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Relationship between Inflammatory Cytokines and Hematological Parameters for Infection Severity in Cases of *Klebsiella pneumoniae* Infections in Samarra City, Iraq

Waser saad khalaf *

Department of field crop, College of Agriculture, University of Samarra, Iraq.

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Abstract

Background: Infections caused by *Klebsiella pneumoniae* have been identified as one of the most significant opportunistic bacterial infections in causing inflammation and hematological complications. The pathogen causes lung, urine tract, blood, and wound infections in immune-compromised individuals.

Objective: This study was conducted to explore the relationship between cytokine levels, hematological factors, and infection severity in patients infected with *Klebsiella pneumoniae* in Samarra, Iraq.

Methods: Cross sectional study was done on 100 patients where 70 of them suffered from *Klebsiella pneumoniae* infection while rest 30 patients served as control group. Blood sample of all participants were tested for assessment of inflammatory cytokines such as IL-6, TNF-α, CRP along with hematological tests like WBC count, % neutrophils, % lymphocytes, hemoglobin, platelets, ESR, and NLR, Statistical analysis was done using SPSS version 26.

Results: The patients harboring *K. pneumoniae* exhibited significant increases in IL-6, TNF-α, CRP, white blood cell counts, neutrophil percentage, ESR, and NLR, whereas hemoglobin concentration and lymphocyte percentage were decreased significantly. Patients with severe infections had much higher levels of inflammatory cytokines and alterations in their blood compared to those with moderate infections. There were positive associations between the concentration of cytokines and infection severity scores.

Conclusion: Increased inflammatory cytokine levels and changes in hematological parameters play an important role in the severity of infection by *Klebsiella pneumoniae*. Such parameters can be used to predict the development of disease.

Keywords: *Klebsiella pneumoniae*; Cytokines; Hematological indices; IL-6; TNF-α; Infection severity; Iraq

1. Introduction

Infection caused by *Klebsiella pneumoniae* is a Gram-negative opportunist which is known to be a causative agent of nosocomial infections on a global scale[1]. It can lead to the development of various diseases such as pneumonia, urinary tract infections, septicemia, and wound infections. This organism often leads to nosocomial infections because of the emergence of multidrug-resistant strains. [2].

The infectivity of *Klebsiella pneumoniae* has been linked to the capsular polysaccharides, lipopolysaccharides, siderophores, and biofilm-forming properties that allow for evasion of host defense[3]. The infection with this bacteria results in a strong inflammatory response with high levels of cytokines including interleukin-6 (IL-6) and tumor

* Corresponding author: Waser saad khalaf

necrosis factor alpha (TNF-a)[4]. These inflammatory mediators play a major role in causing tissue injury and contributing to disease severity[5].

Hematological changes are also frequently observed in bacterial infections. Hematological parameters such as white blood cells count, neutrophil to lymphocyte ratio (NLR)[6], erythrocyte sedimentation rate (ESR), and platelet count are valuable predictors for measuring inflammation in systemic infections[7]. Recently, several studies have shown that a combination of inflammatory and hematological markers might improve diagnosis and prognosis prediction [8].

Although infections caused by *K. pneumoniae* have high clinical significance, few researchers have conducted studies regarding the combined role of cytokines, hematological parameters, and infection severity in Iraqi patients[9]. Hence, this research was conducted to assess the role of inflammatory cytokines and hematological factors in Samarra, Iraq, with respect to infection severity.

2. Materials and Methods

2.1. Study Design

A cross-sectional analytical study was conducted between October 2025 and February 2026 in Samarra General Hospital, Iraq.

2.2. Study Population

The sample comprised 100 subjects, 70 of which were infected with *Klebsiella pneumoniae* while 30 served as the control group. The infected subjects were confirmed through physical examination and the presence of bacteria obtained through cultures. Moreover, the infected subjects were categorized as having moderate or severe infections based on the intensity of their clinical and laboratory manifestations.

2.3. Inclusion Criteria

The research involved patients having a positive bacterial culture of *Klebsiella pneumoniae* infection aged between 18 and 70 years. The patients with any history of autoimmune disorders and malignancies were not included in the study to avoid any interference with inflammation and blood components.

2.4. Blood Sample Collection

Five milliliters of venous blood were collected aseptically from each participant for hematological and biochemical analyses.

2.5. Measurement of Cytokines

IL-6 and TNF-α concentrations in sera were measured by using ELISA kits as per manufacturers' instructions [10], whereas CRP concentrations were measured through the immunoturbidimetric method [11].

