Section: Pediatrics

Original Research Article

TO STUDY PROCALCITONIN AND C-REACTIVE PROTEIN LEVELS IN CHILDREN WITH COMMUNITY ACQUIRED PNEUMONIA IN A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Community-acquired pneumonia (CAP) remains a major cause of morbidity and mortality among children worldwide, particularly in developing countries. Differentiating bacterial from viral pneumonia based solely on clinical presentation is challenging, often resulting in unnecessary antibiotic use and contributing to antimicrobial resistance. Inflammatory biomarkers such as Procalcitonin (PCT) and C-reactive Protein (CRP) may aid in identifying the etiology of pneumonia and improve treatment decisions. The objective is to evaluate the levels of Procalcitonin (PCT) and C-reactive Protein (CRP) in children with community-acquired pneumonia admitted to a tertiary care hospital, assess the epidemiological profile of CAP, and determine the role of PCT and CRP in differentiating bacterial from viral pneumonia.

Materials and Methods: This cross-sectional observational study was conducted at Rainbow Children's Hospital, Vijayawada, over a two-year period from April 2023 to April 2025. Seventy children aged 2 months to 18 years diagnosed with CAP were enrolled after obtaining informed consent. Clinical evaluation, laboratory investigations including complete blood count, serum PCT, serum CRP, blood culture, PCR testing of nasopharyngeal samples, and chest radiography were performed. Patients were categorized into viral, bacterial, and mixed infection groups. Statistical analysis was carried out using SPSS version 21, and a p-value <0.05 was considered statistically significant.

Results: Viral pneumonia was the predominant etiology (74%), followed by mixed infections (20%) and bacterial pneumonia (6%). The majority of children (52.8%) were below five years of age, with males accounting for 60% of cases. Wheezing was predominantly associated with viral pneumonia (77%), while crepitations were present in all bacterial pneumonia cases. Diffuse lung involvement was more common in viral infections, whereas lobar consolidation predominated in bacterial pneumonia. PCT levels were significantly higher in bacterial pneumonia compared to viral pneumonia (p=0.039), while CRP showed no statistically significant difference (p=0.126). ROC analysis demonstrated superior diagnostic performance of PCT compared to CRP, with higher specificity (84.6% vs. 34.6%), accuracy (92.3% vs. 67.3%), and area under the curve (0.812 vs. 0.731).

Conclusion: Procalcitonin demonstrated better diagnostic utility than C-reactive Protein in differentiating bacterial from viral community-acquired pneumonia in children. Although elevated PCT levels may also occur in severe viral infections, its incorporation into routine clinical evaluation may improve diagnostic accuracy, reduce unnecessary antibiotic use, and support antimicrobial stewardship.

Keywords: CAP, PCT, CRP.

INTRODUCTION

Pneumonia is an acute infection involving the lung parenchyma caused mainly by bacteria and viruses and remains an important cause of morbidity and mortality among children worldwide. It continues to be the leading infectious cause of death among children under five years of age, accounting for a significant proportion of childhood mortality, particularly in developing countries where the majority of pneumonia-related deaths occur.[1,2]

Community-acquired pneumonia (CAP) refers to an acute infection of the lungs acquired outside healthcare settings. According to the Revised World Health Organization (WHO) classification (2014), pneumonia in children is diagnosed in the presence of cough and/or breathing difficulty associated with tachypnea and/or chest indrawing. Severe pneumonia is identified by additional danger signs such as inability to drink or feed, persistent vomiting, convulsions, lethargy or unconsciousness, stridor at rest, or severe malnutrition. WHO simplified the classification into two categories: pneumonia and severe pneumonia.[3]

The definition of pneumonia may vary depending on clinical settings. WHO recommendations mainly emphasize clinical evaluation, whereas diagnosis may also include fever and respiratory symptoms with radiological evidence of pulmonary infiltrates. Viral pathogens account for a major proportion of CAP cases in young children, contributing to approximately 83% of cases in children younger than 18 months.[4]

