Preoperative Inflammatory and Nutritional Indices as Predictors of Infectious Complications Following Elective Cesarean Section in Patients With Gestational Diabetes Mellitus: A Retrospective Study

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Xiaoli Zhang[1], Chen Chen[1]

[1]Department of Obstetrics, Tongxiang Maternity and Child Health Care Hospital, 314500 Jiaxing, Zhejiang, China

AIM: Postoperative infection is a significant complication that may adversely affect maternal recovery following cesarean section. Patients with gestational diabetes mellitus (GDM) may be at increased risk due to metabolic dysregulation and altered immune function. This study aimed to investigate preoperative risk factors for infectious complications following elective cesarean section in patients with GDM, with a focus on readily obtainable inflammatory and nutritional indices.

METHODS: This retrospective study included 383 patients with GDM who underwent elective cesarean section at Tongxiang Maternity and Child Health Care Hospital between January 2022 and February 2025. Preoperative inflammatory indices, including neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and C-reactive protein (CRP), as well as nutritional indices, including prognostic nutritional index (PNI) and hemoglobin (Hb), were collected. Univariate and multivariate logistic regression analyses were performed to identify risk factors for postoperative infection, and a risk stratification approach based on inflammatory and nutritional indices was developed.

RESULTS: Among the 383 patients, 72 (18.8%) developed postoperative infections. Multivariable analysis identified elevated CRP (odds ratio (OR) = 2.383, 95% confidence interval (CI): 1.669–4.427), decreased PNI (OR = 0.680, 95% CI: 0.507–0.842), decreased hemoglobin (OR = 0.854, 95% CI: 0.746–0.945), and elevated PLR (OR = 1.046, 95% CI: 1.006–1.101) as independent risk factors for postoperative infection (all $p < 0.05$). Receiver operating characteristic (ROC) analysis demonstrated good discriminative performance of the inflammatory and nutritional indices, with CRP showing the strongest performance. Risk stratification based on the number of these factors (CRP, PLR, PNI, Hb) showed infection rates of 0.0%, 1.4%, 14.1%, 84.2%, and 100.0% for patients with 0, 1, 2, 3, and 4 factors, respectively (trend test $p < 0.001$).

CONCLUSIONS: Preoperative elevation of inflammatory markers (CRP, PLR) and impairment of nutritional status (PNI, Hb) are independent risk factors for post-cesarean infection in patients with GDM. Preoperative risk assessment incorporating these indices may facilitate identification of high-risk patients and support targeted perioperative management strategies.

Keywords: gestational diabetes mellitus; cesarean section; postoperative infection; inflammatory indices; nutritional status

Introduction

Cesarean section is an essential intervention for the management of dystocia and high-risk pregnancies, and its global rate continues to increase [1]. However, the surgical procedure itself exposes parturients to a range of perioperative complications. Postoperative infectious complications, including surgical site infection, endometritis, and urinary tract infection, are significant contributors to prolonged hospitalization, increased healthcare costs, and adverse long-term outcomes [2,3]. Although the use of perioperative prophylactic antibiotics has markedly reduced infection rates, certain populations, particularly those with underlying comorbidities, remain at elevated risk. Therefore, identification of high-risk individuals and implementation of targeted interventions are essential for improving perioperative outcomes in patients undergoing cesarean section.

Gestational diabetes mellitus (GDM) is one of the most common metabolic disorders during pregnancy, with an increasing global prevalence [4]. GDM is associated not only with adverse pregnancy outcomes such as macrosomia and preeclampsia but also affects systemic physiology through chronic hyperglycemia, insulin resistance, and the resulting low-grade inflammation and immune dysregulation [5]. Previous studies suggest that immune function in patients with GDM may be altered, including impaired neutrophil function, an imbalance in lymphocyte subsets, and increased pro-inflammatory cytokines. These alterations may compromise the ability to respond to surgical stress and pathogen invasion, thereby increasing susceptibility to postoperative infection [6]. However, evidence regarding whether GDM independently increases the risk of post-

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Correspondence to: Chen Chen, Department of Obstetrics, Tongxiang Maternity and Child Health Care Hospital, 314500 Jiaxing, Zhejiang, China (e-mail: 15958324773@163.com).
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cesarean infection, as well as the identification of quantifiable predictors, remains inconsistent and insufficiently characterized.

