

## Serum Magnesium Levels In On-Pump Coronary Artery Bypass Graft Surgery

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**Abstract: Background:** The purpose of the study was to analyze serum magnesium concentration in patients undergoing coronary artery bypass grafting on cardio pulmonary bypass.

**Methods:** This prospective study was conducted in 50 patients who underwent elective coronary artery bypass grafting on cardiopulmonary bypass. Blood samples from radial artery were collected just before induction of anesthesia and three days post-operatively for estimation of serum magnesium.

**Results:** Magnesium level was 2.08 mg/dl at baseline, 2.20 mg/dl, 2.04 mg/dl and 1.85 mg/dl respectively on three consecutive days post-operatively.

**Conclusion:** The lowering of serum magnesium in Coronary artery bypass grafting patients postoperatively recommends the use of routine serum magnesium determination and administration to prevent post operative arrhythmias.

**Keywords:** Cardio pulmonary bypass, Coronary artery bypass grafting, Magnesium.

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### I. Introduction

Magnesium is not a trace element but the most abundant essential mineral in the body and fourth most abundant intracellular cation. Physiological roles of Magnesium include its action as a regulator of  $Ca^{2+}$ ,  $K^+$  and  $Na^+$  transport channels and pumps in cell membranes.<sup>[1]</sup> It is distributed approximately one half in the bone, one half in the muscle and other soft tissues, less than one per cent is in the blood. Magnesium is an important regulator of multiple cardiovascular processes, including myocardial contraction and conductivity, transmembrane calcium flux, potassium transport, vascular smooth muscle tone, coronary reactivity and nitric acid synthesis. Its disorders may cause many life threatening arrhythmias.<sup>[2]</sup>

Magnesium is an essential cofactor for the maintenance of myocardial transmembrane potential, and its deficiency decreases the threshold of arrhythmias.<sup>[1]</sup> In cardiac surgery, hypomagnesaemia has been associated with the presence of supraventricular cardiac arrhythmias, atrial fibrillation, lengthened P-R and Q-T segments or ventricular fibrillation. On-pump Coronary artery bypass grafting is a technique of performing coronary anastomosis on a beating heart with instituting cardio pulmonary bypass. Hemodilution is the primary cause of hypomagnesemia on cardio pulmonary bypass. Could this change be prevented and would its prevention prove to be beneficial.<sup>[3,4,5,6]</sup> Despite substantial improvement in surgical techniques, postoperative atrial fibrillation is among the common complication encountered early after coronary artery bypass grafting.<sup>[7]</sup> It generally occurs between 24 and 96 hours postoperatively with a peak incidence on the second postoperative day. Atrial fibrillation potentially leads to complications, including stroke, extended duration of hospitalization and increasing costs. The etiology of atrial fibrillation after coronary artery bypass grafting is unclear. The cause may be multifactorial such as advanced age, male sex, hypertension, hypothyroidism, withdrawal of  $\beta$ -lockers, impaired cardiac function, chronic lung disease, chronic renal failure, diabetes, cardioplegia, myocardial ischemia and reperfusion, myocardial ischemia right coronary artery disease, local inflammatory reaction, metabolic disorder excessive catecholamine and electrolyte imbalance, particularly hypomagnesemia, which has also been identified as an independent predictor of postoperative atrial fibrillation.<sup>[8,9]</sup> Magnesium administration has proved beneficial in preventing ventricular and supraventricular tachyarrhythmia after Coronary artery bypass grafting.<sup>[10]</sup>

### II. Materials And Methods

The prospective study was conducted at NRI Heart Center, NRI General Hospital on 50 consecutive patients who underwent elective cardiac surgery. The study was approved by Institutional Ethics Committee and informed consent was obtained from all patients. 30 males and 20 females with age group of 42 to 76 years were included in the study.

### **Preoperative Patient Demographics**

**Inclusion criteria-** elective On-pump coronary artery bypass grafting with ejection Fraction more than 35%.

**Exclusion criteria** – Emergency surgeries and patients receiving oral or injectable magnesium.

On the day of surgery the patient was premedicated with Morphine (0.2mg/Kg) and promethazine (0.5mg/Kg) intramuscularly about 30-45 minutes prior to induction of anesthesia. Anesthesia was induced with thiopentone (5mg/kg) and vecuronium was used to accomplish endotracheal intubation with appropriately sized tube( generally 9.0mm for males and 7.5mm for females). Anesthesia was maintained with 50% nitrous oxide (N<sub>2</sub>O) along with halothane 0.5% to 1%. The vitals are maintained with the use of dobutamine, noradrenaline and nitroglycerine. Morphine (0.05mg/kg) was given before incision for analgesia.

