The utility of neutrophil-to-lymphocyte and platelet-to-lymphocyte ratios and systemic immune-inflammation index in predicting survival in elderly patients who underwent hemiarthroplasty for hip fracture

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Research Article

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Abstract

Purpose: To determine the most important and objective preoperative and postoperative predictive values for postoperative mortality in our cohort of patients aged over 60 with hip fracture.

Methods: We performed a retrospective analysis of prospectively collected data on patients who had undergone operation for hip fracture between January 2017 and December 2019. Neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and systemic immune-inflammation index (SII) were calculated using biomarker data (neutrophil, lymphocyte, and platelet counts) obtained at admission and on postoperative days 2 and 5.

Results: A total of 176 individuals (119 female, 57 male) were included in the study. The mean age of the participants was 81.36 ± 9.22 years. The mortality rate was 8.0% (n=14) at 30 days, 27.3% (n=48) at 6 months, and 36.4% (n=64) at 1 year postoperatively. Considering the 1-year mortality, age, PLR at postoperative day 2, and NLR and SII at postoperative days 2 and 5 were significantly different between the survivors and those who died.

Increasing age and higher NLR and SII on postoperative days 2 and 5 were significantly associated with higher risk of death at 1-year follow-up. A 1-year increase in age was associated with a 4.9% increased risk of death at 1-year follow-up (p=0.006). A 1-unit increase in NLR on postoperative day 5 was associated with a 4.3% increased risk of death at 1-year follow-up (p=0.004).

Conclusion: It is suggested that SII, PLR, and NLR may constitute the preoperative variables predictive of postoperative mortality risk in orthogeriatric patients admitted to the emergency department for hip fracture and scheduled to undergo hemiarthroplasty.

Introduction

Hip fracture is a leading cause of morbidity and mortality in the elderly population[1]. Despite the advances in the patient care provided in the perioperative and postoperative periods, the mortality rate within 1 year after hip fracture operation has seen an increase of up to 36%. The major causes of death include myocardial infarction, heart failure, pneumonia, and pulmonary embolism. Increased neutrophil-to-lymphocyte ratio (NLR) in the postoperative period after hip fracture operation has been reported as a risk factor for postoperative mortality and cardiovascular complications[2]. Elevated NLR, especially on postoperative day 5, was shown to be associated with poor disease course in patients with COVID 19, tumor, and infection[3].

Platelet-to-lymphocyte ratio (PLR), a novel marker of systemic inflammation, has shown potential as a prognostic predictor in various diseases including inflammatory and cardiovascular diseases, several malignancies, and even COVID-19[4]. PLR is calculated by dividing the platelet count with the lymphocyte count, and increased platelet and decreased lymphocyte counts have been reported to be associated with poor prognosis in patients with hip fracture following operation[4].
There are studies showing that systemic immune-inflammation index (SII), a composite indicator combining platelet, neutrophil, and lymphocyte counts, is associated with malignant tumors, coronary artery disease, acute ischemic stroke, and premature rupture of membranes[1]. In addition, higher SII (≥834.89) has been recently defined as a favorable risk predictor to differentiate osteoporotic fracture risk in patients with postmenopausal osteoporosis[5].

The dynamic profile of the vital hematological parameters of patients undergoing hemiarthroplasty for hip fracture was presented at three different time points. The literature search showed that there was a correlation between the dynamic profile of hematological parameters and mortality, and a significant difference was observed in the preoperative period and postoperative days 2 and 5[6].

To the best of our knowledge, there is no study in the literature investigating the comparison of preoperative and postoperative dynamic SII, NLR, PLR (dSII, dPLR, and dNLR) on the specified days and their effect on mortality in patients over 60 years of age who underwent hemiarthroplasty due to hip fracture. Therefore, this is the first study to evaluate the kinetic relationship between dSII, dPLR and dNLR in patients who underwent hemiarthroplasty.

In this study, we aimed to investigate NLR, SII, and PLR in the preoperative period and postoperative days 2 and 5 and evaluate their correlation with mortality.

**Objectives**

Our first goal was to determine the most significant and objective preoperative and postoperative predictive risk factors for postoperative mortality in our cohort of patients aged over 60 years with hip fracture as well as to establish and evaluate the performance of a predictive risk score based on these risk factors. Thus, as the second goal of this paper, it was crucial to analyze the prognostic value indicated by different hematological parameters and compare their potential performance as a potential alternative to each other.