In recent years, preoperative systemic inflammatory status and nutritional status have received increasing attention as predictors of postoperative complications across various surgical settings. Inflammatory markers such as the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and C-reactive protein (CRP) collectively reflect the inflammatory burden and immune stress of the host [7–9]. Nutritional indices, including the prognostic nutritional index (PNI) and hemoglobin level, reflect nutritional reserve and recovery capacity [10,11]. These parameters are readily obtainable from routine blood tests, are objective and quantifiable, and have demonstrated value in predicting complications, such as infection and anastomotic leakage, across multiple surgical populations [12]. However, their predictive performance for infectious complications following elective cesarean section in patients with GDM has not been systematically investigated.

Based on this background, the present retrospective cohort study aimed to systematically investigate preoperative risk factors for infectious complications in patients with GDM undergoing elective cesarean section, with a focus on the predictive value of inflammatory markers (NLR, PLR, CRP) and nutritional indices (PNI, hemoglobin, and pre-pregnancy body mass index (BMI)). By developing a preoperative risk stratification approach based on these indices, this study aimed to provide a practical tool for the early identification of high-risk GDM parturients and to offer evidence-based support for individualized perioperative management strategies, including optimized glycemic control, nutritional support, and targeted preventive measures. Such an approach may help reduce postoperative infection rates and improve maternal and neonatal outcomes in this population.

Methods

Study Population

This single-center retrospective study included patients with GDM who underwent elective cesarean section in the Department of Obstetrics at Tongxiang Maternity and Child Health Care Hospital between January 2022 and February 2025. The inclusion criteria were as follows: ① singleton pregnancy; ② diagnosis of gestational diabetes mellitus; ③ gestational age ≥37 weeks; and ④ elective cesarean section. The exclusion criteria were: ① emergency surgery; ② premature rupture of membranes >12 hours; ③ preoperative active infection; ④ comorbid autoimmune or hematological diseases; and ⑤ incomplete clinical data. A total of 383 patients were ultimately included.

The study was approved by the Ethics Committee of Tongxiang Maternity and Child Health Care Hospital (Ethics Review 2026 Research No. 002), and the requirement for informed consent was waived. All procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki.

GDM was diagnosed according to the criteria of the International Association of Diabetes and Pregnancy Study Groups (IADPSG), based on a 75 g oral glucose tolerance test, with one or more of the following thresholds: fasting plasma glucose ≥5.1 mmol/L, 1-hour glucose ≥10.0 mmol/L, or 2-hour glucose ≥8.5 mmol/L [13].

Data Collection

Demographic and obstetric characteristics included age, gravidity, parity, pre-pregnancy height and weight for calculation of pre-pregnancy BMI, gestational weight gain, gestational week at GDM diagnosis, and method of glycemic control (diet or insulin).

Preoperative laboratory indices obtained within one week preoperatively included inflammatory markers such as neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, C-reactive protein, as well as nutritional indices including prognostic nutritional index and hemoglobin. Perioperative variables included operative duration and intraoperative blood loss.

Postoperative infectious complications were defined as infections occurring within 30 days after surgery, including surgical site infection, endometritis, urinary tract infection, and organ/space infection (pelvic or intra-abdominal abscess). Surgical site infection (SSI) was classified as superficial or deep incisional infection according to the Centers for Disease Control and Prevention (CDC) criteria. Endometritis was diagnosed based on postpartum fever ≥38 °C, uterine tenderness, and or abnormal lochia, supported by laboratory or imaging findings when available. A urinary tract infection was defined by urinary symptoms combined with a positive urine culture. Deep or organ-space infections were confirmed by imaging modalities such as ultrasound or computed tomography when clinically indicated.

