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CORRELATION BETWEEN PROCALCITONIN VALUES AND PNEUMONIA SEVERITY IN PEDIATRIC PATIENTS

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ABSTRACT
Pneumonia remains one of the leading causes of morbidity and mortality among children, particularly in developing countries. Rapid assessment of disease severity is essential for appropriate clinical management. Procalcitonin (PCT) is recognized as a biomarker of systemic bacterial infection; however, its role in determining the severity of pediatric pneumonia is still debated. This study aimed to analyze the correlation between procalcitonin levels and pneumonia severity in pediatric patient. This was an observational analytic study with a retrospective cross-sectional design using consecutive sampling. Data were collected from medical records of 102 pediatric patients aged 1 month to 18 years who were diagnosed with pneumonia throughout 2024. PCT levels were compared between children with severe pneumonia and those with severe pneumonia accompanied by danger signs. Statistical analysis included the Mann-Whitney test to assess differences in PCT values and ROC curve analysis to determine the optimal cut-off, sensitivity, specificity, and accuracy. The majority of patients (71.6%) presented with severe pneumonia with danger signs. PCT levels differed significantly between groups ($p < 0.001$). ROC analysis identified an optimal cut-off value of ≥1.06 µg/L, yielding a sensitivity of 82.2%, specificity of 79.3%, positive predictive value of 90.9%, negative predictive value of 63.9%, and overall accuracy of 81.37% (AUC = 0.874). There is a significant association between procalcitonin levels and the severity of pneumonia in children. Procalcitonin may serve as a valuable early biomarker for assessing disease severity and guiding clinical decision-making in pediatric pneumonia, particularly in healthcare settings in North Sumatra.

Keywords: biomarker; danger signs; disease severity; pediatric pneumonia; procalcitonin

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INTRODUCTION

The World Health Organization (2014) reported that 14% of toddler deaths were caused by pneumonia. Based on Ministry of Health surveillance data (2023), 1,802,213 cases of pneumonia were reported in toddlers between 2017 and 2020. The higher incidence of cases in toddlers is associated with underdeveloped immune systems. A total of 15%–30% of children with pneumonia require hospitalization (Kementerian Kesehatan Republik Indonesia, 2015; Rizone, Meirina, Hamdi, & Aldy, 2025). Pneumonia severity in children, according to the World Health Organization, is classified as no pneumonia, pneumonia, severe pneumonia, and severe pneumonia with danger signs (World Health Organization, 2014). Supporting tests to determine pneumonia severity in children can be conducted using biomarker tests. Commonly used biomarkers include C-reactive protein (CRP), leukocyte count, and procalcitonin (PCT) (Berlina, Zherdev, & Dzantiev, 2020; Matha, Rahiman, & Gelbart, 2016; Florin & Williams, 2021; Bobillo, Rodríguez, & Garcia, 2018; Stockmann, Ampofo, & Killpack, 2018; Longo et al., 2011). Therefore, this study aimed to examine the association between procalcitonin levels and pneumonia severity in pediatric patients.

METHOD

This study is a descriptive study with a retrospective cross-sectional design conducted from February 2025 to July 2025 using secondary data from medical records of pediatric patients at Adam Malik Hospital Medan who were diagnosed with pneumonia from January 2024 to December 2024. This study has received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, University of North Sumatra and official permission from Adam Malik Hospital Medan. The study sample consisted of 102 children aged 1 month to 18 years who had a procalcitonin test on the first day of treatment and were selected using consecutive sampling. Patients with incomplete medical records, immune disorders, congenital heart disease, physical trauma or burns, or recent surgery were excluded from the study. Data collected included demographic characteristics (age, gender, weight, height, nutritional status), pneumonia severity (severe pneumonia and severe pneumonia with danger signs), and procalcitonin laboratory values. Statistical tests used included the Mann-Whitney test to examine differences in procalcitonin values according to pneumonia severity levels, and ROC curve analysis to determine the cut-off value, sensitivity, specificity, and accuracy of procalcitonin in predicting severe pneumonia with danger signs.

RESULT

This study involved 102 children diagnosed with pneumonia and treated at Adam Malik Hospital Medan between January 2024 and December 2024. Characteristics data include gender, age at hospital admission, weight and height at admission, and nutritional status was presented in table.

