

Clinical Features and Risk Factors for Severe Disease in 57 Cases of *Chlamydia psittaci* Pneumonia: A Retrospective Study

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Background: This study aimed to analyze the clinical features of *Chlamydia psittaci* (*C. psittaci*) pneumonia and identify risk factors for severe patients to facilitate early diagnosis and treatment.

Methods: In this retrospective analysis, we collected and summarized the clinical data of 57 patients with *C. psittaci* pneumonia confirmed by metagenomic next-generation sequencing (mNGS) or targeted next-generation sequencing (tNGS), who were admitted to the First Affiliated Hospital of Guilin Medical University between July 2020 and August 2025. Patients were further divided into a severe group (n=23) and a non-severe group (n=34) for comparative analysis of their clinical characteristics.

Results: The mean age of the patients was 58.68 ± 12.36 years. Common symptoms included fever, cough/sputum, fatigue, dyspnea, and neurological and gastrointestinal symptoms. The severe group had a significantly higher incidence of fatigue, dyspnea, and neurological and gastrointestinal manifestations. Laboratory findings revealed that most patients had normal or mildly elevated white blood cell counts with lymphopenia, alongside significantly elevated levels of C-reactive protein (CRP), procalcitonin (PCT), and erythrocyte sedimentation rate (ESR). Anemia, hypoalbuminemia, and abnormalities in liver enzymes, myocardial enzymes, and electrolytes were also commonly observed. The predominant chest computed tomography finding was consolidation, with pleural effusion present in 59.6% of all patients and occurring more frequently in the severe group. Multivariate analysis identified CRP as an independent risk factor for severe *C. psittaci* pneumonia, while albumin and platelet count were protective factors.

Conclusion: Pneumonia patients presenting with non-specific influenza-like symptoms should raise clinical suspicion for *C. psittaci* pneumonia. Particular vigilance for potential progression to severe disease is warranted in male patients, the elderly, those with underlying comorbidities, and individuals presenting with neurological or gastrointestinal symptoms. Elevated CRP, hypoalbuminemia, and thrombocytopenia serve as significant predictors of severe *C. psittaci* pneumonia.

Keywords: *Chlamydia psittaci*, community-acquired pneumonia, next-generation sequencing

Background

Chlamydia psittaci (*C. psittaci*) is an aerobic, obligate intracellular Gram-negative bacterium that typically infects birds. Human transmission occurs primarily through the inhalation of aerosolized particles contaminated with *C. psittaci*.^{1,2} Human infection most commonly manifests as non-specific influenza-like symptoms or atypical pneumonia, with a severity ranging from asymptomatic infection to multi-organ failure and even death.³

A 2017 meta-analysis by Hogerwerf, L. et al suggested that *C. psittaci* pneumonia accounts for approximately 1.03% of community-acquired pneumonia (CAP).⁴ However, due to the non-specific clinical presentation and limitations of conventional diagnostic methods—including culture, serological testing, and Polymerase Chain Reaction (PCR), in terms of testing requirements, sensitivity, and specificity; the incidence of *C. psittaci* pneumonia is likely significantly underestimated.⁵ A study from the Netherlands indicated that the annual disability-adjusted life years (DALYs) attributable to psittacosis amounted to 222 DALYs per year between 2012 and 2014, with over 1,500 symptomatic patients remaining undiagnosed annually.⁶ With the development

and application of Metagenomic Next-Generation Sequencing (mNGS), case reports of *C. psittaci* pneumonia have increased rapidly. A multicenter prospective study by Wu, X. et al indicated that *C. psittaci* pneumonia accounts for 7.3% of severe community-acquired pneumonia (SCAP), and up to 8% in immunocompetent populations.⁷ With early diagnosis and appropriate treatment, the mortality rate of *C. psittaci* pneumonia is below 1%, but it can be as high as 5%–40% in untreated patients, and potentially even higher in the context of co-infections.⁸ Therefore, the early identification of *C. psittaci* pneumonia, particularly severe cases, is crucial.

Although some case reports and case series have described the clinical features of *C. psittaci* pneumonia, their sample sizes are often limited. Research focusing on risk factors for severe *C. psittaci* pneumonia remains relatively scarce, and existing findings are inconsistent. This study collected 57 patients with *C. psittaci* pneumonia diagnosed by mNGS or Targeted Next-Generation Sequencing (tNGS) to investigate its clinical features and provide references for clinical diagnosis and treatment. Based on CAP diagnostic criteria, patients were further stratified into severe and non-severe groups to compare their clinical characteristics, with the aim of facilitating the early identification of severe cases.

Methods

Study Design and Subjects

This retrospective study analyzed patients with *C. psittaci* pneumonia admitted to the First Affiliated Hospital of Guilin Medical University (Guilin, China) between July 2020 and August 2025.

Inclusion Criteria

1) Age ≥ 18 years; 2) Meeting the diagnostic criteria for CAP; 3)⁹ Detection of specific *C. psittaci* DNA fragments in respiratory or blood samples by mNGS or tNGS, fulfilled the criteria for a positive result, as described by Miao et al¹⁰ and the *Chinese expert consensus on diagnosis and treatment of psittacosis*.¹¹

Exclusion Criteria

Patients with incomplete medical records.

Grouping Criteria

Patients were classified into severe and non-severe groups based on pneumonia severity, according to the *Diagnosis and treatment of community-acquired pneumonia in adults: 2016 clinical practice guidelines by the Chinese Thoracic Society, Chinese Medical Association*.⁹ Severe pneumonia was defined as meeting one major criterion or three or more minor criteria.

Major Criteria: 1) Requirement for tracheal intubation and mechanical ventilation; 2) Septic shock requiring vasopressor support despite aggressive fluid resuscitation.

