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Original article

THE CLINICAL SIGNIFICANCE OF PROCALCITONIN AS A BIOMARKER FOR SEPSIS IN PAEDIATRIC PATIENTS- A PROSPECTIVE OBSERVATIONAL STUDY.

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Abstract.

Introduction:

The complicated condition known as sepsis is characterized by life-threatening organ failure brought on by an unbalanced host response to infection. It has received attention for its early detection and rapid supply of antimicrobials because it is linked to considerable morbidity and mortality rates in both adults and children. With higher diagnostic and prognostic utility for bacterial infections, procalcitonin is a recognized biomarker for bacterial sepsis in the non-pregnant population.

Method:

Children who were admitted between January 2022 and December 2022 to the pediatric intensive care unit at Nalanda Medical College and Hospital with sepsis or septic shock ranged in age from 28 days to 14 years. The children were divided into two groups: the septic shock group (SSG; n = 43) and the sepsis group (SG; n = 47). Procalcitonin levels were assessed at admission (T0) and again 12 hours later (T12h), with the following classifications based on the results: 0.5 ng/mL = sepsis improbable; 0.5 to 2 = sepsis possible; 2 to 10 = systemic inflammation; and 10 = septic shock.

Result:

At T0, there were more SSG patients in the highest PCT class than SG patients [SSG: 30 (38.9%) > SG: 29 (36.2%); $p<0.02$]. In comparison to the other classes, the proportion of SSG patients in this highest PCT class was higher ($p<0.02$; 10 = 38.9%; 2 to 10 = 28.5%; 0.5 to 2 = 28.5%). Procalcitonin behaved similarly at T0 and T12 hours.

Conclusion:

Sepsis can be distinguished from septic shock by procalcitonin, which can also help with pediatric septic disease diagnosis and may be associated with severity.

Recommendation:

Along with procalcitonin, other definitive tests must also be conducted in context with information from clinical data for sepsis diagnosis.

Keywords: Procalcitonin, sepsis, septic shock, children, intensive care, Submitted: 2023-08-28 Accepted: 2023-09-08

1. INTRODUCTION.

Sepsis is a major source of morbidity and mortality in the entire world. It is defined as a life-threatening organ malfunction brought on by an

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unbalanced host response to infection [1]. According to recent estimates, there are close to 50 million incident cases of sepsis each year around the world, with newborns, children, and teenagers accounting for approximately half of these occurrences [2]. In the US, sepsis affects over 1.7 million adults annually, with a fatality incidence of over 20% [3], while sepsis in children is linked to a mortality rate of between 8% and 10% [4]. If the underlying cause is left untreated or is not adequately treated, organ dysfunction can quickly escalate to shock and death. Therefore, educational initiatives have concentrated on identifying sepsis early, to start supportive therapy and antibiotic treatment as soon as feasible. However, effective early identification and risk assessment are difficult since sepsis is a complicated, heterogeneous process rather than a single entity.

In the population of adults who are not pregnant, procalcitonin (PCT) is a recognized marker for sepsis and has superior diagnostic and prognostic value for bacterial infections [5, 6]. PCT, a precursor of calcitonin produced by the C cells of the thyroid gland, aids in the maintenance of blood calcium levels and is released into the circulation in response to endotoxins and proinflammatory stimuli, particularly those coming from bacteria. Healthy individuals and those suffering from viral infections, long-term inflammatory diseases, or autoimmune conditions typically have low levels. In serious bacterial infections, the PCT level rises markedly within the first few hours (latent period, 2–4 hours) and has a brief half-life, assisting in directing and monitoring antibiotic therapy response. [6,7] The use of PCT in the diagnosis of pregnancy-related sepsis is comparatively understudied, and reference values for PCT in pregnancy have not been established. [8,9]

PCT's potential role as a sepsis mediator is still being researched. According to certain research, PCT may help detect sepsis in children early on and serve as a gauge of severity.[10,11]

The utility of PCT for diagnosis and prognosis in patients with sepsis and septic shock has been questioned in various other research, which have found the opposite outcomes.[12,13] Additionally, there is proof that patients with Systemic Inflammatory Response Syndrome (SIRS) with noninfectious aetiology have higher serum PCT levels.[14]

