ORIGINAL ARTICLE
Iran J Allergy Asthma Immunol
August 2026; 25(4):565-575.
DOI: 10.18502/ijaai.v25i4.21742

Analysis of the Correlation between the Pan-immune Inflammation Value and the Prognosis of Patients with Endometrial Cancer

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Received: 31 March 2025; Received in revised form: 17 September 2025; Accepted: 17 October 2025

ABSTRACT

Immune and inflammatory factors influence endometrial cancer outcomes, the pan-immune inflammation value (PIV) shows potential but remains underexplored.

This study aims to evaluate the relationship between preoperative PIV, T cell subtypes, and surgical prognosis in endometrial cancer patients, providing insights for prognostic markers and predictive models. We conducted a prospective observational study involving 101 endometrial cancer patients from August 2022 to August 2024. Based on prognosis within 6 months post-surgery, patients were divided into good and poor prognosis groups. We compared clinical characteristics, inflammatory indices, and T cell immune profiles between the groups.

The mean age of participants was 50.12 years, with 23 patients experiencing a poor prognosis. The poor prognosis group exhibited significantly higher proportions of advanced International Federation of Gynecology and Obstetrics (FIGO) stage, larger tumor diameter, elevated neutrophil-to-lymphocyte ratio (NLR), systemic immune-inflammation index (SII), systemic inflammatory response index (SIRI), and PIV. Conversely, this group showed lower proportions receiving neoadjuvant chemotherapy, $CD4^+$ T cells, and $CD4^+CD8^+$ T cell ratios. Notably, elevated PIV emerged as an independent risk factor for poor prognosis, while increased CD4+ T cell proportion and $CD4^+CD8^+$ ratio were protective.

PIV is significantly associated with poor prognosis in endometrial cancer, serving as an independent risk factor. Higher CD4+ T cell counts and CD4+:CD8+ ratios provide protective benefits. The constructed logistic regression model demonstrates strong predictive capability for post-surgical outcomes. However, limitations, including sample size and short follow-up, necessitate further investigation in larger cohorts.

Keywords: Correlation; Endometrial cancer; Pan-immune inflammation value; Prognosis; T cell function

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INTRODUCTION

Endometrial cancer refers to a group of epithelial malignancies originating in the endometrium, representing a significant threat to women's health and well-being.[1] In recent years, the incidence of endometrial cancer has surged, largely driven by an aging population and changes in lifestyle and dietary patterns. In several developed countries and certain urban areas in China, it has become the leading gynecological malignancy.[2,3] Although the overall prognosis for patients with endometrial cancer is relatively favorable, with a 5-year survival rate of approximately 80%, a substantial number of patients still face adverse outcomes such as recurrence or metastasis, despite receiving standardized, comprehensive treatment. These complications remain a major cause of mortality.[4,5] Bhati et al[6] noted that even in early-stage endometrial cancer patients with tumors confined to the uterine body, there is a persistent risk of recurrence following open or robotic surgery. In high-risk patients, the invasiveness of the disease is greater, significantly elevating the likelihood of distant recurrence and metastasis post-surgery.

Accurate prognostic evaluation in endometrial cancer is crucial for developing personalized treatment strategies, improving survival rates, and enhancing quality of life.[7] Currently, prognosis assessment relies on traditional markers, including the International Federation of Gynecology and Obstetrics (FIGO) staging, tumor histological grading, myometrial invasion depth, and vascular invasion.[8] However, these indicators have notable limitations in predicting patient outcomes and fail to fully reflect the complexity of a patient's condition and prognosis.[9] In recent years, growing research into tumor immunity and the tumor microenvironment has highlighted the significant role of nutritional and immune-inflammatory responses in tumor development. Inflammation plays a critical role in tumor biology, where chronic inflammation can promote tumor initiation, progression, and metastasis. Various indicators of the body’s nutritional and immune status-such as the neutrophil-to-lymphocyte ratio (NLR), systemic immune-inflammation index (SII), and pan-immune inflammation value (PIV)—have demonstrated prognostic value in solid tumors, including gastrointestinal cancers, lung cancer, and ovarian cancer.[10,11] Specifically, elevated levels of these inflammatory markers have been associated with poorer outcomes, suggesting that they may reflect underlying tumor biology and the host’s immune response to malignancy. Moreover, multiple studies have shown that markers like NLR and SII can enhance the predictive value of traditional staging systems, offering more refined prognostic insights. However, the relationship between these indicators and the prognosis of endometrial cancer patients remains under investigation, and their specific mechanisms and clinical relevance are not yet fully understood.