2.6. Hematological Analysis

Complete Blood Count (CBC) analysis was conducted using the automatic hematology analyzer in accordance with routine laboratory protocols. The obtained hematological values were as follows: WBC count, neutrophil percentage, lymphocyte percentage, hemoglobin level, platelets count, erythrocyte sedimentation rate (ESR), and neutrophil-to-lymphocyte ratio (NLR)[12]. Neutrophil-to-lymphocyte ratio (NLR) is defined as the absolute neutrophil count divided by the absolute lymphocyte count [13].

2.7. Statistical Analysis

Statistical analyses were carried out using SPSS software ver 26. Data were reported as mean ± SD. Group comparisons were done via One Way ANOVA and independent t-test. The Pearson correlation coefficient was used for assessing correlation. Statistical significance level was set at $p<0.05$.

3. Results

The demographics of the participants used in the experiment is presented in Table 1 and Figure 1. The study sample comprised of 100 people, out of which, 70 people had *Klebsiella pneumoniae* infection while the other 30 were taken

from healthy individuals. The average age of the healthy group was 42.3 ± 9.1, whereas that of the infected group was 44.8 ± 10.4. It can be said that both samples have almost similar age distribution. In terms of gender distribution, the healthy group had 18 males and 12 females, while the infected group had 41 males and 29 females.

Figure 1 Representative culture plate showing growth of *Klebsiella pneumoniae* colonies on blood agar medium

Table 1 Demographic Characteristics of Study Participants

Parameter	Control	Patients
Number	30	70
Age (years)	42.3 ± 9.1	44.8 ± 10.4
Male/Female	18/12	41/29

As seen in Table 2, there was a significant rise in the inflammatory marker levels in patients infected with *Klebsiella pneumoniae* compared to the controls. This indicated a gradual rise in the levels of IL-6, TNF-α, and CRP depending on the severity of the disease.

The patients with moderate infection had significantly elevated levels of IL-6 (24.5 ± 4.8 pg/mL), TNF-α (29.8 ± 5.2 pg/mL), and CRP (18.6 ± 3.1 mg/L) in comparison with the controls, whereas these levels were even higher for the patients with severe infections, being 46.3 ± 6.2 pg/mL for IL-6, 52.7 ± 7.1 pg/mL for TNF-α, and 37.5 ± 5.4 mg/L for CRP (with highly significant $p < 0.001$).

Table 2 Inflammatory Cytokines in Study Groups

Parameter	Control	Moderate Infection	Severe Infection	p-value
IL-6 (pg/mL)	7.2 ± 1.1	24.5 ± 4.8	46.3 ± 6.2	<0.001
TNF-α (pg/mL)	9.1 ± 1.5	29.8 ± 5.2	52.7 ± 7.1	<0.001
CRP (mg/L)	3.4 ± 0.8	18.6 ± 3.1	37.5 ± 5.4	<0.001

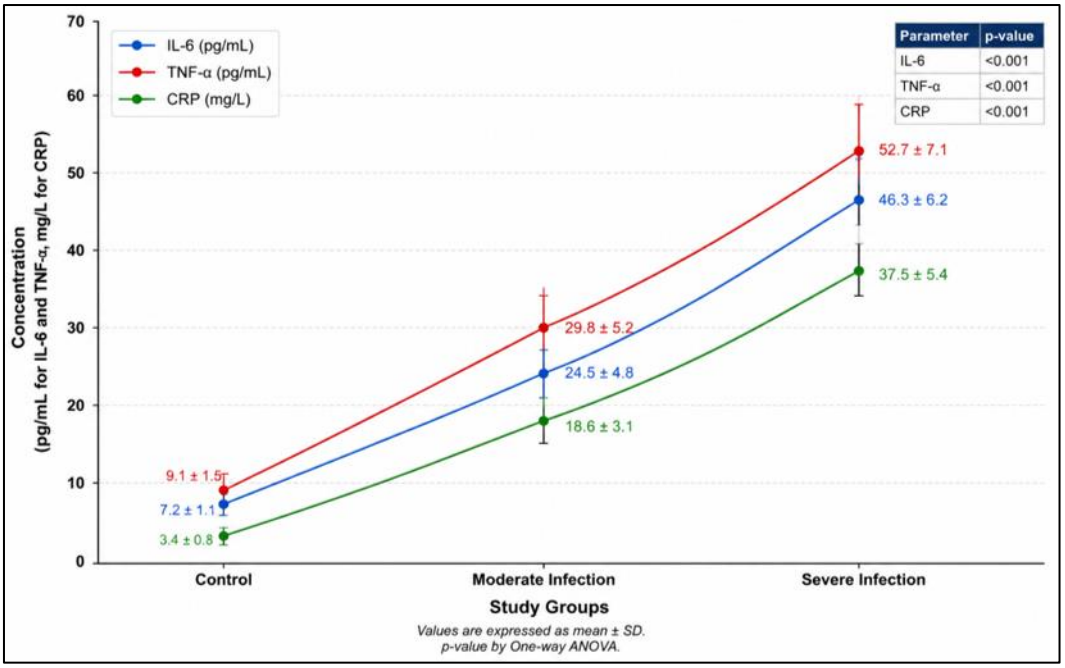

Figure 2 Serum inflammatory markers (IL-6, TNF-α, and CRP) across control, moderate, and severe *Klebsiella pneumoniae* infection groups

