Section: Cardiothoracic & Vascular Surgery

Research

HYPOMAGNESAEMIA AND ROLE OF MAGNESIUM SUPPLEMENTATION DURING CARDIOPULMONARY BYPASS IN PEDIATRICS CARDIAC SURGERY

Hemant Namdev[1], Ankur Goel[1], Piyushgupta[1]

[1]Assistant Professor, Department of Cardiothoracic and Vascular Surgery, Superspeciality Hospital, MGMMC, Indore, Madhya Pradesh, India

Received : 09/09/2022
Received in revised form : 03/10/2022
Accepted : 14/10/2022

Keywords:
Arrhythmias, Intra-Cardiac Repair, MgSO4, hypomagnesaemia.

Corresponding Author:
Dr. Hemant Namdev,
Email: drhemantnamdev@yahoo.com
ORCID: 0000-0002-4557-1099

DOI: 10.47009/jamp.2022.4.5.6

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2022; 4 (5); 23-26

Abstract

Background: A significant source of morbidity and mortality following cardiac surgery for congenital heart disease is postoperative arrhythmias. Patients with congenital cardiac disease are particularly susceptible to rhythm abnormalities in the early postoperative period. Little is known about the prevalence, danger signs, treatment, and prevention of early postoperative arrhythmias in juvenile cardiac surgery. An incidence of between 15% and 17.7% was observed in a recent report by Roos-Hesselink and Karamermer. **Materials and Methods:** This prospective study was conducted at Super speciality hospital GMC Nagpur, All patients with tetralogy of Fallot undergoing intra-cardiac repair in the Department of Cardiothoracic and Vascular Surgery between February 2019 to February 2020 were enrolled in this study. A total of 90 patients were included in this study.The patients receiving any antiarrhythmic medication either prior to surgery or intraoperative were excluded from the study.The patients were randomly assigned to one of the following groups: Group 1 (Mg0), receiving normal saline (placebo), group 2 (Mg25), receiving 25mg/kg of MgSO4, and group 3 (Mg50), and receiving 50mg/kg of MgSO4. Maximum total dose of MgSO4 did not exceed 2g. All subjects received a single bolus of either placebo or drug into the CPB circuit at the initiation of the rewarming period. MgSO4 (500mg/mL; 4mEq/mL). The composition of the bypass circuit and perfusion protocols were according to established institutional practices. Patients receiving antiarrhythmics preoperatively or intraoperatively were excluded from the study. **Result:** Hypomagnesaemia was present in 28% of patients. None of the patients who were administered magnesium developed hypomagnesaemia. The incidence of JET was found to be increased (53.3%) in the placebo group as compared to 13.3% and 6.7% in the groups receiving 25 and 50mg/kg of magnesium ($p<.001$). 22 patients having JET 14 (64%) had hypomagnesaemia and rest of the 8(36%) occurred in patients with normal magnesium levels ($p<.001$). The mean mechanical ventilation time and the mean length of ICU stay were both prolonged those with hypomagnesaemia. The mean mechanical ventilation time and length of ICU stay were both prolonged in the patients with JET. **Conclusion:** Hypomagnesemia is one of the factors responsible for JET and in turn with prolonged ICU stay and prolonged mechanical ventilation time. Our study suggests that supplementation of MgSO4 during CPB reduces the incidence of hypomagnesaemia and reduces the overall incidence of JET.

INTRODUCTION

A significant source of morbidity and mortality following cardiac surgery for congenital heart disease is postoperative arrhythmias. Patients with congenital cardiac disease are particularly susceptible to rhythm abnormalities in the early postoperative period. Little is known about the prevalence, danger signs, treatment, and prevention of early postoperative arrhythmias in juvenile cardiac surgery. An incidence of between 15% and 17.7% was observed in a recent report by Roos-Hesselink and Karamermer.[1] After juvenile cardiac surgery, postoperative junctional ectopic tachycardia (JET) continues to be one of the most frequent arrhythmias (8%–20%). JET is linked to increased mechanical ventilation time, hemodynamic instability, and cardiac critical care unit

ISSN (O): 2687-5365; ISSN (P): 2753-6556

hospitalizations (CICU). Despite the fact that the cause of JET is multifaceted, some studies have linked it to hypomagnesemia during cardiopulmonary bypass (CPB).[2]

Magnesium is an essential cofactor for the maintenance of myocardial transmembrane potential, magnesium deficiency decreases the threshold for arrhythmias.[3] In adults undergoing cardiac surgery, hypomagnesaemia has been associated with the presence of arrhythmias, especially postoperative atrial fibrillation. Furthermore, in adults the administration of magnesium sulfate (MgSO4) during cardiac surgery reduces the occurrence of postoperative atrial fibrillation. In paediatric patients undergoing cardiac surgery with CPB, hypomagnesaemia is common (34%) and is associated with longer ICU stay, higher Paediatric Risk of Mortality (PRISM) score and longer mechanical ventilation time.[4] Although magnesium supplementation during CPB reduces the incidence of arrhythmias in adults, the benefits of magnesium administration in paediatric cardiac patients have neither been demonstrated nor have dosage guidelines been established.[5]

The aim of this study is to evaluate the effect of prophylactic administration of magnesium on the occurrence of postoperative arrhythmias in patients undergoing intracardiac repair for Tetralogy of Fallot and to determine the incidence of hypomagnesaemia in paediatric patients undergoing cardiac surgery who require CPB.

