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Original Research

Early Prediction of Post-Cesarean Infection Using Preoperative and Postoperative Hematologic Markers: A Case-Control Study

Isa Temur[1,*]

[1]Department of Obstetrics and Gynecology, Faculty of Medicine, Nigde Omer Halisdemir University, 51240 Nigde, Turkey
*Correspondence: t.isatemur@gmail.com (Isa Temur)
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Abstract

Background: Postoperative infections remain a significant complication following cesarean delivery, highlighting the need for reliable and accessible methods for early detection. This study aimed to evaluate the predictive value of preoperative and postoperative systemic inflammation markers for post-cesarean section infections. **Methods**: This case-control study included women admitted to the maternity ward of Niğde Ömer Halisdemir University Hospital between 1 October 2021, and 1 October 2023. 50 patients who developed infections following cesarean sections (CS) were compared with 50 control patients. Demographic, clinical, and obstetric information was collected from hospital records. Complete blood count (CBC) results collected 3–10 days prior to surgery and 24 hours post-surgery were analyzed and compared between the two study groups. **Results**: Among patients in the study group, 84% developed surgical site infection (SSI), while the remaining 16% experienced other types of infections. No significant differences were observed between the groups in terms of maternal age, body mass index (BMI), birth weight, length of surgery, blood loss, gestational age at delivery, smoking history, gestational diabetes mellitus, hypertensive disorders of pregnancy, intensive care unit admission, history of emergency CS, gravidity, and parity ($p > 0.05$). No significant differences were observed between preoperative and postoperative values for platelet count (PLT), mean platelet volume (MPV), mean platelet volume-to-platelet ratio (MPV/PLT), or platelet-to-lymphocyte ratio (PLR) ($p > 0.05$). Postoperative monocyte-to-lymphocyte ratio (MLR) and neutrophil-to-lymphocyte ratio (NLR) were significantly in patients with post-CS infections; receiver operating characteristic (ROC) analysis was used to determine optimal cut-off values ($p < 0.001$). **Conclusions**: NLR and MLR may serve as reliable, simple, and effective biomarkers to enhance clinical decision-making for the early detection and prediction of post-cesarean infections.

Keywords: cesarean section; complete blood count; markers; systemic inflammation

1. Introduction

The frequency of cesarean sections (CS), a common obstetric procedure, has gradually increased over the last 10 years [1]. Post-cesarean infections are classified into 2 main categories: general (systemic) infections and specific gynecological infections. General infections include urinary tract infections, pyelonephritis, pneumonia, and mastitis, whereas gynecological infections encompass conditions such as ovarian vein thrombosis, endometritis, and surgical site infections (SSIs) [2].

Specifically, surgical site infection (SSI) following cesarean delivery is defined as an infection occurring within 30 days after the surgical procedure, involving the incision site or deeper tissues manipulated during the operation [3]. SSI is one of the most serious infectious side effects of cesarean delivery, involving either an abdominal incision or a uterine infection. Due to variations in surveillance procedures, patient characteristics, and the use of antibiotic prophylaxis, the incidence of SSI ranges from 3 to 30 percent [4].

SSI is typically characterized by symptoms such as erythema, induration, and purulent or serous discharge, usually occurring within the first week after CS [5]. The occurrence of SSI after CS may be influenced by patient characteristics, healthcare provider factors, and perioperative conditions [6]. Known risk factors for maternal infections following cesarean section include excessive weight or obesity, emergency cesarean delivery, pre-existing psychiatric disorders, the need for blood transfusion during or after delivery, hypertension (gestational hypertension and/or preeclampsia), undergoing 5 or more vaginal examinations during labor, Black race, tobacco use, vertical skin incision, diabetes (pre-gestational and/or gestational), multiple pregnancy, anemia, younger maternal age, and premature rupture of membranes [7].

The most commonly reported risk factors associated with SSIs following cesarean section include preoperative membrane rupture, labor duration exceeding 24 hours, chorioamnionitis, elevated body mass index, severe anemia, vertical skin incision, emergency cesarean delivery, and the lack of preoperative antibiotic prophylaxis. Additionally, prolonged operative time, estimated blood loss greater than 500 mL, postoperative hemoglobin levels below 11 g/dL, advanced maternal age, and a history of more than 6 pregnancies have also been identified as significant risk factors for the development of SSIs [8,9].

In order to reduce the risk of infection after CS, recommendations include controlling blood glucose and blood pressure, using a preoperative antiseptic douche, preparing the incision site with antiseptics, administering prophylactic antibiotics, performing vaginal cleansing, removing the placenta with traction, applying subcutaneous suturing (for subcutaneous tissue >3 cm), and early removal of the bladder catheter [5,10].

