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Original Research

A Clinical Study of C - reactive protein Levels in Patients with Community-Acquired Pneumonia: A Cross-Sectional Observational Study.

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Abstract
Background: Community-acquired pneumonia (CAP) is a major cause of morbidity and mortality worldwide and remains an important public health concern, particularly among hospitalized adults. Early identification of severe disease is essential for prompt therapeutic intervention and improved clinical outcomes. C-reactive protein (CRP), an acute-phase inflammatory marker, has gained considerable attention owing to its potential role in assessing disease severity, predicting clinical outcomes, and monitoring therapeutic response in patients with community-acquired pneumonia. *Aim:* To study serum C-reactive protein levels in patients with community-acquired pneumonia.
Objectives:
1. To determine serum C-reactive protein levels among patients diagnosed with community-acquired pneumonia.
2. To evaluate the association between serum C-reactive protein levels and disease severity and clinical outcomes in patients with community-acquired pneumonia.

Materials and Methods: A hospital-based cross-sectional observational study was conducted among 100 adult patients diagnosed with community-acquired pneumonia. Detailed clinical evaluation, laboratory investigations including serum CRP estimation, and radiological assessment were performed. Disease severity was assessed using the CURB-65 scoring system. Statistical analysis was carried out using SPSS version 26.0. Appropriate statistical tests, including Chi-square test, Independent Student's t-test, One-way ANOVA, and Pearson's correlation coefficient, were employed wherever applicable. A p-value of less than 0.05 was considered statistically significant. *Results:* The mean age of the study participants was 55.4 ± 13.6 years, with a male predominance (64%). Elevated serum CRP levels were observed in the majority of patients, with a mean CRP level of 94.6 ± 48.2 mg/L. Serum CRP levels demonstrated a significant positive association with disease severity as assessed by CURB-65 scores ($p < 0.001$). Patients with severe community-acquired pneumonia exhibited significantly higher CRP levels than those with mild and moderate disease. Elevated serum CRP levels were significantly associated with ICU admission, oxygen requirement, and prolonged hospital stay. Significant positive correlations were observed between serum CRP levels and total leukocyte count, ESR, respiratory rate, and CURB-65 scores, whereas oxygen saturation demonstrated a significant negative correlation. *Conclusion:* Serum C-reactive protein is a reliable and clinically useful inflammatory biomarker for assessing disease severity and predicting clinical outcomes in patients with community-acquired pneumonia. Its routine use in clinical practice may aid in early risk stratification, facilitate appropriate therapeutic interventions, and improve patient management. Given its cost-effectiveness and widespread availability, serum CRP remains a valuable tool in the comprehensive evaluation of patients with community-acquired pneumonia.

Keywords: *Community-Acquired Pneumonia, C - reactive protein, Inflammatory Marker, CURB-65 score, Disease Severity.*

Introduction

Community-acquired pneumonia (CAP) remains one of the most common infectious diseases encountered in clinical practice and continues to be a major cause of morbidity and mortality worldwide. It is defined as an acute infection of the pulmonary parenchyma acquired outside healthcare settings and is characterized by clinical features such as fever, cough, dyspnea, pleuritic chest pain, and radiological evidence of pulmonary infiltrates. Despite advances in antimicrobial therapy and preventive strategies, CAP remains a significant public health challenge, particularly among the elderly and patients with underlying comorbidities. Early identification of disease severity and appropriate risk stratification are crucial for optimizing patient management and improving clinical outcomes. [1]

Globally, community-acquired pneumonia accounts for millions of hospital admissions annually and is among the leading causes of infectious disease-related mortality. The World Health Organization has consistently recognized lower respiratory tract infections as one of the leading causes of death worldwide. Community-acquired pneumonia affects individuals across all age groups but disproportionately impacts older adults, immunocompromised individuals, and patients with chronic medical illnesses. Mortality rates among hospitalized patients with severe CAP continue to remain substantial despite improvements in diagnostic modalities and antimicrobial therapy. [2]

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The inflammatory response plays a pivotal role in the pathogenesis of community-acquired pneumonia. Infection of the lower respiratory tract stimulates the release of pro-inflammatory cytokines, which activate hepatic synthesis of acute-phase reactants. Among these biomarkers, C-reactive protein (CRP) has emerged as one of the most widely studied inflammatory markers because of its rapid response to infection, ease of measurement, and clinical utility in monitoring disease activity. Serum CRP levels rise significantly within six to eight hours following the onset of infection and correlate closely with the severity of systemic inflammation. [3]