According to reports, chorioamnionitis complicates anywhere between 1% and 4% of deliveries globally and is linked to serious poor outcomes for both the mother and the baby.[15,16] Therefore, it is advisable to start empirical broad-spectrum antibiotics with a low threshold in women who develop intrapartum pyrexia.[17-19] Between 3% and 7%, a high incidence of intrapartum pyrexia has been documented.[20,21] Infants born to mothers who experienced intrapartum pyrexia have a minimal risk of neonatal sepsis of 0.24% (rate of 1 in 400 occurrences).[21-27]

There is a need to more clearly characterize PCT's utility for the early identification of sepsis in this population, as evidenced by the inconsistent results about its function and the dearth of research on children that have evaluated this mediator. Our theory is that, following the neonatal period, PCT is helpful for both diagnosing and evaluating the severity of children with septic diseases.

2. MATERIALS AND METHODS.

2.1. Study design, setting, and participants.

Children aged 28 days to 14 years who were admitted to the pediatric intensive care unit (PICU) at the Nalanda Medical College and Hospital, Patna, and who were diagnosed with sepsis or septic shock were included in this prospective observational study, which was conducted between January 2022 and December 2022. Children were disqualified if they had burns, trauma, or were in postoperative care. They were also disqualified if they had chronic systemic inflammatory diseases, degenerative neurological diseases, primary or acquired immunodeficiency diseases, or were taking corticosteroids, nonsteroidal anti-inflammatories, or antibiotics for longer than 24 hours.

The occurrence of SIRS symptoms and signs in conjunction with a confirmed or suspected infection is referred to as sepsis. The presence of two

or more of the following indicators led to the diagnosis of SIRS:

- A temperature (rectal, oral, or central) > 38.5 oC or 35 oC
- Tachycardia (may be absent if there is hypothermia)
- Tachypnea
- A white blood cell count that is abnormally high or low for the patient's age (and not as a result of chemotherapy) or
- Immature neutrophils that make up more than 10% of the total count. Additionally, at least one of the following requirements had to be met: broad pulses, hypoxemia, a rise in serum lactate, or an altered state of consciousness. Septic shock was described as the presence of tachycardia (which may not exist if there is hypothermia) along with indicators of decreased perfusion, such as altered levels of consciousness or decreased urine output. Uncompensated shock is indicated by hypotension, a late indication.

On admission, patients were divided into one of two research groups: the septic shock group (SSG) or the sepsis group (SG). Each patient's sepsis or septic shock diagnosis was accepted by all researchers at weekly meetings. Since septic shock may develop in a patient with sepsis, the initial diagnosis was regarded as the sole factor in determining the study group.

The College of Critical Care and Society of Critical Care Medicine task force recently established the hemodynamic support treatment, and patients were watched and received it.[11] Daily records were kept on the amounts of fluid provided during the first hour and the vasoactive medications used with shock patients. MOSF was defined as the existence of at least two organs that were determined to be dysfunctional based on recognized standards.[12] All patients' Paediatric Risk of Mortality (PRISM) ratings were computed at the time of admission.[23]

2.2. Laboratory tests.

The first blood sample was taken on admission and labeled T0. Once 12 hours had passed, another sample was taken and labeled T12h. The results of the biochemical analyses were not made available to the treating doctors. The blood sample taken for PCT assay was 5 mL at T0 and 3 mL on subsequent occasions, from central venous catheter. After collection, the blood was immediately refrigerated and, no more than 8 hours later, the material was centrifuged so that the mediators could be assayed in plasma. The PCT assay was a semi-quantitative method using immunochromatography (BRAHMS PCT®-Q - Diagnostica GmbH, Hennigsdorf, Germany), the so-called rapid test (30 minutes). The PCT concentration classes and their possible interpretations were as follows:6 1) < 0.5 ng/mL = sepsis unlikely, there may be a localized infection; 2) ≥ 0.5 ng/mL to < 2 ng/mL = sepsis possible; 3) ≥ 2 ng/mL to < 10 ng/mL = bacterial infection complicated by systemic inflammation; and 4) ≥ 10 ng/mL = septic shock.