Respiratory Syncytial Virus (RSV) is the most common viral cause of childhood pneumonia, followed by influenza A and B viruses, parainfluenza viruses, and adenovirus. Other viral pathogens include human metapneumovirus, rhinovirus, and human bocavirus. Among bacterial pathogens, Streptococcus pneumoniae remains the most common cause in children below five years and contributes to nearly one-third of cases. Other bacterial pathogens include Streptococcus pyogenes, Staphylococcus aureus, Moraxella catarrhalis, and Haemophilus influenzae type b. In children older than five years, Mycoplasma pneumoniae is frequently identified, while Chlamydia pneumoniae may also contribute to disease occurrence.[5,6]

The clinical presentation of CAP varies according to age, infecting organism, immune response, and severity of illness. Symptoms are frequently nonspecific, especially in neonates and infants. Pneumonia should be suspected in children presenting with cough and fever associated with tachypnea, chest retractions, nasal flaring, expiratory grunting, or increased use of accessory muscles. Additional symptoms may include chest pain, abdominal pain, vomiting, diarrhea, and headache.[6,7]

The exact etiology of CAP often remains undetermined, resulting in empirical and sometimes unnecessary antibiotic use among children with non-bacterial infections. Excessive antibiotic administration contributes significantly to antimicrobial resistance. Therefore, reliable methods to distinguish bacterial pneumonia from viral pneumonia are important for appropriate patient management.[8]

Inflammatory biomarkers such as procalcitonin (PCT) and C-reactive protein (CRP) have gained increasing importance in the differential diagnosis of respiratory tract infections. Both biomarkers are associated with inflammatory activity and may aid in differentiating bacterial from viral infections.[9]

Procalcitonin is a precursor peptide of calcitonin consisting of 116 amino acids encoded by the CALC-1 gene on chromosome 11. Under normal physiological conditions, circulating PCT levels are minimal. During bacterial infections, inflammatory cytokines such as interleukin-6, interleukin-1β, and tumor necrosis factor-alpha stimulate PCT production in various tissues, leading to increased serum concentrations. Viral infections, however, suppress PCT production through interferon-mediated pathways, making PCT relatively more specific for bacterial infections. Elevated PCT levels may also occur in certain noninfectious conditions including major surgery, trauma, burns, and prolonged circulatory shock.

C-reactive protein is an acute-phase reactant synthesized mainly by hepatocytes in response to inflammatory stimuli, predominantly mediated by interleukin-6. CRP levels increase rapidly following inflammation and decline with resolution of the inflammatory process. Structurally, CRP exists as pentameric and monomeric forms, each possessing distinct biological properties.

Assessment of PCT and CRP may provide useful clinical information in differentiating bacterial and viral pneumonia and may support appropriate treatment decisions, thereby potentially reducing unnecessary antibiotic use.

The present study aims to differentiate viral and bacterial pneumonia in children using clinical, laboratory, and radiological parameters and to evaluate the diagnostic utility of the biomarkers procalcitonin (PCT) and C-reactive protein (CRP) in distinguishing between these two etiologies. The primary objective of this study is to evaluate the levels of Procalcitonin (PCT) and C-Reactive Protein (CRP) in children diagnosed with Community-Acquired Pneumonia (CAP) admitted to a tertiary care hospital. The secondary objectives are to assess the epidemiological profile of CAP in children and to determine the role of PCT and CRP as biomarkers in differentiating bacterial pneumonia from viral pneumonia.

MATERIALS AND METHODS

This cross-sectional observational study was conducted at Rainbow Children's Hospital,

Vijayawada, among children aged 2 months to 18 years diagnosed with community-acquired pneumonia. Following approval from the Institutional Ethics Committee, hospital-based data were collected from children admitted to the pediatric wards and PICU over a two-year period from April 2023 to April 2025. After obtaining informed consent, eligible children meeting the inclusion criteria were enrolled, and relevant clinical and laboratory data were collected and analyzed. As the required sample size of 68 patients was achieved earlier than anticipated, data collection and analysis were completed by March 2025.

