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Evaluation of Atrial Fibrillation and Premature Ventricular Contractions due to Magnesium Sulfate Administration after Open Heart Surgery

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Abstract

Background and Objectives: One of the common complications of open heart surgery is AF and PVC arrhythmias. Since the highest share of care and treatment in cardiac arrhythmias, especially in critical care departments, is done by nurses, and in order to increase awareness for better nursing care, the current study was designed to evaluate the effect of magnesium sulfate on the incidence of AF and PVC after open heart surgery.
Methods: In this semi-experimental study, 140 patients were randomly divided to intervention and control groups. Seventy patients (intervention group-magnesium sulfate) received 2 g of intravenous magnesium before surgery, 2 g during the operation, and 30 mg/kg on days one, two, three, and four after surgery, and 70 patients in the control group underwent surgery routinely. The serum level was measured before, during, and after the operation. Chi-square and Fisher's exact tests were used to analyze the qualitative variables ($P > 0.05$).
Results: The incidence of postoperative atrial fibrillation in the intervention group was 1.4% and in the control group, this was 10% (seven patients). P was 0.02 and the incidence of premature ventricular contractions in the intervention group was 24.2% (17 cases) and in the control group, this was 51% (36 patients), $P = 0.03$.
Conclusions: Administration of magnesium sulfate before, during, and after open heart surgery seems to be useful in preventing new cases of atrial fibrillation and premature ventricular contractions. The results of this study can help improve nursing care in critical care departments.

Keywords: AF, PVC, CABG, Magnesium Sulfate

1. Background

Cardiovascular disease is one of the most important causes of death in males and females of most countries of the world (1). The disease leads to 17 million deaths every year (one third of deaths), and if there is no specific preventive action by 2020, this number will reach 24.8 million people (2). Cardiovascular diseases are one of the most important causes of mortality in Iran, and death figures in 18 provinces indicate that 46% of all deaths and 27.2% of lost years of life are due to this disease (3).

According to the World Health Organization (WHO) protocol, the treatment of cardiovascular diseases (coronary arteries) is a medical treatment and is coronary artery bypass graft surgery (4). Despite the effectiveness of this method, there are some complications during and after surgery. One of the common complications of open heart surgery is cardiac arrhythmia, which is actually costly and time-consuming to patients and the health sector (5).

Hypomagnesaemia is one of the common causes of cardiac arrhythmias after open heart surgery. Often, arrhythmias that occur after CABG that do not respond to drug therapy and cardioversion shock, are treated with magnesium sulfate, and therefore intravenous magnesium sul-

fate is a common method for prevention of a number of cardiac arrhythmias (6).

A number of studies have found magnesium administration effective in preventing arrhythmias, and several other papers have reported this treatment as ineffective (7-9).

Since the highest share of care and treatment in cardiac arrhythmias, especially at critical care departments, is done by nurses (10), and thus to increase awareness for better nursing care, the current study was designed and implemented to obtain the effect of intravenous magnesium sulfate on the prevention of cardiac arrhythmias, such as AF and PVC, after CABG.

2. Methods

The current semi-experimental study was performed on 140 patients, who were CABG candidates at Baqiyatallah and Shahid Mahallati Hospitals in 2017 and 2018. Exclusion criteria were history of cardiac arrhythmias (the patient does not have AF and PVC), history of liver, kidney, and thyroid disorders, history of anti-arrhythmic drugs, and in the post-operative stage, showing complications and returning the patient to the operating room. Overall, 70 patients were treated with magnesium and 70 patients were allocated to the control group. All patients with CABG were randomly divided to two groups: intervention group (Mg group) and control group after receiving demographic information.

The intervention group received 2 g of intravenous magnesium at night before surgery, 2 g during surgery and 30 mg intravenously on days one, two, three, and four after surgery. Magnesium was measured in patients in the Magnesium group at five time points: the day before surgery, the first, second, third, and fourth day after surgery. Electrocardiogram (ECG) was used to confirm arrhythmias in patients with arrhythmias. Data were analyzed by the SPSS software.

3. Results

There were no significant differences between the two intervention and control groups regarding age, gender, and risk factors for cardiovascular disease (history of hypertension, diabetes, hyperlipidemia, smoking, and family history) ($P > 0.05$). The number of vessels involved in the intervention group was 3 ± 0.90 and in the control group, this was 3.1 ± 0.92 ($P > 0.05$), which in fact confirmed the similarity of the two groups (Table 1). In all tests, the confidence coefficient was calculated as 95%.

The level of magnesium was measured at five (five days) intervals, which was statistically different between the two intervention and control groups on the third day ($P = 0.015$). However, there was no significant difference on the other days ($P > 0.05$).

