

**Research Article**

## Evaluation of Relationship Between Inflammation Based Scores and Early Post- Operative Events in Supra Major Abdominal Surgeries

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**OPEN ACCESS****ABSTRACT**

**Background:** Supra-major abdominal surgeries are associated with significant physiological stress and a high risk of post-operative complications. Inflammation-based prognostic scores such as the neutrophil-to-lymphocyte ratio (NLR) and the Onodera Prognostic Nutritional Index (ONI) have emerged as simple biomarkers reflecting systemic inflammation and nutritional status, respectively. However, their role in predicting early post-operative outcomes in supra-major abdominal surgeries remains inadequately explored.

**Aims and Objectives:** The study aimed to evaluate the relationship between inflammation-based prognostic scores, namely pre-operative NLR, post-operative day seven (POD7) NLR, and pre-operative ONI, with the occurrence of early post-operative complications in patients undergoing supra-major abdominal surgeries.

**Materials and Methods:** This prospective observational analytical study was conducted at a tertiary care hospital over a period of one year. A total of 100 patients aged 18–70 years undergoing elective supra-major abdominal surgeries were included. Pre-operative blood investigations were used to calculate baseline NLR and ONI, while POD7 NLR was calculated from routine post-operative blood samples. Patients were followed for early post-operative outcomes, which were graded based on severity. NLR scores were categorized using a cut-off value of 2, and ONI scores were categorized using a cut-off of 45. Statistical analysis was performed using SPSS software, and associations were assessed using Pearson's chi-square test, with  $p < 0.05$  considered statistically significant.

**Results:** Post-operative complications were observed in 42% of patients, including a mortality rate of 13%. Patients with unfavourable pre-operative NLR had a significantly higher incidence of complications compared to those with favourable scores (52.9% vs 16.7%). Similarly, unfavourable POD7 NLR was significantly associated with increased post-operative complications (50% vs 27.3%). Patients with persistently elevated NLR values both pre-operatively and on POD7 demonstrated the highest risk of adverse outcomes. In contrast, ONI did not show a significant association with post-operative complications, as the majority of patients had favourable ONI scores.

**Conclusion:** The study concludes that NLR, particularly when assessed serially, is a reliable, cost-effective, and easily available biomarker for predicting early post-operative complications following supra-major abdominal surgeries. Persistently elevated NLR values are associated with poorer outcomes, whereas ONI showed limited prognostic utility in this cohort. Incorporation of NLR into routine peri-operative evaluation may aid in early risk stratification and improved post-operative management.

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## INTRODUCTION

Supra-major abdominal surgeries are associated with significant surgical stress, tissue injury, and metabolic derangements, often resulting in a high incidence of early post-operative complications such as surgical site infections, sepsis, anastomotic leaks, organ dysfunction, prolonged hospital stay, and mortality. Despite advances in peri-operative care, accurate early prediction of post-operative morbidity remains a major challenge, especially in patients undergoing extensive abdominal procedures involving malignancy, multiorgan resections, or bowel anastomosis [1].

Surgical trauma induces a complex inflammatory response characterized by activation of the innate immune system, release of cytokines, acute phase reactants, and alterations in circulating leukocyte subpopulations. Excessive or dysregulated inflammation has been shown to impair wound healing, predispose to infections, and contribute to post-operative organ dysfunction. Therefore, markers reflecting the magnitude of systemic inflammation have gained increasing importance as potential prognostic tools in surgical patients [2,3].

Among inflammation-based biomarkers, the **neutrophil-to-lymphocyte ratio (NLR)** has emerged as a simple, inexpensive, and reproducible index derived from routine complete blood counts. Neutrophilia reflects the magnitude of the inflammatory response, while lymphopenia represents surgical stress-induced immunosuppression. Elevated NLR values have been consistently associated with adverse outcomes across various clinical settings, including malignancy, sepsis, cardiovascular disease, and major surgeries [4–6]. Several studies have demonstrated that a high pre-operative NLR is predictive of increased post-operative complications, prolonged hospitalization, and mortality following gastrointestinal and hepatopancreatobiliary surgeries [7,8].