This study aims to explore the correlation between peripheral blood inflammatory markers, such as PIV, and the prognosis of endometrial cancer patients. By analyzing these indicators, the study identified risk factors associated with poor surgical outcomes and developed a predictive model for poor prognosis. Additionally, this study assessed the individual and combined predictive power of these markers, thereby providing clinicians with more accurate and comprehensive tools for prognosis evaluation. Through the incorporation of inflammatory markers into prognostic models, this research not only seeks to clarify their predictive capacity but also aims to elucidate the biological mechanisms whereby these inflammatory responses influence tumor behavior and patient outcomes. In conclusion, this study contributes to a deeper understanding of the pathogenesis and prognostic factors of endometrial cancer, offering a theoretical basis for personalized treatment approaches and enhancing patient outcomes and quality of life.

MATERIALS AND METHODS

Research Subjects

This study is a prospective, observational, open cohort study. Based on prior research indicating a short-term recurrence rate of approximately 18% in endometrial cancer patients, the sample size was calculated using PASS 2023 software.[12] With a 95% confidence level, the minimum required sample size was determined to be 98 patients. In order to ensure the statistical validity of the research results and the reliability of their clinical application, power analysis was considered during the design stage to assess the sufficiency of the selected sample size. The results of the power analysis indicated that selecting 101 patients could provide sufficient statistical power ($1-\beta$) to

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detect key variables related to prognosis at the preset significance level ($\alpha = 0.05$). Moreover, considering the potential loss of samples (such as dropout or data missing), a certain degree of redundancy was added to the sample size design to ensure that adequate statistical power could still be maintained during the final analysis. Therefore, a total of 101 patients with endometrial cancer, admitted to our hospital between August 1, 2022, and August 31, 2024, were selected for the study.

Inclusion criteria were as follows:

① Patients who meet the clinical diagnostic criteria for endometrial cancer. Diagnosis was confirmed through pathological tissue biopsy and other methods, as outlined in the "European Society for Medical Oncology (ESMO) Clinical Practice Guidelines for Endometrial Cancer".[13]

② Patients who are eligible for surgical treatment and voluntarily agree to undergo surgery.

③ Patients with complete clinical data and laboratory test results, including information on age, medical history, surgical records, and test reports.

④ Patients for whom recurrence and survival status can be clearly determined through follow-up. Follow-up methods included outpatient reexaminations, telephone follow-ups, and others, with a minimum follow-up period of 6 months after surgery.

Exclusion criteria were as follows:

① Patients with other types of malignant tumors of the reproductive system, such as ovarian or cervical cancer.

② Patients who develop severe postoperative complications or infections, such as wound infection, pulmonary infection, or deep vein thrombosis.

③ Patients with coagulation disorders, such as thrombocytopenic purpura or hemophilia.

④ Patients for whom the prognosis after surgery cannot be determined, such as those lost to follow-up or unreachable due to a change in contact information.

⑤ Those whose clinical data are incomplete.

Grouping Situation

Based on the prognosis within 6 months post-surgery, the 101 patients were divided into two groups: good prognosis and poor prognosis. Patients in the good prognosis group showed no signs of recurrence or metastasis within 6 months post-surgery, maintained good physical condition, experienced minimal impact on quality of life, and had mostly normal examination results. Patients in the poor prognosis group had recurrence or metastasis within 6 months after surgery, exhibited poor physical condition, experienced a significant decline in quality of life, or had abnormal examination results.

