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Original Research Article

Association of prophylactic intravenous magnesium sulfate for prevention of post cardiac surgery arrhythmias

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ABSTRACT

Background: Arrhythmia is a common complication after heart surgery and is a major source of morbidity and mortality. In this study we aimed to investigate the effectiveness of prophylactic magnesium sulfate in the reduction of post-operative arrhythmia after cardiac surgery.
Methods: This comparative cross sectional study was carried out in the Department of Cardiac Surgery, National Institute of Cardiovascular Disease (NICVD), Sher E Bangla Nagar, Dhaka from 01 January 2022 to 31 December 2023. Total 100 patients were selected on the basis of inclusion and exclusion criteria. Among them 50 patients (group A) received prophylactic IV magnesium sulfate and other 50 patients (group B) did not receive prophylactic IV magnesium sulfate. A p value <0.05 was considered statistically significant.
Results: During the observation period overall, 31 out of 100 patients (31%) developed postoperative arrhythmia with varying severity. Among them, 10 patients were from group-A (prophylactic IV magnesium sulfate group) and 21 patients belonged to group-B (control group) (20% versus 42%; p=0.017). Duration of mechanical ventilation (6.89±3.95 versus 10.22±4.56 hours; p<0.001), ICU stay (4.48±2.29 versus 9.83±4.12 days; p<0.001) and length of postoperative hospital stay (7.86±3.04 versus 12.83±4.98 days; p<0.001) were also found to be significantly prolonged in group B patients. No significant difference was observed between the two groups in regards to demographics, associated risk factors, baseline cardiac function, type of disease, operative time and use of CPB (p>0.05).
Conclusions: The current research indicated that administering prophylactic intravenous magnesium sulfate could effectively decrease the occurrence of early postoperative arrhythmia in patients undergoing cardiac surgery.

Keywords: Intravenous magnesium sulphate, Cardiac surgery, Arrhythmia

INTRODUCTION

Arrhythmias are common issue that can occur after cardiac surgery and can lead to significant morbidity, longer hospital stays and increase hospital costs. However, there is limited understanding about the frequency, risk factors and treatment of arrhythmias that occur shortly after the surgery. The early postoperative period, both tachyarrhythmia and bradyarrhythmias had been addressed in previous studies.[1] The occurrence of atrial arrhythmia after CABG, mitral valve surgery, aortic valve surgery and heart transplantation are 31.9%, 63.6%, 48.8%, and 11.1% respectively.[2] Arrhythmias are also common complications in the patients with congenital heart disease and are the leading cause of morbidity and mortality in pediatric age group. Biphasic electrical

cardioversion (CV) is a commonly used method of treating symptomatic atrial fibrillation (AF) patients.[3] In addition to this, several pharmacological agents had proved their efficacy to prevent post-operative arrhythmias. Although not all studies showed consistent results, beta blockers and amiodarone had been used to decrease the incidence of postoperative arrhythmias.[4,5]

Magnesium is an essential element of our normal physiological function. It is very important in maintaining normal muscle contraction, nervous system function, cardiac rhythm and contraction, energy production, DNA and RNA synthesis, electrolyte balance, bone maturation, and anti-inflammatory effect. It is central to a healthy heart rhythm because it is involved in transportation of other electrolyte such as calcium and potassium into the cells. Besides this magnesium has anti ischemic effects by calcium antagonism and vasodilation. Studies have shown that low level of magnesium in the blood are linked to a higher risk of atrial fibrillation. The balance of potassium and magnesium levels within the cells is important for preventing atrial fibrillation.[6] In fact, researchers had found that upto 20% of the patients with new onset of atrial fibrillation have significantly lower levels of magnesium in the comparison to the patients who do not have atrial fibrillation.[7,8] AF is the most prevalent arrhythmia following cardiac surgery, affecting around 20-40% of patients.[8] Studies have shown that IV magnesium sulfate can effectively reduce the risk of AF in this setting.[8,9] Magnesium supplementation helps stabilize the electrical activity of the atria and reduces their susceptibility to fibrillation. Magnesium sulfate administration has been shown to have antiarrhythmic effects on the ventricles and other arrhythmias.[10] The addition of magnesium to the cardioplegic solution is beneficial in reducing the occurrence of perioperative ischemia and arrhythmia in patients who undergo coronary artery bypass grafting.[11]

