Research on the Relationship Between Imaging Characteristics Changes of Pulmonary Infections in Patients with Hypo-immunity and NLR, PCT Levels and Their Severity

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Abstract: *Objective:* To explore the imaging characteristics changes of pulmonary infections in patients with hypo-immunity and analyze the correlation between NLR, PCT levels and their severity. *Methods:* This study included 80 patients with hypo-immunity and pulmonary infections who were diagnosed and treated at our hospital from October 2022 to October 2024. Imaging examinations were performed on the patients. Subsequently, the patients were divided into a severe group and a mild group based on the severity of their disease. Univariate analysis was conducted, and variables with statistical significance from the univariate analysis were included in a multivariate logistic regression analysis to clarify the correlation between plasma NLR, PCT levels, and their severity. *Results:* Imaging examinations revealed that ground-glass opacities in the lungs were centered around the hilum, with patchy or map-like distributions accompanied by reticular shadows. The affected areas and normal lung areas were interspersed, with a tendency to merge. Some patients also developed pneumothorax. Ground-glass opacities were the most characteristic manifestation, which could also present as reticular shadows, interstitial thickening, miliary shadows, multiple small nodules, intrathoracic lymphadenopathy, and a small amount of pleural effusion. In the correlation analysis, NLR and PCT were statistically significant in the univariate analysis ($p < 0.05$). When included in the multivariate logistic regression analysis, NLR (OR = 2.846, 95% CI: 2.402–3.358) and PCT (OR = 1.958, 95% CI: 1.554–2.601) were found to be positively correlated with the severity of pulmonary infections in patients with hypo-immunity. *Conclusion:* The imaging manifestations of patients with impaired immune function are complex and diverse, primarily including patchy, linear, massive, cavitary, and diffuse lesions, among other forms. These manifestations not only assist physicians in identifying the presence of pulmonary infections but also provide crucial information for diagnosing the type, severity, and complications of the infections. The levels of NLR (Neutrophil-to-Lymphocyte Ratio) and PCT (Procalcitonin) exhibit a positive correlation with the severity of pulmonary infections in patients with impaired immune function, warranting significant attention.

Keywords: Impaired immune function; Pulmonary infection; Imaging characteristics; Disease severity; Correlation

1. Introduction

Patients with impaired immune function experience damage to their immune barriers, leading to certain differences in the clinical manifestations and imaging characteristics of pulmonary infections [1]. Generally, after the onset of pulmonary infection, the pathogen spectrum is broad, and the infection process may exhibit atypical disease manifestations due to abnormal host immune status. Consequently, clinical diagnosis poses significant challenges and may result in delayed treatment, substantially increasing the risk of infection. Some studies have directly pointed out that, compared to individuals with normal immune function, patients with impaired immune function experience a significantly higher mortality rate following pulmonary infection [2]. This is particularly true in cases of multidrug-resistant bacterial infections, where the disease progresses rapidly, severely compromising patient prognosis [3]. Following neutropenia, the reduction in neutrophils weakens the inflammatory response. The Neutrophil-to-Lymphocyte Ratio (NLR), as a biomarker of systemic inflammatory response, holds significant value in infectious diseases [4]. An elevated NLR reflects the dual mechanism of an absolute increase in neutrophils and an absolute decrease in lymphocytes. Procalcitonin (PCT) is a specific marker of bacterial infection, with its levels positively correlating with the severity of infection [5]. However, in patients with impaired immune function, PCT levels are typically directly related to bacterial infection, particularly in neutropenic patients, where dynamic changes in PCT hold substantial reference value for guiding antibiotic therapy [6]. Based on this, this study included 80 patients with impaired immune function complicated by pulmonary infection who were diagnosed and treated at our hospital from October 2022 to October 2024. It aimed to explore the imaging characteristic changes of pulmonary infections in patients with impaired immune function and the correlation between NLR, PCT levels, and their severity.

2. Materials and methods

2.1. General information

Eighty patients with immunodeficiency complicated by pulmonary infection who were treated in our hospital from October 2022 to October 2024 were selected and divided into a severe group and a mild group based on the severity of their conditions.

