Identify clinical factors related to Mycoplasma pneumoniae pneumonia with hypoxia in children

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Abstract

Background: Analyze the clinical characteristics of Mycoplasma pneumoniae pneumonia with hypoxia in children, and identify the related factors of hypoxia in MPP.

Methods: A retrospective case-control study was performed on 345 children with Mycoplasma pneumoniae pneumonia (MPP) hospitalized in our hospital from January 2017 to June 2019. The clinical features, laboratory data and radiological findings were compared between the MPP with hypoxia, refractory Mycoplasma pneumoniae pneumonia (RMPP) and general Mycoplasma pneumoniae pneumonia (GMPP) groups.

Results: MPP with hypoxia patients (n=69) had a higher incidence of extra-pulmonary complications and more serious radiological findings (P<0.05), besides the days of fever and in the hospitals were longer. And they also need more complicated treatments (P<0.05). Meanwhile, the levels of white blood cell count (WBC), C-reactive protein (CRP), lactic dehydrogenase (LDH), interleukin (IL)-6, ferritin, D-dimer, fibrinogen (FG), alanine aminotransferase (ALT) and the percentage of neutrophils in the MPP with hypoxia group were significantly higher than those in the RMPP group and the GMPP group (P<0.05). In ROC curve analysis, the percentage of neutrophils, WBC, CRP, LDH, IL-6, ferritin, D-dimer, and ALT were contributed to identify MPP with hypoxia patients. Multivariate logistic regression analysis showed that ferritin>174.15 ng/mL, IL-6>25.475pg/ml and pleural effusion had important effects on hypoxia in MPP (P<0.01).

Conclusion: MPP with hypoxia patients presented more serious clinical manifestations. Ferritin>174.15 ng/mL, IL-6>25.475pg/ml and pleural effusion were related clinical factors for hypoxia in MPP.

Background

Mycoplasma pneumoniae pneumonia (MPP) is one of the commonest causes of pediatric community- acquired pneumonia, causing 10-40% of cases [1, 2]. Although MPP is known to be a mild, self-limiting disease with a good response to macrolides [3], sometimes it can also progress into a severe and fulminant disease, which are always with severe complications such as respiratory failure, hypoxia, and even short-term progression to acute respiratory distress syndrome (ARDS) [4, 5]. As we have known, hypoxia is a risk factor affecting the prognosis of patients in MPP. Therefore, clinicians need to pay high attention to MPP with hypoxia.

To explore the related factors predicting MPP with hypoxia earlier, provide appropriate treatments and reduce complications, we retrospectively analyzed the cases of MPP hospitalized in our hospital between January 2017 and June 2019, then compared the differences of clinical features, laboratory data, and radiological findings, between the MPP with hypoxia, refractory Mycoplasma pneumoniae pneumonia (RMPP) and general Mycoplasma pneumoniae pneumonia (GMPP).
Methods

Patient Selection

Clinical information: 69 patients in MPP with hypoxia were admitted to the Respiratory Department of Tianjin Children's Hospital from January 2017 to June 2019. We also randomly selected 86 patients in the RMPP group and 190 patients in the GMPP group from the same period. All cases met the diagnostic criteria.

Diagnostic criteria: All patients had clinical evidence of pneumonia on admission such as a fever, cough and pneumonic infiltrations in the chest radiograph. MP infection was based on the positive results for MP polymerase chain reaction (PCR) tests of nasopharyngeal secretions (88.70%) or positive results of a serological test (11.3%). Patients underwent anti-MP IgM titrations twice at the time of admission and before discharge, and we selected whose test results was a seroconversion (negative to positive), four-fold or greater increase in IgM titers, or both high titers of ≥1:640 (MP-IgM antibody titer ≥ 1:160)[6]. Hypoxia was defined as any recorded oxygen saturation of <92% by pulse oximetry, measured on room air[7]. The diagnosis of RMPP was based on clinical and radiological deterioration after azithromycin treatment for 7 days or longer[8].

