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Expression and Diagnostic Value of D-Dimer, CRP, and IL-6 in Children with *Mycoplasma* Pneumonia

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Abstract: *Objective:* To investigate the expression and diagnostic value of D-dimer, CRP, and IL-6 in children with *Mycoplasma* pneumonia. *Methods:* A total of 100 children diagnosed with *Mycoplasma* pneumonia from the pediatric department of the First Affiliated Hospital of Shaoyang University, admitted between November 2023 and June 2024, were selected for the study. According to the severity of the condition, they were divided into two groups: a mild group (50 cases) and a severe group (50 cases). After treatment, they were further divided into an effective group (63 cases) and a non-effective group (37 cases) based on the treatment outcomes, to compare their diagnostic values. *Results:* The levels of D-dimer, CRP, IL-6, length of hospital stay, fever resolution time, cough resolution time, and the time for lung rales to disappear were higher in the severe group than in the mild group ($P < 0.05$). The levels of D-dimer, CRP, and IL-6 in the non-effective group were higher than those in the effective group ($P < 0.05$). In this study, using pathological results as the "gold standard," it was found that the positive detection rate for the combined detection of D-dimer, CRP, and IL-6 was higher than the detection rate for each of D-dimer, CRP, and IL-6 alone, suggesting that the combined diagnosis had a higher positive detection rate ($P < 0.05$). Compared with D-dimer, CRP, and IL-6, the combined sensitivity, specificity, and accuracy were all higher ($P < 0.05$). *Conclusion:* D-dimer, CRP, and IL-6 are closely related to *Mycoplasma* pneumonia in children and can serve as auxiliary diagnostic tools for *Mycoplasma* pneumonia in children, offering significant value.

Keywords: *Mycoplasma* pneumonia in children; D-dimer; CRP; IL-6

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1. Introduction

Mycoplasma pneumoniae pneumonia (MPP) primarily affects children and adolescents. The pathogenesis of this disease is complex, and it is widely believed that it is closely related to immune responses triggered by inflammatory mediators [1]. In pediatric MPP cases, in addition to lung damage, damage to multiple systems such as the skin, digestive system, and central nervous system can also occur. Therefore, early identification and

targeted treatment of MPP are of crucial importance in reducing the risk of complications in affected children [2]. C-reactive protein (CRP), as an acute-phase protein, plays a key role in the progression of many diseases, and its levels gradually increase during inflammatory responses [3]. Interleukin-6 (IL-6), as a key cytokine, is a significant marker for diagnosing MPP and helps clinicians better understand the infection status. D-dimer, a unique fibrin degradation product, is generated through the interaction of fibrin monomers and activators and is considered a specific marker of the fibrinolytic system [4]. Based on this, this study investigates the expression and diagnostic value of D-dimer, CRP, and IL-6 in children with MPP.

2. Materials and methods

2.1. General information

A total of 100 children diagnosed with MPP at the First Affiliated Hospital of Shaoyang University were selected as the research subjects. Based on the severity of the condition, they were divided into a mild group (50 cases) and a severe group (50 cases). Among them, the mild group consisted of 31 boys and 19 girls, with an average age of (6.63 ± 3.11) years; the severe group consisted of 23 boys and 27 girls, with an average age of (7.06 ± 2.97) years. The general data of both groups were balanced and comparable ($P > 0.05$).

Inclusion criteria:

(1) Mild group: Children with symptoms such as fever and cough, clinically diagnosed according to the MPP diagnostic criteria in the 8th edition of Practical Pediatrics by Chu Futang, and who did not meet the criteria for severe community-acquired pneumonia in children [5]. Additionally, the children had not received treatment for MPP before admission.

(2) Severe group: Children with symptoms such as fever and cough, clinically diagnosed according to the MPP diagnostic criteria in the 8th edition of Practical Pediatrics by Chu Futang, and who had not received treatment for MPP before admission. They met any of the following criteria:

(a) Persistent high fever (above 39°C) for ≥ 5 days or fever for ≥ 7 days, with no decreasing trend in the peak temperature.

(b) The appearance of wheezing, shortness of breath, difficulty breathing, chest pain, hemoptysis, etc. These symptoms were associated with severe lesions, complicating bronchitis, asthma exacerbation, pleural effusion, or pulmonary embolism.

(c) The occurrence of extra-pulmonary complications, but without meeting critical illness criteria.

