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RESEARCH ARTICLE

Evaluation on the diagnostic model of COVID-19 by comparing the features of SARS-COV-2 infection with other viral infections

Qian Zhang[1,*], Siyi Lei[1,*], Lei Luo[2,*], Tingting Xiong[1], Li Long[1], Xianwei Ye[3,#], Hong Peng[1,#], Xinhua Luo[1,#]

[1] *Department of Infectious Diseases, Guizhou Provincial People's Hospital, Guiyang, Guizhou 550002, China*
[2] *Good Clinical Practice Center, Guizhou Provincial People's Hospital, Guiyang, Guizhou 550002, China*
[3] *Department of Respiratory and Critical Care Medicine, Guizhou Provincial People's Hospital, Guiyang, Guizhou 550002, China*

[*] These authors contributed equally to this work.
[#] Correspondence: Xianwei Ye, Hong Peng, Xinhua Luo
E-mail: yxw1205@163.com, penghonggz@126.com or Luoxinhua1972@126.com
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Coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection has become a global pandemic. The purpose of our study was to compare the clinical characteristics of SARS-CoV-2 infection with other viral infections in the suspected COVID-19 patients and attempted to explore an ideal diagnostic model of COVID-19. A total of 60 viral pneumonia patients were selected from 86 suspected patients and then assigned into the COVID-19 group (19 cases) and other viral infection group (41 cases). The blood test results, biochemical indexes, and chest computed tomography (CT) scanning changes were compared and analyzed. These 60 patients were mainly young and middle-aged men, of which 60% were infected with influenza virus and 31.6% were infected with SARS-COV-2. There were statistical differences in blood cell count and blood biochemistry indexes between the two groups. The lung lesions of COVID-19 patients were mainly bilateral nodule or appeared to be patchy and ground glass shadowed, while most of the lung lesions caused by other viral infections were mainly unilateral patchy shadow ($P < 0.05$). We found a new multi-marker PTG, which was composed of platelet to neutrophil ratio (PNR), total bilirubin (TBIL), and ground-grass density. The area under receiver operator characteristic curve (AUC) of PTG was 0.908, with the sensitivity of 73.17% and specificity of 94.44%. The ratio of blood routine to its subgroup and chest CT were considered to be an important reference for differential diagnosis. PTG showed high specificity and sensitivity in the early differential diagnosis of COVID-19 and other viral pneumonia, which had a significant clinical value.

Keywords: COVID-19, viral pneumonia, influenza virus, clinical features, diagnostic model

Abbreviations: COVID-19, Coronavirus disease 2019; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; PNR, platelet to neutrophil ratio; TBIL, total bilirubin; AUC, area under receiver operator characteristic curve; CT, computed tomography; ICTV, International Committee on Taxonomy of Viruses; WHO, World Health Organization; RSV, respiratory syncytial virus; ADV, adenovirus; FluA, influenza A virus; FluB, influenza B virus; PFlu, parainfluenzavirus; MP, Mycoplasma pneumonia; CP, Chlalmydia pneumoniae; CoxB, Coxsackie virus type B; CoxA, Coxsackie virus type A; LP, legionella pneumophilia; PCR, polymerase chain reaction; ROC, receiver operator characteristic curve; NLR, neutrophil to lymphocyte ratio; LMR, lymphocyte to monocyte ratio; PNR, platelet to neutrophil ratio; PTG, PNR+ TBIL+ ground-glass density shadows; CRP, C-reactive protein; PCT, procalcitonin; ESR, erythrocyte sedimentation rate; ESR, erythrocyte sedimentation rate; PPV, positive predictive value; NPV, negative predictive value; ACE2, angiotensin-converting enzyme 2.

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Introduction

In December 2019, a pneumonia outbreak of unknown etiology was reported in Wuhan, Hubei province, China. Later, a novel coronavirus was isolated from the respiratory epithelium of those patients [1-2]. On 31st, Jan 2020, the World Health Organization (WHO) declared this ongoing outbreak as a global health emergency [3]. This novel coronavirus was officially named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by the International Committee on Taxonomy of Viruses (ICTV) on 11 February 2020[4]. Soon later, WHO designated this pandemic caused by SARS-CoV-2 infection as Coronavirus Disease 2019 (COVID-19)[5]. Up till now, China has published the seventh edition of guidelines for the diagnosis and treatment of novel coronavirus (2019-nCoV) infected pneumonia [6], which has provided a scientific guidance in terms of etiology, diagnosis, and treatment. However, there is a lack of clear illustration and comparative study on the identification of other viral infections in the COVID-19 suspected patients.

Since the outbreak of COVID-19, more than 1 million confirmed cases have been reported globally by 9th April, 2020, and the cumulative number of confirmed cases in China was 81,907[7]. COVID-19 has rapidly evolved into a sweeping pandemic, which has affected more than 80 countries including Italy, Iran, Spain, Germany, and America, and a large number of suspected cases remain to be diagnosed. Thus, it is urgent to find efficient and feasible diagnostic criteria to advance the early screening, diagnosis, and differential diagnosis of suspected cases. It is beneficial to provide timely treatment for patients and also save more medical resources. On the other hand, the outbreak time of COVID-19 is the flu season. Due to similar clinical symptoms such as fever and cough, it is more difficult to identify SARS-CoV-2 and common influenza virus. Disease progress and delayed diagnosis were independent variables for mortality [8]. Thus, timely identification and diagnosis are essential to the COVID-19 patients. This study made a statistical analysis of the pathogen distribution and laboratory indicators of suspected COVID-19 patients to compare the clinical characteristics of confirmed COVID-19 patients with pneumonia patients infected by other virus. Also, this study sought to establish an ideal diagnostic model of COVID-19.

