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Original Research Article

Effects of Perioperative Intravenous Magnesium Sulphate Infusion on Prevention of Myocardial Injury and Arrhythmia in Patients Undergoing Off-Pump Coronary Artery Bypass Surgery: A Prospective Placebo Controlled Study

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Conflict of interest: Nil

Abstract

Introduction: Perioperative myocardial injury and cardiac arrhythmias remain common complications in patients undergoing off-pump coronary artery bypass (OPCAB) surgery despite avoidance of cardiopulmonary bypass. Magnesium sulphate has known anti-arrhythmic and cardioprotective properties, but its role in preventing myocardial injury and arrhythmias in OPCAB surgery remains inadequately defined.

Aim: To evaluate the effect of perioperative intravenous magnesium sulphate infusion on the prevention of myocardial injury and cardiac arrhythmias in patients undergoing off-pump coronary artery bypass surgery.

Materials and Methods: This prospective, randomized, placebo-controlled, double-blind clinical trial was conducted over a period of one year in the Department of Cardiac Anesthesia at NH- Rabindranath Tagore International Institute of Cardiac Sciences, Kolkata. Ethical permission was issued from RN Tagore. The study included 100 adult patients aged 18–75 years of either gender who were scheduled to undergo elective off-pump coronary artery bypass surgery. Patients were divided to two groups to receive either intravenous magnesium sulphate infusion 2gm intraoperative and 1gm each twice post-operatively at 6hours and 12hours post cabg. Placebo group received Normal saline at same time interval.

Results: In our study, baseline demographics and cardiac characteristics were comparable between groups. Mean age was 62.4 ± 8.1 vs 61.7 ± 7.9 years (p = 0.650), BMI 26.8 ± 3.2 vs 27.1 ± 3.5 kg/m² (p = 0.720), and LVEF 55 ± 6% vs 54 ± 7% (p = 0.450). Male patients were 72% vs 68% (p = 0.680), hypertension 56% vs 60% (p = 0.680), diabetes 44% vs 48% (p = 0.690), and smokers 40% vs 36% (p = 0.670). Heart rates (Baseline, Post-protamine, Post-operative at 24 hours) were 73 ± 10, 78 ± 8, 85 ± 7 vs 76 ± 10, 80 ± 9, 90 ± 8 bpm Differences at baseline and post-protamine were not significant (p = 0.24, 0.45), but at 24 hours the Magnesium group had a significantly lower heart rate (p = 0.02); MAP differences were non-significant (p = 0.41, 0.97, 0.97). Postoperative myocardial injury was significantly less in Magnesium treated group over control as judged by TropI (1.2 ± 0.5 vs 2.1±0.8 ng/ml, p=0.001), CKMB (18±6 vs. 28±10 U/L, p=0.002 and BNP (120±40 vs 160±50, p=0.005).Postoperative cardiac arrhythmia was also significantly less in magnesium treated patients over control group like atrial fibrillation (8% vs 24%, p 0.03 and ventricular tachycardia (2% vs 10 %, p=0.09), need for antiarrhythmic drugs (12% vs 30%, p=0.03).

Conclusion: Perioperative intravenous magnesium sulphate infusion appears to be an effective and safe strategy for reducing myocardial injury and preventing cardiac arrhythmias in patients undergoing off-pump coronary artery bypass surgery. Its routine use may contribute to improved perioperative cardiac outcomes in this patient population. Magnesium modestly reduced postoperative heart rate at 24 hours without affecting blood pressure, indicating a mild cardioprotective effect

Keywords: Magnesium Sulphate; Off-Pump Coronary Artery Bypass; Myocardial Injury; Arrhythmia; Atrial Fibrillation.

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Introduction

Coronary artery bypass grafting (CABG) remains one of the most effective surgical strategies for the treatment of advanced coronary artery disease. Off-pump coronary artery bypass (OPCAB) surgery, performed on the beating heart without cardiopulmonary bypass, has gained popularity due to reduced systemic inflammatory response, decreased need for blood transfusion, and lower incidence of neurological and renal complications compared to on-pump CABG [1,2]. However, despite these advantages, perioperative myocardial injury and cardiac arrhythmias continue to be significant contributors to postoperative morbidity following OPCAB surgery [3]. Perioperative myocardial injury, commonly detected using sensitive biomarkers such as cardiac troponins, is associated with adverse short- and long-term outcomes including myocardial infarction, prolonged intensive care unit stay, and increased mortality [4,5]. In addition, arrhythmias—particularly atrial fibrillation—occur in 20–40% of patients undergoing CABG and are associated with hemodynamic instability, thromboembolic events, and extended hospitalization [6,7]. Multiple factors including electrolyte imbalance, surgical manipulation, ischemia-reperfusion injury, and sympathetic stimulation play a role in the development of these complications [8].

