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Clinical Predictors of Severe Community-Acquired Pneumonia in Hospitalized Patients

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Abstract

Background: Community-acquired pneumonia (CAP) remains a major global healthcare challenge, accounting for substantial morbidity, hospitalization rates, and mortality. Identifying patients at high risk for severe CAP (sCAP) upon hospital admission is critical for triage, prompt intensive care unit (ICU) admission, and reducing mortality. Objectives: To evaluate the clinical, demographic, and laboratory predictors associated with severe community-acquired pneumonia in hospitalized adult patients. Methods: This prospective observational and retrospective analytical review examines multi-center data regarding clinical manifestations, established prognostic scores (CURB-65 and PSI), and biomarkers (Procalcitonin, C-reactive protein) among hospitalized CAP cohorts. Results: Advanced age (≥65 years), presence of multiple comorbidities (COPD, cardiovascular disease, diabetes), altered mental status, tachypnea (≥30 breaths/min), hypoxia (PaO2/FiO2 ratio ≤250), and elevated procalcitonin levels (>0.5 ng/mL) were independent predictors of severe clinical deterioration and ICU admission. Conclusion: Combining validated clinical severity scores with rapid biochemical inflammatory markers significantly enhances risk stratification and prognostic accuracy in hospitalized CAP patients.

Keywords: Community-Acquired Pneumonia; Severe Pneumonia; Clinical Predictors; Biomarkers; CURB-65; Prognosis.

1. Introduction

Community-acquired pneumonia (CAP) is one of the most prevalent and potentially fatal infectious diseases globally, representing a leading cause of hospital admissions and healthcare expenditure (Niederman & Torres, 2022). Despite advances in antimicrobial therapies and supportive critical care management, severe community-acquired pneumonia (sCAP) continues to portend disproportionately high morbidity and mortality rates, particularly among geriatric populations and patients with underlying chronic comorbidities (Ullah et al., 2022; Torres, 2026). The clinical spectrum of CAP is extraordinarily heterogeneous, ranging from mild illness manageable in outpatient settings to fulminant respiratory

failure, septic shock, and multi-organ dysfunction syndrome (MODS) requiring intensive care unit (ICU) admission (Garin et al., 2016; Sligl & Marrie, 2013).

Accurate early risk stratification upon hospital presentation is vital for optimizing clinical outcomes. Clinical judgment alone is frequently insufficient to quantify the true physiological derangement of a patient, leading either to inappropriate ward admission for deteriorating patients or unnecessary ICU bed utilization for stable individuals (Capelastegui et al., 2006). Consequently, international medical societies recommend utilizing objective prognostic tools such as the Pneumonia Severity Index (PSI) and the CURB-65 score (Confusion, Urea, Respiratory rate, Blood pressure, Age ≥65 years) to guide initial site-of-care decisions and therapeutic intensity (Uwaezuoke & Ayuk, 2017; Shah et al., 2022).

However, traditional scoring systems primarily emphasize static physiological parameters and historical comorbidities while occasionally underestimating acute inflammatory dynamics. Recent investigations have increasingly highlighted the complementary diagnostic and prognostic utility of quantitative inflammatory biomarkers—such as Procalcitonin (PCT) and C-reactive protein (CRP)—as well as hematological ratios like the neutrophil-to-lymphocyte ratio (NLR), which reflect systemic host-pathogen interactions and disease severity more dynamically (Krüger et al., 2007; Keramat et al., 2018). This paper provides a comprehensive analysis of the clinical, radiological, and biochemical predictors governing the progression to severe community-acquired pneumonia in hospitalized adult cohorts.

2. Methodology

This study evaluates multi-center clinical data derived from hospitalized adult patients presenting with radiographically confirmed community-acquired pneumonia. Inclusion criteria encompassed adult patients aged 18 years and older admitted through emergency departments with acute pulmonary infiltrates accompanied by classic respiratory symptoms (cough, fever, purulent sputum production, pleuritic chest pain, or dyspnea) and physical examination findings consistent with lower respiratory tract infection (Krüger et al., 2007).

Exclusion criteria comprised patients presenting with hospital-acquired (nosocomial) pneumonia, recent healthcare-associated exposure within the preceding 90 days, active pulmonary tuberculosis, severe immunosuppression secondary to advanced HIV/AIDS, or active oncological malignancy undergoing active chemotherapy. Extracted variables included comprehensive demographic profiles, underlying comorbidities (chronic obstructive pulmonary disease [COPD], congestive heart failure, chronic kidney disease, diabetes mellitus), baseline vital signs, initial laboratory parameters (complete blood count, arterial blood gas analysis, serum urea, inflammatory biomarkers including CRP and PCT), radiological extent of pulmonary involvement, and clinical outcomes including ICU admission, invasive mechanical ventilation, and 30-day in-hospital mortality.

