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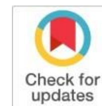

Evaluate the diagnostic value of ESR, CRP, Procalcitonin, and Presepsin in Children with CAP

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ABSTRACT

Background: Community-acquired pneumonia (CAP) is one of the leading causes of morbidity and mortality in children worldwide, particularly in low- and middle-income countries. Clinical signs and radiological findings alone may be insufficient to predict disease severity. In this context, biomarkers such as procalcitonin (PCT), C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR) have been studied as potential predictors of severe pneumonia. **Objective:** To evaluate the role of serum procalcitonin in predicting the severity of community-acquired pneumonia in children and to compare its performance with serum CRP and ESR. **Materials and Methods:** This cross-sectional analytical study was conducted in the Department of Pediatrics, Bangladesh Medical University, Dhaka. A total of 60 children aged 2 months to 5 years who fulfilled the WHO criteria for CAP were enrolled. Children were categorized into pneumonia, severe pneumonia, and very severe pneumonia groups based on WHO guidelines. Clinical examination and demographic data were recorded. Serum PCT was measured using the Atellica IM BRAHMS PCT assay, CRP by latex agglutination, and ESR by standard methods. Statistical analysis was performed using SPSS version 25. Receiver-operating characteristic (ROC) curves were generated to determine sensitivity, specificity, and cutoff values of biomarkers in predicting severe CAP. A p value <0.05 was considered significant. **Results:** The mean serum PCT level was significantly higher in children with severe/very severe pneumonia (12.93 ± 10.12 ng/ml) compared to those with pneumonia (1.53 ± 0.81 ng/ml) ($p<0.001$). Similarly, CRP (70.75 ± 37.10 mg/dl vs. 16.12 ± 14.79 mg/dl, $p<0.001$) and ESR (36.87 ± 13.98 mm/hr vs. 26.0 ± 8.15 mm/hr, $p<0.001$) were elevated in severe cases. ROC curve analysis demonstrated the highest diagnostic accuracy for serum PCT (AUC = 0.942, sensitivity 94.9%, specificity 70.0%) compared to CRP (AUC = 0.912) and ESR (AUC = 0.738). **Conclusion:** Serum procalcitonin is a highly sensitive and specific biomarker for predicting the severity of community-acquired pneumonia in children, outperforming CRP and ESR. Incorporation of PCT measurement in routine clinical practice may aid in early identification of severe cases and guide timely management.

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INTRODUCTION

Community-acquired pneumonia (CAP) is an acute infection of the lung parenchyma acquired outside hospital or long-term care facilities and remains a leading cause of morbidity and mortality in children worldwide. Globally, CAP accounts for nearly one million deaths annually among children under five years, ranking second only to complications of preterm birth in high-mortality countries [1]. In Bangladesh, pneumonia contributes to about 15% of under-five deaths, making it a major public health concern [2]. The World Health Organization (WHO) classifies CAP severity based on clinical features

such as fast breathing, chest indrawing, and general danger signs, guiding appropriate management strategies [3] However, clinical signs alone may be insufficient, and chest radiography, although widely used, has limitations in sensitivity and specificity [4].

In this context, biomarkers have gained importance for the diagnosis and severity assessment of CAP. C-reactive protein (CRP) is a widely used inflammatory marker, but it lacks specificity in distinguishing bacteria from viral infections [5]. Procalcitonin (PCT), a precursor of calcitonin secreted in response to bacterial infection, has emerged as a promising biomarker with higher sensitivity and specificity for severe CAP [6, 7]. Early identification of children at risk of severe pneumonia is crucial to improving outcomes. This study was conducted to evaluate the role of serum procalcitonin in predicting the severity of community-acquired pneumonia in children.

