International Journal of General Medicine

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

The Value of Preoperative Systemic Immune-Inflammation Index as a Predictor of Prolonged Hospital Stay in Orthopedic Surgery: A Retrospective Study

Mohmad H Alsabani[1,2], Badi A Alotaibi[2,3], Lafi H Olayan[1,2], Abdulrhman S Alghamdi[2,4], Malik A Alshammasi[1], Bassam Abdulrahman Alqasir[1], Salman Madyan Alrashidi[1], Majed Saad Alshugair[1], Mohammed K Al Harbi[2,5,6]

[1]Anesthesia Technology Department, College of Applied Medical Sciences, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia; [2]King Abdullah International Medical Research Centre, Riyadh, Saudi Arabia; [3]Clinical Laboratory Sciences Department, College of Applied Medical Sciences, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia; [4]Emergency Medical Services Department, College of Applied Medical Sciences, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia; [5]Department of Anesthesia, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia; [6]College of Medicine, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia

Correspondence: Mohmad H Alsabani, Anesthesia Technology Department, College of Applied Medical Sciences, King Saud bin Abdulaziz University for Health Sciences, Riyadh, 11481, Saudi Arabia, Tel +966114298206, Email sabanim@ksau-hs.edu.sa

Purpose: Many risk factors, such as the duration of surgery and higher ASA scores, are associated with longer hospitalization in patients undergoing orthopedic surgery. However, no studies have evaluated the relationship between the preoperative systemic immune-inflammation index (SII) and length of hospital stay in orthopedic surgical patients. Therefore, this study aimed to investigate whether the SII is associated with the length of hospital stay in orthopedic surgery in adults.

Patients and Methods: This was a retrospective cohort study, and data were extracted from electronic health records. Patients were included if they were older than 18 years and had undergone orthopedic surgery between [2016–2021]. The patients were divided into two groups according to the median duration of hospitalization and according to SII cut-off value (high-SII group: ≥799.86, low-SII group: <799.86). Univariate and multivariate linear regression analyses were used to identify the association between SII and length of hospitalization.

Results: A total of 196 patients who underwent orthopedic surgery were included, and 62 were hospitalized for >21 days. There were significant differences in terms of ASA score ($P = 0.041$). Patients who required a longer hospitalization of >21 days had significantly lower hemoglobin level ($P < 0.001$), higher duration of surgery ($P = 0.015$), and increased requirement of ICU admission ($P < 0.001$). The optimal cut-off value for preoperative SII of 799.86 stratified the patients into high-SII and low-SII groups. Patients in high-SII group had higher median LOHS (22 days) compared to low-SII group (17 days; P = 0.006). In the multivariable linear regression analysis, the SII was significantly related to the length of hospital stay (β = 0.246, 95% confidence interval [CI] 0.000–0.005, $P = 0.031$).

Conclusion: A high-SII value is associated with an increased risk of longer hospitalization after orthopedic surgery.

Keywords: systemic immune-inflammation index, neutrophils, platelets, lymphocytes, hospital stay, orthopedic surgery

Introduction

Orthopedic procedures are commonly performed, focusing on the diagnosis and treatment of musculoskeletal disorders such as bone fractures, joint replacements, and spinal deformities.[1] While these procedures are generally performed safely, they can be associated with prolonged length of stay and various postoperative complications, such as infection, bleeding, and pain.[2]

Received: 22 August 2023
Accepted: 19 October 2023
Published: 25 October 2023

There are several risk factors associated with postoperative infection following orthopedic surgeries, such as age, sex, body mass index (BMI), duration of surgery, and anesthetic technique.[2] While most of these risk factors are not modifiable, predictive biomarkers can be useful tools to predict postoperative outcomes.

Numerous metrics such as operative time, preoperative stay, length of hospitalization, blood loss, length of incision, and postoperative pain scores are employed to assess the degree of invasiveness of various treatments across a range of surgical specialties.[3–5] A defensive inflammatory response, on the other hand, can be brought on by tissue damage, infection, or ischemia and can result in an increase in platelets, which are the main players in this reaction.[6] Additionally, connected to playing a predicative role in stress and trauma was an elevated leukocyte count. It is well known that neutrophils contribute to bone fracture healing because their levels rise in the early fracture hematoma, triggering the secondary immune response. They also play a significant role in the elimination of damage-associated molecular patterns (DAMPs) as well as microbe- or pathogen-associated molecular patterns (MAMPs) in unsterile skin wounds, which can improve healing.[7] Furthermore, lymphopenia is linked to trauma, which increases mortality rates and lengthens hospital admissions.[8]

Several inflammation markers, such as the neutrophil-to-lymphocyte ratio (NLR), C-reactive protein (CRP), and soluble urokinase plasminogen activating receptor, have been suggested to predict mortality and postoperative outcomes in orthopedic patients.[9–11] Complete blood counts (CBCs) are obtained routinely on all patients at admission and the first day following any surgical procedure. As a result, simple and inexpensive predictive hematologic biomarkers such as the NLR, platelet-to-lymphocyte ratio (PLR), monocyte-to-lymphocyte ratio (MLR), and systemic immune-inflammation index (SII) can be obtained.[12,13] These biomarkers have recently been linked to systemic inflammation that the human body experiences following various fracture types, polytraumatisms, carcinomas, and numerous musculoskeletal illnesses. Several fields relevant to surgery have been associated with their diagnostic and prognostic values.[6]