Statistical Analysis

Normality of continuous variables was assessed using the Shapiro–Wilk test. Continuous variables with normal distribution are presented as mean ± standard deviation, while non-normally distributed variables are presented as median with interquartile range. Categorical variables are expressed as frequency with percentage. Comparisons between the infection and non-infection groups were performed using the independent samples *t*-test, Mann-Whitney *U* test, or chi-square test, as appropriate. Variables with $p < 0.05$ in univariate analysis were entered into a multivariable binary logistic regression model using a stepwise method with an entry threshold of $p < 0.05$ to identify independent risk factors. Odds ratios (ORs) and corresponding 95% confidence intervals (CIs) were calculated. Receiver operating characteristic (ROC) curve analysis was conducted to determine optimal cut-off values, sensitivity,

Table 1. Distribution and incidence of postoperative infections.

Type	Incisional infection	Endometritis	Urinary tract infection	Others
Number (%)	38 (52.8%)	20 (27.8%)	10 (13.9%)	4 (5.6%)

specificity, and area under the curve (AUC) for each inflammatory and nutritional index in predicting postoperative infection. Based on identified independent risk factors, a combined multivariable risk stratification model was constructed using logistic regression, and its discriminative performance was evaluated using ROC curve analysis.
Furthermore, patients were stratified according to the number of identified risk factors to assess trends in infection incidence, which were evaluated using the chi-square test for trend. All statistical analyses were performed using R software (version 4.3.0, R Development Core Team). A p-value < 0.05 was considered statistically significant.

Results

Infection Incidence

As shown in Table 1, the most common postoperative infection was incisional infection, followed by endometritis and urinary tract infection. A total of 383 patients with GDM were included, among whom 72 (18.8%) developed postoperative infections. The infection types included incisional infection (n = 38), endometritis (n = 20), urinary tract infection (n = 10), and others.

Baseline Characteristics and Univariate Analysis

Baseline comparisons between the infection and non-infection groups are presented in Table 2. Univariate analysis revealed significant differences in hemoglobin (Hb), pre-pregnancy BMI, NLR, PNI, preoperative 2-hour postprandial glucose (Pre-op 2h PPG), CRP, and PLR (all $p < 0.05$). Variables including age, parity, gestational age, operative duration, intraoperative blood loss, and fasting glucose showed no statistically significant differences between the groups.

Univariable Logistic Regression Analysis

Baseline comparisons between the infection and non-infection groups were performed, followed by univariable logistic regression analysis to quantify the association between each variable and postoperative infection. The analysis identified hemoglobin, pre-pregnancy BMI, NLR, PNI, preoperative mean 2-hour postprandial glucose, CRP, and PLR as significantly associated with postoperative infection (all $p < 0.05$). In contrast, age, parity, gestational age, operative duration, intraoperative blood loss, and preoperative fasting glucose were not significantly associated with infection risk (all $p > 0.05$). Detailed results are presented in Table 3.

Multivariable Logistic Regression Analysis

Although preoperative 2-hour postprandial glucose was statistically significant in univariable analysis, it did not retain independent significance in the stepwise multivariable regression model and was therefore excluded from the final model, likely due to collinearity with inflammatory and nutritional indices. Variables with statistical significance in univariable analysis were entered into the multivariable logistic regression model. The results indicated that elevated CRP, decreased PNI, decreased Hb, and elevated PLR were independent risk factors for post-cesarean infection in patients with GDM (all $p < 0.05$; Table 4). Pre-pregnancy BMI and NLR did not demonstrate independent predictive value in the multivariable analysis (all $p > 0.05$; Table 4).