(d) Oxygen saturation ≤ 0.93% during rest while inhaling air.

(e) Radiological findings, one of the following:

(i) More than 2/3 of a single lung lobe involved, with uniform high-density consolidation or involvement of two or more lung lobes with high-density consolidation (regardless of the area affected), possibly accompanied by moderate to large pleural effusion or localized bronchiolitis.

(ii) Diffuse involvement of a single lung or ≥4/5 of bilateral lung lobes with bronchiolar involvement.

Exclusion criteria: (1) Children in the recovery phase of MPP; (2) those with previous chronic pulmonary diseases; (3) children with congenital or secondary immunodeficiency diseases or connective tissue diseases, etc.

2.2. Methods

Monitoring methods: Blood samples of 3 mL of fasting venous blood were collected on the 2nd day of admission and the day before discharge from both the mild and severe groups. The blood was centrifuged, and the serum

was stored in a low-temperature refrigerator (4–8°C). CRP levels were detected using the AU5800 fully automatic biochemical analyzer (Beckman, USA), employing the turbidimetric immunoassay method. D-dimer levels were measured using the Sysmex CS-5100 fully automatic coagulation analyzer (Sysmex, Japan), using the immunoturbidimetric method. IL-6 levels were measured using the BD FACSCanto II detector (BD, USA), employing the multiplex bead-based immunofluorescent assay method. All tests were strictly performed according to the manufacturer's instructions.

2.3. Observation indicators

2.3.1. Comparison of D-dimer, CRP, and IL-6 levels between the two groups

D-dimer, CRP, and IL-6 levels in the two groups of children were compared and analyzed by professional medical staff.

2.3.2. Comparison of related indicators between the two groups

Hospital stay duration, fever resolution time, cough resolution time, and lung rales disappearance time were compared and analyzed by professional medical staff.

2.3.3. Efficacy analysis of D-dimer, CRP, and IL-6 levels in the two groups

D-dimer, CRP, and IL-6 levels in the two groups were compared and analyzed according to different clinical efficacy by professional medical staff.

2.3.4. Comparison of D-dimer, CRP, and IL-6 with "gold standard" testing

D-dimer, CRP, and IL-6 tests were performed on all subjects, and statistical analysis of the resulting data was conducted using the following formulas:

$$Positive\ predictive\ value = \frac{a}{a+b} \times 100\%$$

$$Negative\ predictive\ value = \frac{d}{c+d} \times 100\%$$

Where: a = true positive; b = false positive; c = false negative; d = true negative.

2.3.5. ROC curve analysis of D-dimer, CRP, IL-6, and combined tests for the diagnostic value of MPP in children

The sensitivity, specificity, and accuracy of four testing methods for diagnosing MPP in children were compared.

$$Sensitivity = \frac{a}{a+c} \times 100\%$$

$$Specificity = \frac{d}{d+b} \times 100\%$$

$$Accuracy = \frac{a+d}{total\ number\ of\ cases} \times 100\%$$

2.4. Statistical processing

Data processing was performed using SPSS 26.0 statistical software. Measurement data were expressed as mean ± standard deviation (SD). For group comparisons, *t*-tests were used. Count data were expressed as [*n* (%)], and χ^2

tests were used for group comparisons. A P value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of D-dimer, CRP, and IL-6 levels between the two groups

As shown in **Table 1**, the levels of D-dimer, CRP, and IL-6 in the severe group were higher than those in the mild group, with significant differences ($P < 0.05$).

Table 1. Comparison of D-dimer, CRP, and IL-6 levels between the two groups (mean ± SD)

Group	*n*	CRP (mg/L)			D-dimer (mg/L)			IL-6 (pg/mL)		
		Admission	Discharge	Difference	Admission	Discharge	Difference	Admission	Discharge	Difference
Mild group	50	9.78 ± 1.56	1.30 ± 0.36	8.48 ± 1.20	0.44 ± 0.09	0.26 ± 0.07	0.18 ± 0.02	1.54 ± 1.02	5.13 ± 0.89	3.34 ± 0.13
Severe group	50	25.75 ± 2.39	1.35 ± 0.68	24.40 ± 1.71	0.62 ± 0.15	0.27 ± 0.12	0.35 ± 0.03	2.48 ± 1.15	14.35 ± 1.65	9.33 ± 0.50
t		39.570	0.459	53.890	7.276	0.509	33.340	4.323	34.780	21.035
P		0.001	0.646	0.001	0.001	0.611	0.001	0.001	0.001	0.001

3.2. Comparison of related indicators between the two groups

As shown in **Table 2**, the hospital stay, fever resolution time, cough resolution time, and lung rales disappearance time in the severe group were higher than those in the mild group, with significant differences ($P < 0.05$).