MATERIALS AND METHODS

This cross-sectional analytical study was conducted in the Inpatient and Outpatient Department of Pediatrics, Bangladesh Medical University (BMU), Dhaka. A total of 80 children aged 2 months to 5 years who fulfilled the World Health Organization (WHO) criteria for community-acquired pneumonia (CAP) were enrolled. Children with malignancy, chronic illnesses, hospital-acquired pneumonia, or whose caregivers declined participation were excluded. The primary objective of the study was to evaluate the role of serum procalcitonin (PCT) in predicting the severity of CAP. Participants were categorized into three groups based on WHO severity criteria: pneumonia, severe pneumonia, and very severe pneumonia. A detailed history and clinical examination were performed, including assessment of vital signs (temperature, respiratory rate, heart rate, and blood pressure) as well as clinical features such as lower chest indrawing, cyanosis, and other systemic signs. Respiratory rate was measured twice within five minutes while the child was at rest; if the readings differed by more than five breaths per minute, or if the second reading was below the cut-off, a third measurement was obtained. Demographic and clinical data were recorded in a structured proforma. For laboratory analysis, 2 mL of venous blood was collected aseptically from the median cubital vein into a clean, dry test tube. After clotting, samples were centrifuged at 2000 rpm for 5 minutes, and the separated serum was stored at –20°C until testing. Procalcitonin (PCT): Serum PCT was measured using the Atellica IM BRAHMS PCT assay, a two-site sandwich immunoassay employing three mouse monoclonal antibodies. The reference value was ≤0.5 μg/L. PCT secretion typically begins within 2–3 hours after bacterial infection, peaks at 6 hours, and has a half-life of 22–35 hours. C-reactive protein (CRP): CRP was measured using the Atellica CH High Sensitivity CRP latex reagent assay. This test is based on latex particle agglutination with anti-CRP antibodies and has a duration of 8 minutes. The reference upper limit was ≤5 mg/L. CRP secretion starts within 4–6 hours of infection, doubles every 8 hours, and reaches a peak within 36–50 hours. Erythrocyte sedimentation rate (ESR): Measured by standard laboratory methods and used as an additional inflammatory marker. All procedures followed institutional ethical guidelines. Written informed consent was obtained from caregivers prior to participation. Statistical analysis was performed using SPSS version 25.0 for Windows (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Group comparisons were made using the Chi-square test for categorical variables and the unpaired t-test for continuous variables. Receivers operating characteristic (ROC) curves were constructed to determine the cutoff values of biomarkers with the best sensitivity, specificity, and predictive values for identifying severe CAP. A p value <0.05 was considered statistically significant.

RESULTS

Table 1: Distribution of Age and Sex According to Severity of CAP (N=80)

Age (months)	Study group		Total	p value
	Pneumonia (n=40)	**Severe and Very Severe Pneumonia (n=40)**		
2-12	25 (62.50%)	32 (70.0%)	57	0.08
13-59	15 (37.5%)	08 (30.0%)	23	
Mean ± SD	20.58±20.23	10.13±7.75		0.004

Range (min-max)	2-59	2-36		
Gender				
Male	27 (67.5%)	22 (55.0)	49	0.26
Female	13 (32.50%)	18 (45.0)	31	

Among the 80 children included in the study, the majority (71.3%) were aged between 2–12 months, with 62.5% in the pneumonia group and 70.0% in the severe/very severe pneumonia group. Children aged 13–59 months accounted for 37.5% of the pneumonia group and 30.0% of the severe/very severe group. The mean age was significantly lower in the severe/very severe pneumonia group (10.13 ± 7.75 months) compared to the pneumonia group (20.58 ± 20.23 months), with a statistically significant difference (p = 0.004). With respect to gender distribution, males predominated overall (61.3%), comprising 67.5% in the pneumonia group and 55.0% in the severe/very severe group, whereas females accounted for 32.5% and 45.0%, respectively. However, the difference in sex distribution between groups was not statistically significant (p = 0.26).

Table 2: Mean of Serum Procalcitonin, Serum CRP and ESR Between Pneumoni and Severe and Very Severe of CAP (N=80)

	Pneumonia (n=20)	**Severe and Very Severe Pneumonia (n=40)**	**p value**
	Mean±SD	**Mean±SD**	
Serum procalcitonin (ng/ml)	1.53±0.81	12.93±10.12	<0.001
Serum CRP (mg/dl)	16.12±14.79	70.75±37.10	<0.001
ESR	26.0±8.15	36.87±13.98	<0.001

The mean levels of serum procalcitonin, serum CRP, and ESR were markedly higher in children with severe and very severe CAP compared to those with pneumonia. Serum procalcitonin was significantly elevated in the severe/very severe group (12.93 ± 10.12 ng/ml) compared to the pneumonia group (1.53 ± 0.81 ng/ml, p < 0.001). Similarly, serum CRP levels were substantially higher in the severe/very severe group (70.75 ± 37.10 mg/dl) than in the pneumonia group (16.12 ± 14.79 mg/dl, p < 0.001). ESR also showed a significant difference, with mean values of 36.87 ± 13.98 mm/hr in the severe/very severe group versus 26.0 ± 8.15 mm/hr in the pneumonia group (p < 0.001). These findings indicate that serum procalcitonin, CRP, and ESR are significantly elevated in severe forms of CAP, suggesting their potential role as markers of disease severity.