Observation Indicators

General Clinical Data

Clinical data, including age, body mass index (BMI), family history of endometrial cancer, number of pregnancies (categorized as 0, 1, or ≥ 2), degree of myometrial invasion ($\geq 1/2$ or $< 1/2$), FIGO staging (stage I and stage II based on the 2023 FIGO surgical pathological staging criteria for endometrial cancer),[14] tumor diameter, pathological grade (poorly differentiated or moderately/highly differentiated), albumin (ALB), and prognostic nutritional index (PNI), were collected for patients in both groups.

Peripheral Blood-related Inflammatory Indicators

Peripheral venous blood samples were obtained prior to surgery. An automatic hematology analyzer measured neutrophil count (NEUT), lymphocyte count (LYM), platelet count (PLT), and monocyte count (MONO). NLR, platelet-to-lymphocyte ratio (PLR), lymphocyte-to-monocyte ratio (LMR), SII, systemic inflammatory response index (SIRI), and PIV were then calculated. Specifically, $SII = PLT \times NEUT / LYM$; $SIRI = NEUT \times MONO / LYM$;
$PIV = PLT \times NEUT \times MONO / LYM$.

Treatment-related Characteristics

Treatment-related characteristics, such as surgical approach (laparoscopic or open surgery), duration of surgery, use of neoadjuvant chemotherapy, chemotherapy regimen (paclitaxel combined with carboplatin or other regimens), chemotherapy course, and whether radiotherapy was administered, were recorded.

T Cell Immune Indicators

Peripheral venous blood samples were also co-incubated with CD3, CD4, and CD8 flow antibodies. Flow cytometry was employed to measure the proportions of $CD4^+$ T lymphocytes and $CD8^+$ T lymphocytes, and the $CD4^+$:$CD8^+$ T ratio was calculated.

Statistical Analysis

Data analysis was performed using SPSS 26.0

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statistical software. For continuous variables such as age, tumor diameter, peripheral blood inflammatory markers, and T cell immune indicators, data conforming to a normal distribution were expressed as mean ± standard deviation, and comparisons between groups were conducted using an independent samples t-test. For categorical variables, such as family history of endometrial cancer, number of pregnancies, degree of myometrial invasion, FIGO staging, pathological grade, surgical method, chemotherapy regimen, and radiotherapy status, data were presented as frequencies (n, %) and compared using a chi-square test.

Spearman's correlation analysis was employed to assess the relationship between each observation variable and poor prognosis in endometrial cancer patients, with the correlation coefficient (r) calculated. A positive correlation was indicated by $r > 0$, and a negative correlation by $r < 0$. Variables with an absolute correlation coefficient greater than 0.300 were considered potential influencing factors and were included in multivariate logistic regression analysis to identify their impact on poor surgical prognosis. The odds ratio (OR) and 95% confidence interval (CI) were computed.

A logistic regression model was developed to predict poor prognosis based on influencing factors such as peripheral blood inflammatory indicators. The model's predictive performance was evaluated using the receiver operating characteristic (ROC) curve and the area under the curve (AUC). A $p<0.05$ was considered statistically significant.

RESULTS

Comparison of General Clinical Data between Patients in the Poor Prognosis Group and the Good Prognosis Group

The average age of the enrolled patients was 50.12 ± 3.78 years, with 23 patients in the poor prognosis group. No statistically significant differences were observed between the two groups in terms of general clinical data, including age, BMI, family history of endometrial cancer, number of pregnancies, degree of myometrial invasion, pathological grade, ALB, and PNI ($p>0.05$). However, the poor prognosis group had a significantly higher proportion of patients with advanced FIGO stage and larger tumor diameter compared to the good prognosis group ($p<0.05$), as shown in Table 1. These results suggest that a higher FIGO stage and larger tumor diameter may serve as risk factors for poor prognosis in endometrial cancer patients. A higher FIGO stage indicates a broader invasive range of the tumor and a more severe condition, which may complicate complete surgical resection, thereby increasing the risk of recurrence and metastasis and negatively affecting prognosis. Similarly, a larger tumor diameter may reflect a faster tumor growth rate and a higher degree of malignancy, further impacting patient outcomes.