According to recent research, hematologic indices such as neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and mean platelet volume (MPV) are being used as indicators of systemic inflammation [11,12]. In obstetrics and gynecology, NLR and PLR have been identified as biomarkers associated with SSIs in several studies [13].

The aim of this study was to investigate whether hematologic indices derived from complete blood count, measured both preoperatively and postoperatively, could be used as early and accessible biomarkers for predicting infections following cesarean delivery.

Null Hypothesis

No significant association was found between hematologic indices (platelet count (PLT), MPV, MPV/PLT, NLR, PLR, and monocyte-to-lymphocyte ratio (MLR)) measured before and after cesarean delivery and the occurrence of post-cesarean infections.

2. Material and Methods

2.1 Ethical Approval and Study Design

The study was approved by the local ethics committee under decision number 2022/128. A research design combining both case-control and cross-sectional methodologies was utilized. This retrospective case-control study included women admitted to the maternity ward of Niğde Ömer Halisdemir University Application and Research Hospital between 1 October 2021, and 1 October 2023.

2.2 Sample Size Determination

The effect size value of d = 0.4275 corresponds to a medium effect size as defined by Cohen (1988) [14] and was assumed based on findings from previous studies conducted on similar topics. Since our study is retrospective, the sample was selected based on existing patient records; however, a post hoc power analysis conducted using this effect size indicated that our study could yield statistically significant results with 80% power.

2.3 Study and Control Groups

The case group consisted of patients who developed infections after cesarean delivery, including endometritis, SSIs, mastitis, and urinary tract infections. These infections were identified based on either the presence of fever or clinical signs of infection during the postoperative hospital stay or a return to a healthcare facility due to such symptoms within 4 weeks postpartum, in accordance with previously published criteria [2].

The control group included patients who underwent CS during the same period but exhibited no clinical or laboratory evidence of infection before or after delivery. To reduce potential confounding, cases and controls were matched based on key maternal characteristics such as age, body mass index (BMI), gravidity, and parity.

Exclusion criteria: Patients with maternal infections, recent corticosteroid use, hematologic diseases (immune thrombocytopenic purpura (ITP), thrombotic thrombocytopenic purpura (TTP), malignancies), chronic conditions affecting complete blood count (systemic lupus erythematosus (SLE), nephropathy, renal/hepatic dysfunction, rheumatoid arthritis, asthma), and pregnancies with chromosomal abnormalities or congenital malformations were excluded. Furthermore, patients who were found to have laboratory or clinically confirmed active infection or sepsis, including upper respiratory tract infection, urinary tract infection, dental infection, pulmonary infection, mastitis, or preterm premature rupture of membranes (P-PROM), based on blood count assessments performed 3 to 10 days prior to cesarean section, were also excluded from the study.

2.4 Maternal and Neonatal Data Collection

Computerized hospital medical records covering the delivery period and all hospital stays were used to gather patient data. Maternal age, BMI, gravidity and parity, prior cesarean deliveries, smoking status, presence of diabetes or hypertension, history of emergency cesarean sections, operative time, amount of intraoperative blood loss, admission to the intensive care unit, and neonatal weight were among the demographic, medical, obstetric, and neonatal variables that were gathered. Additionally, the length of hospital stay (in days) and indications for intensive care unit (ICU) admission were recorded to assess the clinical severity of postoperative complications. Among the patients in both the case and control groups, 8 required admission to the ICU during the postoperative period. The indications for ICU care included preeclampsia, clinical signs of sepsis observed in the postoperative period, hemodynamic instability, and the need for close monitoring. The duration of ICU stay ranged from 48 to 72 hours. Based on existing clinical records, the onset time of infection (in days after cesarean delivery) was recorded.

2.5 Cesarean Surgical Technique

In the cesarean operation performed using the Pfannenstiel technique, the patient was placed in the supine position, the bladder was emptied, and the surgical field was sterilized. A transverse skin incision measuring approximately 10–15 cm in length was made about 2–3 cm above the pubic symphysis. After passing through the subcutaneous tissue, the rectus fascia was incised transversely, the rectus muscles were separated along the midline using blunt dissection, and the peritoneum was opened. The bladder was mobilized inferiorly to expose the lower uterine segment. A small transverse incision was made in this area, which was then enlarged manually, and the baby was delivered, followed by the placenta. During cesarean delivery, placental expulsion was generally achieved spontaneously with gentle cord traction, supported by routine administration of intravenous oxytocin and uterine massage. Following placental delivery, manual exploration of the uterine cavity was routinely performed to confirm complete evacuation and detect any retained tissue. The uterus was closed with a single layer of absorbable sutures; the fascia was meticulously sutured, and the skin was closed with sutures, completing the procedure. This technique was performed to offer advantages such as reduced postoperative pain, improved cosmetic outcomes, and a lower risk of infection. As part of routine perioperative care, all patients received a prophylactic intravenous dose of 1 g of cefazolin approximately 30 minutes prior to skin incision. Postoperative management included daily wound inspection, early mobilization, and standard clinical monitoring for signs of infection throughout the hospital stay.