The main objective of this study was to conduct a comprehensive evaluation of the effectiveness of IV magnesium sulfate on the prevention of postoperative arrhythmia following cardiac surgery. By elucidating the underlying pathophysiological mechanisms, identifying risk factors, this study intends to contribute valuable insights for prevention of postoperative arrhythmias.

METHODS

The comparative cross-sectional study was conducted at the Department of Cardiac Surgery, National Institute of Cardiovascular Diseases (NICVD), Sher-E-Bangla Nagar, Dhaka, Bangladesh from 01 January 2022 to 31 December 2023 (2 years). A total number of 100 patients were included in the study after convenient sampling method.

Group A

50 patients who met the inclusion criteria within the study period and who received prophylactic IV magnesium sulfate.

Group B

50 patients who met the inclusion criteria within the study period and who did not receive prophylactic IV magnesium sulfate.

Selection criteria

Inclusion criteria

All adult (18-65 years) patients with normal sinus rhythm undergoing open heart surgery were included.

Exclusion criteria

Patients of age <65 years and >18 years, preoperative arrhythmia, with ejection fraction <30%, history of previous cardiac surgery, emergency cardiac surgery, renal failure, severe lung diseases (FEV1 <30% of predicted normal value), electrolyte imbalance, hyperthyroidism, and self-withdrawal of patient willfully/who did not give consent were excluded.

An approval for the study was obtained from the ethical review committee of NICVD, Sher-E-Bangla Nagar, and Dhaka. A detailed history was taken and a comprehensive clinical examination was carried out and recoded on a pre–designed structured data sheet. Demographic data e.g., age, sex comorbidities were recorded. All patient received a standard general anesthesia protocol for surgery through standard median sternotomy approach. All the surgeries were performed by a team of experienced cardiac surgeons. After induction of anesthesia, standard midline sternotomy and pericardiotomy was done. CPB was established using standard ascending aorta cannulation and single stage or two-stage venous cannulation according to the case profile.

Magnesium sulfate was administered to patients of group A, each time as an infusion of 20.34 mEq (2.5 g=1 ampule=20.34 mEq) in 100 ml of normal saline solution for a duration of 2 hours and with a rate of 50 ml/hour. This dose was administered 12 hours before the operation to all patients, after termination of cardiopulmonary bypass in patients who were operated on with cardiopulmonary bypass and after anastomosis of the last graft in patients who underwent beating-heart operations (perioperative dose) and it was repeated in all cases at postoperative days 0, 1, 2, and 3. Only 100 ml of normal saline solution was administered to the control group for the placebo effect. Clinical outcomes, including the post-operative arrhythmia, duration of mechanical ventilation, ICU and postoperative hospital stays, and mortality were observed until discharge.

Statistical analyses were conducted using statistical package for social science (SPSS) 26 software developed by SPSS Inc. Descriptive and inferential statistical methods were used to analyze the data. In descriptive statistics, continuous data was summarized by mean±SD.

Categorical data were summarized into frequency, distribution and percentage. To draw conclusions from data, inferential statistics were used, including Chi-square or Fisher's exact test for qualitative data and unpaired t-test for quantitative data. Statistical significance threshold was set at 5% ($p \leq 0.05$) for all analytic tests.

RESULTS

Total 100 patients of different cardiac diseases who underwent cardiac surgery were enrolled in this study. Among them 50 patients (group A) received prophylactic IV magnesium sulfate with 100 ml of normal saline and other 50 patients (group B) received placebo (IV 100 ml normal saline without any IV magnesium sulfate).

