



The Effect of Magnesium Infusion in Postoperative Analgesia in Coronary Artery Bypass Graft Surgery

Şahin Yılmaz, Şefika Türkan Kudsioğlu

Department of Anesthesiology and Reanimation, Ministry of Health, Dr. Siyami Ersek Cardiovascular and Thoracic Surgery Center Training and Research Hospital, İstanbul, Türkiye

ABSTRACT

Objectives: It has been shown that patients who have undergone noncardiac surgery experience decreased postoperative pain when given magnesium sulfate (MgSO₄). In this study, we aimed to investigate the effects of MgSO₄ infusion on postoperative pain in coronary artery bypass graft (CABG) surgery.

Methods: After approval from the Ethics Committee and obtaining informed consent, 100 patients undergoing elective CABG, classified as ASA-III and having a preoperative EF above 40%, were selected. The patients were prospectively randomized to group I (n=50), which received MgSO₄ (15 mg⁻¹kg⁻¹h⁻¹), and group II (control) (n=50). Both groups received morphine infusion (0.07 mg⁻¹kg⁻¹h⁻¹) postoperatively via PCA. To evaluate analgesia, pain scores were assessed using VAS immediately after extubation and at 2, 6, and 12 hours. Simultaneously, the number of requests made to the PCA device, the number of requests met, and the total morphine dose were determined and recorded. In the statistical analysis (SPSS), differences between groups were evaluated using Student's t test and two-way analysis of variance (p<0.05). The results were expressed as mean value±standard deviation.

Results: VAS scores at the 6th and 12th hours after extubation were lower in the magnesium group compared with the control group (p<0.05). The total morphine amount and frequency of PCA use were lower in the magnesium group than in the control group. However, these differences were not statistically significant.

Conclusion: We suggest that magnesium therapy for postoperative analgesia could be a useful option in CABG surgery.

Keywords: Coronary artery bypass graft surgery, magnesium sulfate, postoperative analgesia

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Introduction

Postoperative pain is an important clinical issue in cardiac surgery, as inadequate analgesia may lead to increased sympathetic activation, hemodynamic instability, impaired pulmonary function, and delayed recovery. Therefore, effective pain management is essential to support optimal outcomes in this high-risk population.^[1] Opioids are commonly used for postoperative analgesia in cardiac surgery. However, they are less preferred due to side effects such as nausea and vomiting and the potential to prolong the stay in the intensive care unit.^[2] The implementation

of Enhanced Recovery After Surgery (ERAS) protocols has encouraged the use of multimodal analgesic strategies incorporating non-opioid agents to optimize postoperative pain control while reducing opioid-related adverse effects.^[1] Among these, magnesium sulfate (MgSO₄) is used to reduce opioid requirements as an analgesic. Moreover, MgSO₄ has effects as a neuromuscular relaxant, antiarrhythmic, vasodilator, and postoperative anti-shivering agent.^[3,4] Magnesium infusion during coronary artery bypass grafting (CABG) surgery has been studied for its potential benefits in postoperative pain management. ^[1] Magnesium is an NMDA receptor antagonist that can

Address for correspondence: Şahin Yılmaz, MD. Sağlık Bakanlığı, Dr. Siyami Ersek Kalp ve Göğüs Cerrahisi Eğitim ve Araştırma Hastanesi, Anesteziyoloji ve Reanimasyon Kliniği, İstanbul, Türkiye

Phone: +90 532 221 64 99 **E-mail:** drsahinyilmaz@gmail.com

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block catecholamine release by acting on both adrenergic nerve terminals and the adrenal gland. Additionally, $MgSO_4$ activates Ca-ATPase and Na-K-ATPase by causing calcium inhibition in the cell membrane and cytoplasm.^[5]

