

To estimate a 95% S with a precision of 5%, a 95% confidence level, and an estimated prevalence of 50% for clinical and confirmed sepsis, a sample size of 146 events was calculated. This prevalence is based on our database records. Continuous variables were expressed as median and interquartile range (IQR), and categorical variables, such as proportion and absolute frequency. The Wilcoxon and Kruskal-Wallis tests were used to compare continuous variables. The Youden index was used to determine the optimal cutoff point. For both biomarkers, the sensitivity (Sn), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), and ROC curve were determined. The DeLongest test was used to

compare the AUCs of both curves. Data were analyzed using Stata™ 13.0, and a *p*-value <0.05 was considered statistically significant.

### Ethical considerations

The study protocol was approved by the CEPI (Research Protocol Ethics Committee) on June 9, 2016, with approval number 2739. Prospective written informed consent was obtained from the parents.

## RESULTS

Over the two-year study period, a total of 150 suspected sepsis events in 122 newborns were included. The median GA at the time of enrollment in the study was 32 weeks (IQR 29-37); birth weight (BW), 1530 grams (IQR 990-2705); and age at study enrollment, 7 days (IQR 0-15). Patients with major congenital malformations, TORCH infections, fetal hydrops, and those whose parents refused to provide informed consent were excluded. Those whose samples were lost were also excluded (*Figure 1*).

The frequencies of suspected early sepsis (43%) and late sepsis (57%) were similar, and the most common clinical manifestations were sustained tachycardia (25%), hypothermia or hyperthermia (20%), and worsening of the baseline respiratory pattern (15%). The demographic and clinical characteristics of patients are shown in *Table 1*.

The incidence of confirmed sepsis was 12% (95%CI 7.3-18.3; n = 19), and that of clinical sepsis was 22% (95%CI 16-30; n = 34). Most cases were late-onset sepsis caused by Gram-positive bacteria (80%), except for one 27-week-old patient with *Enterococcus faecalis* meningitis. Four neonates (3.2%) died of septic shock caused by Gram-negative bacilli, with a median gestational age of 24 weeks (IQR 23-25.5).

The median PSEP was 511 pg/mL (IQR 392-785), and there was no statistically significant difference between confirmed sepsis, clinical sepsis, and no sepsis (*Table 2*). A Mann-Whitney test was performed to compare PSEP levels between confirmed sepsis and no sepsis ($p = 0.06$) and between confirmed sepsis and clinical sepsis ($p = 0.28$), with no statistically significant differences found. In cases of confirmed sepsis, the population was found to have a lower birth weight ($p = 0.0004$), lower birth weight ($p = 0.0005$), and lower Apgar score at

**Table 1. Clinical and demographic characteristics of patients (n = 122)**

| | |
|---|---|
| Gestational age, <28 weeks, n (%) | 28 (23) |
| Gestational age 29-32 weeks, n (%) | 43 (36) |
| Gestational age 33-36 weeks, n (%) | 20 (16) |
| Gestational age ≥37 weeks, n (%) | 31 (25) |
| Cesarean section, n (%) | 106 (87.6) |
| 1-minute Apgar score, median (IQR) | 7 (5-8) |
| 5-minute Apgar score, median (IQR) | 8 (7-9) |
| Suspected early sepsis, n (%) | 64 (43) |
| Suspected late sepsis, n (%) | 86 (57) |
| Postnatal age at admission, days, median (IQR) | 7 (0-15) |

*IQR: interquartile range.*

**Table 2. Baseline characteristics and biomarkers according to culture results (n = 150 suspected sepsis cases)**

| | Confirmed sepsis (n = 19) | Clinical sepsis (n = 34) | No sepsis (n = 97) | *p*- value |
|---|---|---|---|---|
| GA, weeks; median (IQR) | 28 (26-30) | 30 (26-35) | 32 (29-35) | 0.0004* |
| BW, grams; median (IQR) | 955 (710-1080) | 1217 (850-2230) | 1410 (1000-2645) | 0.0005* |
| Cesarean section, n (%) | 15 (79) | 28 (84) | 87 (89) | 0.39** |
| 1-minute Apgar score, median (IQR) | 6 (1-7) | 5 (4-8) | 7 (5-8) | 0.036* |
| 5-minute Apgar score, median (IQR) | 8 (5-9) | 8 (7-8) | 8 (7-9) | 0.14* |
| Days of life at study enrollment, median (IQR) | 9 (7-25) | 11.5 (0-30) | 3 (0-10) | 0.0017* |
| PSEP pg/mL (median, IQR) | 559 (418-1233) | 563 (418-782) | 469 (363-750) | 0.13* |
| CRP mg/dL (median, IQR) | 14.8 (2.4-39) | 3.3 (0.3-15.8) | 0.6 (0.2-4.4) | 0.0001 |

***Kruskal-Wallis test, **chi-square; GA: gestational age; BW: birth weight; PSEP: presepsin; CRP: C-reactive protein.*

1 minute ($p$ = 0.036). They also had higher CRP levels, with a median of 14.8 mg/dL ($p$ = 0.0001) (*Table 2*).

