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Evaluation of Inflammatory Markers in Patients with COVID-19 Combined with Type 2 Diabetes Mellitus

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Purpose: To explore the value of different inflammatory markers in predicting the severity of coronavirus disease 2019 (COVID-19) in patients with type 2 diabetes mellitus (T2DM).

Patients and Methods: A total of 116 patients with COVID-19 in patients with T2DM were collected from December 2022 to March 2023 and were divided into a mild case group (77 cases) and a severe case group (39 cases). The ratio of neutrophil to lymphocyte (NLR), platelet-to-lymphocyte ratio (PLR), neutrophil to lymphocyte × platelet ratio (NLPR), lymphocyte ratio to monocyte (LMR), systemic inflammatory response index (SIRI), systemic inflammatory index (SII), systemic inflammatory composite index (AISI), procalcitonin (PCT), C-reactive protein (CRP) and lactate dehydrogenase (LDH) were compared between the two groups. The screening effect of each variable on the progression of the disease was analyzed using receiver operating characteristic (ROC) curves.

Results: NLR, PLR, NLPR, MLR, SIRI, SII, AISI, LDH, CRP and PCT in severe case group were higher than those in mild case group ($P<0.05$), and LMR was lower than those in mild case group ($P<0.05$). ROC curve analysis further demonstrated the diagnostic performance of these biomarkers, with PCT having the largest area under the ROC curve (AUC^{ROC}) of 0.83.

Conclusion: NLR, PLR, NLPR, SIRI, SII, LDH, CRP and PCT demonstrate greater reliability in diagnostic value and clinical utility for predicting the severity of COVID-19 in patients with T2DM.

Keywords: COVID-19, T2DM, inflammatory index, LDH, CRP, PCT

Introduction

The coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. It is a highly infectious and pathogenic disease. It is characterized by severe inflammatory response and a wide range of clinical manifestations, which can progress from mild flu-like symptoms and fever to adult respiratory distress syndrome (ARDS), coagulation dysfunction, and even death.[1] According to the latest data from the World Health Organization, more than 7 million people have died from COVID-19 globally since the outbreak began in late 2019, with the most deaths reported in the United States (1.2 million), Brazil (702,000), India (534,000) and Russia (403,000).[2] Studies have shown that angiotensin-converting enzyme 2 was the target of SARS-CoV-2 infection,[3] and angiotensin-converting enzyme 2 receptors were commonly expressed in alveolar type I and type II epithelial cells and were also found in several organs such as the pancreas.[4] A meta-analysis has shown that diabetes mellitus (DM) was the most important cause of death among hospitalized patients with COVID-19, with a 1.85-fold increased risk of death.[5] Therefore, identifying some early biomarkers of the severity of COVID-19 in patients with type 2 diabetes (T2DM) may help to aggressively treat the disease at an early stage and reduce mortality.

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Routine blood tests can be used to assess inflammatory status and aid in early diagnosis of the disease. Blood tests, in particular, are readily available and inexpensive, and can provide information about a variety of cell parameters, such as white blood cell counts, lymphocytes, neutrophils, etc. In addition, the ratio combination of these parameters is also used as an indicator of inflammation. Examples include neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), lymphocyte-to-monocyte ratio (LMR), neutrophil to lymphocyte × platelet ratio (NLPR), systemic inflammatory Response Index (SIRI), systemic inflammatory index (SII), and systemic inflammatory composite Index (AISI) and other indicators can be used as biomarkers to assist disease and risk stratification.[6–8] However, few studies have examined the value of these measures in assessing disease severity in patients with COVID-19 in patients with T2DM. Therefore, we attempted to compare the ability of NLR, PLR, MLR, NLPR, SIRI, SII, AISI, etc. to predict disease development in patients with COVID-19 in patients with T2DM.

Materials and Methods

Study Object

A total of 116 patients with COVID-19 in patients with T2DM who were hospitalized in the First Hospital of Hohhot from December 2022 to March 2023 were retrospectively collected through the hospital electronic medical record system. The diagnosis, classification, treatment, and discharge criteria for COVID-19 are all based on the relevant diagnostic criteria in the Diagnosis and Treatment Protocol for Novel Coronavirus Infection (Trial 10th edition).[9] Patients with T2DM meet the diagnostic criteria of the 2020 Chinese Guidelines for T2DM Prevention and Treatment.[10] Exclusion criteria: 1) age < 18 years old; 2) Pregnant or lactating women; 3) combined with tuberculosis, fungi and other infections; 4) Patients with hematological diseases and malignant tumors; 5) Patients treated with hormone and immunosuppressive therapy; 6) Patients with incomplete clinical data. According to the clinical classification of patients, 116 patients were divided into a mild case group (mild and ordinary patients) with 77 cases, and a severe case group (severe and critical ill patients) with 39 cases (Figure 1). This study was approved by the Ethics Review Committee of the First Hospital of Hohhot (Ethics number: KYLL-2023-159).

