The Effect of Postoperative Analgesia Induced by Peripheral Nerve Block on Inflammatory Biomarkers in Patients Undergoing Upper Extremity Surgery

Doğa Meriç Yükselen[1], *Cansu Ofluoğlu*[1], *Öznur Demiroluk*[1], *Kadir Kuran*[1], *Arzu Yıldırım Ar*[1]

[1] University of Health Sciences Fatih Sultan Mehmet Health Applications and Research Center, Department of Anesthesiology and Reanimation, Istanbul, Türkiye

Correspondence: Doğa Meriç Yükselen, MD; d.m.boybeyi@gmail.com

Abstract

Introduction: Surgical stress and inadequate analgesia may increase perioperative inflammatory response. This study aimed to retrospectively evaluate the effect of brachial plexus blocks used for postoperative analgesia in upper extremity surgery on hematological inflammatory biomarkers. **Materials and Methods:** After ethics committee approval, 67 adult patients who underwent unilateral forearm surgery between November 2024 and June 2025 were reviewed. Patients who received general anesthesia alone were allocated to Group G (n=22), and those who received ultrasound-guided infraclavicular or supraclavicular peripheral nerve block in addition to general anesthesia were allocated to Group P (n=45). Preoperative and postoperative 24-hour total leukocyte, neutrophil, lymphocyte and platelet counts, mean platelet volume, neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio were compared. **Results:** Demographic characteristics and ASA classifications were comparable between groups. No significant intergroup differences were detected in preoperative or postoperative total leukocyte, neutrophil, lymphocyte or platelet counts, mean platelet volume, neutrophil-to-lymphocyte ratio or platelet-to-lymphocyte ratio. Changes from the preoperative to postoperative period were also similar between groups. **Conclusion:** The addition of peripheral nerve block to general anesthesia in upper extremity surgery did not produce a statistically significant reduction in inflammatory biomarkers. However, the numerically lower increase in inflammatory markers in patients receiving peripheral nerve block suggests that this effect should be investigated in larger prospective studies.

Keywords: Neutrophil-to-lymphocyte ratio; platelet-to-lymphocyte ratio; peripheral nerve block

Received: 15.12.2025
Accepted: 09.06.2026
Published: 30.06.2026

1. Introduction

Anesthetic and analgesic agents, along with surgical stress, play a key role in the etiology of perioperative systemic inflammation. Regional anesthesia can help reduce surgical stress through various immunological and neurohumoral mechanisms. Epidural anesthesia administered concurrently with general anesthesia reduces cortisol and urinary adrenalin levels during abdominal aortic surgery, and performs better than general anesthesia alone[1]. Similarly, spinal anesthesia suppresses serum cortisol more effectively than general anesthesia[2].

Pain is a key component of surgical stress, activating the hypothalamic-pituitary-adrenal axis and elevating serum cortisol levels. Inadequate analgesia increases perioperative systemic inflammation, and leads to sustained sympathetic stimulation in patients with cardiac risk factors, exposing them to postoperative myocardial injury or infarction[3]. Perioperative inflammation not only causes acute pain but is also associated with such adverse postoperative outcomes as chronic pain, delirium, cardiovascular events and cancer recurrence[1,2]. Therefore, strategies targeting the reduction of the inflammatory response may have a positive effect on recovery.

Studies have reported an association between the inflammation level and the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and mean platelet volume (MPV)[4].

In the present study, the effects of brachial plexus blocks used for postoperative analgesia on postoperative inflammatory response in patients undergoing upper extremity surgery are evaluated retrospectively based on an assessment of biomarkers.

2. Materials and Method

After approval for the study was granted by the ethics committee (Sancaktepe BAEK 2025/373), a retrospective review was conducted of the medical records of 67 patients who underwent unilateral upper extremity surgery in the Orthopedics and Traumatology Clinics of R.T Health Sciences University Fatih Sultan Mehmet Training and Research Hospital between November 2024 and June 2025, all of whom received general anesthesia along with a brachial plexus block for analgesia. Included in the study were patients aged 18 years or older who underwent elective forearm surgery, and whose blood count data from within the first 24 hours following surgery was available. All patients received general anesthesia either alone or in combination with ultrasound-guided infraclavicular/supraclavicular peripheral nerve block (PNB). Patients undergoing emergency surgery, those undergoing revision or bilateral surgery, those with a history of hematological, renal or hepatic disorders, those with severe respiratory or cardiac insufficiency, malignancy or coagulopathy, and those with a history of chronic analgesic use, chronic alcohol consumption or substance abuse were excluded from the study.

