Journal of Clinical and Nursing Research, 2025, Volume 9, Issue 1
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

# C-reactive Protein (CRP) and Procalcitonin (PCT) Combined Testing in the Diagnosis of Elderly Patients with Bacterial Pneumonia

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**Abstract:** *Objective:* To analyze the diagnostic value of combined testing of C-reactive protein (CRP) and procalcitonin (PCT) in elderly patients with bacterial pneumonia. *Methods:* This study included 50 elderly patients with bacterial pneumonia as the observation group and 50 patients with non-bacterial pneumonia as the control group, recruited from May 2022 to October 2023. Fasting venous blood samples were collected in the morning from all 100 participants. CRP levels were measured using a fully automated biochemical analyzer, while PCT levels were detected using the immunoturbidimetric luminescence method. *Results:* CRP and PCT levels were significantly higher in bacterial pneumonia patients [(98.25 ± 11.59) mg/L and (3.57 ± 1.35) μg/L, respectively] compared to the control group [(5.55 ± 2.78) mg/L and (0.25 ± 0.12) μg/L, respectively], with significant intergroup differences ($P < 0.05$). Patients with severe bacterial pneumonia exhibited higher serum CRP and PCT levels compared to those with moderate or mild disease ($P < 0.05$). The combined testing of CRP and PCT showed higher sensitivity and specificity than individual tests. In the observation group, CRP and PCT levels significantly decreased after treatment compared to pre-treatment levels. *Conclusion:* The combination of CRP and PCT testing provides high diagnostic accuracy for bacterial pneumonia in elderly patients. It effectively differentiates bacterial from non-bacterial infections, offering valuable data to guide clinical treatment.

**Keywords:** C-reactive protein (CRP); Procalcitonin (PCT); Combined testing; Elderly bacterial pneumonia

**Online publication:** February 17, 2025

## 1. Introduction

Elderly individuals are among the high-risk populations for bacterial pneumonia, where diagnosis and treatment often present significant challenges. Due to age-related immune decline and coexisting chronic conditions, the clinical manifestations of bacterial pneumonia in elderly patients are often atypical and easily confused with other respiratory diseases, leading to unclear diagnostic results and worse patient outcomes [1]. Timely diagnosis and effective treatment are therefore critical for reducing mortality and complications associated with bacterial

pneumonia in elderly patients.

C-reactive protein (CRP) and procalcitonin (PCT) are commonly used inflammatory biomarkers widely applied in diagnosing and assessing infectious diseases. Advances in medical technology and an increasing understanding of elderly bacterial pneumonia have demonstrated that the combined testing of CRP and PCT improves diagnostic accuracy for bacterial pneumonia in elderly patients [2].

Based on this, the present study aims to comprehensively analyze the value of CRP and PCT combined testing in the diagnosis of elderly bacterial pneumonia, providing a new diagnostic approach for clinical practice. This study involved 50 cases of bacterial pneumonia and 50 cases of non-bacterial pneumonia recruited from May 2022 to October 2023.

## 2. Materials and methods

### 2.1. Clinical data

The study was conducted from May 2022 to October 2023 and included 50 elderly patients with bacterial pneumonia as the observation group and 50 patients with non-bacterial pneumonia as the control group.

Inclusion criteria: (1) Age ≥ 60 years; (2) Agreed to participate in the study and signed an informed consent form.

Exclusion criteria: (1) Patients with mental disorders who could not communicate autonomously or had poor compliance; (2) Patients with coagulation disorders; (3) Patients with malignant tumors.

The clinical data of the two groups, including gender and age, showed no statistically significant differences. Detailed information is displayed in **Table 1**.

**Table 1.** Clinical data of patients

| Group | *n* | Age | Average age (years) | Gender | | Body mass index (kg/m²) |
|---|---|---|---|---|---|---|
| | | | | Male | Female | |
| Observation group | 50 | 61–92 | 78.21 ± 5.33 | 26 | 24 | 20.16 ± 1.77 |
| Control group | 50 | 60–93 | 78.37 ± 5.65 | 28 | 22 | 20.24 ± 1.52 |
| $t / \chi^2$ | | | 0.067 | 0.043 | | 0.039 |
| *P* | | | > 0.05 | > 0.05 | | > 0.05 |

### 2.2. Methods

Fasting venous blood samples were collected in the morning from the elbow of all 100 participants. CRP levels were measured using a fully automated biochemical analyzer, and PCT levels were detected using the immunoturbidimetric luminescence method.

