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Original Research Article

Serum Procalcitonin Levels in Children with Community-Acquired Pneumonia: A Cross-Sectional Study

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Abstract:

Background: Community-acquired pneumonia (CAP) continues to be a major contributor to both mortality and morbidity among children under five years of age. Recently, there has been growing interest in procalcitonin (PCT) as potential biomarker for CAP. Emerging evidence indicates that a low procalcitonin level has a high negative predictive value for ruling out typical bacterial infections in pediatric patients. In light of this, the present study aims to evaluate the clinical utility of PCT in managing pediatric CAP.

Materials and Methods: This hospital-based, cross-sectional, observational study was carried out on 78 children, aged between 2 months and 5 years, who were diagnosed with CAP. The study collected various clinical details including age, sex, and symptoms such as fever history, feeding difficulties, convulsions, lethargy, cyanosis, chest in drawing, respiratory rates, auscultatory findings (e.g., bilateral lung air entry, inspiratory crepitations, bronchial breathing), and oxygen saturation levels. Routine laboratory tests, including complete blood count, serum CRP, blood cultures, chest X-rays, and serum PCT levels, were conducted.

Results: Of the 78 children diagnosed with CAP, 60.26% were aged between 2 to 5 months. In the study population, 69.23% showed mildly elevated serum PCT levels, while 20.51% had significantly elevated levels. A robust correlation was found between PCT levels and pneumonia severity ($P < 0.01$), as well as between PCT levels and clinical outcomes ($P < 0.01$). However, PCT's role in aiding early diagnosis remained inconclusive.

Conclusion: The study suggests that serum PCT could serve as a valuable marker for determining the severity and prognosis of CAP in children. None of the children with elevated PCT levels, who received antibiotics, developed further CAP-related complications.

Keywords: Community-acquired Pneumonia; Procalcitonin; Children.

Introduction

Pneumonia is becoming increasingly prevalent among children under five years of age, contributing to approximately 14% of childhood fatalities. Although the incidence of community-acquired pneumonia (CAP) has declined in this age group in recent years, primarily due to the introduction of pneumococcal and Haemophilus influenza type b vaccines, it continues to be a significant cause of morbidity and mortality. India ranks among the top five nations globally in all reported cases of pneumonia.

Notably, there has been a considerable reduction in pneumonia cases among HIV-negative children in India. Effective diagnostic and therapeutic strategies are vital to minimize the incidence of CAP and to avert complications or deaths [1-3]. The World Health Organization (WHO) characterizes pneumonia and categorizes its severity based solely on clinical observations in children aged up to five years. Key symptoms include Chest retraction, cough or difficulty breathing, elevated respiratory rate, and other significant warning signs such as altered consciousness, inability to breastfeed or drink, and lethargy [4, 5]. Several diagnostic methods exist for CAP, including chest radiography as one approach. In conjunction with modern techniques like lung ultrasound and microbiological tests, clinicians can also utilize biomarker studies to distinguish between bacterial and viral pneumonia [6,7].

Procalcitonin (PCT), a precursor of calcitonin produced in response to severe bacterial infections, sepsis, and organ dysfunction, offers enhanced diagnostic accuracy compared to C-reactive protein (CRP) for differentiating pneumonia from asthma or other non-infectious respiratory conditions in adults. The most extensively researched algorithm classifies PCT values into four categories (<0.1 ng/mL, 0.1 to <0.25 ng/mL, 0.25–0.5 ng/mL, and >0.5 ng/mL), each correlating with the likelihood

of bacterial infection (very low, low, moderate, and high), where elevated values suggest a greater probability of bacterial disease [8-11]. A pediatric investigation indicated a significant 14% reduction in antibiotic use within a PCT-guided group of hospitalized children with CAP, particularly those with PCT levels below 0.25 ng/mL [12].

However, studies assessing whether serum PCT can effectively classify the etiology of CAP have produced inconsistent findings, likely due to variations in methodologies and reference standards [13]. Research by Stockmann et al. supports the use of PCT to adjust antibiotic treatment protocols in pediatric CAP cases, particularly for patients with PCT levels under 0.1 ng/mL [14]. It is essential to utilize biomarkers to enhance and refine the outcomes of clinical assessments rather than solely rely on them in decision-making processes [8]. Several biomarkers have been explored and utilized in clinical practice for adults to indicate the etiology and severity of CAP, contributing to advancements in addressing diagnostic and therapeutic challenges. However, the investigation of their role in pediatric CAP has yielded inconsistent results across numerous studies.