Research Methods

Basic information such as age, gender, whether insulin was used, whether antiviral drugs were used, vaccination times, major clinical manifestations were collected, and the results of the first laboratory examination after admission [including blood routine, biochemical index, procalcitonin (PCT), C-reactive protein (CRP), lactate dehydrogenase (LDH), etc.] were collected. The results of lymphocytes (L), neutrophils (N), monocyte (M) and platelet (PLT, P) in mild and severe patients were analyzed, and NLR, PLR, LMR, NLPR, SIRI, SII and AISI were calculated between the two groups according to the above statistical data. The calculation methods are: NLR=N/L, PLR=P/L, LMR=L/M, NLPR=(N×100)/(L×P), SIRI=N×M/L, SII=N×P/L, AISI=N×P×M/L. The outcome indexes [the time of nucleic acid turning negative (the number of days from

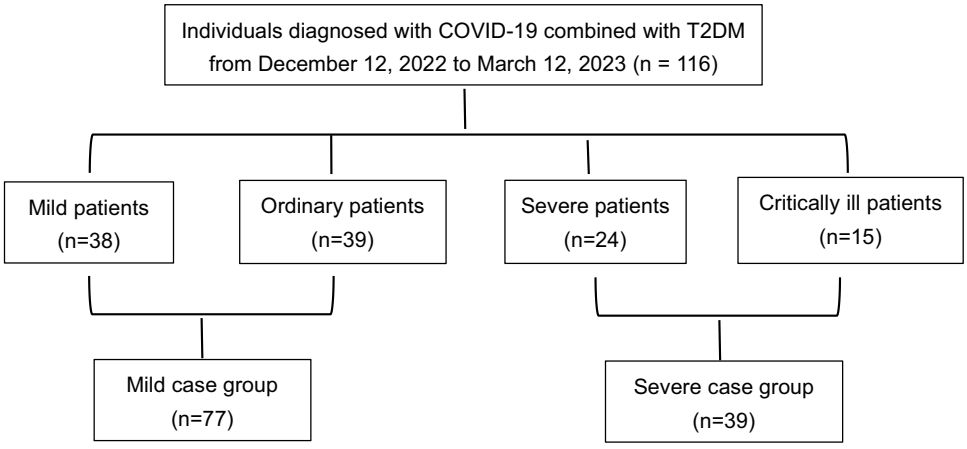

Figure 1 Flowchart of inclusion patients.

onset to two consecutive negative nucleic acid tests), the length of hospital stay, etc] and the clinical characteristics of the patients were analyzed.

Statistical Analysis

IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., Armonk, NY, USA) and GraphPad Prism version 8.0.0 for Windows (GraphPad Software, San Diego, California, USA, www.graphpad.com) were used for statistical analysis. Measurements in the normal distribution form were provided in (Mean ± SD) form, and non-normal forms were provided in the M (Q_1, Q_3) form. Two independent samples *t*-test was used to compare two groups with normal distribution and uniform variance, and the Mann–Whitney U rank-sum test was used to compare two groups with non-normal distribution or uneven variance form. The count data were expressed by frequency and percentage (n,%), and χ^2-test was used for comparison between groups. Spearman correlation analysis was used to analyze the correlation between NLR, PLR, MLR and hospitalization days. Receiver operating characteristic (ROC) curve was performed to determine the diagnostic boundary value, sensitivity, specificity and diagnostic value of each indicator in COVID-19 in patients with T2DM. $P < 0.05$ indicated that the difference was statistically significant.

Results

Characteristics of the Study Population

Finally, a total of 116 patients with COVID-19 in patients with T2DM were included, including 77 cases in the mild case group and 39 cases in the severe case group. The male was 55.17% (64/116), the average age was 67.72 ± 11.87 years. There were significant differences between the two groups only in age, hospitalization days, cycle of negative conversion, Urea, AST, insulin use, vaccination status, fever, fatigue and chronic pulmonary disease ($P < 0.05$). Among them, patients in the severe group were older, stayed in hospital longer, nucleic acid conversion negative longer, and had higher rates of insulin use, non-vaccination and preexisting underlying chronic lung disease ($P < 0.05$). In terms of clinical manifestations, there were differences between the two groups only in fever and fatigue, and there were no significant differences in other clinical manifestations between the two groups ($P > 0.05$) (Table 1).