The inclusion criteria: (1) met the diagnostic criteria; (2) the age was less than 15 years old.

The exclusion criteria: (1) someone had other respiratory pathogen infections and tuberculosis by following tests: blood cultures, nasopharyngeal aspirate cultures, nasopharyngeal aspirate for virus reverse transcriptase real-time multiplex PCR, serology for Chlamydia pneumoniae (CT) and Legionella pneumophila (LG) and protein purified derivative (PPD). (2) someone had basic diseases such as asthma, chronic cardiopulmonary disease, rheumatism and immune deficiency. (3) someone had a previous history of hypoxia. (4) someone had used glucocorticoid before admission.

Data collection: Hospitalization demographic, clinical information, laboratory data and radiological findings of all children included in the study were collected retrospectively. Nasopharyngeal aspirate specimens were routinely collected within 24 hours of admission. Respiratory specimens were tested for bacterial culture, virus using RT-mPCR and MP using PCR. Peripheral blood samples were obtained on admission for the determination of complete blood count, C-reactive protein (CRP), lactic dehydrogenase (LDH), procalcitonin (PCT), interleukin (IL)-6, lactic acid, ferritin(Fer), D-dimer, fibrinogen (Fg), alanine aminotransferase (ALT), aspartate aminotransferase (AST) and specific antibody to MP. Blood culture was also performed on admission. Chest radiography was performed before admission or during hospitalization. And patients would have a CT scan if he or she has one of the following situations: 1. the clinical manifestations are inconsistent with the chest radiograph; 2. airway and lung malformations are suspected; 3. there are serious complications associated with pneumonia; 4. patients fail to respond to treatment and need to exclude other diseases such as interstitial lung disease, pulmonary tuberculosis.
and so on[9,10]. The percent of CT scans in MPP with hypoxia, RMPP and GMPP was 100%, 84.88% and 17.69% respectively.

**Observation indexes:** clinical features (sex, age, duration of fever, peak fever, dyspnea, complications, etc.), laboratory data, radiological findings, hospitalization time and treatments.

**Ethics:** The study was approved by the ethics committee of the Tianjin Children's Hospital. And the data from patients were analyzed anonymously.

**Data analysis:** SPSS 22.0 was used for statistical analysis. The normal distribution data was represented by mean ± SD (). One-way ANOVA was used for comparison between groups. The LSD-t-test was used for comparison within the group. The skewed distribution data were expressed as median (P25, P75), which comparisons were made by the Mann-Whitney U-test. And Chi-squared tests were used to compare categorical data. Receiver operating characteristic (ROC) curves were operated to evaluate candidate markers related to MPP with hypoxia, and logistic regression analysis was performed to select variables associated with MPP with hypoxia. The difference was considered statistically significant at P < 0.05.

**Results**

**Basic information of patients**

194 male and 151 female patients with a median age of 8 (4-6) years were included in this study. There were 69 cases in the MPP with hypoxia group (34 men; 35 women), 86 cases in the RMPP group (48 men; 38 women) and 190 cases in the GMPP group (112 men; 78 women). The median age was 6 (4-8) years in the MPP with hypoxia, 6 (4-8) years in the RMPP and 6 (4-7) years in GMPP. There was no statistically significant difference in age and gender among the three groups.

**Clinical characteristics of patients (table1)**

All patients presented a cough, and 350 (98.87%) patients had fever. Also, the MPP with hypoxia group had a higher fever (39.1-41°C) than the other two groups (P<0.05). Moreover significant differences were observed in the incidence of rash, liver function damage, chest pain, toxic encephalopathy, thromboembolism, dyspnea, mucous plugging between the MPP with hypoxia and the other two groups (P<0.05).