Magnesium contributes to hemodynamic stability while reducing pain intensity and opioid requirements, and by lowering the risk of postoperative complications such as tachycardia, it may further enhance overall postoperative recovery.^[1,6] In addition, hypomagnesemia is a common condition, especially in cardiac patients, due to diuretic use and nutritional habits. However, it is often overlooked during the treatment phase because blood level measurements do not reflect the actual magnesium level in the body and there is no established protocol for magnesium replacement in these patients. Hypomagnesemia can also cause serious problems in the early postoperative period after CABG; low serum magnesium levels have been observed in most patients who developed atrial fibrillation and arrhythmias. In studies conducted on its application after acute myocardial infarction, a decrease in mortality due to early arrhythmias and a significant decrease in the frequency of left ventricular failure have been observed clinically and echocardiographically.^[6] It has been shown that patients who have undergone noncardiac surgery had decreased postoperative pain scores and required less opioid treatment when given magnesium infusion. In this study, we aimed to investigate the effects of $MgSO_4$ infusion on postoperative pain in coronary artery bypass graft (CABG) surgery.

Methods

Study Design and Patient Selection

This prospective study was conducted at the Department of Anesthesiology and Reanimation, Ministry of Health University Dr. Siyami Ersek Cardiovascular and Thoracic Surgery Center Training and Research Hospital. After obtaining approval from the Institutional Ethics Committee (approval number: 112; date: 15.03.2020) and written informed consent, 100 patients scheduled for coronary

artery bypass surgery (CABG) were included in this study. The study adhered to the ethical principles outlined in the Declaration of Helsinki.

Patient inclusion criteria were defined as ASA physical status III and a preoperative left ventricular ejection fraction greater than 40%. Patients were randomly allocated into two equal groups: Group I (Magnesium Group, n=50), which received intravenous magnesium sulfate ($MgSO_4$), and Group II (Control Group, n=50).

Anesthesia and Surgical Protocol

Standardized anesthesia and cardiopulmonary bypass (CPB) protocols were applied to all patients. Prior to surgery, all participants received detailed instructions regarding the use of the patient-controlled analgesia (PCA) device. Anesthesia induction was performed with fentanyl $15\text{ mg}\cdot\text{kg}^{-1}$, propofol $2\text{ mg}\cdot\text{kg}^{-1}$, and rocuronium. Maintenance was achieved using a continuous infusion of fentanyl $6\text{ mg}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$, propofol $2\text{ mg}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$, and sevoflurane (1–2% MAC). During CPB, perfusion pressure was maintained between 65 and 80 mmHg, and arterial blood gas parameters were kept within physiological limits. Moderate hypothermia was implemented for myocardial protection.

Intervention and Analgesia Management

Group I received a continuous IV infusion of $MgSO_4$ ($15\text{ mg}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$) initiated at anesthesia induction and continued throughout the postoperative period. Both groups received morphine infusion ($0.07\text{ mg}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$) postoperatively via PCA. The PCA device was programmed with a $0.005\text{ mg}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$ demand bolus and a 10 min lockout time.

Data Collection

Patient characteristics and hemodynamic parameters were recorded at the following time intervals: before induction, after intubation, before CPB, at the 5th minute of CPB, after aortic cross-clamping, at the 10th minute post-bypass, at the 2nd and 4th postoperative hours, and before and after extubation (Tables 1-3). Pain scores were evaluated using

Table 1. Demographic data

Parameters	Group I (Magnesium) (n=50)	Group II (Control) (n=50)
Age (years)	54.6±8.1	53.6±9.1
Gender (female/male) (n)	3/22	4/21
Preoperative EF (%)	51.7±2.09	49.7±2.2
Number of grafts (1/2/3/4) (n)	0/10/7/8	0/9/10/6
Operation time (min)	242.1±45	280±60.3
CPB time (min)	84.9±23.5	92.4±25.1
Aortic cross-clamping time (min)	51.6±23.2	53.2± 15.3
Extubation time (min)	481.8±182.8	480±144.1

Mean±SD, p>0.05. EF: Ejection fraction; min: minute; CPB: Cardiopulmonary bypass; SD: Standard deviation.