C-reactive protein is an acute-phase protein synthesized predominantly by hepatocytes under the influence of interleukin-6 and other pro-inflammatory cytokines. Elevated CRP levels have been associated with bacterial infections, tissue injury, and inflammatory disorders. In patients with community-acquired pneumonia, CRP serves as a valuable biomarker for diagnosis, assessment of disease severity, prediction of complications, and evaluation of therapeutic response. Several studies have demonstrated that higher CRP levels are associated with increased severity scores, prolonged hospital stay, and greater mortality risk among patients with CAP.[4]

Various clinical severity assessment tools such as CURB-65 and the Pneumonia Severity Index (PSI) are routinely used for risk stratification in community-acquired pneumonia. However, these scoring systems may not always accurately reflect the underlying inflammatory burden. Biomarkers such as CRP provide additional prognostic information and have increasingly been incorporated into clinical decision-making. Serial CRP measurements have also been shown to predict treatment response and facilitate antimicrobial stewardship by identifying patients who may safely undergo early de-escalation of antibiotic therapy. [5]

In India, community-acquired pneumonia constitutes a major cause of hospitalization among adults and contributes significantly to healthcare expenditure and mortality. Factors such as delayed healthcare access, high prevalence of diabetes mellitus, smoking, chronic obstructive pulmonary disease, and increasing antimicrobial resistance further complicate disease management. Several Indian studies have reported that elevated CRP levels correlate significantly with disease severity and adverse clinical outcomes among patients with community-acquired pneumonia. The use of CRP as an inflammatory biomarker is particularly advantageous in resource-limited settings because of its availability, cost-effectiveness, and reproducibility. [6] Despite the established role of inflammatory markers in infectious diseases, there remains considerable variation in their clinical application across healthcare settings. Comprehensive evaluation of serum CRP levels in patients with community-acquired pneumonia may facilitate early identification of severe disease, guide treatment decisions, and improve prognostic assessment. Hospital-based studies evaluating the clinical significance of CRP levels among patients with CAP are limited in several regions of India. Therefore, the present study aims to evaluate serum C-reactive protein levels in patients with community-acquired pneumonia and determine their association with clinical severity and patient outcomes. [7]

AIM
To study serum C-reactive protein levels in patients with community-acquired pneumonia.

OBJECTIVES
1. To determine the serum C-reactive protein levels among patients diagnosed with community-acquired pneumonia.
2. To evaluate the association between serum C-reactive protein levels and disease severity and clinical outcomes in patients with community-acquired pneumonia.

Materials and Methods
Study Design
A Hospital-based cross-sectional observational study.

Study Population
Adult patients diagnosed with community-acquired pneumonia.

Inclusion Criteria
- Patients aged ≥18 years.
- Patients diagnosed with community-acquired pneumonia based on clinical and radiological findings.
- Patients willing to provide written informed consent.

Exclusion Criteria
- Hospital-acquired pneumonia.
- Ventilator-associated pneumonia.
- Patients with active tuberculosis.
- Patients with chronic inflammatory or autoimmune disorders.
- Patients receiving immunosuppressive therapy.
- Patients with malignancy.
- Patients unwilling to participate.

SAMPLE SIZE CALCULATION
The sample size was calculated using the formula:
$n = Z^2 \times P \times Q / d^2$
Where:
n = Required sample size, Z = 1.96 at 95% confidence interval
P = Prevalence of elevated CRP levels among CAP patients (approximately 70%), Q = 30%, d = 9%
Substituting the values:
$n = (1.96)^2 \times 70 \times 30 / (9)^2$, n = 99.5
The minimum calculated sample size was approximately 100.
Therefore, the final sample size considered for the study will be: **100 patients**

Sampling Technique
Consecutive sampling.

Disease Severity Assessment
Severity will be assessed using the CURB-65 scoring system.

CURB-65 score	Severity
0-1	Mild
2	Moderate
≥3	Severe

STATISTICAL ANALYSIS

Data will be entered into Microsoft Excel and analysed using SPSS version 26.0.
The following statistical tests will be employed: Mean ± Standard Deviation for continuous variables. Frequency and percentages for categorical variables. Independent Student's t-test. Chi-square test or Fisher's Exact test. One-way ANOVA for comparison of CRP levels across severity groups. Pearson's correlation coefficient for CRP levels and CURB-65 score. Logistic regression analysis for predictors of severe CAP. A p-value <0.05 will be considered statistically significant.

Results

A total of 100 patients diagnosed with Community-Acquired Pneumonia (CAP) were included in the study. Demographic characteristics, serum C-reactive protein (CRP) levels, disease severity, clinical outcomes, and their associations were analysed.

