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Comparison of the Effect of Different Anesthesia Maintenance on Hemodynamics in Coronary Artery Bypass Grafting Surgery: A Retrospective Cohort Study

Koroner Arter Baypas Greftleme Cerrahisinde Farklı Anestezi Idamesinin Hemodinami Üzerine Etkisinin Karşılaştırılması: Retrospektif Bir Kohort Çalışması

Hülya Yılmaz Ak[1], Yasemin Özşahin[1], Mehmet Ali Yeşiltaş[2], İsmail Haberal[1], Mustafa Yıldız[1], Ziya Salihoğlu[1], Kerem Erkalp[1]

[1]İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, Department of Cardiology, İstanbul, Turkey
[2]University of Health Sciences Turkey, İstanbul Bakırköy Dr. Sadi Konuk Training and Research Hospital, Clinic of Cardivascular Surgery, İstanbul, Turkey

Abstract

Objective: General anesthesia management in coronary artery bypass graft surgery (CABGC) should preserve myocardial function, prevent ischemic damage, and maintain stable hemodynamics. There is not a universally accepted technique for anesthetic management during CABGC. Drugs or drug combinations and maintenance of infusions are decided based on the pathophysiological condition of the patient and the individual preference and experience of the anesthesiologist (1). Although there are many studies about an anesthesia induction in CABGC, studies about anesthetic maintenance are very limited. In this study, we compared the hemodynamic effects of three different methods that were used in anesthetic maintenance in CABGC.

Method: The retrospective records of 108 patients in ASA II-III group who underwent elective CABGC were divided into 3 groups according to their anesthetic maintenance methods. Group I was maintained with 1-3% sevoflurane and fentanyl 4 mcg/kg/hour infusion, group II with propofol 1.5-4 mg/kg/hour and fentanyl 4 mcg/kg/hour infusion, and group III with propofol 1.5-4 mg/kg/hour and remifentanil infusion of 0.03 mg/kg/hour. Systolic blood pressure, diastolic blood pressure, mean arterial pressure (MAP) and heart rate (HR) were measured and recorded after induction (T0), after sternotomy (T1), after pericardiotomy (T2), 5 minutes after cardiopulmonary bypass (CPB) (T3), after thorax closure (T4), at the end of the operation (T5). The vasodilator requirements in the time period before CBP and the inotropic agent requirements after CPB were noted.

Öz

Amaç: Koroner arter baypas greft cerrahisinde (KABGC) genel anestezi yönetimi miyokard fonksiyonunu korumalı, iskemik hasarı önlemeli ve stabil hemodinamiyi sağlamalıdır. KABGC sırasında anestezi yönetimi için evrensel olarak kabul edilmiş olan tek bir teknik bulunmamaktadır. Kullanılan ilaçlar ve ilaç kombinasyonları, idame infüzyonları hastanın patofizyolojik durumu ile anesteziyoloji ve reanimasyon uzmanın bireysel tercihi ile deneyimine dayanır. KABGC'sinde anestezi indüksiyonu ile ilgili çok sayıda çalışma olsa da anestezi idamesi ile ilgili çalışmalar kısıtlıdır. Bu çalışmada, retrospektif olarak KABGC'sinde anestezi idamesinde kullanılmış 3 farklı yöntemin hemodinami üzerine etkileri karşılaştırıldı.

Yöntem: Elektif KABGC uygulanmış olan ASA II-III grubu 108 hastanın kayıtları anestezi idame yöntemlerine göre 3 gruba ayrılmıştır. Grup I; %1-3 sevofluran ve fentanil 4 mcg/kg/saat infüzyonu, grup II; propofol 1,5-4 mg/kg/saat ve fentanyl 4 mcg/kg/saat infüzyonu, grup III; propofol 1,5-4 mg/kg/saat ve remifentanil 0,03 mg/kg/saat infüzyonu ile idame edilmişti. İndüksiyon sonrası (T0), sternotomi sonrası (T1), perikardiyotomi sonrası (T2), CPB sonrası beşinci dakikada (T3), toraks kapatılırken (T4) ve operasyon bitiminde (T5) olmak üzere sistolik kan basıncı (SKB), diyastolik kan basıncı, ortalama arter basıncı (OAB), kalp hızı (nabız) kaydedilmişti. Kardiyopulmoner baypas (KBP) öncesi dönemde kullanılan vazodilatatör ilaç ihtiyacı ile KPB sonrasında kullanılmış olan inotropik ajan miktarları hesaplandı.