Minor Criteria: 1) Respiratory rate ≥ 30 breaths/min; 2) Ratio of arterial oxygen partial pressure to fractional inspired oxygen ($\text{PaO}_2/\text{FiO}_2$) ≤ 250 mmHg; 3) Multi-lobar infiltrates; 4) Confusion/Disorientation; 5) Blood urea nitrogen (BUN) ≥ 7.14 mmol/L; 6) Systolic blood pressure (SBP) < 90 mmHg requiring aggressive fluid resuscitation.

Data Collection

Comprehensive data were extracted from the electronic medical record system, including gender, age, underlying diseases, time from symptom onset to admission, epidemiological history, symptoms, signs, laboratory test results within 24 hours of admission, chest computed tomography (CT) findings, treatment regimens, and clinical outcomes.

Statistical Analysis

All statistical analyses were performed using SPSS version 29.0 (IBM Corp., USA). Normally distributed continuous variables were expressed as mean $\pm$ standard deviation (SD) and compared using the Student's *t*-test. Non-normally distributed continuous variables were expressed as median (interquartile range) and compared using the Mann–Whitney *U*-test. Categorical variables were described as frequencies and percentages and compared using the Chi-square test or

Fisher's exact test, as appropriate. Multivariate logistic regression analysis was employed to identify risk factors associated with severe disease. When constructing the multivariate regression model, laboratory indicator variables with a P-value <0.01 in the univariate analysis were included in the initial model. A backward stepwise selection method was then used, sequentially removing the least significant variable with a significance level >0.05. A two-tailed P-value <0.05 was considered statistically significant.

Results

Demographic and Clinical Characteristics

During the study period, a total of 58 patients were identified who had specific *C. psittaci* DNA fragments detected in respiratory or blood samples by mNGS or tNGS, and all 58 patients fulfilled the diagnostic criteria for CAP. Among them, one patient aged <18 years was excluded, and a total of 57 patients were ultimately included in the analysis.

The mean age was 58.68 ± 12.36 years, and 33 patients (57.89%) were male. Twenty-six patients had underlying diseases. Only 20 patients (35.1%) had a clear history of environmental exposure: contact with parrots (n=10), pigeons (n=2), chickens/ducks (n=6), cleaning a pigsty (n=1), and contact with bird droppings (n=1). Cases occurred throughout the year but were more frequent in winter (36.8%). The main symptoms included fever (100%), cough (80.7%), dyspnea (54.4%), neurological symptoms (52.6%), fatigue (47.4%), sputum production (45.6%), and gastrointestinal symptoms (40.4%). The median time from symptom onset to hospitalization was 7(4.5, 7.5) days.

After enrollment, patients were divided into a severe group (n=23) and a non-severe group (n=34), as previously mentioned. Patients in the severe group were significantly older than those in the non-severe group (63.08 vs 55.7 years, $P=0.026$) and had a higher proportion of males (73.9% vs 47.1%, $P=0.044$). The prevalence of underlying diseases, particularly diabetes and cerebrovascular diseases, was significantly higher in the severe group. Regarding clinical symptoms, the incidence of fatigue, dyspnea, and neurological and gastrointestinal symptoms was significantly higher in the severe group, whereas the incidence of cough was significantly higher in the non-severe group. No significant differences were observed between the two groups regarding season of admission or time from symptom onset to admission (Details in Tables 1 and 2).

Table 1 Demographic Characteristics of Patients with *C. psittaci* Pneumonia

Characteristics	Total (n=57)	Severe Pneumonia (n=23)	Non-Severe Pneumonia (n=34)	P value
Age, years	58.68±12.36	63.09±10.18	55.71±12.94	0.026
Male sex	33(57.9%)	17(73.9%)	16(47.1%)	0.044
Underlying disease	26(45.6%)	15(65.2%)	11(32.4%)	0.015
Hypertension	13(22.8%)	8(34.8%)	5(14.7%)	0.076
Diabetes	11(19.3%)	8(34.8%)	3(8.8%)	0.02
Malignant tumor	2(3.5%)	2(8.7%)	0(0)	0.159
Cerebrovascular diseases	4(7.0%)	4(17.4%)	0(0)	0.022
Respiratory diseases	2(3.5%)	1(4.3%)	1(2.9%)	1
Chronic hepatitis	3(5.3%)	1(4.3%)	2(5.9%)	1
Environmental exposure	20(35.1%)	3(13.0%)	17(50%)	0.004
Symptom onset to admission, days	7(4.5,7.5)	7(3,7)	7(5,8)	0.407
Season of admission				0.272
Spring	14(24.6%)	5(21.7%)	9(26.5%)	
Summer	10(17.5%)	3(13.0%)	7(20.6%)	
Autumn	12(21.1%)	3(13.0%)	9(26.5%)	
Winter	21(36.8%)	12(52.2%)	9(26.5%)	

Table 2 Clinical Characteristics of Patients with *C. psittaci*

Characteristics	Total (n=57)	Severe Pneumonia (n=23)	Non-Severe Pneumonia (n=34)	P value
Temperature, °C	39.6(39.4,40.05)	39.7(39.5,40.3)	39.6(39.2,40.0)	0.307
Cough	46(80.7%)	15(65.2%)	31(91.2%)	0.02
Sputum	26(45.6%)	11(47.8%)	15(44.1%)	0.783
Myalgia	9(15.8%)	3(13.0%)	6(17.6%)	0.726
Fatigue	27(47.4%)	15(65.2%)	12(35.3%)	0.026
Dyspnea	31(54.4%)	21(91.3%)	10(29.4%)	<0.001
Chest tightness and pain	5(8.8%)	2(8.7%)	3(8.8%)	1
Gastrointestinal symptoms	23(40.4%)	13(56.5%)	10(29.4%)	0.041
Neurological symptoms	30(52.6%)	18(78.3%)	12(35.3%)	0.001