### 2.3. Observation indicators

(1) Compare CRP and PCT data between the two groups;

(2) Analyze CRP and PCT levels in patients with different severities of bacterial pneumonia in the observation group. According to the CPIS score, the 50 patients were classified into a severe group (> 6 points) and a mild/moderate group (≤ 6 points);

(3) Assess the diagnostic efficacy of single testing and combined testing for bacterial pneumonia;

(4) Observe the data before and after two weeks of treatment in the observation group.

## 2.4. Statistical methods

Statistical analyses were performed using SPSS 23.0. Differences in indicators between the observation and control groups were analyzed using *t*-tests and $\chi^2$-tests. A significance level of $P < 0.05$ was considered statistically significant.

# 3. Results

## 3.1. Serum CRP and PCT levels in both groups

Analysis of CRP and PCT levels in the 100 patients revealed significantly higher values in patients with bacterial pneumonia compared to the control group ($P < 0.05$). See **Table 2**.

**Table 2.** Serum CRP and PCT levels (mean ± SD)

| Group | *n* | CRP (mg/L) | PCT (μg/L) |
|---|---|---|---|
| Observation group | 50 | 98.25 ± 11.59 | 3.57 ± 1.35 |
| Control group | 50 | 5.55 ± 2.78 | 0.25 ± 0.12 |
| *t* | | 37.652 | 9.939 |
| *P* | | < 0.05 | < 0.05 |

## 3.2. Indicators for patients with different severity levels in the observation group

Combined testing of serum CRP and PCT levels revealed that patients with more severe conditions had significantly higher levels compared to those with mild or moderate conditions ($P < 0.05$). See **Table 3**.

**Table 3.** Indicators by severity in the observation group (mean ± SD)

| Group | *n* | CRP (mg/L) | PCT (μg/L) |
|---|---|---|---|
| Severe group | 27 | 104.37 ± 12.01 | 3.92 ± 1.89 |
| Moderate and mild group | 23 | 90.77 ± 10.49 | 2.69 ± 1.05 |
| *t* | | 6.506 | 10.290 |
| *P* | | < 0.05 | < 0.05 |

## 3.3. Diagnostic efficiency of CRP, PCT, and combined testing

Comparison of CRP, PCT, and combined testing results showed that combined testing achieved higher sensitivity, specificity, and accuracy. See **Tables 4** and **5**.

**Table 4.** Diagnostic accuracy of single and combined testing

| Pathological results | CRP (mg/L) | | PCT (μg/L) | | Combined testing | |
|---|---|---|---|---|---|---|
| | Positive | Negative | Positive | Negative | Positive | Negative |
| Positive (50) | 41 | 9 | 47 | 3 | 50 | 0 |
| Negative (50) | 5 | 45 | 2 | 48 | 0 | 50 |
| Total | 46 | 54 | 49 | 51 | 50 | 50 |

**Table 5.** Diagnostic efficiency of single and combined testing

| Testing methods | *n* | Sensitivity | Specificity | Accuracy | Positive predictive value | Negative predictive value |
|---|---|---|---|---|---|---|
| CRP (mg/L) | 100 | 82.00% | 90.00% | 86.00% | 89.00% | 83.00% |
| PCT (μg/L) | 100 | 93.18% | 96.00% | 94.68% | 95.35% | 94.12% |
| Combined testing | 100 | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |

## 3.4. Changes in indicators in the observation group before and after treatment

Analysis of the 50 patients in the observation group before and after treatment showed a significant reduction in CRP and PCT levels following treatment ($P < 0.05$). See **Table 6**.