In addition to inflammatory status, **nutritional reserve** plays a critical role in post-operative recovery. Malnutrition is known to impair immune competence, delay wound healing, and increase susceptibility to infections. The **Onodera Prognostic Nutritional Index (ONI)**, calculated using serum albumin levels and total lymphocyte count, was originally developed to assess surgical risk and nutritional status in gastrointestinal malignancies. Lower ONI scores have been associated with poor surgical outcomes in selected populations, particularly in oncological surgeries [9,10]. However, evidence regarding its predictive value for early post-operative complications remains inconsistent, with some studies demonstrating strong associations and others reporting limited prognostic utility [11].

While both NLR and ONI are attractive due to their ease of calculation and cost-effectiveness, most existing studies have evaluated these markers independently, focused on single surgical subgroups, or assessed long-term oncological outcomes rather than **early post-operative events**. Moreover, limited data exist comparing **baseline inflammatory status (pre-operative scores)** with **dynamic post-operative inflammatory changes**, such as post-operative day 7 (POD7) NLR, in predicting early complications following supra-major abdominal surgeries [12,13].

The present study aims to evaluate the relationship between inflammation-based prognostic scores, namely the neutrophil-to-lymphocyte ratio (NLR) and the Onodera Prognostic Nutritional Index (ONI), and early post-operative events in patients undergoing supra-major abdominal surgeries. The primary objective is to assess the association between baseline (pre-operative) NLR and ONI scores and the development of post-operative complications, while the secondary objective is to evaluate the relationship between post-operative day 7 (POD7) NLR and early post-operative morbidity. The justification for this study lies in the need for simple, cost-effective, and routinely available biomarkers that can reliably predict post-operative complications and enable early risk stratification in high-risk surgical patients. By identifying patients with unfavourable inflammatory profiles pre-operatively and in the early post-operative period, this study seeks to facilitate timely intervention, closer monitoring, and individualized peri-operative management. The expected future outcome of this study is to support the incorporation of inflammation-based scores, particularly NLR, into routine peri-operative assessment protocols, thereby improving post-operative outcomes and optimizing surgical care.

## METHODOLOGY

This prospective, observational analytical study was conducted at a tertiary care general hospital to evaluate the relationship between inflammation-based prognostic scores and early post-operative events in patients undergoing supra-major abdominal surgeries. The study was carried out over a period of one year from September 2016 to September 2017, after obtaining approval from the Institutional Ethics Committee. A total of 100 indoor patients posted for elective supra-major abdominal surgeries were included after fulfilling the inclusion and exclusion criteria.

All eligible patients aged between 18 and 70 years undergoing open laparotomy procedures of 2–5 hours duration were enrolled after obtaining written informed consent. The included surgical procedures comprised abdominal cancer surgeries, surgeries involving two or more abdominal organs, gastrointestinal resections with anastomosis, and peritonectomy procedures with or without associated resections. Patients with infective or inflammatory co-morbidities

likely to alter leukocyte counts, uncontrolled diabetes mellitus, major organ dysfunction, or those who had received chemotherapy or radiotherapy within four weeks prior to surgery were excluded to avoid confounding of inflammatory parameters.

Pre-operative evaluation included detailed history taking, documentation of demographic variables, clinical examination, and assessment of co-morbid conditions. Laboratory data from routine pre-operative blood investigations performed within five days prior to surgery were recorded. Baseline neutrophil-to-lymphocyte ratio (NLR) was calculated as the ratio of absolute neutrophil count to absolute lymphocyte count, while baseline Onodera Prognostic Nutritional Index (ONI) was calculated using the formula:  $ONI = (\text{serum albumin} \times 10) + (0.005 \times \text{total lymphocyte count})$ .

Post-operatively, patients were monitored daily for the occurrence of early surgical complications during the hospital stay and within the 30-day post-operative period. Post-operative complications were graded according to the severity, ranging from complications requiring only medical management to those necessitating surgical re-intervention or resulting in mortality. Routine post-operative blood investigations performed on post-operative day 7 were used to calculate the POD7 NLR score. Patients who were discharged early or expired before post-operative day 7 were excluded from POD7 NLR analysis.