Magnesium is an essential intracellular cation involved in myocardial energy metabolism, regulation of ion channels, and stabilization of myocardial cell membranes. Hypomagnesemia is frequently observed during cardiac surgery due to hemodilution, catecholamine release, and increased urinary loss, and has been linked to myocardial ischemia and arrhythmogenesis [9, 10]. Magnesium sulphate possesses anti-ischemic, anti-arrhythmic, and calcium-antagonistic properties, making it a potentially beneficial agent in the perioperative cardiac surgical setting. The aim of this study is to evaluate the effect of perioperative intravenous magnesium sulphate infusion on myocardial protection and cardiac rhythm stability in patients undergoing off-pump coronary artery bypass surgery. The primary objective is to assess the role of magnesium sulphate in reducing perioperative myocardial injury as measured by cardiac biomarkers, particularly serum troponin levels. The secondary objectives are to determine its effectiveness in preventing perioperative atrial and ventricular arrhythmias, to compare the incidence of arrhythmias between the magnesium and placebo groups, and to evaluate its impact on relevant postoperative outcomes such as hemodynamic stability and need for anti-arrhythmic interventions.

Materials and Methods

Study design: This study was designed as a prospective, randomized, placebo-controlled, double-blind clinical trial

Study duration: 1 year

Study place: Department of Cardiac Anesthesia, NH- Rabindranath Tagore International Institute of Cardiac Sciences, Kolkata

Study population: The study population comprised adult patients aged 18–75 years of either gender, scheduled to undergo elective off-pump coronary artery bypass (OPCAB) surgery at a tertiary care cardiac center during the study period. All eligible patients fulfilling the inclusion criteria and providing informed written consent were enrolled and randomly allocated to either the magnesium sulphate group or the placebo group. Magnesium group received intravenous Magnesium sulphate infusion 2gm in 50ml syringe pump over 3 hours after induction of anaesthesia, subsequently 1gm each twice at 6 hours and 12 hours post cabg over 30 minutes while Placebo group received normal saline infusion over same time interval.

Sample size: 100 patients undergoing off-pump coronary artery bypass surgery.

Study variables

- Baseline Demographic Characteristics
- Perioperative Hemodynamic Parameters
- Postoperative Cardiac Biomarkers
- Postoperative Arrhythmias and Clinical Outcomes

Inclusion Criteria

- Adults aged 18–75 years of either gender.
- Scheduled for elective off-pump coronary artery bypass (OPCAB) surgery.
- Patients providing informed written consent.

Exclusion Criteria

- History of severe renal or hepatic dysfunction.
- Pre-existing significant arrhythmias or conduction abnormalities.
- Patients on chronic magnesium therapy or drugs affecting magnesium levels.
- Emergency surgery or hemodynamic instability preoperatively.
- Known hypersensitivity to magnesium sulphate.

Statistical analysis: Data from the study were analyzed using SPSS software. Continuous variables (e.g., age, laboratory values) were expressed as mean ± SD and compared using t-tests

or Mann–Whitney U tests, depending on the distribution. Categorical variables (e.g., gender, complications) were presented as frequencies and percentages, and compared using Chi-square or Fisher's exact tests as appropriate.

A p-value < 0.05 was considered statistically significant.

Result

Table 1: Baseline Demographic Characteristics (Continuous Variables)

Parameter	Magnesium Group (n=50)	Placebo Group (n=50)	p-value
Age (years)	62.4 ± 8.1	61.7 ± 7.9	0.65
BMI (kg/m²)	26.8 ± 3.2	27.1 ± 3.5	0.72
Left Ventricular Ejection Fraction (%)	55 ± 6	54 ± 7	0.45

Table 2: Baseline Demographic Characteristics (Categorical Variables)

Variable	Magnesium Group (n=50)	Placebo Group (n=50)	p-value
Male Gender (n, %)	36 (72%)	34 (68%)	0.68
Hypertension (n, %)	28 (56%)	30 (60%)	0.68
Diabetes Mellitus (n, %)	22 (44%)	24 (48%)	0.69
Smoking History (n, %)	20 (40%)	18 (36%)	0.67