Laboratory Findings

On admission, 24 of the 57 patients (42.1%) had abnormal white blood cell (WBC) counts. Among these, 22 patients had elevated WBC, with 19 cases being mild elevations ($WBC < 15 \times 10^9/L$). Thirty-three patients (57.9%) had elevated neutrophil counts (NEUT), while 43 patients (75.4%) had decreased lymphocyte counts (LYM). All patients exhibited elevated high-sensitivity C-reactive protein (CRP) levels, with 30 patients (52.6%) having a CRP level greater than 200 mg/L. All patients who underwent testing had elevated erythrocyte sedimentation rate (ESR) and procalcitonin (PCT) levels. Forty-seven patients (82.5%) had elevated D-dimer levels. Over 50% of patients showed elevated levels of lactate dehydrogenase (LDH), alpha-hydroxybutyrate dehydrogenase (a-HBDH), creatine kinase (CK), alanine amino-transferase (ALT), and aspartate aminotransferase (AST).

Furthermore, among the 57 patients, 35 (61.4%) had decreased hemoglobin (HB), 51 (89.5%) had decreased albumin (ALB), 50 (87.7%) had hyponatremia, 39 (68.4%) had hypochloremia, and 16 (28.1%) had hypokalemia.

Compared with the non-severe group, patients in the severe group had significantly higher levels of CRP, PCT, AST, D-dimer, LDH, a-HBDH, CK, and CK-MB, alongside a more pronounced decrease in ALB and LYM. Platelet count (PLT), blood urea nitrogen (BUN), serum creatinine (Cr), total bilirubin (T-BIL), and direct bilirubin (D-BIL) remained within normal limits in over 80% of patients. However, compared to the non-severe group, the severe group had significantly higher levels of BUN, Cr, T-BIL, and D-BIL, and a significantly lower PLT (Details in Table 3).

Imaging Findings

Chest CT was performed for all patients either before admission or within 72 hours of hospitalization. Pulmonary lesions were unilateral in 37 cases (64.9%), involving the right lung in 26 cases and the left lung in 11 cases. Bilateral lung involvement was observed in 20 cases (35.1%). Lesions were primarily located in the lower lobes in 36 patients (63.2%) and in the upper or middle lobes in 21 patients (36.8%). The most common imaging manifestation was consolidation,

Table 3 Laboratory Findings of Patients with *C. psittaci* Pneumonia

Laboratory Test (Reference Range)	No. (%) of Patients	Total (n=57)	Severe Pneumonia (n=23)	Non-Severe Pneumonia (n=34)	P value
WBC ($3.5\text{--}9.5$) $\times 10^9/L$	22(38.6)↑	8.34(6.28,11.73)	9.85±4.8	8.64±2.9	0.287
HB (male:130–175, female:115–150) g/L	35(61.4)↓	120.54±15.93	117.35±18.84	122.71±13.49	0.216
PLT ($125\text{--}350$) $\times 10^9/L$	6(10.5)↓	214.91±78.52	153(122,198)	240(188.25,294.5)	<0.001
NEUT ($1.8\text{--}6.3$) $\times 10^9/L$	33(57.9)↑	6.87(4.89,9.94)	7.99(5.55,12.31)	6.3(4.66,9.4)	0.057
LYM ($1.1\text{--}3.2$) $\times 10^9/L$	43(75.4)↓	0.59(0.34,1.07)	0.33(0.27,0.43)	0.98(0.67,1.25)	<0.001
CRP (0–10) mg/L	57(100)↑	216.38±110.78	300.6±96.15	159.4±79.82	<0.001
ESR (0–43) mm/h (n=42)	42(100)↑	97(81,119.5)	118(89.5,120)	94(81,108.5)	0.06
PCT (0–0.046) ng/mL (n=46)	46(100)↑	0.81(0.21,4.21)	3.42(1.32,9.81)	0.223(0.16,0.81)	<0.001

(Continued)

Table 3 (Continued).

Laboratory Test (Reference Range)	No. (%) of Patients	Total (n=57)	Severe Pneumonia (n=23)	Non-Severe Pneumonia (n=34)	P value
D-dimer (0–0.55) ug/mL	47(82.5)↑	1.78(0.63,2.77)	2.82(1.75,3.91)	0.74(0.47,2)	<0.001
ALT (0–50) U/L	37(64.9)↑	65.8(46.2,104.35)	77.7(54,161.6)	60.5(40.15,97.13)	0.12
AST (0–40) U/L	42(73.7)↑	97.2(42.25,155.4)	145.83(102,280)	63.9(34.45,98.98)	<0.001
T-BIL (0–23) umol/L	6(10.5)↑	10.3(7.54,14.95)	14.55(10.3,19.4)	9.45(7.05,11.9)	0.003
D-BIL (0–8) umol/L	6(10.5)↑	6.3(4.1,10.7)	10.7(5.22,14.6)	5.4(3.28,6.85)	<0.001
BUN (3.6–9.5) mmol/L	9(15.8)↑	4.9(3.05,8.14)	8.5(5,10.7)	3.6(2.78,5.43)	<0.001
Cr (57–111) umol/L	10(17.5)↑	80(64.5,100.5)	99(81,131.2)	70.81(59.6,85.55)	<0.001
ALB (40–55) g/L	51(89.5)↓	33.01±5.9	28.29±4.6	36.2±4.36	<0.001
Globin (20–40) g/L	–	34.6±4.19	34.57±4.2	34.61±4.25	0.971
LDH (120–250) U/L	47(82.5)↑	365(251.5,572)	514(345,701.22)	303.5(223.75,398.5)	<0.001
A-HBDH (72–182) U/L	41(71.9)↑	252(178.1,375)	350(252,519)	189(159.25,293.75)	<0.001
CK (male:50–310, female:40–200) U/L	30(52.6)↑	247(73.38,526)	373(198,1356)	151(69.5,324)	0.016
CK-MB (0.001–24) U/L	14(24.6)↑	15(10.9,23.77)	18.04(12.39,37.9)	12.75(9.52,17.15)	0.01
K (3.2–5.2) mmol/L	16(28.1)↓	3.54±0.51	3.62±0.66	3.49±0.39	0.408
Na (137–147) mmol/L	50(87.7)↓	132.67±3.75	131.68±3.89	133.34±3.56	0.101
Cl (99–110) mmol/L	39(68.4)↓	96.57±5.33	95.9±7.25	97.02±3.55	0.496