Comparison of Inflammation Indexes Between the Two Groups

The levels of NLR, PLR, NLPR, SIRI, SII, AISI, LDH, CRP and PCT in the severe group were higher than those in the mild group ($P < 0.05$), and the MLR was lower ($P < 0.05$) (Table 2).

ROC Curve Analysis

Inflammatory indicators with statistical differences between the two groups were selected to draw ROC curves. The results indicated that CRP had the highest specificity (96%) and PCT had the highest sensitivity (85%). In addition, PCT had the greatest diagnostic value in judging the severity of COVID-19 in patients with T2DM (AUC = 0.830, 95% CI: 0.750–0.910, $P < 0.001$). When the cut-off value was 0.612 ng/mL, the sensitivity and specificity were 85% and 77%, respectively, and the Jorden index was 0.612. Therefore, PCT > 0.612 ng/mL was a risk factor for exacerbation of COVID-19 in patients with T2DM. The AUC of the remaining indicators (NLR, PLR, NLPR, LMR, SIRI, SII, AISI, LDH and CRP) was 0.723, 0.693, 0.721, 0.674, 0.699, 0.698, 0.808 and 0.741, respectively, with $P < 0.05$ (Table 3 and Figure 2).

Correlation Analysis of NLR, PLR and Other Indicators with the Length of Hospitalization

The average hospitalization days of 116 patients with COVID-19 in patients with T2DM were 10.09 ± 5.30, and all inflammatory indicators were correlated with the hospitalization days (all $P < 0.05$). Among them, NLR, PLR, NLPR, SIRI, SII, AISI, LDH, CRP and PCT were positively correlated with the length of stay, while LMR was negatively correlated with the length of stay. (Figure 3A–J).

Table 1 Comparison of Clinical Data Between the Two Groups

	Total (n = 116)	Mild case group (n = 77)	Severe case group (n = 39)	$t/Z/\chi^2$	P value
Age, year, Mean ± SD	67.72 ± 11.87	64.53 ± 12.04	74.03 ± 8.66	t=−4.38	<0.001
Length of stay, days, Mean ± SD	10.09 ± 5.30	8.49 ± 3.76	13.26 ± 6.41	t=−4.28	<0.001
Negative cycle, days, M (Q_1, Q_3)	12.00 (9.00, 16.00)	11.00 (8.00, 13.00)	15.00 (12.00, 20.00)	Z=−4.53	<0.001
Male, n(%)	64 (55.17)	44 (57.14)	20 (51.28)	χ^2=0.36	0.549
Glu, mmol/L, M (Q_1, Q_3)	8.53 (6.86, 9.47)	8.53 (7.23, 9.45)	7.96 (6.60, 9.41)	Z=−0.08	0.935
Urea, mmol/L, M (Q_1, Q_3)	5.00 (3.77, 6.90)	4.88 (3.73, 6.54)	5.73 (4.03, 8.26)	Z=−2.18	0.029
UA, μmmol/L, M (Q_1, Q_3)	304.75 (256.95, 364.62)	316.30 (263.70, 365.00)	285.50 (249.50, 362.90)	Z=−0.93	0.353
Cr, μmmol/L, M (Q_1, Q_3)	70.95 (60.18, 91.30)	70.20 (61.60, 85.00)	80.50 (57.35, 106.20)	Z=−1.22	0.224
TC, mmol/L, M (Q_1, Q_3)	3.87 (3.44, 4.35)	3.86 (3.42, 4.22)	3.96 (3.49, 4.57)	Z=−1.17	0.244
TG, mmol/L, M (Q_1, Q_3)	1.48 (1.15, 1.91)	1.38 (1.13, 1.93)	1.55 (1.25, 1.90)	Z=−1.10	0.272
AST, U/L, M (Q_1, Q_3)	22.85 (17.60, 29.00)	20.60 (16.80, 26.80)	24.90 (21.25, 32.70)	Z=−2.45	0.014
ALT, U/L, M (Q_1, Q_3)	21.05 (15.47, 26.13)	21.05 (15.50, 25.50)	19.80 (15.15, 27.65)	Z=−0.11	0.914
Use insulin, n(%)	33 (28.45)	12 (15.58)	21 (53.85)	χ^2=18.62	<0.001
Antiviral therapy, n(%)	77 (66.38)	48 (62.34)	29 (74.36)	χ^2=1.68	0.195
Vaccination status, number of shots,				χ^2=15.34	0.002
Stitch number, n(%)					
0	30 (25.86)	14 (18.18)	16 (41.03)		
1	12 (10.34)	6 (7.79)	6 (15.38)		
2	18 (15.52)	10 (12.99)	8 (20.51)		
3	56 (48.28)	47 (61.04)	9 (23.08)		
Clinical picture					
Fever, n(%)	55 (47.41)	26 (33.77)	29 (74.36)	χ^2=17.11	<0.001
Dry cough, n(%)	71 (61.21)	45 (58.44)	26 (66.67)	χ^2=0.74	0.390
Fatigue, n(%)	58 (50.00)	33 (42.86)	25 (64.10)	χ^2=4.67	0.031
Decreased sense of smell, n(%)	7 (6.03)	4 (5.19)	3 (7.69)	χ^2=0.01	0.904
Nasal congestion, runny nose, n(%)	23 (19.83)	16 (20.78)	7 (17.95)	χ^2=0.13	0.718
Sore throat, n(%)	50 (43.10)	33 (42.86)	17 (43.59)	χ^2=0.01	0.940
Muscle pain, n(%)	45 (38.79)	26 (33.77)	19 (48.72)	χ^2=2.44	0.118
Diarrhea, n(%)	7 (6.03)	4 (5.19)	3 (7.69)	χ^2=0.01	0.904
Headache, n(%)	29 (25.00)	21 (27.27)	8 (20.51)	χ^2=0.63	0.427
Complication					
High blood pressure, n(%)	74 (63.79)	53 (68.83)	21 (53.85)	χ^2=2.52	0.113
Coronary heart disease, n(%)	50 (43.10)	29 (37.66)	21 (53.85)	χ^2=2.76	0.096
Cerebrovascular diseases, n(%)	14 (12.07)	7 (9.09)	7 (17.95)	χ^2=1.17	0.279
Chronic lung disease, n(%)	37 (31.90)	13 (16.88)	24 (61.54)	χ^2=23.76	<0.001
Chronic kidney disease, n(%)	9 (7.76)	4 (5.19)	5 (12.82)	χ^2=1.17	0.279