Table 1.
Demographic characteristics of pediatric patients with pneumonia

Demographic Characteristics	n = 102
Gender, f (%)	
Male	54 (52,9)
Female	48 (47,1)
Age, f (%)	
1 months old – 5 years old	60 (58,8)
>5 years old – 10 years old	10 (9,8)
>10 years old – 18 years old	32 (31,3)
Height by age, f (%)	
Short	59 (57)
Normal	32 (31,3)
Tall	11 (10,7)
Weight based on age, f (%)	
Severely Underweight	40 (39,2)
Moderately Underweight	25 (24,5)
Normal	30 (29,4)
Overweight	7 (6,8)
Nutritional status, f (%)	
Severe Malnutrition	23 (22,5)
Malnutrition	25 (24,5)
Good Nutrition	50 (49)
Overweight	1 (1)
Obesity	3 (2,9)
Pneumonia Severity, f (%)	
Severe Pneumonia with Danger Signs	73 (71,6)
Severe Pneumonia	29 (28,4)
Use of Breathing Aids, f (%)	
Invasive mechanical ventilator	70 (68,6)
Continous Positive Airway Pressure (CPAP)	3 (2,9)
Oxygen Mask	1 (0,9)
Nasal Cannula Oxygen	28 (27,4)
Mortality, f (%)	
Yes	46 (45,1)
No	56 (54,9)

The research data also showed that the majority of patients with severe pneumonia with danger signs used invasive mechanical ventilators (95.9%) and CPAP (4.1%). Meanwhile, the majority of children with severe pneumonia used nasal cannula oxygen (96.6%), and only one child (3.4%) used mask oxygen. No patients with severe pneumonia used ventilators or CPAP. The chi-square test results showed a statistically significant correlation between the type of breathing aid used and pneumonia severity in children ($p < 0.001$). In the group with severe pneumonia with danger signs, 46 (45.1%) patients died, while in the group with only moderate pneumonia, no patient died. The analysis showed a statistically significant correlation between pneumonia severity and mortality ($p < 0.001$). This indicates that more severe the pneumonia, more higher death risk. (Table 2)

Tabel 2.
Correlation between demographic characteristics and pneumonia severity in pediatric patient

Demographic Characteristics	Pneumonia Severity		P value
	Severe Pneumonia with Danger Signs	Severe Pneumonia	
Gender, f (%)			0,469[a]
Male	37 (68,5)	17 (31,5)	
Female	36 (75)	12 (25)	
Age, f (%)			0,106[b]
1 months old – 5 years old	26 (25,4)	35 (34,3)	
>5 years old – 10 years old	1 (0,98)	10 (9,8)	
>10 years old – 18 years old	11 (10,78)	19 (18,62)	
Height by age, f (%)			0,683[b]
Short	43 (42,1)	16 (15,6)	
Normal	24 (23,5)	9 (8,8)	
Tall	6 (5,8)	4 (3,9)	
Weight based on age, f (%)			0,659[b]
Severely Underweight	29 (28,4)	11 (10,7)	
Moderately Underweight	20 (19,6)	5 (4,9)	
Normal	19 (18,6)	11 (10,7)	
Overweight	5 (4,9)	2(1,9)	
Nutritional status, f (%)			0,246[c]
Severe Malnutrition	15 (14,7)	8 (7,8)	
Malnutrition	22 (21,5)	3 (2,9)	
Good Nutrition	33 (32)	17 (16,7)	
Overweight	1 (0,9)	0	
Obesity	2 (0,01)	1 (0,98)	
Use of Breathing Aids, f (%)			<0,001[b]
Invasive mechanical ventilator	70 (68)	0	
Continous Positive Airway Pressure (CPAP)	3 (2,9)	0	
Oxygen Mask	0	1 (0,9)	
Nasal Cannula Oxygen	0	28 (27,4)	
Mortality, f (%)			<0,001[a]
Yes	46 (45,1)	0	
No	0	56 (54,9)	

Numerical data is presented with median values (min – max)
[a]Chi Square, [b]Mann Whitney, [c]Kruskal Wallis

A total of 29 patients (28.4%) had procalcitonin levels in the range of 2–10 µg/L, followed by 27 patients (26.5%) with levels >10 µg/L. Meanwhile, 22 patients (21.6%) had procalcitonin levels between 0.05–0.5 µg/L, and 18 patients (17.6%) were in the range of 0.5–2 µg/L. Only 6 patients (5.9%) had very low procalcitonin levels, <0.05 µg/L. (Table 3)

Table 3.
Distribution of procalcitonin levels in pediatric patient with pneumonia treated

Procalcitonin Value (µg/L)	Frequency (n)	Percentage (%)
< 0.05	2	1,9
0,05-0,5	26	25,4
0,5-2	18	17,6
2-10	30	29,4
>10	26	25,4