Patients and Methods

This retrospective study included 86 patients who were under medical observation or hospitalized in Guizhou Provincial People's Hospital from January to February and obtained the materials and documents of their first medical examination. The diagnosis was conducted according to the diagnostic criteria quoted from the Diagnostic Plan on Novel Coronavirus Disease-1-5 Edition. Patients who came back from travel or made close contact with confirmed patients, as well as patients with respiratory symptoms of fever and cough were all included in this study. Chest computed tomography (CT) scan and SARS-CoV-2 nucleic acid reverse transcription-polymerase chain reaction (RT-PCR) analysis were performed on the patients. Samples were collected from different parts of the patient, and the patient was determined as a confirmed case if the sample from any part showed twice positive reactionsto nucleic acid test. A total of 19 patients were diagnosed as COVID-19 by using the above method. Meanwhile, we also used respiratory tract 11-items detection reagent kits to measure the serum levels of IgM antibody of atypical respiratory pathogens, including respiratory syncytial virus (RSV), adenovirus (ADV), influenza A virus (FluA), influenza B virus (FluB), parainfluenzavirus (PFlu), Mycoplasma pneumonia (MP), Chlalmydia pneumoniae (CP), Coxsackie virus type B (CoxB), Coxsackie virus type A (CoxA), and legionella pneumophilia (LP). FluA and FluB nucleic acid test and Epstein-Barr (EB) virus DNA test were performed on the 86 patients, and it was found that 41 of them were infected by other virus. The blood test results, biochemical indexes, and chest CT scan of the two groups of patients were compared and analyzed. All data were enrolled and inspected by two doctors from the infection department. This study was approved by Guizhou Provincial People's Hospital Ethics Committee. Informed consent was waived because of the retrospective nature of the study and the anonymous clinical data.

The patents were grouped into suspected cases and confirmed cases. According to the prevention and control program of COVID-19 as well as the guidelines for the diagnosis and treatment of COVID-19, the patient who experienced any of the following epidemiological histories was defined as a suspected case: 1. once traveling to Wuhan or its surrounding regions, or visiting and living in communities where there were patients with fever or respiratory symptoms in the 14 days before the history of epidemiology; 2. having contact with COVID-19 nucleic acid-positive cases; 3. having contact with patients from Wuhan or its surrounding regions, or from communities where there were patients with fever or respiratory symptoms; 4. clustering with COVID-19. The patient without definite epidemiological history but meeting any of the following two or three clinical manifestations was also defined as a suspected case: 1. having fever or respiratory symptoms; 2. having radiographic features of COVID-19; 3. the total number of leukocyte and the lymphocyte count remained normal or decreased at early stage of the disease. The suspected cases who showed positive for COVID-19 nucleic acid twice in RT-PCR were defined as confirmed cases.

Statistical Analysis

Data were processed and analyzed using Excel, SPSS 25.0, and MedCalc 15.6. The measurement data were presented in interquartile range (IQR) and analyzed using the non-parametric test. The enumeration data were presented in n (%) and compared using the X2 test. Receiver operator characteristic (ROC) curves and the area under the ROC curve (AUC) were used to evaluate the diagnostic values of PTG, platelet to neutrophil ratio (PNR), lymphocyte to monocyte ratio (LMR), C-reactive protein (CRP), monocyte, and total bilirubin (TBIL) in COVID-19. The cutoff point that optimized the sensitivity and specificity was selected for the subsequent prediction. Univariable and multivariable logistic

