

Comparison of Preoperative and Postoperative Inflammatory Markers as Predictors of Surgical-Site Infection in Elective General Surgery

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ABSTRACT

Background: Surgical-site infection is a significant postoperative complication in general surgery and is associated with delayed recovery, readmission, reoperation, and higher health care costs. Clinically, early detection of patients at higher risk is important. Some inflammatory markers like C-reactive protein, total leukocyte count, neutrophil-to-lymphocyte ratio, and platelet-to-lymphocyte ratio may be helpful in understanding the development of a postoperative infection.

Objective: To compare preoperative and postoperative inflammatory markers and assess their value in predicting surgical-site infection among patients undergoing elective general surgery.

Methods: The study was a prospective observational study of 88 patients who were undergoing elective general surgical procedures from September 2025 to February 2026 at the Department of General Surgery, Jakarta State University, Indonesia. Preoperative and early postoperative inflammatory markers (total leukocyte count, neutrophil count, lymphocyte count, neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, and C-reactive protein) were taken. Surgical-site infection (SSI) was followed in patients. Patients with and without SSIs were compared and receiver operating characteristic curve analysis was used to assess the predictive capacity of individual inflammatory markers.

Results: Surgical-site infection developed in 16 of 88 patients (18.2%). Postoperative inflammatory markers were significantly higher than their corresponding preoperative values. Patients who developed SSI had substantially higher postoperative CRP, NLR, WBC, and PLR compared with patients without infection. Postoperative CRP demonstrated the highest predictive performance, with an AUC of 0.86, followed by postoperative NLR with an AUC of 0.82 and postoperative WBC with an AUC of 0.79. Multivariable analysis showed that elevated postoperative CRP, elevated postoperative NLR, and prolonged operative duration were independently associated with SSI.

Conclusion: Postoperative inflammatory markers, particularly CRP and NLR, appear to be more useful than preoperative measurements for predicting surgical-site infection after elective general surgery. Their routine assessment may assist in early identification of high-risk patients and support closer postoperative surveillance.

Keywords: Surgical-site infection, C-reactive protein, neutrophil-to-lymphocyte ratio, inflammatory markers, elective surgery, postoperative infection

INTRODUCTION

Surgical-site infection is considered to be one of the most clinically significant complications after surgical procedures. Can have a negative impact on the healing process, length of hospital stays, need for extra medical interventions like antibiotics, and can be expensive for patients and health systems. Despite advances in surgical technique, peri-operative antibiotic prophylaxis, better sterilisation and infection control measures, postoperative wound infections are still a clinically significant problem in a substantial proportion of those undergoing general surgical procedures (1-3).

There are two types of factors that play a role in the development of SSI, patient-related and procedure-related factors (4). The factors that have been linked to an increased risk of postoperative infection include advanced age, obesity, diabetes mellitus, smoking, poor nutritional status, longer surgical time, ASA classification and surgical drainage. But, symptoms of infection can be delayed after surgery. This lag time makes targeted laboratory markers that can detect an abnormal inflammatory response post-surgery early on desirable (5, 6).

A variety of commonly available inflammatory parameters have been studied for this. C-reactive protein (CRP) is an acute-phase protein that is primarily synthesized in the liver in response to pro-inflammatory cytokines and is often elevated following tissue injury, infection, and surgery. Surgical stress and bacterial infection also causes the rise of total leukocyte count and

neutrophil count (7). More recently, the neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio have become the focus of interest as simple markers of systemic inflammation. This is appealing because these ratios can be quickly and easily generated from a routine complete blood count without extra costs or special laboratory testing (8, 9).

However, it can sometimes be difficult to interpret inflammatory markers post-operatively as surgery causes a physiological inflammatory response. If CRP, leukocyte count or NLR rises in the early postoperative period, this does not necessarily mean that the patient has become infected (10). Therefore, it might be more useful to assess the magnitude of the postoperative change as well as comparing postoperative values between patients with and without SSI. Likewise, comparisons of the pre- and post-operative inflammatory profile can be used to see if pre-operative inflammatory profile or the post-operative inflammatory profile is more predictive (11).

Patient risk for SSI may be identified at an early stage, which will facilitate improved clinical decision making, including the ability to monitor the wound more closely, promptly order microbiological testing to determine if infection is present or to guide judgment about when to intervene, and intervene appropriately when there is a suspicion of infection. The ability to use simple and low-cost inflammatory markers is especially useful in areas where access to more complicated diagnostic testing may be difficult. But, the relative predictive value of surgical, versus post-surgical inflammation markers in elective general surgery is poorly characterized (12, 13).

