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Prognostic performance of the neutrophil-lymphocyte ratio for early complications following sleeve gastrectomy

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Abstract

Aim: To evaluate the prognostic performance of the preoperative neutrophil-to-lymphocyte ratio (NLR) for early complications following sleeve gastrectomy.

Methods: A retrospective cohort study was conducted by analyzing the institutional database of a bariatric clinic from 2017 to 2020. The neutrophil-to-lymphocyte ratio was determined from the preoperative blood count. The area under the curve (AUC) was calculated to determine the performance of the preoperative NLR for early postoperative complications following sleeve gastrectomy.

Results: Among the 387 patients who underwent sleeve gastrectomy, 45 experienced complications within the first 30 postoperative days (11.6%). The AUC for NLR as a predictor of overall early complications after sleeve gastrectomy was 0.42, and for severe complications, it was 0.39.

Conclusion: The preoperative NLR does not perform well as a prognostic indicator for early complications from sleeve gastrectomy.

Keywords: Neutrophils, lymphocytes, bariatric surgery, gastrectomy, postoperative complications (MeSH-NLM)

INTRODUCTION

Obesity is a significant public health issue. According to the World Health Organization (WHO), over 650 million adults were living with obesity in 2016, and over the last 40 years, the global prevalence of obesity has tripled[1]. Obesity is also linked to elevated rates of illness and death, along with a substantial decrease in life expectancy[2]. Bariatric surgery has proven to be an effective long-term treatment for obesity, offering remission of comorbidities, sustained weight loss, improved quality of life, and extended survival[3]. Currently, various types of bariatric surgeries are available, with the most commonly known and performed being Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG)[4].

The criteria for bariatric surgery have evolved over time, from the NIH consensus in 1991 and guidelines from the American Society for Metabolic and Bariatric Surgery (ASMBS) to present-day assessments. These evaluations go beyond the traditional body mass index (BMI) criterion, incorporating factors such as weight history, previous unsuccessful weight loss treatments, and comorbidities[5,6]. Bariatric surgery has a 30-day postoperative mortality rate of 0.08% and a complication rate of up to 17%[7]. Sleeve gastrectomy has one of the lowest complication rates, around 13%[7]. Complications can be classified as early (within 30 days postoperatively) or late (occurring thereafter)[8], as well as surgical or non-surgical[9]. Non-surgical complications include thromboembolic events (0%-0.6% pulmonary embolism), respiratory complications (0.6%-1.1%), and nutritional deficiencies such as anemia in 20%-50% of RYGB or BPD patients. Surgical complications encompass gastric or esophageal perforation, fistula (2.3% for SG, 1.9% for RYGB), stenosis (12% for RYGB, 0.7%-4% for SG), and bleeding (1.5% for SG, 1.7% for RYGB), with many presenting during the early postoperative period [9,10].

Numerous studies have investigated the utility of inflammatory markers, such as C-reactive protein (CRP) and procalcitonin, for identifying early complications following SG and RYGB[11-13]. Another inflammatory marker, the neutrophil-to-lymphocyte ratio (NLR), has been explored as a prognostic marker in various inflammatory conditions, including cancer, cardiovascular diseases, acute pancreatitis, and diabetes mellitus[14-17]. Elevated NLR has been associated with poorer outcomes in major upper gastrointestinal tract surgeries[18] and increased mortality risk in patients with recent acute coronary syndrome[19].

The relationship between obesity, a chronic proinflammatory state, and NLR remains unclear[20]. While some studies have found no significant association between NLR and BMI, they do report that higher BMI correlates with elevated neutrophil and lymphocyte counts[21]. Conversely, other research has identified a significant inverse relationship between NLR and BMI[22]. Currently, few studies evaluate the prognostic utility of NLR in bariatric surgery. A study by Da Silva *et al.* reported a significant association between postoperative day 1 NLR and complications within 30 days post-bariatric surgery[8], and Mari *et al.* found similar results using preoperative NLR[23]. However, neither study involved Latin American populations; they were conducted in countries such as the United States and Israel. Ethnicity is an important factor given that Latin American populations have a higher predisposition to obesity and may have distinct sociodemographic characteristics and surgical considerations, such as a higher prevalence of RYGB in bariatric practice elsewhere[24,25].

In Peru, in 2016, 56.3% of the population was reported to have excess weight[26]. As noted, NLR is an established marker for inflammatory processes and a prognostic tool for various diseases and procedures. Therefore, studying NLR in individuals with a chronic inflammatory state related to excess weight, especially concerning complications following sleeve gastrectomy - a widely utilized bariatric procedure - is highly relevant. Additionally, the limited evidence on NLR's prognostic utility in our study population and the accessibility of NLR through routine blood counts - an affordable and widely available test - highlight

the need for this investigation. This study thus aimed to evaluate the prognostic performance of the neutrophil-to-lymphocyte ratio for early complications after sleeve gastrectomy.

