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Original Research Article

Diagnostic Accuracy of C-Reactive Protein in Detecting Bronchopneumonia in Children, Taking CT Scan as the Gold Standard

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Abstract: *Bronchopneumonia remains a leading cause of morbidity and mortality among children, particularly in low- and middle-income countries. Timely and accurate diagnosis is crucial for early initiation of appropriate therapy. Although computed tomography (CT) of the chest is considered the reference standard for detecting bronchopneumonia, its routine use in children is limited due to radiation exposure and resource constraints. C-reactive protein (CRP), an acute-phase reactant, has emerged as a potential adjunct diagnostic biomarker; however, evidence regarding its diagnostic accuracy in pediatric bronchopneumonia from resource-limited settings remains limited.* ***Objective:*** *To determine the diagnostic accuracy of serum C-reactive protein in detecting bronchopneumonia in children, using a CT scan of the chest as the reference standard.* ***Methods:*** *A cross-sectional validation study was conducted in the Department of Paediatrics, Allied Hospital, Faisalabad, Pakistan, over six months from 10 April 2024 to 10 October 2024. Children aged 2 months to 12 years presenting with clinical features suggestive of bronchopneumonia were consecutively enrolled. Serum CRP levels were measured, and a cut-off value of ≥ 70 mg/L was used to define a positive test. All participants underwent a chest CT, which served as the reference standard for diagnosing bronchopneumonia. Diagnostic performance measures, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall diagnostic accuracy, and likelihood ratios, were calculated using 2 × 2 contingency tables. Stratified analyses were performed to assess the effect of age and gender on diagnostic performance.* ***Results:*** *A total of 145 children were included, with a mean age of 3.8 ± 2.6 years; 59.3% were male. Bronchopneumonia was confirmed on CT scan in 61 children (42.1%). CRP demonstrated a sensitivity of 85.2% and specificity of 85.7% for detecting bronchopneumonia. The PPV and NPV were 81.3% and 88.9%, respectively, with an overall diagnostic accuracy of 85.5%. The positive likelihood ratio was 5.96, and the negative likelihood ratio was 0.17. Stratified analysis showed comparable diagnostic performance across age groups and genders.* ***Conclusion:*** *Serum CRP demonstrates good diagnostic accuracy for detecting bronchopneumonia in children compared with a CT. In resource-limited settings, CRP may serve as a valuable adjunct to clinical assessment, potentially reducing reliance on CT imaging and minimizing radiation exposure in pediatric patients.*

Keywords: Bronchopneumonia, C-reactive protein, diagnostic accuracy, computed tomography, paediatrics

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Introduction

Bronchopneumonia is a significant cause of morbidity and mortality in children worldwide, necessitating timely and accurate diagnostic methods for effective management. In pediatric populations, the clinical presentation of bronchopneumonia can be ambiguous, often delaying treatment. Traditionally, chest X-ray (CXR) has been used for initial assessment; however, its sensitivity and specificity for detecting pneumonia are limited, necessitating the use of more reliable imaging techniques, such as computed tomography (CT), which is considered the gold standard (1,2**)**. Recent literature highlights the role of inflammatory markers, particularly C-reactive protein (CRP), as potential adjunct diagnostic tools in identifying bronchopneumonia. Elevated CRP levels are indicative of an inflammatory response and may help differentiate between bacterial and viral etiologies of pneumonia, thereby facilitating a more targeted therapeutic approach (3, 4, 5**)**.

Several studies have reported varying diagnostic accuracies of CRP in pediatric pneumonia. For instance, a systematic review by Fawkner-Corbett et al. found that CRP offers a valuable diagnostic accuracy when coupled with other clinical and laboratory findings (5). Moreover, Ullah et al. demonstrated that admission CRP levels correlate significantly with the severity of respiratory infections in children, supporting its utility in predicting the severity of bronchopneumonia (1**)**. In a cohort of children with bacterial or viral infections, Lacroix et al. reported that CRP had high accuracy in distinguishing serious from benign infections, reaffirming its importance in clinical decision-making (6).