Table 2. Hemodynamic parameters of magnesium group

Time interval	HR (beat/min)	MAP (mmHg)	CVP (mmHg)	PAP (mmHg)	PCWP (mmHg)
Before induction	74.1±14.4	96.6±17.8			
After intubation	70±11.9	77.1±12.1	5.4±3.7	20.9±5.1	7.2±3.7
Before CPB	81.4±14.9	83.5±12	6.6±3.7	21.5±3.6	8.3±3.3
5 th min CPB		56.1±12.6	6.5±3.9		
After CC	96.6±21.1	68.5±10.6	5.8±3.8		
After CPB	91.9±11.4	75.6±9.1	7.4±2.1	26.6±4.7	9.9±1.7
10 nd min postop	88.9±19.3	84.9±13.1	4.8±1.7	25.4±4.1	6.5±1.7
2 nd hour postop	98.2±12.4	100.8±22.7	6.2±2.4	27.1±6.1	8.2±3.2
4 nd hour postop	102.3±12.6	95.6±21.8	6.1±3.7	27.7±8.1	8.4±2.9
Before extubation	97.6±14.8	89.4±14.6	5.8±2.4	26.6±7.1	8.2±2.7
After extubation	98.4±14.9	98.8±11.6	6.1±1.7	29±6.1	8.1±2.8

Mean±SD, p<0.05. HR: Heart rate; MAP: Mean arterial pressure; CVP: Central venous pressure; PAP: Pulmonary artery pressure; PCWP: Pulmonary capillary wedge pressure; CPB: Cardiopulmonary bypass; CC: Aortic cross-clamping; min: minute; postop: postoperative; SD: Standard deviation.

Table 3. Hemodynamic parameters of magnesium group

Time interval	Time interval	Time interval	Time interval	Time interval	Time interval
Before induction	73.9±17.4	101.6±21.8			
After intubation	70.5±14.9	81.1±9.1	6.6±3.4	23.7±6.7	10.2±3.7
Before CPB	77.4±17.9	88.5±10.6	7.1±3.2	25.8±11	9.3±3.3
5 th min CPB		56.1±12.6	7.4±3.3		
After CC	80.6±17.1	66.5±11.6	5.9±3.3		
After CPB	87.7±14.4	65.6±9.1	9.1±2.4	29±5.4	12.9±1.7
10 nd min postop	87.9±19.3	72.9±8.1	4.5±2.7	22.2±3.1	6.2±1.9
2 nd hour postop	93.2±18.4	85.8±12.7	5.2±2.2	25.5±3.3	6.2±3.4
4 nd hour postop	96.3±16.6	92.1±15.8	6.5±2.7	26.4±3.4	7.4±2.6
Before extubation	96.6±14.8	91.8±15.1	7.2±2.2	28.6±5.9	8.9±2.8
After extubation	100.4±14.9	90.8±11.6	6.8±2.7	29±4.8	9.1±2.9

Mean±SD, p<0.05. CPB: Cardiopulmonary bypass; CC: Aortic cross-clamping.

the Visual Analog Scale (VAS) immediately following extubation and at the 2nd, 6th, and 12th postoperative hours (Table 4). Simultaneously, the number of requests made from the PCA device, the number of requests met, and the total morphine dose were determined and recorded during the same time intervals (Table 5).

Statistical Analysis

Statistical analysis was performed using SPSS software. Differences between groups were evaluated using Student's t test and two-way analysis of variance (p<0.05). The results were expressed as mean value±standard deviation.

Results

Patients in both groups did not differ in terms of age, EF, sex, operation duration, number of grafts, CPB time, cross-clamping time, and extubation time; p>0.05. The mean age in the magnesium group was 54.6±8.1 years, while the mean age in the control group was 53.8±9.1 years.

Table 4. VAS values

	Extubation	2 nd hour	6 nd hour	12 nd hour
Group I (Magnesium)	2.5±2.2	2.5±2.6	1.5±2.1*	0.7±1.3*
Group II (Control)	3.4±3.4	3.3±2.7	4.5±3.2	3.4±2.9

Mean±SD, *: p<0.05. VAS: Visual analog scale.

The mean EF in the magnesium group was 51.76±2.09%, whereas in the control group the mean EF was 49.7±2.2%. The mean times for surgery, CPB, cross-clamping, and extubation were 242.1±45, 84.9±23.5, 51.6±23.2, and 481.8±182.8 minutes, respectively, in the magnesium group. In the control group, these values were 280±60.3, 92.4±25.1, 53.2±15.3, and 480±144.1 minutes, respectively. These data showed no statistically significant differences, p>0.05 (Table 1). No statistically significant differences were found in hemodynamic data in either the magnesium or control group, p>0.05 (Tables 2, 3).