**Laboratory and imagine the features of patients**

Laboratory and radiological findings in MPP WITH HYPOXIA, RMPP and GMPP patients were summarized in Tables 2 and 3. In MPP with hypoxia patients, the average of white blood cell count (WBC), percentage of peripheral neutrophils (N%), CRP, IL-6, ALT and ferritin (fer) was 10.19×10⁹/L, 68.81%, 51.21mg/L, 69.96pg/ml, 47.17U/L and 421.61ng/L respectively, which were significantly higher than those in other groups (P all<0.05). And the level of fibrinogen was lowest in MPP with hypoxia (3.70g/L: 4.27g/L: 4.52g/L, p<0.05). As for LDH and D-dimer, there were statistical
differences only between MPP with hypoxia and GMPP groups (p<0.01), besides PCT was observed differences only between MPP with hypoxia and RMPP groups (p<0.05). In contrast, lactic acid and AST showed no difference among the three groups (p>0.05).

In addition to laboratory data, radiological findings were more serious in patients with MPP with hypoxia. The proportion of pulmonary consolidation among MPP with hypoxia, RMPP and GMPP was 79.71%, 80.23% and 64.74% respectively (p<0.01). Pulmonary complications were more likely to occur in MPP with hypoxia. And there were significant differences among the three groups, including atelectasis (31.88%: 23.25%: 12.11%, P < 0.01) and pleural effusion (65.22%: 32.56%: 9.47%, P < 0.01). However, the incidence of pleural thickening among the three groups was not statistically significant (p>0.05).

Clinical course and treatment of patients

Regarding the clinical course, the median duration of fever was 12 (9-14) days in the MPP with hypoxia group, 10 (8-12) days in the RMPP group and 9 (8-10) days in the GMPP group (P < 0.01). And The median length of hospital stay was 12 (9-15) days in the MPP with hypoxia group, 9 (8-10) days in the RMPP group and 6 (5-7) days in the GMPP group (P < 0.01). A total of 205 patients (57.90%) were treated with glucocorticoid after admission, and the number of MPP with hypoxia group was significantly higher than that in the other two groups (100% versus 84.06%, 71.05% P < 0.01). Fiberoptic bronchoscopy was performed in 201 cases (56.77%). The number of patients using the fiberoptic bronchoscope in the MPP with hypoxia group was significantly higher than that in the other two groups (84.06% vs 70.93% vs 43.16% P < 0.01). Additionally, the proportion of patients required oxygen-therapy and gamma globulin in the MPP with hypoxia group was higher than that in the others (P<0.01). All patients were treated with azithromycin.

Predictive values of the independent correlation factors in patients with MPP with hypoxia

The ROC analysis was performed to explore predictive values of laboratory date for MPP with hypoxia, and the critical value with maximum sensitivity and specificity was also determined. ROC analysis revealed that IL-6, ferritin and D-dimer were of great significance in the diagnosis of MPP with hypoxia, the area of which under the curve was above 0.7. When the cut-off value for the IL-6, ferritin and D-dimer was set at 25.47 pg/ml, 171.15 ng/mL, and 0.45 μg/L, the sensitivity and specificity in recognized MPP with hypoxia were 73.5% and 68.9%, 82.4% and 69.3%, 64.7% and 75.1%, respectively.

Multiple logistic regression analysis for the related factors predicting the MPP with hypoxia

To further evaluate the predictors associated with MPP with hypoxia, multiple logistic regression was performed. IL-6 > 25.47 pg/ml ferritin > 174.15 ng/mL, and pleural effusion played a significant role in predicting the MPP with hypoxia, with the odds ratio (OR) values of 3.005, 3.430, and 3.183, respectively in Table 5.
Discussion

Mycoplasma pneumoniae pneumonia continues to be a significant cause of childhood community-acquired pneumonia, and is usually a benign self-limited disease. However, sometimes it progresses to severe or fulminant cases, even endanger the lives\(^\text{[11]}\). And death always was associated with diffuse pneumonia, acute respiratory distress syndrome (ARDS), brain herniation, vascular thrombosis, and disseminated intravascular coagulation\(^\text{[12-16]}\). Hypoxia is an important indicator of disease severity. So it is crucial to early diagnosis and early intervention for MPP with hypoxia. However, there were still few studies on MPP with hypoxia, especially in children. Therefore, we conducted a retrospective study, including 69 cases of the MPP with hypoxia group, and randomly selected 86 cases of the RMPP group and 190 cases of the GMPP group as a control. All cases met the diagnostic criteria.