Abbreviations: Glu, Glucose; UA, Uric acid; Cr, Creatinine; TC, Total cholesterol; TG, Triglyceride; AST, Glutamic oxaloacetic transaminase; ALT, Glutamic pyruvic transaminase.

Discussion

Current studies believe that COVID-19 was associated with a higher risk of T2DM infection, and was more likely to develop into severe pneumonia, multiple organ damage and even death. However, SARS-CoV-2 can induce or aggravate T2DM, cause ketoacidosis, and increase the mortality of T2DM patients. It can be seen that T2DM and SARS-CoV-2 infection promote each other and were risk factors for each other.[11,12] T2DM combined with SARS-CoV-2 infection was more dangerous than SARS-CoV-2 infection alone.[13] The pathophysiological mechanisms associated with DM and COVID-19-related adverse outcomes may be as follows: Elevated blood glucose level will impair the immune response to COVID-19, inhibit lymphocyte proliferation, and weak the role of immune cells, including macrophages and natural killer cells.[14–16] In addition, chronic inflammatory state and elevated baseline cytokine levels associated with DM may enhance the cytokine response intensity of the body to COVID-19 and increase the possibility of cytokine storm, thus

Table 2 Comparison of Inflammatory Indicators Between the Two Groups [M(Q_1, Q_3)]

	Total (n = 116) M (Q_1, Q_3)	Mild case group (n = 77) M (Q_1, Q_3)	Severe case group (n = 39) M (Q_1, Q_3)	*Z*	P value
NLR	3.33 (1.93, 6.50)	2.68 (1.62, 4.89)	5.65 (3.14, 10.19)	−3.92	<0.001
PLR	160.40 (119.46, 286.35)	146.27 (111.72, 212.66)	214.12 (151.70, 330.86)	−3.38	<0.001
NLPR	1.95 (1.04, 4.31)	1.48 (0.90, 2.89)	3.55 (1.90, 6.65)	−3.87	<0.001
LMR	2.50 (1.53, 3.94)	2.64 (1.91, 4.62)	1.97 (1.27, 3.02)	−2.39	0.017
SIRI	1.58 (0.75, 2.84)	1.15 (0.58, 2.14)	2.41 (1.38, 4.46)	−3.49	<0.001
SII	617.19 (302.59, 1224.86)	464.53 (279.00, 966.00)	1162.58 (505.32, 1891.46)	−3.48	<0.001
AISI	256.85 (124.92, 617.05)	219.22 (91.82, 417.48)	383.01 (202.68, 888.99)	−3.25	0.001
LDH, U/L	185.60 (167.55, 227.55)	181.40 (163.90, 195.20)	239.60 (191.85, 285.30)	−5.40	<0.001
CRP, mg/L	9.85 (4.27, 26.50)	8.10 (3.50, 17.40)	19.00 (8.25, 108.30)	−4.23	<0.001
PCT, ng/mL	0.09 (0.07, 0.17)	0.08 (0.06, 0.09)	0.17 (0.11, 0.36)	−5.84	<0.001