MATERIALS AND METHODS

Study Design: A prospective study
Study Location: Super speciality hospital GMC Nagpur
Study Duration: Feb 2019 to Feb 2020
Sample Size: 90 patients

This prospective study was conducted at Super speciality hospital GMC Nagpur. All patients with tetralogy of Fallot undergoing intra-cardiac repair in the Department of Cardiothoracic and Vascular Surgery between February 2019 to February 2020were enrolled in this study.

Patient Population

A total of 90 patients were included in this study.

Exclusion Criteria

The patients receiving any antiarrhythmic medication either prior to surgery or intraoperative were excluded from the study.

The patients were randomly assigned to one of the following groups: Group 1 (Mg0), receiving normal saline (placebo), group 2 (Mg25), receiving 25mg/kg of MgSO4, and group 3 (Mg50), and receiving 50mg/kg of MgSO4. Maximum total dose of MgSO4 did not exceed 2g. All subjects received a single bolus of either placebo or drug into the CPB circuit at the initiation of the rewarming period. MgSO4 (500mg/mL; 4mEq/mL). The composition of the bypass circuit and perfusion protocols were according to established institutional practices. Patients receiving antiarrhythmics preoperatively or intraoperatively were excluded from the study. At the end of the surgical procedure, all the patients were transferred to the ICU. The potassium levels in all the patients were kept above 4mEq/L by repeated ABG and potassium administration. Postoperative arrhythmias were managed by the ICU intensivist. Occurrence of postoperative arrhythmia requiring intervention was the end point of the study.

The Mg level was measured at 4 time points: (1) baseline (time 1), before CPB, (2) after CPB (time 2): (3) 24 hrs. After CPB (time 3). All the measurements were performed by the same operator and using the Autoanalyser Roche Modular P 800. The reagent kit used for Autoanalyser Roche Modular P 800 is Audit, Hitachi make. The procedure involves formation of diazonium salt with magnesium and Xylidyl blue. The amount of complex formed is directly proportional to amount of magnesium in the sample and it is read spectrophotometrically in the range of 505-600nm. The presence of hypomagnesaemia was based on Mg reference levels. Normal values being 1.58mg/dL to 2.55mg/dL. A 12-lead electrocardiogram was performed on arrival in the ICU and a 2-channel, 5-lead continuous electrocardiography was done for documentation of arrhythmias during ICU stay after surgery.

RESULTS

Each group had 30 patients. The age of patients of TOF ranged from 1 to 18 years. The mean weight of enrolled patients was 18.29kgm with no statistical difference between the groups. There was no statistically significant difference between the groups in relation to age, weight, BSA, sex and preoperative sinus rhythm.

The baseline laboratory parameters measured were haemogram, RFT and LFT of the patients. There was no statistical difference found between the groups. There was no patient with renal azotaemia or hepatic dysfunction included in the study. Haemoglobin level and platelet counts were also comparable between the groups with no statistically significant difference.

Table 1: Patient demographics

Characteristics	Study group			P Value
	Group 1: Placebo	Group 2: Mg 25mg/kg	Group 3: Mg 50mg/kg	
Mean age (years)	6.33	6.93	7.07	>.05
Mean weight (kg)	16.8	18.4	19.67	>.05

ISSN (O): 2687-5365; ISSN (P): 2753-6556

BSA (m2/kg) Mean	0.7	0.76	0.76	>.05
Male	10	8	8	>.05
Female	20	22	22	
Sinus rhythm	30	30	30	>.05
Mean Cross Clamp time (min)	109.2	112.73	109.92	>.05
Mean Cardiopulmonary Bypass time (min)	164.93	168	167.27	>.05

Table 2: Magnesium levels in the Mg Groups

Mg group	Baseline		Post CPB			POD1		
	<1.58 mg/dL (n)	1.58-2.55 mg/dL (n)	<1.58 mg/dL (n)	1.58-2.55 mg/dL (n)	>2.55 mg/dL (n)	<1.58 mg/dL (n)	1.58-2.55 mg/dL (n)	>2.55 mg/dL (n)
Mg 0	6	24	18	12	0	10	18	2
Mg 25	12	18	0	30	0	0	30	0
Mg 50	8	22	0	22	4	0	28	2

Table 3: Association between Magnesium Groups and Post-Operative Arrhythmias

	Type I AV Block	Type II AV Block	Type III AV Block	JET	Nil	Total
Mg 0	0	0	0	16	14	30
Mg 25	0	2	4	4	20	30
Mg 50	2	0	0	2	26	30
Total	2	2	4	22	60	90

The overall incidence of post-operative arrhythmias in TOF in our study was consistent with previous studies with incidences being JET (24.44%), Complete AV Block (4.44%), Type II AV Block (2.22%), Type I AV Block (2.22%) and Ectopic beats (15.55%).