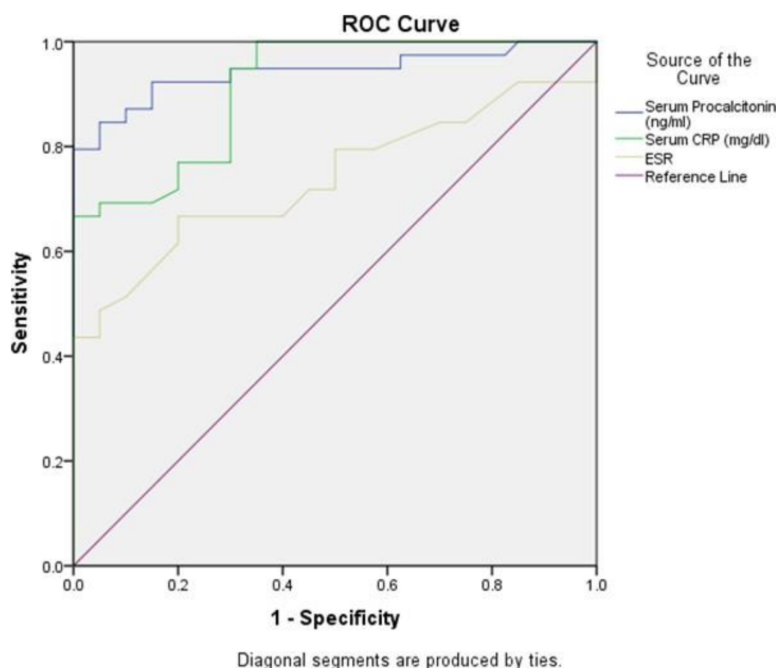

Figure 1: Receiver-Operator Characteristic Curves of Serum Procalcitonin, Serum CRP and ESR To Differentiate Combined Severe and Very Severe Pneumonia from Pneumonia.

Table 3: Receiver-Operator Characteristic (ROC) Curve of Serum Procalcitonin, Serum CRP and ESR For Prediction of Severe Pneumonia

	Cut of value	Sensitivity	Specificity	Area under the ROC curve	95% Confidence interval (CI)	
					Lower bound	Upper bound
Serum procalcitonin ng/ml)	≥1.72	94.9	70.0	0.942	0.886	0.997
Serum CRP (mg/dl)	≥19.66	94.9	70.0	0.912	0.853	0.971
ESR	≥34.50	64.0	80.0	0.738	0.624	0.853

The diagnostic performance of serum procalcitonin, serum CRP, and ESR in predicting severe pneumonia was evaluated using receiver-operator characteristic (ROC) curve analysis. Serum procalcitonin at a cutoff value of ≥1.72 ng/ml demonstrated the highest diagnostic accuracy, with a sensitivity of 94.9% and specificity of 70.0%, yielding an area under the curve (AUC) of 0.942 (95% CI: 0.886–0.997). Serum CRP at a cutoff value of ≥19.66 mg/dl showed similar sensitivity (94.9%) and specificity (70.0%), with an AUC of 0.912 (95% CI: 0.853–0.971). In comparison, ESR at a cutoff of ≥34.50 mm/hr demonstrated lower sensitivity (64.0%) but higher specificity (80.0%), with an AUC of 0.738 (95% CI: 0.624–0.853). Overall, serum procalcitonin exhibited the best predictive accuracy for severe pneumonia, followed by serum CRP, while ESR showed relatively lower diagnostic performance.

DISCUSSION

In the present study, the majority of children with community-acquired pneumonia (CAP) were aged between 2–12 months (71.3%). The mean age was significantly lower in the severe/very severe pneumonia group (10.13 ± 7.75 months) compared to the pneumonia group (20.58 ± 20.23 months, p = 0.004). This finding indicates that younger children are more vulnerable to developing severe forms of CAP. Similar age-related patterns have been reported previously. Yadav *et al.*, observed that children aged >1–5 years were more frequently represented in severe pneumonia groups, although the difference between groups was not statistically significant [8]. Wu *et al.*, reported an average age of 19.18 ± 9.1 months among hospitalized children with pneumonia, while Jain *et al.*, found that the majority (45%) of children were under 2 years, with a median age

of 2 years. Agnello *et al.*, reported a higher mean age (5.25 ± 3.61 years), reflecting differences in study populations across regions [9-11].

