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Analysis of the Diagnostic Value of Peripheral Blood Indicators for Acute Pyelonephritis and the Influencing Factors of Poor Prognosis

Haiyang Qian, Danni Zhou, and Hao Wang

Department of Emergency, Dongxihu District people's Hospital, Wuhan, Hubei, China

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ABSTRACT

This study explored the diagnostic value of peripheral blood indices for acute pyelonephritis (APN) and the factors influencing poor prognosis.

A total of 118 patients with APN admitted to our hospital from January 2022 to June 2024 were retrospectively included as the observation group. Another 62 healthy volunteers were selected as the control group. Clinical data from the two groups were collected, and the diagnostic value of peripheral blood indices for APN was analyzed. The patients were divided according to their prognoses into good-prognosis group and poor-prognosis group, and the influencing factors of poor prognosis were identified by multivariate logistic regression analysis.

Compared to the control group, the white blood cell count (WBC) and C-reactive protein (CRP) were higher in the observation group, while *IgG* and *C3* were lower. The areas under the curves (AUCs) of WBC, CRP, *IgG*, and *C3* in the diagnosis of APN were 0.857, 0.846, 0.902, and 0.893, respectively, and their combined AUC was 0.981. After 3 months of follow-up, there were 43 cases of recurrence (36.44%). The multivariate logistic analysis showed that serum albumin< 35 g/L and a decrease of the IgG level were the influencing factors of poor prognosis in patients with APN.

In conclusion, WBC, CRP, *IgG*, and *C3* had high value for the diagnosis of APN, and serum albumin< 35 g/L and the decrease of *IgG* level were the i factors influencing prognosis.

Keywords: Acute pyelonephritis; C-reactive protein; Diagnosis; White blood cell count

INTRODUCTION

Acute pyelonephritis (APN) is a common infectious disease of the urinary tract and has a high global incidence. The risk of APN in women is 20%–35%, and the number of cases per year is 10.5–25.9 million.[1,2] The symptoms include fever and low-back pain, which seriously affect the lives of patients. It may also lead to serious complications such as sepsis and perirenal abscess, increase medical burdens, damage renal function, and even endanger life.

At present, clinical diagnosis of APN mainly depends on symptoms, signs, and laboratory tests.[3,4] Conventional inflammatory indicators such as white blood cell count (WBC), neutrophil percentage, and C-reactive protein (CRP) are widely used in the diagnosis of infectious diseases, but their specificity and sensitivity in the diagnosis of APN are controversial.[5,6]

Corresponding Author: Hao Wang, MBBS;
Department of Emergency, Dongxihu District people's Hospital, Wuhan, Hubei, China. Tel: (+86 139) 9558 4889, Email, yukidad0908@hotmail.com

*The first and second authors contributed equally to this study

Some non-infectious diseases or other diseases of the urinary system can also lead to an increase in these indicators, which affects the accuracy of APN diagnosis.

Immunoglobulins (*IgA*, *IgG*, *IgM*) and complements (*C3*, *C4*) are important components of immunity and are involved in pathogen recognition, clearance, and immune regulation.[7] *IgA* dominates mucosal immunity, and its level may be significantly increased in cases of APN.[8] However, there are few studies on the role of peripheral-blood immune-related indicators in the diagnosis and prognosis evaluation of APN, the conclusions differ, and their role has not been fully clarified. This study focused on these indicators to explore their diagnostic value for APN and the factors affecting poor prognosis, as well as to provide a basis for clinical diagnosis and treatment.