For analytical purposes, NLR values were categorized using a cut-off of 2, with values  $\leq 2$  considered favourable and  $> 2$  considered unfavourable. ONI scores were initially categorized using a cut-off of 45, with scores  $> 45$  considered favourable. Additional analysis was performed using an adjusted ONI cut-off of 74 based on receiver operating characteristic curve analysis to explore its predictive relevance. The association between inflammatory scores and post-operative complications was evaluated using appropriate statistical methods.

All collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software. Categorical variables were expressed as frequencies and percentages, and associations between inflammation-based scores and post-operative complications were analyzed using Pearson's Chi-square test. A p-value of less than 0.05 was considered statistically significant.

## RESULT

A total of 100 patients undergoing supra-major abdominal surgeries were included in the final analysis. The study population had a mean age of  $46.64 \pm 10.44$  years, with a male predominance (56%). The most common surgical category was bowel resection with or without anastomosis, accounting for 59% of cases, followed by bowel resection with stoma creation (14%) and peritonectomy-based procedures (10%). Overall, 58% of patients did not develop any post-operative complications within the 30-day follow-up period, while 42% experienced complications of varying severity. The most frequent complications were Grade 1 events requiring medical management (20%), whereas Grade 5 complications (post-operative mortality) were observed in 13% of patients.

Pre-operative inflammatory profiling revealed that 70% of patients had unfavourable baseline neutrophil-to-lymphocyte ratio (NLR  $> 2$ ), while only 30% had favourable NLR values. In contrast, pre-operative Onodera Prognostic Nutritional Index (ONI) values were favourable ( $> 45$ ) in 99% of patients, limiting its discriminatory ability in this cohort. Analysis of post-operative day 7 (POD7) NLR showed that 73.8% of patients had unfavourable scores, whereas 26.2% had favourable values.

A significant association was observed between pre-operative NLR and post-operative complications. Patients with unfavourable pre-operative NLR had a markedly higher complication rate (52.9%) compared to those with favourable NLR scores (16.7%), and this association was statistically significant ( $p < 0.05$ ). Patients with unfavourable pre-operative NLR were over three times more likely to develop post-operative complications than those with favourable scores. Similarly, POD7 NLR demonstrated a significant correlation with post-operative morbidity, with 50% of patients having unfavourable POD7 NLR developing complications compared to 27.3% among those with favourable scores ( $p < 0.05$ ). Further stratified analysis demonstrated that patients who exhibited persistently unfavourable NLR values both pre-operatively and on POD7 had the highest incidence of complications, whereas those who maintained favourable NLR values throughout the peri-operative period had the lowest complication rates. Patients who transitioned from favourable pre-operative NLR to unfavourable POD7 NLR also showed an increased risk of complications, highlighting the dynamic prognostic significance of NLR monitoring.

In contrast, pre-operative ONI did not show a statistically significant association with post-operative outcomes at the conventional cut-off value of 45. Even after adjusting the ONI cut-off to 74 using ROC curve analysis, no meaningful correlation between ONI scores and post-operative complications could be demonstrated. These findings suggest that inflammation-based markers, particularly NLR, serve as more reliable predictors of early post-operative outcomes than nutritional indices in patients undergoing supra-major abdominal surgeries.

**TABLE 1. Demographic Profile, Surgical Characteristics, and Clinical Outcomes (n = 100)**

| Variable                     | Category                                | n (%) / Mean ± SD |
|------------------------------|---|-------------------|
| Age (years)                  | Mean ± SD                               | 46.64 ± 10.44     |
|                              | Range                                   | 18 – 66           |
| Sex                          | Male                                    | 56 (56.0)         |
|                              | Female                                  | 44 (44.0)         |
| Surgical Groups              | Group 1 – Whipple's procedure           | 8 (8.0)           |
|                              | Group 2 – Bowel resection ± anastomosis | 59 (59.0)         |
|                              | Group 3 – Solid organ cancer resection  | 9 (9.0)           |
|                              | Group 4 – Bowel resection with stoma    | 14 (14.0)         |
|                              | Group 5 – Peritonectomy ± HIPEC         | 10 (10.0)         |
| Post-operative Complications | No complication                         | 58 (58.0)         |
|                              | Grade 1                                 | 20 (20.0)         |
|                              | Grade 2                                 | 2 (2.0)           |
|                              | Grade 3                                 | 3 (3.0)           |
|                              | Grade 4                                 | 4 (4.0)           |
|                              | Grade 5 (Death)                         | 13 (13.0)         |