Optimal Cut-Off Values and Discriminative Performance of Inflammatory and Nutritional Indices

Receiver operating characteristic curve analysis was performed to evaluate the discriminative performance and optimal cut-off values of each inflammatory and nutritional index for predicting postoperative infection (Fig. 1 and Table 5). CRP demonstrated the highest discriminative potential, with an AUC of 0.966 and an optimal cut-off value of 10.95 mg/L. Hemoglobin also showed good discriminative performance (AUC = 0.828), with an optimal cut-off of 109.25 g/L, followed by PNI (AUC = 0.771; cut-off = 44.85).
Among the inflammatory ratio indices, PLR exhibited moderate discriminative performance, with an AUC of 0.714 and an optimal cut-off value of 169.05. Furthermore, a comprehensive multivariate risk stratification model incorporating CRP, PLR, PNI, and hemoglobin demonstrated excellent apparent discrimination performance (AUC = 0.995).
CRP showed high sensitivity (88.9%) and specificity (99.0%), whereas PLR demonstrated moderate sensitivity but relatively lower specificity. Detailed values for sensitivity, specificity, Youden index, and AUC for each index are summarized in Table 5. Given the retrospective, single-center design, the exceptionally high AUC of the combined model should be interpreted with caution, and its discriminative performance should be validated in independent cohorts.

Risk Stratification

Based on the four independent inflammatory and nutritional risk factors (CRP >10.95 mg/L, PLR >169.05, PNI <44.85, Hb <109.25 g/L), patients were stratified according to the number of risk factors present. Fig. 2 shows that the incidence of postoperative infection increased signifi-

Table 2. Baseline characteristics and univariate comparisons between infection and non-infection groups.

Variables	Total (n = 383)	Infection (n = 72)	Non-infection (n = 311)	Statistic	*p*-value
Fasting glucose (mmol/L), mean ± SD	4.77 ± 0.50	4.82 ± 0.53	4.76 ± 0.49	$t = 0.95$	0.340
Hb (g/L), mean ± SD	114.82 ± 10.75	104.38 ± 9.67	117.23 ± 9.48	$t = -10.32$	<0.001
Age (years), M (Q_1, Q_3)	31.00 (28.00–34.00)	31.00 (28.00–34.00)	30.00 (27.00–34.00)	$Z = -0.60$	0.547
BMI (kg/m^2), M (Q_1, Q_3)	24.20 (22.80–25.70)	26.15 (24.12–27.83)	23.90 (22.60–25.45)	$Z = -6.73$	<0.001
Pre-op 2h PPG (mmol/L), M (Q_1, Q_3)	7.90 (7.30–8.60)	8.55 (7.70–9.00)	7.70 (7.20–8.40)	$Z = -6.27$	<0.001
Operative duration (minutes), M (Q_1, Q_3)	58.00 (55.00–62.00)	59.00 (55.00–63.25)	58.00 (55.00–62.00)	$Z = -1.09$	0.274
Intraoperative blood loss (mL), M (Q_1, Q_3)	344.00 (311.00–374.00)	346.00 (316.75–378.75)	343.00 (310.00–373.00)	$Z = -1.49$	0.136
NLR, M (Q_1, Q_3)	3.50 (3.10–4.10)	4.40 (3.48–4.80)	3.50 (3.10–4.00)	$Z = -6.60$	<0.001
PLR, M (Q_1, Q_3)	170.60 (152.85–190.80)	187.95 (169.25–210.48)	166.70 (148.80–184.90)	$Z = -5.67$	<0.001
CRP (mg/L), M (Q_1, Q_3)	7.10 (5.50–9.25)	19.95 (15.55–24.72)	6.60 (5.10–8.20)	$Z = -12.33$	<0.001
PNI, M (Q_1, Q_3)	45.60 (42.75–48.30)	42.30 (39.30–44.80)	46.20 (43.65–48.65)	$Z = -7.17$	<0.001
Parity, n (%)				$\chi^2 = 3.03$	0.082
0	188 (49.09)	42 (58.33)	146 (46.95)		
1	195 (50.91)	30 (41.67)	165 (53.05)		
Gestational age (weeks), M (Q_1, Q_3)	38.00 (37.00–39.00)	38.00 (37.00–39.00)	38.00 (37.00–39.00)	$Z = -1.12$	0.261

Note: BMI, body mass index; CRP, C-reactive protein; Hb, hemoglobin; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; PNI, prognostic nutritional index; Pre-op 2h PPG, preoperative 2-hour postprandial glucose.