Sample Size: A minimum sample size of 70 participants was required to ensure that the study findings could be generalized to the target population. The sample size was calculated based on the study by Vinod et al., "Role of Procalcitonin in Diagnosis of Community-Acquired Pneumonia in Children," in which 23.4% of children with pneumonia were found to be procalcitonin-positive. Using the formula (n = Z^2P(1-P)/d^2), with a 95% confidence level (Z = 1.96), prevalence (P) of 23.4%, and absolute precision (d) of 10%, the estimated sample size was 68.8, which was rounded off to 70 participants.

Inclusion Criteria

All children of 2 months to 18 years of age who presented with Community Acquired Pneumonia were included in the study.

Exclusion Criteria

1. Children with prior antibiotic use (started on antibiotics already)
2. Hospital Acquired Pneumonia
3. Tuberculosis
4. Chemical pneumonitis
5. Aspiration pneumonia
6. Immunodeficiency
7. Parents who are not willing to participate in the study

Methodology and Statistical Analysis: Children fulfilling the study eligibility criteria were enrolled after obtaining informed consent from parents or legal guardians. Detailed clinical history and physical examination findings were documented for all participants, with emphasis on respiratory symptoms and signs such as tachypnea, wheeze, and crepitations.

Investigations performed included complete blood count, serum procalcitonin, serum C-reactive protein, blood culture, and polymerase chain reaction testing of nasopharyngeal samples for bacterial and viral pathogens. Chest radiography in posteroanterior view was performed to evaluate pulmonary involvement and radiological characteristics.

Based on the combined assessment of clinical findings, laboratory investigations, radiological features, blood culture results, and PCR findings, cases were categorized into viral pneumonia, bacterial pneumonia, and mixed infection groups.

Data obtained from the study were compiled and analyzed using Statistical Package for Social Sciences (SPSS) software version 21. Continuous variables were summarized using mean and standard deviation or median values as appropriate, while categorical variables were expressed using frequencies and percentages. Distribution of variables was assessed using the Kolmogorov–Smirnov test. Appropriate statistical tests were applied according to the pattern of distribution. Statistical significance was considered at a p-value less than 0.05.

RESULTS

Table 1: Age Distribution in Group

Age	Viral		Bacterial		Mixed		Total		Chi square	P value
	No	%	No	%	No	%	No	%		
<5years	29	55.7	0	0	8	57	37	52.8	4.77	0.092
>5years	23	44.2	4	100	6	42.8	33	47		

Among the study population, 52.8% of children were below 5 years of age, while 47.2% were older than 5 years. In the viral pneumonia group, 55.7% of cases occurred in children under 5 years and 44.3% in those above 5 years. All children in the bacterial pneumonia group were older than 5 years. In the mixed infection group, 57.1% of cases were below 5 years of age and 42.9% were above 5 years.

Table 2: Gender Distribution

Gender	Viral		Bacterial		Mixed		Total		Chi square	P value
	No	%	No	%	No	%	No	%		
Male	35	67.3	2	50	5	35.7	42	60	4.764	0.092
Female	17	32.6	2	50	9	64.2	28	40		

In our study, Males comprised 60% of the study population. The viral pneumonia group showed male predominance (67.3%), the bacterial group had equal sex distribution, and the mixed infection group showed female predominance (64.3%).

Table 3: travel history in the study group

Travel history	Viral		Bacterial		Mixed		Total		Chi square	P value
	No	%	No	%	No	%	No	%		
Yes	32	61.5	0	0	4	28.5	36	51.4	9.29	0.0096
No	20	38.4	4	100	10	71.4	34	48.6		

In our study, 61.5% of viral pneumonia cases and 4% of mixed infection cases were associated with travel history. No case of bacterial pneumonia was associated with travel history.

