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Original Article

# Serum Magnesium Levels in Type 2 Diabetes Mellitus

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## Abstract

**introduction:** Magnesium deficiency is proposed as a factor in the pathogenesis of diabetic complications. Hypomagnesemia can be both a cause and a consequence of diabetic complications.

**Materials and Methods:** This study was undertaken at MGM Hospital, Warangal, from August 2014 to October 2015. A total of 75 cases of Type 2 diabetes mellitus were taken for the study after satisfying the inclusion and exclusion criteria.

**Results:** The serum magnesium levels among cases and controls were 1.88 ± 0.28 mg/dl and 2.1 ± 0.29 mg/dl, respectively.

**Conclusion:** There was a significant reduction in serum magnesium levels in diabetics compared to the controls. There was a significant correlation between magnesium levels and level of control of diabetes. Uncontrolled diabetics had a low level of serum magnesium.

**Key words:** Deficiency, Magnesium, Type 2 diabetes mellitus

## INTRODUCTION

Diabetes mellitus (DM) refers to a group of common metabolic disorders that share the phenotype of hyperglycemia. Several distinct types of DM are caused by a complex interaction of genetics and environmental factors. Depending on the etiology of the DM, factors contributing to hyperglycemia include reduced insulin secretion, decreased glucose utilization, and increased glucose production. The metabolic dysregulation associated with DM causes secondary pathophysiologic changes in multiple organ systems, leading to microvascular (retinopathy, nephropathy, and neuropathy) and macrovascular (coronary heart disease, peripheral arterial disease, and cerebrovascular disease).[1] Low magnesium status has repeatedly been demonstrated in patients with Type 2 diabetes. Magnesium deficiency appears to have a negative impact on glucose homeostasis and insulin sensitivity in patients with Type 2 diabetes.[2]

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Magnesium deficiency has been found to be associated with microvascular disease in diabetes. Hypomagnesemia has been demonstrated in patients with diabetic retinopathy, lower levels of magnesium predicting a greater risk for diabetic retinopathy. Magnesium depletion has also been associated with arrhythmogenesis, vasospasm, platelet activity, and hypertension.[3] 25-39% of outpatient diabetics has low concentrations of serum magnesium[4] and numerous studies have shown lower serum magnesium concentrations in Type 2 diabetics compared to healthy controls.[5,6] The reasons why magnesium deficiency occurs in diabetes are not clear but may include increased urinary loss, lower dietary intake, or impaired absorption of magnesium compared to healthy individuals.[7]

Several studies have reported increased urinary magnesium excretion in Type 1 and 2 diabetes,[8-11] some reporting a correlation between glycemic control and urinary magnesium loss.[10]

Magnesium is involved in insulin secretion, binding, and activity. Cellular deficiency of magnesium can alter

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the membrane-bound sodium-potassium-adenosine triphosphatase which is involved in maintaining the gradient of sodium and potassium and also in glucose transport.[12]

Low dietary intake may also contribute to low magnesium status in diabetics. Patients with Type 2 diabetes are often overweight and may consume a diet higher in fat and lower in magnesium density than non-diabetics. However, the few studies that have reported magnesium intake in Type 2 diabetes are equivocal.[6,13] Impaired intestinal absorption might also contribute to low magnesium status in diabetics. However, there are no published data on magnesium absorption in humans with diabetes. Despite the growing realization of the importance of magnesium in human health and disease, measurement of magnesium status remains problematic. Serum magnesium concentrations can be normal despite depletion of intracellular magnesium.[14]

Magnesium deficiency may result in disorders of tyrosine-kinase activity on the insulin receptor, event related to the development of post-receptoral insulin resistance and decreased cellular glucose utilization that is, the lower the basal Mg, the greater the amount of insulin required to metabolize the same glucose load, indicating decreased insulin sensitivity. Experimental researches have shown that patients with diabetic retinopathy present low concentration of plasma magnesium, disposing to a higher risk of advanced retinopathy.

In Type 2 diabetic patients with microalbuminuria or clinical proteinuria, it showed a significant decrease in serum ionized Mg levels. It was also observed a significant negative correlation between serum ionized Mg and hemoglobin A1c (HbA1c) and triglycerides in both microalbuminuria and clinical proteinuria groups. In elderly Type 2 diabetics, Paolisso *et al.* demonstrated that oral supplementation of magnesium for 4 weeks resulted in lower fasting plasma glucose levels, increased plasma and erythrocyte magnesium levels and an increase in B-cell response to glucose.

The present study was undertaken with an aim to correlate serum magnesium levels with micro and macrovascular complications of diabetes - retinopathy, nephropathy, neuropathy and ischemic heart disease, and peripheral vascular disease.

## MATERIALS AND METHODS

### Source of Data

Patients with Type 2 diabetes admitted in the MGM Hospital between August 2014 and October 2015 were included in the study. Furthermore, 35 non-diabetic patients admitted during this period were also included in the study under the control group.

