Original Research Article

Study of serum magnesium level in patients with type 2 diabetes mellitus and it’s correlation with glycosylated hemoglobin and diabetic complications

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ABSTRACT

Background: Hypomagnesemia has been proposed as a novel factor implicated in the pathogenesis of poor glycemic control and diabetic complications. Aim of the present study is to study serum magnesium level in patients with type 2 DM and to find the correlation between serum magnesium levels, HbA1c and diabetic complications.

Methods: 100 patients with Type 2 DM (50 males and 50 females) who were diagnosed on the basis of ADA criteria or taking treatment for Diabetes were included in the study. All patients underwent tests for serum magnesium level, fasting blood sugar, postprandial blood sugar, HbA1c and also target organ evaluation for Diabetes. A detailed history and examination was also done.

Results: There was significant difference in the prevalence of hypomagnesemia (34% versus 6%) and serum magnesium levels (1.59±0.187 versus 1.78±0.126, p <0.0001) between diabetics and control group. FBS (172.17±30.55 versus 137.06±37.76, p<0.0001), PPBS (243±61.21 versus 195.84±59.1, p = 0.0003) and HbA1C (8.42±1.292 versus 7.04±0.956, p<0.0001) were significantly higher in hypomagnesemic diabetics as compared to normomagnesemic diabetics. Significant proportion of hypomagnesemic diabetics were suffering from retinopathy as compared to normomagnesemic diabetics (47.06% versus 19.70%, p = 0.0042). Diabetic nephropathy, neuropathy, hypertension and IHD were also higher in hypomagnesemic diabetics as compared to normomagnesemic diabetics, but insignificant.

Conclusions: Prevalence of hypomagnesemia in Type 2 diabetics was 34%. Diabetics with hypomagnesemia had poor glycemic control. Hypomagnesemia was significantly associated with diabetic retinopathy.

Keywords: Diabetic retinopathy, Glycosylated haemoglobin, Hypomagnesemia, Type 2 DM

INTRODUCTION

The term diabetes mellitus (DM, derived from Greek words meaning - Siphon and sweet) refers to a group of common metabolic disorders that share the phenotype of hyperglycemia which results from reduced insulin secretion and/or action, decreased glucose utilization, and increased glucose production. Incidence of diabetes is increasing worldwide due to population ageing and growth, obesity, unhealthy diets and sedentary life style. Microvascular and macrovascular complications of diabetes increase as a function of the duration of hyperglycemia. So, a reduction of chronic hyperglycemia prevents or delays these complications.6

Magnesium is an essential element and has a fundamental role in carbohydrate metabolism in general and in the insulin action in particular. Magnesium is a cofactor in
both glucose transport mechanism of the cell membranes and for various intracellular enzymes involved in carbohydrate oxidation. Magnesium is involved in multiple levels in insulin secretion, binding and activity. Cellular magnesium deficiency can alter the activity of the membrane bound Na+K+ ATPase, which is involved in the maintenance of gradients of sodium and potassium and in glucose transport.

The concentrations of magnesium in serum of healthy people are remarkably constant, whereas 25-39% of diabetics have low concentrations of serum magnesium. Hypomagnesemia in diabetics can be due to: osmotic renal losses from glycosuria, decreased intestinal magnesium absorption and redistribution of magnesium from plasma to red blood cells caused by insulin effect. Mc Nair P et al indicated that the net tubular reabsorption (in the thick ascending loop of Henle or more distally) of magnesium is decreased in diabetic patients in presence of hyperglycemia, leading to hypomagnesuria and hypomagnesemia. Magnesium depletion has a negative impact on glucose homeostasis and insulin sensitivity in patients with type 2 diabetes as well as on the evolution of complications such as retinopathy, arterial atherosclerosis and nephropathy. Moreover, low serum magnesium is a strong, independent predictor of development of type 2 diabetes. In the atherosclerosis risk in communities (ARIC) Study, a dose response inverse relation between serum magnesium concentrations and the incidence of type 2 diabetes was observed amongst white participants. Several subsequent large prospective cohort studies have reported a statistically significant reduction in risk of type 2 diabetes associated with increased magnesium intake. In humans, several experimental metabolic studies have suggested that magnesium supplementation has beneficial effects on glucose metabolism, insulin action and/or insulin sensitivity. In addition, cross-sectional studies have found an inverse association between magnesium intake and fasting insulin concentrations, a good marker of insulin resistance.