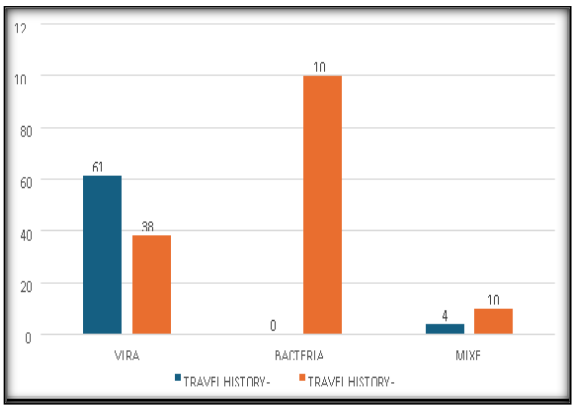

Figure 1: travel history in the study group.

In our study, 77% of viral pneumonia cases had wheeze, 17.3% of them had crepitations and 5.7% of them had both wheeze and crepitations. All cases of bacterial pneumonia were associated with crepitations. Of mixed infection, 71.4% had wheeze and 28.5% cases had crepitations.

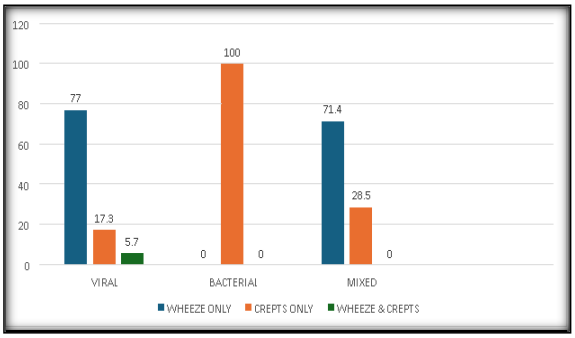

Figure 2: auscultatory findings in the study group

Table 4: auscultatory findings in the study group

Examination	Viral		Bacterial		Mixed		Total		Chi square	P value
	No	%	No	%	No	%	No	%		
Wheeze only	40	77	0	0	10	71.4	50	71.4	14.71	0.00535
Crepts only	9	17.3	4	100	4	28.5	17	24.2		
Wheeze and crepts	3	5.7	0	0	0	0	3	4.3		

Table 5: total leucocyte count in the study group

Total leucocyte count	Viral		Bacterial		Mixed		Total		Chi square	P value
	No	%	No	%	No	%	No	%		
Leucocytosis	13	25	2	50	3	21.4	18	25.7	3.09	0.543
Leucopenia	5	9.6	0	0	3	21.4	8	11.4		
Normal tlc	34	65.3	2	50	8	57.2	44	62.8		

In the viral pneumonia group, 65.3% of patients had normal total leucocyte counts, while 25% had leucocytosis and 9.6% had leucopenia. In the bacterial group, 50% each showed normal counts and leucocytosis. In the mixed group, 57.2% had normal counts, and both leucocytosis and leucopenia were observed in 21.4% of cases each.

Table 6: Chest Xray In The Study Group

X-ray	Viral		Bacterial		Mixed		Total		Chi square	P value
	No	%	No	%	No	%	No	%		
Diffuse involvement	43	82.6	1	25	9	64.2	53	75.7	7.97	0.0186
Lobar consolidation	9	17.3	3	75	5	35.7	17	24.2		

In the viral pneumonia group, 82.6% of cases showed diffuse involvement, while 17.3% had lobar consolidation. In the bacterial group, 75% presented with lobar consolidation and 25% with diffuse involvement. In the mixed group, 64.2% had diffuse involvement and 35.7% showed lobar consolidation.

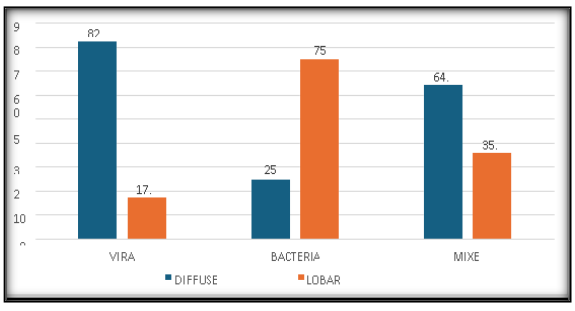

Figure 3: chest x-ray findings in the study group

In our study, 74% cases were of viral etiology, 20% cases had mixed etiology and 6% cases had bacterial etiology.