The patients were divided into two groups: those who received general anesthesia alone (Group G) and general anesthesia combined with brachial plexus block (Group P). Group G included 22 patients and Group P included 45 patients. General anesthesia was induced with intravenous propofol (2–2.5 mg/kg) and fentanyl (1–2 mcg/kg), and maintained with sevoflurane in an oxygen/air mixture. Additional opioids were administered as needed. Brachial plexus blocks (infraclavicular or supraclavicular) were performed under ultrasound guidance using 20 ml of 0.25% bupivacaine local anesthetic. Block success was assessed clinically by sensory loss in the corresponding dermatomes.

Demographic characteristics, American Society of Anesthesiologists (ASA) class, total leukocyte count (TLC), neutrophil count, lymphocyte count, platelet count, and mean platelet volume measured preoperatively and at 24 hours postoperatively were analyzed. Additionally, NLR, PLR, ΔTLC (preoperative TLC−postoperative TLC), ΔNLR (preoperative NLR−postoperative NLR) and ΔPLR (preoperative PLR−postoperative PLR), calculated from the above values, were also evaluated.

2.1.Statistical Analysis

The statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to assess the normality of data distribution. Continuous variables were presented as mean

± standard deviation (SD) or median with interquartile range (IQR), depending on the distribution, while categorical variables were expressed as numbers and percentages. Normally distributed variables were compared using the independent samples t-test, while non-normally distributed variables were analyzed using Mann–Whitney U test. A chi-square test or Fisher's exact test was applied for categorical variables, as appropriate. A p-value of less than 0.05 was considered statistically significant.

3. Results

A total of 67 patients were included in the study, with 45 in Group P and 22 in Group G. The mean age was slightly higher in Group P than in Group G (50.2 ± 20.5 vs. 41.3 ± 19.4 years, p = 0.092). Both groups had a predominance of male patients, with a comparable gender distribution (p = 0.529). The distribution of ASA scores showed no statistically significant difference between the two groups, although there was a tendency toward higher ASA classes in Group P (p = 0.057) (Table 1).

Table 1. Baseline demographic and clinical characteristics

	Group P (n=45)	Group G (n=22)	p-value
Age (years)	50.2 ± 20.5	41.3 ± 19.4	0.092
Sex, n (%)			0.529
Female	20 (44.4%)	8 (36.4%)	
Male	25 (55.6%)	14 (63.6%)	
ASA physical status, n (%)			0.057
I	1 (2.2%)	4 (18.2%)	
II	17 (37.8%)	13 (59.1%)	
III	21 (46.7%)	5 (22.7%)	
IV	4 (8.9%)	0 (0%)	

Values are presented as mean ± standard deviation (SD) and number (percentage). Independent samples t-test was used for continuous variables, and chi-square or Fisher's exact test for categorical variables.

An analysis of laboratory findings revealed the preoperative and postoperative total leukocyte counts (TLC), neutrophil counts, lymphocyte counts, platelet counts and mean platelet volume (MPV) to be similar between the two groups (all p > 0.05). Similarly, no significant differences were noted in the preoperative or postoperative NLR and PLR values (Table 2).

Table 2. Comparison of preoperative and postoperative hematologic and inflammatory parameters

	Group P (n=45)	Group G (n=22)	p-value
Preoperative TLC	9.43 ± 3.47	9.01 ± 2.56	0.617
Postoperative TLC	9.30 ± 4.21	9.26 ± 3.16	0.972
Preoperative neutrophil counts	7.06 ± 3.59	6.67 ± 2.50	0.648
Postoperative neutrophil counts	6.95 ± 4.25	6.97 ± 3.56	0.989
Preoperative lymphocyte counts	1.69 ± 0.71	1.71 ± 0.75	0.924
Postoperative lymphocyte counts	1.81 ± 1.21	1.66 ± 0.84	0.612
Preoperative platelet counts	247.88 ± 85.47	256.31 ± 58.51	0.678
Postoperative platelet counts	244.17 ± 63.96	255.77 ± 57.91	0.475
Preoperative NLR	6.07 ± 9.01	5.52 ± 7.08	0.804
Postoperative NLR	6.01 ± 10.22	6.79 ± 7.23	0.750
Preoperative PLR	172.59 ± 95.80	194.25 ± 137.94	0.457
Postoperative PLR	173.63 ± 103.06	199.89 ± 117.74	0.349
Preoperative MPV	9.46 ± 1.01	9.55 ± 0.98	0.726

Postoperative MPV	9.43 ± 1.16	9.51 ± 1.16	0.775

Values are presented as mean ± standard deviation (SD). Independent samples t-test was used for normally distributed variables, while the Mann–Whitney U test was used for non-normally distributed variables. NLR and PLR values are presented as mean ± SD for consistency but were analyzed using non-parametric tests due to non-normal distribution. TLC, neutrophil, lymphocyte, and platelet counts are expressed as ×10⁹/L, and MPV is expressed in fL. NLR: neutrophil-to-lymphocyte ratio; PLR: platelet-to-lymphocyte ratio; MPV: mean platelet volume.