Clinicians are becoming more aware of the immunological responses that occur postoperatively and their possible harmful consequences. The SII, which is a comprehensive indicator integrating neutrophils, platelets, and lymphocytes, has been recently identified[14] and has been shown to serve as a potential prognostic marker for different medical conditions such as cancer,[15,16] cardiac disorders,[17–19] and autoimmune diseases.[20] In non-orthopedic patients, Parmana et al showed that high preoperative SII levels (>878.05) after off-pump coronary artery bypass graft surgery can predict longer intensive care unit (ICU) stay and prolonged mechanical ventilation.[21] Furthermore, Song et al demonstrated that SII (>650) can predict postoperative delirium in patients undergoing non-neurosurgery and non-cardiac surgery.[22] In orthopedic surgical patients, SII value was elevated (934) among patients with postoperative cognitive decline compared to those without (388). The authors also demonstrated that preoperative SII was independently associated with the occurrence of postoperative cognitive decline in elderly patients undergoing orthopedic operation.[23] In another study, SII was independently associated with poor all-cause mortality in elderly patients undergoing hip fracture surgery.[24]

Previous studies have highlighted that the SII is a simple, inexpensive, and effective tool for predicting postoperative complications and mortality. However, there is a paucity of research investigating the usefulness of the SII index in predicting the length of hospital stay following orthopedic surgery. In the previous literature, the criteria to assess long-term versus short-term hospitalization vary between studies. Hospitalization period that exceeds the average length of hospital stay (LOHS) is considered long-term admission.[25] In the current study, the median LOHS was measured, and the study cohort was divided into two groups according to their LOHS. This study aimed to explore the relationship between the SII and length of stay for patients undergoing orthopedic surgery.

Materials and Methods

Study Design

This retrospective study included patients who underwent orthopedic surgery at King Abdulaziz Medical City (KAMC), Riyadh, Saudi Arabia, from 2016 to 2021. The study was approved by the Institutional Review Board of the King Abdullah International Medical Research Centre (KAIMRC) (IRB/1263/22). The ethics committee/Institutional Review Board of KAIMRC waived the need for informed consent since this is a retrospective study and all identifying information was removed to ensure patient confidentiality. The study was performed according to the Helsinki Declaration and local and institutional regulations.

Inclusion and Exclusion Criteria

Patients who were admitted to undergo orthopedic procedures from 2016 to 2021 were at the Department of Orthopedic Surgery in KAMC and were considered for inclusion in our retrospective study if they (1) were 18 years and over; (2) underwent elective orthopedic surgery; (3) has complete medical records. Patients were excluded from the study if they (1) are younger than 18 years old; (2) non-orthopedic surgeries or underwent emergency orthopedic surgery; (3) had prior malignancy; (4) had hematological disorder; (5) had incomplete medical records (Figure 1).

Data Collection

From the database, we identified 196 patients who underwent orthopedic surgery at our institution. From the database, the median length of stay of the identified patients in our

institution during the study period was 21 days. Therefore, the study cohort of 196 patients was divided into two groups according to their length of hospitalization. Patients whose length of hospitalization was 21 days and less were included in study group A, and patients hospitalized for more than 21 days were included in study group B.

The outcome variable, the LOHS, was obtained from the electronic medical records and examined in the current study. LOHS indicates the number of days from patient's admission until discharge after surgery.

The independent variables were composed of demographic data (age, gender, BMI) and baseline data (ASA score and type of surgery). The name of surgery was recorded from the electronic medical records and classified as (1) spinal decompression; (2) close reduction and internal fixation of a fracture; (3) arthroplasty; (4) open reduction and internal fixation of a fracture; (5) segmental fixation of spine; (6) correction of spinal deformity; (7) spinal fusion; (8) arthroscopy; (9) others such as revision and nailing surgeries. Preoperative laboratory parameters from routine blood test were also obtained including neutrophil and lymphocyte counts, platelet count, white blood cell count, and hemoglobin level. The SII inflammatory marker was obtained using the following formula: SII = platelet × neutrophil/lymphocyte count, as previously defined.[14] We also collected duration of surgery, postoperative admission to the ICU,