Table 3: Perioperative Hemodynamic Parameters (Continuous Variables)

	Group	Baseline (Mean ± SD)	Post-protamine (Mean ± SD)	Post-operative at 24 hours (Mean ± SD)
Heart Rate (per minute)	Magnesium Group (n=50)	73 ± 10	78 ± 8	85 ± 7
	Placebo Group (n=50)	76 ± 10	80 ± 9	90 ± 8
	P-value	0.24	0.45	0.02
MAP (mmhg)	Magnesium Group (n=50)	85 ± 10	82 ± 9	80 ± 8
	Placebo Group (n=50)	86 ± 11	83 ± 10	81 ± 9
	P-value	0.41	0.97	0.97

Table 4: Postoperative Cardiac Biomarkers (Continuous Variables)

Parameter	Magnesium Group (n=50)	Placebo Group (n=50)	p-value
Troponin I (ng/mL)	1.2 ± 0.5	2.1 ± 0.8	0.001
CK-MB (U/L)	18 ± 6	28 ± 10	0.002
BNP (pg/mL)	120 ± 40	160 ± 50	0.005

Table 5: Postoperative Arrhythmias and Clinical Outcomes (Categorical Variables)

Outcome	Magnesium Group (n=50)	Placebo Group (n=50)	p-value
Atrial Fibrillation (n, %)	4 (8%)	12 (24%)	0.03
Ventricular Tachycardia (n, %)	1 (2%)	5 (10%)	0.09
Bradyarrhythmia (n, %)	2 (4%)	3 (6%)	0.64
Postoperative Myocardial Injury (n, %)	5 (10%)	14 (28%)	0.02
Need for Antiarrhythmic Drugs (n, %)	6 (12%)	15 (30%)	0.03
ICU Stay >48 hrs (n, %)	12 (24%)	20 (40%)	0.08

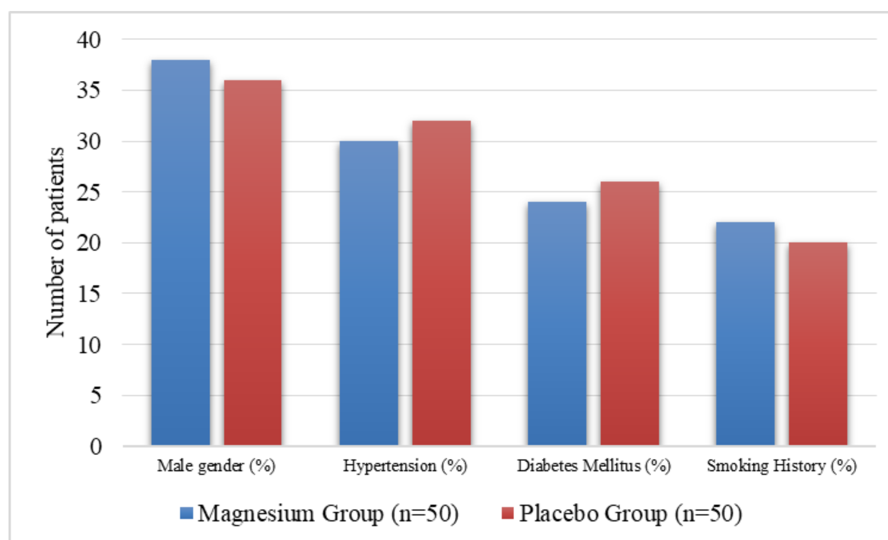

Figure 1: Baseline Demographic Characteristics (Categorical Variables)