2.6 Hematological Parameters

Hematologic indices selected for this study (PLT, MPV, MPV/PLT, NLR, PLR, and MLR) have previously been suggested as markers of systemic inflammation and potential predictors of infectious complications in surgical patients. Each index was evaluated at 2 time points: 3–10 days preoperatively and 24 hours postoperatively. Statistical comparisons were conducted to assess whether these parameters could serve as predictive or associative markers for post-CS infection development [2,12].

2.7 Statistical Analysis

In this study, the conformity of continuous variables to a normal distribution was examined using the Shapiro-Wilk test. Based on the test results, variables were reported as descriptive statistics, including mean, standard deviation, median, minimum, and maximum values. Categorical variables were presented as frequency and percentage values. Comparisons of continuous variables between the study groups were conducted using the Independent Samples *t*-test and the Mann-Whitney U test. For time-dependent measurements between groups, percentage change values were calculated and compared using the Independent Samples *t*-test and the Mann-Whitney U test. Yates' corrected Chi-square test and Fisher's exact test were employed for the comparison of categorical variables between the study groups. Receiver operating curve (ROC) analysis was used to identify cut-off points predictive of surgical infection for blood parameters that were found to differ significantly between the groups. The corresponding values were then computed. Statistical analyses were carried out using SPSS statistics 25.0 software (Version 25.0, IBM Corp., Armonk, NY, USA) and MedCalc version 12.3.0.0 (MedCalc Software, Mariakerke, Belgium), with a type I error rate set at 5% for statistical comparisons.

3. Results

Throughout the study, 50 control subjects and 50 study group patients were paired. Of the patients in the study group, 42 (84 percent) had SSI, 4 (8 percent) had endometritis, 2 (4 percent) had urinary tract infections, and 2 (4 percent) had mastitis. In 70% of the cases, the infection developed between the 4th and 7th days, while in 30% it occurred after the 7th day. SSI developed in 42 out of 50 patients (84%) in the study group. Wound dehiscence occurred in 30 of the patients (71.4%) diagnosed with SSI, and the wounds were resutured. All 50 patients received antibiotic treatment; 45 (90%) were managed with intravenous antibiotics, while 5 (10%) received oral antibiotic therapy.

The median maternal age of patients with postoperative infections was 28.0 years, while it was 26.5 years in the control group, with no significant difference observed (p = 0.417). Likewise, the median BMI was 30 kg/m^2 in the infection group and 29 kg/m^2 in the control group, showing no notable difference (p = 0.994). The median birth weight was 3150 g in the infection group and 3180 g in the control group, also with no significant variation (p = 0.852). The mean operative time was 40.42 minutes for patients with infections and 39.86 minutes for controls, showing no significant variation (p = 0.513). Both groups had a median blood loss of 500 cc and a median gestational age of 38 weeks, with no notable differences (p = 0.678, p = 0.974). Regarding prior cesarean history, 66% (n = 33) of patients with infections and 70% (n = 35) of controls had a history of previous cesarean delivery, with no significant difference (p = 0.830). Additionally, smoking, gestational diabetes mellitus (GDM), hypertensive disorders of pregnancy, intensive care unit admission, history of emergency CS, gravidity and parity were similar between the groups (p = 0.287, p = 1.000, p = 0.795, p = 0.712, p = 0.173, p = 0.057 and p = 0.155, respectively) (Table 1).

There were no significant differences in preoperative and postoperative measurements of PLT, MPV/PLT, PLR, and MPV between the case and control groups ($p > 0.05$). Similarly, the percentage changes in PLT, MPV/PLT, PLR, and MPV values before and after surgery were not significantly different in the postoperative infection group (p = 0.888, p = 0.874, p = 0.128 and p = 0.815, respectively). While preoperative MLR measurements did not differ significantly between the groups (p = 0.749), postoperative MLR values showed a significant difference (p = 0.002), with an increase of 61% in the infection group and a decrease of 29% in the control group. The percentage changes in MLR between the groups were also significant (p = 0.007). Preoperative NLR measurements showed no significant difference (p = 0.087), but postoperative NLR values were significantly higher in the infection group ($p <$

Table 1. Shows the results of the analyses comparing the variables between the patients with postoperative infection and the control group.