Table 3. Univariable logistic regression analysis of risk factors for postoperative infection.

Variables	β	SE	Z	*p*-value	OR (95% CI)
BMI (kg/m^2)	0.610	0.087	7.046	<0.001	1.839 (1.563–2.197)
Pre-op 2h PPG (mmol/L)	1.348	0.210	6.410	<0.001	3.848 (2.590–5.924)
NLR	1.764	0.251	7.018	<0.001	5.833 (3.630–9.757)
PLR	0.038	0.006	5.962	<0.001	1.039 (1.026–1.052)
CRP (mg/L)	0.826	0.131	6.285	<0.001	2.284 (1.834–3.091)
Hb (g/L)	–0.152	0.019	–7.800	<0.001	0.859 (0.825–0.891)
PNI	–0.261	0.038	–6.858	<0.001	0.771 (0.713–0.828)
Intraoperative blood loss (mL)	0.007	0.004	1.887	0.059	1.007 (1.000–1.014)
Parity	–0.459	0.265	–1.734	0.083	0.632 (0.374–1.058)
Gestational age (weeks)	–0.177	0.158	–1.124	0.261	0.838 (0.613–1.139)
Operative duration (minutes)	0.031	0.031	1.005	0.315	1.031 (0.971–1.095)
Fasting glucose (mmol/L)	0.251	0.263	0.955	0.340	1.285 (0.769–2.156)
Age (years)	0.022	0.040	0.551	0.582	1.022 (0.945–1.105)

Note: OR, odds ratio.

cantly with increasing numbers of risk factors (trend test, $\chi^2 = 269.47$, $p < 0.001$). Specifically, the infection rates were as follows: 0 factors (n = 90), 0.0%; 1 factor (n = 144), 1.4%; 2 factors (n = 85), 14.1%; 3 factors (n = 38), 84.2%; and 4 factors (n = 26), 100.0%.

Discussion

This retrospective study of 383 patients with GDM undergoing elective cesarean section systematically evaluated the predictive value of preoperative inflammatory and nutritional indices for postoperative infectious complications. Multivariable logistic regression analysis identified elevated CRP, decreased PNI, decreased hemoglobin, and elevated PLR as independent risk factors for postoperative infection. Risk stratification based on the number of these factors demonstrated a marked increase in infection risk with accumulating risk factors. These findings confirm the critical roles of preoperative systemic inflammation and nutritional status in perioperative infection and provide a concise, objective approach to preoperative risk assessment in patients with GDM.

Elevated preoperative inflammatory markers directly reflect a "pro-inflammatory" state that is unfavorable for surgical stress response and infection control. In patients with GDM, chronic hyperglycemia and insulin resistance may lead to persistent low-grade inflammation, manifested as elevated baseline levels of acute-phase proteins, such as CRP [4,5]. This study confirms that elevated preoperative CRP is a strong independent predictor of postoperative infection. As a sensitive marker of systemic inflammatory burden, increased CRP not only reflects pre-existing inflammation but may also indicate that the innate immune system is under sustained stress or near exhaustion, thereby reducing its capacity to respond effectively to surgical trauma

Table 4. Multivariable logistic regression analysis of independent risk factors.

Variables	β	SE	Z	p-value	OR (95% CI)
CRP (mg/L)	0.869	0.243	3.570	<0.001	2.383 (1.669–4.427)
PNI	–0.386	0.124	–3.104	0.002	0.680 (0.507–0.842)
Hb (g/L)	–0.158	0.059	–2.694	0.007	0.854 (0.746–0.945)
PLR	0.045	0.022	2.025	0.043	1.046 (1.006–1.101)
NLR	1.568	0.888	1.766	0.077	4.795 (0.993–35.261)
BMI (kg/m^2)	0.495	0.291	1.702	0.089	1.640 (0.973–3.136)

Table 5. Discriminative performance of preoperative inflammatory and nutritional indices for postoperative infection.