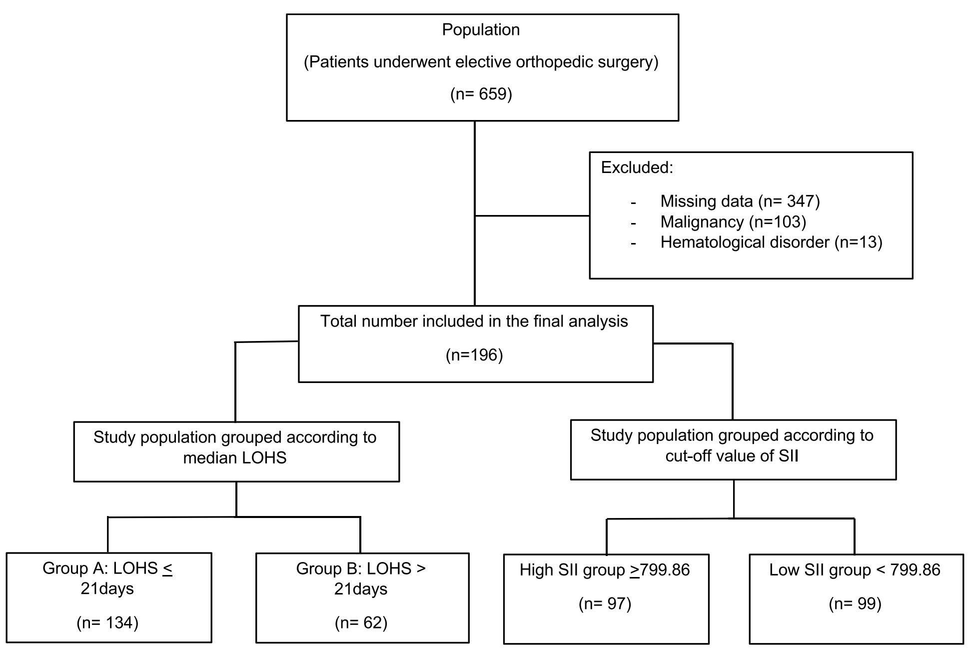

Figure 1 Flowchart of the study population.
Abbreviations: LOHS, length of hospital stay; SII, systemic immune-inflammation index.

and length of ICU stay. The duration of surgery was measured based on the time of surgery, excluding anesthesia. All outcome and predictor variables were obtained from the electronic medical records.

Statistical Analysis

All statistical analyses were performed using SPSS 28.0 (IBM, Armonk, NY, United States). Distribution of continuous variables was assessed using Shapiro–Wilk test, and clinical variables were expressed as median (interquartile range) as it was nonparametric in nature. Mann Whitney *U*-test was used for comparisons of continuous variables and chi-square test or Fisher's exact test for categorical variables. Categorical parameters were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test. The receiver operating characteristic (ROC) curve analysis was performed to determine the cut-off value of SII, and the area under the curve (AUC) was calculated. The sensitivity and specificity values were calculated, and patients were divided into high- and low-SII value groups, based on the cutoff values. Univariate analysis was conducted to identify variables associated with the LOHS using simple linear regression analysis. Further multivariate analysis was conducted, which incorporated variables with significant differences in the univariate analysis, along with age, sex, and ASA classification. Variables in the SII formula, including neutrophils, lymphocytes, and platelets, were not included in multivariate analysis. The results of the linear regression analysis are expressed as standardized beta and 95% confidence intervals (CI). Statistical significance was set at $P < 0.05$ (two-sided) was considered significant.

Results

Baseline Characteristics

A total of 196 patients who underwent orthopedic surgery were enrolled in this study. The median age of all patients was 60 years, and the majority of patients were male (59.7%). Clinical features, laboratory parameters, and patient outcomes are shown in Table 1. In summary, most patients were classified as ASA III (46.9%) followed by ASA II (34.7%). The

Table 1 Baseline Demographic and Clinical Characteristics of the Studied Population Grouped According to LOHS

Parameters	All Cohort (n= 196)	Group A (≤ 21 Days) (n= 134)	Group B (>21 Days) (n= 62)	P value
Age, years	60.00 (45.00)	66.00 (43.50)	59.00 (42.50)	0.07
Male, n (%)	117 (59.7%)	76 (56.7)	41 (66.1)	0.27[a]
BMI, kg/m^2	27.92 (8.14)	26.38 (6.14)	28.34 (9.53)	0.14
ASA classification, n (%)				
ASA I	6 (3.1%)	3 (2.2)	3 (4.8)	0.041*
ASA II	68 (34.7%)	55 (41.0)	13 (21.0)	
ASA III	92 (46.9%)	59 (44.0)	33 (53.2)	
ASA IV	28 (14.3%)	16 (11.9)	12 (19.4)	
Type of surgery, n (%)				
Spinal decompression	54 (27.6)	36 (26.9)	18 (29.0)	0.48
Closed reduction and internal fixation	43 (21.9)	29 (21.6)	14 (22.6)	
Arthroplasty	33 (16.8)	25 (18.7)	8 (12.9)	
ORIF	29 (14.8)	15 (11.2)	14 (22.6)	
Segmental fixation of spine	11 (5.6)	9 (6.7)	2 (3.2)	
Correction of spinal deformity	8 (4.1)	6 (4.5)	2 (3.2)	
Spinal fusion	6 (3.1)	5 (3.7)	1 (1.6)	
Arthroscopy	5 (2.6)	3 (2.2)	2 (3.2)	
Others	7 (3.6)	6 (4.5)	1 (1.6)	
Laboratory values				
Neutrophils, (x10^9/L)	5.89 (5.24)	5.50 (3.91)	6.41 (6.28)	0.14
Platelets, (x10^9/L)	239.00 (164.00)	233.00 (144.25)	274.00 (229.00)	0.21

(*Continued*)

Table 1 (Continued).

