J. Dhaka National Med. Coll. Hos. 2011; 17 (01): 33-36

Original article

Comparison of Serum Magnesium and Potassium in Acute Myocardial Infarction and Chronic Ischemic Heart Disease

MBK Choudhury[1], MS Rahman[2], MM Hassan[3], R Begum[4], N Hoque[5], M Akhtaruzzaman[6], AN chowdhury[7]

[1]Directorate General Health Services, Dhaka, [2]Dept of Biochemistry, National Medical College, Dhaka, [3]Dept of Chemistry, MC College, Sylhet, [4]Dept of Biochemistry, Bangladesh Medical College, Dhaka, [5]Dept of Biochemistry, Sir Salimullah Medical College, Dhaka, [6]Dept of Biochemistry, Shaeed Suhrawardy Medical College, Dhaka, [7]Department of Biochemistry, Dhaka National Medical College, Dhaka;

ABSTRACT

The comparative study has been designed to estimate serum magnesium (Mg) and potassium (K) in patients with acute myocardial infarction (AMI) and chronic ischemic heart disease (CIHD). A total 61 subjects were selected and were divided as group-I (30 subjects of AMI) and group-II (31 subjects of CIHD). Laboratory investigations were done for estimation of serum glucose and serum creatinine to exclude the diabetesmellitus and renal disease. Serum Mg was estimated by atomic absorption spectrophotometer and serum K by ion selective electrode. This study showed that Mg and K level in serum is significantly lower in patients with AMI than that of CIHD subjects. Findings of the study suggested that significantly reduced serum level of Mg and K persists in AMI than those of CIHD, which may be the cause of further cardiac complications. So it may be recommended for estimation and supplementation of Mg and K in both the cases of AMI and CIHD patients for better management.

Introduction

Ischemic Heart Disease (IHD) is the generic designation for a group of closely related syndromes resulting from ischemia – an imbalance between the supply and demand of the heart for oxygenated blood. Ischemia comprises not only insufficiency of O_2 (hypoxia, anoxia), but also reduced availability of nutrient substrates and inadequate removal of metabolites. Because coronary artery narrowing or obstruction owing to atherosclerosis underlies myocardial ischemia in the vast majority of cases, IHD is often termed coronary artery disease (CAD) or coronary heart disease (CHD)[1]. CHD is the commonest cause of heart disease and the most important single cause of death in the affluent countries of the World. Myocardial infarction (MI) is the term applied to myocardial necrosis secondary to an acute interruption of the coronary blood supply[2]. On the other hand Angina pectoris and old MI are considered as chronic ischemic heart disease (CIHD).

Magnesium (Mg) is the second most common intracellular electrolyte after potassium (K), and the fourth most abundant cation in the body. Approximately 40% of the Mg contained in the adult human body resides in the muscles and soft tissue, about 1% in the extracellular fluid (ECF), and the remainder in the skeleton[3]. Mg is a cofactor in more than 300 enzyme systems in human cells and it has a predominant role in normal myocardial physiology. Possible sites of action of Mg include vascular smooth muscle[4], platelets[5] and myocardial cells. Mg helps to suppress arrhythmias during ischemia and reperfusion[6,7]. It also increases the ventricular threshold of arrhythmias in normal and also in digitalis-treated hearts, and thus, indicates its usefulness in the treatment of ventricular arrhythmias[8]. Animals fed on a Mg deficient diet developed larger infarcts than did control animals[9]. Thus hypomagnesemia could produce progressive vasoconstriction, resulting in coronary arterial spasm and ischemia, which would lead to sudden death ischemic heart disease (SDIHD)[10]. Lowering of Mg enhances reactivity of a number of arterial, arteriolar and venous vessels to norepinephrine, acetylcholine, serotonin, angeotensin and K[11].

K is the principal cation in intracellular fluid (ICF), nerve and muscle function and Na-K-ATPase[12]. It also regulates the P^H and maintains the osmolarity of both the ICF and ECF (extracellular fluids)[13].