Serum levels of calcium and potassium in both groups were not significantly different ($P > 0.05$), which indicates that other predisposing factors for arrhythmias were not involved in electrolyte disturbances.

The incidence of arrhythmia in AF was investigated at five time intervals, which was found in one case (1.4%) of the magnesium group and five cases (7.1%) of the control group ($P = 0.01$), and indicates a statistically significant correlation between the administration of magnesium as a prophylaxis and the incidence of AF arrhythmias after surgery (Table 2).

The incidence of PVC at the five time points was reported in 10 cases (14.2%) in the magnesium group and 23 (33%) in the control group ($P = 0.03$), which indicates a statistically significant association between the administration of magnesium and the incidence of arrhythmia PVC after surgery (Table 3).

In Table 4, the serum levels of magnesium in the group that had AF for four days and the group that did not have AF was studied. In the current study, the serum level of magnesium was statistically different on the first day after surgery ($P = 0.001$). This can be a sign of the importance of magnesium in preventing dysrhythmias.

In table 5, the incidence of atrial fibrillation and premature ventricular contraction was compared in both intervention and control groups.

4. Discussion

Coronary artery disease is the leading cause of death around the world (11). More than 50% of all deaths in developed countries are due to cardiovascular disease, and 80% of deaths from these diseases occur throughout the world in developing countries (12). CABG surgery is one of the most important treatments for this disease. Cardiac arrhythmias, the most common AF, are major complications after CABG surgery (13). Embolism, stroke, and the imposition of exorbitant economic costs are a dangerous complication of this arrhythmia (14). Risk factors, such as history of hypertension, old age, involvement of multiple vessels, previous history of AF, and electrolyte imbalances, such as magnesium deficiency, are responsible for this arrhythmia (15). In various studies, it has been shown that magnesium deficiency is one of the most important causes of atrial fibrillation. One of the ways to cope with this arrhythmia has been intravenous infusion of magnesium sulfate before and after surgery (16).

Reducing serum concentrations of ions, such as potassium and magnesium, on the day after surgery, is one of

Table 1. Demographic Information and Risk Factors of Patients in the Two Study Groups

Variable	Intervention Group (Magnesium Sulfate)	Control Group	P Value
Age	55.3 ± 9.5	58.4 ± 8.7	0.19
Gender (male)	67%	54%	0.11
Gender (female)	33%	46%	0.11
Hyperlipidemia	37%	29%	0.07
Smoking	42%	51%	0. 73
Family history	27%	31%	0. 68
Hypertension	54%	58%	0.81
Diabetic	30%	46%	0.07
Myocardial infarction	25%	37%	11%
Number of vessels involved	3 ± 0.81	3.1 ± 0.9	0.18
Time under ventilator in ICU	8.14 ± 2.2	7.46 ± 35	0.05
Level of magnesium sulfate before surgery	0.51 ± 0.07	0.53 ± 0.09	0.18
Level of magnesium sulfate on the first day after surgery	0.53 ± 0.06	0.55 ± 0.19	0.44
Level of magnesium sulfate on the second day after surgery	0.50 ± 0.15	0.51 ± 0.21	0.61
Level of magnesium sulfate on the third day after surgery	0.50 ± 0.17	0.52 ± 0.19	0.015
Level of magnesium sulfate on the fourth day after surgery	0.53 ± 0.09	0.53 ± 0.12	0.013
Level of potassium before surgery	4.23 ± 0.03	4 ± 0.39	0.19
Level of potassium on the first day after surgery	4.5 ± 0.5	4.3 ± 0.26	0.19
Level of potassium on the second day after surgery	4.32 ± 0.53	4.4 ± 0.09	0.89
Level of potassium on the third day after surgery	4. 3 ± 0.03	4.3 ± 0.41	0.18
Level of potassium on the fourth day after surgery	4.23 ± 0.03	4.05 ± 0.55	0.063
Level of calcium before surgery	0.82 ± 0.11	0.84 ± 0.13	0.54
Level of calcium on the first day after surgery	0.94 ± 0.15	0.95 ± 0.53	0.5
Level of calcium on the second day after surgery	0.90 ± 0.18	0.93 ± 0.13	0.14
Level of calcium on the third day after surgery	0.88 ± 0.21	0.90 ± 0.22	0.94
Level of calcium on the fourth day after surgery	0.87 ± 0.11	0.89 ± 0.17	0.52

Table 2. The Incidence of AF in Both Intervention and Control Groups

Incidence rate of AF	Intervention Group		Control Group		Total	
	Number	Percent	Number	Percent	Number	Percent
Yes	1	1.4	5	7.1	6	8.5
No	69	98.6	65	92.9	134	91.5
Total	70	100	70	100	140	100