present in 55 patients (96.5%). Among these, consolidation accompanied by ground-glass opacities was observed in 36 cases (63.2%). Only two patients presented with interstitial changes. Furthermore, pleural effusion was identified in 34 patients (59.6%).

Compared with the non-severe group, the severe group had a significantly higher incidence of pleural effusion, involvement of more than one lobe, and bilateral lung involvement. In contrast, the non-severe group had a higher proportion of patients with lesions confined to the unilateral right lung (Details are shown in [Figure 1](#) and [Table 4](#)).

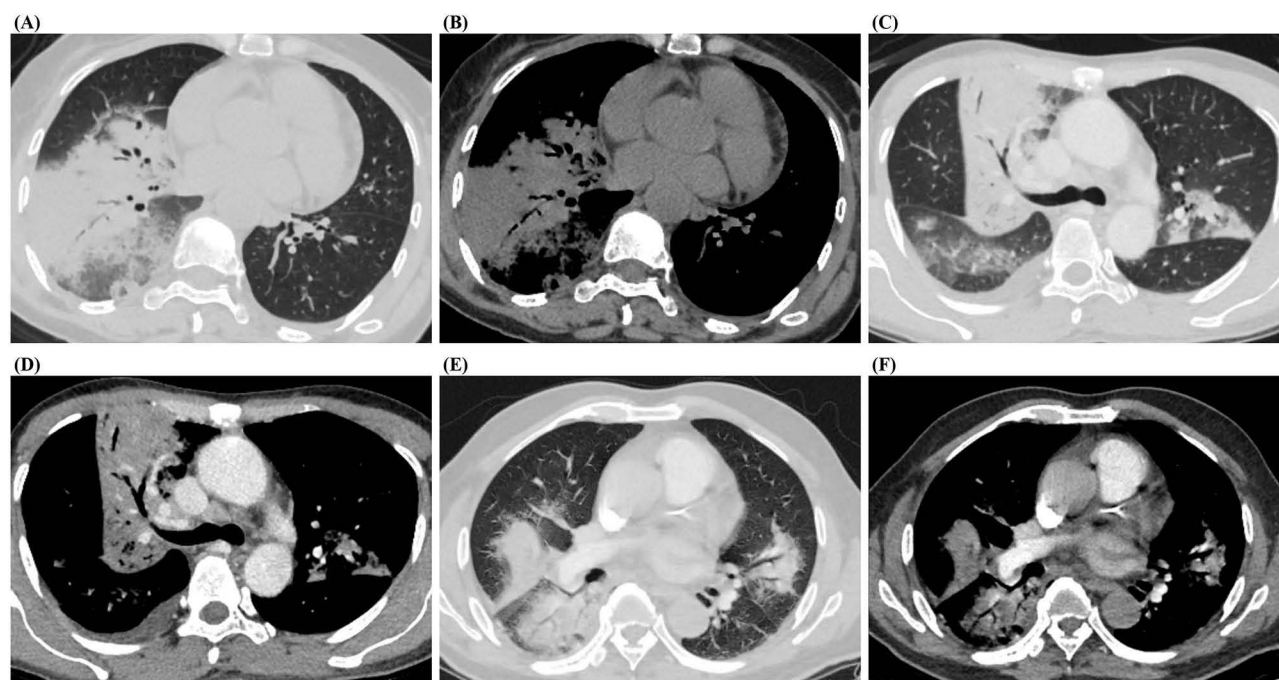


Figure 1 Image characteristics. Chest CT findings of a patient with unilateral lobar consolidation are shown in (A and B). Chest CT findings of a patient with consolidation +Ground-glass opacity and pleural effusion are shown in (C and D). Chest CT findings of a patient with multiple lobar consolidation are shown in (E and F).

Table 4 Imaging Findings of Patients with *C. psittaci* Pneumonia

Characteristics	Total (n=57)	Severe Pneumonia (n=23)	Non-Severe Pneumonia (n=34)	P value
Consolidation	55(96.5%)	23(100%)	32(94.1%)	0.51
Consolidation+Ground-glass opacity	36(63.2%)	18(78.3%)	18(52.9%)	0.052
Interstitial changes	2(3.5%)	0(0)	2(5.9%)	0.51
Pleural effusion	34(59.6%)	20(87%)	14(41.2%)	<0.001
Distribution				
Unilateral, left lung	11(19.3%)	3(13%)	8(23.5%)	0.497
Unilateral, right lung	26(45.6%)	5(21.7%)	21(61.8%)	<0.001
Bilateral lungs	20(35.1%)	15(65.2%)	5(14.7%)	0.003
Lobes involvement >1	35(61.4%)	22(95.7%)	13(38.2%)	<0.001
Lesions were mainly in the upper and middle lobes	21(36.8%)	6(26.1%)	15(44.1%)	0.166
Lesions were mainly in the lower lobe	36(63.2%)	17(73.9%)	19(55.9%)	0.166