Variables	Case (n = 50)	Control (n = 50)	p-value
Maternal age (years)	28.0 (17)	26.5 (15)	0.417^a
BMI (kg/m^2)	30 (10)	29 (12)	0.994^a
Birth weight (gram)	3150 (1150)	3180 (1200)	0.852^a
Duration of surgery (min)	40.42 ± 4.62	39.86 ± 3.87	0.513^b
Amount of blood loss (mL)	500 (500)	500 (500)	0.678^a
Gestational age at birth (weeks)	38 (6)	38 (5)	0.974^a
Previous cesarean section n (%)			
Yes	33 (66)	35 (70)	0.830^c
No	17 (34)	15 (30)	
Smoking n (%)			
Yes	11 (22)	6 (12)	0.287^c
No	39 (78)	44 (88)	
Gestational diabetes mellitus n (%)			
Yes	6 (12)	7 (14)	1.000^c
No	44 (88)	43 (86)	
Hypertensive disorders of pregnancy n (%)			
Yes	10 (20)	8 (16)	0.795^c
No	40 (80)	42 (84)	
Intensive care unit admission n (%)			
Yes	3 (6)	5 (10)	0.712^d
No	47 (94)	45 (90)	
History of emergency cesarean section n (%)			
Yes	11 (22)	5 (10)	0.173^c
No	39 (78)	45 (90)	
Gravidity			
1	14 (28)	6 (12)	0.057^c
2	14 (28)	25 (50)	
3	18 (36)	13 (26)	
4	4 (8)	6 (12)	
Parity			
0	14 (28)	8 (16)	0.155^d
1	17 (34)	28 (56)	
2	15 (30)	10 (20)	
3	4 (8)	4 (8)	

$p < 0.05$ significance level. Variables are presented as mean ± standard deviation, median (range).

^{a}: Mann-Whitney U test; ^{b}: Independent Samples t-test; ^{c}: Yates' corrected Chi-square test; ^{d}: Fisher's exact test.

BMI, body mass index.

0.001). NLR increased by 57% in the infection group and by 42% in the control group compared to the preoperative period. Although both groups showed a notable increase, the difference in percentage change between the groups was statistically significant (p = 0.026) (Table 2).

ROC analysis was used to examine significant differences in preoperative and postoperative blood measurements, as well as in percentage changes between the groups (Table 3).

With an area under the ROC curve (AUC) of 0.656 ($p < 0.001$), the cut-off value for the percentage change in MLR from preoperative to postoperative was found to be >74.01 for the prediction of surgical infections ($p < 0.001$). This suggests that patients with an MLR percentage change exceeding 74.01 are at higher risk of developing surgical infections (Fig. 1). The cut-off value for postoperative MLR was identified as >0.43 and 0.681 ($p < 0.001$) as the AUC ($p < 0.001$), indicating a significant association with surgical infections (Fig. 2). Similarly, the cut-off value for post-

Table 2. Presents the changes observed in blood values between the case and control groups before and after surgery.

Blood Values		Case (n = 50)	Control (n = 50)	p-value
	Preoperative	220.50 (146–364)	220.50 (124–353)	0.200[a]
PLT (10^3/µL)	Postoperative	197.50 (135–347)	188.50 (102–288)	0.279[a]
	• $\%\Delta_{POST\rightarrow PRE}$	↓12% ± 13.24%	↓11% ± 13.67%	0.888[b]
	Preoperative	0.05 (0.03–0.10)	0.05 (0.03–0.10)	0.347[a]
MPV/PLT	Postoperative	0.05 (0.03–0.71)	0.05 (0.04–0.42)	0.287[a]
	• $\%\Delta_{POST\rightarrow PRE}$	↑11% (↓34.0%–↑1126.0%)	↑13% (↓24.0%–↑1298.0%)	0.874[a]
	Preoperative	108.56 (59.46–243.15)	110.82 (58.39–212.15)	0.967[a]
PLR	Postoperative	119.73 (56.55–257.37)	110.08 (48.5–229.59)	0.174[a]
	• $\%\Delta_{POST\rightarrow PRE}$	↑10% (↓44.0%–↑115.0%)	↓5% (↓36.0%–↑67.0%)	0.128[a]
	Preoperative	0.31 (0.14–0.85)	0.29 (0.18–0.61)	0.749[a]
MLR	Postoperative	0.49 (0.18–1.31)	0.40 (0.19–1.07)	0.002[a]
	• $\%\Delta_{POST\rightarrow PRE}$	↑61% (↓36.0%–↑328.0%)	↓29% (↓43.0%–↑256.0%)	0.007[a]
	Preoperative	3.51 (1.75–6.31)	3.24 (0.84–5.79)	0.087[a]
NLR	Postoperative	6.26 (2.63–13.98)	4.65 (1.51–7.29)	<0.001[a]
	• $\%\Delta_{POST\rightarrow PRE}$	↑57% (↓37.3%–↑483.3%)	↑42% (↓47.3%–↑691.5%)	0.026[a]
	Preoperative	10.83 ± 1.07	10.80 ± 1.03	0.872[b]
MPV	Postoperative	10.64 ± 1.13	10.63 ± 0.95	0.977[b]
	• $\%\Delta_{POST\rightarrow PRE}$	↓3% (↓17.0%–↑19.0%)	↓2% (↓21.0%–↑17.0%)	0.815[a]