Parameters	All Cohort (n= 196)	Group A (≤ 21 Days) (n= 134)	Group B (>21 Days) (n= 62)	*P* value
Lymphocytes, (x10^9/L)	1.52 (1.45)	1.51 (1.26)	1.58 (1.73)	0.38
WBC, (x10^9/L)	8.75 (5.50)	8.58 (4.32)	9.80 (6.15)	0.19
Hemoglobin	116.00 (34.00)	113.00 (38.25)	104.00 (25.50)	<0.001*
Postoperative outcomes				
Duration of surgery, minutes	199.00 (179.00)	172.00 (136.75)	225.00 (180.50)	0.015*
ICU admission, n (%)	87 (44.4%)	46 (34.3%)	41 (66.1%)	<0.001*
LOS in ICU, days	2.00 (5.00)	2.00 (4.00)	5.00 (12.00)	0.003*

Notes: *Statistically significant results. Categorical variables are presented as n (%) and compared using Chi-square test or Fisher's Exact test. Continuous variables are presented as median (IQR) and compared using Mann–Whitney *U*-test. [a]Fisher's Exact test.
Abbreviations: LOHS, length of hospital stay; BMI, body mass index; ASA, American Society of Anesthesiologists classification system; ORIF, open reduction and internal fixation; WBC, white blood cell; ICU, intensive care unit; LOS, length of stay.

most common type of surgical procedures that were performed among all patients was spinal decompression (27.6%) followed by closed reduction and internal fixation (21.9%) and arthroplasty (16.8%). The median length of ICU stay among all patients was two days. The patients were divided into two groups according to the median LOHS (Table 1). In the subgroup analysis, significant differences were observed in ASA score between both groups. In addition, we observed that those who has longer hospitalization had lower hemoglobin levels, higher duration of surgery, ICU admission requirements and increased stay in the ICU.

ROC Analysis for Cut-Off Value of SII

We investigated the ideal cut-off value for the SII, determined by ROC analysis. The SII had area under the curve (AUC) of 0.568. The optimal SII cut-off value was 799.86 with a sensitivity of 0.597 and specificity of 0.448.

Subgroup Analysis by SII Cut-Off Value

Based on the cut-off value of SII, patients were divided into a high-SII group (SII ≥799.86) and a low-SII group (SII <799.86). Results indicated that significant differences exist on the type of surgery between both groups. Furthermore, patients in the high-SII group had higher neutrophil, platelet, and WBC counts ($P < 0.001$ for all). They also had lower lymphocyte count ($P < 0.001$). Moreover, patients in the high-SII group had higher median LOHS (22 vs 17 days; $P =$ 0.006). No significant differences were observed in age, gender, ASA score, duration of surgery, requirement of ICU admission and length of ICU stay (P>0.05) (Table 2).

Table 2 Baseline Demographic and Clinical Characteristics of the Studied Population Grouped According to SII Cut-Off Value

Parameters	SII<799.86 (n= 99)	SII≥799.86 (n= 97)	*P* value
Age, years	58.00 (51.00)	60.00 (40.25)	0.21
Male, n (%)	54 (54.5)	63 (64.9)	0.14[a]
BMI, kg/m^2	27.94 (7.38)	27.77 (9.53)	0.93
ASA classification, n (%)			
ASA I	2 (2.0)	4 (4.1)	0.21
ASA II	39 (39.4)	29 (29.9)	
ASA III	46 (46.5)	46 (47.4)	
ASA IV	10 (10.1)	18 (18.6)	

(*Continued*)

Table 2 (Continued).

Parameters	SII<799.86 (n= 99)	SII≥799.86 (n= 97)	*P* value
Type of surgery, n (%)			
Spinal decompression	38 (38.4)	16 (16.5)	0.002*
Closed reduction and internal fixation	17 (17.2)	26 (26.8)	
Arthroplasty	17 (17.2)	16 (16.5)	
ORIF	9 (9.1)	20 (20.6)	
Segmental fixation of spine	2 (2.0)	9 (9.3)	
Correction of spinal deformity	7 (7.1)	1 (1.0)	
Spinal fusion	4 (4.0)	2 (2.1)	
Arthroscopy	2 (2.0)	3 (3.1)	
Others	3 (3.0)	4 (4.1)	
Laboratory values			
Neutrophils ($\times10^9$/L)	3.93 (2.88)	7.77 (5.59)	<0.001*
Platelets ($\times10^9$/L)	226.00 (130.00)	287.00 (209.25)	<0.001*
Lymphocytes ($\times10^9$/L)	1.92 (1.41)	1.25 (1.10)	<0.001*
SII	406.00 (277.93)	1463.55 (1687.42)	<0.001*
WBC ($\times10^9$/L)	6.80 (3.96)	10.45 (6.26)	<0.001*
Hemoglobin	123.00 (35.00)	110.00 (31.00)	<0.001*
Postoperative outcomes			
Duration of surgery, minutes	200.00 (133.00)	197.50 (196.50)	0.14
ICU admission, n (%)	39 (39.4)	48 (49.5)	0.19[a]
LOS in ICU, days	2.00 (5.00)	2.50 (4.75)	0.91
LOHS, days	17.00 (37.00)	22.00 (25.75)	0.006*

Notes: *Statistically significant results. Categorical variables are presented as n (%) and compared using chi-square test or Fisher's Exact test. Continuous variables are presented as median (IQR) and compared using Mann–Whitney *U*-test. [a]Fisher's Exact test.
Abbreviations: SII, systemic immune-inflammation index; BMI, body mass index; ASA, American Society of Anesthesiologists classification system; ORIF, open reduction and internal fixation; WBC, white blood cell; ICU, intensive care unit; LOS, length of stay; LOHS, length of hospital stay.