NGS

All patients underwent testing via either mNGS or tNGS on bronchoalveolar lavage fluid (BALF) samples (n=52) or peripheral blood samples (n=5). Specifically, 31 patients (54.4%) were tested by mNGS and 26 patients (45.6%) by tNGS. *C. psittaci* DNA fragments was detected in all samples, with sequence reads ranging from 3 to 641,134. The number of *C. psittaci* sequence reads was significantly higher in the severe group compared to the non-severe group. Additionally, *Chlamydia abortus* was co-detected in 2 patients, and *Mycoplasma hominis* was co-detected in 1 patient.

Mixed infections were identified in 25 of the 57 patients (43.9%). Among these, co-detections of bacteria, fungi, and viruses were found in 16, 10, and 11 patients, respectively, with no significant differences in the rates of mixed infections between the severe and non-severe groups (Details in Table 5). *Streptococcus pneumoniae* and *Haemophilus influenzae* were the most commonly identified bacterial co-infections, while *Candida albicans* and Epstein-Barr virus were the most prevalent fungal and viral co-infections, respectively.

Treatment and Clinical Outcomes

During hospitalization, 47 out of the 57 patients (82.5%) received respiratory support. This included oxygen therapy (29, 50.9%), high-flow nasal cannula oxygen therapy (4, 7%), non-invasive mechanical ventilation (3, 5.3%), and invasive mechanical ventilation (11, 19.3%). Compared to the non-severe group, a significantly higher proportion of patients in the severe group required respiratory support modalities beyond simple oxygen therapy (78.3% vs 0%, $p < 0.001$).

Antimicrobial Therapy

All patients received empirical antibiotic therapy after admission. In the non-severe group, 23 patients (67.6%) were empirically treated with fluoroquinolones or tetracyclines; specifically, 15 received fluoroquinolones alone, and 8 received a combination of fluoroquinolones and tetracyclines. The remaining patients in this group received β -lactamase inhibitor combinations (n=6), cephalosporins (n=3), or a carbapenem (n=2). In the severe group, only 4 patients (17.4%) empirically

Table 5 NGS

Characteristics	Total (n=57)	Severe Pneumonia (n=23)	Non-Severe Pneumonia (n=34)	P value
Sequence number of <i>C. psittaci</i>	511(45,5019.5)	909(283,33,794)	214.5(33.25,2298.75)	0.031
Combine detection of other pathogens	25(43.9%)	12(52.2%)	13(38.2%)	0.298
Combine detection of bacteria	16(28.1%)	8(34.8%)	8(23.5%)	0.354
Combine detection of fungal	10(17.5%)	6(26.1%)	4(11.8%)	0.298
Combine detection of virus	11(19.3%)	3(13%)	8(23.5%)	0.521

Table 6 Risk Factors for Severe *C. psittaci* Pneumonia

Variables	Odds ratio	95% confidence Interval	P value
CRP	1.029	1.004–1.056	0.025
PLT	0.966	0.938–0.995	0.022
ALB	0.562	0.36–0.879	0.012

received fluoroquinolones. The others in this group received β -lactamase inhibitor combinations (n=11), carbapenems (n=7), or a cephalosporin (n=1). The proportion of patients receiving empirical antibiotics effective against *C. psittaci* was significantly higher in the non-severe group compared to the severe group (67.6% vs 17.4%, $P < 0.001$).

Following etiological confirmation by mNGS or tNGS, targeted anti-*C. psittaci* therapy was adjusted. In the non-severe group, 7 patients received fluoroquinolone monotherapy, 5 received tetracycline monotherapy, and 22 received combination therapy with fluoroquinolones and tetracyclines. Of the 15 patients in this group who had initially received empirical fluoroquinolones, 9 had a tetracycline added, 3 were switched to a tetracycline, and 3 continued fluoroquinolone monotherapy. In the severe group, 3 patients received fluoroquinolone monotherapy, 4 received doxycycline monotherapy, and 16 received combination therapy. All 4 patients in this group who had received empirical fluoroquinolones had a tetracycline added. There were no significant differences in the final targeted treatment regimens between the two groups (all $P > 0.05$).

The median time from hospital admission to diagnosis was 5(3, 5) days. After treatment, all patients in the non-severe group improved and were discharged. In the severe group, 3 patients died, 1 left the hospital without improvement, and 19 showed improvement and were discharged. The four patients with poor outcomes (death or non-improvement) were aged 74, 66, 67, and 73 years. All four had underlying comorbidities: one had a history of coronary heart disease, diabetes, and cerebral infarction; one had hypertension and diabetes; one had hypertension, diabetes, and cerebral infarction; and the other had a history of nasopharyngeal carcinoma and had undergone systemic chemotherapy one week before illness onset. The time from symptom onset to diagnosis for these four patients was 9, 24, 18, and 6 days, respectively. Crucially, none of them had received antibiotics effective against *C. psittaci* prior to diagnosis.

Risk Factors for Severe *C. psittaci* Pneumonia

Multivariate analysis identified CRP as an independent risk factor for severe *C. psittaci* pneumonia, while albumin and platelet count were identified as protective factors (Details are shown in Table 6).

The predictive value of CRP for severe disease was further evaluated using receiver operating characteristic (ROC) curve analysis, and its optimal clinical cut-off value was determined. The analysis revealed that CRP predicted severe disease with an area under the ROC curve (AUC) of 0.868 (95% confidence interval: 0.774–0.963, $P < 0.001$). The Youden index was maximized to identify an optimal cut-off value of 261.95, which yielded a sensitivity of 0.739 and a specificity of 0.912 (Details are shown in Figure 2).