The changes in hematologic parameters from pre- to postoperative periods (ΔTLC, ΔNLR, ΔPLR) did not differ significantly between Group P and Group G (p = 0.517, p = 0.674, and p = 0.704, respectively). Overall, none of the evaluated inflammatory markers demonstrated a statistically significant intergroup difference (Table 3).

Table 3. Changes (Δ) in hematologic and inflammatory parameters between preoperative and postoperative periods

	Group P (n=45)	Group G (n=22)	p-value
Δ TLC	0.50 [−10.20 to 11.20]	−0.50 [−7.30 to 3.90]	0.517
ΔNLR	0.23 [−12.60 to 16.88]	−0.04 [−26.60 to 19.19]	0.674
ΔPLR	−2.08 [−360.31 to 378.89]	−18.40 [−354.89 to 397.14]	0.704

Δ: difference between pre- and postoperative values. Values are presented as median (interquartile range). TLC: total leukocyte count; NLR: neutrophil-to-lymphocyte ratio; PLR: platelet-to-lymphocyte ratio; MPV: mean platelet volume.

4. Discussion

In the present retrospective study, a smaller increase in inflammatory markers such as NLR, PLR and MPV was noted in patients who received PNB for postoperative pain management following forearm surgery under general anesthesia when compared to those who did not receive PNB, although the differences between the groups were not statistically significant.

Previous studies have reported the frequent use of a variety of inflammatory markers in oncology, rheumatologic disorders and surgical settings[5]. Biomarkers such as the NLR, PLR, TLC, and MPV can be easily derived from routine complete blood count parameters, and are readily accessible and less expensive than proinflammatory cytokines such as TNF-alpha and IL-6. In a study by Gibson et al., NLR demonstrated high sensitivity but low specificity for detecting stress and inflammatory response[6]. NLR and PLR reflect the dynamic relationship between adaptive and cellular response in various pathological conditions. In a study of intensive care unit patients with COVID-19 conducted by Regolo et al., NLR was reported to be associated with increased mortality[7]. Dynamic changes in NLR occur hours before clinical manifestations, and thereby serve as an early warning signal for imminent pathological processes[8]. Studies have reported that factors such as age, sex, chronic steroid use, and active hematological or malignant conditions can lead to false-positive results in NLR[9]. The present retrospective study examined the inflammatory biomarkers NLR, PLR, TLC and MPV, which can reflect dynamic changes in inflammatory processes, using data from the pre- and post-operative complete blood counts performed as routine in our hospital. To avoid potential false-positive results, patients with a history of hematological, renal or hepatic disorders, those with severe respiratory or cardiac insufficiency, malignancy or coagulopathy, and those with a history of chronic analgesic use, chronic alcohol consumption or substance abuse were excluded from the study.

Immune response is strongly influenced by patient-related factors, including preoperative health status and the presence of comorbid conditions[10]. Azab et al. demonstrated significantly higher NLR values in patients with a history of diabetes, cardiovascular disorders or smoking in comparison with patients without such conditions[11]. The present study identified no differences in ASA class and demographic parameters between the two groups.

The median NLR has been reported as 2.15 in studies establishing normal NLR values in healthy adult populations[11]. In a study by Duran et al., NLR values greater than 3.0 were associated with pathological conditions such as infections, inflammation, stress and cancer[12]. In a study by Zahorec et al., NLR values greater than 3.0 or less than 0.7 in adults were classified as pathological[8]. The median preoperative NLR values in the present study were 6.01 in Group P and 6.79 in Group G, which were well above the normal range, as all patients in the present study had fractures secondary to trauma. In the postoperative period, the median NLR values were numerically higher in the general anesthesia group compared with the PNB group.