Various studies in different part of the world suggest that Mg and K play an important role in cardiovascular system (CVS) especially on heart and blood vessels. Deficiency of both of them can cause serious cardiac disease[14,15]. Studies also found specific correlation between serum Mg and K axis[16]. Often Mg and K deficiency occurs simultaneously in the heart[17] but deficiency of Mg is more predictable than K[18].

Experimental observations to data support the view that Mg and K metabolism are closely linked[16,19] investigated the frequency with which hypomagnesemia is found in hypokalemic patients.

From the varying results in previous studies, it is a matter of dispute whether Mg and/or K deficiency preceding the development of IHD or whether it is secondary to AMI. On the other hand ventricular arrhythmias occurring in the presence of hypokalemia which may result from concurrent Mg deficiency, whereas Mg deficiency may potentiate the tendency to early ventricular tachyarrhythmias in the setting of AMI. Despite this, controversy persists regarding the importance of Mg and K in the patients of IHD, the merits of routine screening of these two electrolytes continue to be debated. Thus, this prospective study was undertaken of patients admitted to CCU.

Subjects and Methods

The study was carried out in the biochemistry department of BSMMU in collaboration with CCU of SSMC & MH and atomic energy center, Dhaka during the period from July 2000 to December 2001. A total 61 both male and female subjects without persisting diabetes mellitus (DM) or Chronic renal disease were included in this study. The subjects who were taking diuretics were excluded.

Distribution of subjects: Group-I (n=30) included patients with AMI. In Group-II (n=31) included patients suffering with angina pectoris or old MI (CIHD). The diagnoses were based on history, clinical examination, resting and / or exercise ECG and elevated levels of serum CK-MB isoenzymes. Sample was collected within 24 hours from the onset of AMI.

Collection of sample: Blood samples were collected from the subjects with all aseptic precautions. 10 ml of venous blood were collected from the median cubital vein by a disposable plastic syringe. The needle was detached from the nozzle and blood was transferred immediately into a dry, clean, de-ionized, graduated, screw-capped plastic test tube with a gentle push to avoid hemolysis. The test tubes were kept in slanting position till formation of clot. Centrifuging the blood at 3000 rpm for 5 minutes, serum was separated and supernatant was taken into three small plastic test tubes (eppendorf), containing 1 ml in each. All the tests were carried out as early as possible. Whenever there was a delay, the serum samples were stored in the ultra freeze at -20^0C.

Laboratory methods: Estimation of serum glucose was done by enzymatic glucose oxidase method, serum creatinine by alkaline picrate method and serum CK-MB by kinetic immunoinhibition method using the available reagent kit. Serum Mg was estimated by atomic absorption spectrophotometer and serum K by ion selective electrode.

Results

The mean ± SD level of serum glucose (mmol/L) of group-I and group-II were 6.12 ± 1.09 and 5.94 ± 1.21 respectively. No statistically significant mean difference of serum glucose level between the groups found ($p > 0.05$). In group-I, the mean ± SD serum creatinine level (µmol/L) was 83.50 ± 20.06 and in group-II it was 81.74 ± 23.25. No statistically significant mean difference of serum creatinine level between the groups observed ($p > 0.05$). The mean level of serum CK-MB was 216 ± 71.31 U/L in group-I and 18.44 ± 7.37 U/L in group-II. A highly significant mean difference was found statistically between the groups ($p < 0.001$) indicating group-I had too much higher level of serum CK-MB then group-II (Table-1).

Table-1: Comparison of Serum glucose and creatinine status between group-I and Group-II.

Groups	Number of subjects (n)	Value (Mean ± SD)		
		Serum glucose (mmol/L)	Serum creatinine (µmol/L)	Serum CK-MB (U/L)
Group-I	30	6.12 ± 1.09	83.50 ± 20.06	216 ± 71.31
Group-II	31	5.94 ± 1.21	81.74 ± 23.25	18.44 ± 7.37

Means compared using Student's unpaired 't' test.