DISCUSSION

In this study, we found that in children undergoing ICR for TOF, the administration of a single dose of MgSO4 during CPB reduces the incidence of hypomagnesaemia and also decreases the incidence of JET in the immediate postoperative period.[6] In addition, this effect of magnesium seems to be dose related. Incidence of tachyarrhythmias in the patients who received 50mg/kg of MgSO4 was 6.7%, whereas the incidence was 13.3% in patients who received 25mg/kg of MgSO4 and 53% in patients who received placebo.[7]

The data analysed in the study suggests that supplementation of magnesium during Cardiopulmonary Bypass reverses hypomagnesaemia and reduces the frequency of arrhythmias in the immediate postoperative period. This finding supports the notion that hypomagnesaemia should be aggressively treated to potentially prevent JET in the immediate postoperative period. Although the specific mechanism by which the appropriate magnesium level during CPB prevents JET is not known; it is speculated that magnesium stabilizes the myocyte ionic channels leading to myocardial protection and electrical equilibrium. The critical magnesium level that protects the myocardium during CPB is unknown, but it may vary among different pathologic conditions, surgical strategies and degrees of injury.[8]

The incidence of hypomagnesaemia was 60% in the placebo group in our patients. This was comparatively higher than the previous studies as done by Dittrich and associates.and by Dorman and associates. The lower incidence of hypomagnesaemia in these studies was attributed to higher concentration of magnesium in cardioplegia solution used as compared to our study and also to supplementation of magnesium after CPB.[9] In the placebo group, there was also a slight elevation in the levels of Mg post bypass. This effect may be related to the hemoconcentration during the rewarming period of CPB.[10]

CONCLUSION

Hypomagnesemia is one of the factors responsible for JET and in turn with prolonged ICU stay and prolonged mechanical ventilation time. Our study suggests that supplementation of MgSO4 during CPB reduces the incidence of hypomagnesaemia and reduces the overall incidence of JET.

REFERENCES

1. Booth JV, Phillips-Bute B, McCants CB, Podgoreanu MV, Smith PK, Mathew JP, et al. Low serum magnesium level predicts major adverse cardiac events after coronary artery bypass graft surgery. Am Heart J. 2003;145(6):1108-13. doi: 10.1016/S0002-8703(03)00077-2.
2. Magnesium in Coronaries (MAGIC) Trial Investigators. Early administration of intravenous magnesium to high-risk patients with acute myocardial infarction in the Magnesium in Coronaries (MAGIC) Trial: a randomised controlled trial. Lancet. 2002;360(9341):1189-96. doi: 10.1016/s0140-6736(02)11278-5.
3. Miller S, Crystal E, Garfinkle M, Lau C, Lashevsky I, Connolly SJ. Effects of magnesium on atrial fibrillation after cardiac surgery: a meta-analysis. Heart. 2005;91(5):618-23. doi: 10.1136/hrt.2004.033811.
4. Kohno H, Koyanagi T, Kasegawa H, Miyazaki M. Three-day magnesium administration prevents atrial fibrillation after coronary artery bypass grafting. Ann Thorac Surg. 2005;79(1):117-26. doi: 10.1016/j.athoracsur.2004.06.062.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

5. Mayson SE, Greenspon AJ, Adams S, Decaro MV, Sheth M, Weitz HH, et al. The changing face of postoperative atrial fibrillation prevention: a review of current medical therapy. Cardiol Rev. 2007;15(5):231-41. doi: 10.1097/CRD.0b013e31813e62bb.
6. Shepherd J, Jones J, Frampton GK, Tanajewski L, Turner D, Price A. Intravenous magnesium sulphate and sotalol for prevention of atrial fibrillation after coronary artery bypass surgery: a systematic review and economic evaluation. Health Technol Assess. 2008;12(28):iii-iv, ix-95. doi: 10.3310/hta12280.
7. Delaney JW, Moltedo JM, Dziura JD, Kopf GS, Snyder CS. Early postoperative arrhythmias after pediatric cardiac surgery. J Thorac Cardiovasc Surg. 2006;131(6):1296-300. doi: 10.1016/j.jtcvs.2006.02.010.
8. Munoz R, Laussen PC, Palacio G, Zienko L, Piercey G, Wessel DL. Whole blood ionized magnesium: age-related differences in normal values and clinical implications of ionized hypomagnesemia in patients undergoing surgery for congenital cardiac disease. J Thorac Cardiovasc Surg. 2000;119(5):891-8. doi: 10.1016/S0022-5223(00)70083-3.
9. Azzam FJ, Fiore AC. Postoperative junctional ectopic tachycardia. Can J Anaesth. 1998;45(9):898-902. doi: 10.1007/BF03012227.
10. Dittrich S, Germanakis J, Dähnert I, Stiller B, Dittrich H, Vogel M, et al. Randomised trial on the influence of continuous magnesium infusion on arrhythmias following cardiopulmonary bypass surgery for congenital heart disease. Intensive Care Med. 2003;29(7):1141-4. doi: 10.1007/s00134-003-1802-3.

ISSN (O): 2687-5365; ISSN (P): 2753-6556