Table 2. Comparison of related indicators between the two groups (mean ± SD, days)

Group	*n*	Hospital stay	Fever resolution time	Cough resolution time	Lung rales disappearance time
Mild group	50	6.00 ± 0.65	3.00 ± 0.36	4.00 ± 0.68	5.00 ± 0.41
Severe group	50	7.00 ± 0.78	4.00 ± 0.40	5.00 ± 0.77	6.00 ± 0.63
t		6.964	13.140	6.883	9.407
P		0.001	0.001	0.001	0.001

3.3. Efficacy analysis of D-dimer, CRP, and IL-6 levels in the two groups

As shown in **Table 3**, the levels of D-dimer, CRP, and IL-6 in the non-effective group were higher than those in the effective group, with significant differences ($P < 0.05$).

Table 3. Efficacy analysis of D-dimer, CRP, and IL-6 levels in the two groups (mean ± SD)

Group	n	CRP (mg/L)			D-dimer (mg/L)			IL-6 (pg/mL)		
		Admission	Discharge	Difference	Admission	Discharge	Difference	Admission	Discharge	Difference
Effective	63	13.19 ± 2.36	1.20 ± 0.39	12.50 ± 1.97	0.51 ± 0.29	0.22 ± 0.36	0.26 ± 0.07	1.98 ± 1.01	5.59 ± 2.39	3.46 ± 1.38
Non-effective	37	25.96 ± 3.26	1.50 ± 1.02	21.79 ± 2.24	0.57 ± 0.39	0.30 ± 0.41	0.26 ± 0.02	2.56 ± 1.13	22.73 ± 5.69	19.03 ± 4.56
t		22.620	2.094	21.630	0.877	1.019	0.001	2.653	21.010	25.280
P		0.001	0.038	0.001	0.382	0.310	0.925	0.009	0.001	0.001

3.4. Comparison of D-Dimer, CRP, IL-6 with "gold standard" testing

As shown in **Table 4**, using pathological results as the "gold standard," it was found that the number of positive cases for combined testing of D-dimer, CRP, and IL-6 was higher than that for each individual test, indicating a higher positive detection rate for the combined diagnostic approach, with significant differences ($P < 0.05$).

Table 4. Comparison of D-dimer, CRP, IL-6 with "gold standard" testing

Gold Standard	D-Dimer		Total	CRP		Total	IL-6		Total	Combined Testing		Total
	Positive	Negative		Positive	Negative		Positive	Negative		Positive	Negative	
Positive	47	3	50	43	7	50	45	5	50	49	1	50
Negative	6	44	50	9	41	50	7	43	50	2	48	50
Total	53	47	100	52	48	100	52	48	100	51	49	100

3.5. ROC curve analysis of D-dimer, CRP, IL-6, and combined testing for the diagnostic value of MPP in Children

As shown in **Table 5** and **Figure 1**, compared to D-dimer, CRP, and IL-6, the combined test exhibited higher sensitivity, specificity, and accuracy, with significant differences ($P < 0.05$).

Table 5. ROC curve analysis of D-dimer, CRP, IL-6, and combined testing for the diagnostic value of MPP in children

Examination method	AUC value	*Z* value	*P* value	Sensitivity (%)	Specificity (%)	Accuracy (%)	95% CI
D-dimer	0.516	2.548	0.001	88.67	93.61	91.00	0.524–0.952
CRP	0.541	2.412	0.001	82.69	85.41	84.00	0.512–0.912
IL-6	0.462	2.105	0.001	86.53	89.58	88.00	0.457–0.847
Combined detection	0.526	2.841	0.001	96.07	97.95	97.00	0.502–0.881