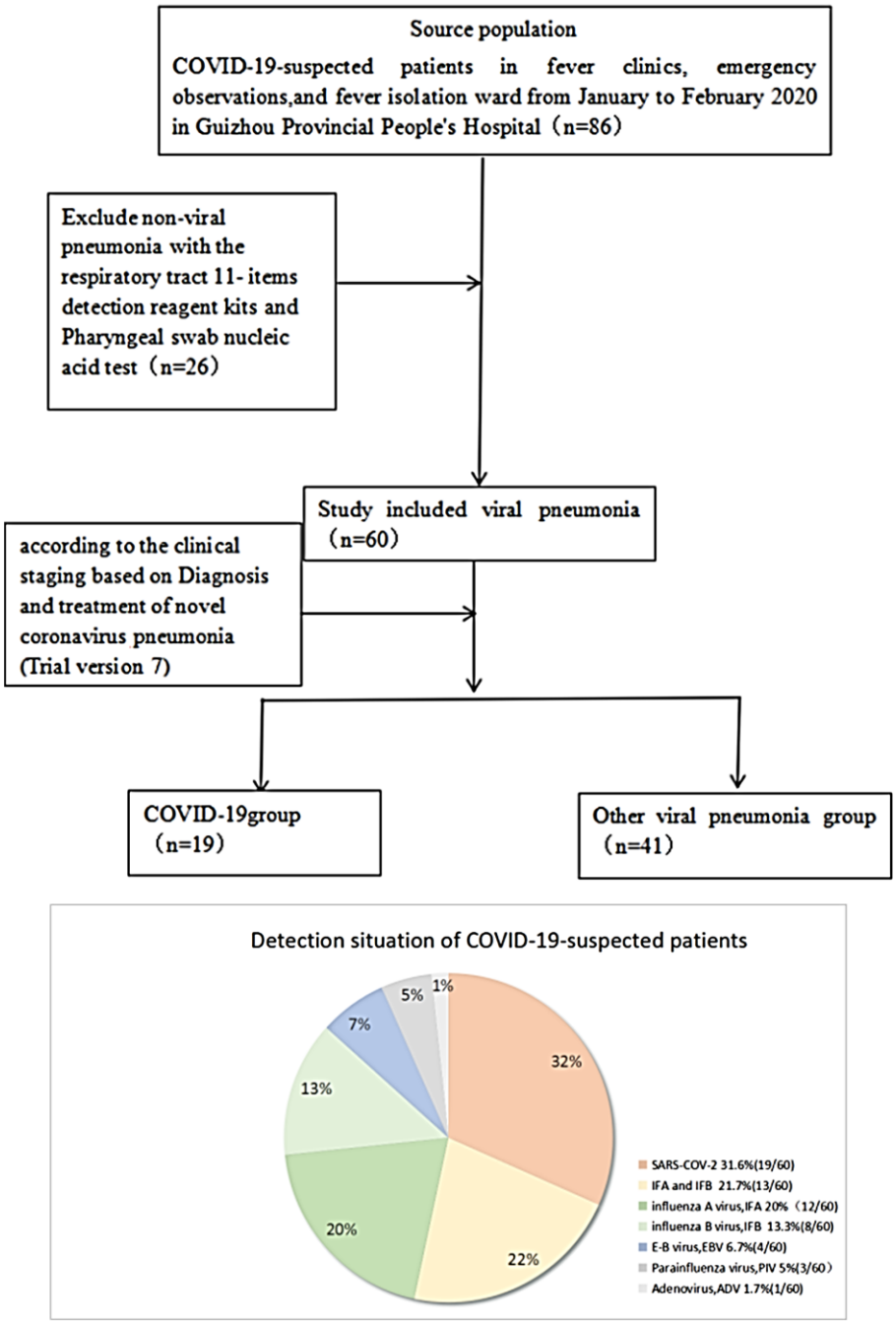


Figure 1. Screening process of COVID-19-suspected patients and etiology factors.

regression analyses were conducted to evaluate the magnitude and significance of the correlation. A two-sided P value＜0.05 was considered statistically significant. Graphics were illustrated using Graphpad prism 6.0.

Results

1. Demographic and etiological characteristics of patients with viral pneumonia and their laboratory examinations

After the examination of the 86 COVID-19-suspected patients, 26 non-viral infection patients were excluded. Finally, 19 patients were diagnosed as COVID-19 infection and 41 patients were infected with other viruses. The screening process of COVID-19-suspected patients is shown in Figure 1, and the specific etiology of viral pneumonia in these patients was determined. The

Table 1. Demographics and baseline characteristics of viral pneumonia patients.

Characteristics	All patients (n = 60) (95%CI)	Normal Range
Age(years)	53.0 (39.8-58.7)	
Men	36 (60%)	
Women	24 (40%)	
White blood cell count, × 10^9/L	5.5 (5.03-8.04)	3.5-9.5
Neutrophil count, × 10^9/L	3.9 (3.5-6.3)	1.8-6.3
Lymphocyte count, × 10^9/L*	1.0 (0.8-1.4)	1.1-3.2
Monocyte count, × 10^9/L	0.4 (0.3-0.6)	0.1-0.6
Platelet count, × 10^9/L	205.0 (198.7-275.9)	125-350
Lactate dehydrogenase, U/L	236.5 (191.0, -291.3)	120-250
Erythrocyte sedimentation rate mm/h*	48.0 (33.3-56.4)	2-20.9
C-reactive protein, mg/L*	24.4 (19.8-74.7)	0-5
Procalcitonin, ng/mL*	0.06 (0.06-0.11)	0-0.046
Interleukin-6, pg/mL*	20.5 (14.3-54.2)	0-7
Albumin, g/L	41.4 (39.1-43.4)	40-55
Alanine aminotransferase, U/L	34.0 (26.4-50.8)	9-50
Aspartate aminotransferase, U/L	28.0 (20.4-60.2)	15-40
Total bilirubin, mmol/L	14.0 (12.5-16.8)	3.4-20.5
CD3+ T cell, /uL	796.0 (704.4-1258.6)	770-2860
CD4+ T cell, /uL*	384.0 (315.0-583.7)	500-1440
CD8+ T cell, /uL	372.0 (335.0-630.6)	238-1250
CD4: CD8	1.1 (0.9-1.4)	1-2.47

Note: Laboratory test did not include the baby assessed. *The test results were beyond the normal range.

etiological distribution showed that the proportion of influenza virus infection was the highest, accounting for 60% (33/60), followed by SARS-CoV-2 infection, accounting for 31.6% (19/60) (shown in Figure 1). This study included 60 patients with viral pneumonia, including 36 men and 24 women, with an average age of 53 years. The lymphocyte count was 1.0 × 10^9/L, lower than the normal range, while other blood routine indexes were within the normal range. Infection indexes such as erythrocyte sedimentation rate (ESR), CRP, procalcitonin (PCT), and interleukin (IL)-6 distinctively exceeded the normal range. The liver function indexes were within the normal range. CD4+ T cell count was obviously lower than the normal range (384.0/uL) (shown in Table 1).