Anticoagulation is achieved with heparin 3mg/kg to maintain activated clotting time of more than 480 seconds. Adequate mean arterial pressure and urine output is maintained during cardiopulmonary bypass and throughout surgery. Additional morphine (0.01mg/kg) and vecuronium (0.1mg/kg) were administered during re-warming. After the surgery anticoagulation is reversed with protamine with 1 : 1 ratio with heparin. The target ACT was baseline ACT. Hemoglobin was maintained at 10 mg/dl. A normal arterial blood gas was maintained. Adequate hemostasis was achieved before chest closure. Post cardio pulmonary bypass anesthesia was maintained with 50% O<sub>2</sub>, 50% N<sub>2</sub>O, halothane 0.5 to 1% and vecuronium (1/4<sup>th</sup> of induction dose). After skin closure patient was shifted to post operative ICU for elective ventilation.. Most of the patients are extubated within 6-8 hrs of surgery. Inotropes are gradually weaned off.

### **Magnesium Administration:**

40mg/kg of magnesium sulphate(50%) in 100 ml normal saline was given intravenously over 15 minutes after induction of anesthesia.

### **Surgical Procedure:**

Standard surgical procedure was applied for all cases. After midline incision, sternotomy was done, followed by vein harvesting along with LIMA (left internal mammary artery) pericardium was opened. After achieving adequate anticoagulation aorta was cannulated, then followed by right atrial cannulation. After cross clamping of aorta heart was arrested with infusion of cold blood cardioplegia. After the heart was arrested appropriate surgery was carried out. After the surgery the patient was rewarmed gradually to normal body temperature. Once the all parameters are met to wean off the bypass, patient was gradually weaned off the bypass with inotropic support with dobutamine and noradrenaline. Blood was infused as required to maintain the hemoglobin more than 10mg/dl. After successful weaning off bypass, test dose of protamine to reverse the effect of heparin was given. Both arterial and venous cannulae were removed. Complete dose of protamine followed the decannulation. Adequate homeostasis was achieved and sternum closed with steel wires. Chest was closed in layers. Patient was shifted to post –operative intensive care unit for elective ventilation.

### **Cardio pulmonary bypass technique:**

Pump was primed with 1.5liters with ringer lactate [1 lit] and 6% hydroxyethyl starch (0.5lit). Additives to the priming were mannitol 100ml and sodium bicarbonate 100ml. After adequate anticoagulation and successful cannulation, heart was arrested after cross clamping with cold blood cardioplegia. The contents of the cardioplegia include potassium 16meq, magnesium hydrochloride 162.65mg and procaine hydrochloride 13.64 mg in 20ml solution. Potassium is the main ingredient responsible for arresting heart. The other additives help in myocardial protection.

Cardioplegia solution given at 4-8°centigrade. Core temperature was maintained at 30° degrees. Mean arterial pressure of 60-80 mm Hg was maintained. Hematocrit was maintained at 20-30% with addition of blood if required. A normal arterial blood gas was maintained through-out. Cardioplegia was repeated every 20 minutes. After the surgery was gradually re-warmed to 37° degrees. Patient gradually weaned off the bypass after the parameters were met for weaning.

The blood sample were collected from radial artery.

1. just before anaesthesia after artery cannulation
2. 1<sup>st</sup> Post operative day
3. 2<sup>nd</sup> Post operative day
4. 3<sup>rd</sup> Post operative day

The blood was immediately centrifuged at 3000 rpm at room temperature after clotting and the obtained serum was determined by colorimetric method using xylydyl blue.

**III. Results**

The patients in the study were in the age group of 42 – 76 years. Cardiac surgeries were performed on 30 males and 20 females.

**Table 1:** Case distribution according to age & sex

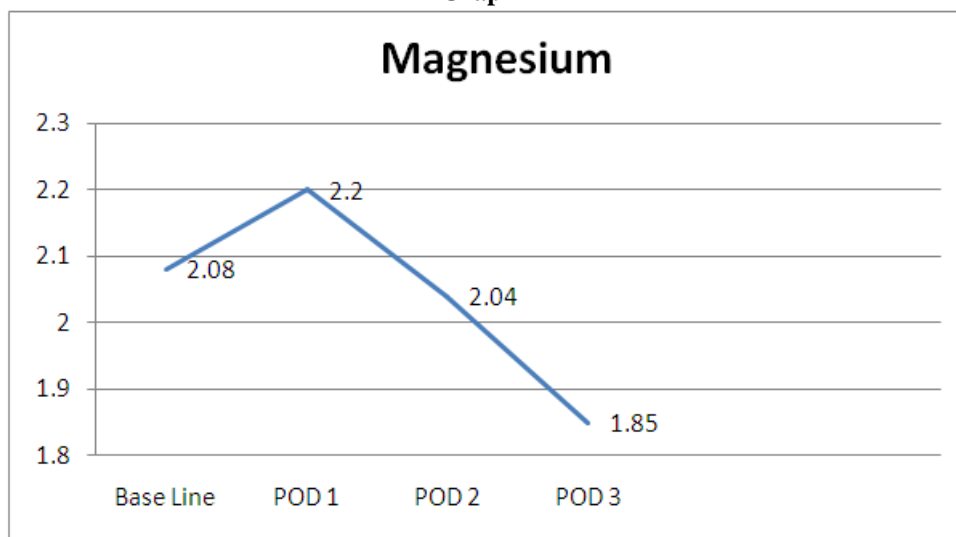
Age (Yrs)	Male	Female	Total %
40-49	4	6	20%
50-59	10	7	34%
60-69	9	3	24%
70-79	7	4	22%
Total (n)	30(n)	20(n)	100%

\* Mean age (m)= 57.3 years

sd = 11.5

m +SE (stadarad error) = 54-60.2

**Graph 1**



\* Observed serum magnesium levels (mean) three days post operatively.