METHODS

Study design and setting

This is a retrospective cohort study based on a secondary analysis of the institutional database from a private bariatric center located in Lima, Perú.

Data source

The study's data source was the institutional database at Clínica Avendaño, from which information on patient demographics, preoperative blood count values, comorbidities, surgical characteristics, hospital stay, and the presence or absence of complications within the first postoperative month was obtained.

Study population

The study population consisted of all patients who underwent sleeve gastrectomy at Clínica Avendaño between 2017 and 2020. We included all patients who underwent sleeve gastrectomy during this period. Exclusion criteria were patients lacking complete medical records in the database, those who underwent revision surgery, individuals under 18 years of age, patients aged 60 years or older, and those with a history of previous bariatric surgery or intragastric balloon placement. Additionally, patients self-reporting harmful alcohol, tobacco, or drug use were excluded. It should be noted that the criteria at this clinic focus on patients with overweight and high body mass who, regardless of BMI, have undergone one or more unsuccessful non-surgical weight loss treatments and present comorbidities such as insulin resistance, dyslipidemia, hypertension, diabetes, fatty liver disease, and obstructive sleep apnea syndrome. Each case is then reviewed in a multidisciplinary meeting for approval prior to surgery.

After applying the selection criteria, 387 participants remained for analysis. For power calculation, we referenced an AUC of 0.8404 from Mari A *et al.*'s study, though a moderate discriminative power of NLR (AUC = 0.70) was assumed for conservativeness[23]. With a total of 45 cases (early complications), 342 controls (absence of complications), and a 95% confidence level, the study achieved a statistical power of 99.4%.

Variables

The dependent variable was early complications, defined as complications occurring within 30 days post-sleeve gastrectomy. Recorded complications included bleeding, deep vein thrombosis or pulmonary embolism, atelectasis, fistula, dehiscence, stenosis, surgical site infection, and urinary tract infection. Bleeding was defined by a positive abdominal trauma ultrasound (FAST) during the postoperative period. Complications were classified by severity using the Clavien-Dindo classification, with mild complications categorized as less than grade III, and severe complications as grade III or higher[27].

The main independent variable was the neutrophil-to-lymphocyte ratio (NLR), calculated by dividing the absolute neutrophil count by the absolute lymphocyte count from the patient's preoperative blood count. Other analyzed variables included age, sex, BMI, operative time (measured in minutes), hospital stay duration (measured in hours), history of smoking (recorded in cardiology's surgical risk assessment), and patient medical history (including hypertension, diabetes, insulin resistance, hypothyroidism, dyslipidemia, obstructive sleep apnea syndrome, asthma, deep vein thrombosis history, and anticoagulant use).

Procedures

While this is a secondary data study, it is important to note that all surgical procedures at the clinic were performed by a bariatric surgery team composed of surgeons formally trained in general surgery with additional subspecialty experience in bariatric surgery. Moreover, all procedures followed standardized institutional protocols for operative techniques and perioperative management.

Statistical analysis

The database underwent an initial quality control process, including checks for missing data and implausible values. Inconsistencies were resolved through thorough reviews of physical or electronic medical records. Following this process, the cleaned database was imported into Stata v16.0 (StataCorp, TX, USA) for analysis.

In univariate descriptive analysis, categorical variables were presented as absolute and relative frequencies. Quantitative variables were summarized with mean and standard deviation (SD) or median and interquartile range (IQR), depending on normality assessments. Normality was evaluated through kurtosis, skewness, histograms, quantile plots, and the Shapiro-Wilk test as a reference.

For bivariate analysis, independent variables were cross-tabulated with early complications (dichotomous outcome). The Student's t-test was used for continuous independent variables with normal distribution; otherwise, the Mann-Whitney U test was employed. For categorical covariates, the chi-squared test was applied, and if more than 20% of expected cell values were ≤ 5, Fisher's exact test was used.

ROC (Receiver Operating Characteristic) curves were constructed for NLR, with the corresponding AUC calculated. The optimal cutoff point was initially identified using the Youden Index. However, given our results, four individual cutoff points with their respective Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value, Positive Likelihood Ratio, and Negative Likelihood Ratio were presented. Cutoff determination was based on tertiles of NLR values.