Linear Regression Analyses

In univariate linear regression analysis, SII was significantly associated with LOHS (β = 0.246, 95% confidence interval [CI] 0.002–0.006, $P < 0.001$). In addition, LOHS was associated with ASA classification, platelet count, hemoglobin level, and duration of surgery (Table 3).

Table 3 Univariate Linear Regression Analysis of Factors Associated with LOHS

Variable	Standardized β [95% CI]	*P* value
Age	−0.131 [−0.278 to 0.009]	0.06
Gender	−0.094 [−11.139 to 2.216]	0.19
BMI	0.138 [−0.003 to 0.355]	0.05
ASA	0.210 [2.229 to 11.011]	0.003*
Type of surgery	−0.061 [−1.979 to 0.781]	0.39
Platelets	0.185 [0.009 to 0.061]	0.009*
Neutrophils count	0.081 [−0.371 to 1.361]	0.26
Lymphocytes count	−0.025 [−3.375 to 2.371]	0.73
SII	0.246 [0.002 to 0.006]	<0.001*
WBC	0.044 [−0.560 to 1.064]	0.54
Hemoglobin	−0.324 [−0.494 to −0.205]	<0.001*
Duration of surgery	0.220 [0.016 to 0.070]	0.002*

Note: * Statistically significant results.
Abbreviations: LOHS, length of hospital stay; CI, confidence interval; BMI, body mass index; ASA, American Society of Anesthesiologists classification system; SII, systemic immune-inflammation index; WBC, white blood cell.

Table 4 Multivariate Linear Regression Analysis of Factors Associated with LOHS

Variable	Standardized β [95% CI]	*P* value
Age	−0.134 [−0.286 to 0.011]	0.07
Gender	−0.057 [−8.752 to 3.302]	0.37
ASA	0.262 [3.882 to 12.672]	<0.001*
SII	0.143 [0.000 to 0.005]	0.031*
Hemoglobin	−0.285 [−0.448 to −0.166]	<0.001*
Duration of surgery	0.260 [0.024 to 0.078]	<0.001*

Note: *Statistically significant results.
Abbreviations: LOHS, length of hospital stay; CI, confidence interval; ASA, American Society of Anesthesiologists classification system; SII, systemic immune-inflammation index.

In the multivariable linear regression analysis, the SII was significantly related to LOHS after adjusting for confounders [β = 0.143, 95% CI 0.000–0.005, *P* = 0.031]. ASA (β = 0.262, 95% CI 3.882–12.672, *P* < 0.001), hemoglobin level (β = -0.285, 95% CI −0.448– −0.166, *P* < 0.001), and duration of surgery (β = 0.260, 95% CI 0.024–0.078, *P* < 0.001) were associated with LOHS but independent of the SII (Table 4).

Discussion

Numerous disorders have shown that the systemic immune-inflammation index (SII), a newly identified composite indicator incorporating platelet, neutrophil, and lymphocyte counts, is a promising prognostic predictor.[14,24] These involve cardiac disorders,[17–19] malignant tumors,[15] critical illness,[26,27] and patients undergoing surgical interventions.[22,28,29] In this study, the laboratory indicator SII was collected to determine whether it was associated with LOHS in patients who underwent major orthopedic surgery. Multivariate linear regression analysis showed that SII was independently associated with LOHS.

A local inflammatory response, characterized by the recruitment of polymorphonuclear neutrophils (PMN) and monocytes, facilitates the faster healing of surgical wounds by limiting tissue damage and clearing cell debris. The increased production of several proinflammatory mediators, such as interleukin (IL)-1 and tumor necrosis factor (TNF-), as well as other cytokines, such as IL-6, has been linked to postoperative complications following orthopedic surgery and has also been used in several studies to characterize this postoperative inflammatory reaction.[30] However, previous studies have demonstrated that surgery causes immunological suppression, in contrast to reports of heightened proinflammatory responses following surgery.[31]

For instance, during the postoperative period, PMN, monocyte, and macrophage phagocytic activity are lowered, potentially resulting in a window for infection susceptibility.[32] Other reports have shown that during prosthetic joint infection, a heterogeneous population of immature monocytes and granulocytes known as myeloid-derived suppressor cells (MDSCs) are recruited to tissues where they have an anti-inflammatory effect.[33,34] Furthermore, during the postoperative period, higher levels of anti-inflammatory molecules can also be produced, such as IL-4, IL-10, soluble tumor necrosis factor receptor 1 (sTNFR1), IL-1 receptor antagonist (IL-1Ra), and transforming growth factor (TGF), which may further bias the anti-inflammatory properties of wound-associated leukocytes.[35,36]