Table 3. The Incidence of PVC in Both Intervention and Control Groups

Incidence Rate of PVC	Intervention Group		Control Group		Total	
	Number	Percent	Number	Percent	Number	Percent
Yes	10	14.2	23	33	33	23.5
No	60	85.8	47	67	107	76.5
Total	70	100	70	100	140	100

the major causes of arrhythmias that has no organic cause, such as insufficient revascularization and thrombosis of the graft. Among physiological ions, magnesium plays an important role in maintaining cardiac rhythm through the stabilization of membrane function (17). Serum magnesium level decreases below normal levels during the first day after open heart surgery. Therefore, in any patient undergoing surgery, magnesium deposits should be increased. In the phases before and after magnesium surgery, it can help reduce pain, lower blood pressure, and reduce arrhythmias. It also prevents blood clots and reduces depression after CABG and improves cognitive and

Table 4. Evaluation of Serum Magnesium Levels in the Two Groups of Patients with and without AF

Serum Level of Magnesium, mmol/L	Patients with AF	Patients without AF	P Value
Level of magnesium sulfate before surgery	0.51 ± 0.08	0.51 ± 0.09	0.56
Level of magnesium sulfate on the first day after surgery	0.55 ± 0.06	0.57 ± 0.07	0.015
Level of magnesium sulfate on the second day after surgery	0.49 ± 0.15	0.54 ± 0.05	0.018
Level of magnesium sulfate on the third day after surgery	0.50 ± 0.17	0.55 ± 0.17	0.001
Level of magnesium sulfate on the fourth day after surgery	0.52 ± 0.06	0.53 ± 0.16	0.05

Table 5. Evaluation of the Incidence of AF and PVC in the Two Study Groups

	Intervention Group (Magnesium Sulfate)	Control Group	P Value
Rate of AF	1.4%	7.1%	0.03
Rate of PVC	14.2%	33%	0.01

energy performance after surgery (18). High levels of hypomagnesaemia after heart surgery are well documented. After cardiac surgery, the mean magnesium level is reduced. Magnesium sulfate solution prolongs the refractory period of atrial node and the atrioventricular node (19). Hypomagnesaemia is reported in about 70% of patients using CPB (20). Intravenous infusion of magnesium during surgery has been studied in several studies, and the results include reduction of BP after surgery, reduction of arrhythmias, decrease in the level of cardiac enzymes, increased blood flow to the coronary arteries and reduction of ECG changes, reduction of the need for mechanical ventilation and mortality (21). A study by Lomivorotov et al. from Turkey in 2016, indicated that prophylactic treatment of magnesium sulfate has been effective in preventing ventricular arrhythmias (22). Another study by the Royal Hospital in Adelaide, Australia during year 2015, reported that 65% of patients, who received magnesium sulfate had a heart rate below 100 beats per minute, which was 34% in the placebo group (23). A study published by Dr. Sunilk. Bhudia in 2018 in the journal thoracic and cardiovascular surgery, suggested that intravenous infusion of magnesium improves postoperative neurological performance, especially short-term memory and brain function (10). A study by Muhammad at AFIC in Rawalpindi, Pakistan, during year 2014, reported that after a three-day intravenous infusion of magnesium, the incidence of AF in the intervention group decreased to 9%, while in the control group it was 23% (24). A study by Nicholas J. Wilke during year 2012 showed that the correction of serum magnesium level in the preoperative and inoperative period decreased the amount of ventricular arrhythmias after cardiac surgery (25). In a study conducted by Dr. Eugene Crystal in 2010, 20 randomized trials were conducted, in which 2490 patients were evaluated. Magnesium sulfate decreased the incidence of postoperative AF from 28% in the control group to 18% in the magnesium group yet magnesium had no effect on hospital length of stay (LoS) and mortality (26). In a study by Treggiari Venzi et al., the intravenous infusion of prophylactic amiodarone reduced AF after cardiac surgery, yet intravenous magnesium infusion did not have any effect (27). In a study by Anthony Rostron in 2015, prophylactic intravenous magnesium infusion reduced the incidence of post-cardiac arrhythmias and reduced the need for treatment in these arrhythmias (28). In a study by Shiga et al. in 2014, prophylactic magnesium therapy reduced the risk of AF, ventricular and supraventricular arrhythmias, yet did not have any effect on hospitalization, infarction Myocardium or death (29). In a study done by Dr. Gordon in England during year 2017, magnesium serum levels correction decreases ventricular arrhythmias and increases cardiac index and stroke volume in the postoperative period (30). The mean age of the patients studied in the current research was similar in comparison with many similar studies (Table 1). In this study, factors, such as history of CHF, history of COPD, right coronary artery involvement, and the duration of cross-clamping were not associated with AF, which is consistent with the study of Kohno (31). In the current study, there were no significant differences between the two intervention and control groups regarding age, gender, and risk factors for cardiovascular disease (history of hypertension, diabetes, hyperlipidemia, smoking, and family history) ($P > 0.05$). The number of involved vessels in the intervention group was 3 ± 0.90 and in the control group, this was 3.1 ± 0.92 ($P > 0.05$), which in fact confirmed the similarity of the two groups (Table 1). Concerning the reduction of serum magnesium level following CABG, different patterns have been suggested, including CPB reduction, intracerebral magnesium reduction during and after post-hypoxic myocardium, ionizing magnesium with heparin and the use of allogeneic blood in prime with a blood preservative solution (32). Although there is a consensus on the reduction of serum magnesium levels following CABG surgery, the role of this phe-