Ethics

This study involved secondary data analysis and was approved by the Ethics Committee of the Universidad Peruana de Ciencias Aplicadas (UPC) and the Multidisciplinary Research Unit at Clínica Avendaño. No personal identifiers, such as names or surnames, were stored, thereby minimizing any potential risk to patient privacy. Furthermore, access to the database was restricted solely to the researchers.

RESULTS

General characteristics

Initially, data from 472 patients were reviewed retrospectively. After applying the exclusion criteria, 387 patients who underwent sleeve gastrectomy were included in the analysis. Among the studied patients, 72.6% were female (n = 281). The mean age was 35.69 ± 9.63 years, with a median BMI of 36.74 kg/m^2 (IQR: 33.53-40.55). The median NLR was 1.93 (IQR: 1.58-2.44), and 11.6% (n = 45) of the patients experienced complications within the first postoperative month [Table 1].

Complications frequency

The most frequently observed complications were bleeding (62.2%, n = 28), dehiscence or fistula (15.6%, n = 7), and atelectasis (13.3%, n = 6). According to the Clavien-Dindo classification, 71.1% of the complications were classified as mild, while 28.9% were severe [Table 1].

Table 1. General characteristics of patients undergoing sleeve gastrectomy, 2017-2020 (*n* = 387)

Characteristics	*n* (%)
Age*	35.69 ± 9.63
Sex	
Male	106 (27.4)
Female	281 (72.6)
BMI (kg/m^2)**	36.74 [33.53-40.55]
Medical history†	
Hypertension	71 (18.4)
Diabetes Mellitus	19 (4.9)
Insulin resistance	328 (84.8)
Dyslipidemia	93 (24.0)
Deep vein thrombosis	3 (0.8)
Hypothyroidism	35 (9.0)
Asthma	47 (12.1)
Obstructive sleep apnea	4 (12.7)
Use of anticoagulants	1 (0.3)
Smoking	99 (25.6)
Neutrophil-to-lymphocyte ratio (NLR)**	1.93 [1.58-2.44]
Log NLR*	0.68 ± 0.37
Surgery duration (min)**	110 [8-135]
Hospital stay duration (h)**	24 [21-30]
Early complications	
Yes	45 (11.6)
No	342 (88.4)
Type of complications†	
Bleeding	28 (62.2)
Dehiscence/Fistula	7 (15.6)
Surgical site infection (SSI)	5 (11.1)
Lithiasis	3 (6.7)
Atelectasis	6 (13.3)
Pleural effusion	2 (4.4)
Respiratory failure	2 (4.4)
Others	5 (11.1)
Severity of complications	
Minor	32 (71.1)
Major	13 (28.9)

*Mean ± SD; **Median [IQR]; †Values may exceed 100%. IQR: interquartile range; SD: standard deviation.

NLR performance

In the initial bivariate analysis, no significant differences were found between NLR values and the presence or absence of complications [Table 2]. The AUC was calculated for NLR in assessing the prognostic ability for both general and severe complications, with an AUC of 0.42 and 0.39, respectively [Table 3 and Supplementary Figure 1]. The AUC for female patients was 0.40 for general complications and 0.34 for severe complications, compared to 0.48 and 0.50, respectively, for male patients.

Sensitivity and specificity were calculated for various NLR cutoff points, as presented in Table 4. Among these, the cutoff points of NLR > 1.70 and NLR > 2.23 offered the best balance. NLR > 1.70 demonstrated higher sensitivity (62.22%), positive predictive value (PPV) (10.94%), and negative predictive value (NPV)

Table 2. Frequency and percentage of early complications according to demographic and laboratory characteristics of patients undergoing sleeve gastrectomy