Recently, several indicators such as NLR, PLR, and MLR have been shown to be important in various disorders. However, these indicators integrate only two cells. The SII, which is based on peripheral lymphocyte, neutrophil, and platelet counts, has recently been studied as a prognostic marker for multiple disorders. In the present study, we observed that the SII was independently associated with prolonged LOHS in patients undergoing orthopedic surgery. The findings of this study are consistent with previous research that has shown that inflammation is a significant risk factor for prolonged LOS in patients undergoing orthopedic surgery.[37] Inflammation can lead to a number of complications such as infection, sepsis, and organ failure, all of which can contribute to a longer LOS. In line with our findings, we also observed that the median LOHS was significantly higher in patients with SII value ≥ 799.86 compared to those with lower SII value (<799.86). These findings suggest that an elevated preoperative SII, which reflects systemic inflammation, may contribute to more complicated recovery and longer hospitalization in orthopedic patients. In support of this theory, Parmana et al reported the effectiveness of SII as a predictor of prolonged mechanical ventilation and ICU stay and its positive correlation with LOHS after off-pump coronary artery bypass grafting.[21] Furthermore, Zinellu et al showed that SII and other immune-inflammatory ratios that were measured on admission positively correlate with LOHS in COVID patients. They also demonstrated in multiple regression analysis that only the SII was significantly associated with prolonged LOHS.[38]

Furthermore, our study showed that ASA classification, hemoglobin level, and duration of surgery were independently associated with a prolonged length of hospital stay. ASA class and duration of surgery are indicators of the severity of surgical intervention and patient health status, and their associations with prolonged LOHS have been proven in previous studies.[39–41] In this study, we observed no significant relationship in terms of laboratory values with longer hospital stay. However, other reports have shown no direct evidence that elevated neutrophil counts are associated with poor prognosis. In addition, an elevated NLR was found to be an independent risk factor for postoperative myocardial injury, in-hospital mortality, and 1-year mortality after hip fracture surgery.[10,42] In contrast, a high platelet count is considered a risk factor for the development of postoperative pressure ulcers after hip fracture surgery.[43] In addition, a study reported that a high PLR (≥189) is associated with increased 1-year all-cause mortality in older adults with hip fractures.[44]

This study has some limitations. Due to the retrospective nature of the study, which makes it dependent on data from medical records, which might be more prone to human error, as well as the relatively modest patient sample size, further confirmation is necessary in the future. The current study does not focus on a specific type of orthopedic procedure, and therefore our findings may not guide orthopedic surgeons with specialized practices. Nonetheless, these limitations should be addressed in a future work that investigates individual procedure types to broaden understanding of the SII, with a longer follow-up and larger patient sample, allowing the findings to be generalized to the local population. However, a significant strength of the current work is that the SII has demonstrated potential utility in clinical practice to identify patients at risk of prolonged hospitalization after orthopedic surgery.

Conclusion

Higher preoperative SII levels were independently associated with a higher risk of extended hospital stay. Thus, measuring simple/inexpensive inflammatory markers may help identify patients at risk of longer hospitalization. Based on observations from the current study, the SII has advantages regarding cost and time and may have a role in the field of orthopedic surgery, but further prospective studies with bigger samples of patients are necessary to corroborate our findings before their application in clinical practice.

Acknowledgments

The authors are grateful to the staff of the King Abdullah International Medical Research Centre for their kind assistance in data collection.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision Hip and knee arthroplasty in the United States from 2005 to 2030. *Jbjs*. 2007;89(4):780–785. doi:10.2106/00004623-200704000-00012
2. Li T, Zhang H, Chan PK, Fung WC, Fu H, Chiu KY. Risk factors associated with surgical site infections following joint replacement surgery: a narrative review. *Arthroplasty*. 2022;4(1):11. doi:10.1186/s42836-022-00113-y
3. Trejo-Avila ME, Valenzuela-Salazar C, Betancourt-Ferreyra J, Fernández-Enríquez E, Romero-Loera S, Moreno-Portillo M. Laparoscopic versus open surgery for abdominal trauma: a case-matched study. *J Laparoendoscop Adv Surg Techn*. 2017;27(4):383–387. doi:10.1089/lap.2016.0535
4. Li G, Kong L, Kou N, et al. The comparison of limited-incision versus standard-incision in treatment of carpal tunnel syndrome: a meta-analysis of randomized controlled trials. *Medicine*. 2019;98(18):1.