2. Clinical features of patients with COVID-19 and other viral pneumonia

Generally, male viral pneumonia patients outnumbered female ones (36:24). However, the gender ratio stayed approximately even in the COVID-19 group (10:9). Besides, most of the patients were young and middle-aged (44 [25, 58] in the COVID-19 group VS 41 [27.5, 51] in the other viral pneumonia group). In terms of liver functions, the TBIL level of patients in the COVID-19 group was obviously higher than that of patients in the other viral pneumonia group (15.10 [11.85, 18.40] mmol/L VS 11.55 [9.08, 14.70] mmol/L) (P = 0.036). For CD cell count, the number of CD3+ T cells in COVID-19 patients was lower than the normal level (748 [390, 1520]/uL VS 1068 [628, 1220]/uL); the number of CD4+ T cells in both groups was lower than the normal level (354 [180, 680]/uL VS 452 [296, 592]/uL); the CD8+ T cell count and the CD4/CD8 ratio in the two groups remained at the normal level and no statistical difference was observed (shown in Figure 2).

We compared the blood routine examination results and found that there were statistical differences between the two groups in leukocytes, neutrophils, monocytes, and blood platelets. Although there was no statistical difference in lymphocytes between the two groups, but the level of lymphocytes in the COVID-19 group was lower than the average level of lymphocytes in the other viral pneumonia group (0.95 [0.64, 1.39] ×10^9/L). We found significant statistical differences in neutrophil to lymphocyte ratio (NLR), LMR, and PNR between the COVID-19 group and other viral pneumonia group. By comparing CRP, PCT, and IL-6, it was found that the level of inflammatory responses in the COVID-19 group was higher than that in the other viral pneumonia group (9.55 mg/L VS 66.56 mg/L in CRP; 0.05 ng/mL VS 0.17 ng/mL in PCT; 5.97 pg/mL VS 26.89 pg/mL in IL-6) (shown in Figure 3). There was no statistical differences in platelet to lymphocyte ratio (PLR), ESR, and lactate dehydrogenase (LDH) between the two groups.

By comparing the radiological features, we found that most of the COVID-19 patients [17/19 (89.5%)] presented bilateral lung lesions and close to pleura, while the lung lesions could either be unilateral [15/41 (36.6%)] or bilateral [26/41 (63.4%)] among the patients infected by other virus. For the features of lesions, the predominant pattern of lung lesions in COVID-19 patients were nodule or appeared to be patchy shadowed and ground-glass density shadowed, while in pneumonia patients infected with other viruses, the major pattern of lesions appeared to be patchy-shadowed. Other radiological features including obscure margin, partial consolidation, pulmonary interstitial changes, air-bronchial signs, increased lymph nodes, and pleural effusion had no