High concentration of glucose can increase the glycation of hemoglobin, forming Glycosylated hemoglobin (HbA1c). It is a simple and economical way for assessment of long term glycemic control (6-8 weeks). American Diabetes Association recommends twice per year measurements for patients who are meeting treatment goals and quarterly measurements for those whose therapy has changed or who are not meeting treatment goals.

The present study was undertaken with an aim to estimate prevalence of hypomagnesemia in patients with type 2 Diabetes mellitus and to correlate the serum magnesium concentrations with glycosylated hemoglobin (glycemic control), and with microvascular and macrovascular complications of diabetes.

METHODS

The subjects were selected from the cases presenting with diabetes mellitus in the OPD and ward of department of medicine, in MBS Hospital, Kota, Rajasthan. The study population consisted of 100 Diabetic (type 2) and 50 non-diabetic subjects. All the patients in the diabetic group were confirmed diabetics as per ADA criteria or were receiving treatment for diabetes mellitus. A detailed history was taken and examination done. Age- and sex-matched healthy volunteers without a history of diabetes were considered to be control subjects. All subjects were informed about the objectives of the study and an informed written consent was taken.

The study excluded patients with diabetes mellitus other than type 2, critically ill patients (patients with significant hepatic and renal disease, haematological malignancy, chronic kidney disease, acute cerebrovascular accidents, acute myocardial infarction etc.), pregnant women with diabetes mellitus, patients receiving magnesium supplements or magnesium containing antacids, patients on diuretics, patients with history of alcohol abuse, malabsorption or chronic diarrhea, patients refusing to give informed consent for the study.

Blood samples were collected from all the 150 subjects. They were kept on overnight fast at least for 8 hrs before blood collection. 5 ml of venous blood was taken in dry disposable syringe under aseptic conditions in sterile, dry vial for biochemical analysis. Calfmate dye method was used for quantitative estimation of serum magnesium. FBS, PPBS, HbA1c, cholesterol, triglycerides, HDL, LDL, VLDL, blood urea, serum creatinine, SGOT and SGPT, were determined on semi-automated clinical chemistry analyzer.

Statistical analysis

The results were expressed as mean±SD of each variable. Student t test is used to compare parametric data. Chi square test used to compare groups wherever applicable. P value of <0.05 has been considered significant.

RESULTS

Prevalence rate of hypomagnesemia was 34% in the study group. The clinical and laboratory characteristics of the study patients according to the presence or absence of hypomagnesemia are showed in Table 1.

There was significant difference in respect to serum magnesium levels between the cases and controls, with low value in the case group (1.59±0.187 versus 1.78±0.126, p<0.0001) (Table 2).

Diabetic patients with hypomagnesemia did not differ from normomagnesemic diabetics in terms of age, sex, duration of diabetes and BMI. However, diabetic patients with hypomagnesemia had higher values of fasting
plasma glucose (Table 3), post prandial plasma glucose (Table 4) and HbA1c (Table 5) in comparison with the diabetic patients with normomagnesemia. Significantly higher proportion of diabetic patients with hypomagnesemia have found to be suffering from retinopathy as compared to normomagnesemic diabetics (47.06% versus 19.7%, p = 0.0042) (Table 6). Prevalence of diabetic neuropathy, nephropathy, hypertension and IHD were more in hypomagnesemic diabetics when compared with normomagnesemic diabetics, but found statistically insignificant.