The mean ± SD level of serum Mg (mmol/L) was 0.59 ± 0.09 in group-I and 0.67 ± 0.07 in group-II. A highly significant mean difference ($p < 0.001$) was found in serum Mg level between the two groups, indicating group-I had significantly lower level of serum Mg than group-II (Table-2).

Table-2: Comparison of Serum magnesium level between group-I and Group-II.

Groups	Number of subjects (n)	Serum magnesium (mmol/L)	
		Mean ± SD	Range
Group-I	31	0.59 ± 0.09	0.46-0.82
Group-II	32	0.67 ± 0.07	0.51-0.84

Means compared using Student's unpaired 't' test.

The mean ± SD level of serum K (mmol/L) in the individual groups were 3.28 ± 0.45 and 3.67 ± 0.43 respectively. A significant mean difference ($p < 0.01$) was found in serum K level between the groups. It indicates group-I had significantly lower level of serum K than group-II (Table-3).

Table-3: Comparison of Serum potassium level between group-I and Group-II.

Groups	Number of subjects (n)	Serum potassium (mmol/L)	
		Mean ± SD	Range
Group-I	31	3.28 ± 0.45	2.20-4.10
Group-II	32	3.67 ± 0.43	2.60-4.20

Means compared using Student's unpaired 't' test.

The incidence of hypomagnesemia in AMI patients was 86.66% and in CIHD it was 58.06%. The incidence of hypokalemia in AMI

patients was 60% and in CIHD it was 22.58%. 76.92% hypomagnesemia in hypokalemic subjects was reported in this study.

Discussion

Serum glucose and serum creatinine were estimated to exclude diabetes and renal alignment. Serum CK-MB was estimated to diagnose the AMI. ECG monitoring was done to categorize the subjects into groups. All the subjects in the study were non-diabetic. All the subjects of group-I showed a very high level of serum CK-MB and the mean value was 216.36 ± 71.31 U/L and in group II it was 18.44 ± 7.37 U/L.

The mean level of serum Mg (mmol/L) was 0.59 ± 0.09 in group-I and 0.67 ± 0.07 in group-II. A highly significant mean difference ($p < 0.001$) was found in serum Mg level between the groups of study subjects. The mean level of serum K (mmol/L) in group-I and group-II were 3.28 ± 0.45 and 3.67 ± 0.43 respectively. Here also a highly significant mean difference ($p < 0.001$) was found between the groups.

In this study a significant lower serum Mg level in AMI group in comparison with chronic IHD patients ($p < 0.001$) were observed. The exact cause of Mg deficiency in patients with IHD still remains to be settled. Earlier these findings were attributed to chronic diuretic therapy[20], but this explanation is not supported by this study, which also shows Mg deficiency in patients with IHD who had not been receiving long-term diuretic therapy previously.

Hypokalemia in this study were 60% patients with AMI and 22.58% in chronic IHD patients. In AMI patients it is much higher than 10% to 17% incidence reported by Dyckner (1980)[21] and Kafka et al. (1987)[22]. They did not mention whether the patients took diuretics or not. Non-diuretic-induced hypokalemia accounted for 47% to 70% seen in patients with AMI from the other centers[14,23,]. Of particular interest was the finding that hypokalemic patients with AMI in this study had not been taking diuretics, and also chronic IHD patients had not the same recent history of taking diuretics. Nordrehaug (1981)[14] found that only one third of his hypokalemic patients with AMI who developed ventricular fibrillation had received diuretics. Hulting (1981)[23] commended that "a number of cardiac patients are hypokalemic without prior diuretic therapy". The reason for wide variation in percentage of serum K level of our IHD patients with that of others may be due to our small sample size. The cause of decreased serum K level in IHD patients is not clear but immediately following an AMI the reduction of serum K level may be due to increased plasma catecholamine levels[24].

