Journal of The Cardiovascular Thoracic Anaesthesia and Intensive Care Society

GKDA Derg 2023;29(4):177-182
DOI: 10.14744/GKDAD.2023.83584

RESEARCH ARTICLE

Effects of the Anesthesia Type on Hematological Parameters in Coronary Artery Bypass Grafting

Tuna Şahin,[1] Semiha Görgün,[1] Suat Karaca,[2] İbrahim Özsöyler[2]

[1]Department of Anesthesiology and Reanimation, Adana City Training and Research Hospital, Adana, Türkiye
[2]Department of Cardiovascular Surgery, Adana City Training and Research Hospital, Adana, Türkiye

ABSTRACT

Objectives: This study evaluated the effects of sevoflurane-based inhalation anesthesia and propofol-based total intravenous anesthesia on hematological parameters in coronary artery bypass grafting (CABG).

Methods: In this study, 125 patients who underwent elective on-pump CABG between November 2021 and April 2022 were retrospectively analyzed. Patients aged 35–80 years with an ejection fraction of ≥25% were included. The patients were separated into two groups: The sevoflurane group (Group SEVO) and the total intravenous anesthesia group (Group TIVA). Patient characteristics, operative clinical data, and preoperative and postoperative hematological parameters: [white blood cell (WBC) count, red cell distribution width (RDW), neutrophil/lymphocyte ratio (NLR)] were analyzed.

Results: The mean age of the patients was 62.0±8.7 years. Group SEVO comprised 70 patients, and Group TIVA comprised 55 patients. Significant increases in postoperative WBC count, RDW, and NLR values were observed in both groups. No statistically significant differences in WBC count, RDW, and NLR values were observed between the two groups (p>0.05).

Conclusion: The effects of sevoflurane-based inhalation anesthesia or propofol-based total intravenous anesthesia on WBC count, RDW, and NLR values among patients undergoing elective on-pump CABG were similar.

Keywords: Anesthesia, coronary artery bypass grafting, neutrophil/lymphocyte ratio, red cell distribution width, white blood cell count

Please cite this article as: "Şahin T, Görgün S, Karaca S, Özsöyler İ. Effects of the Anesthesia Type on Hematological Parameters in Coronary Artery Bypass Grafting. GKDA Derg 2023;29(4):177-182".

Introduction

Coronary artery bypass grafting (CABG) is commonly performed worldwide.[1] The choice of anesthesia with inhalation agents, intravenous anesthetics, or a combination of inhalation and intravenous agents during CABG is controversial. Volatile anesthetics have cardioprotective effects that depend on multiple mechanisms, including modulation of G-protein-coupled receptors, gene expression, mitochondrial function, signaling pathways, and potassium channels.[2,3] It has been reported that propofol has an anti-inflammatory effect and that propofol-based total intravenous anesthesia (TIVA) reduces the inflammatory effect in CABG.[4–6]

The white blood cell (WBC) count, red cell distribution width (RDW), and neutrophil/lymphocyte ratio (NLR) are the parameters used in hemogram analysis. They are inflammatory biomarkers and predictive indicators of the risk of cardiovascular events.[7–9] Changes in WBC count, RDW, and NLR values may occur in patients who have undergone cardiac surgery.

In this study, we evaluated the effects of sevoflurane-based inhalation anesthesia and propofol-based TIVA on WBC count, RDW, and NLR values in patients undergoing CABG.

Methods

Study Design

The study protocol was approved by the Ethics Committee of Adana City Training and Research Hospital (approval number: 2011 on June 23, 2022). We retrospectively analyzed 125 patients who underwent elective on-pump CABG between November 2021 and April 2022.