Data are expressed as mean ± standard deviation and median (range).

[a]: Mann-Whitney U test; [b]: Independent Samples t-test; $\%\Delta_{POST\rightarrow PRE}$: percentage change value calculated according to the preoperative value of the measurement value obtained after the operation.

↑: It indicates that the related percentage change value shows an increase; ↓: It indicates that the related percentage change value shows a decrease.

NLR, neutrophil to lymphocyte ratio; PLR, platelet to lymphocyte ratio; MLR, monocyte to lymphocyte ratio; MPV, mean platelet volume; PLT, platelet count; MPV/PLT, mean platelet volume to platelet count ratio.

Table 3. Results of ROC analysis.

	AUC	95% CI (AUC)	p-value	Cut-off	Sensitivity	Specificity	Youden J
MLR $\%\Delta_{POST\rightarrow PRE}$	0.656	0.563–0.749	<0.001	>74.01	44.0	84.0	0.28
NLR $\%\Delta_{POST\rightarrow PRE}$	0.629	0.534–0.724	0.022	>34.21	78.0	46.0	0.24
NLR Postoperative	0.727	0.640–0.814	<0.001	>6.16	54.0	88.0	0.42
MLR Postoperative	0.681	0.590–0.772	<0.001	>0.43	70.0	62.0	0.32

AUC, area under the ROC curve; ROC, receiver operating curve.

operative NLR was calculated as >6.16's predictive potential for surgical infections is further highlighted by its AUC of 0.727 ($p < 0.001$) (Fig. 3). With an area AUC of 0.629 ($p = 0.022$), the cut-off value for the percentage change in NLR from preoperative to postoperative was found to be >34.21 for the prediction of surgical infections. This suggests that patients with an NLR percentage change exceeding 34.21 are at higher risk of developing surgical infections (Fig. 4). The blue dashed lines surrounding the ROC curve represent the 95% confidence interval and indicate the statistical reliability of the curve. These lines reflect the variation at each point on the ROC curve, corresponding to the uncertainty in the measurement of sensitivity. Confidence intervals provide an important statistical reference in the interpretation of ROC analysis, as they demonstrate the extent to which the diagnostic performance of the test may vary depending on the sample.

4. Discussion

Given the increasing rates of CS worldwide, along with the associated infection risks and the potential adverse effects of mother-infant separation, addressing this issue and developing new strategies for the early diagnosis of infections is critical. In this context, considering the high incidence of infections following cesarean delivery and the advantages of readily available blood tests with predictive potential, this study examined the relationship between hematologic indices measured before and after CS, the development of these infections, and their contribution to early diagnosis. The null hypothesis was rejected for NLR and MLR.

A significant difference was observed in postoperative MLR levels ($p = 0.002$), with a 61% increase in the infection group and a 29% decrease in the control group. The inter-