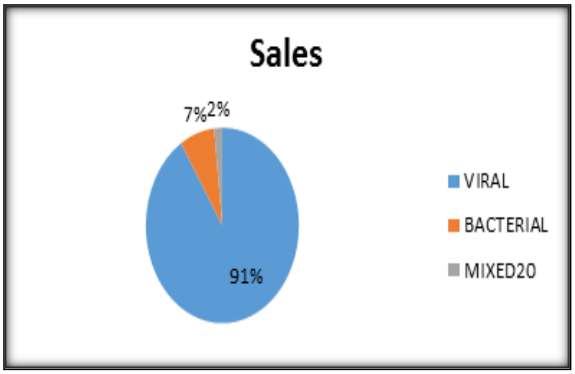

Figure 4: Distribution of pneumonia by etiology

Table 7: distribution of pneumonia by etiology

Pneumonia	Number	Percentage
Viral	52	74
Mixed	14	20
Bacterial	4	6

Table 8: Comparing CRP and pct in bacterial and viral groups

Variable	Group	N	Mean Rank	Sum of Ranks	Mann–Whitney U	Wilcoxon W	Z value	p value
CRP	Bacterial	4	40.50	162.00	56.000	1434.000	-1.531	0.126
	Viral	52	27.58	1434.00	—	—	—	—
PCT	Bacterial	4	44.75	179.00	39.000	1417.000	-2.068	0.039*
	Viral	52	27.25	1417.00	—	—	—	—

CRP levels were higher in the bacterial group than in the viral group, as reflected by a higher mean rank (40.50 vs. 27.58); however, this difference was not statistically significant (p = 0.126).
In contrast, PCT levels were significantly higher in the bacterial group compared to the viral group (mean rank: 44.75 vs. 27.25), with the difference reaching statistical significance (p = 0.039)

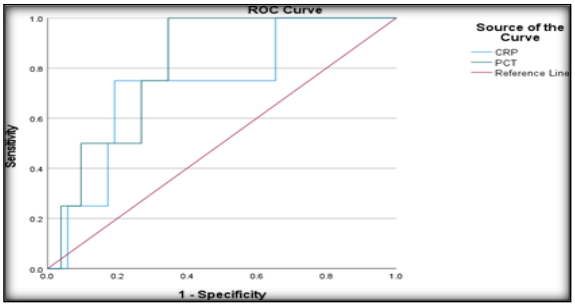

Figure 4: ROC analysis for bacterial and viral groups

Table 9: AUC for CRP and PCT in the study group:

Variable	Group	N	Mean Rank	Sum of Ranks	Mann–Whitney U	Wilcoxon W	Z value	p value
CRP	Viral	52	32.23	1676.00	298.000	1676.000	-1.038	0.299
	Mixed	14	38.21	535.00	—	—	—	—
PCT	Viral	52	30.82	1602.50	224.500	1602.500	-2.188	0.029*
	Mixed	14	43.46	608.50	—	—	—	—

Both CRP and PCT demonstrated 100% sensitivity and NPV for identifying bacterial pneumonia. However, PCT showed markedly higher specificity (84.6% vs. 34.6%), PPV (84.6% vs. 60.5%), and overall accuracy (92.3% vs. 67.3%) compared with CRP. ROC analysis further revealed a higher AUC for PCT (0.812) than CRP (0.731), indicating superior diagnostic performance. Additionally, the narrower confidence interval for PCT suggests greater reliability and precision as a diagnostic marker.

Table 10: comparing CRP and PCT in viral and mixed groups

	Area	Std. Error[a]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
CRP	0.731	.122	.492	.970
PCT	0.812	.076	.664	.961

CRP levels were higher in the mixed infection group than in the viral group (mean rank: 38.21 vs. 32.23); however, the difference was not statistically significant (p = 0.299).
In contrast, PCT levels were significantly higher in the mixed infection group compared with the viral group (mean rank: 43.46 vs. 30.82), with a statistically significant difference observed (p = 0.029).