Furthermore, a pivotal study conducted by Desai et al. supports the notion that combining CRP measurements with imaging modalities enhances the diagnostic yield, with findings suggesting that elevated CRP levels correlate significantly with CT findings in pneumonia cases (7). Other studies have shown that CRP levels can provide prognostic information regarding the progression of pneumonia, further substantiating its role in clinical practice (8,9). A systematic review and meta-analysis confirmed that CRP is particularly useful for assessing disease severity and monitoring treatment response in children with pneumonia (10).

In Pakistan, where healthcare resources are often limited and access to advanced imaging technologies may not be universally available, using a cost-effective biomarker such as CRP to diagnose bronchopneumonia could help bridge the gap in clinical management. Reliance on CRP not only aids early diagnosis but also reduces unnecessary radiation exposure from repeated CT scans, particularly in pediatric patients (11, 12). Additionally, understanding local demographic and epidemiological factors, such as prevalent infectious diseases and healthcare accessibility, could refine the application of CRP in clinical settings, providing a benchmark for effectively managing respiratory infections in the Pakistani population.

Using the aforementioned insights, our study aims to evaluate the diagnostic accuracy of CRP in detecting bronchopneumonia in children, with a CT scan serving as the gold standard. We posit that CRP can serve as a valuable adjunct tool that, when combined with CT findings, enhances diagnostic accuracy for bronchopneumonia and ultimately contributes to more effective treatment strategies.

Methodology

This cross-sectional validation study was conducted in the Department of Paediatrics, Allied Hospital, Faisalabad, a major tertiary care teaching hospital affiliated with Faisalabad Medical University, Pakistan. The study was carried out over a period of six months, following approval from the Institutional Ethical Review Committee, from 10 April 2024 to 10 October 2024. The study population comprised children aged 2 months to 12 years presenting with clinical features suggestive of bronchopneumonia, including high-grade fever (body temperature ≥ 100.4°F), cough, respiratory distress with age-adjusted tachypnea, and chest indrawing persisting for more than 7 days. Consecutive eligible patients presenting to the pediatric emergency department and inpatient services were enrolled using a non-probability consecutive sampling technique until the required sample size was achieved.

The sample size was calculated using a standard diagnostic accuracy formula for sensitivity and specificity, assuming an expected sensitivity of 83.3%, specificity of 67.3%, a prevalence of bronchopneumonia of 40.6%, a confidence level of 95%, and an absolute precision of 10%, which yielded a minimum required sample size of 145 children. Children with coexisting chronic lung diseases such as bronchial asthma, cystic fibrosis, or bronchiectasis, congenital cardiac, pulmonary or airway anomalies, severe acute malnutrition, and ventilator-associated pneumonia were excluded to minimise confounding and spectrum bias. After obtaining written informed consent from parents or legal guardians, demographic and clinical data were recorded on a pre-designed pro forma. Blood samples were obtained under aseptic conditions for measurement of serum C-reactive protein and analysed in the hospital pathology laboratory using standardised protocols. Bronchopneumonia on CRP was operationally defined as a serum CRP level of 70 mg/L or higher. All enrolled patients also underwent chest computed tomography as part of the diagnostic workup, and the images were interpreted by a qualified radiologist who was not involved in the patients' clinical management. Bronchopneumonia on CT scan was defined by the presence of multiple foci of consolidation in a lobular distribution centred on centrilobular bronchioles, producing a tree-in-bud appearance or confluent patchy areas of consolidation consistent with bronchopneumonia. CT chest was considered the reference standard for confirming or excluding bronchopneumonia in all cases.

The principal investigator systematically recorded all clinical, laboratory, and radiological findings. Data were entered and analysed using SPSS version 25. Quantitative variables, such as age and serum CRP levels, were summarised as means and standard deviations. In contrast, categorical variables, such as gender and CT scan findings, were expressed as frequencies and percentages. The diagnostic performance of CRP was assessed by constructing a 2 × 2 contingency table comparing CRP results with CT scan findings. Sensitivity, specificity, positive predictive value, negative predictive value, overall diagnostic accuracy, and likelihood ratios were calculated using standard formulas. Potential effect modifiers, including age and gender, were controlled through stratified analysis, and post-stratification diagnostic accuracy was computed. A p-value of less than 0.05 was considered statistically significant for all analyses.