Improved ability to predict both in-hospital adverse clinical events and postdischarge mortality using these parameters may provide further benefit to the physician.

**Materials And Methods**

**Study design and patient selection**

*Planning the operation and postoperative care*

The medical records of patients over the age of 60 who underwent hemiarthroplasty due to hip fracture in our institution between January 2017 and April 2020 were examined. All patients underwent clinical follow-up after operation by a multidisciplinary medical team consisted of surgeons, geriatricians, anesthetists, and a supervisor internist.
The inclusion criteria were as follows:

1) age > 60, 2) a minimum of 1-year follow-up, 3) low-energy hip fractures

The exclusion criteria were as follows:

1) history of previous operation on the same hip, 2) intraoperative fractures, 3) fractures other than hip fractures, 4) high-energy hip fractures 5) fractures due to direct blunt trauma, 6) pathological fractures, 7) cancer patients, 8) patients under dialysis, 9) severe liver disease

**Vital status**

For a complete and high-quality follow-up data, we obtained the survival status and the date of death (if it occurred) from the Turkish Social Security Institution using the national identification number of the patients. Causes of death were not available.

**Blood count**

The leukocyte counts of all the patients were evaluated in our biochemistry laboratory on the day of hospitalization, postoperative day 2 and day 5. Blood samples containing EDTA as the anticoagulant were processed in an autohematology (Abbott, Cell-Dyn Ruby, Illinois, USA) analyzer used in our laboratory for the determination of complete blood cell counts and differential leukocyte counts. SII, NLR, and PLR were calculated based on the absolute total neutrophil, platelet, and lymphocyte counts. Samples collected up to 3 days before operation were used for calculating preoperative values.

**Analysis procedure**

**Follow-up**

All patients were allowed to walk with the aid of a walker on postoperative day 1. After discharge, the patients were followed up in the outpatient clinic at 2, 4, and 8 weeks and 6 and 12 months after the operation. Further, the follow-up was continued once a year or until death. The survival status of the patients was determined either through hospital follow-up or governmental institution records. The mortality rate was recorded at 1 month, 6 and 12 months, and at the end of the study. The primary endpoint was determined as either the day of death or the end of the study.

**Determination of the prognostic risk factors**

In previous studies, advanced age and male gender were identified as risk factors in patients with hip fracture. Thus, age and gender were selected as variables with discriminatory ability[7].

Pre and postoperative total leukocyte, platelet, and neutrophil counts; SII; NLR; and PLR were analyzed. NLR was defined as the absolute neutrophil count divided by the absolute lymphocyte count. PLR was
defined as the absolute platelet count divided by the absolute lymphocyte count. SII was calculated using the following formula: platelet count × neutrophil count/lymphocyte count[5].

**Statistical Analysis**

Continuous data are expressed as mean ± SD or median (Interquartile range (IQR): 25th-75th quartile) according to the distribution, and categorical variables are presented as the frequency (percentage). Univariable Cox proportional hazard models were fitted to estimate the effect of each predictor on 1-year mortality. Furthermore, multivariable Cox regression analysis was conducted to identify independent risk factors of mortality. In the multivariable analysis, the variables which were found to have p<0.40 in univariable analysis were included as independent variables in the model. Hazard ratios (HR) along with their 95% confidence intervals were calculated. The proportional hazard assumption of the models were confirmed with Shoenfeld's global test. For determining the predictive ability of variables on 1-year mortality, receiver-operating characteristic (ROC) curve analysis was used. Furthermore, the optimal cut-off values for the Platelet- lymphocyte ratio (PLR), Neutrophil-lymphocyte ratio (NLR), and Systemic immune-inflammation index (SII) at the preoperative and post-operative times were determined. Based on these cut-off values these variables are dichotomized to represent high and low groups. Then survival was estimated using the Kaplan–Meier curves and the differences between high and low groups were assessed using the log-rank test. The analyses were performed using the Statistical Package for Social Sciences 25.0 for Windows (SPSS Inc., Chicago, Illinois, USA) and STATA 16.0. The results were assessed within a 95% reliance and at a level of p < 0.05 significance.

**Results**

A total of 176 individuals (119 female, 57 male) were included in the study. The baseline characteristics of the study population are presented in Table 1. The mean age of participants was 81.36±9.22 years. The median SII was 1007.7 (IQR:654.2-1496)×10⁹/L.