Table 1. Demographic and Clinical Characteristics of Study Participants (n = 100)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
18-40	18	18.0
41-50	24	24.0
51-60	32	32.0
>60	26	26.0
Gender		
Male	64	64.0
Female	36	36.0
Smoking History	42	42.0
Diabetes Mellitus	28	28.0
Hypertension	24	24.0
Mean Age (years)	55.4 ± 13.6	

Interpretation

The majority of patients belonged to the 51-60 years age group (32%) with a male predominance (64%). Smoking, diabetes mellitus, and hypertension were common associated risk factors among patients diagnosed with community-acquired pneumonia.

Table 2. Distribution of Serum CRP Levels Among CAP Patients (n = 100)

Serum CRP Level (mg/L)	Frequency (n)	Percentage (%)
<50	22	22.0
50-99	34	34.0
100-149	28	28.0
≥150	16	16.0
Mean CRP Level	94.6 ± 48.2 mg/L	

p <0.001 (Highly significant).

Interpretation

The majority of patients demonstrated serum CRP levels between 50 and 99 mg/L. Elevated CRP levels were observed in most patients, indicating significant systemic inflammatory responses associated with community-acquired pneumonia.

Table 3. Association Between Serum CRP Levels and Disease Severity (CURB-65 Score) (n = 100)

CURB-65 Severity	Mean CRP (mg/L)	Frequency (%)
Mild (0-1)	48.6 ± 14.2	36
Moderate (2)	96.8 ± 28.6	38
Severe (≥3)	156.4 ± 36.8	26

p <0.001.

Interpretation

Patients with severe community-acquired pneumonia demonstrated significantly higher serum CRP levels when compared to those with mild and moderate disease. Serum CRP levels showed a strong positive association with CURB-65 severity scores.

Table 4. Association Between Serum CRP Levels and Clinical Outcomes (n = 100)

Clinical Outcome	Mean CRP (mg/L)	p-value
ICU Admission (n=18)	164.2 ± 42.8	<0.001
Non-ICU Admission (n=82)	78.4 ± 31.5	
Oxygen Requirement (n=32)	142.6 ± 38.4	<0.001
No Oxygen Requirement (n=68)	68.8 ± 24.6	
Prolonged Hospital Stay (>7 days)	148.3 ± 44.2	0.002
Hospital Stay ≤7 days	76.2 ± 29.6	

Interpretation

Patients requiring ICU admission, supplemental oxygen therapy, and prolonged hospitalization demonstrated significantly higher serum CRP levels. Elevated CRP levels were associated with poorer clinical outcomes among CAP patients.

Table 5. Correlation Between Serum CRP Levels and Laboratory Parameters (n = 100)

Laboratory Parameter	Correlation Coefficient (r)	p-value
Total Leukocyte Count	+0.68	<0.001
ESR	+0.61	<0.001
Respiratory Rate	+0.54	<0.001
Oxygen Saturation	-0.47	0.003
CURB-65 Score	+0.73	<0.001

Interpretation

Serum CRP levels demonstrated significant positive correlations with total leukocyte count, ESR, respiratory rate, and CURB-65 scores. A significant negative correlation was observed between serum CRP levels and oxygen saturation, suggesting that higher inflammatory burden

is associated with greater disease severity and impaired respiratory status.

Overall Results Summary
The present study demonstrated that elevated serum C-reactive protein levels are significantly associated with increased disease severity and adverse clinical outcomes among patients with community-acquired pneumonia. Higher CRP levels correlated strongly with CURB-65 severity scores, ICU admission, oxygen requirement, prolonged hospital stay, and inflammatory laboratory parameters. These findings suggest that serum CRP is a valuable and cost-effective inflammatory biomarker that may aid clinicians in assessing disease severity, predicting clinical outcomes, and guiding therapeutic decision-making in patients with community-acquired pneumonia.

Discussion
The present cross-sectional observational study evaluated serum C-reactive protein (CRP) levels among 100 patients diagnosed with community-acquired pneumonia (CAP). The findings demonstrated that elevated serum CRP levels are significantly associated with disease severity, inflammatory burden, and adverse clinical outcomes. CRP has emerged as a valuable inflammatory biomarker in CAP because of its rapid response to infection and its ability to reflect the extent of systemic inflammatory activation. [8]

The majority of the study participants belonged to the 51-60 years age group, with a mean age of 55.4 ± 13.6 years. Males constituted 64% of the study population. Similar demographic trends have been reported in previous Indian and international studies, which demonstrated that community-acquired pneumonia is more prevalent among middle-aged and elderly males owing to greater exposure to smoking, chronic respiratory diseases, and other comorbid conditions. Increasing age has consistently been identified as an important predictor of severe CAP and poorer clinical outcomes. [9] Smoking history was observed in 42% of patients, while diabetes mellitus and hypertension were present in 28% and 24% of patients, respectively. These findings are consistent with previous studies that have established smoking and metabolic comorbidities as important risk factors for community-acquired pneumonia. Smoking impairs mucociliary clearance and host immune responses, thereby predisposing individuals to lower respiratory tract infections. Similarly, diabetes mellitus adversely affects innate immunity and has been associated with increased severity and mortality among CAP patients. [10]