MATERIALS AND METHODS

Participants

This study retrospectively included 118 patients with APN who were treated in the Emergency Department of Dongxihu District people's Hospital from January 2022 to June 2024 as the observation group. The inclusion criteria were (1) meeting the diagnostic criteria of APN:[9] (i) Typical clinical manifestations: body temperature> 38°C and chills, nausea, vomiting, frequent urination, urgency and other related symptoms; (ii) Laboratory examination: urine routine with white blood cells≥5/high power field and bacterial positive, and the bacterial count isolated from urine samples exceeded 10^4 CFU/mL; (iii) Imaging examinations-such as ultrasound, X-ray and CT scans-to evaluate the renal structure and determine characteristic manifestations of acute pyelonephritis (e.g., renal enlargement, effusion, renal pelvis dilatation, local inflammation). Patients need to meet at least two of the above criteria. (2) detection of peripheral blood indicators after admission, and (3) complete clinical data. The exclusion criteria were (1) any other liver or kidney diseases, such as nephrotic syndrome, and glomerular inflammation; (2) a history of renal surgery; (3) recurrent urinary tract infection; (4) malignant tumors, autoimmune diseases, or infectious diseases; and (5) incomplete clinical data or loss to follow-up. This study has been approved by the Ethics Committee of our hospital (2022-0113).

Another 62 healthy volunteers were selected from the same period and included as the control group. All routine examination results were within normal ranges in this group, including blood count, urine analysis, liver and kidney function, blood sugar, and lipids. Additionally, ultrasound of the urinary system revealed no abnormalities or changes in structure and function. The exclusion criteria were the same as those of the observation group.

Methods

Clinical data of patients were collected, including general data (gender, age, body mass index (BMI), drinking history, and smoking history) and peripheral blood indicators (WBC, CRP, immunoglobulin G (*IgG*), and complement *C3*). A follow-up of 3 months was conducted for patients with acute pyelonephritis (APN), during which prognosis was assessed based on the following clinical indicators. Patients were classified into the poor prognosis group if any of the following conditions occurred: (1) Recurrence of APN within 3 months, characterized by a re-emergence of typical clinical symptoms such as fever>38°C, urinary frequency and urgency, along with urinalysis indicating leukocytes≥ 5 per high power field and urine culture showing bacterial counts exceeding 10^4 colony-forming units; (2) Treatment failure, defined as persistent symptoms including fever≥ 38°C or lumbar pain after standard antibacterial treatment for 72 hours, or failure to restore normal results in urinalysis and urine culture; (3) Development of complications confirmed by imaging studies such as ultrasound or CT scans, or laboratory tests indicating the presence of renal abscesses, sepsis, emphysematous pyelonephritis, etc.; (4) Renal function impairment indicated by a decline in estimated glomerular filtration rate (eGFR)≥ 25% compared with baseline prior to treatment or an increase in serum creatinine (Scr) levels>133 μmol/L; (5) Prolonged hospitalization due to APN-related symptoms lasting more than 14 days or readmission for treatment related to APN within the subsequent three months. Patients who did not experience any of these conditions were classified into the good prognosis group. The influencing factors for prognosis were explored by comparing the clinical data of these groups (gender, age, BMI, drinking history, smoking history, hemoglobin < 110 g/L, random blood glucose≥ 11.1 mmol/L, serum albumin< 35 g/L, diabetes, urinary calculi, bladder residual urine, hydronephrosis, long-term bed rest, catheterization), as well as their peripheral blood indies.

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Statistical Analyses

Statistical software IBM SPSS 29.0 (Manufacturer: IBM Corporation, Armonk, New York, USA, https://www.ibm.com/spss) was used to describe and analyze the data. Data that conformed to a normal distribution were expressed as the mean±standard deviation, and a t test was used for comparisons. Numerical data were described as numbers (n) and percentages, and the χ^2 test was used for comparisons. The receiver operating characteristic (ROC) curve was used to explore the predictive value of peripheral blood indicators for APN. Multivariate logistic regression was used to analyze the influencing factors of poor prognosis. A p value<0.05 was considered statistically significant.

RESULTS

Compared to the control group, WBC and CRP were higher in the observation group, and *IgG* and *C3* were lower (p<0.05). There was no significant difference in gender, age, BMI, drinking history, and smoking history between the two groups (p>0.05, Table 1). The areas under the curves (AUCs) of peripheral-blood WBC, CRP, *IgG*, and *C3* for the diagnosis of APN were 0.857, 0.846, 0.902, and 0.893, respectively. The combined AUC of the four indicators was 0.981, the sensitivity was 96.60%, and the specificity was 95.16% (p<0.05, Figure 1).