In group of severe pneumonia with danger signs, majority of patients had high procalcitonin levels, ranging from 2–10 µg/L (n = 25) to >10 µg/L (n = 26). Conversely, in group of severe pneumonia, most patients had lower procalcitonin levels, ranging from 0.05–0.5 µg/L (n = 20). Only a small proportion of patients in both groups had procalcitonin levels <0.05 µg/L. The Mann-Whitney test showed a statistically significant difference between the two groups, with a p value of <0.001. This indicates a significant correlation between procalcitonin levels and pneumonia severity in pediatric patient, especially in group of severe pneumonia with danger signs. (Table 4)

Tabel 4.
Correlation between procalcitonin levels and pneumonia severity in pediatric patient treated

Procalcitonin Value (µg/L)	Pneumonia Severity		P value
	Severe Pneumonia with Danger Signs	Severe Pneumonia	
< 0.05	1	1	<0,001*
0,05-0,5	6	20	
0,5-2	13	5	
2-10	25	5	
>10	26	0	

*Mann Whitney

Receiver Operating Characteristic (ROC) analysis was performed to evaluate the ability of procalcitonin to predict pneumonia severity in pediatric patients. The analysis results showed that PCT performed well as a predictor of severe pneumonia with danger signs, with an Area Under the Curve (AUC) value of 0.874 (p < 0.001). An AUC value greater than 0.8 indicates good diagnostic accuracy, with a 95% confidence interval between 0.807 and 0.942, indicating consistent and statistically significant results. (Figure 1)

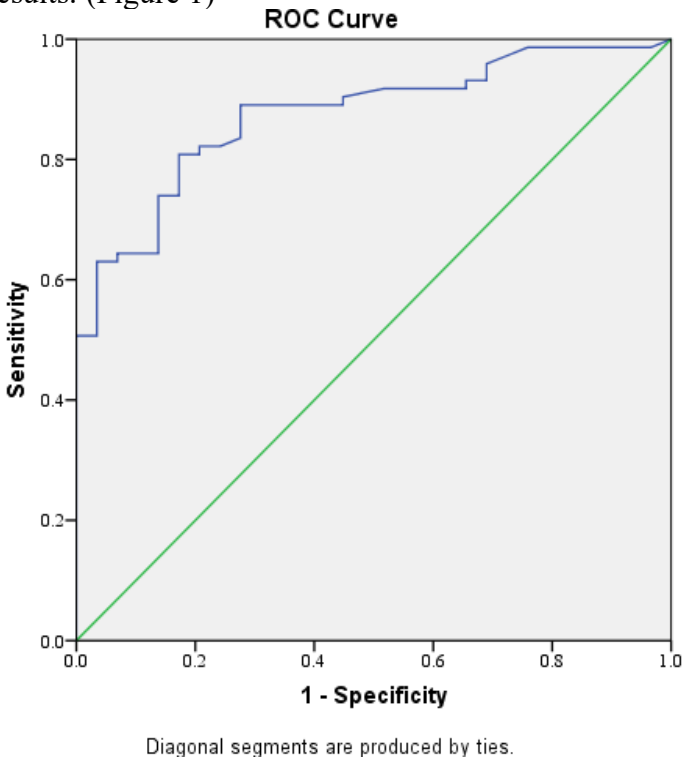

Figure 1. ROC curve of procalcitonin values as a predictor of pneumonia severity in pediatric patients with pneumonia.

Based on the coordinates of the ROC curve, the optimal PCT cut-off value was ≥ 1.06 µg/L with sensitivity of 82.2% and a specificity of 79.3%. This high sensitivity means PCT is capable of detecting most cases of severe pneumonia with danger signs, while its relatively good specificity helps reduce the possibility of false positives. Therefore, this cut-off value can be a useful clinical reference for early identification of pediatric patients at risk of severe pneumonia with danger signs. (Table 5)

Table 5.
Accuracy value of procalcitonin as a predictor of pneumonia severity in pediatric patient with pneumonia treated

Procalcitonin Value	Pneumonia Severity		Sensitivity	Specificity	PPV	NPV	Accuracy
	Severe Pneumonia with Danger Signs	Severe Pneumonia					
≥ 1,06 µg/L	60	6	82,2%	79,3%	90,9%	63,9%	81,37%
< 1,06 µg/L	13	23					

Furthermore, the Positive Predictive Value (PPV) reached 90.9%, indicating that most patients with PCT values above the cut-off actually had severe pneumonia with danger signs. Meanwhile, the Negative Predictive Value (NPV) of 63.9% indicated that PCT values <1.06 µg/L tended to indicate severe pneumonia. The overall accuracy of using this cut-off point was 81.37%.