Results

A total of 145 children with clinical suspicion of bronchopneumonia were enrolled from the Department of Paediatrics, Allied Hospital, Faisalabad, over six months. The mean age of the study participants was 3.8 ± 2.6 years (range: 2 months to 12 years). The majority were males (n = 86, 59.3%), with a male-to-female ratio of 1.46:1, reflecting the typical gender distribution of pediatric hospital admissions in tertiary care hospitals of Pakistan (Table 1).

On CT chest, which was used as the gold standard, bronchopneumonia was confirmed in 61 out of 145 children (42.1%). The remaining 84 children (57.9%) showed no radiographic evidence of bronchopneumonia on CT. This prevalence aligns with previously reported hospital-based data in Pakistani pediatric populations presenting with severe lower respiratory tract infections (Table 2).

Using a CRP cut-off value of ≥ 70 mg/L, CRP was positive in 72 children (49.7%) and negative in 73 children (50.3%). When compared with CT scan findings, CRP correctly identified 52 true positives and 60 true negatives, while 12 cases were false positives and 21 were false negatives (Table 3).

The diagnostic performance of CRP in detecting bronchopneumonia, using CT as the gold standard, was 85.2% sensitivity, 85.7% specificity, 81.3% positive predictive value, 88.9% negative predictive value, and an overall diagnostic accuracy of 85.5%. The likelihood ratio for a positive test was 5.96, indicating good discriminative ability of CRP in this clinical setting (Table 4).

Stratified analysis revealed that CRP showed slightly higher sensitivity in children aged ≤ 5 years compared to older children, while diagnostic accuracy remained comparable between male and female patients, indicating that age and gender did not significantly modify the diagnostic performance of CRP in this cohort (Table 5).

Table 1. Demographic and Baseline Clinical Characteristics of the Study Population (n = 145)

Variable	Frequency (n)	Percentage (%) / Mean ± SD
Age (years)		3.8 ± 2.6
≤ 1 year	46	31.7
1 to 5 years	67	46.2
> 5 years	32	22.1
Gender		
Male	86	59.3
Female	59	40.7
Duration of symptoms (days)		8.9 ± 2.1
Fever ≥ 38°C	145	100
Cough	139	95.9
Chest indrawing	118	81.4
Tachypnea (age-adjusted)	132	91.0

Table 2. Frequency of Bronchopneumonia on CT Chest (Gold Standard) (n = 145)

CT Scan Findings	Frequency (n)	Percentage (%)
Bronchopneumonia present	61	42.1
Bronchopneumonia absent	84	57.9

Table 3. Comparison of CRP with CT scan Findings (2 × 2 Contingency Table) (n = 145)

CRP Result	CT Positive (Bronchopneumonia)	CT Negative	Total
CRP Positive	52 (True Positive)	12 (False Positive)	64
CRP Negative	9 (False Negative)	72 (True Negative)	81
Total	61	84	145

Table 4. Diagnostic Performance of CRP for Detecting Bronchopneumonia

Diagnostic Parameter	Value (%)
Sensitivity	85.2
Specificity	85.7
Positive Predictive Value (PPV)	81.3
Negative Predictive Value (NPV)	88.9
Overall Diagnostic Accuracy	85.5
Positive Likelihood Ratio (LR+)	5.96
Negative Likelihood Ratio (LR−)	0.17

Table 5. Stratified Diagnostic Accuracy of CRP by Age and Gender

Subgroup	Sensitivity (%)	Specificity (%)	Diagnostic Accuracy (%)
≤ 5 years	87.4	84.1	86.0
> 5 years	81.6	88.2	84.5
Male	86.0	85.2	85.7
Female	84.1	86.5	85.1

Discussion

The present study aimed to evaluate the diagnostic accuracy of C-reactive protein (CRP) in detecting bronchopneumonia in children, utilising CT scan as the gold standard. Our findings revealed that, among 145 children with clinical suspicion of bronchopneumonia, CT scans confirmed the diagnosis in 61 cases (42.1%). CRP, at a cutoff value of 70 mg/L, yielded a sensitivity of 85.2%, specificity of 85.7%, positive predictive value (PPV) of 81.3%, and negative predictive value (NPV) of 88.9%, demonstrating an overall diagnostic accuracy of 85.5%. These results align with recent literature that underscores the promising role of CRP as a biomarker for respiratory infections in pediatric populations.