First of all, there was no significant difference in age and sex among the three groups, and the median age of all groups was 6 years old, which was consistent with the age of the high incidence of MPP\(^\text{[1]}\).

Secondly, the signs and symptoms in the MPP with hypoxia group were more serious, and the incidence of extrapulmonary complications was higher. In the study, the median time to hypoxia was 10(9-12) days, which was consistent with the study on fulminant MPP of Izumikawa et al\(^\text{[7]}\). Some literature has shown that liver function damage was the most common extrapulmonary complication of MPP with hypoxia\(^\text{[17,18]}\). In our research, 13 cases (18.84%) of MPP with hypoxia complicated with liver function damage. Moreover, MP infection might contribute to hypercoagulability and cause thromboembolism itself, which was serious extrapulmonary complication\(^\text{[19]}\). In this study, in total 7 patients developed thromboembolism, which was located in the lower limb artery (2 cases), lung (4 cases) and heart (1 case). These serious complications also lead to longer hospitalization and more complex treatments in patients with MPP with hypoxia. Our study showed the number of people using glucocorticoids in the MPP with hypoxia group was significantly more than that in the other two groups, and only the MPP with hypoxia group used gamma immunoglobulin.

At present, there are few studies on MPP with hypoxia. However, the current theory of excessive immune response causing MPP disease progression is generally accepted\(^\text{[20-23]}\). In the laboratory indicators, the level of WBC, neutrophil ratio, CRP, LDH, IL-6 and ferritin were related to MPP with hypoxia, which was similar to the previous case reports\(^\text{[24-26]}\). Taken together, the evidence suggested a serious immune-inflammatory reaction in MPP with hypoxia.

The radiological manifestations of mycoplasma pneumoniae pneumonia were various, mostly bronchial wall thickening, centrilobular nodules, ground-glass attenuation and consolidation\(^\text{[27]}\). Besides, our study showed that the imaging findings of MPP with hypoxia were not specific, mainly pulmonary inflammatory consolidation (79.71%), but MPP with hypoxia was more likely to be accompanied by atelectasis, pleural effusion, and aggravated in a short period. Miyashita et al indicated that bilateral infiltrates and pleural effusion commonly present in the MPP with hypoxia group compared to the other
groups\textsuperscript{[18]}. It further suggested the severity of the disease, which may be related to the direct invasion of MP and excessive host immune response.

As for the treatment of macrolides, there was no significant difference between the three groups, which may be related to high rate of macrolide-resistant M. pneumoniae(MRMP) in China, ranging from 69 to 100% in recent years\textsuperscript{[28]}. Chen Z et al found that there was no significant difference of resistance rate of MP between the GMPP group and the RMPP group\textsuperscript{[29]}. But there were reports of severe cases in MRMP among children treated with macrolides\textsuperscript{[30-32]}. This may be related to a higher host immune response caused by higher and more persistent stimulation of M. pneumoniae. So, we think a high macrolide-resistant rate may be a factor leading to hypoxia in MPP.

MP infection may cause varying degrees of respiratory mucus thrombus obstruction, even form bronchial molding, resulting in airway stenosis and occlusion\textsuperscript{[33]}. We compared the incidence of mucous plugging between the three groups and found that the MPP with hypoxia group was significantly higher than the other two groups. We suspect that may be related to the occurrence of hypoxia in MPP. Pediatric flexible fiberoptic bronchoscopy can clear respiratory secretions under direct view, relieve airway obstruction, and reduce the occurrence of complications\textsuperscript{[9]}. In our study, the indications for bronchoscopy were atelectasis or segmental inflammatory consolidation on imaging, with lesion area of one or more lung segments, rinsing local lesions and taking alveolar lavage fluid for pathogen detection\textsuperscript{[9]}. A total of 201 children (58.26\%) received fiberoptic bronchoscopy intervention therapy, among which the MPP with hypoxia group received more of this treatment(p<0.01).