Present study reveled 76.92% hypomagnesemia in hypokalemic subjects. This finding supports the study of Boyd et al. (1983)[25], and Whang et al. (1984)[19], who reported a 38% and 42% incidence of coexisting hypomagnesemia in hypokalemic patients respectively. Furthermore they proposed that in hypokalemic patients, serum Mg level should be routinely determined. In studying experimental depletion of Mg in humans, Shils (1969)[26] described the subsequent development of hypokalemia and hypocalcemia and stated that Mg is essential for the normal metabolism of both K and Ca. Kafka et al. (1987)[22] concluded in a study that hypokalemia and hypomagnesemia may occur in AMI in the absence of prior diuretic use. All of these studies make agreement with our findings.

The present study did not fully correlate with the findings of Cummings (1960)[27] and Bakos et al. (1988)[28]. In a study Cummings (1960)[27] observed that there was an increase in serum K and Mg and a decrease in Ca and Na, 8 to 11 hours after coronary ligation of dog sample. Bakos et al. (1988)[28] studied serum Cu, Mg, Zn, Ca and K changes following AMI. They observed lowered serum Cu & Mg and significant elevation of serum Ca & K in these patients.

The basis for hypokalemia and hypomagnesemia in the patients with AMI who are not taking diuretics is unclear but may relate to elevated levels of plasma catecholamines. Dyckner and Wester (1979)[29] examined the effects of Mg and K repletion on the incidence of extrasystoles in patients receiving diuretics and suggested that Mg deficiency on a cellular level may lead to defective function of the Na-K pump and thus to the inability of the cell to accumulate K against a concentration gradient.

It is evident from the findings of present study that there is a significant lower serum Mg and K level in AMI then chronic IHD and there may be a positive correlation between them. Evaluating the total findings from home and abroad we want to say that low serum level of Mg and K may be the risk factor for IHD. Fall of serum Mg immediately after AMI may be due to the catecholamine induced high FFA which causes bindings and precipitation of Mg into the cells, resulting in a sudden decrease in total plasma Mg level. The reason of low plasma K concentration in IHD is still unclear.

Conclusion

Thus it is suggested from the above discussion that estimation and supplementation of both Mg and K is essential in case of IHD and AMI patients. But from the present study with a small sample size it is too early to confirm Mg and K as protective as well as curative agent for IHD. So, further study involving a larger sample size in different states of IHD is needed.