nomenon in increasing the incidence of post-operative arrhythmias has been discussed (33). In the current study, serum levels of magnesium were measured at five intervals (five days), which was statistically different between the intervention and control groups on the third day (P = 0.015). However, there were no significant differences on the other days (P > 0.05), which is consistent with the studies of solar (2017), Dibroz (2014), and Almor (2016). Almor emphasized that in patients with AF, the level of serum magnesium was lower than normal on the first day after surgery (hypomagnesaemia). However, in this study, the serum level of magnesium on the third day in both groups was in the normal range. On the other hand, in the present study, serum magnesium levels in the first turn of patients with AF was lower than other patients (Table 4). In many studies, intravenous infusion of magnesium before and after surgery was reported to reduce cardiac arrhythmias (17, 19 - 21, 24, 26, 28 - 32). In the current study, the incidence of arrhythmia in AF was investigated in five episodes: one case (1.4%) in the magnesium group and five cases (7.1%) in the control group, which indicated a statistically significant (P = 0.01) association between intravenous infusion of magnesium as a prophylaxis and the incidence of AF arrhythmias after surgery (Table 2). This is practically consistent with the results of most studies in this area. In Sabzi (2016) and Pinard's (2014) studies that investigated the incidence of PVC and intravenous infusion of magnesium before and during surgery, the similarity of arrhythmia was reported in two intervention and control groups that did not conform to the results of the current study (34). In the present study, the incidence of PVC in five trials in the magnesium group was 10 cases (14.2%) and 23 cases (33%) in the control group (P = 0.03), which indicates a statistically significant association between the intravenous infusion of magnesium and the incidence PVC arrhythmia after surgery (Table 3). In a number of studies, (including research (1, 2, 7, 9, 10, 14, 16, 18, 20, 31, 32), serum magnesium level in the AF patients after CABG surgery was lower than that of NSR patients, which matches the current study because this study looked at the level of magnesium in the group that had AF for four days and the group that did not have AF, and the results indicated that the serum level of magnesium was statistically different on the first day after surgery (P = 0.001). This can be an indication of the importance of magnesium in preventing dysrhythmias (Table 4). In general, in the current study, the effect of magnesium sulfate on the reduction of AF and PVC arrhythmias was investigated, which was statistically significant in the magnesium group (intervention) and control group, and consistent with the results of most similar studies.

4.1. Conclusion

The results of this study can help improve nursing care in critical care departments. According to the results of the current study, there were significant complications after CABG, which may occur in critical care departments and need care and attention from nurses. The findings of this research can be a guide for all critical care units for heart surgery. They must be open to understanding the complications and needs of patients to carry out necessary prevention strategies, and detect and resolve these complications as soon as possible. Based on the results of this study, adjunctive magnesium sulfate intravenous infusion to CABG patients is recommended. Further studies are recommended to determine more effective treatment protocols. However, as long as the causes of postoperative dysrhythmia, especially AF, are not clearly identified, a definitive treatment for this common condition cannot be expected. The current study showed that prescribing magnesium can be used as a safe and cost-effective way to prevent AF and PVC after surgery. Finally, according to the results and factors affecting electrolyte disorders in patients under cardiac surgery and the role of nurses in the care of these patients, it is important to conduct research on the knowledge of nurses working in critical care departments for open heart surgery, and promote proper care of patients to reduce physical complications after coronary artery bypass grafting.

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Footnotes

Authors' Contribution: Esmail Heidaranlu and Mohammad Pourebrahimi: study design and supervision of the study process. Masoumeh Rashidi, Arman Zarbizadeh, Nahid Aghdasi Mehrabad, Morteza Moradi and Kosar Eftekhari: data collection. Mohsen Mollahadi: extraction and analysis of the data and interpretation of the findings. Esmail Heidaranlu: supervision, drafting, submission, and revising the manuscript. All authors read and approved the final manuscript.

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