In the post hoc analysis of suspected late-onset sepsis (n = 86), the median PSEP was statistically different between the groups ($p$ = 0.02), as was the CRP (*Figure 2* and *Table 3*).

The AUC for PSEP in confirmed sepsis was 0.62 (95% CI 0.48–0.76) and 0.77 (95% CI 0.68–0.86) for CRP *(Figure 3*). According to the Youden index, the optimal cutoff value for PSEP was 447 pg/mL (S 73%, E 42%) and 14.8 mg/dL for CRP (Sn 52%, Sp 82%).

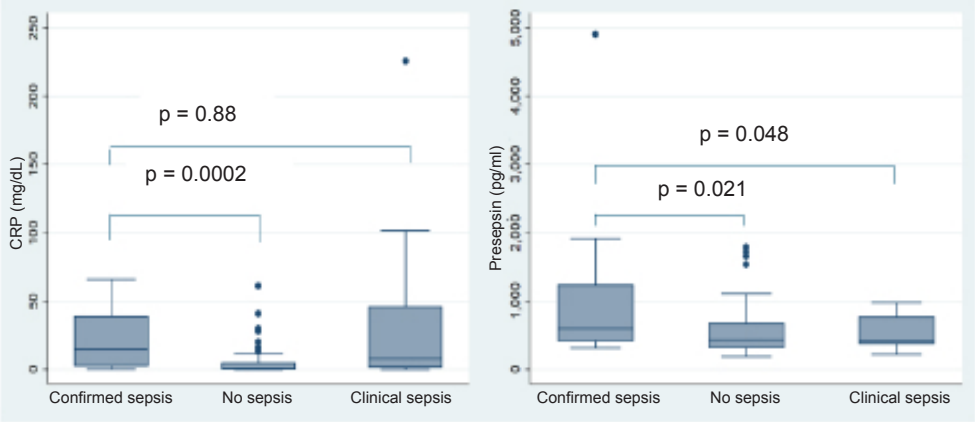
## DISCUSSION

In this prospective study, which included term and preterm newborns with suspected early- or late-onset sepsis, we found that PSEP had low diagnostic accuracy during the initial evaluation.

The median PSEP (511 pg/mL) across the 150 events and among those with confirmed sepsis (559 pg/dl) was similar to the values reported by Pugni *et al*. in asymptomatic preterm infants, as well as in a recent study of early sepsis in late preterm and term infants when compared with healthy controls.[14,15] It is worth noting that the low discriminatory power may be related to the timing of the onset of the systemic inflammatory response cascade. However, a recent multicenter study of newborns with suspected late-onset sepsis showed low diagnostic accuracy and no variation in presepsin levels during the first 12 to 24 hours.[16] The variability of the newborn's immune response leads us to speculate that the rise in PSEP and CRP levels is slower.[17]

Given the importance of a test with high sensitivity due to the associated morbidity and mortality, and acceptable specificity to avoid the indiscriminate use of antibiotics, we determined the cutoff value that best combined both to be 447 pg/mL, based on the Youden index. Topcuoglu et al. compared healthy infants with preterm infants <32 weeks with suspected late-onset sepsis, defining the optimal cutoff value as 800 pg/mL, with a sensitivity of 67% and a specificity of 100%; whereas Dierikx et al., in patients with suspected late-onset sepsis, found a cutoff value of 554 pg/mL, with a sensitivity of 70% and a specificity of 77%.[16,18]