The mortality rates at 30 days, 6 month and 1 year were 8.0% (n = 14), 27.3 (n=48) and 36.4% (n = 64), respectively. In Table 2, comparison of patients’ characteristics between survivors and non-survivors based on 1-year mortality showed that age, PLR at 2nd day, NLR and SII at the 2nd and 5th days, were statistically significantly different between survivors and non-survivors. Furthermore, a significant increase in PLR from the pre-operative time to the post-operative 5th day was observed in both survivor and non-survivors. In both groups, the elevation in NLR was significant at the 2nd day compared to pre-operative time, however no significant difference between the pre-operative time and 5th day were observed in NLR. SII at the 2nd and 5th days were found to be significantly higher compared to pre-operative time in both groups. However, no difference was observed in SII between the 2nd and 5th days.
Univariable Cox proportional hazard models revealed that increasing age, higher NLR and SII at 2\textsuperscript{nd} and 5\textsuperscript{th} days were significantly associated with higher hazard of death at 1-year follow-up (Table 3). After adjusting for other variables in multivariable model, age, PLR and NLR at the 5\textsuperscript{th} post-operative days were identified as independent predictors of 1-year mortality. Results of the multivariable model indicated that, one year increase in age was associated with a 4.9% increased hazard of death at 1-year follow-up (HR: 1.049, 95% CI: 1.014-1.086, p=0.006), increase of 10 units of PLR at the 5\textsuperscript{th} post-operative day was associated with 4% increased hazard of death at 1-year follow-up (HR: 1.004, 95% CI: 1.001-1.009, p=0.009), and increase of one unit of NLR at the 5\textsuperscript{th} post-operative day was associated with 4.3% increased hazard of death at 1-year follow-up (HR: 1.043, 95% CI: 1.013-1.073, p=0.004). Moreover, multivariable analysis indicated a borderline significance for SII at the 5\textsuperscript{th} day implying that, increase of 100 units of SII at the 5\textsuperscript{th} post-operative day was associated with 2.3% increased hazard of death at 1-year follow-up (HR: 1.023, 95% CI: 1.000-1.047, p=0.055).

ROC curve analysis (Figure 1) revealed that the post-operative variables have the ability to detect 1-year mortality. Table 4 juxtaposes characteristics of the predictive power of the ROC curve analysis. The PLR, NLR and SII measurements at the 2\textsuperscript{nd} post-operative day, and NLR and SII at the 5\textsuperscript{th} post-operative day had a good ability to differentiate between survivors and non-survivors. For PLR an AUC of 0.604 (95% CI: 0.517-0.690, p=0.022) was obtained at the 2\textsuperscript{nd} day, with an optimal cutt-off value of $\geq 256.88$. For NLR, AUCs of 0.652 (95% CI: 0.568-0.736, p=0.001, optimal cut-off $\geq 8.25$) and 0.690 (95% CI: 0.610-0.769, p $<0.001$, optimal cut-off $\geq 4.70$) were obtained at the 2\textsuperscript{nd} and 5\textsuperscript{th} days, respectively. When SII considered, we found that SII $\geq 1800.94 \times 10^9$/L at the 2nd post-operative day and SII $\geq 1500.78 \times 10^9$/L at the 2nd post-operative day were optimal cut-offs for differentiating between survivors and non-survivors (AUC of 0.638 (95% CI: 0.551-0.725, p=0.002) and 0.642 (95% CI: 0.556-0.729, p=0.002), respectively). The log-rank test of the Kaplan–Meier curves based on the dichotomized variables also showed that patients with high pre-operative SII, high PLR, NLR and SII at the 2nd post-operative day, and high NLR and SII at the 5th post-operative day had worse 1-year mortality (Figure 2).

**Discussion**

The incidence of hip fractures in the elderly population has tripled in the last 20 years, and there is a parallel increase in mortality rates\cite{8}. In our study, the postoperative 30-day, 6-month, and 1-year mortalities after hip fracture operation were evaluated and predictive values for mortality were defined. dSII, dPLR, and dNLR were included in our analysis as the dynamic values, and SII, PLR, and NLR were obtained on the day of admission and postoperative days 2 and 5 (SII, PLR, and NLR kinetics). We aimed to explore the prognostic value of dSII, dPLR, and dNLR in early risk stratification of patients from hospital admission to the postoperative period in terms of overall survival regardless of known and unknown comorbidities. The prognostic value of SII, PLR, and NLR may ascertain the worse outcome of patients with ongoing inflammation. The cumulative effect of persistent acute inflammatory response and the body’s response to it are thought to increase toxicity.
The present study confirms the previously demonstrated prognostic ability of dSII, dPLR, and dNLR in a vulnerable patient population. These measures provide clinicians with a simple and readily available tool to facilitate accurate prognosis prediction in patients with hip fracture. The low-cost SII, NLR, and PLR measurements are obtained via simple, near real-time calculations using routine laboratory test values without the need to use high-cost assays. SII, PLR, and NLR are available at the time of patient presentation and can be used as rapid and simple parameters in clinical practice. The inflammatory response increases proinflammatory mediators and aggravates hyperinflammation. Inflammatory comorbid conditions accompanied with the gradual collapse of the immune system results in increased mortality and fatality rates[6].