**TABLE 2. Association of Pre-operative Inflammatory Scores with Post-operative Complications**

| <b>A. Pre-operative NLR vs Complications (n = 100)</b>      |                            |                       |                  |
|---|----------------------------|-----------------------|------------------|
| Pre-op NLR Category   | Complication Present n (%) | No Complication n (%) | Total n (%)      |
| Favourable ( $\leq 2$ )                                     | 5 (16.7)                   | 25 (83.3)             | 30 (100)         |
| Unfavourable ( $> 2$ )                                      | 37 (52.9)                  | 33 (47.1)             | 70 (100)         |
| <b>Total</b>  | <b>42 (42.0)</b>           | <b>58 (58.0)</b>      | <b>100 (100)</b> |
| <b>B. Pre-operative ONI vs Complications (Cut-off = 45)</b> |                            |                       |                  |
| Pre-op ONI Category   | Complication Present n (%) | No Complication n (%) | Total n (%)      |
| Favourable ( $> 45$ )                                       | 41 (41.4)                  | 58 (58.6)             | 99 (100)         |
| Unfavourable ( $\leq 45$ )                                  | 1 (100)                    | 0 (0)                 | 1 (100)          |
| <b>Total</b>  | <b>42 (42.0)</b>           | <b>58 (58.0)</b>      | <b>100 (100)</b> |

**TABLE 3. Association of POD7 NLR with Post-operative Complications (n = 84)**

| POD7 NLR Category       | Complication Present n (%) | No Complication n (%) | Total n (%)     |
|-------------------------|----------------------------|-----------------------|-----------------|
| Favourable ( $\leq 2$ ) | 6 (27.3)                   | 16 (72.7)             | 22 (100)        |
| Unfavourable ( $> 2$ )  | 31 (50.0)                  | 31 (50.0)             | 62 (100)        |
| <b>Total</b>            | <b>37 (44.0)</b>           | <b>47 (56.0)</b>      | <b>84 (100)</b> |

**TABLE 4. Detailed Test of Significance and Risk Estimation for Inflammatory Scores**

| <b>A. Pre-operative NLR and Post-operative Complications (n = 100)</b> |  |
|--|--|
| Parameter  | Value                                    |
| Statistical test   | Pearson Chi-square                       |
| p-value  | <0.05                                    |
| Probability of complication (Favourable NLR)                           | 5/30 = 16.7%                             |
| Probability of complication (Unfavourable NLR)                         | 37/70 = 52.9%                            |
| Relative risk (Unfavourable vs Favourable)                             | 3.17 times higher risk                   |
| Odds of complication (Unfavourable NLR)                                | 0.52 / 0.48 = 1.08                       |
| Interpretation   | Significant association                  |
| <b>B. POD7 NLR and Post-operative Complications (n = 84)</b>           |  |
| Parameter  | Value                                    |
| Statistical test   | Pearson Chi-square                       |
| p-value  | <0.05                                    |
| Probability of complication (Favourable POD7 NLR)                      | 6/22 = 27.3%                             |
| Probability of complication (Unfavourable POD7 NLR)                    | 31/62 = 50.0%                            |
| Relative risk (Unfavourable vs Favourable)                             | 1.83 times higher risk                   |
| Odds of complication (Unfavourable POD7 NLR)                           | 0.50 / 0.50 = 1.0                        |
| Interpretation   | Significant association                  |
| <b>C. Pre-operative ONI and Post-operative Complications</b>           |  |
| Parameter  | Value                                    |
| Statistical test   | Pearson Chi-square                       |
| p-value  | >0.05                                    |
| Interpretation   | No statistically significant association |