Address for Correspondence: Kerem Erkalp, İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, Department of Cardiology, İstanbul, Turkey
E-mail: keremerkalp@hotmail.com **ORCID:** orcid.org/0000-0002-4025-7092 **Received:** 03.11.2020 **Accepted:** 15.12.2020
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Abstract

Results: Data of 108 patients (88 men/20 women) were analyzed. Demographic characteristics of the patients were similar in all the groups. Statistical analysis was made among the groups depending on coronary artery bypass graft number, cross-clamp time, total fluid administration, total blood transfusion, total urine volume, inotropic agent requirement after CPB, postoperative central venous pressure, and pre- and postoperative lactate levels; however, there was no statistical difference. There was not change more than 20-25% in MAP and HR in group I than the others.

Conclusion: Better hemodynamic results were achived with sevoflurane and fentanyl in the anesthetic maintenance of CABGC.

Keywords: Cardiovascular anesthesia, hemodynamics, inhalation, intravenous

Öz

Bulgular: Yüz sekiz hastadan (88 erkek/20 kadın) elde edilen veriler analiz edildi. Hastaların demografik özellikleri her üç grupta da benzerdi. Koroner arter baypas greft sayısı, kros klemp süresi, toplam sıvı, toplam kan transfüzyonu, toplam idrar hacmi, KPB sonrası inotropik ajan gereksinimi, ameliyat sonrası santral venöz basınç, ameliyat öncesi ve sonrası laktat ve laktat artışı açısından gruplar arasında istatistiksel olarak fark yoktu. Grup I'de diğer gruplara göre, OAB ve nabızda %20-25'ten fazla değişiklik yoktu.

Sonuç: KABGC'de sevofluran ve fentanil ile anestezi idamesi daha stabil hemodinami sağladı.

Anahtar kelimeler: Hemodinami, inhalasyon, intravenöz, kardiyovasküler anestezi

Introduction

Purpose of coronary artery bypass graft surgery (CABGS) anesthesia is to provide hemodynamic stability in patients who do not have sufficient cardiac reserve (1). Coronary artery disease patients with limited cardiac reserves are highly sensitive to the factors that increase myocardial oxygen demand such as blood pressure increase, myocardial contractility, and systemic and pulmonary vascular resistance. These patients are also more vulnerable in events that reduce coronary perfusion, such as hypotension. These factors lead to increase in current ischemia with an increase in the incidence of perioperative myocardial infarction (MI) (2). Therefore, the selection of anesthetic agents is very important in anesthetic induction and maintenance.

There is no accepted technique for CABGS anesthesia. Preferred drug combinations and maintenance of drug infusions may vary depending on the pathophysiological condition of the patient and the personal experience and preference of the anesthesiologist (3,4). Although there are many studies on CABGS anesthesia induction, studies on anesthetic maintenance seem to be insufficient (2-4).

In our study, we compared the hemodynamic effects of different anesthesia maintenance methods from the records of patients who underwent anesthesia induction with the combination of opioids and benzodiazepines. Our aim is to determine the most stable hemodynamic anesthetic method during CABGS and to share its advantages over other methods with the readers.

Materials and Methods

As of the approval of the Ethics Committee (59491012-604.01.02), retrospectively 108 patients in the ASA II-III group, who underwent elective CABGS between September 2018 and September 2020, were included in our study. Exclusion criteria were recorded as emergency surgery, history of drug allergy, body mass index (BMI) >30 kg/m², presence of unregulated hypotension or hypertension, ejection fraction <25%, preoperative intraaortic balloon pump requirement, history of neurological or psychiatric disease, peripheral vascular disease, hepatic or renal dysfunction, presence of uncontrolled arrhythmia and heart valve surgery in addition to CABGS. The records of re-operation and development of serious postoperative complications (cardiac arrest, pulmonary embolism, pneumonia, sepsis, septic shock, need for postoperative intraaortic balloon pump, postoperative cerebral embolism) were determined as exclusion criteria as well.