5. Chang W, Zhang D, Liu W, Lian X, Jiao Z, Chen W. Posterior paraspinal muscle versus post-middle approach for the treatment of thoracolumbar burst fractures: a randomized controlled trial. *Medicine*. 2018;97(25):e11193. doi:10.1097/MD.0000000000011193
6. Moldovan F, Ivanescu AD, Fodor P, Moldovan L, Bataga T. Correlation between inflammatory systemic biomarkers and surgical trauma in elderly patients with hip fractures. *J Clin Med*. 2023;12(15):5147. doi:10.3390/jcm12155147
7. Baht GS, Vi L, Alman BA. The role of the immune cells in fracture healing. *Curr Osteoporos Rep*. 2018;16(2):138–145. doi:10.1007/s11914-018-0423-2
8. Heffernan DS, Monaghan SF, Thakkar RK, Machan JT, Cioffi WG, Ayala A. Failure to normalize lymphopenia following trauma is associated with increased mortality, independent of the leukocytosis pattern. *Crit Care*. 2012;16(1):1–10. doi:10.1186/cc11157
9. Norring-Agerskov D, Bathum L, Pedersen OB, et al. Biochemical markers of inflammation are associated with increased mortality in hip fracture patients: the bispebjerg hip fracture biobank. *Aging Clin Exp Res*. 2019;31(12):1727–1734. doi:10.1007/s40520-019-01140-7
10. Forget P, Moreau N, Engel H, et al. The neutrophil-to-lymphocyte ratio (NLR) after surgery for Hip fracture (HF). *Arch Gerontol Geriatr*. 2015;60 (2):366–371. doi:10.1016/j.archger.2014.11.008
11. Wang Z, Wang H, Yang L, Jiang W, Chen X, Liu Y. High platelet-to-lymphocyte ratio predicts poor survival of elderly patients with Hip fracture. *Int Orthop*. 2021;45(1):13–21. doi:10.1007/s00264-020-04833-1
12. Wu L, Zou S, Wang C, Tan X, Yu M. Neutrophil-to-lymphocyte and platelet-to-lymphocyte ratio in Chinese Han population from Chaoshan region in South China. *BMC Cardiovasc Disord*. 2019;19(1):1–5. doi:10.1186/s12872-019-1110-7
13. Dincer AK, Sezer S. Systemic immune inflammation index as a reliable disease activity marker in psoriatic arthritis. *J Coll Physicians Surg Pak*. 2022;32:773–778.
14. Hu B, Yang X-R, Xu Y, et al. Systemic immune-inflammation index predicts prognosis of patients after curative resection for hepatocellular carcinoma. *Clin Cancer Res*. 2014;20(23):6212–6222. doi:10.1158/1078-0432.CCR-14-0442
15. Li X, Zhang S, Lu J, Li C, Li N. The prognostic value of systemic immune-inflammation index in surgical esophageal cancer patients: an updated meta-analysis. *Front Surg*. 2022;9:922595. doi:10.3389/fsurg.2022.922595
16. Hang W, Luo J, Wen J, Jiang M. The relationship between systemic immune inflammatory index and prognosis of patients with non-small cell lung cancer: a meta-analysis and systematic review. *Front Surg*. 2022;9:898304. doi:10.3389/fsurg.2022.898304
17. Yang YL, Wu CH, Hsu PF, et al. Systemic immune-inflammation index (SII) predicted clinical outcome in patients with coronary artery disease. *Eur J Clin Invest*. 2020;50(5):e13230. doi:10.1111/eci.13230
18. Hou D, Wang C, Luo Y, et al. Systemic immune-inflammation index (SII) but not platelet-albumin-bilirubin (PALBI) grade is associated with severity of acute ischemic stroke (AIS). *Int J Neurosci*. 2021;131(12):1203–1208. doi:10.1080/00207454.2020.1784166
19. Tang Y, Zeng X, Feng Y, et al. Association of systemic immune-inflammation index with short-term mortality of congestive heart failure: a retrospective cohort study. *Front Cardiovasc Med*. 2021;8:753133. doi:10.3389/fcvm.2021.753133
20. Liu B, Wang J, Y-y L, Li K-P, Zhang Q. The association between systemic immune-inflammation index and rheumatoid arthritis: evidence from NHANES 1999–2018. *Arthritis Res Ther*. 2023;25(1):1–10. doi:10.1186/s13075-023-03018-6
21. Parmana IMA, Boom CE, Poernomo H, et al. Systemic immune-inflammation index predicts prolonged mechanical ventilation and intensive care unit stay after off-pump coronary artery bypass graft surgery: a single-center retrospective study. *Vasc Health Risk Manag*. 2023;19:353–361. doi:10.2147/VHRM.S409678
22. Song Y, Luo Y, Zhang F, et al. Systemic immune-inflammation index predicts postoperative delirium in elderly patients after surgery: a retrospective cohort study. *BMC Geriatr*. 2022;22(1):730. doi:10.1186/s12877-022-03418-4
23. Lu W, Zhang K, Chang X, Yu X, Bian J. The association between systemic immune-inflammation index and postoperative cognitive decline in elderly patients. *Clin Interv Aging*. 2022;17:699–705. doi:10.2147/CIA.S357319
24. Wang Z-C, Jiang W, Chen X, Yang L, Wang H, Liu Y-H. Systemic immune-inflammation index independently predicts poor survival of older adults with Hip fracture: a prospective cohort study. *BMC Geriatr*. 2021;21(1):1–8. doi:10.1186/s12877-021-02102-3
25. Urechescu H, Gheran-Vida E, Cuzic C, Ancusa O, Ursoniu S, Pricop M. Inflammatory markers as predictors for prolonged duration of hospitalization in maxillofacial infections. *J Clin Med*. 2023;12(3):871.
26. Jiang D, Bian T, Shen Y, Huang Z. Association between admission systemic immune-inflammation index and mortality in critically ill patients with sepsis: a retrospective cohort study based on MIMIC-IV database. *Clin Exp Med*. 2023;1–10. doi:10.1007/s10238-023-01029-w
27. Chen L, Xia S, Zuo Y, et al. Systemic immune inflammation index and peripheral blood carbon dioxide concentration at admission predict poor prognosis in patients with severe traumatic brain injury. *Front Immunol*. 2023;13:1034916. doi:10.3389/fimmu.2022.1034916
28. Zhang F, Niu M, Wang L, et al. Systemic-immune-inflammation index as a promising biomarker for predicting perioperative ischemic stroke in older patients who underwent non-cardiac surgery. *Front Aging Neurosci*. 2022;14:865244. doi:10.3389/fnagi.2022.865244
29. Inoue H, Kosuga T, Kubota T, et al. Significance of a preoperative systemic immune-inflammation index as a predictor of postoperative survival outcomes in gastric cancer. *World J Surg Oncol*. 2021;19(1):173. doi:10.1186/s12957-021-02286-3
30. Randau TM, Friedrich MJ, Wimmer MD, et al. Interleukin-6 in serum and in synovial fluid enhances the differentiation between periprosthetic joint infection and aseptic loosening. *PLoS One*. 2014;9(2):e89045. doi:10.1371/journal.pone.0089045
31. Liu Y, Zhang H, Zhang W, Gu C. Effect of dexmedetomidine combined with ropivacaine on cognitive dysfunction and inflammatory response in patients undergoing craniocerebral surgery. *Biomed Res Int*. 2021;2021:1–8. doi:10.1155/2021/4968300
32. van Dijk WC, Verbrugh HA, van Rijswijk RE, Vos A, Verhoef J. Neutrophil function, serum opsonic activity, and delayed hypersensitivity in surgical patients. *Surgery.* 1982;92(1):21–29.
33. Heim CE, Vidlak D, Kielian T. Interleukin-10 production by myeloid-derived suppressor cells contributes to bacterial persistence during Staphylococcus aureus orthopedic biofilm infection. *J Leuco Biol*. 2015;98(6):1003–1013. doi:10.1189/jlb.4VMA0315-125RR
34. Heim CE, Vidlak D, Scherr TD, Hartman CW, Garvin KL, Kielian T. IL-12 promotes myeloid-derived suppressor cell recruitment and bacterial persistence during Staphylococcus aureus orthopedic implant infection. *J Immunol*. 2015;194(8):3861–3872. doi:10.4049/jimmunol.1402689
35. Rosenberger PH, Ickovics JR, Epel E, et al. Surgical stress-induced immune cell redistribution profiles predict short-term and long-term postsurgical recovery: a prospective study. *J Bone Joint Surg Am*. 2009;91(12):2783. doi:10.2106/JBJS.H.00989
36. Stoecklein VM, Osuka A, Lederer JA. Trauma equals danger—damage control by the immune system. *J Leukoc Biol*. 2012;92(3):539–551. doi:10.1189/jlb.0212072