Neutrophils increase the secretion of prostaglandins, growth factors, cytokines, and reactive oxygen species that lead to vascular damage and cause endothelial dysfunction by interfering with platelets. Elderly patients who are under stress due to hip fracture, hemiarthroplasty, general anesthesia, and pain have difficulty maintaining homeostasis. Systemic changes caused by increased stress result in increased neutrophil count and decreased lymphocyte count. Increased SII, PLR, and NLR on postoperative days 2 and 5 may be suggestive of increased stress[9].

The utility of SII, PLR, and NLR is limited to prognosis prediction in our study considering our goals; however, these measures can also enable the prediction of patient outcomes. Thus, we can improve the revalidation process using early and individualized interventions for high-risk patients and, consequently, reduce mortality. This is possible by measuring the risk factors.

In their study involving 50 patients who underwent hemiarthroplasty, Temiz et al.[10] have reported the NLR cut-off value as 5.34. A study by Forget et al.[9] including 237 patients with intracapsular or extracapsular hip fracture, the postoperative NLR cut-off value has been reported as 4.9 (sensitivity: 62.9%, specificity: 57.6%). In our study, unlike the literature, the cut-off value was 8.25 (sensitivity: 67%, specificity: 56%, P = 0.001) on postoperative day 2 evaluation, whereas on postoperative day 5, it was 4.7 (sensitivity: 71.19%, specificity: 56.2%, P < 0.001) similar to the literature.

In the study performed by Bingol et al.[11] that included 345 patients with hip fracture, the cut-off value of NLRs calculated at the time of admission for 1-year mortality was 6.55 (sensitivity: 77%, specificity: 71.1%, P < 0.001). In our study, the values at the time of admission were not found to be significant, and postoperative values were considered as more significant.

Increased PLR has been found to be significantly associated with increased all-cause mortality in the general population, particularly in the elderly[12]. Mathur et al.[12] have reported that mean PLR was significantly higher in those who died compared to those who survived in the general population and participants in the fourth quartile of PLR exhibit a significantly higher risk of death than those in the first quartile (19.8 vs. 13.9 per 1000 person-years). Wang et al.[4] have reported a 18.06% increase in annual mortality in patients with high PLR (≥189) compared to patients with low PLR (<189). Similarly, patients who died had significantly higher platelet counts and PLR and lower lymphocyte counts than survivors. In our study, only the PLR (256.88) obtained at postoperative day 2 was significant (P = 0.022).
A recent study has showed that high PLR was associated with increased all-cause mortality in the elderly but not in middle-aged or younger participants[12].

Wang et al.[4] have found a hazard ratio (HR) of 1.05 for each 1-year age increment in patients with hip fracture [95% confidence interval (CI): 1.01–1.08]. Our study showed that a 1-year increment in age was associated with an increased HR of 4.9% at 1-year follow-up (HR: 1.049, 95% CI: 1.014–1.086, \( P = 0.006 \)).

Wang et al.[1] have found that SII was associated with 1-year mortality as an independent risk factor in elderly patients with hip fractures (HR = 1.08 per 100 units, 95% CI: 1.01–1.17). In our study, we revealed that SII was statistically significant, particularly on postoperative day 2.

A limitation of this study is related to the nutritional status of the patients. Malnutrition is a risk factor for worse outcomes after hip fracture and typically associated with lymphopenia.

Some significant data could not be collected in the study. In particular, we did not have relevant information about the degree of osteoporosis, which may reflect the most important comorbidities. In addition, the cause of death was known only in a limited number of patients.

Specifically, no exclusion criteria were applied to the parameters obtained, although patients who receive steroid therapy and have a smoking habit may show high neutrophil counts.