Address for correspondence: Tuna Şahin, MD. Adana Şehir Eğitim ve Araştırma Hastanesi, Anesteziyoloji ve Reanimasyon Kliniği, Adana, Türkiye
Phone: +90 322 455 90 00 **E-mail:** drtunas@hotmail.com

Submitted: July 17, 2023 **Revised:** October 31, 2023 **Accepted:** November 22, 2023 **Available Online:** December 16, 2023

The Cardiovascular Thoracic Anaesthesia and Intensive Care - Available online at www.gkdaybd.org

Clinical Data

Data were obtained from the written and electronic medical charts of the patients. The analyzed data comprised patient demographics; preoperative history of comorbidities; ejection fraction values; preoperative and postoperative WBC count, RDW, and NLR values; anesthesia duration; surgery duration; cardiopulmonary bypass and cross-clamping duration; inotropic and vasopressor support administration (i.e., dopamine and norepinephrine); and the number of grafts, red blood cell (RBC) units, and fresh frozen plasma given were recorded.

The study comprised patients aged 35–80 years. Patients with an ejection fraction of ≥25% were included. Patients who underwent concurrent heart valve surgery, off-pump surgery, and emergency surgery and those with thyroid dysfunction, atrial arrhythmias, autoimmune and systemic inflammatory diseases, and preoperative inotropic medication support or intra-aortic balloon pump (IABP) were excluded.

Anesthetic Management

All patients were premedicated with midazolam (0.05 mg/kg) and fentanyl (0.5 mcg/kg). Anesthesia was induced with midazolam (0.15 mg/kg), fentanyl (5–10 mcg/kg), and rocuronium (0.6 mg/kg). The patients were separated into two groups according to the anesthesia type: the sevoflurane group (Group SEVO) and the total intravenous anesthesia group (Group TIVA). Anesthesia in-Group SEVO was maintained with 2%–3% sevoflurane (1–2 minimum alveolar concentration) + 0.05–2 mcg/kg/min remifentanil + 5–12 mcg/kg/min rocuronium. Anesthesia in-Group TIVA was maintained with 25–100 mcg/kg/min propofol + 0.05–2 mcg/kg/min remifentanil + 5–12 mcg/kg/min rocuronium. Because of the absence of a waste gas scavenging system that would allow sevoflurane to be directed to the outlet central waste system in the operating room, all patients received TIVA (propofol+ remifentanil) during cardiopulmonary bypass. Cardiopulmonary bypass was performed using a roller pump, open reservoir, and membrane oxygenator with a target flow of 2.2–2.4 L/min/m2 at 36°C. Moderate hypothermia (30°C–32°C) was applied. Crystalloid cardioplegia was used. Target hemoglobin concentrations were maintained above 7.5 g/dL and above 8.5 g/dL after the operation. Heparin administration was reversed with protamine sulfate after cardiopulmonary bypass.

Blood samples were taken before surgery and at the 6th postoperative hour.

Statistical Analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (version 25.0; Armonk, NY: IBM Corp.) and MedCalc 15.8 (MedCalc Software bbba, Ostend, Belgium). While evaluating the study data, descriptive statistical methods (i.e., frequency, percentage, mean, standard deviation, median, and min–max) were used. To compare qualitative data, chi-square tests (i.e., Pearson's chi-square test, Yates' corrected chi-square test, and Fisher's exact test) were employed. The suitability of the data to the normal distribution was evaluated using the Kolmogorov–Smirnov test, skewness–kurtosis, and graphical methods (i.e., histogram, Q-Q plots, stem and leaf plots, and boxplots). In the comparison of normally distributed quantitative data between the groups, the independent samples t-test (t-test in independent groups) was used. Paired samples t-test (t-test in dependent groups) or McNemar's test was used for in-group comparisons. P-values <0.05 were used to denote statistical significance.

For comparisons between groups, power analysis was performed using G*Power 3.1.9.7 (Franz Foul, Universitat Kiel, Germany). For n1=70, n2=55, α=0.05, effect size (d)=0.6, and power=91%.

Results

The mean age of the patients included in the study was 62.0±8.7 years (range, 37–82 years); 36 patients were women and 89 were men. Among the 125 patients included in the study, 70 were in-Group SEVO and 55 were in-Group TIVA.

Of the 125 patients, 105 had a preoperative history of comorbidities, and the most common comorbidities were diabetes mellitus, hypertension, hyperlipidemia, cerebrovascular disease, asthma, and chronic obstructive pulmonary disease (Table 1).