Marker	Cut-off	Sensitivity	Specificity	Youden index	AUC (95% CI)
CRP	10.95	88.90%	99.00%	0.879	0.966 (0.932–1.000)
PLR	169.05	76.40%	54.30%	0.307	0.714 (0.646–0.782)
PNI	44.85	76.40%	66.60%	0.429	0.771 (0.712–0.830)
Hb	109.25	72.20%	81.70%	0.539	0.828 (0.774–0.883)

Note: AUC, area under the curve.

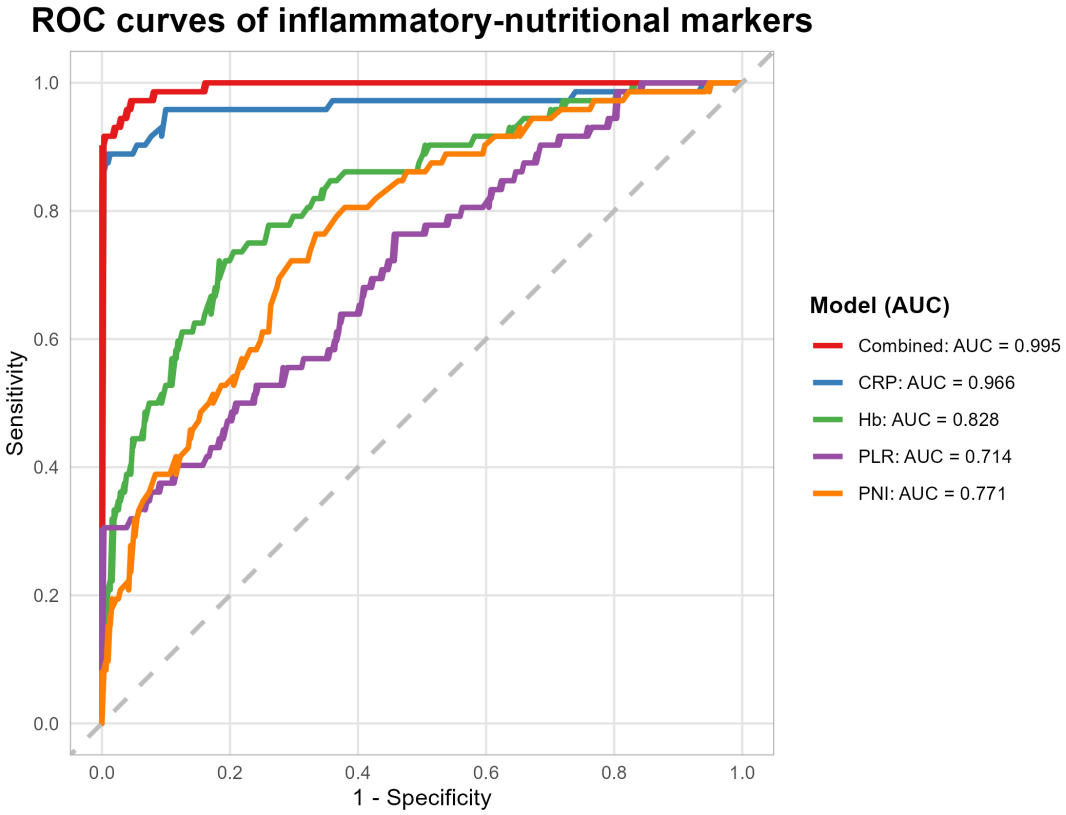

Fig. 1. Receiver operating characteristic (ROC) curve for preoperative inflammatory and nutritional markers. AUC, area under the curve; CRP, C-reactive protein; Hb, hemoglobin; PLR, platelet-to-lymphocyte ratio; PNI, prognostic nutritional index.

and pathogen invasion [14]. The high discriminative performance of CRP observed in this study (AUC = 0.966) may reflect subclinical systemic inflammation in patients with GDM prior to surgery rather than overt infection. Given that CRP was measured preoperatively in the absence of clinically evident infection, its elevation likely represents impaired immune reserve and heightened inflammatory burden, supporting its predictive rather than diagnostic value.