**Table 2 :** The number of patients arranged according to the levels of serum magnesium

Serum Mg Levels	Baseline	1 <sup>st</sup> POD	2 <sup>nd</sup>	3rd
1.51 – 1.70	-	-	-	4
1.71 – 1.90	4	-	1	30
1.91 – 2.10	25	10	38	16
2.11 – 2.30	17	30	10	-
2.31 – 2.50	4	10	1	-
Total (n)	50	50	50	50

\* The observed difference of serum magnesium levels between baseline value and 3<sup>rd</sup> POD is statistically highly significant with P <0.01.

**IV. Discussion**

Magnesium has an essential role in numerous cellular process and if metabolism is disturbed it can have serious biological consequences. Discovery of the degree of its importance had a long history from the time that Epsom Spa Water, which had a embittered taste due to containing the sulphate of Magnesium was drunk in 1645.<sup>[2]</sup>In 1808 Sir Humphrey Davy isolated the alkaline metal by electrolysis, a pioneering technique developed by himself which was also used to isolate sodium and potassium.<sup>[1]</sup>

Magnesium plays an important role in cardiovascular physiology. It is an essential co-factor in maintaining the intracellular electrolyte balance and membrane potential by acting on Na-K-ATP channels.<sup>[11]</sup>It is also like a natural calcium antagonist. Magnesium is also an antagonist of the N-methyl-D-aspartate (NMDA) receptor and its associated ion channels.<sup>[12]</sup>Studies on the pathophysiology of myocardial ischemia-reperfusion

injury suggests there is a rational basis for magnesium therapy. Magnesium reduces the extent of infarct, but only when administered before reperfusion. The positive effect of magnesium may also result from its significant role in the pathomechanism of reperfusion injury. Thus, it may be suggested that intra-operative magnesium intravenous infusion is important and required in patients undergoing coronary artery bypass grafting. Preoperative factors may include the fact that many of cardiac patients receiving diuretics and digitalis cause renal loss of magnesium. During the surgery, patients are exposed to hemodilution, blood loss, blood transfusion and an increase of catecholamines that cause chelation of magnesium. All these factors contribute to the decrease in plasma magnesium levels. During surgery, continuous hemofiltration, modified ultrafiltration and administration of large dose of calcium and diuretics can cause depletion of magnesium.<sup>[4]</sup> Other factor causing hypomagnesemia is the decrease in body temperature during surgery. Postoperative three day magnesium infusion is effective in reducing the incidence of atrial fibrillation & junctional ectopic tachycardia occurring after coronary artery bypass grafting.<sup>[11,12]</sup>

Magnesium reaches its minimum levels on first postoperative day and returns to its preoperative value on 4<sup>th</sup> post-operative day.<sup>[13]</sup>

Studies show about 17% decrease in plasma magnesium persists until the first post operative day. Hypomagnesemia observed on 1<sup>st</sup> post-operative day is a relevant symptom preceding atrial fibrillation.<sup>[13]</sup>

Hypomagnesemia is known to cause muscle weakness and respiratory failure. It is one factor causing difficulty in weaning the patient from ventilator. Patients with hypomagnesemia needed ventilator support more frequently and for a longer duration. Patients with low muscle magnesium were on ventilator support for more number of days.<sup>[14]</sup> Hypomagnesaemia is commonly associated with other electrolyte abnormalities. Hypokalemia, hypocalcemia, hypophosphatemia are said to be the predictors of hypomagnesemia.

Magnesium supplementation before beating heart can stabilize the plasma membrane of the myocardium and thereby mediate the protective effect. Low levels of magnesium cause not only cardiac arrhythmias like atrial fibrillation,<sup>[14]</sup> but also hypertension and vasoconstriction.

Administration of a single dose of magnesium during coronary artery bypass grafting is a safer practice and has a protective effect at the moment of heart reperfusion.

Analyzing the changes in blood magnesium levels, the correlation between magnesium and ischemic heart area is worth stressing. This seems to be very important in patients with post-bypass with stunned hearts, who require inotropic drug infusion. High blood magnesium concentration may result in an increasing cardiac contractions strength, and thus it is likely to decrease the demand for Dopamine & Dobutamine infusions.<sup>[15]</sup>

Studies demonstrated that intravenous magnesium infusion was capable of reducing the infarct extent by more than 50% and it also had positive effects on ejection fraction and left ventricular function.<sup>[16]</sup> Thus magnesium supplementation is particularly relevant in patients with impaired heart function after On-pump coronary artery bypass grafting.

## V. Conclusion

This study shows that there is a decrease in serum magnesium level post-operatively for coronary artery bypass grafting patients done on cardiopulmonary bypass. The administration of supplemental magnesium sulphate does not keep serum magnesium in high levels for long time and thus does not prevent atrial fibrillation or other post coronary bypass grafting surgical arrhythmias.

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