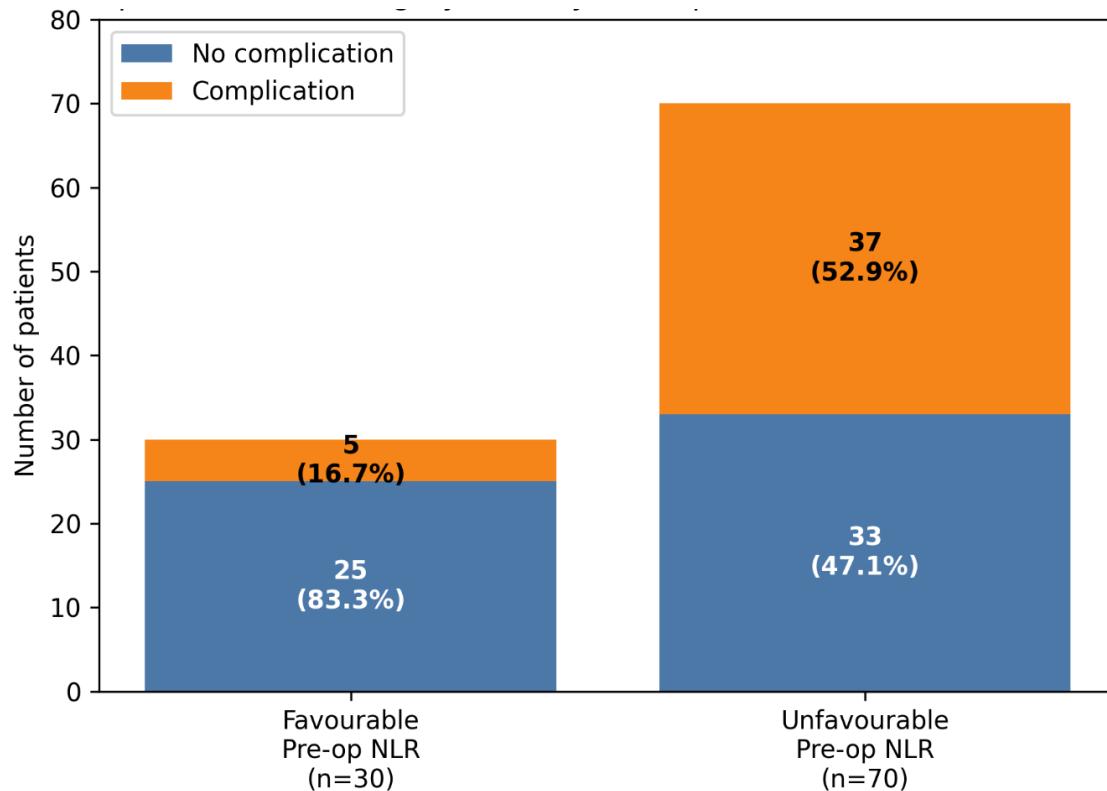


Figure 1: Pre-Operative NLR Category Vs. Early Post-Operative Outcomes

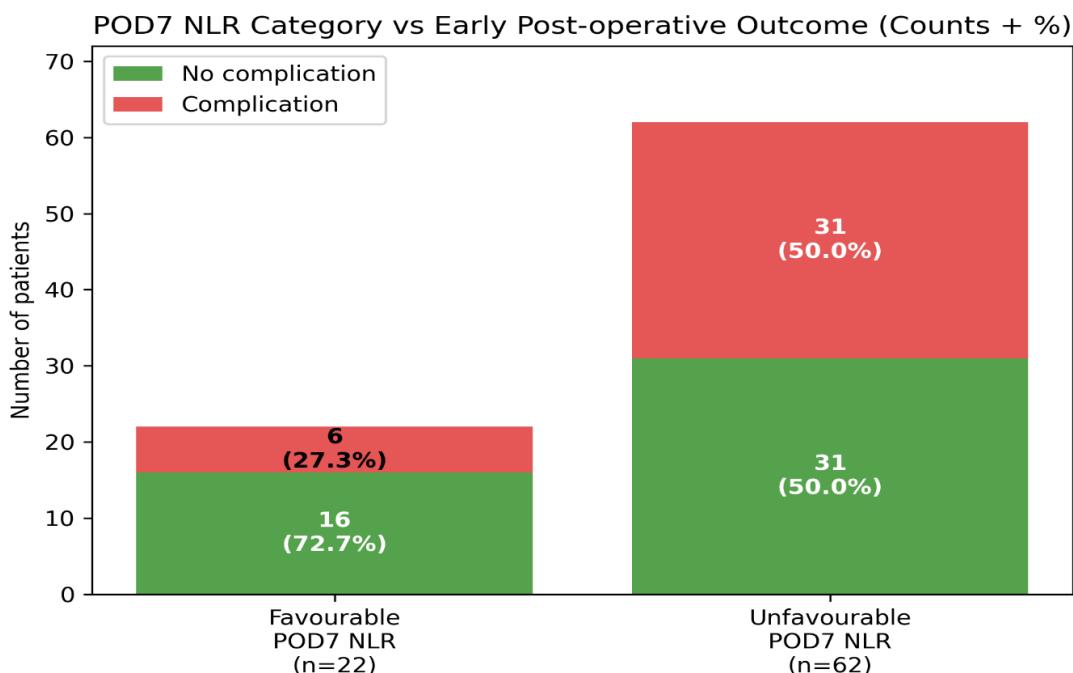


Figure 2: POD7 NLR Category Vs. Early Post-Operative Outcome

## DISCUSSION

The present study evaluated the prognostic role of inflammation-based scores, namely the neutrophil-to-lymphocyte ratio (NLR) and the Onodera Prognostic Nutritional Index (ONI), in predicting early post-operative outcomes following supra-major abdominal surgeries. In this cohort, **42% of patients developed post-operative complications**, including **13% mortality**, underscoring the substantial inflammatory burden and physiological stress associated with extensive abdominal surgical procedures.

### Pre-operative NLR and Post-operative Complications

This study demonstrated that patients with **unfavourable pre-operative NLR ( $>2$ )** had a significantly higher incidence of post-operative complications (**52.9%**) compared to those with favourable NLR values (**16.7%**). Patients with elevated

baseline NLR were **over three times more likely** to develop complications. These findings are concordant with the observations of **Forget et al.**, who first highlighted NLR as a superior predictor of post-operative complications compared to conventional inflammatory markers in major abdominal surgery [14].