No statistically significant differences in sex, age, ejection fraction values, and chronic diseases were observed between the two groups (p>0.05) (Table 1).

Preoperative and postoperative values and preoperative–postoperative change percentage values for WBC count, RDW, and NLR in both groups are presented in Table 2. When preoperative and postoperative WBC count, RDW, and NLR values in both Groups SEVO and TIVA were examined, a statistically significant difference in these values was observed (p<0.05), and postoperative values were higher in all cases. In the comparisons between the groups, no statistically significant differences in WBC count, RDW, and NLR values were observed between the groups (p>0.05).

The intraoperative data in both groups, such as the number of grafts, cross clamp duration, cardiopulmonary bypass duration, duration of surgery, duration of anesthesia, inotropic and vasopressor support administrations (dopamine and norepinephrine), and blood product transfusions, are shown in Table 3. No statistically significant

Table 1. Demographic and preoperative data of the groups

Variables	Group SEVO		Group TIVA		p
	n	%	n	%	
Age (years)	61.8±8.7		62.3±8.7		0.787[a]
Sex					
Female	15	21.4	21	38.2	0.064[b]
Male	55	78.6	34	61.8	
Diabetes mellitus	36	51.4	35	63.6	0.236[b]
Hypertension	35	50.0	30	54.5	0.614[c]
Hyperlipidemia	36	51.4	28	50.9	0.954[c]
Cerebrovascular diseases	5	7.1	5	9.1	0.748[d]
Asthma	3	4.3	3	5.5	1.000[d]
Chronic obstructive pulmonary disease	2	2.9	2	3.6	1.000[d]
Ejection fraction (%)	50.3±10.6		51.4±8.9		0.567[a]

Data are presented as numbers (%) or means±standard deviations. [a]: Independent samples t-test; [b]: Yates' corrected chi-square test; [c]: Pearson's chi-square test; [d]: Fisher's exact test. SEVO: Sevoflurane; TIVA: Total intravenous anesthesia.

Table 2. Comparisons of NLR, WBC count, and RDW values between groups and in groups

Value	Group SEVO	Group TIVA	p
NLR			
Preoperative	2.4±1.3	2.6±1.1	0.293[a]
Postoperative	27.1±12.4	28.7±15.7	0.524[a]
p[b]	**0.000**	**0.000**	
Pre-post change %	1.363.40±1.436.56	1.085.26±579.93	0.179[a]
WBC			
Preoperative	6.8±2.0	6.7±1.6	0.604[a]
Postoperative	14.9±3.9	14.0±4.0	0.202[a]
p[b]	**0.000**	**0.000**	
Pre-post change %	131.43±80.17	115.70±62.90	0.235[a]
RDW			
Preoperative	14.0±2.4	14.4±2.6	0.382[a]
Postoperative	14.6±2.0	15.3±3.5	0.168[a]
p[b]	**0.045**	**0.020**	
Pre-post change %	6.92±24.98	7.09±21.76	0.969[a]

Data are presented as means±standard deviations. [a]: Independent samples t-test; [b]: paired samples t-test. NLR: Neutrophil/lymphocyte ratio; WBC: White blood cell; RDW: Red cell distribution width.

differences in these intraoperative data were observed between the groups (p>0.05).

Discussion

In this study, no difference was found between sevoflurane-based inhalation anesthesia and propofol-based TIVA in terms of effects on WBC count, RDW, and NLR values in patients undergoing CABG.

Choosing an anesthesia technique in cardiac surgery as an inhalation agent, TIVA, or a combination of inhalation and intravenous agents commonly depends on the clinician's practices.

It has been reported that volatile anesthetics have cardioprotective effects with a preconditioning effect on myocardial ischemia and reduce the incidence of infarction in cardiac surgery.[10,11]

On the other hand, TIVA with remifentanil and propofol has been suggested as a safe anesthetic option for cardiac surgery in patients with severe left ventricular dysfunction.[12,13]

In the literature, many studies have compared inhalation anesthesia with TIVA.