Comparison of Peripheral Blood-related Inflammatory Indicators between Patients in the Poor Prognosis Group and the Good Prognosis Group

Levels of NLR, SII, SIRI, and PIV were significantly higher in the poor prognosis group compared to the good prognosis group, with statistical significance ($p<0.05$). No significant differences were found in PLR and LMR levels between the two groups ($p>0.05$), as shown in Table 2. These results indicate that elevated levels of NLR, SII, SIRI, and PIV are associated with poor prognosis in endometrial cancer, likely reflecting an exacerbation of the body's overall inflammatory status. This inflammatory microenvironment may promote the growth, invasion, and metastasis of tumor cells.

Comparison of Treatment-related Characteristics between Patients in the Poor Prognosis Group and the Good Prognosis Group

The proportion of patients undergoing neoadjuvant chemotherapy was significantly lower in the poor prognosis group compared to the good prognosis group, with a statistically significant difference ($p<0.05$). No significant differences were observed between the groups in surgical method, operation duration, chemotherapy regimen, number of chemotherapy cycles, or radiotherapy status ($p>0.05$), as shown in Table 3.

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Table 1. Comparison of general clinical data between patients in the poor prognosis group and the good prognosis group [(mean ± SD), n (%)]

General clinical data	Poor prognosis group (n=23)	Good prognosis group (n=78)	t/χ^2	*p*
Age, y	50.57±2.92	49.71±4.29	0.901	0.370
BMI, kg/m²	22.32±0.93	22.37±0.85	-0.221	0.826
Family history of endometrial cancer			0.000	1.000
Yes	4(17.4)	15(19.2)		
No	19(82.6)	63(80.8)		
Number of pregnancies, times			1.113	0.573
0	1(4.3)	7(9.0)		
1	14(60.9)	51(65.4)		
≥2	8(34.8)	20(25.6)		
Tumor diameter, cm	2.47±0.53	2.20±0.55	2.084	0.040
Pathological grade			0.102	0.749
Poorly differentiated	15(65.2)	48(61.5)		
Moderately/highly differentiated	8(34.8)	30(38.5)		
FIGO staging			4.794	0.029
Stage I	7(30.4)	44(56.4)		
Stage II	16(69.6)	34(43.6)		
Degree of myometrial invasion			1.361	0.243
<1/2	5(21.7)	27(34.6)		
≥1/2	18(78.3)	51(65.4)		
ALB, g/L	43.35±5.83	43.53±4.85	-0.147	0.883
PNI	54.64±4.32	55.47±5.31	-0.687	0.494

ALB: albumin; BMI: body mass index; FIGO: International Federation of Gynecology and Obstetrics; PNI: prognostic nutritional index.

Table 2. Comparison of peripheral blood-related inflammatory indicators between patients in the poor prognosis group and the good prognosis group (mean ± SD)

Blood-related inflammatory indicators	Poor prognosis group (n=23)	Good prognosis group (n=78)	t	*p*
NLR	3.54±0.79	3.16±0.72	2.193	0.031
PLR	155.13±38.98	146.07±29.63	1.196	0.235
LMR	2.57±0.51	2.78±0.51	-1.705	0.091
SII	717.76±350.60	588.03±147.55	2.413	0.018
SIRI	2.44±0.72	2.16±0.36	2.550	0.012
PIV	464.30±142.36	359.2±110.70	3.745	<0.001

LMR: lymphocyte-to-monocyte ratio; NLR: neutrophil-to-lymphocyte ratio; PIV: pan-immune inflammation value; PLR: platelet-to-lymphocyte ratio; SII: systemic immune-inflammation index; SIRI: systemic inflammatory response index.