2.1.1. Inclusion criteria

(1) Meeting the diagnostic criteria outlined in the "Chinese Guidelines for the Diagnosis and Treatment of Community-Acquired Pneumonia in Adults (2016 Edition)"
(2) Aged ≥ 18 years
(3) High compliance with treatment and follow-up
(4) Patients and their family members signed informed consent forms, indicating their voluntary participation in this study

2.1.2. Exclusion criteria

(1) Simple infection with special pathogens
(2) Simple pulmonary fungal disease
(3) Non-infectious diseases
(4) Contraindications to bronchoscopy

2.2. Methods

2.2.1. Imaging examination

Patients were examined using CT, with the following specific steps

(1) Pre-examination preparation

Evaluate the patient's symptoms, have the patient remove their upper garments and any metallic objects to reduce metallic artifacts. Instruct the patient to practice holding their breath after deep inhalation to minimize respiratory motion artifacts

(2) CT scan parameter settings

The scan range extends from the apex of the lung to the base, covering the entire lung field, including the costophrenic angles. Routine CT scans are performed with a slice thickness of 5 mm, tube voltage of 120 kVp, matrix of 512×512, and FOV of 350 mm

(3) Scan procedure

The patient lies in a supine position with their shoulders lowered and head advanced to ensure consistent scan orientation. An anterior-posterior scout view is obtained to determine the scan range and angle. The patient is prompted to hold their breath after deep inhalation 3 seconds before scanning, and to continue holding their breath during the scan. After scanning, coronal and sagittal reconstructions are performed to aid in observing the distribution of lesions.

2.2.2. Correlation analysis

In this study, the severity of the patient's condition was selected as the dependent variable, while general patient information and laboratory indicators were chosen as independent variables. General information includes the patient's gender, age, presence of respiratory failure, onset time, and history of underlying diseases. Laboratory indicators include white blood cell count (WBC), C-reactive protein (CRP), procalcitonin (PCT), and the neutrophil-to-lymphocyte ratio (NLR).

2.3. Statistical methods

Statistical analysis was performed using SPSS 24.00 software. Count data were analyzed using the chi-square test and expressed as n (%), while measurement data were analyzed using the t-test and expressed as (mean ± standard deviation). A p-value of less than 0.05 was considered statistically significant. For univariate analysis, ANOVA was used, while multivariate analysis employed stepwise linear regression. The significance level (α) was set at 0.05, and a p-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Analysis of patient imaging results

Imaging analysis revealed that patients with compromised immune function exhibited complex imaging manifestations, including patchy, linear, mass-like, cavitary, and diffuse lesions, among others. These findings are helpful for identifying pulmonary infections, as shown in **Figure 1**.
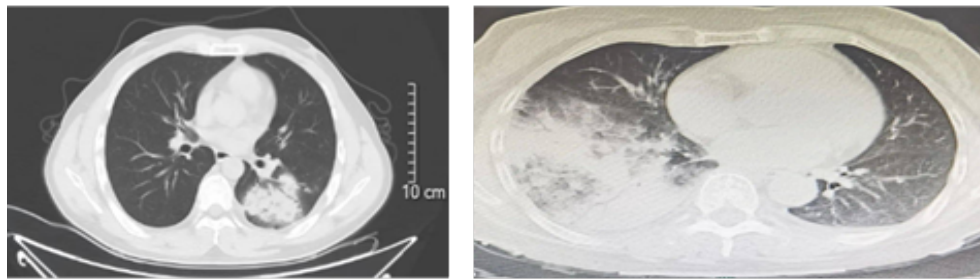
Figure 1. Analysis of patient imaging results.

3.2. Univariate analysis of NLR, PCT levels, and disease severity

The study results indicated that the severe group included 34 patients, while the mild group included 46 patients. NLR and PCT levels showed statistically significant differences in the univariate analysis ($p < 0.05$), while other variables did not show statistical significance in the data comparison ($p > 0.05$). Specific data are shown in **Table 1**.