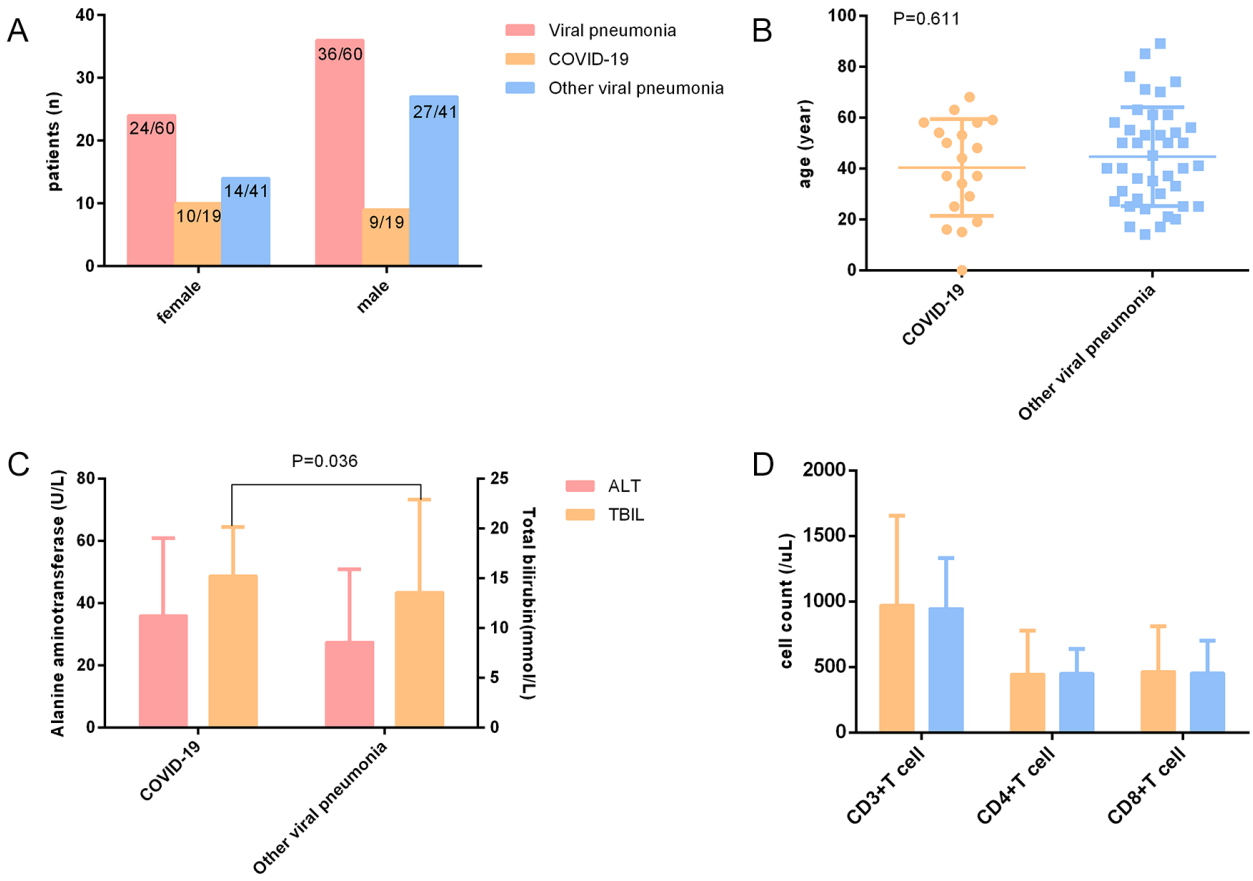


Figure 2. Gender (a) and age (b) distribution in patients with viral pneumonia; comparison of ALT, TBIL (c) and CD cell counts (d) between the patients with COVID-19 and other viral pneumonia.

statistical difference between the two groups (shown in Table 2).

3. Diagnostic value of clinical indexes in COVID-19

The analysis of patients at admission showed that there were significant differences in blood routine, blood biochemistry, and imaging changes between the two groups. The disparity index concerning leukocyte and the probability of ground glass opacity shown in the images were screened by univariable logistic regression analysis. The collinearity diagnosis of the indexes above showed that the VIF of leukocyte and neutrophil were 44.256 and 41.975 respectively. Thus, multivariable logistic regression analysis should be excluded due to the existence of multicollinearity. We optimized the combination of the indexes above and acquired three disparity indexes: PNR as well as the ground glass opacity by adapting multivariable logistic regression analysis (shown in Table 3).

We used ROC curves to evaluate the diagnostic efficiency of those disparity indexes. The AUCs of TBIL, monocyte, CRP, LMR, and PNR were 0.688, 0.684, 0.741, 0.757, and 0.824 respectively. The sensitivity fluctuated between 58.54%-85.37%; the specificity fluctuated between 64.71%-88.89%; the positive predictive value (PPV) and negative predictive value (NPV) fluctuated between 48-64.7 and 82.9-92.3 respectively. The AUC of PTG (PNR+ TBIL+ ground-glass density shadow) was 0.908, with the cutoff value of 0.799, the sensitivity of 73.17%, the specificity of 94.44%, the PPV of 96.8, and the NPV of 60.7 (shown in Figure 4).

Discussion

As the surging number of people affected by the epidemic worldwide, coronavirus detection kits have become extremely important. Due to the shortage of medical resources and medical personnel and poor environmental and economic conditions, disease control and timely diagnosis may be enormous challenges faced by certain regions. The same problem has also extended to the diagnosis of suspected patients. Thus, earlier quarantine and diagnosis lead to less medical resources and treatment time.

This study involved 60 suspected patients. By comparing the clinical characteristics of suspected patients and confirmed patients, this study explored effective indexes to design convenient