Table 3. Comparison of treatment-related characteristics between patients in the poor prognosis group and the good prognosis group [(mean ± SD), n(%)]

Treatment-related characteristics	Poor prognosis group (n=23)	Good prognosis group (n=78)	t/χ²	*p*
Surgical method			1.581	0.209
Laparoscopic surgery	13(56.5)	55(70.5)		
Open surgery	10(43.5)	23(29.5)		
Operation time, min	130.35±20.23	122.85±19.40	1.614	0.110
Receiving neoadjuvant chemotherapy			4.325	0.038
No	19(82.6)	46(59.0)		
Yes	4(17.4)	32(41.0)		
Chemotherapy regimen			1.066	0.302
Paclitaxel combined with carboplatin	12(52.2)	50(64.1)		
Other regimens	11(47.8)	28(35.9)		
Number of chemotherapy cycles	4.91±0.83	5.13±0.59	-1.453	0.149
Receiving radiotherapy			0.021	0.884
No	16(69.6)	53(67.9)		
Yes	7(30.4)	25(32.1)		

Comparison of T Cell Immune Indices between Patients in the Poor Prognosis Group and the Good Prognosis Group

The proportion of $CD4^+$ T cells and the $CD4^+$:$CD8^+$ T ratio in the poor prognosis group were significantly lower than those in the good prognosis group ($p<0.05$). No statistically significant difference was observed in the proportion of $CD8^+$ T cells between the two groups ($p>0.05$), as shown in Table 4. These results suggest that a decrease in the proportion of $CD4^+$ T lymphocytes and the $CD4^+$:$CD8^+$ T ratio may be associated with poor prognosis in endometrial cancer patients.

Correlation Analysis between Inter-group Differential Indexes and Poor Postoperative Prognosis of Patients with Endometrial Cancer

The prognosis of patient's post-surgery was assigned values: poor prognosis = 1, good prognosis = 0. Spearman correlation analysis revealed that both FIGO stage and PIV were positively correlated with poor prognosis, while receiving neoadjuvant chemotherapy and the $CD4^+$:$CD8^+$ T ratio were negatively correlated with poor prognosis ($p<0.05$), as shown in Table 5.

Analysis of Influencing Factors for Poor Surgical Prognosis in Patients with Endometrial Cancer

Variables with $p<0.05$ from univariate analysis were included as independent variables: FIGO stage II and receiving neoadjuvant chemotherapy were assigned as 1, while FIGO stage I and no neoadjuvant chemotherapy were assigned as 0. Original values were used for tumor diameter, NLR, SII, SIRI, PIV, the proportion of $CD4^+$ T cells, and the $CD4^+$:$CD8^+$ T ratio. Multivariate logistic regression analysis identified that PIV was an independent risk factor for poor prognosis in endometrial cancer, while the proportion of $CD4^+$ T cells and the $CD4^+$:$CD8^+$ T ratio were independent protective factors ($p<0.05$), as shown in Table 6.

Table 4. Comparison of T cell immune indices between patients in the poor prognosis group and the good prognosis group (mean ± SD)

T cell immune indices	Poor prognosis group (n=23)	Good prognosis group (n=78)	t	*p*
Proportion of $CD4^+$ T cells	41.94±5.16	43.79±3.27	-2.077	0.040
Proportion of $CD8^+$ T cells	32.73±3.75	31.08±3.64	1.903	0.060
Ratio of $CD4^+$ $CD8^+$	1.17±1.31	1.26±0.17	-2.346	0.021

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Table 5. Correlation analysis between inter-group differential indexes and poor postoperative prognosis of patients with endometrial cancer

Correlation analysis parameters	**r**	***p***
Tumor long diameter, cm	0.189	0.059
FIGO stage	0.218	0.029
NLR	0.192	0.055
SII	0.118	0.239
SIRI	0.122	0.225
PIV	0.286	0.004
Receiving neoadjuvant chemotherapy	-0.207	0.038
CD4+ T cell proportion	-0.156	0.120
CD4+:CD8+ ratio	-0.233	0.019

FIGO: International Federation of Gynecology and Obstetrics; NLR: neutrophil-to-lymphocyte ratio; PIV: pan-immune inflammation value; SII: systemic immune-inflammation index; SIRI: systemic inflammatory response index.