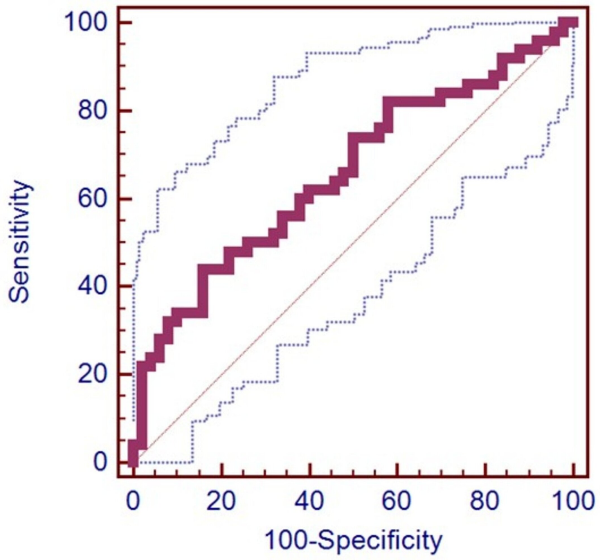

Fig. 1. ROC Analysis of Pre- and Postoperative MLR Change in Infection Prediction (AUC = 0.656, $p < 0.001$). ROC, receiver operating curve; MLR, monocyte-to-lymphocyte ratio; AUC, area under the ROC curve.

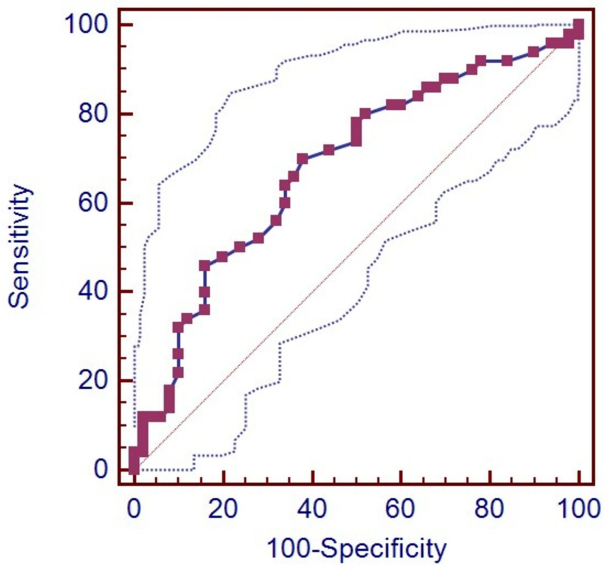

Fig. 2. ROC Analysis of Postoperative 24 h MLR in Predicting Post-Cesarean Infection (AUC = 0.681, $p < 0.001$).

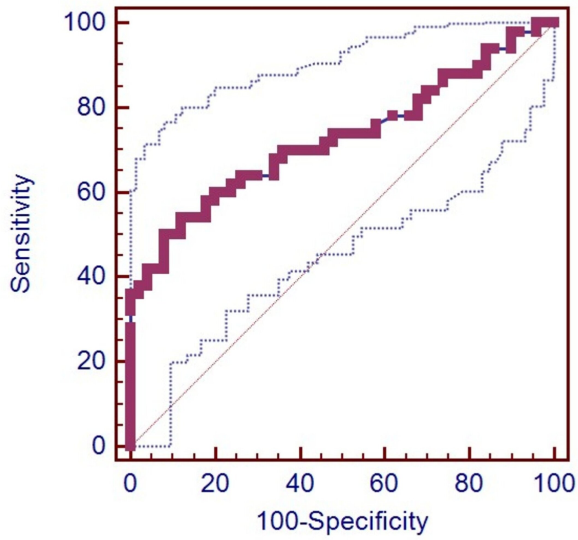

Fig. 3. ROC Curve for 24-Hour Postoperative NLR in Predicting Post-Cesarean Infection (AUC = 0.727, $p < 0.001$). NLR, neutrophil-to-lymphocyte ratio.

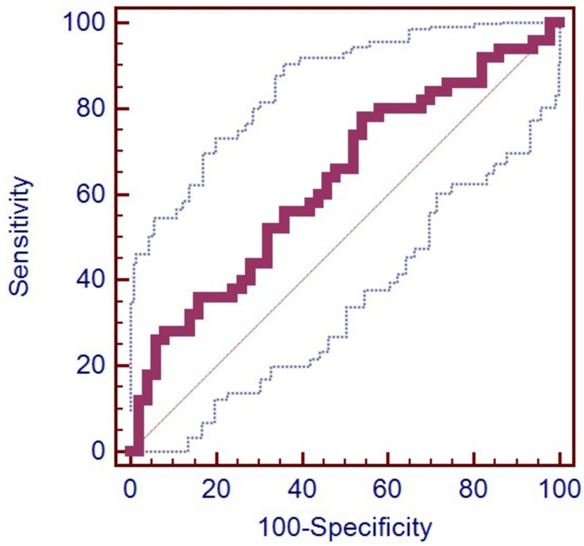

Fig. 4. ROC Analysis of Pre- and Postoperative NLR Change in Infection Prediction (AUC = 0.629, $p = 0.022$).

group difference in the percentage change in MLR was also statistically significant ($p = 0.007$). Similarly, the infection group had a significantly higher postoperative NLR level ($p < 0.001$). Compared to the preoperative period, NLR increased by 57% in the infection group and by 42% in the control group. Although both groups exhibited a substantial rise, the difference in the percentage change between them was statistically significant ($p = 0.026$).