Managing CAP in resource-limited settings within developing countries presents considerable challenges, making it beneficial to have a rapid marker available for assessing severity and prognosis in pediatric cases. This study aims to evaluate the efficacy of serum PCT in diagnosing community-acquired pneumonia in children. The objective is to assess the relevance of serum PCT in the prompt detection, evaluation of severity, and management of children hospitalized with CAP.

Material and Methods

This cross-sectional, hospital-based observational study included children aged 2 months to 5 years who were diagnosed with CAP. Pneumonia diagnosis was based on the guidelines provided by the World Health Organization (WHO) and the Integrated Management of Neonatal and Childhood Illness (IMNCI) protocols [4,5,15]. Children who had received antibiotics within the preceding 14 days, those with concurrent acute croup, chronic infections, cystic fibrosis, severe immunosuppression, those undergoing immunosuppressive therapy, as well as children with major trauma, meningitis, neutropenia, recent major surgical interventions, were excluded from the study.

A total of 78 children were enrolled in the study. The clinical parameters recorded included age, sex, chest in drawing, cyanosis, difficulty in feeding or drinking, febrile or afebrile status, history of convulsions, lethargy, respiratory rates, and auscultatory findings such as bilateral lung air entry, bronchial breathing, inspiratory crepitations, and oxygen saturation levels. Laboratory investigations included blood cultures, complete blood count, chest radiographs, serum CRP, and serum PCT measurements. Blood samples were collected within 1 hour of hospital admission. Serum PCT levels were quantified using the electrochemiluminescence immunoassay method on an automated analyzer. The PCT levels were categorized as negative (<0.5 ng/mL), weakly positive (0.5–2 ng/mL), and strongly positive (>2 ng/mL).

The data were presented as frequencies, percentages, and ranges, depending on the distribution of the variables. The independence of variables was tested using either the Chi-square test or Fisher's exact test, depending on the data's normality and frequency. Sensitivity analysis was performed to identify parameters with higher classification accuracy. All statistical analyses were carried out using SPSS, with a significance level set at $P < 0.05$.

Results

Table 1 outlines the demographic and clinical characteristics of patients diagnosed with community-acquired pneumonia (CAP). The majority of the patients (60.26%) were in the age group of 2–5 months, with fewer cases observed in older children. Several key clinical signs and symptoms were observed as outlined in Table 1. Regarding biomarkers, Procalcitonin (PCT) levels were elevated in a significant number of cases, with 69.23% of patients having PCT levels between 0.5–2 ng/mL, while 20.51% had levels exceeding 2 ng/mL.

Table 1: Demographic and clinical variables in CAP cases

Variable	n	%
Age (months)		
2–5	47	60.26
6–12	20	25.64
>12	11	14.10
Gender		
Male	37	47.44
Female	41	52.56
Bronchial Breathing		

Present	6	7.69
Absent	72	92.31
Chest Indrawing		
Present	76	97.44
Absent	2	2.56
Fever		
Absent	41	52.56
Present	37	47.44
Convulsion		
Present	6	7.69
Absent	72	92.31
Cyanosis		
Present	3	3.85
Absent	75	96.15
Difficulty Feeding/ Drinking		
Present	45	57.69
Absent	33	42.31
Diminished Breath Sounds		
Present	61	78.21
Absent	17	21.79
Inspiratory Crepitations		
Present	48	61.54
Absent	30	38.46
Lethargy		
Present	44	56.41
Absent	34	43.59
Oxygen Saturation		
≤92	44	56.41
>92	34	43.59
Respiratory Rate		
>40/min	6	7.69
>50/min	10	12.82
>60/min	62	79.49
PCT		
>2 ng/mL	16	20.51
>0.5-2 ng/mL	54	69.23
<0.5 ng/mL	8	10.26
CRP		
Positive	73	93.59
Negative	5	6.41

Table 2 highlights the association of PCT levels with key clinical parameters.

A significant association was found between positive blood culture and elevated PCT levels, with all 12 blood culture-positive cases having elevated PCT, while none of the PCT-negative patients had a positive blood culture. Similarly, the prescription of antibiotics was more common in PCT-positive patients.

The severity of pneumonia was also significantly associated with PCT levels, with more severe cases tending to have higher PCT levels.