Abbreviations: NLR, neutrophil to lymphocyte; PLR, platelet to lymphocyte ratio; NLPR, neutrophil to lymphocyte × platelet ratio; LMR, lymphocyte ratio to monocyte; SIRI, systemic inflammatory response index; SII, systemic inflammatory index; AISI, systemic inflammatory composite index; LDH, lactate dehydrogenase; CRP, C-reactive protein; PCT, procalcitonin.

Table 3 ROC Curve Analysis of the Diagnostic Value of NLR, PLR and Other Indicators in COVID-19 in Patients with T2DM

Index	Jorden index	Optimum tangent point	Sensitivity	Specificity	AUC	95% confidence interval	P value
NLR	0.368	4.91	62%	75%	0.723	0.626~0.820	<0.001
PLR	0.315	164.47	69%	62%	0.693	0.595~0.791	0.001
NLPR	0.368	2.19	67%	70%	0.721	0.621~0.820	<0.001
LMR	0.291	1.98	59%	70%	0.674	0.572~0.775	0.002
SIRI	0.356	2.30	56%	79%	0.699	0.598~0.800	<0.001
SII	0.343	1067.31	54%	81%	0.698	0.597~0.799	0.001
AISI	0.281	719.82	39%	90%	0.685	0.583~0.787	0.001
LDH	0.522	185.9	82%	70%	0.808	0.721~0.894	<0.001
CRP	0.346	44.25	39%	96%	0.741	0.646~0.836	<0.001
PCT	0.612	0.095	85%	77%	0.83	0.750~0.910	<0.001

Abbreviation: AUC, area under the curve.

leading to aggravation of disease and even multiple organ failure in COVID-19 patients.[15,17,18] One study found that infected people were 2.35 times more likely to be diagnosed with DM within 90 days of infection.[19] A number of studies have found that compared with non-DM patients, DM patients have an increased risk of hospitalization, length of stay, ICU hospitalization, and death from COVID-19.[20–22]

General Clinical Indicators

The results of this study found that compared with the mild case group, patients in the severe case group were older, had longer hospital stay and negative nucleic acid transition, and had higher rates of insulin use, non-vaccination and chronic pulmonary disease ($P < 0.05$). In terms of clinical manifestations, the two groups only showed differences in fever and fatigue ($P < 0.05$). It may be related to the fact that most patients in the severe group have more serious illness, and their clinical symptoms are mostly forwarded by their families, and they cannot accurately describe their discomfort. The length of hospital stay can reflect the outcome of patients to some extent. This study found that compared with the mild group, the hospital stay in the severe group was significantly longer, and all inflammatory indicators were correlated with the length of hospital stay, suggesting that the inflammatory response in the patients was severe, and SARS-CoV-2

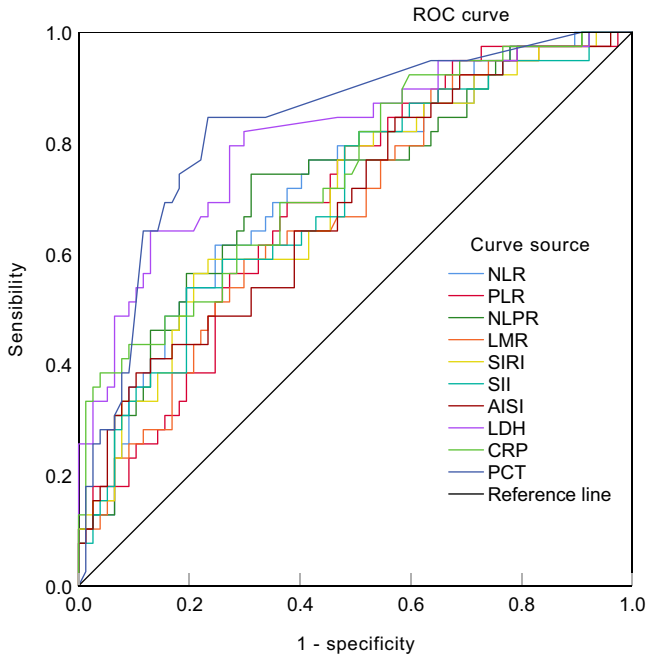

Figure 2 ROC curve.