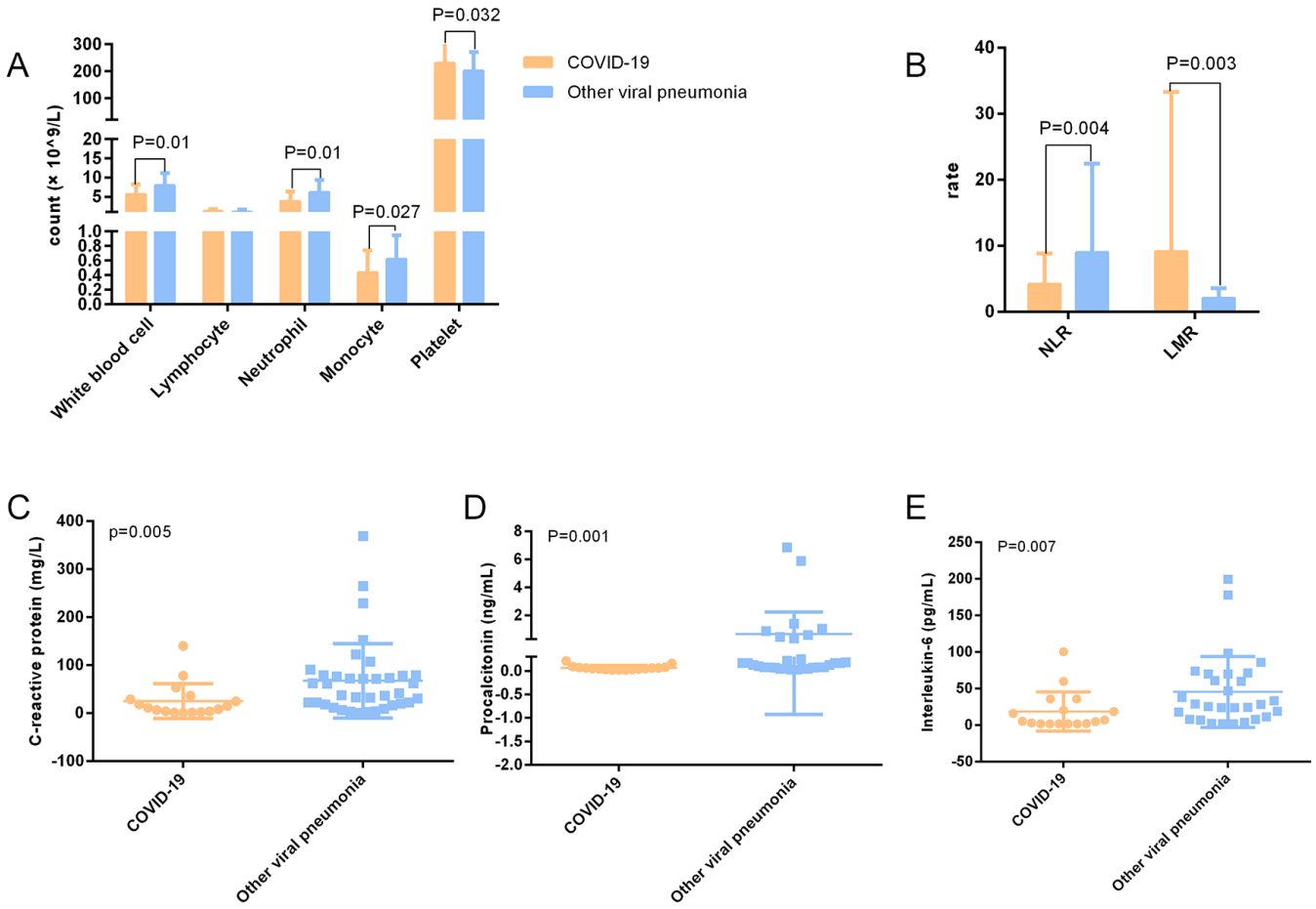


Figure 3. Comparison of blood routine indexes (a), blood cell subsets ratio (b), and infection indexes (c, d, e) between the patients with COVID-19 and other viral pneumonia. NLR, neutrophil to lymphocyte ratio; LMR, lymphocyte to monocyte ratio; PNR, platelet to neutrophil ratio.

and rapid diagnostic methods of COVID-19. These indexes could guide medical departments to timely pre-examine and quarantine suspected patients, especially in regions lacking nucleic acid test kits or facing economic difficulties. Also, they were considered as references for diagnosis and medical services.

From the perspective of demographic and etiological characteristics, most of the 60 suspected cases were young and middle-aged men. However, this study found no significant difference in the number of male and female patients (10:9), which might be due to the small number of cases involved or the pattern of infection. Previous studies found gender differences existing between sporadic cases and cluster cases. Specifically, the number of male patients in the sporadic group was higher, while the number of female patients was higher than that of male patients in the cluster group [9]. This may be one of the factors that make men more susceptible to infection. Thus, we need to focus on screening male suspected patients. In terms of age, the youngest COVID-19 patient was 58 days old and the oldest was 68 years old. It is suggested that COVID-19-infected people are widely distributed in age group, and general screening should be conducted for suspected cases. According to the etiology distribution, influenza virus ranked first and coronavirus ranked second among suspected cases. Some studies discovered that the common pathogens of viral pneumonia were influenza virus > coronavirus > parainfluenza virus > adenovirus > respiratory syncytial virus [10], which was consistent with the viral infection tendency in this study. This study found the T cell descending between the two groups of viral pneumonia patients, suggesting that patients from the two groups developed immunity degradation or immunity injury. Hence, it is essential to screen and diagnose the suspected patients in time. Some studies considered that the imbalance of immune response, especially T lymphocytes, might engage in the pathological process of COVID-19 to a large extent[11]. CD4+ and CD8+ cells were crucial to the immune response, and disordered immune response led to excessive inflammation or death[12]. The COVID-19 patients involved in this study showed an obvious decrease in CD3+ and CD4+ T cell counting, which verified the deduction of immunity response disorder in the pathogenesis of COVID-19.

Table 2. Comparison of lung CT features between two groups.

Chest CT imaging features	COVID-19 Group (n = 19, %)	Other viral pneumonia group (n = 41, %)	P*
Lesion distribution			
Unilateral lung*	2 (10.5%)	15 (36.6%）	0.037
Bilateral and close to pleura	17 (89.5%）	26 (63.4%）	
Radiographic changes			
Patchy shadow*	0	19 (46.3%)	0.000
Ground-glass density shadow*	13 (68.4%)	14 (34.1%)	0.013
Obscure margin	14 (73.6%)	26 (63.4%)	0.432
Consolidation shadow	1 (5.3%)	7 (17.1%)	0.416
Interstitial lung changes	0	2 (4.9%)	0.463
Air-bronchial signs	1 (5.3%)	8 (19.5%)	0.249
Increased lymph nodes	1 (5.3%)	4 (9.7%)	0.490
Pleural effusion	1 (5.3%)	5 (12.2%)	0.654

*$P<0.05$.