Subsequently, **Gibson et al.** reported that elevated pre-operative NLR was associated with increased post-operative morbidity and prolonged hospital stay following colorectal surgery [15]. **Cook et al.** further reinforced these findings by demonstrating that patients with higher NLR values had significantly increased infectious and non-infectious complications after gastrointestinal surgery [16]. The pathophysiological explanation lies in the fact that neutrophilia reflects systemic inflammatory response to surgical stress, while lymphopenia represents impaired cell-mediated immunity, together predisposing patients to sepsis, wound complications, and organ dysfunction [17].

#### **Post-operative Day 7 (POD7) NLR and Outcomes**

In the present study, **50% of patients with unfavourable POD7 NLR (>2)** developed complications compared to **27.3%** among those with favourable POD7 NLR, with this association reaching statistical significance. These findings are consistent with **Forget et al.**, who demonstrated that persistently elevated post-operative NLR, particularly on post-operative day 7, was strongly associated with early morbidity and mortality following major abdominal surgeries [14].

Further supporting this, **Mohri et al.** observed that elevated post-operative NLR was an independent predictor of post-operative infectious complications in colorectal cancer surgery [18]. **Liu et al.** also reported that persistently raised NLR in the early post-operative period was associated with adverse surgical outcomes and prolonged recovery [19]. These findings collectively suggest that **dynamic monitoring of NLR provides better prognostic information than a single pre-operative measurement**.