Table 1. Comparison of baseline data between the observation group and the control group

Groups	Observation group (n=118)	Control group (n=62)	t/χ^2	p
Sex			0.112	0.737
Male	54 (45.76)	30 (48.39)		
Female	64 (54.24)	32 (51.61)		
BMI, kg/m^2	65.22 ± 8.45	64.37 ± 9.13	0.623	0.534
Age, years	22.10 ± 13.30	22.29 ± 1.24	0.987	0.325
History of drinking			0.140	0.708
Yes	51 (43.22)	25 (40.32)		
No	67 (56.78)	37 (59.68)		
Smoking history			3.460	0.063
Yes	59 (50.00)	22 (35.48)		
No	59 (50.00)	40 (64.52)		
WBC, ×10^9/L	16.28 ± 3.85	8.68 ± 2.13	14.400	<0.001
CRP, mg/L	41.22 ± 11.05	18.68 ± 5.16	15.202	<0.001
***IgG*, g/L**	13.21 ± 2.58	17.85 ± 2.61	11.427	<0.001
***C3*, g/L**	0.93 ± 0.25	1.43 ± 0.29	12.022	<0.001

BMI: body mass index; WBC: white blood cell count; CRP: C-reactive protein; *IgG*: Immunoglobulin G; *C3*: Complement 3

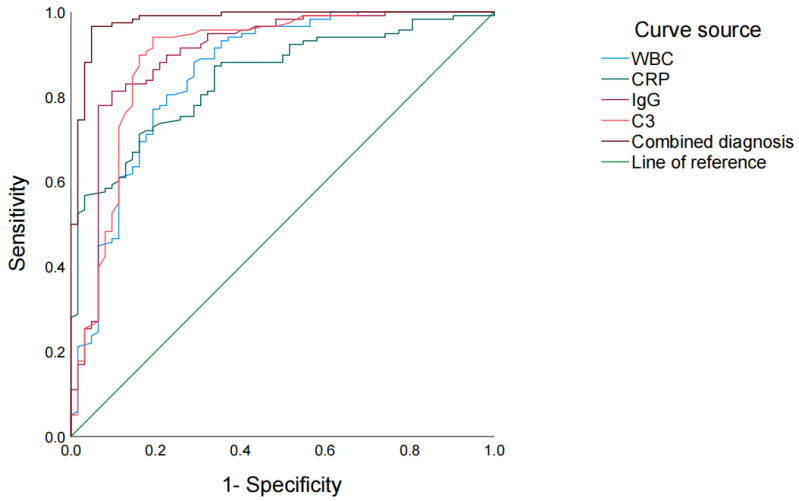

Figure 1. The diagnostic value of peripheral blood indexes for APN. WBC: white blood cell count; CRP: C-reactive protein; *IgG*: Immunoglobulin G; *C3*: Complement 3.

After 3 months of follow-up, there were 43 patients (36.44%) with recurrence in the poor-prognosis group and 75 patients (63.56%) without recurrence in the good-prognosis group. The poor-prognosis group had higher rates of random blood glucose≥ 11.1 mmol/L and serum albumin< 35 g/L than the good-prognosis group, as well as higher *IgG* levels (p<0.05, Table 2). In the multivariate logistic regression analysis, the prognosis of patients was used as a dependent variable (poor prognosis=1, good prognosis=0), and the index of p<0.05 was used as the independent variable. The results showed that serum albumin< 35 g/L and a decrease of the *IgG* level were influencing factors for poor prognosis in patients with APN (p<0.05, Table 3).

Table 2. Comparison of clinical data of APN patients with different prognosis

Groups	Good prognosis group (n=75)	Poor prognosis group (n=43)	t/χ^2	*p*
Sex			0.039	0.844
Male	35 (46.67)	19 (44.19)		
Female	40 (73.33)	24 (55.81)		
BMI, kg/m²	65.79 ± 8.10	64.23 ± 9.07	1.132	0.260
Age, years	22.15 ± 1.36	22.00 ± 1.19	0.545	0.587
History of drinking			0.051	0.821
Yes	33 (44.00)	17 (39.53)		
No	42 (56.00)	26 (60.47)		
Smoking history			0.329	0.566
Yes	36 (48.00)	22 (51.16)		
No	39 (52.00)	21 (48.83)		
Hemoglobin< 110 g/L			2.103	0.147
Yes	20 (26.67)	17 (39.53)		
No	55 (73.33)	26 (60.47)		
Random blood glucose≥ 11.1 mmol/L			5.427	0.020
Yes	6 (8.00)	10 (23.26)		
No	69 (92.00)	33 (76.74)		

Table 2. Continued...