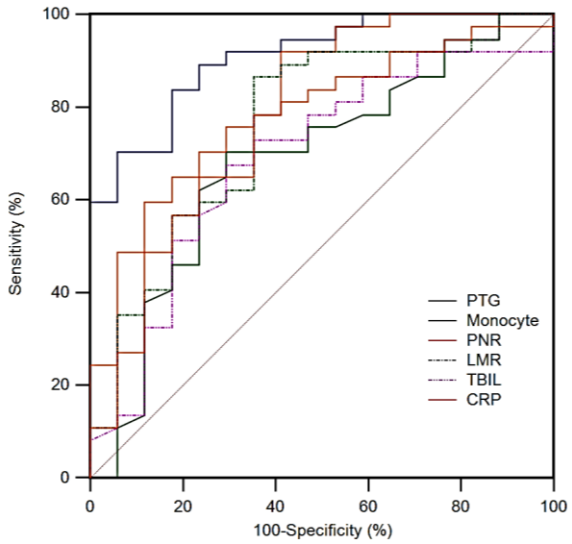
Table 3. Baseline variables associated with diagnosis of COVID-19.

Variables	OR	Univariable Analysis 95%CI	P	OR	Multivariable Analysis 95%CI	P
Gender	2	(0.625-5.953)	0.253	——	——	——
Age	1.006	(0.976-1.037)	0.697	——	——	——
White blood cell	1.453	(1.072-1.968)	0.016	——	——	——
Neutrophil	1.51	(1.081-2.110)	0.016	——	——	——
Platelet	0.995	(0.987-1.002)	0.165	——	——	——
Monocyte	9.016	(1.006-80.806)	0.049	——	——	——
NLR	1.191	(0.994-1.426)	0.058	——	——	——
LMR	0.659	(0.450-0.963)	0.031	——	——	——
PNR	0.943	(0.910-0.976)	0.001	0.921	（0.877-0.968）	0.001
C-reactive protein	1.02	(1.000-1.040)	0.046	——	——	——
Total bilirubin	0.272	(0.082-0.908)	0.034	0.097	（0.015-0.632）	0.015
Lesion distribution	0.217	(0.044-1.075)	0.061	——	——	——
Ground-glass density shadow	0.259	(0.08-0.838)	0.024	0.185	（0.035-0.986）	0.048

Abbreviations: NLR, neutrophil to lymphocyte ratio; LMR, lymphocyte to monocyte ratio; PNR, platelet to neutrophil ratio.

Liver damages caused by SARS-CoV-2 infection had been well-documented, and most studies ascribed liver damages to systemic inflammatory response, ischemia-hypoxia reperfusion injury, and drugs[13]. This study compared the liver functions of the two groups of patients and did not observe significant difference in enzymology index and synthesis function. However, the bilirubin level of patients in the COVID-19 group was distinctively higher than that in the other viral pneumonia group, although the bilirubin of both groups was within the normal range. The reasons for the bilirubin disparity between the two groups were considered to be relevant to the specific binding of SARS-CoV-2 with angiotensin-converting enzyme 2 (ACE2) and the high expression of ACE2 in the bile duct[14]. These findings contribute to identifying SARS-CoV-2 and protecting against other viral infections. Meanwhile, we need to pay more attention to the changes of during treatment.

This study also found that there were numeral differences in leukocytes, neutrophils, monocytes, and blood platelets between the COVID-19 patients and pneumonia patients infected by other viruses, while there was no difference in lymphocyte count.. Some studies found that the number of neutrophils was relatively increased and the number of lymphocytes was decreased in the



Variables	AUC	95% CI	cut off	Sensitivity (%)	Specificity (%)	+PV	-PV
PTG	0.908	0.797 - 0.969	0.799	73.17	94.44	96.8	60.7
PNR	0.824	0.696 - 0.914	40.941	58.54	88.89	92.3	48.5
LMR	0.757	0.621 - 0.863	3.088	85.37	61.11	83.3	64.7
CRP	0.741	0.604 - 0.851	18.03	78.38	64.71	82.9	57.9
Monocyte	0.684	0.544 - 0.804	0.425	73.17	66.67	83.3	52.2
TBIL	0.688	0.548 - 0.807	13.3	65.79	70.59	83.3	48

Figure 4. Figure 4 Receiver operator characteristic curves of baseline PTG, PNR, CRP, LMR, monocyte, and TBIL on the diagnosis of COVID-19. PTG, PNR+ TBIL+ Ground-glass density shadows; PNR, platelet to neutrophil ratio; CRP, C-reactive protein; LMR, lymphocytes to monocytes ratio; TBIL, total bilirubin.