In the study by Rotem *et al*. [2], NLR was found to be independently associated with infections after CS, and PLR values were also found to be significant. This study is one of the few in the literature that attempts to predict infections after obstetric and gynecological surgeries. They found SSI to be the most prevalent infection (71 percent), which is consistent with this study [2]. Similarly, Erciyestepe *et al*. [15] examined the role of NLR and PLR in predicting the risk of infection after hysterectomy and demonstrated that postoperative NLR and PLR levels were higher in patients with infections. İbanoğlu *et al*. [16] highlighted the prognostic significance of NLR in wound infections following CS and found a relationship between increased infection risk and factors such as high BMI, multiple cesarean sections, and operation times of 30–50 minutes, although they did not categorize infections. Aktoz *et al*. [12] also reported that both NLR and PLR levels increased in the SSI group after CS. Differences in results between studies may stem from population characteristics, study design, type of infection, and measurement methods. However, according to this study, high postoperative NLR (>6.16) and MLR (>0.43) values can serve as predictive criteria for infection development. Furthermore, the percentage changes in preoperative and postoperative NLR and MLR values (AUC: 0.629 and AUC: 0.656, respectively) may help predict the risk of postoperative infection. These findings suggest that MLR and NLR may be an effective marker for predicting infections, not only as a single measurement but also through its change over time. Patients with elevated NLR and MLR values may be at increased risk for post-cesarean infections, and in such cases, proper wound care, adherence to hygiene practices, adequate nutrition, early mobilization, observation for potential signs of infection, and regular medical follow-up are recommended to support early detection and timely intervention. However, large-scale prospective randomized studies are needed to establish specific treatment strategies.

Similar results have been reported in studies involving surgical procedures outside the field of obstetrics and gynecology. For instance, Wang *et al*. [17] demonstrated that postoperative NLR could predict complications secondary to infections, with an AUC value of 0.641. In the context of diabetic nephropathy, the optimal MLR cut-off value was reported to be 0.23, with 85% sensitivity, 74% specificity, and an AUC of 0.874 [18]. Zhuo *et al*. [19] found that NLR and PLR effectively predicted SSI in the preoperative period. NLR achieved an AUC of 0.875, with a sensitivity of 97.44% and specificity of 70.3%, while PLR had an AUC of 0.723, with a sensitivity of 74.36% and specificity of 64.24%. However, in this study, preoperative NLR, PLR, and MLR values, as well as postoperative PLR values, were not found to be significant. Similarly, the preoperative and postoperative percentage changes in NLR and PLR were also not significant.

When neutrophils are inappropriately activated, they can cause tissue damage by producing reactive oxygen species, a process that constitutes one of the fundamental mechanisms of inflammatory diseases [20]. Lymphocytopenia serves as an indicator of cytokine activity, while neutrophilia highlights the prominence of the inflammatory response. In this context, NLR is regarded as a reliable predictor of post-surgical complications and a significant marker of systemic inflammation [21–23]. Similarly, PLR is associated with elevated levels of pro-inflammatory mediators and is recognized as an effective indicator of inflammation [24]. Studies by Yombi *et al*. [25] and Naess *et al*. [26] demonstrated that high NLR and MLR levels are directly linked to infection and inflammation.

On the other hand, maintaining the balance between immune tolerance and inflammation during pregnancy is essential for successful implantation and the healthy progression of gestation. Controlled inflammatory activity is necessary for successful implantation, placental development, and the initiation of labor. While regulated inflammation supports physiological processes, disruption of this balance may lead to complications such as pregnancy loss and preterm birth. Therefore, inflammation in pregnancy should be considered a dynamic process that can result in both physiological and pathological outcomes [27].

In our study, no significant differences were observed in inflammatory markers during the preoperative period, whereas a marked increase was noted postoperatively in patients who developed infections. These findings suggest that changes in hematologic parameters may be more closely associated with the development of infection rather than the natural physiological course of pregnancy. This distinction is important for the accurate interpretation of hematological findings in obstetric populations.