#### **Sequential Changes in NLR and Risk Stratification**

An important observation in this study was that patients with **persistently unfavourable NLR scores both pre-operatively and on POD7** experienced the highest complication rates, whereas patients maintaining favourable scores had the lowest risk. Patients whose NLR shifted from favourable pre-operative values to unfavourable POD7 values showed a marked increase in complications. Similar trends were reported by **Forget et al.** and **Liu et al.**, who emphasized the prognostic importance of serial NLR assessment rather than isolated values [14,19]. This supports the concept that **ongoing systemic inflammation in the post-operative period is a key determinant of adverse outcomes**.

#### **ONI and Post-operative Complications**

In contrast to NLR, the present study did not demonstrate a significant association between **pre-operative ONI (cut-off 45)** and post-operative complications. This lack of association can be attributed to the fact that **99% of patients had favourable ONI values**, limiting statistical discrimination. **Onodera et al.**, who originally described the ONI, reported its usefulness in identifying malnourished gastrointestinal cancer patients at increased surgical risk [17].

Later studies by **Mohri et al.** and **Yang et al.** showed that low ONI was associated with increased post-operative complications and poorer outcomes in colorectal and gastric cancer surgeries [18,20]. However, unlike these populations, patients in the present study largely had preserved nutritional status, explaining the absence of correlation. Even after adjusting the ONI cut-off value to 74 using ROC analysis, ONI failed to predict post-operative complications, suggesting that **inflammation-driven indices such as NLR may be more sensitive markers of early surgical stress than nutritional indices alone** in supra-major abdominal surgeries.

#### **Clinical Implications**

The findings of this study indicate that **NLR is a simple, inexpensive, and easily reproducible biomarker** with strong predictive value for early post-operative complications. Pre-operative NLR aids in **pre-surgical risk stratification**, while POD7 NLR serves as an effective **early warning marker during post-operative recovery**. In contrast, ONI did not demonstrate predictive utility in this cohort, highlighting the importance of patient selection and baseline nutritional status when applying prognostic nutritional indices.

#### **CONCLUSION**

The present study establishes that inflammation-based prognostic scores, particularly the neutrophil-to-lymphocyte ratio (NLR), are effective predictors of early post-operative outcomes in patients undergoing supra-major abdominal surgeries. Patients with unfavourable pre-operative NLR values and those with persistently elevated NLR on post-operative day seven were observed to have a significantly higher incidence of post-operative complications, including increased mortality. Serial assessment of NLR offered superior prognostic value compared to isolated baseline measurements, emphasizing its role as a dynamic marker of systemic inflammatory response to surgical stress. In contrast, the Onodera Prognostic Nutritional Index (ONI) did not demonstrate a meaningful association with early post-operative complications in this cohort, likely due to the predominance of patients with preserved nutritional status. Overall, the findings suggest that NLR is a simple, cost-effective, and easily accessible biomarker that can be incorporated into routine peri-operative assessment to aid in early risk stratification and clinical decision-making.

## LIMITATIONS

This study has certain limitations that should be considered while interpreting the findings. Being a single-center study conducted at a tertiary care hospital, the generalizability of the results to other healthcare settings may be limited. Although the sample size was adequate for primary analysis, it restricted detailed subgroup evaluation across different surgical categories. Additionally, the predominance of favourable ONI scores among study participants limited the ability to fully assess the prognostic utility of ONI. Patients who succumbed to illness or were discharged before post-operative day seven could not be included in the POD7 NLR analysis, which may have introduced attrition bias. Furthermore, the study focused solely on early post-operative outcomes, and long-term morbidity and survival were not evaluated.

## RECOMMENDATIONS

Based on the findings of this study, routine evaluation of pre-operative and post-operative NLR is recommended in patients undergoing supra-major abdominal surgeries to facilitate early identification of individuals at higher risk for adverse outcomes. Serial monitoring of NLR, particularly up to post-operative day seven, may help guide closer surveillance and timely interventions during the critical recovery period. Future research should involve larger, multi-center prospective studies to validate these findings and improve external applicability. Additionally, integrating NLR with other inflammatory and nutritional biomarkers may enhance prognostic accuracy. Long-term follow-up studies are also recommended to evaluate the association of inflammation-based scores with late complications, readmission rates, and overall survival.

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