Majority patients were between 30-49 years of age which was 40% in group A and 38% in group B. The average age was 41.22±9.43 in group A and 42.15±10.01 in group B. Male patients were predominant in both groups (66% versus 60%). Out of 100 patients, 33 patients were smokers (28% in group A versus 38% in group B), 43 patients had diabetes mellitus (46% in group A versus 40% in group B), 34 patients had hypertension (32% in group A versus 36% in group B) and 28 patients had dyslipidemia (26% in group A versus 30% in group B). But no statistically significant difference was found between the two groups ($p>0.05$) in their demographic characteristics (Table 1).

Table 1: Demographic variables of the patients.

Variables	Group-A (%)	Group-B (%)	P value
Age	41.22±9.43	42.15±10.01	0.319
Male	30 (60)	33 (66)	0.534
Female	20 (40)	17 (34)	
Smoking	14 (28)	19 (38)	0.288
Diabetes mellitus	23 (46)	20 (40)	0.545
Hypertension	16 (32)	18 (36)	0.673
Dyslipidemia	13 (26)	15 (30)	0.656

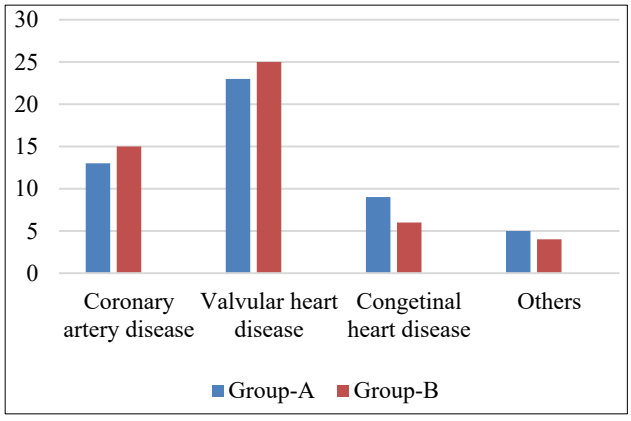

Figure 1: Disease pattern of patients between two groups.

Among the cases in group A, 26% had coronary artery disease, 46% had valvular heart disease, 18% had congenital heart disease and 10% had other diseases. In group B, 30% had coronary artery disease, 50% had valvular heart disease, 12% had congenital heart disease and 8% had other diseases. Majority of the patients in both groups had valvular heart diseases (Figure 1).

There was no significant difference in the duration of surgery between the two groups (4.99±1.16 versus 5.18±1.07 $p=0.198$). Cardiopulmonary bypass was used in 38 (76%) patients in group A and 36 (72%) patients in group B ($p>0.05$). A total number of 31 patients developed post-operative arrhythmia of varying severity. There was significant difference of arrhythmias in group A and group B (42% versus 20%, $p=0.017$) (Table 3). Among them, atrial fibrillation was the most prevalent post-operative arrhythmia in both groups. The current study showed that patients in group B had significantly longer mechanical ventilation time (6.89±3.95 versus 10.22±4.56 hours; $p<0.001$), longer length of ICU stay (4.48±2.29 versus 9.83±4.12 days; $p<0.001$) and postoperative hospital stay (7.86±3.04 versus 12.83±4.98 days; $p<0.001$) compared to group A. There were two in-hospital mortalities, one from each group which was statistically insignificant (Table 3).

Table 2: Comparison of postoperative arrhythmia between two groups.

Post-operative arrhythmia	Group A (n=50), f (%)	Group B (n=50), f (%)	P value
Arrhythmia	10 (20)	21 (42)	0.017
Atrial fibrillation	5 (10)	14 (28)	
Ventricular fibrillation	1 (2)	3 (6)	
Ventricular tachycardia	2 (4)	3 (6)	
Premature ventricular contraction	2 (4)	1 (2)	

Table 3: Comparison of post-operative clinical outcome between two groups.

Post-operative outcome	Group A	Group B	P value
Mech. ventilation time (hours)	6.89±3.95	10.22±4.56	<0.001
ICU stay (days)	4.48±2.29	9.83±4.12	<0.001
Postop. hospital stay (days)	7.86±3.04	12.83±4.98	<0.001
In hospital mortality	1 (2%)	1 (2%)	1.0

In risk factor analysis of post-operative arrhythmia, significant association ($p<0.05$) was found in patients who did not receive magnesium infusion (Table 2). Other

factors like smoking, smoking, hypertension, diabetes mellitus and dyslipidemia had failed to show any statistically significant relationship in developing post-operative arrhythmias (Table 4).