Anesthesia procedure: Thirty minutes before starting the surgery, 1 mg of intravenous midazolam was administered each patient. Five-channel electrocardiography, peripheral oxygen saturation (SpO_2), and invasive arterial blood pressure monitoring were performed. Before anesthesia induction, preoxygenation was performed with 100% oxygen for 3 minutes. Standard anesthesia induction was applied to all patients with midazolam 0.2 mg/kg, fentanyl 10 mcg/kg, and rocuronium 1 mg/kg. A central venous catheter was placed in the right internal jugular vein. A probe was placed in the esophagus for body temperature measurement. Anesthetic maintenance was provided with 1-3% sevoflurane and fentanyl 4 mcg/kg/hour infusion in group I, with propofol 1.5-4 mg/kg/hour and fentanyl 4 mcg/kg/hour infusion in group II, and with propofol 1.5-4 mg/kg/hour and remifentanil 0.03 mg/kg/hour in group III. All patients have routinely received rocuronium 10 mg/hour infusion. No inhalation anesthesia had been used in the patients in group II and III. Three hundred ml colloid was infused when the mean arterial pressure (MAP) fell below 70 mmHg and central venous pressure (CVP) was less than 12 mmHg in the pre-cardiopulmonary bypass (CPB) period. When the cause of hypotension did not require fluid infusion, dopamine infusion (3-8 mcq/kg/min) was started. Moderate hypothermia (28-32 °C) was applied to the patients during CPB. MAP was stabilized between 50 and 80 mmHg using vasopressors (norepinephrine) or vasodilators (nitroglycerin). The doses of anesthetic drugs were reduced in all groups during CBP (sevoflurane 1%, propofol 2 mg/kg/h, fentanyl 3 mcg/kg/hour, remifentanil 0.03 mg/kg/hour). The previous doses were resumed when the patient warmed up. In addition, intravenous dormicum 3 mg was administered to all patients during warming up. Inotropic support was provided so that the MAP was 70 mmHg at the weaning of CPB. Arterial blood gas analysis was evaluated at thirty-minute intervals during the operation. At the end of the operation, the patients were transferred to the intensive care unit (ICU).

Outcome measures: The demographic data of the patients (age, gender, BMI), the number of coronary bypasses, the duration of the cross-clamp period, the duration of CPB, the duration of the operation, the total amount of fluid administered during the surgery, bleeding, transfusion of blood and products, the CVP value at the beginning and the end of the operation and lactate levels in arterial blood gas were recorded. T0 (after induction of anesthesia), T1 (after sternotomy), T2 (after pericardiotomy), T3 (5^{th} minute after CPB), T4 (after thorax closure), and T5 (at the end of the operation) were six moments that systolic blood pressure (SBP), diastolic blood pressure (DBP), MAP, heart rate (HR) were recorded. The need for vasodilators before CBP and the number of inotropic agents used after CPB were recorded as well.

Statistical Analysis

SPSS v21.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Normality was assessed by using the Shapiro-Wilk test and descriptive statistics. Continuous variables were presented as mean ± standard deviation or median (minimum-maximum), and categorical variables were presented as frequency and percentage. The chi-square test or Fisher Exact test was used to analyze categorical variables. Comparison of continuous variables was performed by using one-way Mann-Whitney U test or Kruskal-Wallis test, where appropriate. A p-value <0.05 was accepted for statistical significance.

Results

Data of 108 patients (88 men/20 women) were analyzed. Demographic characteristics of the patients were similar in all three groups. There was no statistical difference between the groups in terms of number of CABG, cross clamp duration, total fluid, total blood transfusion, total urine volume, inotropic agent requirement after CPB, CVP after operation, lactate before and after operation and increase in lactate. The mean operative duration of group I, II, and III were 6±1, 6±1 and 5±1, respectively. The mean operation duration of group I was significantly lower than that of the other groups (p=0.001). The CPB duration was also significantly lower in group III (p=0.001). The mean total blood loss of group III was 1.293±475 and significantly more than the other groups (p<0.001). Inotropic requirement before CPB was different among groups (p=0.021). Increase in CVP was higher (32%±42%) in group II (p=0.008) (Table 1).

The systolic arterial pressure, diastolic arterial pressure, MAP and HR of the groups were compared every mentioned moment (T0-T5). The HR of group III was lower than that of group II in T4 and both groups in T5 (p=0.013, p<0.001, respectively). SBP was different at all times except T4 (p=0.221). SBP of group III was higher than group II in T0 and T2 and both groups in T3 but lower than group I in T5 (p=0.003, p=0.011, p=0.030, respectively). SBP in T1 was significant but there was no statistical significance in pair wise comparisons. DBP was different in T3-T5 among groups. DBP of group II was lower than that of group III in T3 and both groups in T4 and T5 (p=0.015, p=0.003, p<0.001, respectively). The MAP was different at all times except T1 and T2. MAP of group III was higher than that of group II in T0 and T3 (p=0.024, p=0.006, respectively). MAP of group II was lower than that of group I in T4 and both groups in T5 (p=0.031, p=0.009, respectively) (Table 2).