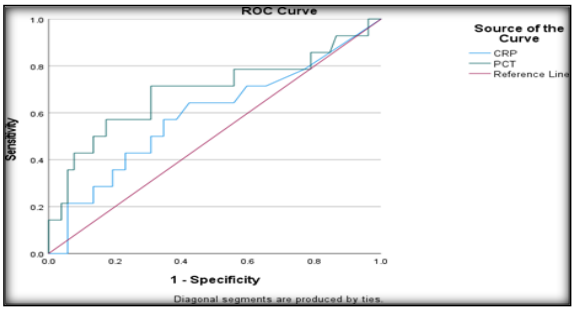

Figure 5: ROC analysis for viral and mixed groups.

Table 11: AUC for CRP and PCT in study groups

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
CRP	0.591	.091	.412	.769
PCT	0.692	.092	.510	.873

PCT demonstrated higher sensitivity than CRP (78% vs. 57%), whereas CRP showed greater specificity (65% vs. 40%). CRP had slightly higher positive predictive value (62.27% vs. 56.87%) and overall accuracy (61.25% vs. 59.50%), while PCT exhibited a higher negative predictive value (65.37% vs. 60.39%). ROC analysis showed a higher AUC for PCT than CRP (0.692 vs. 0.591), indicating better overall diagnostic performance, although both biomarkers demonstrated limited-to-moderate diagnostic ability.

DISCUSSION

This cross-sectional observational study was conducted over two years (April 2023–April 2025) at Rainbow Children's Hospital, Vijayawada, and included 70 children aged 2 months to 18 years diagnosed with community-acquired pneumonia (CAP). Viral pneumonia was the most common etiology (74%), followed by mixed infections (20%) and bacterial pneumonia (6%). The mean age of the study population was 3.4 years, with viral pneumonia occurring at a younger age (3.15 years) than bacterial pneumonia (6.99 years). Males constituted 60% of cases, and the majority of patients were from Krishna (31.4%), Guntur (24.3%), and West Godavari (24.2%) districts. A significant association was observed between viral pneumonia and travel history, with 61.5% of viral cases reporting recent travel.

Clinically, wheezing was the predominant finding in viral pneumonia (77%), whereas crepitations were present in all bacterial pneumonia cases. Among mixed infections, 71.4% had wheeze and 28.4% had crepitations. Radiologically, diffuse lung involvement was more common in viral (82.6%) and mixed infections (64.2%), while lobar consolidation was predominantly seen in bacterial pneumonia (75%) and in 35.7% of mixed infections ($p = 0.0186$). Laboratory findings showed that leucocytosis and neutrophilia were more frequent in bacterial pneumonia, whereas leucopenia and neutropenia were observed mainly in viral and mixed infections.

Respiratory Syncytial Virus (31%) was the most common viral pathogen identified, followed by Adenovirus (25%), Influenza A (16%), Human Metapneumovirus (12%), Influenza B (10%), Parainfluenza virus (3%), and Rhinovirus (3%). Among bacterial pathogens, Streptococcus pneumoniae was the most frequently detected organism (50%), followed by Mycoplasma pneumoniae (28%), Klebsiella pneumoniae (11%), Haemophilus influenzae (6%), and Pseudomonas aeruginosa (5%).

Comparison of PCT and CRP in bacterial and viral groups: Several studies have demonstrated the superiority of procalcitonin (PCT) over C-reactive protein (CRP) in distinguishing bacterial from viral pneumonia in children. Moulin et al. (2011) reported that PCT rises rapidly in bacterial infections while remaining low in viral cases, with higher specificity than CRP (86% vs. 40%). Similarly, Khan et al. (2010) found significantly higher PCT levels in bacterial pneumonia, with better diagnostic performance than CRP (AUC 0.89 vs. 0.79) and higher sensitivity. Toikka et al. (2000) also observed significantly elevated PCT and CRP levels in bacterial pneumonia, with PCT showing high specificity. A review by Esposito and Principi (2019) further emphasized that PCT is more specific than CRP for bacterial pneumonia diagnosis.