The present study demonstrated that elevated serum CRP levels were observed in the majority of patients, with a mean CRP level of 94.6 ± 48.2 mg/L. CRP is synthesized by hepatocytes in response to pro-inflammatory cytokines, particularly interleukin-6, and serves as an important marker of bacterial infection and systemic inflammation. Several studies have reported that serum CRP levels rise significantly during bacterial pneumonia and correlate closely with disease severity and therapeutic response. [11] A highly significant association was observed between serum CRP levels and CURB-65 severity scores ($p < 0.001$). Patients with severe CAP demonstrated markedly elevated CRP levels compared with patients presenting with mild and moderate disease. Similar findings have been reported by Chalmers et al., who demonstrated that elevated CRP levels independently predict severe community-acquired pneumonia and adverse clinical outcomes. Higher CRP concentrations reflect a more robust inflammatory response and may indicate greater pulmonary involvement and systemic complications. [12] The present study further demonstrated that patients requiring ICU admission exhibited significantly higher serum CRP levels than those managed in general wards. Elevated CRP levels were also significantly associated with oxygen requirement and prolonged hospitalization. Previous investigations have consistently shown that serum CRP is an independent predictor of ICU admission and mortality among hospitalized CAP patients. Serial CRP measurements have additionally been shown to assist clinicians in monitoring therapeutic response and identifying patients at risk of clinical deterioration. [13]

Patients with prolonged hospital stays (>7 days) demonstrated significantly elevated serum CRP levels. Persistent elevation of inflammatory markers has been associated with delayed clinical recovery, complications such as pleural effusion and sepsis, and increased healthcare utilization. Several prospective studies have reported that CRP-guided assessment may facilitate early identification of patients likely to experience prolonged hospitalization and may contribute to more individualized treatment strategies. [14] The present study identified significant positive correlations between serum CRP levels and total leukocyte count, ESR, respiratory rate, and CURB-65 scores. Conversely, serum CRP levels demonstrated a significant negative correlation with oxygen saturation. These findings indicate that CRP accurately reflects the underlying inflammatory burden and physiological derangements associated with severe pneumonia. Similar correlations have been reported in several multicentric studies evaluating inflammatory biomarkers in lower respiratory tract infections. [15] The prognostic significance of serum CRP in community-acquired pneumonia has been increasingly recognized in contemporary clinical practice. Elevated CRP levels have been associated with greater radiological severity, bacteraemia, respiratory failure, septic shock, and mortality. The incorporation of inflammatory biomarkers alongside established clinical severity scoring systems enhances risk stratification and facilitates timely therapeutic intervention. [16]

Compared with other inflammatory biomarkers such as procalcitonin and interleukin-6, CRP offers several advantages, including widespread availability, affordability, and rapid turnaround time. Its utility extends beyond diagnosis to prognostication and monitoring of treatment response. [17] Several studies have further demonstrated that serial CRP measurements may assist in antibiotic stewardship by identifying patients demonstrating adequate clinical response to antimicrobial therapy. Reduction in CRP levels during hospitalization has been associated with favourable outcomes and may support early de-escalation of antibiotic therapy when clinically appropriate. [18] The present study reinforces the role of serum CRP as a clinically useful biomarker in community-acquired pneumonia. Elevated CRP levels provide valuable prognostic information regarding disease severity, oxygen requirement, intensive care admission, and duration of hospitalization. Routine assessment of serum CRP may therefore improve clinical decision-making and optimize patient management. [19]

Overall, the findings of the present study suggest that serum C-reactive protein is a reliable, cost-effective, and readily available inflammatory marker that significantly correlates with disease severity and adverse clinical outcomes in community-acquired pneumonia. Early identification of patients with markedly elevated CRP levels may facilitate prompt intervention and improve clinical outcomes. [20]

Conclusion
The present study demonstrated that serum C-reactive protein (CRP) is a valuable inflammatory biomarker in patients with community-acquired pneumonia and shows significant associations with disease severity and clinical outcomes. Elevated CRP levels were strongly correlated with higher CURB-65 severity scores, intensive care unit admission, oxygen requirement, prolonged hospital stay, and inflammatory laboratory parameters. Patients with severe community-acquired pneumonia exhibited significantly higher serum CRP levels compared to those with mild and moderate disease. These findings highlight the clinical utility of serum CRP as a simple, cost-effective, and readily available biomarker for early risk stratification and prognostic assessment. Routine measurement of serum CRP may facilitate timely clinical decision-making, optimize patient management, and improve outcomes in patients with community-acquired pneumonia.

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