Discussion

There is no universally accepted anesthetic method for cardiac surgery, and differences can be observed even among doctors in the same clinic (1). Anesthetic management is preferred according to the degree of ventricular dysfunction, accompanying diseases and physiological and pharmacological effects of drugs on the particular patient (2,3). In every stage of cardiac surgery, the depth of anesthesia should be adjusted according to the level of surgical stress. At the same time, systemic hypotension should be prevented, adequate intravascular volume should be provided, the continuity of sinus rhythm and the protection of myocardial oxygen demand balance should be aimed (4). Recent literature has referred that inhalational anesthesia technique might be associated with lower mortality (5). The American College of Cardiology/American Heart Association Guidelines recommends that inhalational anesthesia is superior than Total Intra Venous Anesthesia (TIVA) in CABGS (6).

In this study, nitroglycerin requirement before CBP was more in group III than the others. Nitroglycerin improves coronary arterial blood flow intraoperatively (7) and its use for prophylaxis is very common in high risk patients to reduce the incidence of perioperative MI (8). On the other hand, there is no evidence from randomized controlled trials (RCTs) (9). Before CBP, the mean MAP values were higher in group III than the others. Remifentanil reduces blood pressure and provides stable hemodynamics, it is used in combination with propofol in cardiac surgery (10); however, these effects are dose-depended (11). The first limitation of our study was not able to *monitorize* the depth of anesthesia with bispectral index (BIS). Our findings may be related to *inadequate level of anesthesia* in group III. Conversely, Lehmann et al. (12) declared that the different levels of BIS values had no influence on hemodynamics or the need of catecholamines in the pre-CPB period. Yet, MAP was also higher in group III than in group II. Kapoor et al. (13) also reported that their patients in the TIVA group

Table 1. Demographic data and clinical parameters of the groups

	Group I (n=35)	Group II (n=36)	Group III (n=37)	p
Age (years)	63 (39-82)	60 (40-72)	60 (38-81)	0.334[a]
Gender (male)	28 (80)	33 (92)	27 (73)	0.116[b]
Weight (kg)	79±10	80±15	78±11	0.777[c]
Height (cm)	167±7	170±7	168±7	0.495[c]
BMI (kg/m²)	27.8±4.1	27.4±3.9	27.6±4	0.948[c]
Number of CABG	3±1	3±1	3±1	0.153[a]
Duration of operation (hour)	6±1	6±1	5±1	0.001[a,III]
Cross clamp duration (min)	80±27	81±27	69±21	0.088[a]
CPB duration (min)	118±35	116±30	94±24	0.001[c,III]
Total fluid (mL)	2.176±603	2097±591	1.939±360	0.135[a]
Total blood transfusion (mL)	891±397	765±249	895±347	0.326[a]
Total blood loss (mL)	771±258	712±402	1.293±475	<0.001[a,III]
Total urine volume (mL)	1.448±495	1.550±567	1.305±621	0.083[a]
Vasodilatator agent requirement before CPB				0.021[d]
No requirement	17 (49)	17 (47)	10 (27)	-
Nitroglycerin	15 (43)	19 (53)	27 (73)	-
Inotropic agent requirement after CPB				0.943[d]
No requirement	4 (11)	6 (17)	7 (19)	-
1 (dopamine)	25 (71)	25 (69)	24 (65)	-
2 (dopamine + adrenaline)	6 (17)	5 (14)	5 (14)	-
3 (dopamine + adrenaline + dobutamine)	0	0	1 (3)	-
CVP before CPB (mmHg)	11±3.7	9±3.3	11±3.5	0.041[a,Φ]
CVP after CPB (mmHg)	11±1.9	11±2.2	11±1.5	0.740[c]
Increase in CVP (%)	11±39	32±42	7±31	0.008[c,II]
Lactate before operation	1.2±0.5	1.1±0.5	1±0.4	0.212[c]
Lactate after operation	2.8±1.8	2.6±1.5	2.1±1	0.203[c]
Increase in lactate (%)	147±123	149±142	123±86	0.882[c]

BMI: Body mass index, CABG: Coronary artery bypass graft, CPB: Cardiopulmonary bypass, CVP: Central venous pressure, [a]: One-Way ANOVA test, [b]: Chi-square test, [c]: Kruskal-Wallis test, [d]: Fisher's Exact test, [Φ]: No statistical significance in pairwise comparisons, [II]: P-value is significantly difference in group II, [III]: P-value is significantly difference in group III