Table 5. PCA usage and total morphine consumption

Parameter	Group(I/II)	Extubation	2 nd hour	6 nd hour	12 nd hour
Number of request s(n)	Magnesium	1.1±2.5	4±8.2	7±15.3	8.5±18.2
	Control	2.6±5.2	8.9±15	15.6±21.5	27.4±35.7
Requests fulfilled (n)	Magnesium	0.5±0.8	1±1.7	2.4±4.5	3.3±6.3
	Control	0.6±0.8	2.1±2.7	5.2±6.9	7.8±11.4
Total morphine dose (mg)	Magnesium	4.2±1.4	5.4±1.3	7.7±1.4	11.1±2
	Control	5.5±3.1	7.8±4.3	12.1±7	18±9.5

Mean±SD, p<0.05 Bottom of Form. PCA: Patient-controlled analgesia; SD: Standard deviation.

Visual Analog Scale (VAS) scores at the 2nd, 6th, and 12th hours after extubation were lower in the magnesium group compared with the control group, p<0.05 (Table 4). The total morphine amount and the frequency of PCA use were lower in the magnesium group than in the control group. However, these differences were not statistically significant (Table 5).

Discussion

In cardiac surgery, effective postoperative pain management is crucial to prevent sympathetic activation and ensure rapid recovery. Postoperative pain control ensures the stability of hemodynamic and pulmonary functions.^[1]

Opioids are commonly used for postoperative pain control after cardiac surgery. However, their association with side effects, such as respiratory depression and systemic complications, can lead to increased mechanical ventilation and prolonged ICU stays.^[2] Therefore, non-opioid pain management strategies have begun to be implemented. Among these, NSAIDs are frequently employed to reduce morphine requirements and opioid-related emesis, and acetaminophen is utilized for its central analgesic effects, although its efficacy as a monotherapy remains a subject of debate.^[7] Furthermore, alpha-2 agonists such as dexmedetomidine and clonidine have gained prominence for their ability to provide sedation without respiratory depression while attenuating opioid-induced hyperalgesia.^[8] Additionally, local anesthetics used in regional techniques and gabapentin are increasingly incorporated to target neuropathic components of post-sternotomy pain.^[9] In recent studies, magnesium sulfate has served as a crucial adjunct in this multimodal approach and has been demonstrated to decrease postoperative analgesic consumption and associated adverse effects.^[10,11]

In this study, we investigated the impact of perioperative and postoperative intravenous magnesium sulfate infusion on postoperative pain management and hemodynamic stability in patients undergoing CABG.

In previous studies, a loading dose of 30–50 mg·kg⁻¹ followed by a continuous intravenous infusion of approximately 15 mg·kg⁻¹·h⁻¹ has been most commonly

used for postoperative analgesia, and this regimen has been reported to reduce postoperative opioid consumption and pain scores within the first 24 hours.^[12]

In the postoperative period, alpha-2 agonists such as dexmedetomidine and clonidine have been shown to be effective in reducing 24 hour postoperative pain scores in patients undergoing CABG.^[8] However, despite this reduction in pain scores, a significant decrease in opioid consumption has not always been observed. The efficacy of alpha-2 agonists is further enhanced through multimodal analgesia strategies, such as the combination of ketamine and clonidine.^[1,8]

Conclusion

Our findings demonstrate that MgSO₄ administration reduces postoperative opioid consumption and improves analgesic quality, supporting its role as a key component of multimodal analgesia in cardiac surgery. In addition to effective analgesia, our study highlights the role of this agent in maintaining hemodynamic stability throughout the early postoperative period.

This study concluded that magnesium therapy is a highly effective, non-opioid adjunctive treatment that significantly improves postoperative 24-hour pain scores while maintaining hemodynamic stability in patients undergoing coronary artery bypass graft surgery (CABG).

Disclosures

Ethics Committee Approval: The study was approved by the Ministry of Health University Dr. Siyami Ersek Cardiovascular and Thoracic Surgery Center Training and Research Hospital Ethics Committee (no: 112, date: 15/03/2020).

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

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