**Table 6.** Changes in indicators in the observation group before and after treatment (mean ± SD)

| Time | *n* | CRP (mg/L) | PCT (μg/L) |
|---|---|---|---|
| Before treatment | 50 | 98.25 ± 11.59 | 3.57 ± 1.35 |
| After treatment | 50 | 15.53 ± 4.71 | 1.17 ± 0.66 |
| *t* | | 46.754 | 11.293 |
| *P* | | < 0.05 | < 0.05 |

# 4. Discussion

Bacterial pneumonia is a lung infection caused by bacterial pathogens, often introduced through inhalation. The most common causative agents include *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Streptococcus* species [3]. Its clinical manifestations range from mild to severe, including symptoms such as cough, fever, dyspnea, and chest pain [4]. For elderly populations, diagnosing and treating bacterial pneumonia is more complex due to weakened immune function, multiple comorbidities, and physiological decline. Symptoms in older adults often present non-specifically, such as generalized weakness, reduced appetite, or cognitive decline, which can lead to misdiagnosis [4]. Historically, diagnosis relied on clinical symptoms and imaging studies (e.g., X-rays or CT scans). However, because many respiratory diseases share similar symptoms and imaging features, additional methods are needed to determine whether the infection is bacterial [5].

CRP is an acute-phase protein produced by the liver in response to infection, inflammation, or tissue injury. Under normal conditions, CRP levels in the blood are low, but they rise significantly during inflammation or infection, serving as a nonspecific immune response marker. The level of CRP reflects the severity of inflammation and disease activity. Clinical studies have shown that CRP levels peak 6–8 hours after bacterial infection onset [6]. Once the bacterial infection is controlled, CRP levels decrease markedly. However, CRP is not activated in viral infections. Despite its utility, CRP levels can also be influenced by factors like trauma, surgery, or malignancy, resulting in potential misdiagnoses or missed diagnoses if CRP is used as the sole marker [7].

PCT is the precursor form of calcitonin, synthesized by thyroid C cells, and its plasma concentration is typically very low in non-infectious conditions [8]. During infection or severe inflammation, particularly bacterial infections, PCT levels rise significantly. Its production is regulated by bacterial endotoxins and inflammatory mediators such as interleukin-1 and interleukin-6 [9]. Compared to CRP, elevated PCT levels are more specific to bacterial infections, making it a critical biomarker for diagnosing infectious diseases, assessing disease severity,

and guiding antibiotic therapy. Researchers have noted that while PCT does not initiate a sepsis response, it can exacerbate the pathological and physiological processes of sepsis. Thus, elevated PCT levels can differentiate bacterial infections from others, particularly severe bacterial infections, as PCT levels correlate positively with disease severity [10,11].

The combined measurement of CRP and PCT improves diagnostic accuracy. By analyzing both markers, clinicians can assess whether patients require antibiotic therapy, minimizing unnecessary antibiotic use and reducing the risk of antibiotic overuse. Additionally, combined testing helps evaluate the severity of bacterial pneumonia and guide treatment planning, ultimately improving patient outcomes [12].

Ma [13] investigated the clinical value of combined testing for serum prealbumin (PA), PCT, and CRP in diagnosing bacterial pneumonia in elderly patients. Their study found that serum PCT and CRP levels were higher in the bacterial infection group. Serum PCT testing diagnosed 50 cases, CRP testing diagnosed 43 cases, and combined testing confirmed 59 cases. Sensitivity and negative predictive value were higher with combined testing compared to individual tests. This study concluded that PCT and CRP are sensitive indicators for diagnosing bacterial pneumonia in elderly patients, and combined testing has higher sensitivity. These findings are consistent with this study's results, where CRP and PCT levels were significantly higher in bacterial pneumonia patients than in the control group ($P < 0.05$). Moreover, combined testing demonstrated 100% sensitivity, specificity, accuracy, positive predictive value, and negative predictive value, confirming its high diagnostic value.

## 5. Conclusion

In summary, bacterial pneumonia is a common and serious infectious disease with high incidence and mortality rates in elderly populations. Early diagnosis and timely treatment are critical for preventing complications. In diagnosing bacterial pneumonia in elderly patients, combined testing of CRP and PCT has high diagnostic accuracy. It effectively distinguishes bacterial from non-bacterial infections, providing robust data to support clinical decision-making.

## Disclosure statement

The authors declare no conflict of interest.

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