Previous studies have established an association between postoperative pain and elevated inflammatory response[13]. PNB, when used as a part of multimodal analgesia, helps reduce postoperative pain. Erector spinae plane block performed for analgesia in patients undergoing posterior lumbar stabilization surgery has been found to reduce postoperative inflammatory response by decreasing NLR, PLR and opioid consumption[14]. Tantri et al. demonstrated that the addition of PNB to posterior lumbar decompression and stabilization procedures is associated with lower serum levels of proinflammatory cytokines such as IL-6 and IL-10[15]. Liu et al. reported that patients who received an ESP block for postoperative analgesia following video-assisted thoracoscopic surgery had significantly lower IL-6, IL-10 and TNF-α levels than those who received no such block[16]. Bagry et al. studied two groups of patients undergoing knee arthroplasty, one of which received intravenous morphine while the other received continuous PNB. C-reactive protein (CRP) and total leukocyte count were found to be lower in the group that received continuous PNB[17]. In their study, Köksal et al. examined two patient groups undergoing forearm surgery, one of which received infraclavicular nerve block for anesthesia, while the other received general anesthesia. The authors reported that the use of infraclavicular nerve block as an alternative to general anesthesia was associated with significant reductions in the neutrophil-to-lymphocyte ratio, total leukocyte count, and platelet-to-lymphocyte count[18]. Due to the retrospective design of the present study, IL-6, CRP and TNF-α level data were not available; however, lower postoperative levels of bioinflammatory markers such as NLR, PLR and MPV were observed in the patients who received PNB in addition to general anesthesia.

In clinical practice, PNBs are frequently used in patients undergoing upper extremity surgery either as the primary mode of anesthesia, or as a component of multimodal analgesia. Brachial plexus blocks used for this purpose may offer such benefits as reduced systemic inflammatory response and opioid consumption, while also helping to prevent the development of chronic pain. In a study assessing metabolic, hormonal and hemodynamic responses in patients undergoing elective surgery, regional anesthesia performed better than general anesthesia in suppressing stress response, and the former was found to be associated with a reduction in systemic cortisol levels[19]. In another study, regional anesthesia was shown to reduce inflammatory response through various mechanisms, including attenuating the immunosuppressive effect of surgery by inhibiting neuroendocrine stress response, decreasing postoperative opioid requirements and reducing total anesthetic consumption when used in conjunction with general anesthesia[20]. Due to the retrospective design of the present study and gaps in patient records, no postoperative opioid consumption data were available.

The present study is limited by the lack of an analysis examining correlations between biomarkers such as NLR, PLR, TLC and MPV, and inflammatory markers such as CRP, IL-6 and TNF-α. Another limitation is the lack of long-term data on the effect of the anesthesia technique on immune response, as the patients were not monitored beyond 24 hours following surgery. Finally, the small sample size can be regarded as another limitation. The authors believe that case series involving larger number of patients may yield results with statistically significant differences.

In conclusion, regional anesthesia involving peripheral nerve block administered as part of multimodal analgesia in patients undergoing general anesthesia, particularly when regional anesthesia is not feasible due to surgical or patient-related factors, may be beneficial in reducing postoperative systemic inflammation.

genAI: No artificial intelligence (AI)-based tools or generative AI technologies were used in this study. The entire content of the manuscript was originally prepared, reviewed and approved by all authors.

Congress Presentation: This study was previously presented as an oral presentation at the TARK 2025 Congress. This submission represents the full manuscript version of that presentation.

Statement of Ethics: Approval for the study was granted by the Prof. Dr. Şehít İlhan Varank EAH Non-Interventional Clinical Research Ethics Committee (Sancaktepe BAEK 2025/373). The study was conducted in accordance with the Declaration of Helsinki.

Data Availability: The data and materials related to this study can be obtained from the researchers upon reasonable request.

Funding: This study received no financial support from any public, commercial, or non-profit funding agency.

Conflict of Interest: The authors declare no conflicts of interest.

Author Contributions: All authors contributed to the study design, data collection and/or analysis, manuscript preparation, and approved the final version of the manuscript.