In our case, all the children recovered and discharged from the hospital without death.

To explore the related risk factors predicting MPP with hypoxia, we used the ROC curve and multivariate logistic regression analysis. ROC analysis revealed that the area under the curve of ferritin, IL-6 and D-dimer were above 0.7, which were helpful to recognize the patients in MPP with hypoxia. And the optimal cutoff value for three factors was 174.15 ng/mL, 25.47 pg/ml and 0.45 μg/L, respectively. Besides, multiple logistic regression analysis was made to improve the predicted accuracy. We found that ferritin >174.15 ng/mL, IL-6 >25.47 pg/ml and pleural effusion were good predictors of MPP with hypoxia. Ferritin not only represents iron reserves, but also an inflammatory marker\textsuperscript{[34]}. When inflammation occurs, inflammatory factors act on the body to increase the production of ferritin in serum. At the same time, inflammatory factors cause degeneration and necrosis of local tissue cells, dissolution and rupture of the cell membrane, resulting in leakage of serum ferritin from damaged cells. As a result, ferritin is significantly increased in the inflammatory response. However, there is still no report about the correlation of ferritin in MPP with hypoxia. Some studies\textsuperscript{[35]} on RMPP reported when the ferritin level was 230 ng/mL or higher, the sensitivity and specificity for diagnosing refractory MP pneumonia were 67 and 67\%, respectively. In our study, the optimal cutoff point for ferritin was 174.15 ng/mL, with a sensitivity of 82.4 % and specificity of 69.3%, and the odds ratio of logistic regression analysis was 3.430. The reason for which made it different may be the presence of mixed infection in our case. IL-6 plays an important role
in the early stage of the immune response. In our study the area under the curve for IL-6 was 0.737, and the optimal cutoff point was 25.47 pg/ml, with a sensitivity of 73.5% and specificity of 68.9%, the odds ratio of logistic regression analysis was 3.005. Chen et al showed that the cutoff value of IL-6 for RMPP was 14.75pg/ml\textsuperscript{[21]}. At present, it is considered that the increase of IL-6 is related to the severity and course of the disease\textsuperscript{[36]}, which further suggests that there may be an excessive immune response in MPP with hypoxia. The advantage of this study is that we first explore the predictors with MPP with hypoxia. Starting from the actual clinical cases, the differences between MPP with hypoxia, RMPP and GMPP in large samples are compared and analyzed, and the interference of mixed factors is eliminated. It provides a strong basis for the early identification of MPP with hypoxia and has a certain degree of innovation and practicality.

There are several limitations to this study. Firstly, it was a retrospective study, and there may have been some selection bias. Secondly, there may be the presence of mixed infection in some cases which cannot be detected. Therefore, in the future work, we should further carry out long-term multicenter, large sample prospective studies, and further explore the problems found in clinical work, to provide a reliable theoretical basis for early identification, early diagnosis and early intervention of MPP with hypoxia.

**Conclusion**

Our study shows that excessive immunological inflammation may play an important role in MPP with hypoxia. FER > 174.15 ng/mL, IL-6 >25.47pg/ml and pleural effusion were high risk factors for MPP with hypoxia. MPP with hypoxia patients may need to require glucocorticoid therapy and bronchoscopy.

**Declarations**

**Ethics approval and consent to participate**

All procedures performed in studies involving human participants were following the ethical standards of the institution and/or national research committee. This article does not contain any studies with animals performed by any of the authors.

**Consent for publication**

Not applicable.

**Availability of data and materials**

All data generated or analyzed during this study are included in this published article.

**Competing interests**

The authors declare no conflict of interest
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Authors’ contributions

Conception and Design: YYL, TQZ and YSX; Extraction of Data: YYL, WG, ZLZ and JT; Drafting the Article: YYL; Revising It for Intellectual Content: YYL and YSX; Final Approval of the Completed Article: YYL, TQZ, CQC and YSX. All authors read and approved the final manuscript.