infection would cause a decrease in L and CD4+ T cells, thus delaying the clearance of the virus. Therefore, longer anti-inflammatory therapy was needed to delay disease progression.[23,24]

NLR

When the disease is severe, N as effector cells play an important role in the "cytokine storm", and the inflammatory state of T2DM patients is aggravated after infection with COVID-19. Therefore, the number of N that promote the inflammatory state increases rapidly and inhibits L production. Increase in N count and decrease in L count together lead to an increase in NLR values.[25,26] It has been reported that NLR values were more sensitive indicators than N and L alone.[27] Consistent with previous reports,[28,29] we found that NLR was increased in the critically ill group. In addition, the AUC data of NLR was consistent with literature reports, ranging from 0.65 to 0.73.[30–32] When NLR > 4.91, the sensitivity and specificity of predicting the development of severe disease in COVID-19 in patients with T2DM were 62% and 75%.

PLR

PLR is another nonspecific marker of inflammation. In addition to their main hemostatic function, platelets also play an indirect role in inflammation. After infection with SARS-CoV-2, platelets are directly activated by broken cell fragments and viral proteins, and sensitized platelets appear to assemble, congeal, or degrade. As a result, a reduction in PLR can be observed in patients who are generally stable PLR increases significantly in patients with severe disease, which is also related to a reduction in the number of L.[33] This study also found that PLR values in severe patients were higher than those in mild patients ($P < 0.05$). Efficacy for predicting risk of severe illness was acceptable (AUC = 0.693).

LMR

LMR is commonly used to assess a patient's inflammatory status and condition. The role of this indicator in assessing viral diseases such as influenza was first mentioned in a paper published in 2010.[34] During infection with SARS-CoV-2, cytokines and growth factors trigger granulocyte production, leading to an increase in N and M at inflammatory sites, and a "cytokine storm" state inhibits lymphocyte production.[35] Therefore, low levels of LMR can be used to assess disease