2.3. Statistical analysis.

Using the Goodman test for contrasts between multinomial populations, analysis of the distribution of sex, foci of infection, PCT classes by time and groups, and change in PCT classes by group, was carried out. PRISM scores and age categories were evaluated using the Mann-Whitney U test. A 5% significance level was used to establish all results.

3. RESULTS.

A total of 157 patients were included in this study. At the initial stage, several 200 patients were examined for eligibility, however, 43 patients were excluded from this study due to not being eligible. The groups are contrasted by age, sex, and PRISM score in Table 1. Age and sex differences between the groups were statistically insignificant. However, there was a statistically significant difference in the PRISM score, which was higher in the SSG [SSG: 43.5 > SG: 66; p<0.02] in terms of illness severity.

In 157 individuals, bacteria could be isolated from blood or cerebrospinal fluid cultures. Of 40 patients, 43.5 (56.5%) of the SSG patients had positive blood cultures, and 35 (45.5%) of the SSG youngsters had positive cerebrospinal fluid cultures.

Gram-negative bacteria (P. aeruginosa, H. influenzae, A. baumanii, and Klebsiella species) were found in 68 patients (43.3%), gram-positive germs (S. aureus, S. pneumoniae, and S. epidermidis) were found in instances 42(26.75%), and polymicrobial infections were found in four more patients 25(15.9%). 22 patients (14.01%) had a diagnosis of C. albicans, a fungus.

Across the PCT concentration classes at T0 and T12h for the two groups, (Table 2) displays the patient distribution. The majority of patients in the SSG were in the 10 ng/mL class, in contrast to what occurred in the SG, with the difference between groups statistically significant for this class [SSG: 30 (38.9%) > SG: 29(36.2%); $p<0.05$]. At T0, PCT was a marker of severity because it distinguished patients with septic shock from those with sepsis. At T0, the proportion of SSG patients in the highest PCT classes was noticeably higher than that of patients in the other classes [class 10: 30 (38.9%) > class 2 to 10: 21 (27.2%) < class 0.5 to 2: 23 (29.8%) >class 0.5: 3 (3.8%); $p<0.02$]. However, there was no statistically significant difference in the distribution of SG patients among PCT classes.

The PCT behavior at T12h was consistent with that at T0, meaning that there were substantially more patients in the 10 class in SSG than in SG [SSG: 30 (38.9%) > SG: 18.7%); $p<0.02$]. Additionally, there was a statistically significant difference between the groups for the range of 2 to 10 that was in favor of the SG group and showed that there were more patients in that group who were in lower PCT level classes [SG = 40 (50%) > SSG = 22 (28.5%); $p<0.02$]. In the SSG, a significant difference in the frequency of patients in the highest class and the other classes was seen. The distribution of SG patients among PCT classes, on the other hand, showed no statistically significant changes.

4. DISCUSSION.

This investigation showed that PCT could already distinguish between patients with sepsis and those with septic shock based on their severity at the time of admission. Furthermore, individuals with septic shock had greater PCT levels and more increased PRISM scores. These findings are consistent with those of Casado-Flores et al. [28], who examined 80 children suspected of having sepsis and found that PCT had superior diagnostic and prognostic capabilities to C-reactive protein. They also found that levels were significantly higher in children with septic shock than in those with sepsis and were higher in patients with higher PRISM scores. Similar findings have been reported by other investigations, which have identified PCT as a predictor for severity in children with meningococcal sepsis [29] and in septic newborn infants [30]. By using daily PCT assays to examine 70 persons, Luzzani et al. [31] showed that this mediator is associated with the development of MOSF. A link between PCT levels and progression to MOSF could not be found.

In contrast to the children in the SG, a considerably higher percentage of SSG patients had MOSF, and we also noticed that PCT levels were higher in the SSG group.

The component of managing septic patients that has the biggest impact on the clinical course, treatment, and patient survival is early infection diagnosis.[24] The study of indicators of severe infection in children has drawn increasing attention in this setting.