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Abbreviations

MPP: Mycoplasma pneumoniae pneumonia; RMPP: refractory Mycoplasma pneumoniae pneumonia; GMPP: general Mycoplasma pneumoniae pneumonia; MRMP: macrolide-resistant M. pneumoniae; PCR: polymerase chain reaction; CRP: C-reactive protein; LDH: lactic dehydrogenase; PCT: procalcitonin; IL: interleukin lactic acid; Fer: ferritin; Fg: fibrinogen; ALT: alanine aminotransferase; AST: aspartate aminotransferase; ROC: Receiver operating characteristic

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Tables
| Clinical information | MPP WITH HYPOXIA(n=69) | RMPP(n=86) | GMPP(n=190) | P-value |
|----------------------|-------------------------|------------|-------------|---------|
| Sex(male/female)     | 34/35                   | 48/38      | 112/78      | 0.381   |
| Age, years           | 6(4-8)                  | 6(4-8)     | 6(4-7)      | 0.125   |
| Clinical presentation |                        |            |             |         |
| Fever                | 69(100%)                | 86(100%)   | 186(97.89%) | 1.000   |
| 37.5-38°C            | 0(0%)                   | 0(0%)      | 10(5.38%)   | 0.000   |
| 38.1-39°C            | 6(8.69%)                | 20(23.25%) | 53(28.49%)  |         |
| 39.1-41°C            | 61(88.41%)              | 64(74.42%) | 122(65.59%) |         |
| 41°C                 | 2(2.90%)                | 2(2.33%)   | 1(0.54%)    |         |
| Cough                | 69(100%)                | 86(100%)   | 190(100%)   | 1.000   |
| Chest pain           | 18(26.09%)              | 3(3.49%)   | 2(1.05%)    | 0.000   |
| Rash                 | 10(14.49%)              | 3(3.49%)   | 14(7.37%)   | 0.043   |
| Thromboembolism      | 7(10.14%)               | 0(0%)      | 0(0%)       | 0.000   |
| Wheezing             | 8(11.59%)               | 10(11.63%) | 30(15.79%)  | 0.533   |
| Dyspnea              | 69(100%)                | 2(2.32%)   | 0(0%)       | 0.000   |
| Liver function damage| 13(18.84%)              | 5(5.81%)   | 16(8.42%)   | 0.023   |
| Toxic encephalopathy | 9(13.04%)               | 2(2.32%)   | 0(0%)       | 0.000   |
| Mucous plugging      | 36(52.17%)              | 16(18.60%) | 2(1.05%)    | 0.000   |
| Length of fever, days| 12(9-14)                | 10(8-12)   | 6(8-10)     | 0.000   |
| Length of stay, days | 12(9-15)                | 9(8-10)    | 6(5-7)      | 0.000   |
| Management           |                         |            |             |         |
| Using Azithromycin   | 69(100%)                | 86(100%)   | 130(100%)   | 1.000   |
| Using glucocorticoids| 69(100%)                | 58(84.06%) | 78(41.05%)  | 0.000   |
| Using gamma immune globulin | 34(49.27%) | 0(0%) | 0(0%) | 0.000 |
| Using fiberoptic bronchoscope | 58(84.06%) | 61(70.93%) | 82(43.16%) | 0.000 |
| Using oxygen-therapy | 69(100%)                | 2(2.32%)   | 0(0%)       | 0.000   |