### Table 1: Clinical and laboratory characteristics of the study patients.

| Parameter                        | Diabetic subjects with hypomagnesemia (n=34) | Diabetic subjects with normomagnesemia (n=66) | P value |
|----------------------------------|---------------------------------------------|---------------------------------------------|---------|
| Age (years)                      | 59.7±9.37                                   | 54.21±9.84                                  | 0.085   |
| Males/Females number (%)         | 19(55.8%)/15(44.1%)                         | 31(46.9%)/35(53%)                          | 0.3984  |
| Duration of diabetes (years)     | 5.73±3.48                                   | 5.71±3.48                                  | 0.9797  |
| Body mass index (Kg/m2)          | 31.36±4.67                                  | 30.92±5.5                                  | 0.6914  |
| Fasting plasma glucose (mg/dl)   | 172.17±30.55                                | 137.06±37.76                               | <0.0001 |
| Post prandial plasma glucose (mg/dl) | 243±61.21                                | 195.84±59.1                                | 0.0003  |
| HbA1c (%)                        | 8.42±1.292                                  | 7.04±0.956                                 | <0.0001 |
| Total cholesterol (mg%)          | 172.17±42.86                                | 165.1±32.98                                | 0.3625  |
| HDL cholesterol (mg%)            | 39.82±10.44                                 | 40.83±9.69                                 | 0.6317  |
| LDL cholesterol (mg%)            | 102.32±33.49                                | 94.71±22.86                                | 0.1835  |
| Triglycerides (mg%)              | 151.14±46.28                                | 148.51±48.29                               | 0.7942  |
| Serum magnesium (mEq/l)          | 1.39±0.077                                  | 1.69±0.139                                 | <0.0001 |
| Diabetics with complications (50)| 22 (44%)                                    | 28 (56%)                                   | 0.0347  |
| Diabetics without complications (50)| 12 (24%)                                   | 38 (76%)                                   | 0.0347  |
| Hypertension (yes) number (%)    | 9 (26.47%)                                  | 15 (22.73%)                                 | 0.6783  |
| Retinopathy (yes) number (%)     | 16 (47.06%)                                 | 13 (19.7%)                                  | 0.0042  |
| Nephropathy (yes) number (%)     | 7 (20.59%)                                  | 10 (15.15%)                                 | 0.4929  |
| Neuropathy (yes) number (%)      | 10 (29.41%)                                 | 18 (27.27%)                                 | 0.8213  |
| Coronary artery disease (yes) number (%) | 7 (20.59%)                              | 11 (16.67%)                                 | 0.6285  |

Values are given as mean±SD

### Table 2: Serum mg level in case and control groups.

| Serum Mg | Group | t value | P value | Significance |
|----------|-------|---------|---------|--------------|
|          | Diabetic | Control |         |              |
| Mean±SD  | 1.59±0.187 | 1.78±0.126 | 6.4811 | <0.0001 | Highly significant |

### Table 3: Fasting blood glucose in case group subjects.

| Parameter | Mean±SD | t value | P value | Significance |
|-----------|---------|---------|---------|--------------|
| FBS       | 172.17±30.55 | 137.06±37.76 | 4.6856 | <0.0001 | Significant |

### Table 4: Post prandial Blood glucose in case group subjects.

| Parameter | Mean±SD | t value | P value | Significance |
|-----------|---------|---------|---------|--------------|
| PPBS      | 243±61.21 | 195.84±59.1 | 3.7346 | 0.0003 | Significant |

### Table 5: Glycated haemoglobin in case group subjects.

| Parameter | Mean±SD | t value | P value | Significance |
|-----------|---------|---------|---------|--------------|
| HbA1C     | 8.42±1.292 | 7.04±0.956 | 6.0481 | <0.0001 | Significant |
Prevalence of hypomagnesemia in diabetics with microvascular complications was significantly higher when compared to diabetics with no complications (44% versus 24%). This difference was statistically significant ($\chi^2$ value is 4.456 and $P$ value is 0.0347 at DF of 1) (Table 7).

| Retinopathy | Group I | Hypomagnesemia | Group II | Normomagnesemia |
|-------------|---------|----------------|----------|----------------|
|             | No.     | %              | No.      | %              |
| Present     | 16      | 47.06          | 13       | 19.70          |
| Absent      | 18      | 52.94          | 53       | 80.30          |
| Total       | 34      | 100            | 66       | 100            |

$\chi^2 = 8.159; d.f. = 1; P: 0.0042; $Significant

Table 7: Prevalence of hypomagnesemia and diabetic complications.

| Complication                              | No. of patients | Hypomagnesemia | %    |
|-------------------------------------------|-----------------|----------------|------|
| Only retinopathy +                        | 13              | 8              | 61.54|
| Only nephropathy +                        | 2               | 1              | 50   |
| Only neuropathy +                         | 16              | 4              | 25   |
| Retinopathy and nephropathy +             | 7               | 3              | 42.86|
| Retinopathy and neuropathy +              | 4               | 3              | 75   |
| Neuropathy and nephropathy +              | 3               | 1              | 33.33|
| Retinopathy, neuropathy and nephropathy + | 5               | 2              | 40   |
| With complications                        | 50              | 22             | 44   |
| Without complications                     | 50              | 12             | 24   |