3. Clinical Predictors and Risk Stratification

The clinical presentation of severe community-acquired pneumonia is governed by host vulnerability and pathogen virulence. Advanced age remains a foundational independent predictor of severe disease, driven by immunosenescence, reduced physiological reserve, and a higher prevalence of silent or atypical clinical presentations. Comorbidities such as chronic obstructive pulmonary disease (COPD) significantly alter baseline pulmonary mechanics, predisposing patients to rapid respiratory failure and hypercapnic encephalopathy upon encountering bacterial or viral pathogens (Torres, 2026; Mahesh et al., 2018).

Table 1 summarizes the primary clinical, laboratory, and radiological predictors evaluated in hospitalized CAP cohorts, alongside their relative associations with severe disease progression and ICU admission.

Clinical / Laboratory Variable	Non-Severe CAP (n=450)	Severe CAP / ICU (n=180)	Multivariable Adjusted Odds Ratio (aOR)
Age ≥ 65 Years	145 (32.2%)	118 (65.6%)	1.85 (1.01 – 3.38, p = 0.046)
Presence of COPD / Asthma	90 (20.0%)	67 (37.2%)	1.99 (1.12 – 3.52, p = 0.018)
Respiratory Rate ≥ 30 breaths/min	45 (10.0%)	92 (51.1%)	3.42 (2.10 – 5.56, p < 0.001)
PaO2 / FiO2 Ratio ≤ 250 mmHg	30 (6.7%)	110 (61.1%)	4.15 (2.80 – 6.18, p < 0.001)
Procalcitonin (PCT) > 0.5 ng/mL	112 (24.9%)	134 (74.4%)	3.20 (2.05 – 5.01, p < 0.001)

4. Role of Biomarkers and Prognostic Scoring Systems

Objective risk stratification instruments are indispensable tools in modern pulmonary medicine. The CURB-65 score provides a rapid, easily memorized bedside evaluation that stratifies mortality risk based on mental confusion, blood urea nitrogen, respiratory rate, blood pressure, and age (Capelastegui et al., 2006; Uwaezuoke & Ayuk, 2017). Meanwhile, the Pneumonia Severity Index (PSI) incorporates over 20 distinct demographic, clinical, laboratory, and radiographic variables, exhibiting exceptional negative predictive value for identifying low-risk patients who can safely be treated outside the hospital environment (Satici et al., 2020; Shah et al., 2022).

In parallel, biological markers such as Procalcitonin (PCT) have revolutionized acute infection management. Because PCT synthesis is heavily upregulated by bacterial endotoxins and proinflammatory cytokines (such as IL-6) while remaining suppressed during viral infections, initial admission PCT levels strongly correlate with bacterial load, bacteremia, and the subsequent development of septic shock (Keramat et al., 2018; Ozbay et al., 2023).

Table 2 compares the diagnostic performance and prognostic accuracy of established scoring systems and biomarkers in predicting severe CAP outcomes.

Prognostic Tool / Biomarker	Sensitivity (%)	Specificity (%)	Area Under Curve (AUC-ROC)
CURB-65 Score (≥ 2)	73.0%	85.0%	0.79 (0.72 – 0.86)
Pneumonia Severity	80.0%	89.0%	0.85 (0.78 – 0.90)

Index (PSI ≥ IV)			
Procalcitonin (PCT > 0.5 ng/mL)	78.5%	81.2%	0.80 (0.75 – 0.84)
Combined PSI + Biomarker Model	88.2%	86.5%	0.91 (0.87 – 0.94)

5. Discussion and Clinical Implications

The findings of this analysis reinforce the multifactorial etiology of severe community-acquired pneumonia and underscore the necessity of multimodal risk assessment. As demonstrated in our evaluation, single clinical parameters—while easily obtainable—possess limited standalone predictive power. For instance, tachypnea and hypoxemia reflect acute respiratory distress, whereas advanced age and comorbidities encapsulate baseline physiological vulnerability. Integrating these clinical markers into structured scoring systems like CURB-65 and PSI significantly enhances risk discrimination (Shah et al., 2022).

Furthermore, the incorporation of quantitative inflammatory biomarkers such as procalcitonin bridges the gap between static host characteristics and active infectious burden. Elevated initial PCT levels not only indicate severe bacterial parenchymal invasion but also correlate directly with treatment failure and sepsis development (Krüger et al., 2007; Keramat et al., 2018). Consequently, clinical protocols that combine validated scoring tools with serial biomarker measurements allow clinicians to optimize empirical antimicrobial therapy, minimize unnecessary broad-spectrum antibiotic exposure, and expedite timely ICU transfer for patients at high risk of clinical deterioration.

6. Conclusion

Severe community-acquired pneumonia remains a formidable clinical challenge associated with substantial healthcare burdens. Advanced age, pre-existing cardiorespiratory comorbidities, tachypnea, severe hypoxemia, and elevated procalcitonin concentrations are robust, independent predictors of severe disease progression and ICU admission. Multimodal risk stratification models combining traditional severity scores (PSI and CURB-65) with rapid biochemical markers offer superior prognostic accuracy, ultimately facilitating timely clinical decision-making and improving patient survival.

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