Data are presented as number(percentage), median (25th-75th percentile)
Table 1. Clinical characteristic of MPP with hypoxia, RMPP and GMPP patients

| Laboratory information | MPP WITH HYPOXIA (n =69) | RMPP (n=86) | GMPP (n=190) |
|-------------------------|--------------------------|-------------|--------------|
| WBC(×10^9/L)            | 10.19±4.61               | 8.312±3.28  | 8.757±3.79   |
| N,%                     | 68.81±13.3%              | 62.620±13.670* | 60.321±13.249** |
| CRP, mg/L               | 51.21±49.5%              | 26.273±29.850* | 23.771±29.012** |
| LDH,IU/L                | 516.29±22                | 471.92±21   | 414.85±168   |
| PCT,ng/ml               | 0.41±0.68                | 0.22±0.23*  | 0.25±1.31    |
| IL-6,pg/ml              | 69.96±115.23             | 32.13±28.33 | 21.29±28.16* |
| La,mmol/l               | 2.82±1.064               | 2.94±1.13   | 3.00±1.11    |
| AST,U/L                 | 48.68±42.2               | 40.03±29.13 | 37.41±41.5   |
| ALT,U/L                 | 47.17±62.4               | 24.55±27.43 | 23.15±48.36* |
| Fer,ng/L                | 421.61±34                | 230.08±26   | 150.85±167   |
| Fg,g/l                  | 3.70±1.15                | 4.27±1.75*  | 4.52±1.77*   |
| D-D,mg/L                | 1.94±2.91                | 1.86±4.41   | 0.49±1.15*   |

WBC: white blood cell; N: peripheral neutrophils; CRP: C-reactive protein; LDH: lactic dehydrogenase; PCT: procalcitonin; IL-6: interleukin (IL)-6; La: lactic acid; AST: aspartate aminotransferase; ALT: alanine aminotransferase; Fer: ferritin; Fg: fibrinogen; D-D: D-dimer; *MPP WITH HYPOXIA vs RMPP P<0.05; **MPP with hypoxia vs GMPP P<0.05; data are represented by mean ± SD

Table 2. Laboratory characteristic of MPP with hypoxia, RMPP and GMPP patients

| Radiological features | MPP WITH HYPOXIA (n =69) | RMPP (n=86) | GMPP (n=190) | P-value |
|-----------------------|--------------------------|-------------|--------------|---------|
| Pulmonary consolidation | 55(79.71%)               | 69(80.23%)  | 123(64.74%)   | 0.008   |
| Lobar atelectasis     | 22(31.88%)               | 20(23.25%)  | 23(12.11%)    | 0.000   |
| Pleural thickening     | 35(50.72%)               | 46(53.49%)  | 120(63.15%)   | 0.117   |
| Pleural effusion       | 45(65.22%)               | 28(32.56%)  | 18(9.47%)     | 0.000   |

Data are presented as number (percentage).
Table 3. Radiological features of MPP with hypoxia, RMPP and GMPP patients

| Independent factors | Cutoff value | Sensitivity | Specificity | AUC    | P-value |
|---------------------|--------------|-------------|-------------|--------|---------|
| IL-6, pg/ml         | 25.47        | 0.735       | 0.689       | 0.737  | 0.000   |
| Fer, ng/L           | 174.15       | 0.824       | 0.693       | 0.806  | 0.000   |
| D-D, mg/L           | 0.450        | 0.647       | 0.751       | 0.720  | 0.000   |

AUC: area under the ROC curve; Cut-off value: the value on the ROC curve is closest to the upper right to take maximum sensitivity and specificity; P-value: the AUC value of the independent factors compared to ROC curve reference value 0.5.

Table 4. Predictive values of the independent correlation factors in patients with MPP with hypoxia

Table 5. Stepwise logistic regression analysis for the related factors predicting the RMPP

| Variable      | B      | S.E.   | Wald   | P-value | OR     | 95%CI   |
|---------------|--------|--------|--------|---------|--------|---------|
|               |        |        |        |         | Lower  | Upper   |
| IL-6, pg/ml   | 1.100  | 0.366  | 9.043  | 0.003   | 3.005  | 1.467   | 6.156 |
| Fer, ng/L     | 1.233  | 0.409  | 9.066  | 0.003   | 3.430  | 1.538   | 7.653 |
| Pleural effusion | 1.158 | 0.383  | 9.122  | 0.003   | 3.183  | 1.502   | 6.749 |

Figures
Figure 1

ROC Curve for predictive values of the independent correlation factors in patients with MPP with hypoxia.