This is indicated in Table 3, where the hematological indices in patients infected with *Klebsiella pneumoniae* changed significantly compared to those in the control group. The level of the white blood cells (WBCs) was elevated sequentially, starting at 6.3±1.0 in the controls up to 11.7±2.3 in moderate infections and 16.4±3.5 in severe infections.

A significant rise in neutrophils was noted in controls with a value of 55.4 ± 4.2 and increased to 71.6 ± 5.3 and 82.1 ± 6.0 in moderate and severe infections, respectively. On the other hand, the percentage of lymphocytes reduced from 34.5 ± 3.7 in controls to 21.8 ± 2.8 and 13.6 ± .

There was a decline in hemoglobin concentration from 13.8 ± 1.1 in controls to 11.9 ± 1.0 in moderate infection and 10.4 ± 0.9 in cases of severe infections. The platelet concentration was elevated from 251 ± 28 in controls to 318 ± 41 in moderate infection and 372 ± 53 in cases of severe infections.

The ESR was elevated from 10.5 ± 2.4 in controls to 31.7 ± 5.6 in moderate infection and 54.2 ± 7.8 in cases of severe infections. There was also an increase in neutrophil-to-lymphocyte ratio (NLR) from 1.6 ± 0.4 in controls to 3.8 ± 0.7.

Table 3 Hematological Parameters in Study Groups

Parameter	Control	Moderate Infection	Severe Infection	p-value
WBC ($\times 10^9$/L)	6.3 ± 1.0	11.7 ± 2.3	16.4 ± 3.5	<0.001
Neutrophils (%)	55.4 ± 4.2	71.6 ± 5.3	82.1 ± 6.0	<0.001
Lymphocytes (%)	34.5 ± 3.7	21.8 ± 2.8	13.6 ± 2.4	<0.001
Hemoglobin (g/dL)	13.8 ± 1.1	11.9 ± 1.0	10.4 ± 0.9	<0.001
Platelets ($\times 10^9$/L)	251 ± 28	318 ± 41	372 ± 53	<0.001
ESR (mm/hr)	10.5 ± 2.4	31.7 ± 5.6	54.2 ± 7.8	<0.001
NLR	1.6 ± 0.4	3.8 ± 0.7	6.9 ± 1.2	<0.001