Discussion

Chlamydia psittaci comprises 17 genotypes, each exhibiting varying host affinity and virulence. Genotypes A, B, and E/B can infect humans, with birds (particularly parrots and pigeons) being the most common host. Additionally, poultry (eg, chickens, ducks) and livestock (eg, cattle, horses, pigs) can also serve as hosts. Human infection occurs primarily through inhalation of aerosolized particles contaminated with urine, feces, feathers, or other excreta from infected animals.³ Furthermore, Zhang, Z. et al reported human-to-human transmission of psittacosis, occurring not only between index cases and close contacts but also extending to tertiary transmission.¹² Previous studies have indicated that psittacosis occurs more frequently in middle-aged and elderly adults, particularly males, with a peak incidence during the autumn and winter bird migration seasons. A clear history of avian exposure is reported in the majority of cases.^{13–16} Consistent with prior research, our study found that *C. psittaci* pneumonia occurred more often in the winter, with a mean patient age of 58.7 years. Specifically, 86% (49/57) of patients were ≥ 45 years old and 49% (28/57) were ≥ 60 years old, with a male predominance. However, unlike previous reports, only 35.1% of patients in our cohort had a traceable

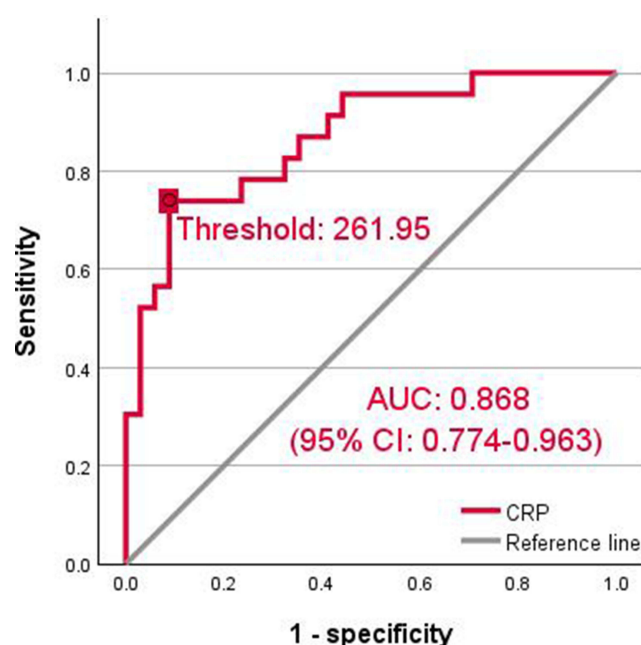


Figure 2 ROC curves of CRP predicted for the severe *C. psittaci* pneumonia.

exposure history, and merely 3 patients in the severe group had such a history. This discrepancy may be attributed to the retrospective nature of our study, potential recall bias due to the prolonged interval from symptom onset to admission, and the difficulty in obtaining comprehensive exposure histories from critically ill patients in the severe group. Alternatively, unidentified hosts or other transmission routes might exist. Therefore, further large-scale epidemiological studies are needed to clarify the transmission of *C. psittaci* pneumonia.

Comparative analysis of baseline data between the severe and non-severe groups in our study revealed that advanced age, male sex, and the presence of underlying comorbidities (particularly diabetes and cerebrovascular disease) were associated with progression to severe disease. Ni, Y. et al also identified male sex and age >65 years as risk factors for severe *C. psittaci* pneumonia.¹⁷ Consequently, heightened clinical vigilance is warranted when managing patients with these characteristics.

C. psittaci has two distinct developmental cycles: the elementary body and the reticulate body. The elementary body is the infectious form, existing extracellularly and possessing considerable resistance to environmental conditions, enabling survival outside the host. The reticulate body develops from the elementary body within the host cell cytoplasm and represents the replicative, metabolically active form.^{1,3} After entering the human body, *C. psittaci* initially replicates in respiratory epithelial cells and macrophages, subsequently disseminating systemically to affect various organs (eg, heart, liver, gastrointestinal tract), thereby causing diverse systemic symptoms. The incubation period is typically 5–14 days.¹⁸

Previous research has shown that human infection with *C. psittaci* primarily manifests as non-specific influenza-like symptoms (including fever, fatigue, myalgia, headache, diarrhea) and respiratory symptoms (cough, sputum, dyspnea).^{14,19,20} Compared to patients with non-*C. psittaci* pneumonia, those with *C. psittaci* pneumonia tend to have higher peak body temperatures and are more likely to experience extrapulmonary symptoms such as fatigue, myalgia, and diarrhea.²¹ Aligning with these earlier findings, our study confirmed high fever in all patients, followed commonly by cough, dyspnea, neurological symptoms, and fatigue.