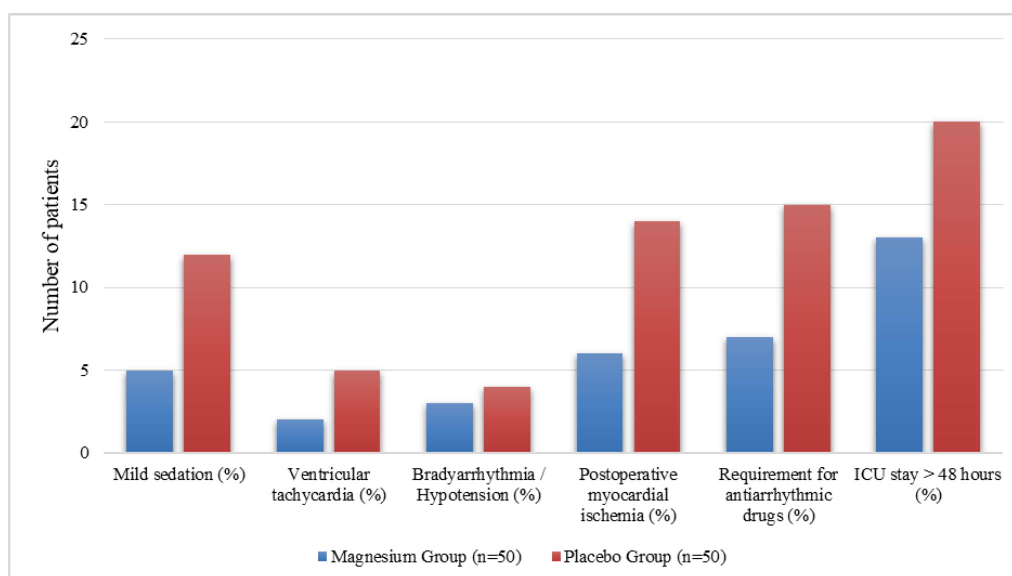

Figure 2: Postoperative Arrhythmias and Clinical Outcomes (Categorical Variables)

In our study, the baseline demographic and cardiac characteristics of patients in both groups were comparable. The mean age in the magnesium group was 62.400 ± 8.100 years, compared to 61.700 ± 7.900 years in the placebo group (p = 0.650, not significant). The mean body mass index (BMI) was 26.800 ± 3.200 kg/m² in the magnesium group and 27.100 ± 3.500 kg/m² in the placebo group (p = 0.720, not significant). The left ventricular ejection fraction was 55.000 ± 6.000% in the magnesium group and 54.000 ± 7.000% in the placebo group (p = 0.450, not significant).

In our study, the baseline categorical characteristics of patients in both groups. In the magnesium group, 36 patients (72%) were male compared to 34 patients (68%) in the placebo group (p = 0.680, not significant). Hypertension was present in 28 patients (56%) in the magnesium group and 30 patients (60%) in the placebo group (p = 0.680, not significant). Diabetes mellitus was observed in 22 patients (44%) versus 24 patients (48%) (p = 0.690, not significant), and a history of smoking was reported in 20 patients (40%) in the magnesium group compared to 18 patients (36%) in the placebo group (p = 0.670, not significant)

In our study, The Magnesium group had heart rates of 73 ± 10, 78 ± 8, and 85 ± 7 beats/min at baseline, post-protamine, and 24 hours postoperatively, respectively, while the Placebo group had 76 ± 10, 80 ± 9, and 90 ± 8. Differences at baseline and post-protamine were not significant (p = 0.24, 0.45), but at 24 hours the Magnesium group had a significantly lower heart rate (p = 0.02), suggesting a protective effect. MAP in the Magnesium group was 85 ± 10, 82 ± 9, and 80 ± 8 mmHg, and in the Placebo group 86 ± 11, 83 ± 10, and 81 ± 9 mmHg; all differences were non-significant (p = 0.41, 0.97, 0.97), indicating magnesium did not affect blood pressure. Overall,

magnesium modestly reduced postoperative heart rate without causing hypotension.

In our study, Postoperative cardiac biomarker levels measured at 24 hours are summarized in Table 4. The mean troponin I level in the magnesium group was 1.200 ± 0.500 ng/mL, significantly lower than 2.100 ± 0.800 ng/mL in the placebo group (p = 0.001, statistically significant). Similarly, the mean CK-MB level was 18.000 ± 6.000 U/L in the magnesium group versus 28.000 ± 10.000 U/L in the placebo group (p = 0.002, statistically significant). The mean BNP level was also significantly reduced in the magnesium group (120.000 ± 40.000 pg/mL) compared to the placebo group (160.000 ± 50.000 pg/mL, p = 0.005, statistically significant).