A systematic review and meta-analysis of randomized controlled trials (RCTs), which comprised 58 studies, including 6,105 patients, compared inhalation anesthesia

Table 3. Intraoperative data in the groups

Value	Group SEVO		Group TIVA		p
	n	%	n	%	
Number of grafts	3.0±0.9		3.0±0.7		0.918[a]
Cross clamp duration (min)	53.0±20.0		50.2±14.9		0.394[a]
Cardiopulmonary bypass duration (min)	97.3±29.6		97.2±25.7		0.984[a]
Duration of surgery (min)	206.9±43.1		205.5±37.2		0.848[a]
Duration of anesthesia (min)	238.6±42.3		237.5±35.4		0.881[a]
Dopamine(mcg/kg/dk) (n_1=48/n_2=26)	4.98±2.57		4.42±1.64		0.259[a]
Norepinephrine(mcg/kg/dk) (n_1=11/n_2=7)	0.09±0.03		0.08±0.03		0.539[a]
Blood product transfusions					
1 unit of RBC+2 units of FFP	11	15.7	13	23.6	0.385[b]
2 units of RBC+2 unit FFP	22	31.4	21	38.2	
2 units of FFP	28	40.0	17	30.9	
3 units of RBC+2 units of FFP	9	12.9	4	7.3	

Data are presented as means±standard deviations. [a]: Independent samples t-test; [b]: Pearson's chi-square test. RBC: Red blood cell; FFP: Fresh frozen plasma.

with TIVA in patients who underwent on-pump or off-pump CABG. It has been reported that there is high-quality evidence that sevoflurane reduces death within 180–365 days of surgery and inotropic and vasoconstrictor support compared with propofol. The cardiac index was also reported to be minimally influenced by sevoflurane and desflurane compared with propofol, with some evidence.[14]

The Mortality in Cardiac Surgery Randomized Controlled Trial of Volatile Anesthetics trial compared volatile anesthetics (desflurane, isoflurane, or sevoflurane) with TIVA in 5,400 patients undergoing elective on-pump and off-pump CABG. The number of deaths at 1 year was investigated. It was reported that intraoperative anesthesia with volatile anesthetics did not result in significantly fewer deaths at 30 days or 1 year than TIVA.[15]

Another meta-analysis which comprised 89 RCTs, including 14,387 patients, compared volatile anesthetics with TIVA in patients who underwent CABG. Arrhythmia, myocardial infarction, heart failure, delirium, stroke, acute kidney injury, postoperative cognitive impairment, and the use of IABP or other mechanical circulatory support were defined as postoperative safety outcomes. It was reported that the length of stay in the intensive care unit and hospital was shorter with volatile anesthetics than with TIVA. However, operative mortality, 1-year mortality, and postoperative safety outcomes were not reduced with the use of volatile anesthetics compared with TIVA.[16]

As seen in the literature, studies comparing inhalation anesthesia with TIVA have mainly focused on 30-, 180-, and 365-day mortality, length of stay in the intensive care unit and hospital, and adverse postoperative outcomes. Unlike these studies, our study focused on the effects of inhalation anesthesia and TIVA on hemogram parameters that is, WBC count, RDW, and NLR.

CABG with cardiopulmonary bypass triggers a systemic inflammatory response.[17]

The complete blood cell count parameters WBC count, RDW, and NLR are also inflammatory biomarkers, and in several studies, they have been used to predict clinical outcomes following cardiac surgery.[18–20]

Aydınlı et al.[21] investigated five parameters of hemogram analysis–hemoglobin, RDW, NLR, mean platelet volume (MPV), and platelet/lymphocyte ratio (PLR)–as predictive data following cardiac surgery. They reported that the prediction success of NLR (4.8 times) was higher than that of RDW (1.8 times) and MPV. Furthermore, they reported that the predictive success of the combination of the parameters NLR, RDW, and MPV was the highest of all combinations.

The use of these hemogram parameters for predicting outcomes after cardiac surgery is well defined in the literature. However, the effects of anesthesia type on these hematological parameters have not been thoroughly examined in the literature.

Aldemir et al.[22] investigated the effects of propofol and desflurane anesthesia on NLR in patients who underwent CABG. They reported that the NLR values at the 12th and 24th postoperative hours were lower in propofol anesthesia than in desflurane anesthesia.