patients with influenza virus infections, which was distinctive from regular viruses such as adenovirus, respiratory syncytial virus, EB virus, HHV-6, and enterovirus[15-16]. This study found that the number of leukocytes, neutrophils, and monocytes of COVID-19 patients was lower than that of pneumonia patients mainly infected by influenza virus, but no significant difference was observed in the number of lymphocytes. Also, studies showed the PLT count of patients with positive influenza virus test was obviously lower than that of patients with negative influenza virus test. However, the PLT resumed to the normal level as the patients recovered. These findings indicated that the reduction of PLT count could distinguish influenza virus infection from other infections, with certain sensitivity and specificity[17]. In this study, we also found statistical differences in PLT between the two groups. The pneumonia patients mainly infected by influenza virus showed an obvious descending of PLT. Influenza virus can lead to uncontrolled platelet activation, thereby causing inflammatory responses harmful to the respiratory tract. It was presumed that influenza virus overactivated blood plateles and led to an obvious descending of blood platelet count[18-21]. A series of indexes reflecting immunity and inflammation were derived from blood platelet count. For example, relevant studies had been conducted in the fields of tumor, bacteria, and virus in terms of NLR, LMR, and PNR[22-23]. NLR was elevated distinctively in the critical patients with COVID-19 infection[11], while the increase of NLR was also detected in the influenza virus-infected patients[17]. We found that the increase of NLR was not as obvious in COVID-19 patients compared with other viral pneumonia patients. LMR appeared to be highly sensitive and specific for the diagnosis of viral influenza infections when it was less than 2[24]. So far, there was no relevant report on LMR in COVID-19 patients yet. Our study found the elevated LMR in COVID-19 infection in comparison with other viral infections. While the LMR was indeed less than 2 in pneumonia patients mainly infected by influenza virus. This index would help us conduct a preliminary screen on COVID-19 out of other viral infections, especially influenza virus infections. PNR, as another inflammation index, was increased rapidly in viral infections than in bacterial infections[16]. Our study also revealed that PNR in COVID-19 was higher than that in other viral infections. Moreover, PNR was an alternative index to identify SARS-CoV-2 against other viral and bacterial infections. To conclude, blood cell count analysis was an efficient, reliable, and

rapid diagnostic method to evaluate and identify infectious inflammatory responses. Since all hospitalized patients, including patients with respiratory infections, were required to receive blood routine examination, it was easy to calculate NLR, LMR, and PNR from the results. Therefore, we could make a preliminary diagnosis of the type and and severity of infection through blood routine examination. Moreover, the commonly used clinical infection indexes such as CRP, PCT, and IL-6 showed significant differences between the two groups. Considering the infection indexes disparities between the two groups, the author reckoned that the patients with other virus infections had more severe inflammation than patients with COVID-19.

As an important detection method for COVID-19 patients, radiology can reflect lung lesions and evaluate the progress of the disease, which bears significant values in early screening, identification, and assessment of disease severity. Based on chest CT scans of the 60 enrolled patients, this study found that the lung lesions evolved to bilateral and subpleural areas in most of the COVID-19 cases, mainly manifested as nodular or patchy ground grass shadow. In pneumonia patients infected with other viruses, the lung lesions located either unilaterally or bilaterally and mostly appeared to be patchy shadow. These characteristics help to distinguish COVID-19 patients from other viral pneumonia patients at an early stage.

Subsequently, we evaluated the diagnostic value of clinical indexes mentioned above by ROC curve and confirmed that the blood routine or biochemical indicators were valuable diagnostic indexes to a certain extent. The coalitional diagnosis of PTG (PNR + TBIL + ground-glass shadow) was conducted through univariable and multivariable regression analysis. Compared with other indexes, PTG had the largest AUC and could be used as an ideal diagnostic model for the early COVID-19 screening in clinical practice due to its ideal specificity and PPV. Moreover, all indexes mentioned above could be obtained from regular medical examinations. So, this model could be extensively applied in areas with limited medical resources or underdeveloped areas.

This study was the first to analyze suspected COVID-19 patients and compare the characteristics of confirmed COVID-19 patients with other viruses-infected patients. We aimed to present an idea model for the early screening and diagnosis of suspected COVID-19 patients in case of limited medical resources. The ratio of blood routine to its subgroup and chest CT scan were of certain value in identifying the type of virus infection. Moreover, the PTG composed of PNR, TBIL, and typical ground-glass shadow had significant value in the early identification of COVID-19 patients. The preliminary diagnosis of COVID-19 could be based on basic medical examinations, which was accessible in areas with limited medical resources and insufficient nucleic acid kits. Early diagnosis of the suspected COVID-19 patients, including some asymptomatic patients with a history of epidemiology, was of great value to clinical practice and enabled disease control to be carried out at a low cost of social resources. This study also had some limitations. Bias might exist due to the limited number of cases collected. Additionally, most of the confirmed COVID-19 patients enrolled were the second or third generation of infection outside Wuhan city, which might be different from the first generation of infection. Therefore, large-scale external validations of clinical cases were required to help clinical doctors better understand COVID-19 and conduct timely quarantine and treatment so as to contain the spread of COVID-19.

Trail Registration and Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by Guizhou Provincial People's Hospital Ethics Committee.

Patient Consent for Publication

Before enrollment, all patients were informed fully and written informed consent was obtained from the patients for the publication of clinical information.

Availability of Data and Material

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Conflicting Interest

No conflicts of interest exist.

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