**Figure 2. *Post hoc* analysis of C-reactive protein and presepsin in late-onset sepsis (n = 86)**



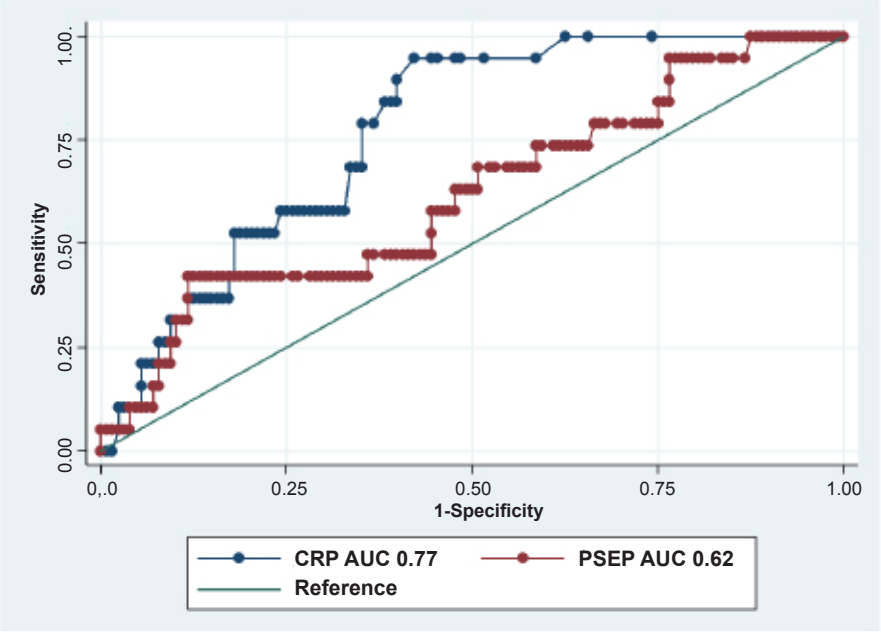

*CRP: C-reactive protein.*

**Table 3. *Post hoc* analysis for presepsin and C-reactive protein in cases of suspected late-onset sepsis**

| | Confirmed sepsis (n = 18) | Clinical sepsis (n = 20) | No sepsis (n = 48) | *p*- value |
|---|---|---|---|---|
| PSEP pg/mL (median, IQR) | 600 (418-1233) | 427 (382-767) | 443 (316-676) | 0.021* |
| CRP mg/dL (median, IQR) | 14.8 (2.4-39) | 7.7 (1.3-46) | 0.7 (0.3-4.9) | 0.0002 |

**Kruskal-Wallis test; PSEP: presepsin, CRP: C-reactive protein, IQR: interquartile range.*

**Figure 3. Area under the ROC curve for presepsin and C-reactive protein in confirmed sepsis**




*AUC: area under the curve; CRP: C-reactive protein; PSEP: presepsin.*

A meta-analysis evaluated the performance of PSEP in early and late sepsis, reporting a pooled Sn of 92% (IQR 0.91-0.93), Sp of 86% (IQR 0.84-0.87), and an AUC of 0.96, and concluded that early and late sepsis should be analyzed as two distinct clinical entities, given that, in early sepsis, suspicion is based on "preclinical stages" of the disease.[19] For this reason, we performed a post hoc analysis in the late sepsis group, and the PSEP performance improved slightly to an AUC of 0.68 (data not shown); however, no significant differences were found, likely due to a Type II error.

In 2011, we implemented an epidemiological surveillance program to reduce the incidence of confirmed sepsis (reported at 45%) and meningitis (5%), with coagulase-negative staphylococci predominating (35%).[20,21] In 2015, the incidence of confirmed sepsis was lower (25%), but the diagnosis of clinical sepsis remained high; therefore, we decided to conduct this study considering both. It was common practice to diagnose clinical sepsis based on clinical and laboratory findings, despite negative cultures, and to administer antibiotics for 5-7 days. Today, our unit has a policy of discontinuing antibiotics 36-48 hours after negative blood cultures, as recent publications have called for an end to the era of sepsis with negative cultures.[22,23]

CRP is the most widely studied, readily available, and commonly used biomarker for complementary use. In our study, it had greater discriminatory power than PSEP, and the optimal cutoff value was similar to that previously reported.[24]

Among the strengths, we consider the prospective design, the requirement for informed consent from both parents, the sample size, and the selected population, since we studied symptomatic patients, as is customary in daily NICU practice. The idea of an early indicator of infection is to obtain useful information before the full-blown onset of sepsis.

The lack of PSEP monitoring as a marker of treatment response could be a limitation of our study, as some studies show correlations between PSEP and sepsis severity and antibiotic response.[13]

According to the evidence, most biomarkers do not demonstrate sufficient diagnostic accuracy to be used as a standalone test; therefore, future studies with less heterogeneity in the study population are needed to combine these markers in the early stages and during sepsis.[25,26]

## CONCLUSION

Our study shows that PSEP has low diagnostic accuracy in the early stages of sepsis, even lower than that of CRP. Further studies are needed to understand the role of this biomarker in neonatal sepsis. ■

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