Table 1. Univariate analysis of NLR, PCT levels, and disease severity

Variable	Category	Severe group (n = 34)	Mild group (n = 46)	χ^2/t	p-value
Gender (%)	Male (n = 42)	18 (52.94)	24 (52.17)	0.005	0.946
	Female (n = 38)	16 (47.06)	22 (47.83)		
Age (years)	Mean Age	67.29 ± 8.49	66.98 ± 8.35	0.163	0.871
Respiratory failure	Yes (n = 16)	7 (20.59)	9 (19.57)	0.013	0.910
	No (n = 64)	27 (79.41)	37 (80.43)		
Time of onset (h)	Mean	8.53 ± 1.28	8.49 ± 1.22	0.142	0.888
Medical history	Yes (n=47)	19 (55.88)	28 (60.87)	0.201	0.654
	No (n = 33)	15 (44.12)	18 (39.13)		
WBC (10^9/L)	Mean	8.27 ± 2.15	8.09 ± 2.21	0.364	0.717
CRP (mg/L)	Mean	49.29 ± 7.53	48.89 ± 7.43	0.237	0.814
PCT (ng/ml)	Mean	0.31 ± 0.06	0.15 ± 0.03	15.654	< 0.001
NLR	Mean	4.58 ± 0.82	4.03 ± 0.64	3.370	0.001

3.3. Multifactorial logistic regression analysis

The study results revealed a positive correlation between NLR (OR = 2.846, 95% CI: 2.402–3.358), PCT (OR = 1.958, 95% CI: 1.554–2.601), and the severity of pulmonary infections in patients with compromised immune function. Specific data are presented in **Table 2**.

Table 2. Multifactorial analysis of NLR and PCT levels and their correlation with disease severity

Variable	β	S.E.	p-value	OR	95% CI
NLR	0.96	0.99	< 0.05	2.846	2.402–3.358
PCT	0.84	0.86	< 0.05	1.958	1.554–2.601

4. Discussion

Pulmonary infections in patients with compromised immune function exhibit certain imaging differences under various infection modalities, with imaging characteristics closely related to the type of pathogen causing the infection [7]. In bacterial infections, the main imaging manifestation is segmental consolidation, which may be accompanied by small abscesses. In fungal infections, typical imaging findings include nodules with a halo sign and crescentic air sign, reflecting vascular invasive lesions [8]. In viral infections, the primary imaging manifestation is diffuse bilateral ground-glass opacities. NLR primarily reflects systemic inflammatory responses and immune balance, with its level changes closely related to the severity of pulmonary infections. In patients with pulmonary infections, neutrophils are extensively activated and accumulate at the site of infection, leading to a significant increase in neutrophil count in peripheral blood [9]. Additionally, lymphocyte function is suppressed, elevating the NLR ratio. Relevant studies indicate that an elevated NLR suggests severe infection, necessitating anti-infective treatment. PCT is a sensitive marker for bacterial infections, with its level changes reflecting the severity and prognosis of the infection. Following bacterial infections, extrathyroidal tissues are stimulated by inflammatory factors to synthesize large amounts of PCT, resulting in a significant increase in blood concentration. In contrast, after viral infections, PCT levels remain unchanged or slightly elevated [10].

Based on this, the present study selected 80 patients with compromised immune function and concurrent pulmonary infections who were diagnosed and treated at our hospital from October 2022 to October 2024. Imaging analysis revealed complex and diverse imaging manifestations in patients with compromised immune function, including patchy, linear, mass-like, cavitary, and diffuse lesions, among others. It provides new ideas for clinical decision-making. In the correlation analysis, it was found that NLR (Neutrophil-to-Lymphocyte Ratio) and PCT (Procalcitonin) exhibited a positive correlation with the severity of pulmonary infections in patients with immunodeficiency. In other words, as NLR and PCT levels increase, the severity of the condition tends to worsen.

5. Conclusion

In summary, this study delves into the imaging characteristic changes of pulmonary infections in patients with immunodeficiency and the relationship between NLR, PCT levels, and the severity of these infections. It not only enhances our understanding of pulmonary infections in this patient group but also offers new insights and methods for clinical diagnosis and treatment. In the future, research in this field will continue to be deepened to explore more precise and effective diagnostic and therapeutic strategies, making greater contributions to improving the prognosis and quality of life of patients with immunodeficiency. With the continuous advancement of research and technology, the diagnostic and therapeutic level for pulmonary infections in patients with immunodeficiency will see significant improvements, bringing hope to more patients.

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Disclosure statement

The authors declare no conflict of interest.

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