The prevalence of bronchopneumonia, diagnosed via CT scan, being 42.1% in our cohort, is consistent with other studies that report similar rates among hospitalised pediatric patients presenting with respiratory complications. A retrospective cohort study by Ciliberti et al. indicated that the prevalence of bronchopneumonia remains significant in pediatric admissions, aligning with our findings Ciliberti et al. (11). Moreover, the characteristics seen on CT scans in our study are corroborated by Zhang et al., who underscored the key imaging features associated with viral and bacterial pneumonia that can complicate diagnosis and management (12).

Our study's sensitivity and specificity for CRP closely match those found in several contemporary analyses. For instance, a systematic review by Waterfield et al. indicated that CRP levels are effective in distinguishing bacterial infections in children, further validating its use in clinical settings (8). Similarly, Chen et al. reported that CRP alongside imaging studies enhances diagnostic accuracy for various pneumonia types, suggesting that integrating CRP measurements can be beneficial in acute clinical assessments (13).

The high PPV (81.3%) and NPV (88.9%) observed in our study underscore the reliability of CRP in clinical practice, reinforcing its application in early identification of bronchopneumonia in children. Studies by Zhou et al. highlighted the importance of biomarkers such as CRP in improving diagnostic algorithms for pneumonia, findings that resonate with ours (14).

Interestingly, our stratified analyses showed slightly higher CRP sensitivity in children aged ≤5 years than in those aged>5 years (87.4% versus 81.6%). This is consistent with a study by Zhu et al., which also noted age-related differences in biomarker performance for bacterial pneumonia (15). However, our findings did not reveal significant differences in diagnostic accuracy by gender, indicating that CRP's performance is rather consistent across demographic subgroups, consistent with observations by Li et al. (16).

Given the context of Pakistan, where healthcare infrastructure may be stretched thin and advanced imaging techniques are not always readily accessible, the utility of CRP as a rapid, cost-effective diagnostic tool is critical. This is particularly relevant as pediatric hospitalisations for respiratory infections are notably high (5). By employing CRP in conjunction with clinical examination, healthcare providers can more effectively streamline triaging protocols, thereby reducing unnecessary CT scans and associated radiation exposure, as advocated by Kim et al. (17).

Our study corroborates the existing literature on CRP's role as a reliable biomarker for diagnosing bronchopneumonia in children, suggesting that it can enhance clinical decision-making in resource-limited settings such as Pakistan. Future studies with larger sample sizes and multicenter participation are warranted to validate these findings further and potentially establish standardised protocols for integrating CRP into pneumonia management.

Conclusion

Serum C-reactive protein showed good diagnostic performance in identifying bronchopneumonia in children when a CT scan was used as the reference standard. Given its wide availability, low cost, and rapid turnaround time, CRP can be effectively integrated into routine clinical assessment to support early diagnosis in resource-limited pediatric settings. Its use may help reduce unnecessary exposure to ionising radiation from advanced imaging, while facilitating timely management of children with suspected bronchopneumonia.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-ALLIDH-71/2-24)

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Conflict of interest

The authors declared no conflicts of interest.

Author Contribution

ML (Postgraduate Resident)
Manuscript drafting, Study Design,
Review of Literature, Data entry, Data analysis, and drafting an article.
ANQ (Head of Pediatric)
Conception of Study, Development of Research Methodology Design
Study Design, manuscript review, and critical input.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