A meta-analysis and systematic review were published in 2004 to examine the utility of PCT as a marker of bacterial infection in both adults and children.[25] Only two of the twelve studies that were examined included children, and one of those studies included newborn newborns.[26,27] The meta-analysis concluded that PCT is a more reliable marker than C-reactive protein for discriminating between viral and bacterial infections as well as between bacterial infection and other causes of systemic inflammation. The analysis did not address whether PCT should be used to determine a child's diagnosis and prognosis for sepsis

Table 1: **Analysis of PRISM scores, sex, and median age (variation) for SG and SSG.**

Variable		Groups		Descriptive level
		SG (n = 80)	**SSG (n = 77)**	
PRISM		25.7	43.5	p > 0.02
Age in months		64	35	p > 0.02
Sex (number)	Female	61 66	67 66	p > 0.02
Male				

Table 2: **Procalcitonin concentration classes at To and T12h and the distribution of patients in SG and SSG.**

Groups	Procalcitonin concentration classes (ng/mL), n(%)			
	< 0.5 (sep-sisun-likely)	**≥ 0.5 to < 2 (sepsis possi-ble)**	**≥2 to <10 (sys-temic inflam-mation)**	**≥ 10 (septic shock)**
SG (n = 80)	4 (5%) 7 (8.75%)	21(26.25%) 30 (37.5%)	40 (50%) 14(17.5%)	15 (18.7%) 29(36.2%)
T12h T0				
SSG (n = 77)	3 (3.9%) 3 (3.8%)	22 (28.5%) 23 (29.8%)	22 (28.5%) 21 (27.2%)	30 (38.9%) 30 (38.9%)
T12h T0				

and septic shock.

The kinetics of the mediator itself may be able to explain why PCT levels rose over time in a sizable portion of this study's patients with septic shock. As previously stated, PCT peaks later, between 6 and 24 hours, and declines later, between 2 and 3 days [4]. It is also important to take into account how antibiotic use affects PCT levels. Even that PCT might be beneficial for evaluating the response to antibiotic treatment has been observed, with reductions in plasma concentrations of this marker being described in response to the administration of antibiotics [32,33].

Given that, antibiotic usage during the illness may have had an impact on this study's findings. This impact may have been amplified in less severe cases, preventing potential PCT rises in children in the SG.

According to reports, some people who don't exhibit sepsis clinical symptoms have high PCT levels, while others who do exhibit the condition's symptoms but don't have high levels of the marker.

Furthermore, due to the challenges in interpreting the result, the 0.5 to 2 ng/mL PCT class (sepsis probable) has been dubbed the "grey zone." We now know that it's possible that some of the septic patients had minimal inflammation, while others who were initially diagnosed with sepsis had more severe systemic inflammatory diseases, which would account for the finding that some SG patients fell into the PCT class for septic shock and some SSG children fell into the class for sepsis possible.

These findings back up the claim that PCT can be used as a secondary approach to diagnose sepsis and can indicate the severity of an infection. The clinical diagnosis of sepsis/septic shock is frequently subjective and therefore uncertain, so this diagnostic method must be evaluated in the context of the patient's clinical status, complementing careful clinical assessment and decisions based on other laboratory parameters. The next step is to show if PCT assaying enhances patient prognosis by facilitating early diagnosis and assisting in therapy monitoring.

5. CONCLUSION.

In the group studied here, plasma PCT levels at admission permitted sepsis and septic shock to be distinguished, with a higher level of significance being attainable after 12 hours. The findings imply that PCT is reliable for auxiliary diagnosis of septic illnesses in children and valuable as a gauge of patient severity. Before these results may be applied to the child population as a whole, double-blind and randomized investigations must be conducted.

6. LIMITATIONS.

The limitations of this study include a small sample population who were included in this study. The findings of this study cannot be generalized for a larger sample population. Furthermore, the lack of a comparison group also poses a limitation for this study's findings.

7. RECOMMENDATION.

Along with procalcitonin, other definitive tests must also be conducted in context with information from clinical data for sepsis diagnosis.

8. ACKNOWLEDGEMENT.

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9. LIST OF ABBREVIATIONS.

SSG- Septic Shock group
SG- Sepsis group
PCT- Procalcitonin
SIRS- Systemic Inflammatory Response Syndrome
PICU- Pediatric intensive care unit
MOSF- Multiple Organ System Failure
PRISM- Pediatric Risk of Mortality

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11. Conflict of interest.

The authors report no conflicts of interest in this work.

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