Therefore, the present study was conducted to compare preoperative and postoperative inflammatory markers and determine their usefulness in predicting surgical-site infection among patients undergoing elective general surgery. The study particularly evaluated CRP, total leukocyte count, NLR, and PLR and assessed whether postoperative values provided better predictive information than their corresponding preoperative measurements.

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METHODOLOGY

This prospective observational study was conducted at the Department of General Surgery, Jakarta State University, Indonesia, from September 2025 to February 2025. A total of 88 patients undergoing elective general surgical procedures were enrolled during the study period. Patients were recruited through a consecutive non-probability sampling technique after assessment of eligibility according to predefined inclusion and exclusion criteria. Ethical approval was obtained from the relevant institutional review committee before initiation of the study, and written informed consent was obtained from all participants after explaining the purpose and procedures of the research.

Included were adult patients (18 years of age or older) scheduled for elective general surgery. Patients with laboratory or follow-up data that was incomplete, those who were taking long-term corticosteroid or immune-suppressing therapy, patients with chronic inflammatory or autoimmune disease, patients with an active infection prior to surgery, and patients undergoing emergency surgery were excluded. Procedures performed for active sepsis or grossly contaminated surgical conditions were also excluded as these may contribute to the inflammation and make the interpretation of postoperative surgical-site infection difficult.

Data collected on a structured data collection form was used to obtain baseline demographic and clinical data. The variables considered were age, sex, body mass index, smoking history, diabetes mellitus, hypertension, American Society of Anesthesiologists physical status classification, type of elective surgical procedure, operation duration, drain placement, and other factors in the surgical procedure that might be relevant. Preoperative preparation, skin antisepsis, prophylactic antibiotic use, surgical technique and postoperative wound care were performed according to standard institutional procedures. Surgery time was recorded as the time elapsed from the beginning of the operative procedure to the end of the closure of the wound. Preoperative and early postoperative (as per the study protocol) blood samples were drawn for evaluation of inflammatory markers. Preoperative samples were taken prior to surgery and postoperative samples were taken within the first 24-48 hours after surgery. The hospital hematology analyzer was used for measuring the total leukocyte count, neutrophil count, lymphocyte count and platelet count. The C-reactive protein was measured by the routine biochemical laboratory method. Neutrophil to lymphocyte ratio was defined as the absolute neutrophils count/absolute lymphocytes count and platelet to lymphocytes ratio was defined as the absolute platelets count/absolute lymphocytes count. WBC, NLR, PLR and CRP were documented before and after surgery and analyzed.

All patients were observed after surgery for the presence of surgical-site infection in hospital and at follow-up. The standard clinical definition of SSI was used and classification was made as superficial incisional, deep incisional and organ/space infection (if applicable). Clinical signs and symptoms recorded were the presence of erythema, local pain or tenderness, swelling, purulent discharge, wound dehiscence, fever and positive microbiological culture. Primary outcome was SSI, and patients were divided into SSI and non-SSI groups for comparison of levels of inflammatory markers.

Data were entered and analyzed by IBM SPSS Statistics version 25.0. Data were reported as a mean value $\pm$ standard deviation for data with normal distribution and as median value with an interquartile range if the data do not have a normal distribution. Categorical variables were presented as frequency and percentage. Preoperative and postoperative levels of inflammatory markers were compared by the paired-samples t test or by Wilcoxon's signed rank test, depending on the distribution of data. Independent-samples t-test, Mann-Whitney U test, chi-square test or Fisher's exact test were applied to compare patients with and without SSI as appropriate. The ability

of inflammatory markers to predict SSI was assessed using receiver operating characteristic curve analysis and area under the curves, optimal cut-off, sensitivity and specificity were reported. Variables with clinically relevant or statistically significant associations were included in multivariable logistic regression to determine independent factors associated with SSI. A p value <0.05 was defined as statistically significant.

RESULTS

There were 88 patients included in the study, who were undergoing elective general surgical procedures. There were 13 male and 2 female participants, with an average age of 46.8 ± 13.2 years (range 19-72 years). Of the total participants, 51 (58.0%) were male and 37 (42.0%) were female. The mean body mass index was 26.7 ± 3.9 kg/m². Diabetes mellitus was present in 19 (21.6%) patients, hypertension was present in 23 (26.1%) patients and 17 (19.3%) participants were current smokers. The majority of the patients were ASA class I or II. Surgical-site infection occurred in 16 patients (18.2%) and was non-occurrence among 72 patients (81.8%) in the follow-up period after surgery.