Characteristics	Early complications		*P*
	Yes (*n* = 45)	No (*n* = 342)	
Neutrophil-to-lymphocyte ratio (NLR)**	1.79 [1.52-2.11]	1.97 [1.58-2.47]	0.093†
Age**	36 [32-43]	35 [28-42]	0.426†
Sex			0.810¶
Male	13 (12.3)	93 (87.7)	
Female	32 (11.4)	249 (88.6)	
BMI (kg/m^2)**	35.59 [33.12-39.88]	37.17 [33.54-40.56]	0.384†
Medical history			
Hypertension			0.917¶
No	37 (11.7)	279 (88.3)	
Yes	8 (11.3)	63 (88.7)	
Diabetes Mellitus			0.090††
No	45 (12.2)	323 (87.8)	
Yes	0 (0)	19 (100)	
Insulin resistance			0.951¶
No	7 (11.9)	52 (88.1)	
Yes	38 (11.6)	290 (88.4)	
Dyslipidemia			0.417¶
No	32 (10.9)	262 (89.1)	
Yes	13 (14.0)	80 (86.0)	
Deep vein thrombosis			0.689††
No	45 (11.7)	339 (88.3)	
Yes	0 (0)	3 (100)	
Hypothyroidism			0.615††
No	41 (11.6)	311 (88.4)	
Yes	4 (11.4)	31 (88.6)	
Asthma			0.334††
No	41 (12.1)	299 (87.9)	
Yes	4 (8.5)	43 (91.5)	
Obstructive sleep apnea			0.885¶
No	39 (11.5)	299 (88.5)	
Yes	6 (12.2)	43 (87.8)	
Use of anticoagulants			0.884††
No	45 (11.7)	341 (88.3)	
Yes	0 (0)	1 (100)	
Smoking			0.205¶
No	30 (10.4)	258 (89.6)	
Yes	15 (15.2)	84 (84.8)	
Log NLR*	0.63 ± 0.37	0.68 ± 0.36	0.367§
Platelet-to-lymphocyte ratio	142.26 [107.69-184.44]	134.09 [106.71-161.78]	0.299†
Surgery duration**	120 [90-140]	110 [80-133]	0.137†
Hospital stay duration**	25 [22-40]	24 [21-29]	0.133†

*Mean ± SD; **Median [IQR]; †Mann Whitney *U* Test; §Student's *t*-test; ¶Chi2 test; ††Fisher exact test. IQR: interquartile range; SD: standard deviation.

(87.02%). In contrast, the NLR > 2.23 cutoff had superior specificity at 64.62%, compared to 33.33% for the > 1.70 cutoff.

Table 3. Area under the curve of the neutrophil-to-lymphocyte ratio for early complications following sleeve gastrectomy

	Overall early complications	Severe early complications
Neutrophil-to-lymphocyte ratio		
All sample	0.42 (0.34 - 0.51)	0.39 (0.22 - 0.57)
Sex		
Male	0.48 (0.31 - 0.65)	0.50 (0.11 - 0.90)
Female	0.40 (0.30 - 0.50)	0.34 (0.15 - 0.54)

Table 4. Cutoff points for the NLR with corresponding descriptive parameters

NLR	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	LR+	LR-
> 0.49	100	0	11.63	--	1	--
> 1.70	62.22	33.33	10.94	87.02	0.93	1.14
> 2.23	20	64.62	6.92	85.99	0.57	1.24
> 11.04	0	100	--	88.37	--	1

NLR: neutrophil-to-lymphocyte ratio; PPV: positive predictive value; NPV: negative predictive value; LR+: positive likelihood ratio; LR-: negative likelihood ratio.

DISCUSSION

Main results

To our knowledge, this is one of the first studies in Latin America evaluating the prognostic performance of preoperative NLR for complications within the first postoperative month following sleeve gastrectomy. We found no significant differences in preoperative NLR values between patients with and without early complications. Additionally, our analysis showed that preoperative NLR had poor discriminative ability for our outcome of interest.

Comparison with other studies and interpretation of results

NLR has been studied in relation to predicting complications following cardiac and coronary bypass surgeries[28-32]. It has also been associated with infectious complications after colon cancer surgery and the development of acute renal failure following major abdominal surgery[33,34]. In the context of bariatric patients, preoperative NLR has been linked to long-term remission of type 2 diabetes after metabolic surgery. One study reported that an NLR ≤ 1.97 was associated with diabetes remission at one, three, and five years post-surgery[35]. Additionally, an inverse correlation has been observed between preoperative NLR and long-term weight loss after bariatric surgery[36].

However, few studies have examined the utility of NLR for predicting early complications following bariatric surgery. Two studies demonstrated an association between NLR (preoperative or postoperative) and early complications after bariatric surgery[8,23]. Specifically, in sleeve gastrectomy, one study reported that preoperative NLR had good predictive performance for complications, particularly for bleeding or pulmonary complications[37]. In the study by Mari *et al.*, a preoperative NLR above 2.67 was found to have a sensitivity and specificity of 77% and 84%, respectively, while a preoperative NLR above 3 had a sensitivity greater than 90% with specificity ranging from 55-67%[23]. However, similar to our findings, other studies conducted in Europe[38] and Asia[39] have reported a poor to limited prognostic capability of the NLR for adverse outcomes, such as postoperative major complications (AUC: 0.52) and intensive care unit admission (AUC: 0.64), respectively.