In our study, The postoperative outcomes of patients in both groups are presented in Table 5. Atrial fibrillation occurred in 4 patients (8%) in the magnesium group compared to 12 patients (24%) in the placebo group (p = 0.030, statistically significant). Ventricular tachycardia was observed in 1 patient (2%) versus 5 patients (10%) (p = 0.090, not significant), and bradyarrhythmia occurred in 2 patients (4%) versus 3 patients (6%) (p = 0.640, not significant). Postoperative myocardial injury was significantly lower in the magnesium group, affecting 5 patients (10%) compared to 14 patients (28%) in the placebo group (p = 0.020, statistically significant). The need for antiarrhythmic drugs was also reduced in the magnesium group, with 6 patients (12%) requiring treatment versus 15 patients (30%) in the placebo group (p = 0.030, statistically significant). Although ICU stay longer than 48 hours was observed in 12 patients (24%) in the magnesium group and 20 patients (40%) in the placebo group, this difference was not statistically significant (p = 0.080).

Discussion

In our study, perioperative intravenous magnesium sulfate infusion was associated with a significantly lower incidence of postoperative myocardial injury and atrial fibrillation in patients undergoing off-pump coronary artery bypass (OPCAB). Specifically, biomarkers of myocardial injury (troponin I, CK-MB, BNP) were significantly lower, and atrial fibrillation occurred in only 8% of patients in the magnesium group versus 24% in the placebo group. These findings are consistent with previous studies. Wan-Jie Gu, Zhen-Jie Wu, Peng-Fei Wang et al. demonstrated in a meta-analysis of 7 double-blind, placebo-controlled randomized trials that intravenous magnesium significantly reduced postoperative atrial fibrillation after CABG (RR 0.64; p = 0.001) [11]. Similarly, Abdullah A. M. Alghamdi, Osman O. Al-Radi, and David A. Latter reported a significant reduction in postoperative atrial fibrillation with magnesium prophylaxis (RR ≈ 0.64, p = 0.004) [12]. Conversely, Najafi M., Hamidian R., and Haghighat B. conducted a randomized trial and found no significant difference in atrial fibrillation incidence between magnesium and placebo groups (20% vs 22.5%; p = 0.9) [13].Taksaudom N., Cheewinmethasiri J., and Chittawatanarat K. demonstrated in a randomized trial that magnesium sulfate reduced the incidence of atrial fibrillation after CABG, suggesting a dose-dependent protective effect [14]. Klinger RY, Thunberg CA, and colleagues reported that intraoperative magnesium alone did not significantly reduce postoperative atrial fibrillation, highlighting the importance of dosing and timing [15]. In another study, Naghipour B. and Faridaalaee G. found that prophylactic magnesium sulfate reduced the incidence of arrhythmias after cardiac surgery [16]. Chaudhary R., Turagam M., and colleagues, in a meta-analysis of 20 randomized controlled trials (2430 patients), reported that postoperative magnesium supplementation was associated with a significant reduction in postoperative atrial fibrillation (RR 0.76; p = 0.04) [17].

Additional studies reinforce these results. Gu WJ et al. reported pooled subgroup data supporting magnesium's cardioprotective effect [18]. Osawa EA, Biesenbach P., and Cutuli SL. demonstrated benefit with bolus plus continuous magnesium infusion after cardiac surgery [19]. Yeatman et al., in a large double-blind RCT using magnesium in cardioplegia, observed a non-significant trend toward reduced atrial fibrillation, with benefit in urgent patient subgroups [20].

In our study, perioperative magnesium sulfate infusion significantly reduced postoperative heart rate at 24 hours (85 ± 7 vs. 90 ± 8 beats/min, p = 0.02) without affecting blood pressure, as MAP differences were non-significant at all-time points (p = 0.41–0.97). This suggests a mild cardioprotective effect by attenuating postoperative tachycardia. These results align with prior evidence: Gu WJ et al. [11] and Alghamdi AAM et al. [12] reported significant reductions in postoperative atrial fibrillation, while Najafi M et al. [13] and Klinger RY et al. [15] found non-significant effects, highlighting the importance of dosing and timing. Magnesium appears safe, lowers heart rate, and may reduce arrhythmic complications.

Conclusion

Perioperative intravenous magnesium sulfate infusion in patients undergoing off-pump coronary artery bypass surgery was associated with reduced postoperative myocardial injury and a lower incidence of atrial fibrillation.

Additionally, the need for antiarrhythmic therapy was decreased in the magnesium group. These findings suggest that magnesium sulfate provides both electrophysiologic stabilization and myocardial protection in the perioperative period, supporting its use as a safe and effective adjunct in cardiac surgery. Magnesium modestly reduced postoperative heart rate at 24 hours without affecting blood pressure, indicating a mild cardioprotective effect.

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