Table 1: Baseline Demographic and Clinical Characteristics of the Study Participants

Characteristics	Total patients (n=88)
Age, years, mean $\pm$ SD	46.8 $\pm$ 13.2
Male	51 (58.0%)
Female	37 (42.0%)
BMI, kg/m ² , mean $\pm$ SD	26.7 $\pm$ 3.9
BMI ≥ 30 kg/m ²	18 (20.5%)
Diabetes mellitus	19 (21.6%)
Hypertension	23 (26.1%)
Current smoking	17 (19.3%)
ASA class I	32 (36.4%)
ASA class II	44 (50.0%)
ASA class III	12 (13.6%)
Drain placement	31 (35.2%)
Duration of surgery, minutes, mean $\pm$ SD	92.6 $\pm$ 29.4
Surgical-site infection	16 (18.2%)
No surgical-site infection	72 (81.8%)

Inflammatory responses after the surgery were noted as an elevation in total leukocyte count, neutrophil count, NLR, PLR, and C-reactive protein as compared to the preoperative levels. Mean WBC increased from $7.43 \pm 1.61 \times 10^9$ /L preoperatively to $10.18 \pm 2.35 \times 10^9$ /L postoperatively ($p < 0.001$). Similarly, mean NLR increased from 2.61 ± 1.02 to 5.17 ± 2.46 ($p < 0.001$). The largest increase in postoperative was shown in CRP with pre and post level of 6.84 ± 4.76 vs. 34.92 ± 22.63 ($p < 0.001$). PLR also increased significantly following surgery.

Table 2: Comparison of Preoperative and Postoperative Inflammatory Markers

Inflammatory marker	Preoperative	Postoperative	Mean change	p-value
WBC, $\times 10^9$ /L	7.43 $\pm$ 1.61	10.18 $\pm$ 2.35	+2.75	<0.001
Neutrophils, $\times 10^9$ /L	4.62 $\pm$ 1.28	7.64 $\pm$ 2.17	+3.02	<0.001
Lymphocytes, $\times 10^9$ /L	1.95 $\pm$ 0.57	1.61 $\pm$ 0.52	-0.34	<0.001
NLR	2.61 $\pm$ 1.02	5.17 $\pm$ 2.46	+2.56	<0.001
Platelets, $\times 10^9$ /L	267.5 $\pm$ 61.2	279.8 $\pm$ 65.7	+12.3	0.041
PLR	142.8 $\pm$ 46.7	182.6 $\pm$ 68.9	+39.8	<0.001
CRP, mg/L	6.84 $\pm$ 4.76	34.92 $\pm$ 22.63	+28.08	<0.001

Patients with subsequent SSI had elevated levels of inflammatory markers as compared with patients without SSI. There were no significant differences in preoperative CRP and NLR levels between patients with and without SSI, although the differences were significant for postoperative levels of these markers. Patients

with SSI had significantly higher mean postoperative CRP than patients without SSI ($p<0.001$); 61.8 ± 23.7 mg/L vs. 28.9 ± 16.4 mg/L, respectively. Similarly, postoperative NLR was significantly higher in the SSI group (7.46 ± 2.59 versus 4.66 ± 2.16 , $p<0.001$). WBC and PLR were also significantly high in those who developed infection in the postoperative period.

Table 3: Comparison of Inflammatory Markers according to Surgical-Site Infection Status

Marker	SSI (n=16)	No SSI (n=72)	p-value
Preoperative WBC, $\times 10^9$ /L	7.92 ± 1.63	7.32 ± 1.59	0.173
Postoperative WBC, $\times 10^9$ /L	12.31 ± 2.39	9.71 ± 2.08	<0.001
Preoperative NLR	3.02 ± 1.15	2.52 ± 0.97	0.071
Postoperative NLR	7.46 ± 2.59	4.66 ± 2.16	<0.001
Preoperative PLR	154.7 ± 49.5	140.2 ± 46.0	0.260
Postoperative PLR	228.9 ± 72.8	172.3 ± 64.1	0.003
Preoperative CRP, mg/L	9.11 ± 5.34	6.34 ± 4.51	0.032
Postoperative CRP, mg/L	61.8 ± 23.7	28.9 ± 16.4	<0.001

Clinical and operative factors were also evaluated with regard to SSI. The diabetes mellitus, obesity, longer surgical time and intra-operative drain placement were significant risk factors for infection. SSI occurred in 7 of 19 diabetic patients (36.8%) compared with 9 of 69 non-diabetic patients (13.0%) ($p=0.021$). Likewise, a longer operative time (more than 120 minutes) was associated with an increased incidence of infection compared with a shorter operative time. Smoking and hypertension had a higher percentage of SSI, though they were not significant.