References

1. Schoen FJ. The heart. In: Cotran RS, Kumar V, Collins T, eds, *Robbins Pathological Basis of Disease*, 6th edn, WB Saunders Company, Philadelphia 1999: **pp** 543-600.
2. Julian DG, Cowan JC, McLenachan JM. Disease of the Coronary Arteries – Causes, Pathology and Prevention. In: *Cardiology*, 7th edn, WB Saunders Company Ltd 1998: **pp** 92-105.
3. Aikawa JK. Magnesium: Its biologic significance. *Boca Raton*, FL: CRC Press: 1981.
4. Chrysant SG, Ganousis L, Chrysant C. Hemodynamic and metabolic effects of hypomagnesemia in spontaneously hypertensive rats. *Cardiology* 1988; 75: 81-89.
5. Adams JH, Mitchell JR. The effect of agents which modify platelet behavior and of magnesium ions on thrombus formation in vivo. *Thromb Haemost* 1979; 42: 603-610.
6. Haverkramp W, Hindricks G, Keteller T. Prophylactic antiarrhythmic and antifibrillatory effects of intravenous magnesium sulphate during myocardial ischemia (Abstract). *Eur Heart J* 1988; 9: 228.
7. Woods KL, Fletcher S. Long-term outcome after intravenous magnesium sulphate in suspected acute myocardial infarction: the second leicester intravenous magnesium intervention trial (LIMIT-2). *Lanect* 1994; 343: **pp** 816-8199.
8. Ghani MF, Rabah M. Effect of magnesium chloride on electrical stability of the heart. *Am Heart J* 1977; 94: 600-602.
9. Chang C, Varghese PJ, Downey J, Bloom S. Magnesium deficiency and myocardial infarct size in the dog. *J Am Coll Cardiol* 1985; 5: 280-289.
10. Turlapaty DMV, Altura BM. Magnesium deficiency produces spasms of coronary arteries: Relationship to etiology of sudden death ischemic heart disease. *Science* 1980; 208: 198-200.
11. Altura BM, Altura BT. Magnesium ions and contraction of vascular smooth muscles: relationship to some vascular disease. *Federation Proceedings* 1981; 40: 2672-2679.
12. Mayes PA. Nutrition. In: Murray RK, Granner DK, Mayes PA, Rodwell VW, eds, *Harper's Biochemistry*, 25th edn, Lange Medical Publication, Prentice-Hall International, USA 2000: **pp** 648-660.
13. Champe PC, Harvey RA. Nutrition. In: Champe PC, Harvey RA, eds, *Lippincott's Illustrated Reviews: Biochemistry*, 2nd edn, Lippincott-Raven Publishers, JB Lippincott Company, Philadelphia 1994: **pp** 303-318.
14. Nordrehaug JE. Malignant arrhythmias in relation to serum potassium values in patients with an acute myocardial infarction. *Acta Med sand Suppl* 1981; 647: 101-7.
15. Sasaki S, Oshima T, Teragawa H, Matsuura H, Kajiyama G, Kambe M. Magnesium status in patients with cardiovascular diseases (Abstract). *Rinsho Buori* 1999; 47: 396-401.
16. Whang R, Flink EB, Dyckner T, Wester PO, Aikawa JK, Ryan MP. Magnesium depletion as a cause of refractory potassium repletion. *Arch Intern Med* 1985; 145: 1688-1689.
17. Flink EB, Brick JE, Shane SR. Alterations of long-chain free fatty acid and magnesium concentrations in acute myocardial infarction. *Arch Intern Med* 1981; 141: 441-443.
18. Flink EB. Magnesium deficiency: Etiology and Clinical Spectrum. *Acta Med Scand* 1981; 647(suppl): 125-137.
19. Whang R, Oei TO, Aikawa JK, Watanabe A, Vannatta J, Fryer A, Markanich M. Predictors of Clinical Hypomagnesemia, Hypokalemia, Hypophosphatemia, Hyponatremia and Hypocalcemia. *Arch Intern Med* 1984; 144: 1794-1796.
20. Dyckner T, Wester PO. Intracellular magnesium loss after diuretic administration. *Drugs 1984*; 28: 161-170.
21. Dyckner T. Serum magnesium in acute myocardial Infarction: Relation to arrhythmias. *Acta Med scand* 1980; 207: 59-66.
22. Kafka H, Langevin L, Armstrong PW. Serum magnesium and potassium in acute myocardial Infarction. *Arch Intern Med* 1987; 147: 465-469.
23. Hulting J. In-hospital ventricular fibrillation and its relation to serum potassium. *Acta Med Scand Suppl* 1981; 647: 109-116.
24. Brown MJ, Brown DC, Murphy MB. Hypokalemia from $beta_2$-receptor stimulation by circulating epinephrine. *N Engl J Med* 1993; 309: 1414-1419.
25. Boyd JC, Bruns DE, Wills MR. Frequency of hypomagnesemia in hypokalemic states. *Clin Chem* 1983; 29: 178-179.
26. Shils ME. Experimental human magnesium depletion. *Medicine* (Baltimore) 1969; 48: 61-85.
27. Cummings JR. Electrolyte changes in heart tissue and coronary arterial and venous plasma following coronary occlusion. *Circulation Research* 1960; 8: 865-870.
28. Bakos SN, Ahmed HK, Nasser TA. Serum copper, magnesium, Zinc, calcium and potassium changes following acute myocardial infarction. *Angiology* 1988; 39: 413-416.
29. Dyckner T, Wester PO. Ventricular extrasystoles and intracellular electrolytes before and after potassium and magnesium infusions in patients on diuretic treatment. Am Heart J 1979; 97: 12-18.