Groups	Good prognosis group (n=75)	Poor prognosis group (n=43)	t/χ^2	*p*
Serum albumin< 35 g/L			6.344	0.012
Yes	18 (24.00)	20 (46.51)		
No	57 (76.00)	23 (53.49)		
Diabetes			0.332	0.565
Yes	19 (25.33)	13 (30.23)		
No	56 (74.67)	30 (69.77)		
Urinary calculi			2.618	0.106
Yes	4 (5.33)	6 (13.95)		
No	71 (94.67)	37 (86.05)		
Bladder residual urine			0.282	0.595
Yes	8 (10.67)	6 (13.95)		
No	67 (89.33)	37 (86.05)		
Hydronephrosis			0.681	0.409
Yes	4 (5.33)	4 (9.30)		
No	71 (94.67)	39 (90.70)		
Long-term bed rest			1.214	0.270
Yes	74 (98.67)	41 (97.67)		
No	1 (1.33)	2 (4.65)		
Front urinary catheter			0.681	0.409
Yes	4 (5.33)	4 (9.30)		
No	71 (94.67)	39 (90.70)		
WBC×10^9/L	16.04 ± 3.87	16.70 ± 3.84	0.894	0.373
CRP, mg/L	40.05 ± 11.07	43.25 ± 10.83	1.527	0.129
***IgG*, g/L**	13.87 ± 2.19	12.05 ± 2.82	3.887	<0.001
***C3*, g/L**	0.94 ± 0.25	0.93 ± 0.24	0.195	0.887

WBC: white blood cell count; CRP: C-reactive protein; *IgG*: Immunoglobulin G; *C3*: Complement 3

Table 3. Logistic multivariate analysis of prognostic factors in APN patients

Factors	β	SE	Wals χ^2	*p*	OR	95% CI
Random blood glucose ≥ 11.1 mmol/L	1.021	0.638	2.566	0.109	2.777	0.796–9.688
Serum albumin < 35 g/L	1.187	0.460	6.654	0.010	3.277	1.330–8.075
IgG	-0.342	0.098	12.203	<0.001	0.710	0.586–0.861
Constant	3.351	1.254	7.148	0.008	28.544	-

IgG: Immunoglobulin G

DISCUSSION

The results of this study indicate that the levels of WBC, CRP, and *IgG* were higher in the observation group than the control group, while *C3* levels were lower. This suggests a close correlation between APN and these levels. WBC is a common indicator of infection. During acute inflammation, neutrophils from the bone marrow rapidly release into peripheral blood, resulting in an increase in both their count and percentage. Song et al[10] conducted a differential analysis of routine blood parameters between patients with COVID-19 and those with bacterial pneumonia, and their findings demonstrated that WBC had good discriminative ability for these two groups (AUC=0.778).

CRP is produced primarily by hepatocytes in the liver which significantly increase in response to infection or tissue damage. The levels of CRP can rise in the serum due to inflammation occurring in any part of the body.[11] Fang et al[12] reported that independent predictive factors for pediatric APN include fever with peak temperatures>39°C, serum procalcitonin levels≥0.52 pg/mL, CRP levels≥ 2.86 mg/dL, and abnormal results from RUBS examinations.