We observed that patients in the severe group were more prone to extrapulmonary manifestations (particularly fatigue, neurological, and gastrointestinal symptoms), while respiratory symptoms like cough were relatively less common compared to the non-severe group. This may be related to the systemic multi-organ dysfunction induced by severe pneumonia. Notably, 78.3% of patients in the severe group presented with neurological symptoms. Four potential mechanisms have been proposed to explain this phenomenon: (1) direct invasion of the central nervous system

by *C. psittaci*; (2) autoimmune mechanisms; (3) embolic phenomena; and (4) electrolyte disturbances.^{22,23} Previous literature has reported the detection of *C. psittaci* in the cerebrospinal fluid of affected patients,^{23,24} supporting the plausibility of the first mechanism. In our study, the significantly higher number of *C. psittaci* sequence reads in the severe group compared to the non-severe group may indicate an increased risk of direct pathogen invasion into the central nervous system. Furthermore, markedly elevated D-dimer levels in severe patients may suggest the presence of embolic phenomena. Further research is required to elucidate the precise mechanisms underlying neurological involvement in *C. psittaci* pneumonia. Therefore, in clinical practice, pneumonia patients presenting with non-specific influenza-like symptoms, with or without respiratory symptoms, should raise suspicion for *C. psittaci* pneumonia. A careful history taking should include inquiries about potential exposure. Patients presenting predominantly with extrapulmonary manifestations, such as neurological or gastrointestinal symptoms, should be closely monitored for potential progression to severe disease, warranting prompt diagnosis and treatment.

Laboratory investigations revealed that the majority of patients (91.2%) had normal or mildly elevated WBC counts, but significantly elevated PCT, CRP, and ESR levels. These elevations, particularly for PCT and CRP, were more pronounced in the severe group. Conversely, lymphocyte counts were significantly decreased, with a more marked decrease observed in the severe group, potentially reflecting a heavier inflammatory burden and more severe immune impairment in severe cases. These findings are consistent with previous studies.^{25–28} Furthermore, most patients present with anemia, and although PLT counts were generally normal, the severe group had significantly lower counts than the non-severe group. When combined with the higher D-dimer levels in the severe group, this may be related to the invasion of the blood system by severe *C. psittaci* pneumonia. Biochemical analysis showed that most patients had elevated liver enzymes, myocardial enzymes, hypoalbuminemia, and electrolyte disturbances. In contrast, bilirubin, BUN, and Cr levels were mostly within the normal range, consistent with some prior reports.^{26,29} Notably, although most BUN, Cr, and bilirubin values were normal, the measured values in the severe group were significantly higher than those in the non-severe group. However, given the relatively small sample size of this study, the clinical significance of this finding requires further investigation. Thus, when a CAP patient presents with a normal or mildly elevated WBC count but markedly elevated other infection markers, coupled with anaemia, lymphocytopenia, hypoalbuminemia, and abnormalities in liver function, myocardial enzymes, and electrolytes (especially hyponatremia and hypochloremia), the possibility of *C. psittaci* infection should be considered.

Multivariate logistic regression analysis indicated that elevated CRP increased the risk of severe disease, while albumin and platelet count served as protective factors. Through further ROC curve analysis, this study established a CRP threshold exceeding 261.95 as a practical early warning indicator for the progression of *C. psittaci* pneumonia to severe disease, demonstrating high specificity (91.2%) and sensitivity (73.9%). Therefore, when a patient's CRP level exceeds this threshold, clinicians should maintain a high index of suspicion for potential progression to severe disease and implement timely interventions.

Albumin, a major plasma protein, plays a broad role in modulating inflammatory responses, maintaining effective immune responses against pathogens, preserving vascular endothelial integrity, and binding endogenous and exogenous compounds. During severe infection, albumin levels decline sharply due to reduced synthetic efficiency, increased catabolism, and enhanced capillary extravasation. This hypoalbuminemia exacerbates vascular leakage, promotes uncontrolled inflammation, and reduces the rate of effective response to antimicrobial therapy, thereby aggravating disease severity.³⁰ Consequently, the development of hypoalbuminemia at admission or during the disease course should raise clinical vigilance for potential progression to severe disease.

Platelets are primarily responsible for hemostasis and thrombosis, but they also participate in inflammatory and immune responses. In severe infection, thrombocytopenia may result from reduced platelet production due to bone marrow suppression. Concurrently, pathogens and excessive inflammatory responses can hyperactivate platelets, leading to the formation of immunothrombi. This physiological process helps contain pathogen dissemination and facilitates pathogen clearance but simultaneously consumes substantial quantities of platelets.³¹ Therefore, a lower platelet count in severely ill patients may indicate entry into this state of “inflammatory consumption.” Dynamic monitoring of platelet counts during clinical management may aid in the early identification of disease deterioration.

C. psittaci pneumonia initially incites a perivascular inflammatory response manifesting as interstitial changes on imaging, which rapidly progresses to involve the alveoli/pulmonary parenchyma, leading to widespread consolidation.³² Our study found that the primary imaging manifestations of *C. psittaci* pneumonia were consolidation with or without ground-glass opacities, and over half of the patients had pleural effusion. This aligns with previous reports.^{13,19,33–35} Yang, F. observed that early lesions in *C. psittaci* pneumonia primarily involved a single lobe of the right lung, progressing to bilateral involvement as the disease advanced.³⁶ Our study revealed that the majority (61.2%) of patients in the non-severe group had lesions confined to the unilateral right lung, whereas over 60% of patients in the severe group presented with bilateral lung involvement. Additionally, the incidence of pleural effusion was significantly higher in the severe group.