DISCUSSION

The study results indicate a significant difference between procalcitonin levels in patients with severe pneumonia compared to those with severe pneumonia with danger signs ($p < 0.001$). The majority of patients with severe pneumonia with danger signs had high procalcitonin levels, particularly in the range of 2–10 µg/L and >10 µg/L. Conversely, patients with severe pneumonia without danger signs tended to have lower procalcitonin levels, particularly in the range of 0.05–0.5 µg/L. This finding aligns with previous research by Sartori, Zhu, and Grijalva (2021), which demonstrated a positive correlation between elevated procalcitonin levels and the progression or severity of pneumonia in children. Research by Stockmann, Ampofo, and Killpack (2018) also supports this finding, noting that procalcitonin levels ≥ 2 µg/L were strongly associated with systemic infection or sepsis. This condition often coexists in pediatric patients with severe pneumonia with danger signs. Procalcitonin is considered a more specific biomarker for bacterial infection compared to C-reactive protein (CRP) and leukocyte count, because its increase occurs more quickly (within 2–4 hours) after bacterial stimulation and peaks approximately 6–24 hours later (Longo et al., 2011).

However, interpretation of procalcitonin values also requires consideration of the timing of examination and phase of disease. In this study, procalcitonin values were obtained from laboratory results on the first day of hospitalization, which may not necessarily coincide with the first day of symptom onset. This may affect the measured procalcitonin values, as procalcitonin values can fluctuate over time, depending on infection phase. Several studies have shown that procalcitonin values tend to increase in the early phase of systemic infection and decrease if there is a response to therapy, or conversely, increase sharply if the disease progresses or complications such as sepsis, septic shock, or acute respiratory distress syndrome (ARDS) occur. Furthermore, length of hospitalization and infectious complications can also affect procalcitonin values. Complications such as empyema, bacteremia, or secondary infections can cause higher procalcitonin values than uncomplicated pneumonia. Procalcitonin may also remain elevated in patients with clinical deterioration or nosocomial infections during hospitalization. Therefore, high PCT values not only reflect the severity of the initial infection, but may also be a response to subsequent complications or secondary systemic infections that develop during hospitalization. Thus, this study results confirm that high procalcitonin values correlate with the pneumonia severity, but the interpretation must be done carefully by paying attention to the day on which procalcitonin value examination after pneumonia symptoms onset, as well as the possibility of other clinical complications that also affect procalcitonin values.

Based on the ROC curve analysis, the AUC value of 0.874 indicates that procalcitonin has high accuracy in distinguishing between severe pneumonia and severe pneumonia with danger signs. The cut-off value obtained was ≥1.06 µg/L, with a sensitivity of 82.2% and a specificity of 79.3%. This indicates that procalcitonin can be used as a good early indicator in assessing the risk of pneumonia

severity, with a Positive Predictive Value (PPV) of 90.9% and a Negative Predictive Value (NPV) of 63.9% and an overall accuracy of 81.37%. These results support the use of procalcitonin as a clinical predictive biomarker that can assist healthcare professionals in making faster and more accurate management decisions. Procalcitonin has quite good sensitivity in identification patients at high risk of developing severe pneumonia with danger signs, while its quite good specificity can help reduce misclassification in patients with severe pneumonia without danger signs.

This study showed that procalcitonin value examination in pediatric patients with pneumonia has high diagnostic and prognostic value in determining severity. The use of a procalcitonin cut-off value of ≥1.06 μg/L can be considered in clinical guidelines to assess the need for intensive care, antibiotic use, and to monitor the risk of adverse clinical outcomes such as need for invasive mechanical ventilation and mortality. Furthermore, these data reinforce the importance of biomarker monitoring from the beginning of hospitalization to ensure more targeted and timely patient care. This study has limitations. It did not include data on clinical complications that may occur in patients during treatment, so the analysis focused on the correlation between procalcitonin levels and pneumonia severity without considering other clinical outcomes associated with complications. Nevertheless, the results provide important insights into the diagnostic value of procalcitonin in assessing pneumonia severity in children.

CONCLUSION

Procalcitonin levels correlate with pneumonia severity (severe pneumonia and severe pneumonia with danger signs) in pediatric patients, with the optimal cutoff value for distinguishing between severe pneumonia and severe pneumonia with danger signs was ≥1.06 μg/L, with a sensitivity of 82.2%, a specificity of 79.3%, and an accuracy of 81.37%. These findings reinforce the potential of procalcitonin as a clinical biomarker that can be used to assist initial assessment of pneumonia severity in children at healthcare facilities.

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