Our findings may reflect various contextual factors. While some studies report a potential utility of NLR in patients with high body mass[23,37], the median BMI in these studies was higher than in our population. It is well established that a higher BMI has been associated with a greater prevalence of metabolic complications[40-42], which may contribute to increased baseline inflammation and, consequently, higher NLR levels. Furthermore, it has been suggested that NLR elevation is more prominent with BMI > 40 kg/m^2 [45], while in our study, fewer than 30% of participants fell within this category. Additionally, a study by Howard *et al.* (2019) involving 48,023 adults found that female sex was associated with lower NLR values[44], which may also explain our findings, as nearly three-quarters of our population were female.

The study by Mari *et al.*[23], which reported a significantly higher AUC (0.84), collected blood samples within 24 h before surgery, whereas our study included preoperative blood tests performed up to three months before the procedure. This difference in timing is relevant, as perioperative stress responses have been linked to transient increases in neutrophil counts[45]. It is possible that NLR values measured closer to surgery better capture acute inflammatory responses, enhancing their prognostic utility. Additionally, differences in patient populations may have influenced the results. The median BMI in Mari *et al.*'s study was higher than in our cohort, which could reflect greater baseline systemic inflammation[38-40]. Furthermore, their study included a higher proportion of patients undergoing Roux-en-Y gastric bypass and mini-gastric bypass procedures, which elicit distinct metabolic and inflammatory responses compared to sleeve gastrectomy[44-46]. These factors may partially explain the discrepancy in predictive performance.

The lack of prognostic utility observed in our study might also reflect the complexity of the surgical context and the influence of additional, unmeasured factors. Previous studies have shown that surgical complications can be linked to the procedure itself, including its quality and the technique employed[46,47]. As previously mentioned, the postoperative complication rate tends to be lower for laparoscopic sleeve gastrectomy compared to Roux-en-Y gastric bypass[48,49]. It should also be noted that all patients in our study underwent a multidisciplinary evaluation, including comprehensive preoperative assessments, particularly for patients with uncontrolled comorbidities. This thorough evaluation likely contributed positively to reducing early postoperative complications in our bariatric population.

Limitations

Some limitations should be acknowledged. This study is retrospective, which limits our ability to control for potential confounding factors such as lifestyle, dietary habits, and variations in postoperative care. These variables were not systematically recorded in the clinic's database and could have influenced postoperative outcomes. Additionally, it utilized a secondary database derived from patient medical records at the clinic, which may have contained data entry errors. However, the dataset underwent a rigorous quality assessment to minimize this risk. Detailed intraoperative variables - such as the specific type of stapler used or variations in postoperative care - were also not available. Nevertheless, all surgeries were conducted under standardized institutional protocols, ensuring a consistent approach. The timing of preoperative blood tests ranged from one day to three months before surgery, which may have influenced our findings, as NLR values measured closer to surgery could better reflect perioperative inflammatory responses. Furthermore, the study was conducted in a single private bariatric surgery center, limiting its generalizability to other settings. Our sample also had a low representation of patients with BMI ≥ 50-60, a group that may exhibit distinct inflammatory responses. Future research should consider larger, multicenter studies with broader BMI distributions to better assess the prognostic utility of NLR across different patient subgroups.

Conclusion

The incidence of complications within the first month following sleeve gastrectomy was 11.6%, with bleeding as the most common complication. Preoperative NLR showed poor prognostic performance for

early complications following sleeve gastrectomy in this Peruvian sample. Future studies should explore alternative biomarkers or evaluate combinations of inflammatory markers to improve the early identification of patients at risk of postoperative complications in Latino populations. Additionally, methodological refinements, such as standardized blood sampling timing and advanced analytical approaches (e.g., machine learning), could further elucidate the role of inflammatory markers in surgical outcomes.

DECLARATIONS

Authors' contributions

Conceptualization: Huertas-Campos LF, Torres-Pesantes L, Toro-Huamanchumo CJ
Data acquisition: Huertas-Campos LF, Torres-Pesantes L, Rodriguez-Sagastegui JO, Pinto-Elera J, Salinas-Sedo G
Data curation: Huertas-Campos LF, Torres-Pesantes L, Toro-Huamanchumo CJ
Methodology: Huertas-Campos LF, Torres-Pesantes L, Toro-Huamanchumo CJ
Writing - original draft: Huertas-Campos LF, Torres-Pesantes L, Rodriguez-Sagastegui JO, Pinto-Elera J, Salinas-Sedo G
Writing - review and editing: Toro-Huamanchumo CJ

Availability of data and materials

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

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Conflicts of interest

The authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

This study involved secondary data analysis and was approved by the Ethics Committee of the Universidad Peruana de Ciencias Aplicadas (UPC) and the Multidisciplinary Research Unit at Clínica Avendaño (#852-10-21). Informed consent was not neccessary. As mentioned in the manuscript, this was a secondary data analysis.

Consent for publication

Not applicable.

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