Traditional diagnostic methods for *C. psittaci* include culture, serological tests, and PCR. However, culture is time-consuming and requires Biosafety Level 3 laboratory facilities. Serological tests have limited sensitivity and specificity and typically require paired acute and convalescent serum samples, making them less suitable for early diagnosis. Real-time PCR offers good specificity and sensitivity but is not routinely available in most hospitals. mNGS employs high-throughput sequencing to comprehensively capture microbial nucleic acid sequences in a sample, which are then compared against existing databases for efficient and accurate pathogen detection. tNGS, on the other hand, involves enrichment and amplification of target nucleic acid sequences prior to high-throughput sequencing. Data analysis is generally simpler for tNGS compared to mNGS, making it potentially faster and more cost-effective.^{37,38} For complex and diagnostically challenging infections, or when considering rare or novel pathogens, mNGS is recommended for rapid pathogen identification. For patients with poor response to conventional therapy but having a specific suspected pathogen, the more economical tNGS can be utilized for etiological clarification.³⁹

In our study, 54.4% of patients were diagnosed via mNGS and 45.6% via tNGS. Following etiological confirmation and subsequent adjustment to targeted therapy, most patients improved and were discharged. Our study found that the number of *C. psittaci* sequence reads was significantly higher in the severe group than in the non-severe group, suggesting that a higher pathogen nucleic acid load may be associated with more severe clinical manifestations. Additionally, 43.9% of patients had co-detections of other pathogens. Similarly, Yuan, L. reported a 41.3% rate of mixed infection in *C. psittaci* pneumonia patients,⁴⁰ which might be associated with reduced pulmonary microbial diversity and alterations in the lower respiratory tract microbiome profile induced by chlamydial infection.⁴¹ However, Contrary to the findings of Yuan, L., who reported a significantly higher rate of mixed infection in the severe group compared to the non-severe group, our study observed that although the mixed infection rate was higher in the severe group than in the non-severe group (52.2% vs 38.2%), this difference did not reach statistical significance. This discrepancy may be attributed, on one hand, to the relatively small sample size of this study, particularly the limited number of patients in the severe group. On the other hand, all patients in this study received prompt empirical anti-infective therapy upon admission, and clinicians administered broader-spectrum anti-infective regimens (including β -lactamase inhibitor combinations and carbapenems) to patients in the severe group at a significantly higher rate than to those in the non-severe group (18/23, 78.3% vs 8/34, 23.5%, $P < 0.001$). This more aggressive empirical coverage may have reduced the microbial load of co-pathogens in the severe group. Therefore, further studies with larger sample sizes are warranted to elucidate the impact of co-infection on the prognosis of *C. psittaci* pneumonia.

Antimicrobial agents for treating *C. psittaci* pneumonia include tetracyclines, fluoroquinolones, and macrolides.^{8,42} A multicenter retrospective study by Yang, M. et al, which included 116 patients with *C. psittaci* pneumonia, found that treatment with fluoroquinolones was associated with shorter hospital stays and fever duration.⁴³ In contrast, another retrospective study of 122 patients reported shorter time to defervescence and higher treatment efficacy with tetracyclines compared to fluoroquinolones.¹⁷ Xu, L. observed that most patients with mild *C. psittaci* pneumonia responded well to fluoroquinolone monotherapy, whereas the response was poorer in severe patients treated with fluoroquinolone monotherapy.¹³ In our study, prior to definitive diagnosis, 67.6% of patients in the non-severe group received empirical fluoroquinolones or tetracyclines, compared to only 17.4% in the severe group. This difference in the use of effective empirical anti-*C. psittaci* antibiotics might be a significant factor preventing the non-severe group from progressing to severe disease. After diagnosis, most patients received combination therapy. With timely treatment, only four severe patients had poor outcomes (death or no improvement). These findings suggest that, for hospitalized patients with

clinically atypical pneumonia, particularly severe cases, empirical use of fluoroquinolones or tetracyclines to cover atypical pathogens should be considered prior to pathogen identification to prevent further disease progression. Following a confirmed diagnosis of *C. psittaci* pneumonia, timely combination therapy with fluoroquinolones and tetracyclines generally yields a favorable prognosis.

The non-specific clinical symptoms of *C. psittaci* pneumonia, the limitations of conventional diagnostic methods, and the high mortality rate associated with delayed treatment collectively underscore its challenge as a neglected zoonotic disease. Grounded in the “One Health” concept, effective prevention and control of this disease require strategies that extend beyond the scope of clinical diagnosis and treatment. A collaborative system integrating human medicine, animal health, and environmental sectors is essential. This includes strengthening surveillance of avian reservoirs and the environment, enhancing clinician awareness and diagnostic capacity (such as reasonable application of mNGS or tNGS), and promoting data sharing. Through such a cross-sectoral, integrated approach, comprehensive management of psittacosis—from its source to clinical care—can be achieved, ultimately reducing its disease burden.⁴⁴

This study has several limitations. First, its retrospective, single-center design with a relatively small sample size may introduce selection bias. Second, all diagnoses were confirmed by mNGS or tNGS without validation by other methods such as culture, PCR, or serology. Third, some patients had co-infections with other pathogens, which could potentially confound the results. Fourth, as some patients empirically received antibiotics effective against *C. psittaci* and treatment regimens were adjusted post-diagnosis based on clinical judgment, a comparative analysis of the efficacy of different drug regimens was not performed. Therefore, future larger-scale prospective studies are warranted.

Conclusion

In summary, pneumonia patients presenting with non-specific influenza-like symptoms, with or without respiratory symptoms, should raise clinical suspicion for *C. psittaci* pneumonia. Particular vigilance for potential progression to severe disease is warranted in male patients, the elderly, those with underlying comorbidities, and individuals presenting predominantly with extrapulmonary manifestations such as neurological or gastrointestinal symptoms. CRP is an independent risk factor for severe *C. psittaci* pneumonia, while ALB and PLT count are protective factors. With rapid diagnosis facilitated by mNGS or tNGS and timely appropriate treatment, the prognosis is generally favorable.

Ethics Approval and Informed Consent

We certify that the study was performed in accordance with the Declaration of Helsinki. This study was approved by the Ethics Committee of the First Affiliated Hospital of Guilin Medical University (NO.2025IITLL-89). The Ethics Committee of the First Affiliated Hospital of Guilin Medical University approved our study also waived informed consent because this study was retrospective, all information was anonymous, and there was no risk to the subjects.

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Disclosure

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