Table 2: Association of PCT with various parameters

Parameters	PCT Positive	PCT Negative	P Value
Blood Culture			<0.01
Positive	12	0	
Negative	11	55	
Prescribed Antibiotics			<0.01
Yes	47	3	
No	23	5	
Severity of Pneumonia			<0.01

Severe	2	32	
Very Severe	22	22	

Table 3 provides a correlation analysis of PCT levels with various clinical and laboratory parameters. There was no significant correlation between PCT levels and CRP positivity.

However, a significant correlation was observed between PCT levels and chest X-ray findings, where positive chest X-ray findings were more frequent in patients with strongly elevated PCT levels (>2 ng/mL). Moreover, PCT levels were significantly correlated with clinical outcomes ($P < 0.01$).

Patients with satisfactory outcomes had predominantly lower PCT levels, whereas those with poor outcomes had higher PCT levels. Our study found an area under the curve (AUC) of 85% for PCT, contrasting with 55% for CRP.

Table 3: Correlation of PCT with various parameters

Parameters	PCT Negative	PCT Weakly Positive	PCT Strongly Positive	P Value
CRP				0.35
Positive	6	51	16	
Negative	2	3	0	
Positive Chest X-ray Finding				<0.01
Present	3	25	16	
Absent	5	29	0	
Clinical Outcome				<0.01
Satisfactory	55	6	9	
Poor	0	2	6	

Discussion

Our research identified a significant relationship between pneumonia severity and procalcitonin (PCT) levels, with a p-value of less than 0.01. Additionally, we observed noteworthy trends regarding the distribution of community-acquired pneumonia (CAP) among various age groups. Specifically, most of the participants were aged 2 to 5 months. In terms of clinical manifestations, the majority of patients with CAP reported difficulties in breastfeeding or drinking, with lethargy being another prevalent symptom. Severe chest retractions were noted in almost all of the children. A significant number of the children had positive C-reactive protein (CRP) results. Our study highlighted an area under the curve (AUC) of 85% for PCT, contrasting with 55% for CRP.

In a related study by Moulin et al., it was noted that cases of bacterial pneumonia with positive blood cultures had markedly elevated PCT levels, corroborating our findings [16]. PCT plays a pivotal role in calcium metabolism regulation and the body's response to infection and inflammation. Other research has indicated that initial peak PCT levels may serve as early predictors of bacterial infections and multi-organ dysfunction [17].

Additionally, Yadav et al. found a robust correlation between PCT levels and radiological findings ($p < 0.01$), with higher PCT concentrations linked to pleural effusion and lung consolidation. Yadav et al. also concluded that PCT is superior to CRP for distinguishing between severe and very severe pneumonia, aligning with our results [18,19]. Several studies have further demonstrated the high specificity of PCT in evaluating pneumonia severity, suggesting more accurate patient outcome classifications. Previous research has indicated that elevated PCT levels correlate with severity and poor prognostic indicators [20,21].

Conversely, studies examining CRP in pediatric CAP have produced inconsistent results and varied threshold values, with some findings indicating that CRP only weakly predicts bacterial pneumonia. According to the British Thoracic Society guidelines, CRP is deemed ineffective for managing uncomplicated pneumonia. Past studies have consistently shown a higher prevalence of CAP in children aged 2 to 11 months compared to those aged 12 to 59 months [22-25]. Research suggests that clinicians generally reach a stronger consensus on observable clinical signs (such as the use of accessory muscles and patient responsiveness) than on auscultated signs (like adventitious sounds). The study by Palafox et al. reported that tachypnea alone exhibited a sensitivity of 74% and a specificity of 67% for diagnosing radiologically confirmed CAP [26-28]. Similar patterns have emerged in previous investigations, with rapid breathing and chest retractions being the most commonly reported symptoms, followed by difficulties in breastfeeding or drinking as the second most frequent presentation [22].

Conclusion

The incidence of CAP was notably higher among children aged 2–6 months. A significant correlation was observed between elevated serum PCT levels and the presence of positive blood culture growth. Thus, Serum PCT has the potential to serve as a reliable marker for evaluating the severity and prognosis of CAP. If incorporated into routine diagnostic protocols, serum PCT could be an effective biomarker for assessing disease severity and guiding therapeutic decisions, thereby reducing the risk of CAP-related complications.

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