Table 6. Logistic regression analysis of poor prognosis factors in patients with endometrial cancer after surgery

Index	**β**	**S.E.**	**Waldχ^2**	**p**	**OR**	**Lower limit of 95% CI**	**Upper limit of 95% CI**
Tumor long diameter, cm	0.919	0.629	2.136	0.144	2.506	0.731	8.591
FIGO stage	0.876	0.625	1.965	0.161	2.402	0.705	8.177
NLR	0.291	0.456	0.407	0.523	1.338	0.547	3.271
SII	-0.001	0.001	0.182	0.669	0.999	0.996	1.002
SIRI	1.166	0.835	1.950	0.163	3.209	0.625	16.489
PIV	0.007	0.003	5.000	0.025	1.007	1.001	1.013
Receiving neoadjuvant chemotherapy	-1.256	0.790	2.528	0.112	0.285	0.061	1.340
$CD4^+$ T cell proportion	-0.174	0.085	4.212	0.040	0.840	0.712	0.992
$CD4^+$:$CD8^+$ T ratio	-5.015	2.245	4.991	0.025	0.007	0.001	0.540
Constant	4.113	1.904	4.666	0.029			

CI: confidence interval; FIGO: International Federation of Gynecology and Obstetrics; NLR: neutrophil-to-lymphocyte ratio; OR: odds ratio; PIV: pan-immune inflammation value; S.E.: standard error; SII: systemic immune-inflammation index; SIRI: systemic inflammatory response index.

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Construction and Effectiveness Evaluation of a Prediction Model for Poor Postoperative Prognosis in Patients with Endometrial Cancer

A logistic regression model was developed to predict poor prognosis in patients, incorporating independent risk factors (PIV) and protective factors ($CD4^+$ T lymphocyte proportion, $CD4^+$:$CD8^+$ ratio) identified through multivariate logistic regression analysis: $\text{Logit}(P) = 4.113 + 0.007 \times \text{PIV} - 0.174 \times$ proportion of $CD4^+$ T lymphocytes $- 5.015 \times CD4^+$:$CD8^+$ T ratio. In this model, P represents the probability of poor prognosis, and Logit(P) denotes the log odds of P.

ROC curve analysis demonstrated an AUC of 0.758 (95% CI, 0.650–0.866) for the model in predicting poor postoperative prognosis in endometrial cancer patients. An AUC greater than 0.7 indicates moderate to high accuracy in predicting poor prognosis. The optimal cut-off value for the model was 0.451, yielding a sensitivity of 78.26% and specificity of 84.62%, as shown in Figure 1.

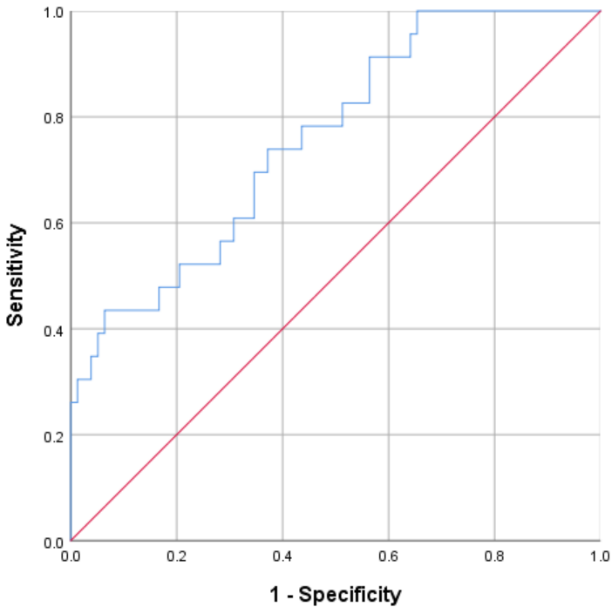

Figure 1. Receiver operating characteristic (ROC) curve of the prediction model for poor postoperative prognosis in patients with endometrial cancer.