Platelets and neutrophils are involved in endothelial dysfunction, atherosclerotic plaque destabilization, and increased coagulation, causing further vascular damage. These effects depend on the magnitude and duration of the response. All this does not exclude the possibility that NLR at postoperative day 5 is a marker of frailty. Hormonal changes caused by stress include the secretion of cortisol, which increases the neutrophil count and decreases the lymphocyte count. All these factors may contribute to higher 1-year mortality in patients with NLR > 5 at postoperative day 5[13].

Despite these limitations, measurements of PLR at postoperative day 2, and NLR and SII at postoperative days 2 and 5 in patients over the age of 60 who underwent hemiarthroplasty were found to have significant predictive value in 1-year mortality rates. A 1-year increase in age was associated with a 4.9% increased risk of death at 1-year follow-up (\( p=0.006 \)). A 1-unit increase in NLR on postoperative day 5 was associated with a 4.3% increased risk of death at 1-year follow-up (\( p=0.004 \)). However, their individual performance in predicting mortality was relatively low depending on the time of collection. Therefore, these predictive values should be considered risk factors rather than predictive biomarkers.

**Conclusion**

In conclusion, our study confirms the poor prognosis of patients undergoing hemiarthroplasty for traumatic hip fracture. Therefore, it is very important to identify novel risk factors for predicting mortality in elderly patients.
In addition to age, gender, and other comorbidities, dSII, dPLR, and dNLR are simple and cost-effective markers. dSII, dPLR, and dNLR can be used as objective risk factors for infections, mortality, and morbidity in the early and late postoperative period after hemiarthroplasty. This study shows that our model for predicting the absolute mortality risk of patients can be improved by evaluating dSII, dPLR, and dNLR in the preoperative period and postoperative days 2 and day 5. However, it cannot be argued that it has the discriminatory ability to exactly predict postoperative mortality. Nevertheless, these parameters may at least allow an early therapeutic intervention to improve patient outcomes.

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Declarations

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Ethical approval: The study was approved by the ethical committee of the University of Health Sciences Trabzon Kanuni Training and Research Hospital with the decision number 2020-49 on September 17, 2020.

Informed consent: It was conducted in accordance with the Helsinki Declaration and in all cases the specific informed consent forms for the surgical treatment were signed. No studies regarding human or animal rights were conducted in the study or used for teaching or new intervention research.

Tables

Table 1. Baseline characteristics

| Characteristics     | Total (n=176)           |
|---------------------|-------------------------|
| Age                 | 81.36±9.22              |
| Gender              |                         |
| Male                | 57 (32.4)               |
| Female              | 119 (67.6)              |
| Platelet (×10⁹/L)   | 195.0 (151.0-250.8)     |
| Lymphocyte (×10⁹/L) | 12.0 (8.0-16.0)         |
| Neutrophil (×10⁹/L) | 55.5 (42.3-77.8)        |
| SII(×10⁹/L)         | 1007.7 (654.2-1496)     |

Continuous data are summarized with mean±sd or median(25th-75th quartile). Categorical data expressed as frequency (%). SII: Systemic immune-inflammation index
**Table 2.** Comparison of patient characteristics between survivors and non-survivors (based on one-year mortality)

| Variables       | Survivor (n=112) | Non-survivor (n=64) | p       |
|-----------------|------------------|---------------------|---------|
| Age             | 80.04±9.81       | 83.68±7.62          | 0.011   |
| Gender          |                  |                     | 0.153   |
| Male            | 32 (28.6)        | 25 (39.1)           |         |
| Female          | 80 (71.4)        | 39 (60.9)           |         |
| PLR Preop       | 151.25 (112.06-233.65) | 175.04 (124.66-248.13) | 0.203   |
| PLR 2nd         | 185.8 (127.55-246.83) | 227.36 (153.17-312.81) | 0.022   |
| PLR 5th         | 229.19 (178.58-298.33) | 256.07 (197.5-349.25) | 0.087   |
| NLR Preop       | 5.07 (3.47-6.93) | 5.48 (3.97-7.53)    | 0.270   |
| NLR 2nd         | 6.92 (4.86-9.36) | 8.71 (6.13-12.19)   | 0.001   |
| NLR 5th         | 4.12 (3.05-6.33) | 5.7 (4.5-9.36)      | <0.001  |
| SII Preop       | 944.67 (627.5-1399.2) | 1121.41 (773.68-1627.22) | 0.09    |
| SII 2nd         | 1362.13 (946.9-1876.5) | 1777.56 (1233.26-3006.51) | 0.002   |
| SII 5th         | 1236.47 (907.75-1868.64) | 1762.23 (1100.13-2748.95) | 0.002   |

Values are expressed as n(%), means ± sd or median (25th - 75th percentile). For categorical variables Pearson’s chi-square are used. For continuous variables, if values are reported in means, p-values are calculated using independent samples t-test; if values are given in medians, p-values are calculated using Mann Whitney U test. Same superscript letters indicate statistically significant difference between the measurement time points based on the Bonferroni adjusted Wilcoxon signed rank test.