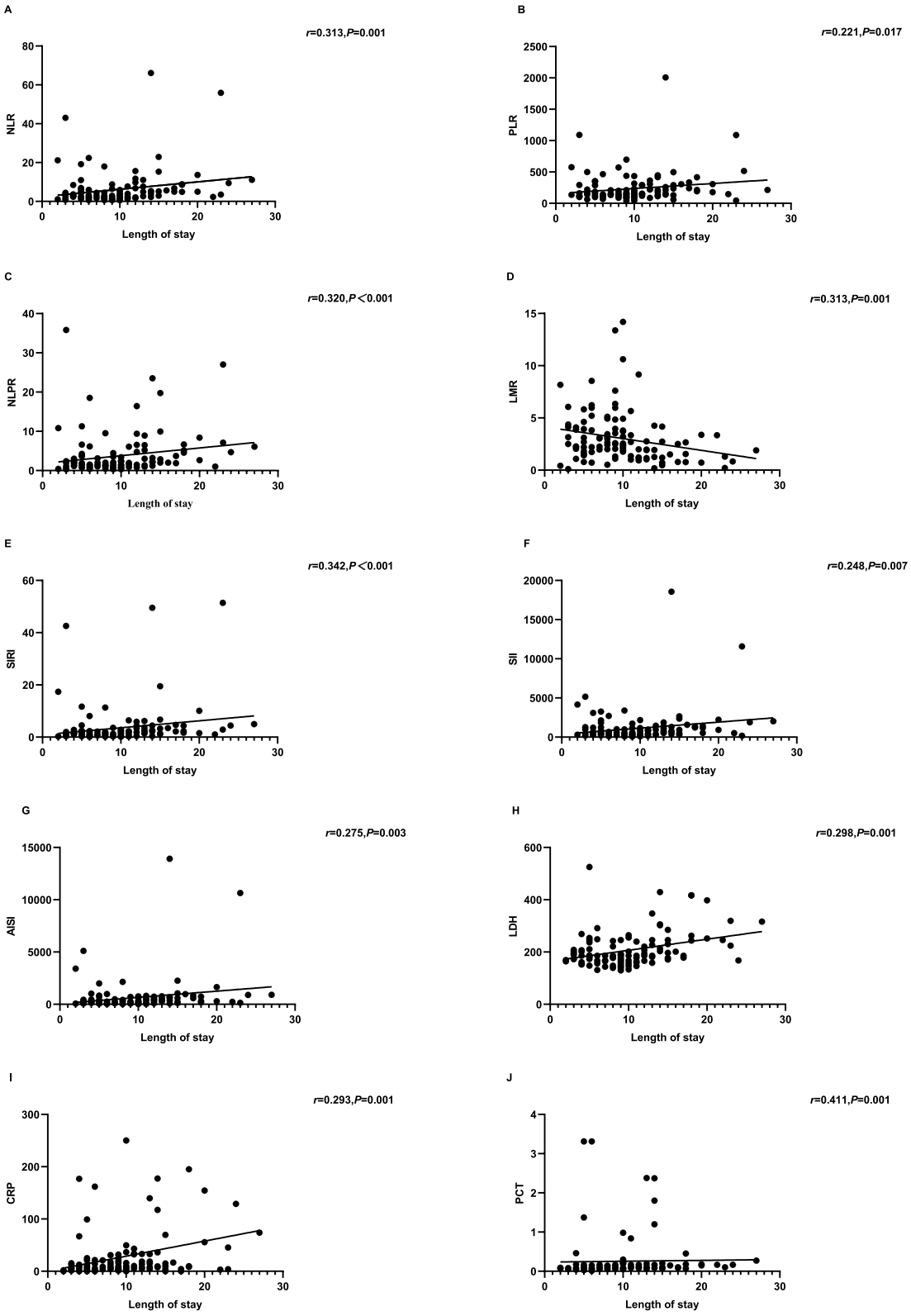

Figure 3 Correlation between NLR, PLR and other indicators with hospitalization days. NLR, PLR, NLPR, SIRI, SII, AISI, LDH, CRP and PCT were positively correlated with the length of stay (subfigures from (**A**–**C**) and (**E**–**J**)), LMR was negatively correlated with the length of stay (subfigure (**D**)).

severity [2.64(1.91, 4.62) vs 1.97(1.27, 3.02), $P = 0.017$], which was consistent with previous studies.[36,37] However, its efficacy in predicting disease severity (AUC = 0.674) was inferior to NLR, PLR and other indicators.

NLPR

N and L are involved in inflammatory processes, and viral infection causes vascular disease and tissue destruction through the interaction between PLT and N to further drive the inflammatory process. Therefore, NLPR is a more accurate indicator of inflammation than using N, L, and PLT alone. Some studies have found that NLPR was associated with severe illness and increased mortality in COVID-19 patients.[38] Another study demonstrated that the NLPR value was higher in severely ill patients, and NLPR (AUC = 0.706) had good predictive value in judging the severity of COVID-19, which was basically in line with the results of our study (AUC = 0.721).[39]

SIRI, SII and AISI

SIRI, SII, and AISI are related to N, M, PLT, and L counts, providing a comprehensive assessment of the relationship between the body's immune and inflammatory states. Some studies have shown that these indicators were associated with increased mortality and disease severity from COVID-19, and that patients who developed ARDS, required intensive care, and died have higher SIRI, AISI, and SII values.[38,40,41] Our study also provided evidence that these indicators were associated with worsening disease severity in COVID-19 in patients with T2DM ($P < 0.001$). When the truncation value of AISI was 719.82, the prediction specificity was as high as 90%.