IgG, as a core effector molecule of humoral immunity, plays a crucial role in the immune response. A decrease in *IgG* levels not only reflects deficiencies in the host's anti-infection immune function but is also closely associated with impaired pathogen clearance and prolonged inflammation. Research indicates that during urinary tract infections (UTIs), *IgG* initiates complement-dependent cytotoxicity (CDC) and antibody-dependent cell-mediated cytotoxicity (ADCC) by recognizing key pathogenic factors such as bacterial capsular antigens and flagellar proteins, thereby directly participating in pathogen elimination.[13,14] When *IgG* levels are reduced, this specific immune defense mechanism is weakened, leading to persistent bacterial colonization in the renal pelvis and renal parenchyma, which creates latent infection foci and poses risks for subsequent recurrence.[15] From a clinical perspective, an imbalance in *IgG* subclasses may further worsen prognosis. Studies have shown that *IgG1* and *IgG3* subtypes play dominant roles in combating extracellular bacterial infections; their decreased levels significantly increase the recurrence rate of Gram-negative bacilli UTIs.[16] Although this study did not differentiate between *IgG* subclasses, low total *IgG* levels may indirectly reflect deficiencies in protective subclasses. Furthermore, through its Fc region binding to Fcγ receptors on phagocytic cells, *IgG* enhances the phagocytic clearance of pathogens (opsonization). Insufficient levels can lead to decreased phagocytosis efficiency by neutrophils and macrophages, resulting in sustained inflammation.[17]

The ROC analysis in this study indicated that WBC, CRP, *IgG*, and *C3* levels had good diagnostic value for APN, and their combined AUC was 0.981. The combined AUC for the diagnosis of APN appears to be significantly higher than the individual AUC values (p<0.05). The recurrence rate of APN within 3 months was 36.44%, and the multivariate logistic regression analysis indicated that elevated *IgG* levels are a significant factor associated with poor prognosis (p<0.05). This suggests a correlation between adverse outcomes regarding the recurrence of APN and *IgG* levels.

In clinical management, the decrease of *IgG* level can be used as an important index to evaluate the immune function. For APN patients with significantly reduced serum *IgG*, in addition to standardized antibacterial treatment, immune regulation intervention should be considered. Studies have shown that for patients with recurrent infection and low *IgG*, intravenous immunoglobulin (IVIG) supplementation can reduce the recurrence rate of urinary tract infection.[18] At the same time, combined with the risk factor of serum albumin< 35 g/L found in this study, clinical attention should be paid to the effect of hypoproteinemia on *IgG* synthesis, that is, albumin is not only an antibacterial drug carrier, but also the ability of liver to synthesize *IgG* is inhibited, forming a vicious circle of 'low protein-low *IgG*-decreased anti-infective ability'.[19] Therefore, hypoproteinemia should be corrected synchronously during the treatment, and the immune reserve of the body should be improved through nutritional support to improve the prognosis.

This study has certain limitations. Only one center was involved, and the sample size was limited, which may have affected the generalizability of the results. Furthermore, the study did not explicitly address the impact of chronic conditions such as diabetes and hypoalbuminemia on inflammatory markers, so further research is needed to validate these factors.

In summary, the combined assessment of peripheral blood WBC, CRP, *IgG*, and *C3* demonstrated significant value in diagnosing patients with APN. Additionally,

serum albumin levels< 35 g/L and reduced *IgG* levels may contribute to poor patient prognosis. Therefore, proactive prevention measures should be implemented in such cases.

STATEMENT OF ETHICS

This study was approved by the Ethics Committee of the Dongxihu District People's Hospital (2022-0113).

FUNDING

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ACKNOWLEDGMENTS

Not applicable.

DATA AVAILABILITY

Upon reasonable request (Data are available upon request to the authors).

AI ASSISTANCE DISCLOSURE

No artificial intelligence (AI) tools were used in the preparation of this manuscript.