Özay et al.[23] compared the effects of midazolam-based TIVA with those of sevoflurane-based inhalation anesthesia on RDW and MPV in patients who underwent CABG. They reported that RDW values were significantly lower in the inhalation group. MPV values were not significantly different between the two groups.

Unlike these studies, we did not find any difference between the inhalation and TIVA groups in terms of either NLR or RDW values. The reason for this may be that we evaluated NLR values at the 6th postoperative hour; however, Aldemir et al. evaluated NLR at the 12th and 24th postoperative hours. Unlike our study, Aldemir et al. compared propofol with desflurane, whereas Özay et al. compared midazolam with sevoflurane.

We found that the postoperative WBC count, RDW, and NLR values were elevated in both groups.

Limitations of the Study

This study adopted a retrospective study design, and because of institutional resource limitations, the implementation of anesthetic depth-measuring techniques, such as BIS monitors, is impossible in our hospital's routine practice. The depth of anesthesia was standardized by maintaining the end-tidal sevoflurane concentration at 1 MAC, with standard monitoring of hemodynamic parameters, such as mean arterial blood pressure and pulse, and clinical parameters, such as tears, sweating, and pupil size. A prospective study with large number of patients and monitoring the depth of anesthesia would be meaningful. We analyzed only on-pump CABG. Further studies, including off-pump CABG, are warranted.

In conclusion, this study found that the effects of sevoflurane-based inhalation anesthesia and propofol-based TIVA on WBC, RDW, and NLR values in patients undergoing elective on-pump CABG were similar.

Disclosures

Ethics Committee Approval: The study was approved by The Adana City Training and Research Hospital Clinical Research Ethics Committee (Date: 23/06/2022, No: 2011).

Informed Consent: Written informed consent was obtained from all patients.

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study has received no financial support.

Authorship Contributions: Concept – T.Ş.; Design – T.Ş.; Supervision – T.Ş., S.G.; Data collection &/or processing – T.Ş., S.G.; Analysis and/or interpretation – T.Ş., S.G., S.K.; Literature search – S.K., İ.Ö.; Writing – T.Ş.; Critical review – S.G., İ.Ö.