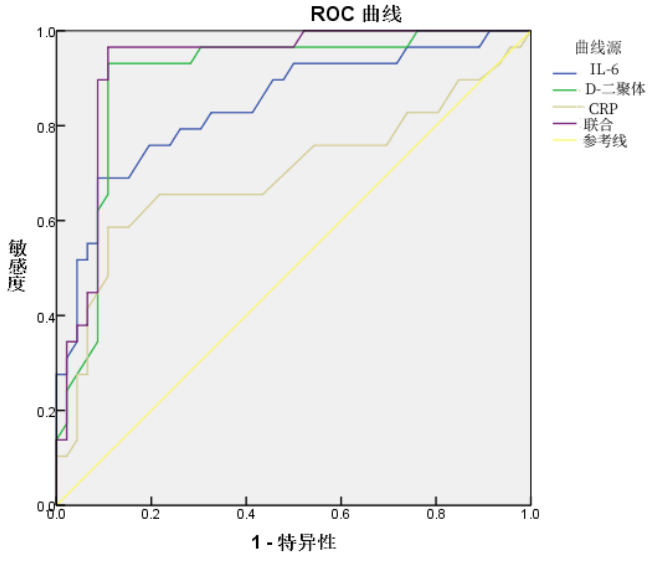

Figure 1. ROC curve analysis of D-dimer, CRP, IL-6, and combined testing for the diagnostic value of MPP in children

4. Discussion

MPP is a common disease in children during the autumn, with symptoms including fever, cough, and sore throat. Due to the lack of etiology-based diagnosis, there is a tendency to overuse antibiotics when treating bacterial and atypical pathogen mixed infections. Therefore, early etiological diagnosis and the development of treatment plans based on biomarkers are crucial for treatment and prognosis [6,7]. MPP is related to immunological characteristics and inflammatory factors, and finding serological markers is important for diagnosis and prognosis [8].

CRP is an inflammatory marker that increases in serum during bacterial infections, activates the complement system, and releases inflammatory mediators. It is a marker of infection or tissue damage [9,10]. CRP levels are associated with the progression of MPP. IL-6 is an inflammatory factor, highly expressed in critically ill patients, and regulates the inflammatory response. D-dimer reflects hypercoagulability and endothelial dysfunction [11]. The results of this study show that the levels of D-dimer, CRP, and IL-6 were higher in the severe group, indicating that children in the severe group had more severe infections, stronger pathogen invasiveness, and more intense inflammatory responses. This led to impaired immune function, reduced ability to clear inflammatory factors, and a sustained inflammatory response, resulting in elevated levels of D-dimer, CRP, and IL-6. The study also found that the severe group had longer hospitalization times, fever resolution times, cough resolution times, and lung rales disappearance times. Additionally, in the non-effective group, D-dimer, CRP, and IL-6 levels were higher, indicating that children in the severe group required more prolonged treatment and observation, with more severe lung inflammation. The weakened cough reflex led to prolonged cough resolution times and slower disappearance of lung rales, which extended the fever resolution time. Children in the non-effective group faced more severe pathogen invasion, leading to more intense inflammatory responses and reduced ability to clear pathogens, thereby sustaining the inflammatory response and increasing D-dimer, CRP, and IL-6 levels.

Clinical investigations show that D-dimer, CRP, and IL-6 have high diagnostic value in pediatric MPP, and they are expected to provide strong support for early diagnosis and treatment [12]. In this study, using pathological results as the “gold standard,” it was found that D-dimer testing had 47 true positives and 6 true negatives, CRP testing had 43 true positives and 9 true negatives, and IL-6 testing had 45 true positives and 7 true negatives. The combined testing of the three had 49 true positives and 2 true negatives. This indicates that the combined testing of the three is more effective than single tests of D-dimer, CRP, or IL-6, with detection rates similar to the “gold standard.” D-dimer showed a sensitivity of 88.67%, specificity of 93.61%, and accuracy of 91.00%. CRP testing had a sensitivity of 82.69%, specificity of 85.41%, and accuracy of 84.00%. IL-6 testing had a sensitivity of 86.53%, specificity of 89.58%, and accuracy of 88.00%. Combined testing of all three showed a sensitivity of 96.07%, specificity of 97.95%, and accuracy of 97.00%. These results show that the combined test offers higher sensitivity, specificity, and accuracy compared to single tests. ROC curve analysis indicates that using the combined test provides superior diagnostic performance for pediatric MPP, making it a better tool for diagnosis and offering better clinical support. It is worth further promoting and applying.

5. Conclusion

In conclusion, D-dimer, CRP, and IL-6 have high predictive value for pediatric *Mycoplasma* pneumonia and are worthy of clinical promotion and use.

Disclosure statement

The authors declare no conflict of interest.

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