REFERENCES

1. Castaigne J, Georges B, Jouret F. Vignette diagnostique de l'étudiantLa pyélonéphrite aiguë [Acute pyelonephritis]. Rev Med Liege. 2022;77(9):544-7.
2. Lee A, Kim HC, Hwang SI, Chin HJ, Na KY, Chae DW, Kim S. Clinical Usefulness of Unenhanced Computed Tomography in Patients with Acute Pyelonephritis. J Korean Med Sci. 2018;33(38):e236.
3. Belyayeva M, Leslie SW, Jeong JM. Acute Pyelonephritis. 2024 Feb 28. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025.
4. Al Lawati H, Blair BM, Larnard J. Urinary Tract Infections: Core Curriculum 2024. Am J Kidney Dis. 2024;83(1):90-100.
5. Huang SY, Hsiao CH, Zhang XQ, Kang L, Yan JY, Cheng PJ. Serum procalcitonin to differentiate acute antepartum pyelonephritis from asymptomatic bacteriuria and acute cystitis during pregnancy: A multicenter prospective observational study. Int J Gynaecol Obstet. 2022;158(1):64-9.
6. Krzemień G, Pańczyk-Tomaszewska M, Górska E, Szmigielska A. Urinary vanin-1 for predicting acute pyelonephritis in young children with urinary tract infection: a pilot study. Biomarkers. 2021;26(4):318-24.
7. Gong X, He S, Luo L, Ding C, Qin X, Yuan Y, et al. The preliminary study of delta checks for immunoglobulins and complements in the clinical laboratory. Ann Clin Biochem. 2025;62(2):83-90. doi: 10.1177/00045632241287135. Epub 2024 Sep 24.
8. Chen K, Deng Y, Shang S, Tang L, Li Q, Bai X, et al. Complement factor B inhibitor LNP023 improves lupus nephritis in MRL/lpr mice. Biomed Pharmacother. 2022;153:113433.
9. Expert Panel on Urological Imaging; Smith AD, Nikolaidis P, Khatri G, Chong ST, De Leon AD, et al. ACR Appropriateness Criteria Acute Pyelonephritis: 2022 Update. J Am Coll Radiol. 2022;19(11S):S224-39.
10. Song L, Liang EY, Wang HM, Shen Y, Kang CM, Xiong YJ, et al. Differential diagnosis and prospective grading of COVID-19 at the early stage with simple hematological and biochemical variables. Diagn Microbiol Infect Dis. 2021;99(2):115169.
11. Ali S, Zehra A, Khalid MU, Hassan M, Shah SIA. Role of C-reactive protein in disease progression, diagnosis and management. Discoveries (Craiova). 2023;11(4):e179.
12. Fang NW, Chiou YH, Chen YS, Hung CW, Yin CH, Chen JS. Nomogram for diagnosing acute pyelonephritis in pediatric urinary tract infection. Pediatr Neonatol. 2022;63(4):380-7.
13. Wu HH, Crames M, Wei Y, Liu D, Gueneva-Boucheva K, Son I, et al. Effect of the ADCC-Modulating Mutations and the Selection of Human IgG Isotypes on Physicochemical Properties of Fc. J Pharm Sci. 2022 Sep;111(9):2411-21.
14. Wöhner M, Nimmerjahn F. Cytotoxic IgG: Mechanisms, functions, and applications. Immunity. 2025;58(6):1378-95.
15. Yang X, Tang X, Li T, Man C, Yang X, Wang M, et al. Circulating follicular T helper cells are possibly associated with low levels of serum immunoglobulin G due to impaired immunoglobulin class-switch recombination of B cells in children with primary nephrotic syndrome. Mol Immunol. 2019;114:162-70.

16. Walker MR, Eltahla AA, Mina MM, Li H, Lloyd AR, Bull RA. Envelope-Specific IgG3 and IgG1 Responses Are Associated with Clearance of Acute Hepatitis C Virus Infection. Viruses. 2020;12(1):75.
17. Hale G, Davy AD, Wilkinson I. Systematic analysis of Fc mutations designed to enhance binding to Fc-gamma receptors. MAbs. 2024;16(1):2406539.
18. Lee JL, Mohamed Shah N, Makmor-Bakry M, Islahudin FH, Alias H, Noh LM, et al. A Systematic Review and Meta-regression Analysis on the Impact of Increasing IgG Trough Level on Infection Rates in Primary Immunodeficiency Patients on Intravenous IgG Therapy. J Clin Immunol. 2020;40(5):682-98.
19. Dalakas MC. Update on Intravenous Immunoglobulin in Neurology: Modulating Neuro-autoimmunity, Evolving Factors on Efficacy and Dosing and Challenges on Stopping Chronic IVIg Therapy. Neurotherapeutics. 2021;18(4):2397-418.
20. Yang H, Wu K, Zhang H, Owyang Q, Miao Y, Gu F, et al. IgA, albumin, and eosinopenia as early indicators of cytomegalovirus infection in patients with acute ulcerative colitis. BMC Gastroenterol. 2020;20(1):294.