References

1. Iwasaki M, Edmondson M, Sakamoto A, Ma D. Anesthesia, surgical stress, and long-term outcomes. Acta Anaesthesiol Taiwan. 2015;53:99-104. https://doi.org/10.1016/j.aat.2015.07.002
2. Cusack B, Buggy DJ. Anaesthesia, analgesia, and the surgical stress response. BJA Educ. 2020;20:321-328. https://doi.org/10.1016/j.bjae.2020.04.006
3. Ivascu R, Dutu M, Stanca A, Negutu M, Morlova D, Dutu C, et al. Pain in colorectal surgery: how does it occur and what tools do we have for treatment? J Clin Med. 2023;12:6771. https://doi.org/10.3390/jcm12216771
4. Kim HA, Jung JY, Suh CH. Usefulness of neutrophil-to-lymphocyte ratio as a biomarker for diagnosing infections in patients with systemic lupus erythematosus. Clin Rheumatol. 2017;36:2479-2485.
5. Wu H, Zhou H, Chen P. Correlation of neutrophil-lymphocyte ratio, platelet-lymphocyte ratio, and mean platelet volume with gout activity: a monocentric and retrospective study. Medicine (Baltimore). 2022;101:e30242. https://doi.org/10.1097/MD.0000000000030242
6. Gibson PH, Cuthbertson BH, Croal BL, Rae D, El-Shafei H, Gibson G, et al. Usefulness of neutrophil/lymphocyte ratio as predictor of new-onset atrial fibrillation after coronary artery bypass grafting. Am J Cardiol. 2010;105:186-191.
7. Regolo M, Vaccaro M, Sorce A, Stancanelli B, Colaci M, Natoli G, et al. Neutrophil-to-lymphocyte ratio is a promising predictor of mortality and admission to intensive care unit of COVID-19 patients. J Clin Med. 2022;11:2235.
8. Zahorec R. Neutrophil-to-lymphocyte ratio, past, present and future perspectives. Bratisl Med J. 2021;122:474-488.
9. Lee JS, Kim NY, Na SH, Youn YH, Shin CS. Reference values of the neutrophil-lymphocyte ratio, lymphocyte-monocyte ratio, platelet-lymphocyte ratio, and mean platelet volume in healthy subjects in South Korea. Medicine (Baltimore). 2018;97:e11138.
10. Kurosawa S, Kato M. Anesthetics, immune cells, and immune responses. J Anesth. 2008;22:263-277.
11. Azab B, Camacho-Rivera M, Taioli E. Average values and racial differences of neutrophil lymphocyte ratio among a nationally representative sample of United States subjects. PLoS One. 2014;9:e112361.

12. Duran H, Alpdemir M, Ceken N, Alpdemir MF, Kula AT. Neutrophil/lymphocyte and platelet/lymphocyte ratios as a biomarker in postoperative wound infections. Turk J Biochem. 2022;47:756-762.
13. Rokyta R, Stopka P, Holecek V, Krikava K, Pekarkova I. Direct measurement of free radicals in the brain cortex and the blood serum after nociceptive stimulation in rats. Neuro Endocrinol Lett. 2004;25:252-256.
14. Domagalska M, Ciftsi B, Janusz P, et al. The neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio levels following erector spinae plane block in posterior lumbar decompression: a randomized controlled trial. Eur Spine J. 2023;32:4192-4199.
15. Tantri AR, Rahmi R, Marsaban AHM, Satoto D, Rahyussalim AJ, Sukmono RB. Comparison of postoperative IL-6 and IL-10 levels following erector spinae plane block and classical thoracolumbar interfascial plane block in posterior lumbar decompression and stabilization: a randomized controlled trial. BMC Anesthesiol. 2023;23:1-8.
16. Liu L, Ni X, Zhang L, Zhao K, Xie H, Zhu J. Effects of ultrasound-guided erector spinae plane block on postoperative analgesia and plasma cytokine levels after uniportal VATS: a prospective randomized controlled trial. J Anesth. 2021;35:3-9.
17. Bagry H, de la Cuadra Fontaine JC, Asenjo JF, Bracco D, Carli F. Effect of a continuous peripheral nerve block on the inflammatory response in knee arthroplasty. Reg Anesth Pain Med. 2008;33:17-23.
18. Koksal BG, Bollucuoglu K, Sahin E, Bayram MG, Kucukosman G, Ayoglu H. The effect of anesthesia methods on the neutrophil-lymphocyte ratio in patients undergoing forearm surgery: a monocentric and retrospective study. Medicine (Baltimore). 2024;103:e40290. https://doi.org/10.1097/MD.0000000000040290
19. Milosavljevic SB, Pavlovic AP, Trpkovic SV, Ilic AN, Sekulic AD. Influence of spinal and general anesthesia on the metabolic, hormonal, and hemodynamic response in elective surgical patients. Med Sci Monit. 2014;20:1833-1840.
20. Myles PS, Peyton P, Silbert B, Hunt J, Rigg JR, Sessler DI. Perioperative epidural analgesia for major abdominal surgery for cancer and recurrence-free survival: randomized trial. BMJ. 2011;342:d1491. https://doi.org/10.1136/bmj.d1491