Table 2. Blood pressure and HR data of the patients

	T0	T1	T2	T3	T4	T5
SAP (mmHg)						
Group I	123±19	133±17	108±14	101±21	110±13	107±10
Group II	119±19	125±15	105±11	105±12	105±10	102±7
Group III	133±17	124±17	114±14	114±15	106±17	99±13
P-value	0.003[a,I-III]	0.031[ϕ]	0.011[II-III]	0.001[III]	0.221	0.030[I-III]
DAP (mmHg)						
Group I	67±12	71±13	64±9	58±7	60±7	57±7
Group II	64±14	72±12	64±12	56±8	55±7	53±5
Group III	69±9	67±10	66±10	60±8	62±13	60±8
P-value	0.098	0.228[a]	0.520	0.015[II-III]	0.003[II]	<0.001[II]
MAP (mmHg)						
Group I	86±14	92±13	79±10	73±9	77±8	74±7
Group II	82±15	90±12	78±11	72±8	72±6	69±4
Group III	90±10	86±10	82±9	78±9	77±11	73±8
P-value	0.024[a,II-III]	0.141	0.155[a]	0.006[II-III]	0.031[I-II]	0.009[II]
HR (bpm)						
Group I	80±15	78±12	75±9	88±14	90±11	90±10
Group II	76±13	78±13	76±14	89±11	93±10	94±9
Group III	77±13	75±12	74±10	85±11	85±15	81±13
P-value	0.602	0.478[a]	0.638[a]	0.239	0.013[II-III]	<0.001[III]

SAP: Systolic arterial pressure, DAP: Diastolic arterial pressure, MAP: Mean arterial pressure, HR: Heart rate, [a]: One-Way ANOVA test, ϕ:No statistical significance in pairwise comparisons, [II]: P-value is significantly difference in group II, [III]: P-value is significantly difference in group III

had higher MAPs on weaning off CPB and lower inotropic support.

MAP was lower in group II than in group I. The reason for the low MAP values especially after CBP in our patients who underwent TIVA with propofol and fentanyl, in intravascular volume loss of propofol, it may be secondary to venodilation with dose-dependent hypotension effect (14,15). Hypotension associated with propofol is also related to the increase in systemic vascular resistance. 2 mg/kg propofol administered into the venous line during CPB reduces SVR. In addition, propofol increases arterial compliance and decreases afterload (16).

While shorter durations were found with remifentanil in early extubation studies, it was also observed that it might cause bradycardia. In CABGS with remifentanil, the hemodynamic response to skin incision and sternotomy occurs with lower HRs (17). Even though remifentanil is used instead of fentanyl during perioperative period, some authors argue that it may not be suitable for hemodynamically unstable patients (18).

Although we did not have the power to detect a serious hemodynamic difference due to the low number of patients in the groups, which is one of the other limitations of our study, we observed that more stable hemodynamics were achieved in patients who used sevoflurane and fentanyl, among the three different methods we used in CABGS, for anesthesia maintenance, especially in the post-CPB period. However, we found that the other two groups did not have serious negative effects on hemodynamics. It is observed that hemodynamic stability does not change more than 20-25% in MAP and HR (19). In classical literature knowledge, inhalational anesthesia was better than intravenous anesthesia in the CABG (20-22). Straarup et al. (23) declared that inhalational anesthesia should be the first option comparing TIVA in CABGS. Ren et al. (24) meta-analyzed that TIVA and inhalational anesthesia had similar results on cardioprotection, renal injury, complications (pulmonary, neurological, postoperative bleeding, mechanical ventilation support), ICU and hospital stay and mortality. Moreover, inhalational agents have a cerebral vasodilatory effect, and as sevoflurane is a cerebroprotective during

CBP. It decreases cerebral metabolic rate (25). Inhalational anesthetics also induce myocardial protection from ischemia reperfusion injury (26).

Conclusion

The use of sevoflurane inhalation and fentanyl infusion was superior to TIVA for CABGS anesthesia maintenance in our study. For clarifying this issue, further high-quality large RCTs are still needed.

Ethics

Ethics Committee Approval: As of the approval of the Ethics Committee (59491012-604.01.02), retrospectively 108 patients in the ASA II-III group, who underwent elective CABGS between September 2018 and September 2020, were included in our study.

Informed Consent: Retrospective study.

Authorship Contributions

Concept: H.Y.A., K.E., Design: H.Y.A., K.E., Data Collection or Processing: Y.Ö., M.A.Y., Analysis or Interpretation: H.Y.A., M.Y., Literature Search: H.Y.A., İ.H., Writing: H.Y.A., K.E.

Conflict of Interest: No conflict of interest was declared by the authors.

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