In our study, PCT levels were significantly higher in bacterial pneumonia compared to viral pneumonia (mean rank: 44.75 vs. 27.25; $p = 0.039$), supporting its diagnostic utility. ROC analysis showed good diagnostic performance for PCT (AUC 0.812) with 100% sensitivity, 84.6% specificity, and 92.3% accuracy.

In contrast, CRP levels were higher in bacterial pneumonia than in viral pneumonia, but the difference was not statistically significant (mean rank: 40.50 vs. 27.58; $p = 0.126$). CRP showed only moderate diagnostic performance with an AUC of 0.731, 100% sensitivity, low specificity (34.6%), and an accuracy of 67.3%.

Comparison of PCT and CRP in mixed and viral groups: Salvador Bello et al. (2014) reported that serum procalcitonin (PCT) levels are higher in mixed and bacterial community-acquired pneumonia (CAP) compared to viral infections.

In our study, PCT levels were significantly higher in the mixed infection group than in the viral group (mean rank: 43.46 vs. 30.82; $p = 0.029$), suggesting its potential usefulness in differentiating mixed from viral pneumonia. ROC analysis showed moderate diagnostic performance (AUC 0.692) with an optimal cut-off of 0.87 ng/ml, sensitivity of 78%, specificity of 40%, and overall accuracy of 59.5%.

In contrast, CRP levels were slightly higher in mixed infections compared to viral infections (mean rank: 38.21 vs. 32.23), but the difference was not statistically significant ($p = 0.299$). ROC analysis demonstrated poor discriminatory ability for CRP (AUC 0.591), with a cut-off of 23.5 mg/dl, sensitivity of 57%, specificity of 65%, and accuracy of 61.25%. The elevated PCT levels in mixed infections may be attributed to associated secondary bacterial infection, whereas CRP showed limited utility in distinguishing mixed from viral pneumonia.

Elevated PCT levels observed in viral group: Constanza Gómez de Oña et al. (2015) demonstrated that adenoviral infections in children are associated with elevated PCT and CRP levels, even in the absence of bacterial coinfection. In their study of 487 children with respiratory symptoms, PCT was altered in nearly half of single adenovirus infections and in over 60% of coinfected cases, indicating that adenovirus alone can significantly increase inflammatory biomarkers and mimic bacterial infection clinically.

Similarly, Laura F. Sartori et al. (2021) reported a significant association between PCT levels and pneumonia severity, with median values increasing

from mild to very severe disease. Gautam et al. (2020) further observed that elevated PCT levels may occur in severe viral infections and correlate more strongly with disease severity than with bacterial coinfection, highlighting its limitation as a sole marker for antibiotic decisions.

In our study, elevated PCT levels were observed in seven viral pneumonia cases, predominantly in severe ARDS (three influenza-related and two adenovirus-related cases), likely reflecting an intense inflammatory response. The remaining two cases were adenoviral pneumonias, also associated with increased PCT levels, suggesting a possible link between adenovirus infection and elevated PCT.

Additionally, elevated PCT levels were noted in seven mixed infection cases, where bacterial pathogens were identified, including Klebsiella pneumoniae in two cases, Streptococcus pneumoniae in four cases, and Mycoplasma pneumoniae in one case by RT-PCR, supporting the association between bacterial involvement and higher PCT levels.

CONCLUSION

Our study demonstrates that procalcitonin (PCT) is a more specific biomarker than C-reactive protein (CRP) for differentiating bacterial from viral community-acquired pneumonia in children. Although CRP shows high sensitivity, its lower specificity limits its diagnostic utility compared to PCT. PCT levels may also be elevated in viral pneumonia, particularly in severe disease states, emphasizing the importance of correlating biomarker values with clinical and radiological findings before determining etiology. Notably, adenoviral and severe influenza pneumonias were associated with higher inflammatory marker levels, including both PCT and CRP. Overall, incorporating PCT into routine clinical evaluation may help reduce unnecessary antibiotic use and support more targeted management of pediatric CAP, thereby strengthening antimicrobial stewardship.

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