37. Zhu Y, Bi Y, Liu B, Zhu T. Assessment of prognostic value of preoperative neutrophil-to-lymphocyte ratio for postoperative mortality and morbidity. *Front Med*. 2023;10:1102733. doi:10.3389/fmed.2023.1102733
38. Zinellu A, Scano V, Masotto E, et al. The systemic inflammation index on admission is independently associated with length of stay in hospitalized COVID-19 patients. *Minerva Respir Med*. 2021;60(3):65–72. doi:10.23736/S2784-8477.21.01932-5
39. Ahmad M, Shaikh A, Ahmad AS, Awan N. Enhanced recovery program–Impact of ASA grade on length of hospital stay in patients undergoing Hip and knee arthroplasties. *Surgeon*. 2023;21(1):16–20. doi:10.1016/j.surge.2022.01.003
40. Yeoh C, Fazal M. ASA grade and elderly patients with femoral neck fracture. *Geriatr Orthop Surg Rehabil*. 2014;5(4):195–199. doi:10.1177/2151458514560471
41. Papalia R, Zampogna B, Torre G, et al. Preoperative and perioperative predictors of length of hospital stay after primary total hip arthroplasty—our experience on 743 cases. *J Clin Med*. 2021;10(21):5053. doi:10.3390/jcm10215053
42. Fisher A, Srikusalanukul W, Fisher L, Smith P. The neutrophil to lymphocyte ratio on admission and short-term outcomes in orthogeriatric patients. *Int J Med Sci*. 2016;13(8):588. doi:10.7150/ijms.15445
43. Galivanche AR, Kebaish KJ, Adrados M, et al. Postoperative pressure ulcers after geriatric Hip fracture surgery are predicted by defined preoperative comorbidities and postoperative complications. *JAAOS*. 2020;28(8):342–351. doi:10.5435/JAAOS-D-19-00104
44. Zhang M, Huang X-Z, Song Y-X, Gao P, Sun J-X, Wang Z-N. High platelet-to-lymphocyte ratio predicts poor prognosis and clinicopathological characteristics in patients with breast cancer: a meta-analysis. *Biomed Res Int*. 2017;2017:1–11. doi:10.1155/2017/9503025