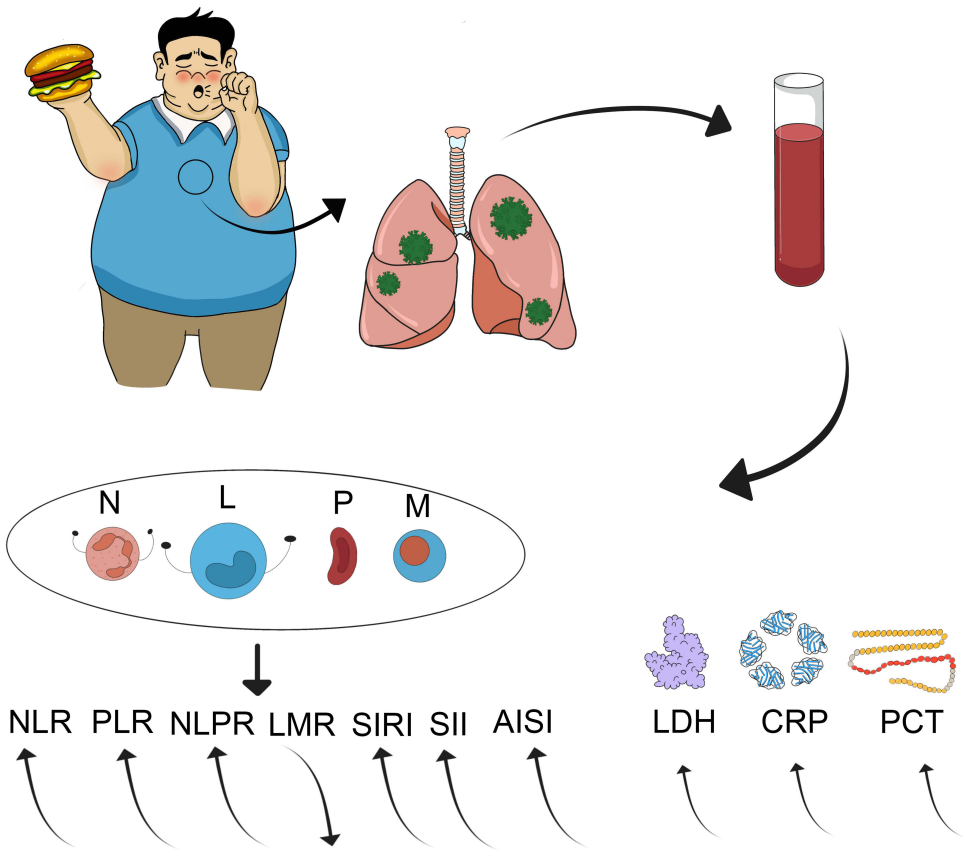

Figure 4 Molecular biomarkers and their role in assessing the severity of COVID-19 in patients with T2DM. This figure provides a visual overview of key molecular biomarkers relevant to the assessment of COVID-19 in patients with T2DM, highlighting their importance and potential utility in early diagnosis and surveillance of the disease.

Abbreviations: N, neutrophils; L, lymphocytes; P, platelet; M, monocyte; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; LMR, lymphocyte-to-monocyte ratio; NLPR, neutrophil to lymphocyte × platelet ratio; SIRI, Systemic inflammatory Response Index; SII, Systemic Immune Inflammatory Index; AISI, Systemic inflammatory Composite Index; PCT, procalcitonin; CRP, C-reactive protein; LDH, lactate dehydrogenase.

LDH, CRP, PCT

A meta-analysis of 32 studies found that a number of indicators related to poor outcomes for hospitalized COVID-19 patients. These markers included such as PCT, LDH, ALT and Cr. In the latest version of the guidelines, LDH, CRP and PCT are also mentioned as heavy/critical early warning indicators.[9] In this study, there were statistical differences in LDH, CRP, PCT and AST between the severe group and the mild group ($P<0.05$), and the abnormalities of these laboratory indicators indicated that patients with severe diseases were more likely to be complicated with secondary infection, obvious inflammatory response and obvious organ damage.[42,43] PCT was the best predictor of disease severity (AUC = 0.83).

This study has some limitations that should be acknowledged. First, it was a retrospective analysis, which may limit the generalizability and validity of the results. Second, the relatively small sample size may affect the statistical power and reliability of the results. Third, we did not compare the effects of these markers in patients with COVID-19 and those without COVID-19. Despite these limitations, the study has its merits. This was the first study to comprehensively compare the value of multiple blood routine-derived indicators and LDH, CRP, and PCT in predicting disease severity in patients with COVID-19 combined with T2DM.

Conclusion

Our results suggested that the ratio of neutrophil to lymphocyte, platelet-to-lymphocyte ratio, neutrophil to lymphocyte × platelet ratio, lymphocyte ratio to monocyte, systemic inflammatory response index, systemic inflammatory index, systemic inflammatory composite index, procalcitonin, C-reactive protein and lactate dehydrogenase can help to rapidly identify high-risk groups in COVID-19 in patients with type 2 diabetes (Figure 4). In addition, these indicators are inexpensive and readily available, helping clinicians to assess patients' immunoinflammatory status more quickly, so as to quickly screen patients in need of attention, and better to take appropriate measures to improve symptoms and reduce patient mortality.

Ethics Statement

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethics Review Committee of the First Hospital of Hohhot (Ethics number: KYLL-2023-159). Informed consent was obtained from all subjects.

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Author Contributions

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Disclosure

The authors report no conflicts of interest in this work.

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