Moreover, the integration of CRP with PLR, PNI, and hemoglobin captures complementary inflammatory and nutritional-hematologic pathways, supporting the clinical relevance of a combined risk stratification approach rather than reliance on a single biomarker. Compared with individual markers, PLR, as a composite inflammatory index, provides broader pathophysiological information. It reflects the balance between platelet activation, which is involved in inflammatory mediator release and hypercoagu-

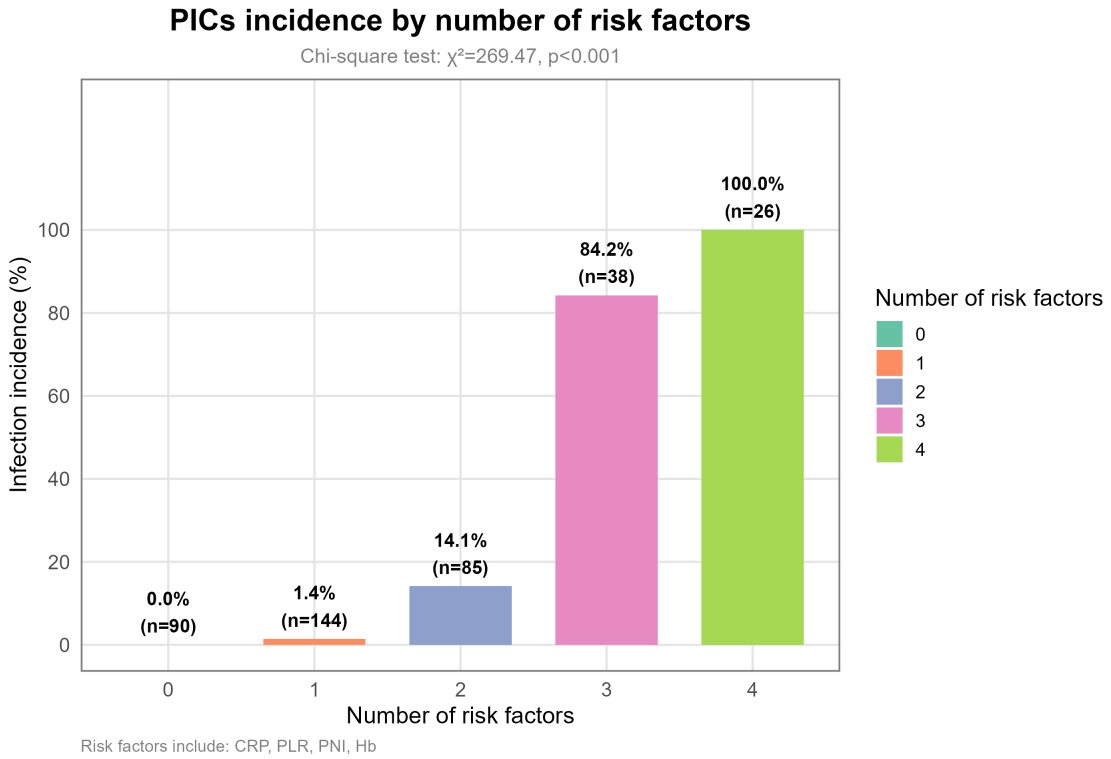

Fig. 2. Incidence of postoperative infection according to the number of risk factors. PICs, postoperative infectious complications.

lability, and lymphocyte count, which reflects adaptive immune function [12,15]. An elevated PLR suggests a pro-inflammatory and pro-thrombotic state accompanied by relative lymphopenia, which may promote postoperative infection by impairing immune surveillance and regulatory mechanisms [16]. This study further supports the predictive value of PLR in the GDM cesarean population, complementing the predictive value of single inflammatory markers.