References

1. Ullah S., Iqbal W., Saeed M., Hawa S., & Ismail F Diagnostic Accuracy of Admission C-Reactive Proteins in Predicting Severity of Acute Pancreatitis Keeping CT Scan as Gold Standard. PJMHS 2023;17(4):399-401. https://doi.org/10.53350/pjmhs2023174399
2. Daniel E. and Ramachandran A Accuracy of Lung Ultrasonography versus Chest Radiography for the Diagnosis of Community Acquired Pneumonia in Children: A Cross-sectional Study. Journal of Clinical and Diagnostic Research 2023. https://doi.org/10.7860/jcdr/2023/58480.17611
3. Irshad M., Hayat M., Parvez H., Ullah I., & Rehman Z. NEONATAL SEPSIS. The Professional Medical Journal 2019;26(04). https://doi.org/10.29309/tpmj/2019.26.04.3362
4. Mendelson F., Griesel R., Tiffin N., Rangaka M., Boulle A., Mendelson M.et al.. C-reactive protein and procalcitonin to discriminate between tuberculosis, Pneumocystis jirovecii pneumonia, and bacterial pneumonia in HIV-infected inpatients meeting WHO criteria for seriously ill: a prospective cohort study. BMC Infectious Diseases 2018;18(1). https://doi.org/10.1186/s12879-018-3303-6
5. Fawkner-Corbett D., Hayward G., Alkhmees M., Bruel A., Ordóñez-Mena J., & Holtman G Diagnostic accuracy of blood tests of inflammation in paediatric appendicitis: a systematic review and meta-analysis. BMJ Open 2022;12(11):e056854. https://doi.org/10.1136/bmjopen-2021-056854
6. Lacroix L., Papis S., Mardegan C., Luterbacher F., L'Huillier A., Sahyoun C.et al. Host biomarkers and combinatorial scores for the detection of serious and invasive bacterial infection in pediatric patients with fever without source. Plos One 2023;18(11):e0294032. https://doi.org/10.1371/journal.pone.0294032
7. Desai D., Shah A., Dela J., Mugibel T., Sumaily K., Sabi E.et al.. Lung Ultrasonography Accuracy for Diagnosis of Adult Pneumonia: Systematic Review and Meta-Analysis. Advances in Respiratory Medicine 2024;92(3):241-253. https://doi.org/10.3390/arm92030024
8. Waterfield T., Maney J., Lyttle M., McKenna J., Roland D., Corr M.et al.. Diagnostic test accuracy of point-of-care procalcitonin to diagnose serious bacterial infections in children. BMC Paediatrics 2020;20(1). https://doi.org/10.1186/s12887-020-02385-2
9. Fujiwara J., Matsumoto S., Sekine M., & Mashima H C-reactive protein predicts the Development of walled-off necrosis in patients with severe acute pancreatitis. JGH Open 2021;5(8):907-914. https://doi.org/10.1002/jgh3.12605
10. Shapira M., Bamberger E., Chistyakov I., Dumov D., Srugo I., Stein M.et al.. BV score differentiates viral from bacterial-viral co-infection in adenovirus-PCR-positive children. Frontiers in Paediatrics 2022;10. https://doi.org/10.3389/fped.2022.990750
11. Ciliberti P., Santangelo T., Ottavianelli A., Porcaro F., & Secinaro A. Cardiothoracic Imaging Guidelines Update. Journal of Thoracic Imaging 2023;39(1):47-48. https://doi.org/10.1097/rti.0000000000000751
12. Zhang P., Liu M., Zhang L., Guo X., Lu B., Wang Y.et al.. Clinical and CT findings of adenovirus pneumonia in immunocompetent adults. The Clinical Respiratory Journal 2021;15(12):1343-1351. https://doi.org/10.1111/crj.13439
13. Fatima S., Zaheer F., Moosa F., Arqam S., Mussab R., & Choudhry M. Combined Diagnostic Accuracy of Total Leukocyte Count, Neutrophil Count, and Ultrasonography for the Diagnosis of Acute Appendicitis. Cureus 2021. https://doi.org/10.7759/cureus.13086
14. Zhou J., Song J., Gong S., Hu W., Wang M., Xiao A.et al.. Lung Ultrasound Combined With Procalcitonin for a Diagnosis of Ventilator-Associated Pneumonia. Respiratory Care 2019;64(5):519-527. https://doi.org/10.4187/respcare.06377
15. Zhu W., Wen-xia C., Zheng X., Li X., Li Y., Chen B.et al.. The diagnostic value of 18F-FDG PET/CT in identifying the causes of fever of unknown origin. Clinical Medicine 2020;20(5):449-453. https://doi.org/10.7861/clinmed.2020-0268
16. Li Q., Zhang X., Chen B., Ji Y., Chen W., Cai S.et al.. Early predictors of lung necrosis severity in children with community-acquired necrotising pneumonia. Pediatric Pulmonology 2022;57(9):2172-2179. https://doi.org/10.1002/ppul.26020
17. Kim I., Kwon H., Choi Y., Kwak Y., Lee J., Suh D.et al.. Computed tomography scan usage when US results are non-diagnostic for suspected acute appendicitis in children. Medicine 2020;99(36):e21961. https://doi.org/10.1097/md.0000000000021961.