DISCUSSION

The results of this study demonstrated that PIV levels were significantly higher in the poor prognosis group than the good prognosis group, with a statistically significant difference. Spearman correlation analysis indicated a positive correlation between PIV and poor prognosis in endometrial cancer patients. Multivariate logistic regression analysis identified PIV as an independent risk factor for poor surgical prognosis, suggesting that higher PIV levels are associated with an increased risk of poor surgical outcomes in endometrial cancer patients. As a novel composite circulating immune biomarker, PIV integrates multiple indicators, including NEUT, PLT, MONO, and lymphocyte proportion, providing a comprehensive assessment of systemic immunity and cancer-related inflammatory responses.[15] In the tumor microenvironment, neutrophils release various cytokines and proteases, such as interleukin-8 (IL-8) and matrix metalloproteinase-9 (MMP-9), which promote tumor cell migration, invasion, and angiogenesis, supplying essential nutrients and oxygen for tumor growth.[16] Platelets contribute to tumor angiogenesis by releasing substances like vascular endothelial growth factor (VEGF) and platelet-derived growth factor (PDGF), thereby facilitating tumor cell growth and metastasis.[17] Monocytes secrete pro-inflammatory factors, such as tumor necrosis factor-α (TNF-α) and interleukin-1 (IL-1), which activate the inflammatory response and promote tumor cell proliferation, invasion, and metastasis.[18] Moreover, monocytes can differentiate into tumor-associated macrophages (TAMs), which exert an immunosuppressive effect in the tumor microenvironment, inhibiting the body's anti-tumor immune response and promoting tumor cell survival and growth.[19] Thus, an increase in PIV reflects an imbalance among immune-inflammatory cells, compromising the body's immune surveillance and defense functions, which accelerates the development and progression of endometrial cancer, increasing the risk of poor prognosis. In a similar study on gastric cancer, it was found that the 5-year survival rate was significantly lower in patients with high PIV levels compared to those with low PIV levels. Furthermore, PIV was closely associated with tumor invasion, lymph node metastasis, and TNM staging, highlighting its prognostic value in gastric cancer.[20] A similar conclusion was reached in a study on lung cancer, where elevated PIV levels correlated with poor prognosis in lung cancer patients.[21] These findings are consistent with the results of this study, further validating the significant role of PIV in the prognostic assessment of various malignant tumors.

In addition to PIV, other factors identified in this study also significantly influence the prognosis of endometrial cancer patients. Peripheral blood inflammatory markers and T cell immune indicators are closely associated with patient outcomes. Elevated levels of NLR, SII, SIRI, and PIV reflect an imbalance in the body's immune-inflammatory status, which may increase the risk of poor prognosis by promoting tumor cell proliferation, invasion, and metastasis. A decrease in the proportion of $CD4^+$ T lymphocytes, an increase in $CD8^+$ T lymphocyte levels, and a reduction in the $CD4^+$:$CD8^+$ T ratio indicate immune dysregulation, impairing immune surveillance and defense functions. This dysregulation facilitates tumor cell growth, proliferation, and metastasis.[22] Specifically, reduced $CD4^+$ T cell levels impact the initiation and regulation of immune responses, while dysfunction of $CD8^+$ T cells hinders effective tumor cell cytotoxicity. The lowered $CD4^+$:$CD8^+$ T ratio further disrupts immune balance, enhancing tumor cells' ability to evade immune surveillance. These factors interact synergistically, collectively influencing the prognosis of endometrial cancer patients.[23,24] The increase in PIV reflects the poor immune adaptation and chronic inflammatory state of the body. This state may lead to changes in the tumor microenvironment, resulting in the infiltration of tumor-associated immunosuppressive cells, thereby suppressing the effective anti-tumor immune response. At the same time, the increase in PIV may also be related to the release of pro-inflammatory cytokines, which can promote the growth and metastasis of tumor cells. The decrease in the ratio of $CD4^+$:$CD8^+$ T cells indicates an imbalance in the immune system. The reduction of $CD4^+$ T cells weakens the initiation and regulation of the immune response, while the excessive increase of $CD8^+$ T cells may lead to their dysfunction. Tumor cells inhibit the effector function of $CD8^+$ T cells by secreting immunosuppressive factors, further reducing the anti-tumor activity. The decrease in the ratio of $CD4^+$:$CD8^+$ T cells not only reflects the imbalance of immune cells but may also indicate the immune escape mechanism in the tumor microenvironment. These factors work together to affect the prognosis of patients with endometrial cancer. Clinicians should consider these indicators comprehensively when evaluating prognosis and formulating treatment plans, thereby providing more personalized management plans for patients.