**Table 3.** Univariable and multivariable Cox proportional hazard models for the risk factors associated with 1-year mortality

| Variables       | Univariable HR (95% CI) | p   | Multivariable HR (95% CI) | p   |
|-----------------|--------------------------|-----|---------------------------|-----|
| Age             | 1.039 (1.009-1.070)      | 0.011| 1.049 (1.014-1.086)       | 0.006|
| Gender          |                          |     |                           |     |
| Male            | 1.000 (reference)        |     |                           |     |
| Female          | 1.457 (0.882-2.407)      | 0.142| 1.667 (0.953-2.916)       | 0.073|
| Preop PLR       | 1.001 (0.999-1.004)      | 0.305| 0.999 (0.994-1.005)       | 0.785|
| PLR 2nd         | 1.002 (1.000-1.004)      | 0.055| 1.002 (0.998-1.006)       | 0.320|
| PLR 5th         | 1.001 (1.000-1.003)      | 0.124| 1.004 (1.001-1.009)       | 0.009|
| Preop NLR       | 1.036 (0.980-1.095)      | 0.213| 1.029 (0.902-1.173)       | 0.675|
| NLR 2nd         | 1.096 (1.049-1.144)      | <0.001| 1.073 (0.988-1.166)       | 0.093|
| NLR 5th         | 1.035 (1.017-1.053)      | <0.001| 1.043 (1.013-1.073)       | 0.004|
| Preop SII (per 100 units) | 1.017 (0.992-1.043)  | 0.180| 0.997 (0.924-1.075)       | 0.937|
| SII 2nd (per 100 units) | 1.018 (1.005-1.030)  | 0.005| 0.994 (0.958-1.031)       | 0.752|
| SII 5th (per 100 units) | 1.019 (1.008-1.030)  | 0.001| 1.023 (1.000-1.047)       | 0.055|
SII value was divided by 100 to improve the interpretability of the results. HR: Hazard ratio, CI: Confidence interval. NLR: Neutrophil-to-lymphocyte ratio PLR: platelet-to-lymphocyte ratio SII: systemic immune-inflammation index

**Table 4.** Diagnostic values of the ROC curve analysis to evaluate the discriminatory ability of each dichotomized variable on 1-year mortality.

| Variable   | AUC(95%CI)        | Optimal cut-off (≥) | Sensitivity | Specificity | p     |
|------------|-------------------|---------------------|-------------|-------------|-------|
| Perop PLR  | 0.558 (0.469-0.647) | 173.75              | 0.531       | 0.607       | 0.203 |
| Preop NLR  | 0.550 (0.462-0.639) | 4.90                | 0.594       | 0.491       | 0.270 |
| Preop SII  | 0.577 (0.488-0.666) | 1000.26             | 0.625       | 0.589       | 0.090 |
| PLR 2nd    | 0.604 (0.517-0.690) | 256.88              | 0.422       | 0.786       | 0.022 |
| NLR 2nd    | 0.652 (0.568-0.736) | 8.25                | 0.679       | 0.562       | 0.001 |
| SII 2nd    | 0.638 (0.551-0.725) | 1800.94             | 0.484       | 0.759       | 0.002 |
| PLR 5th    | 0.578 (0.490-0.665) | 235.58              | 0.641       | 0.518       | 0.087 |
| NLR 5th    | 0.690 (0.610-0.769) | 4.70                | 0.719       | 0.562       | <0.001 |
| SII 5th    | 0.642 (0.556-0.729) | 1500.78             | 0.609       | 0.679       | 0.002 |

AUC: Area under the curve.

**Figures**
Figure 1

Receiver-operating characteristic (ROC) curves to detect the predictive ability of variables on 1-year mortality.

Figure 2

Kaplan–Meier survival analyses according to Platelet- lymphocyte ratio (PLR), Neutrophil-lymphocyte ratio (NLR), and Systemic immune-inflammation index (SII) at the pre-operative and post-operative times. P value was estimated using the log-rank test.