With respect to gender distribution, males predominated overall (61.3%), with a male-to-female ratio similar to that reported in other studies. Although there was no significant difference between pneumonia and severe pneumonia groups (p = 0.26), this male predominance is consistent with findings by Yadav *et al.*, who reported 57–59% of severe pneumonia cases were male, and Wu *et al.*, who found a male-to-female ratio of 1.55:1. Similarly, Agnello *et al.*, and Jain *et al.*, observed male predominance in pediatric CAP cases. This may reflect gender-related healthcare-seeking behaviors in South Asian contexts, in addition to biological susceptibility [8-11].

The present study demonstrated that serum biomarkers including procalcitonin (PCT), C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR) were significantly elevated in severe and very severe CAP compared to pneumonia. Mean serum PCT levels were 12.93 ± 10.12 ng/ml in severe/very severe pneumonia versus 1.53 ± 0.81 ng/ml in pneumonia ($p < 0.001$). Similarly, mean CRP levels were markedly higher in severe cases (70.75 ± 37.10 mg/dl vs. 16.12 ± 14.79 mg/dl, $p < 0.001$). ESR was also significantly elevated (36.87 ± 13.98 vs. 26.0 ± 8.15 mm/hr, $p < 0.001$). These findings indicate that PCT, CRP, and ESR are valuable inflammatory markers in distinguishing between mild and severe pneumonia. Our findings are in line with Yadav *et al.*, who observed significantly higher median PCT and CRP levels in very severe pneumonia (11.38 ng/ml and 95 mg/dl, respectively) compared to severe pneumonia (0.52 ng/ml and 52 mg/dl) [8]. Don *et al.*, also reported that children requiring hospitalization for CAP had significantly elevated PCT levels (median 17.81 ng/ml vs. 0.72 ng/ml, $p < 0.001$) [12]. Similarly, Lee *et al.*, reported higher PCT (5.19 ± 0.74 ng/ml) and CRP (12.27 ± 2.17 mg/L) levels in lobar pneumonia compared to bronchopneumonia [13]. These consistent findings across different settings highlight the robust association between PCT, CRP, and pneumonia severity.

In ROC curve analysis, serum PCT demonstrated the best diagnostic performance in predicting severe CAP, with an AUC of 0.942 (95% CI: 0.886–0.997) at a cutoff ≥1.72 ng/ml, yielding sensitivity of 94.9% and specificity of 70.0%. CRP showed a slightly lower AUC (0.912, 95% CI: 0.853–0.971) at a cutoff ≥19.66 mg/dl with similar sensitivity and specificity, while ESR demonstrated lower accuracy (AUC 0.738, 95% CI: 0.624–0.853). These results suggest that PCT is the most reliable biomarker for predicting pneumonia severity, followed by CRP, while ESR has limited discriminative value. Comparable findings have been reported in previous studies. Yadav *et al.*, reported AUC values of 0.923 for PCT and 0.837 for CRP in differentiating severe from very severe pneumonia, with PCT cutoff >2 ng/ml showing higher specificity (86.4%) compared to CRP >60 mg/dl (63.6%) [8]. Ratageri *et al.*, also noted raised PCT levels in 87.9% of children with pneumonia according to WHO criteria, though its correlation with chest X-ray findings was moderate [14]. Furthermore, correlation analyses from previous studies demonstrate that PCT and CRP levels are strongly associated. Agnello *et al.*, reported a significant correlation (r = 0.538, p = 0.001), while Wu *et al.*, found that increased CRP levels were strongly associated with severe pneumonia ($p < 0.05$) [9, 11]. Overall, the present study supports the role of serum PCT as a superior biomarker for predicting severity in pediatric CAP, consistent with evidence from multiple studies CRP also showed good predictive value, though slightly inferior to PCT, while ESR was less reliable [8-10]. Given the high burden of CAP in under-five children globally, the use of these biomarkers, particularly PCT, may help clinicians in early risk stratification and guiding timely management decisions, especially in resource-limited settings.

CONCLUSION

Serum procalcitonin is a reliable and sensitive biomarker for predicting the severity of community-acquired pneumonia in children. In this study, children with severe and very severe CAP had significantly higher levels of procalcitonin compared to those with mild pneumonia. While CRP and ESR also increased with disease severity, procalcitonin demonstrated superior diagnostic accuracy. Early measurement of serum procalcitonin can aid clinicians in identifying high-risk patients, guiding timely hospital admission and appropriate management, and potentially improving outcomes. Incorporating procalcitonin assessment into routine pediatric practice may enhance severity stratification and support rational use of antibiotics.

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