The predictive value of nutritional indices, PNI and hemoglobin, highlights that adequate nutritional reserves are fundamental for effective perioperative recovery. PNI, which combines serum albumin and lymphocyte count, reflects both protein nutritional status and immune capacity. A reduced PNI indicates protein-energy malnutrition, which may impair immune cell proliferation and function, reduce antibody production, and limit substrate availability for tissue repair processes [17]. This risk may be particularly prominent in patients with GDM due to dietary restrictions and increased metabolic demands.

Hemoglobin level directly determines tissue oxygen delivery. Postoperative wound healing is a highly oxygen-dependent metabolic process involving fibroblast proliferation, collagen synthesis, and epithelialization [18]. Anemia-related tissue hypoxia may impair these processes and reduce the reactive oxygen species-mediated bactericidal activity of neutrophils, thereby increasing susceptibility to infection [19,20]. Therefore, correction of anemia and optimization of nutritional status are important components of perioperative management in patients with GDM and may be as important as glycemic control for improving surgical outcomes.

In this study, inflammatory and nutritional indices are not independent but collectively represent an interrelated inflammation-nutrition axis. Chronic inflammation, reflected by elevated CRP and PLR, may contribute to or exacerbate malnutrition, indicated by reduced PNI and anemia, through increased catabolism, muscle wasting, negative nitrogen balance, and impaired nutrient absorption and utilization [14,21]. Conversely, malnutrition may compromise immune function and reduce anti-inflammatory capacity, thereby sustaining or aggravating the inflammatory state [22,23]. In patients with GDM, this bidirectional interaction may be further amplified by underlying metabolic dysregulation.

The proposed risk stratification model, integrating CRP, PLR, PNI, and Hb, captures the degree of imbalance within this axis. As the number of risk factors increases, the degree of inflammation-nutrition dysregulation becomes more pronounced, accompanied by a marked increase in postoperative infection risk. These findings suggest that clinical assessment should move beyond single indices toward a more comprehensive evaluation to improve identification of high-risk individuals.

This study has several limitations inherent to its single-center retrospective design, including the potential selection bias; thus, the findings require validation in prospective multicenter studies. Moreover, although the combined

model demonstrated exceptionally high discriminative performance, the lack of internal or external validation, such as bootstrap resampling or cross-validation, raises the possibility of overfitting. This combined model has not been internally or externally validated. Therefore, its performance may be overestimated due to potential overfitting, and further validation in independent cohorts is necessary. Additionally, stepwise variable selection may introduce bias during model development. Only patients with complete clinical data were included, and no imputation was performed for missing values, which may further limit generalizability. As the study population was derived from a single institution, its generalizability is limited. Future research should investigate whether targeted interventions, including preoperative nutritional optimization and anti-inflammatory strategies based on this inflammation-nutrition risk stratification, can improve clinical outcomes and facilitate translation of the predictive model into a practical clinical tool.

Conclusions

In conclusion, elevated preoperative inflammatory markers, including CRP and PLR, and impaired nutritional status, reflected by reduced PNI and hemoglobin, are independently associated with postoperative infectious complications following elective cesarean section in patients with gestational diabetes mellitus. Since this model was developed and its performance evaluated within the same queue, this AUC reflects apparent discriminative ability and may contain some optimistic bias. Its generalization performance still needs further external validation for confirmation. A comprehensive preoperative risk stratification approach incorporating these indices may enable early identification of high-risk patients and support individualized perioperative management strategies to reduce postoperative infection rates.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

XLZ and CC designed the research study. XLZ performed the research. CC analyzed the data. XLZ drafted the article. Both authors have been involved in revising the manuscript critically for important intellectual content. Both authors gave final approval of the version to be published. Both authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of Tongxiang Maternity and Child Health Care Hospital (Ethics Review 2026 Research No. 002), and the requirement for informed consent was waived. All procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

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