Table 4: Clinical and Operative Factors Associated with Surgical-Site Infection

Factor	SSI, n (%)	No SSI, n (%)	p-value
Diabetes mellitus	7 (43.8%)	12 (16.7%)	0.021
BMI ≥ 30 kg/m ²	6 (37.5%)	12 (16.7%)	0.048
Current smoking	5 (31.3%)	12 (16.7%)	0.184
Hypertension	6 (37.5%)	17 (23.6%)	0.245
ASA class III	4 (25.0%)	8 (11.1%)	0.137
Surgery >120 minutes	7 (43.8%)	10 (13.9%)	0.006
Drain placement	9 (56.3%)	22 (30.6%)	0.049

ROC analysis showed that postoperative inflammatory markers, but not preoperative, had superior discriminatory power for the prediction of SSI. The highest predictive performance was for postoperative CRP (AUC 0.86), followed by the postoperative NLR (AUC 0.82) and the postoperative WBC (AUC 0.79). A postoperative CRP cut-off of 45 mg/L had a sensitivity of 81.3% and specificity of 79.2% for SSI diagnosis.

Table 5: Diagnostic Performance of Inflammatory Markers for Prediction of Surgical-Site Infection

Marker	AUC	95% CI	Suggested cut-off	Sensitivity	Specificity
Preoperative CRP	0.66	0.53–0.79	7.5 mg/L	62.5%	65.3%
Postoperative CRP	0.86	0.76–0.95	45 mg/L	81.3%	79.2%
Preoperative NLR	0.63	0.49–0.77	2.8	62.5%	61.1%
Postoperative NLR	0.82	0.71–0.92	5.8	75.0%	76.4%
Postoperative WBC	0.79	0.67–0.90	10.8×10^9 /L	75.0%	72.2%
Postoperative PLR	0.73	0.60–0.86	195	68.8%	70.8%

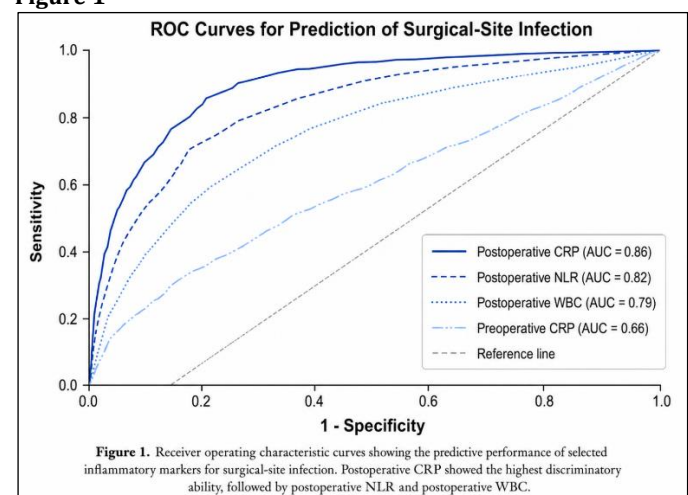
In multivariate logistic regression, CRP, NLR levels at the end of surgery and surgery duration were independently associated with SSI, after adjusting for relevant clinical factors. There was a four-times higher risk of SSI when the postoperative CRP was above the threshold identified. High postoperative NLR was also linked with the risk of infection.

Table 6: Multivariable Predictors of Surgical-Site Infection

Predictor	Adjusted OR	95% CI	p-value
Postoperative CRP ≥ 45 mg/L	4.32	1.32–14.12	0.016
Postoperative NLR ≥ 5.8	3.47	1.08–11.18	0.037
Diabetes mellitus	2.41	0.72–8.06	0.153
BMI ≥ 30 kg/m ²	1.94	0.56–6.70	0.294
Surgery >120 minutes	3.68	1.06–12.74	0.040
Drain placement	1.82	0.55–6.06	0.329

Overall, the findings demonstrated that postoperative inflammatory markers were more strongly associated with SSI than their corresponding preoperative values. Among the evaluated biomarkers, postoperative CRP demonstrated the greatest discriminatory ability, followed by postoperative NLR and WBC. These findings suggest that early postoperative measurement of inflammatory markers may assist in identifying patients at increased risk of developing surgical-site infection after elective general surgery.