Table 4: Association of risk factors with post-operative arrhythmia.

Variables	Arrhythmia present (%)	Arrhythmia absent (%)	P value
Smoking	13 (39.40)	18 (26.87)	0.203
Dyslipidemia	9 (32.14)	22 (30.56)	0.878
Hypertension	8 (23.53)	23 (34.85)	0.246
Diabetes mellitus	15 (34.88)	16 (28.07)	0.466

DISCUSSION

In this study, there were no significant differences observed between the groups in terms of demographic characteristic, comorbidities, and cardiac parameters. These demographic characteristics of our study are consistent with different studies across the world.[12,13]

Regarding per-operative variables, the study shows that the duration of surgery didn't vary significantly between two groups. The duration of surgery was 4.99±1.16 hours in group A and 5.18±1.07 hours in group B (p=0.198). Seventy-four patients were operated under cardiopulmonary bypass (CPB), 76% belonged to group A and 72% belonged to group B. Similar results were demonstrated by Rebecca et al and Zangriloo et al.[14.15]

Our study shows that 31 out of 100 patients developed postoperative arrhythmia of varying severity. The incidence of arrhythmia was significantly higher in group B (control group) than group A (prophylactic IV magnesium sulfate group). Postoperative arrhythmia occurred only in 10 (20%) patients in group A but in group B 21 (42%) patients developed arrhythmia (p=0.017). The difference was statistically significant(p<0.05). Most common form of arrhythmia was atrial fibrillation. Ventricular fibrillation, ventricular tachycardia, and premature ventricular contraction were less common. Naghipour et al observed that in the Mg group, arrhythmia occurred in 16 of 80 patients (20%) and in the control group, arrhythmia occurred in 27 of 80 patients (33.75%) which coincided with our study.[16] In another study conducted by Najafi et al found that atrial fibrillation was more prevalent in the patients not receiving prophylactic magnesium infusion especially in diabetic patients.[17]

While comparing the postoperative clinical outcomes, we can see that it is significantly better in group A, who received prophylactic IV magnesium sulfate. Group B patients experienced notably extended mechanical ventilation time (6.89±3.95 versus 10.22±4.56 hours; p<0.001), a prolonged ICU stay (4.48±2.29 versus 9.83±4.12 days; p<0.001), and an extended postoperative hospital stay (7.86±3.04 versus 12.83±4.98 days; p<0.001) compared to group A. Evidenced by these findings, we can say that postoperative arrhythmia significantly impaired the recovery and imposed a huge cost burden to the patients of the control group.

In a study conducted by Kaplan and colleagues showed that low serum magnesium sulfate levels (<1.8 mg/dl) had significantly increased the risk of atrial fibrillation by 2.66 times (p=0.003).[18] Similarly, Dorman and colleagues conducted a study examining the effectiveness of magnesium supplementation in preventing arrhythmias during pediatric cardiac surgery for congenital heart defects where the control group exhibited a significantly higher occurrence of functional ectopic tachycardia (27% versus 0%, p<0.001).[19]

Limitations

The present study had some limitations. Sampling was not randomized. Besides, ratio of on-pump and off-pump surgeries were unequal. Patients were not followed up beyond discharge from hospital. As a result, we could not comment on any residual arrhythmia after their discharge. So further large scale multicenter randomized study should be conducted to provide a better outcome to the patients.

CONCLUSION

The current research indicated that administering prophylactic intravenous magnesium sulfate could effectively decrease the occurrence of early postoperative arrhythmia in patients undergoing cardiac surgery. This outcome will promote the regular administration of intravenous magnesium sulfate during the perioperative period to prevent arrhythmia after cardiac surgery, thereby aiding in mitigating its dreadful consequences.

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