References

1. Alexander JH, Smith PK. Coronary-Artery bypass grafting. N Engl J Med 2016;374:1954–64.
2. Pagel PS, Crystal GJ. The discovery of myocardial preconditioning using volatile anesthetics: A history and contemporary clinical perspective. J Cardiothorac Vasc Anesth 2018;32:1112–34.
3. Pagel PS. Myocardial protection by volatile anesthetics in patients undergoing cardiac surgery: A critical review of the laboratory and clinical evidence. J Cardiothorac Vasc Anesth 2013;27:972–82.
4. Cruz FF, Rocco PR, Pelosi P. Anti-inflammatory properties of anesthetic agents. Crit Care 2017;21:67.
5. Corcoran TB, Engel A, Sakamoto H, O'Shea A, O'Callaghan-Enright S, Shorten GD. The effects of propofol on neutrophil function, lipid peroxidation and inflammatory res-ponse during elective coronary artery bypass grafting in patients with impaired ventricu-lar function. Br J Anaesth 2006;97:825–31.
6. Sayed S, Idriss NK, Sayyedf HG, Ashry AA, Rafatt DM, Mohamed AO, et al. Effects of propofol and isoflurane on haemodynamics and the inflammatory response in cardi-opulmonary bypass surgery. Br J Biomed Sci 2015;72:93–101.
7. Gurm HS, Bhatt DL, Gupta R, Ellis SG, Topol EJ, Lauer MS. Preprocedural white blood cell count and death after percutaneous coronary intervention. Am Heart J 2003;146:692–8.
8. Fowler AJ, Agha RA. Neutrophil/lymphocyte ratio is related to the severity of coronary artery disease and clinical outcome in patients undergoing angiography--the growing versatility of NLR. Atherosclerosis 2013;228:44–5.
9. Poludasu S, Cavusoglu E, Khan W, Marmur JD. Neutrophil to lymphocyte ratio as a predictor of long-term mortality in African Americans undergoing percutaneous coro-nary intervention. Clin Cardiol 2009;32:E6–10.
10. Minguet G, Joris J, Lamy M. Preconditioning and protection against ischaemia-reperfusion in non-cardiac organs: A place for volatile anaesthetics? Eur J Anaesthesiol 2007;24:733–45.
11. Landoni G, Rodseth RN, Santini F, Ponschab M, Ruggeri L, Székely A, et al. Rando-mized evidence for reduction of perioperative mortality. J Cardiothorac Vasc Anesth 2012;26:764–72.
12. Lehmann A, Boldt J, Zeitler C, Thaler E, Werling C. Total intravenous anesthesia with remifentanil and propofol for implantation of cardioverter-defibrillators in patients with severely reduced left ventricular function. J Cardiothorac Vasc Anesth 1999;13:15–9.
13. Ouattara A, Boccara G, Lemaire S, Köckler U, Landi M, Vaissier E, et al. Target-controlled infusion of propofol and remifentanil in cardiac anaesthesia: Influence of age on predicted effect-site concentrations. Br J Anaesth 2003;90:617–22.
14. El Dib R, Guimarães Pereira JE, Agarwal A, Gomaa H, Ayala AP, Botan AG, et al. Inhalation versus intravenous anaesthesia for adults undergoing on-pump or off-pump coronary artery bypass grafting: A systematic review and meta-analysis of randomized controlled trials. J Clin Anesth 2017;40:127–38.
15. Landoni G, Lomivorotov VV, Nigro Neto C, Monaco F, Pasyuga VV, Bradic N, et al. Volatile anesthetics versus total intravenous anesthesia for cardiac surgery. N Engl J Med 2019;380:1214–25.
16. Jiao XF, Lin XM, Ni XF, Li HL, Zhang C, Yang CS, et al. Volatile anesthetics versus total intravenous anesthesia in patients undergoing coronary artery bypass grafting: An updated meta-analysis and trial sequential analysis of randomized controlled trials. PLoS One 2019;14:e0224562.
17. Czerny M, Baumer H, Kilo J, Lassnigg A, Hamwi A, Vukovich T, et al. Inflammatory response and myocardial injury following coronary

artery bypass grafting with or wit-hout cardiopulmonary bypass. Eur J Cardiothorac Surg 2000;17:737–42.
18. Gurbuz O, Kumtepe G, Ozkan H, Karal IH, Velioglu Y, Ercan A, et al. Predictive value of neutrophil-lymphocyte ratio for long-term cardiovascular event following coronary artery bypass grafting. Braz J Cardiovasc Surg 2020;35:274–84.
19. Newall N, Grayson AD, Oo AY, Palmer ND, Dihmis WC, Rashid A, et al. Preoperati-ve white blood cell count is independently associated with higher perioperative cardiac enzyme release and increased 1-year mortality after coronary artery bypass grafting. Ann Thorac Surg 2006;81:583–9.
20. Benedetto U, Angeloni E, Melina G, Pisano C, Lechiancole A, Roscitano A, et al. Red blood cell distribution width predicts mortality after coronary artery bypass grafting. Int J Cardiol 2013;165:369–71.
21. Aydınlı B, Demir A, Güçlü ÇY, Bölükbaşı D, Ünal EU, Koçulu R, et al. Hematological predictors and clinical outcomes in cardiac surgery. J Anesth 2016;30:770–8.
22. Aldemir M, Bakı ED, Adalı F, Tecer E, Öztürk NK, Kavaklı AS, et al. Comparison of the effects of propofol anaesthesia and desflurane anaesthesia on neutrophil/lymphocyte ratios after coronary artery bypass surgery. J Turgut Ozal Med Cent 2015;22:165–70.
23. Özay HY, Demir ZA, Balcı E, Bahçecitapar MK. Effects of intravenous versus inhalational anesthesia on red cell distribution width and mean platelet volume in patients undergoing coronary artery surgery. J Anesthesiol Reanim Spec Soc 2021;29:184–90.