$\chi^2 = 4.456; P$ value = 0.0347; $DF=1.$

**DISCUSSION**

In the present study, serum magnesium concentrations were below the reference range in 34 (34%) patients with type 2 diabetes (case group) and in 6% of control group. This confirms to the reported prevalence of low plasma magnesium status in type 2 diabetics in several studies, which ranged from 25 to 39%. 4, 6 Walti MK et al, reported a prevalence of hypomagnesemia in type 2 diabetics as 37.6% versus 10.9% in nondiabetic controls in a study conducted in Zurich, Switzerland. 19

The reasons for the high prevalence of magnesium deficiency in diabetes are not clear, but may include increased urinary loss, lower dietary intake, or impaired absorption of magnesium compared to healthy individuals. Recently a specific tubular defect in magnesium reabsorption in thick ascending loop of Henle is postulated. This defect results in reduction in tubular reabsorption of magnesium and consequently hypomagnesemia. Increased urinary magnesium excretion due to hyperglycemia and osmotic diuresis may contribute to hypomagnesemia in diabetics. Insulin treatment has been shown to correct renal magnesium loss in diabetics. 17

Our results confirm to the recent reports that have not shown any significant associations between sex, age, duration of diabetes and obesity with serum magnesium levels. 19-21 (Table 1) Walti MK et al and present study reported that diabetes treatment (insulin or OHA) did not significantly predict hypomagnesemia. 19

Serum levels of magnesium have been found by several investigators to correlate inversely with fasting blood glucose concentration, post prandial blood glucose and the percentage of HbA1C. 6, 8, 20-23 The present study also revealed that patients with low serum magnesium levels had poor glycemic control. There was statistically significant association between low serum magnesium levels and higher FBS, PPBS and HbA1C%.

Hypomagnesemia is reported to be both a cause and result of poor glycemic control. In addition, magnesium deficiency has been shown to promote insulin resistance in multiple studies. 27-29 Nadler et al. have reported that insulin sensitivity decreases even in nondiabetic individuals after induction of magnesium deficiency. 7 Conversely, hyperglycemia and osmotic diuresis may lead to increased urinary magnesium excretion and hypomagnesemia in diabetics. 17

Atherosclerosis risk in communities study, a cohort of 15,792 subjects were studied over 7 years and an increasing relative risk of coronary artery disease with decreasing serum magnesium was reported. 30 However, in present study no significant relationship was found
between hypomagnesemia and hypertension/IHD/lipid profile.

Hypomagnesemia has been reported in patients with diabetic retinopathy, with lower magnesium levels predicting a greater risk of severe diabetic retinopathy. In our study there was a significant difference in prevalence of retinopathy between hypomagnesemic and normomagnesemic diabetics (47.06% versus 19.70%; P = 0.0042). Grafton et al. have proposed the inositol transport theory to explain this association, but the exact reason remains obscure.

With reference to other diabetic microangiopathies, no significant association was found between prevalence of hypomagnesemia and diabetic neuropathy or diabetic nephropathy. Corsonello et al demonstrated significantly lower serum magnesium in type 2 diabetes with nephropathy compared to a normoalbuminuric group. Pham et al demonstrated that lower (Mg2+) is associated with a faster renal function deterioration rate in type2DM patients. Present study also found higher prevalence of diabetic nephropathy in hypomagnesemic diabetics compared to in normomagnesemic diabetics (20.59% versus 15.15%), but difference was statistically insignificant.

CONCLUSION

Prevalence of hypomagnesemia in type 2 diabetics is 34%. Hypomagnesemia is significantly associated with poor glycemic control. Hypomagnesemia is significantly associated with diabetic retinopathy. Hence, diabetic patients with hypomagnesemia must undergo frequent ophthalmic check-ups to rule out retinopathy. Thus according to our study Hypomagnesemia in diabetics can predict the poor glycemic control and diabetic Retinopathy.

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