Platelets play a critical role in wound healing and hemostasis by secreting cytokines to initiate inflammation. Following surgical incision, platelets actively participate in wound sterilization and tissue regeneration processes [28]. However, MPV, a measure of platelet size, is inversely correlated with platelet count. According to the literature, MPV levels decrease in inflammatory conditions, making this parameter a useful marker for the diagnosis and monitoring of certain inflammatory diseases [29]. Furthermore, the MPV/PLT ratio has been proposed as a novel inflammatory marker for predicting both the clinical severity and mortality outcomes in sepsis [30].

However, in our study, preoperative and postoperative MPV, PLT, and MPV/PLT ratio values were not found to be significant. Additionally, the percentage changes in these values before and after surgery were not statistically significant. These results suggest that hematologic parameters used to assess the inflammatory response after surgery may not always yield meaningful insights, as inflammation can be influenced by individual variables and varying clinical contexts. More comprehensive studies involving larger populations are needed to better understand the role of these parameters in predicting infection and inflammatory processes.

There were no significant differences between the infection and control groups in this study in terms of maternal age, BMI, birth weight, length of surgery, blood loss, gestational age at birth, history of CS, smoking, GDM, hypertensive disorders of pregnancy, admission to the intensive care unit, history of emergency CS, gravidity, and parity ($p > 0.05$). But unlike what we found, Castillo *et al*. [10]. Determiend that the following are documented risk factors for infections following cesarean sections: maternal age, insufficient prenatal care visits, chorioamnionitis, multiple cesarean deliveries, emergency procedures, extended operating times, and substantial blood loss.

Furthermore, there was no correlation between maternal BMI and SSI that had been previously documented. The reason for this disparity could be that the study population had a lower prevalence of obesity than in earlier research [31]. Likewise, this study did not find any correlation between GDM or diabetes mellitus (DM) and SSI, despite the fact that these conditions have been linked to SSI in other research [32]. Even though earlier research has shown that longer operating times raise the risk of bacterial contamination and wound desiccation [33], our cohort did not find any evidence of a significant correlation between operating time and risk of SSI. This finding is also inconsistent with the results of Cheng *et al*. [33], who highlighted the role of prolonged surgical times in increasing the risk of SSI. These differences may be attributed to the demographic and clinical characteristics of the study population, assessment methods, and potential environmental or healthcare-related factors. The findings indicate that the etiology of surgical site infections is more complex and not solely confined to known risk factors. Our study highlights the need for further research involving larger and more diverse populations to better identify these factors.

In this retrospective study, only cases of infection that developed during hospitalization or led to rehospitalization after CS were evaluated. The exclusion of outpatient-managed infection cases from the analysis represents an important limitation of the study and may restrict the generalizability of the results regarding infection incidence and risk factors to the broader population. In addition, the relatively limited sample size may reduce the statistical power and the ability to detect weaker associations, underscoring the need for validation through larger-scale studies.

Future research should include outpatient cases and a variety of demographic and geographic groups in order to offer a more comprehensive view. More thorough data could be obtained using this method, which would help to improve management tactics and comprehend the extent of post-cesarean infections. A prospective design may also improve the accuracy of the findings by providing a stronger methodological framework for gathering and analyzing data.

Studying NLR, MLR, and other hematologic and inflammatory biomarkers in a larger patient population could enhance our understanding of the role of these parameters in the early diagnosis and management of infections. Validating the cut-off values established for these biomarkers in diverse populations is essential to improve their applicability in clinical practice. Additionally, evaluating hematological indices in conjunction with other biomarkers may yield more reliable and effective results for predicting infection risk and developing individualized treatment approaches. Such comprehensive studies could contribute to the development of more effective strategies for managing infections following CS.

5. Conclusions

NLR and MLR emerge as easily applicable, cost-effective, and reliable biomarkers for the early detection and prediction of infections after CS. Regular preoperative and postoperative monitoring of these parameters can enhance clinical decision-making and optimize patient management by enabling accurate assessment of infection risk and facilitating early intervention.

Availability of Data and Materials

The data sets analyzed during the current study are not publicly available due to the data that has been used is confidential, but are available from the corresponding author on reasonable request.

Author Contributions

Concept—IT; Design—IT; Supervision—IT; Resources—IT; Materials—IT; Data Collection and Processing—IT; Analysis and Interpretation—IT; Literature Search—IT; Writing Manuscript—IT; Critical Review—IT. The author approved the final version of the manuscript and agrees to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was carried out in accordance with the guidelines of the Declaration of Helsinki and was approved by the Non-Interventional Clinical Research Ethics Committee of Niğde Ömer Halisdemir University (Approval No: 2022/128). Written informed consent was obtained from all participants.

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Conflict of Interest

The author declares no conflict of interest.

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