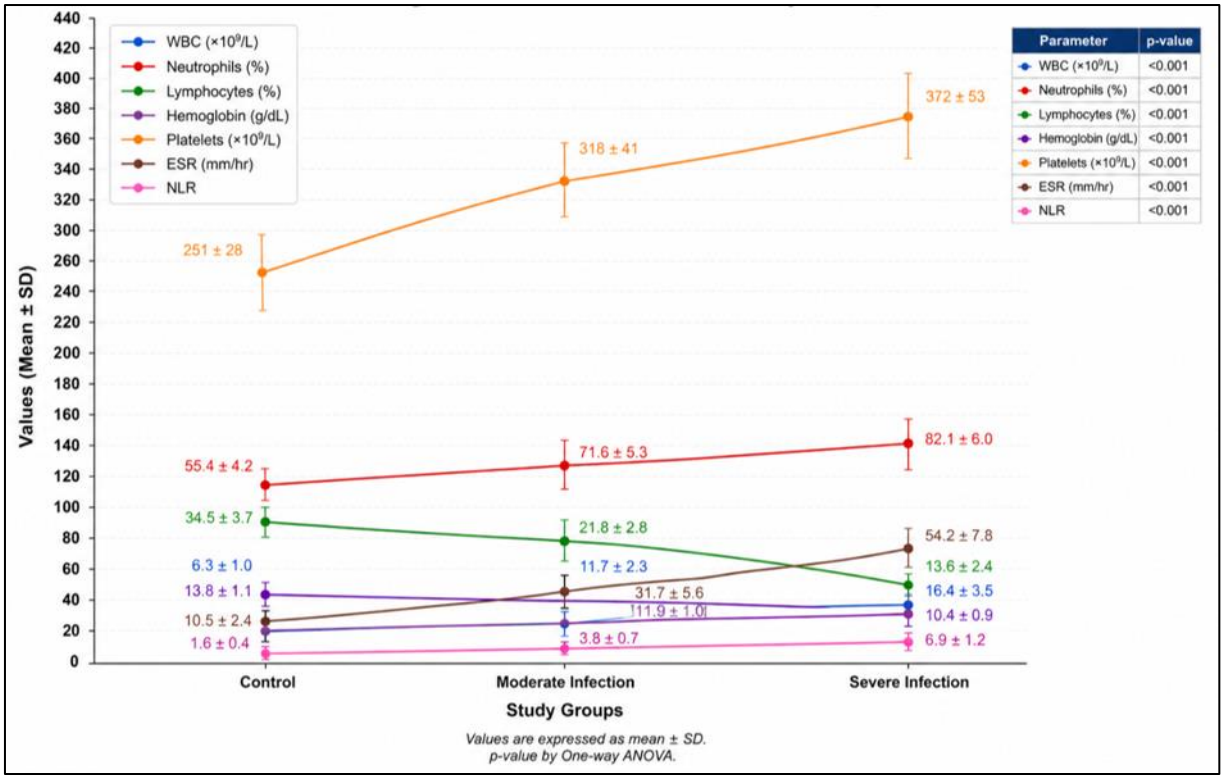

Figure 3 Comparative analysis of hematological biomarkers among control, moderate, and severe *Klebsiella pneumoniae* infection groups

From Table 4, there were apparent differences in the values of some of the haematological variables between the infected patients and the control group. There was an increment in WBC count for the moderate infections and an even higher increment in the severe infections. Neutrophils were found to increment progressively as the severity of infection escalated.

On the other hand, lymphocytes were noted to decrease in the moderate infections and a greater reduction was observed in the severe infections. The level of hemoglobin was lower in the moderate infections than in the severe infections.

There was a rise in platelets during moderate infection and a higher rise in case of severe infection. Similarly, ESR also rose during moderate infection and had an even higher elevation during severe infections. There is also a rising trend in NLR from moderate to severe infections as compared to controls.

Table 4 Additional variables in patients with *Klebsiella pneumoniae* Infection according to infection severity

Parameter	Control	Moderate Infection	Severe Infection	p-value
WBC (×10^9/L)	—	↑	↑↑	<0.05
Neutrophils (%)	—	↑	↑↑	<0.05
Lymphocytes (%)	—	↓	↓↓	<0.05
Hemoglobin (g/dL)	—	↓	↓↓	<0.05
Platelets (×10^9/L)	—	↑	↑↑	<0.05
ESR (mm/hr)	—	↑	↑↑	<0.05
NLR	—	↑	↑↑	<0.05

In Table 4, there are more hematologic and inflammatory factors for patients with *Klebsiella pneumoniae* Infection based on the degree of infection. As shown in the table below, there were significant changes observed in terms of WBC, percent neutrophils, percent lymphocytes, ESR, and NLR, all of which have $p<0.05$ values.

4. Discussion

The current investigation focused on the impact of Klebsiella pneumoniae infection on inflammation and hematology in patients and found that there were remarkable changes in inflammatory cytokines as well as hematological factors depending on the severity of the condition [14].

The elevated WBC count seen in the infected subjects shows a high physiological response to the presence of bacteria [15]. The changes observed for both factors increased with severity of the illness, meaning the greater the severity, the stronger the physiological response [16]. The rise in neutrophils accompanied by the reduction of lymphocytes was another indicator of change in leukocyte profile that depended on the severity of the disease [17].

The increased neutrophil to lymphocyte ratio (NLR) seen in this study also indicates the imbalance in the functioning of the innate immunity as compared to adaptive immunity[18]. The increasing pattern of NLR in moderate and severe infections shows that the ratio can be a useful quantifying indicator with respect to clinical conditions and infection intensity[19].

Hemoglobin levels in the patients showing infections were decreased in this study. The levels were found to be decreased in the severe category of patients. The results might suggest that severe infections lead to a greater level of hematological disorders[20][21]. On the other hand, platelets showed increasing trends with regard to disease severity [22].

Also, an elevation in ESR levels among those infected indicates there is systemic inflammatory activity present[23]. The gradual increase in ESR with increasing severity indicates that ESR may be indicative of inflammatory activity present in disease progression[24].

Generally, from the hematological parameters analyzed, there appears to be a trend between moderate and severe infections[25]. Individuals with severe infections were seen to have high WBC, neutrophilia, elevated platelet count, high ESR, and elevated NLR, along with low lymphocytes and hemoglobin [26].

These findings together show that hematological parameters offer valuable information on the status and level of infection in Klebsiella pneumoniae infection and could help in the evaluation of the disease [27].

5. Conclusion

Klebsiella pneumoniae infected patients demonstrated considerable alterations in inflammatory and hematological parameters that were significantly related to infection severity. High levels of IL-6, TNF-α, CRP, WBC, ESR, and NLR were major determinants of severe infection. These parameters can serve as useful diagnostic markers.

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