The findings of this study have significant clinical relevance and practical value for prognostic assessment and treatment planning. In terms of prognostic assessment, it offers clinicians a more comprehensive and accurate set of evaluation tools. Traditionally, the prognosis of endometrial cancer patients has been primarily based on FIGO staging and tumor diameter. This study, however, highlights the strong association between PIV and T cell immune indicators ($CD4^+$ T cell proportion and $CD4^+$:$CD8^+$ T ratio) with patient outcomes.[25] These markers provide a deeper insight into the patient's condition and prognosis from the perspectives of immune inflammation and immune cell function. By measuring PIV levels, clinicians can more accurately assess the risk of poor prognosis. For patients with higher PIV levels, indicating a worse prognosis, closer monitoring and follow-up are necessary.

The results of this study also offer significant guidance in formulating treatment plans for endometrial cancer patients. For patients with higher PIV levels, indicating an increased risk of poor prognosis, more aggressive treatment strategies may be considered. This could include intensifying chemotherapy or extending its duration, as well as incorporating additional treatment modalities, such as targeted therapy and immunotherapy, to improve therapeutic outcomes and reduce the risk of recurrence and metastasis.[26] Conversely, for patients with higher proportions of $CD4^+$ T lymphocytes and a higher $CD4^+$:$CD8^+$ T ratio, which are associated with better prognosis, treatment intensity and side effects can be reduced to improve the patient's quality of life. Furthermore, treatment decisions should also take into account factors such as surgical approach, chemotherapy regimen, and radiotherapy status. For patients in good physical condition who meet the criteria for laparoscopic surgery, this approach should be prioritized to minimize trauma and accelerate recovery.[27]

The logistic regression model for predicting poor prognosis developed in this study provides a practical tool for clinicians. By inputting patient data, clinicians can estimate the likelihood of poor prognosis, enabling more personalized and targeted treatment strategies. For patients with a higher predicted risk, a tailored follow-up plan can be implemented, allowing for closer monitoring of disease progression, early detection of recurrence or metastasis, and timely intervention. This model can also be applied in clinical research to assess the effectiveness of new therapies and drugs, providing a foundation for optimizing endometrial cancer treatment. Overall, the findings of this study hold substantial clinical significance and application value, enhancing clinicians' ability to assess prognosis, design more effective treatment plans, and ultimately improve both the prognosis and quality of life for endometrial cancer patients.

Although this study has provided valuable insights into the correlation between PIV and the prognosis of endometrial cancer patients, several limitations must be acknowledged. The sample size was relatively small, with only 101 patients included, which may not fully capture the true relationship between PIV, other factors, and endometrial cancer prognosis. A smaller sample size can affect the stability and reliability of the results, leading to potential sampling errors and limiting the generalizability of the findings. Additionally, the observation period was relatively short, focusing only on the prognosis within 6 months after surgery. Given that endometrial cancer can have a latency period for recurrence and metastasis, a 6-month follow-up may not be sufficient to accurately assess long-term outcomes. Some patients might experience recurrence or metastasis beyond this period, which could result in an incomplete and inaccurate prognosis evaluation.

Future research can address these limitations by expanding the sample size and incorporating patients from multiple centers and regions, thus improving the representativeness and reliability of the results. Multi-center collaborative studies would enable the collection of a larger, more diverse dataset, reducing sampling errors and enhancing the validity of the conclusions. Furthermore, extending the follow-up period to monitor the long-term prognosis of patients, conducting subgroup analyses of patients, and analyzing the tumor pathology will provide a clearer understanding of the recurrence patterns and survival outcomes. A longer follow-up period will offer a more reliable basis for evaluating the impact of PIV and other factors on the long-term prognosis of patients with endometrial cancer.

STATEMENT OF ETHICS

This study was approved by the Ethics Committee of The First Hospital of Lanzhou University (LDYYLL2023-361).

FUNDING

1. National Natural Science Foundation of China Project (No: 82160549)

2. Gansu Provincial Health Industry Scientific Research Program Project (No: GSWSKY-2019-25)

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ACKNOWLEDGMENTS

Not applicable.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI ASSISTANCE DISCLOSURE

This study does not involve the use of AI tools.

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