Figure 1



DISCUSSION

The present study evaluated the usefulness of preoperative and postoperative inflammatory markers in predicting surgical-site infection among patients undergoing elective general surgery. The findings showed that postoperative inflammatory markers were more strongly associated with SSI than their corresponding preoperative values. In particular, postoperative C-reactive protein, neutrophil-to-lymphocyte ratio, and total leukocyte count were significantly higher among patients who subsequently developed SSI. These results suggest that the early postoperative inflammatory response may provide clinically useful information for identifying patients at increased risk of infectious complications before clear wound-related manifestations become evident (13, 14).

Inflammatory markers were seen to significantly increase after surgery, as surgical trauma triggers a systemic inflammatory response. This increase, however, was significantly higher in SSI patients. Postoperative CRP showed the best discriminatory ability (AUC 0.86) and was able to distinguish between patients with and without SSI (15). CRP is an acute-phase reactant which increases quickly with tissue damage and infection. Surgery-related rise may be physiological, but if the level is persistently raised or is higher than normal, it may indicate a progressive infectious process, rather than the physiological rise seen after surgery. The relatively poor predictive value of preoperative CRP in the current study is another indication of the value of postoperative monitoring (16).

Postoperative NLR also proved to be a potential predictor of SSI. Patients with infection had significantly higher NLR levels than the patients without infection. The combined processes of

neutrophilia with relative lymphopenia in acute inflammatory and physiological stress may account for this finding. The main advantages of NLR are that it is cheap, can be easily calculated from the standard complete blood count, and is available even in resource-limited settings. However, in this study, postoperative NLR was more predictive than preoperative NLR, indicating that the change or the dynamic response to surgical stress may be more informative than just a baseline measurement. There was also a significant difference in postoperative leukocyte count and PLR between the SSI and non-SSI groups, but their discriminatory power was not as high as that of CRP and NLR (17, 18).

Other clinical and operative factors also were related to the development of SSI. Patients who developed infection had a higher incidence of diabetes mellitus, obesity, longer operation, and placement of the drain. Obesity may be associated with low tissue perfusion and high tension and diabetes may predispose to postoperative infection due to decreased immune function and delayed wound healing. Extended operations might result in longer exposure to environmental contamination and also longer tissue manipulation, increasing the risk of bacterial inoculation. In the multivariable model, surgical duration (longer than 1 hour) was independently associated with SSI as well as increased CRP and NLR values after surgery. These results suggest that prediction of SSI must not rely exclusively on markers of inflammation, and must take into account the patient- and procedure-specific risk factors (19, 20).

The clinical implication is that to help surgeons better recognize patients who are at high risk, and therefore might need special attention to the wound, early diagnostic evaluation or more frequent follow-up, as assessed through measurement of inflammatory markers. Postoperative CRP seemed to be the most powerful marker while NLR may be a valuable complementary marker as it can be computed without extra laboratory expense. These markers in combination with clinical risk factors could help better stratify the risk of early disease and enable management of potential infection. Inflammatory markers should be used in conjunction with other parameters, however, as surgery itself gives rise to a physiological inflammatory response, high levels are not specific for infection (21).

There are some limitations of this study. It was done on a relatively small number of patients (88) and in one surgical location, which may restrict the extent to which the results may be applicable across different surgical locations and different

numbers of patients. There is a degree of variation between the different elective procedures in their inflammatory reaction after surgery, which could lead to variation in the level of biomarker. Moreover, inflammatory markers were evaluated at a single point in time, namely early postoperative time, not over the course of several postoperative days. Serial measurements may give more details of the nature and duration of inflammatory responses related to SSI. Larger multicenter prospective studies are thus recommended for validation of the identified cut-off values and to further investigate whether it is possible to enhance early detection by using a predictive score based on a combination of CRP, NLR and clinical risk factors.

CONCLUSION

Postoperative inflammatory markers were more useful than preoperative measurements for predicting surgical-site infection following elective general surgery. Postoperative CRP demonstrated the strongest predictive performance, followed by NLR and total leukocyte count. Elevated postoperative CRP and NLR, together with prolonged operative duration, were important independent predictors of SSI. Routine assessment of these readily available inflammatory parameters may help identify patients at increased risk of postoperative infection and support closer clinical surveillance. Further larger and multicenter studies are required to validate these findings and establish standardized postoperative cut-off values for clinical use.

Authors' Contribution

AW: Concept & study design, data collection and drafting of the manuscript.

DS: Data entry, statistical analysis, interpretation of the results.

YJ: Manuscript editing and critical revision of the manuscript.

All authors approved the final version of the manuscript to be published.

Conflict of Interest

The authors declared no conflict of interest.

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Data Availability

Data is available with authors and can be provided on request

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