### Method of Collection of Data

Around 75 patients with Type 2 DM and 35 controls admitted to the MGM Hospital underwent the following tests:

1. Fasting blood sugar (FBS)
2. Postprandial blood sugar (measured 2 h after a standard meal)
3. Fasting serum magnesium levels (Calmagite dye method), normal 1.8-2.5 mg/dl
4. 24 h urinary protein
5. Urine routine
6. Electrocardiography
7. Fundoscopy
8. Renal function test
9. HbA1c (Immunoturbidimetric method).

Diabetics was divided into controlled (HbA1c <7) and uncontrolled (HbA1c >7).

### Inclusion Criteria

All cases of Type 2 DM and age- and sex-matched non-diabetic patients admitted to the MGM Hospital.

### Exclusion Criteria

1. Patients with chronic renal failure
2. Acute myocardial infarction in last 6 months
3. Patients on diuretics
4. Patients receiving magnesium supplements or magnesium-containing antacids
5. Malabsorption or chronic diarrhea
6. Patients with a history of alcohol abuse
7. Pregnant women with hypertension, proteinuria, and eclampsia
8. Patients with a history of epilepsy.

## RESULTS

### Study Design

A comparative study consisting of 75 diabetic patients and 35 controls was undertaken to investigate the change pattern of serum magnesium in DM cases when compared to controls and magnesium levels in relation to complications of DM.

The mean age of the diabetics was 59.56 ± 9.70 and 58.66 ± 10.26 in controls.

Sex distribution in diabetics was male 57.33% and females 42.67%, whereas in controls males 57.14% and females 42.86%. The maximum number of patients was in the age group of 51-60 years, i.e., 36.0%.

The mean FBS levels among cases and controls were 206 mg/dl and 94.86 mg/dl, respectively. Among cases,

mean FBS was found to be high as compared to controls, probably because of poor diabetic control. The mean serum creatinine levels among cases and controls were 0.96 and 0.90 mg/dl, respectively.

The mean serum magnesium levels in cases and controls are 1.88 and 2.1 mg/dl with a $P < 0.003$, which is statistically significant. Although the exact reason in not known, this could probably be explained on the basis of increased urinary loss, low dietary intake, or impaired absorption of magnesium in diabetic patients.

Hypomagnesemia was seen in 38.6% of the cases, whereas only 2.9% of the controls had hypomagnesemia.

The mean serum magnesium levels among patients with uncontrolled diabetes were lower as compared to patients with controlled diabetes, which was statistically significant ($P < 0.001$). Hyperglycemia directly causes suppression of magnesium.

Of the 75 diabetic patients, 33 (44%) were on oral hypoglycemic agents (OHAs), 12 (16%) were on insulin alone, and 30 (40%) were on both OHAs and insulin. The mean serum magnesium levels in the OHA group, insulin group, and OHA+ insulin group were 1.99, 1.73, and 1.82 mg/dl, respectively. The serum magnesium levels were significantly lower in the insulin-treated group as compared to the OHA treated group ($P < 0.013$).

This is because insulin causes shift of magnesium from extracellular to intracellular compartment causing low serum magnesium levels (Tables 1-7 and Figures 1-3).

## DISCUSSION

The present study included 75 diabetic patients (cases) and 35 non-diabetic patients (controls). Serum magnesium levels were determined in all the subjects.

The present study had diabetic patients ranging from 41 to 80 years of age. The mean age in cases and controls was 59.56 and 58.66 years, respectively. Male patients in cases and controls were 57.33% and 57.14%, respectively, and females were 42.67% and 42.86%, respectively.

In this study, mean serum magnesium levels in cases and controls were 1.88 ± 0.28 mg/dl and 2.10 ± 0.29 mg/dl, respectively, which means diabetics are having low serum magnesium level compared to non-diabetics, with a $P < 0.003$ which is statistically significant.

**Table 1: Age distribution**

| Age in years | Number of cases (%) | Number of controls (%) |
|---|---|---|
| 41-50 | 17 (22.7) | 7 (20) |
| 51-60 | 27 (36.0) | 13 (37.2) |
| 61-70 | 23 (30.7) | 11 (31.4) |
| 71-80 | 7 (9.3) | 3 (8.6) |
| □80 | 1 (1.3) | 1 (2.9) |
| Total | 75 (100.0) | 35 (100.0) |
| Mean±SD | 59.56±9.70 | 58.66±10.26 |

SD: Standard deviation

**Table 2: Sex distribution**

| Sex | Number of cases (%) | Number of controls (%) |
|---|---|---|
| Male | 43 (57.33) | 20 (57.14) |
| Female | 32 (42.67) | 15 (42.86) |
| Total | 75 (100.0) | 35 (100.0) |

**Table 3: Mean pattern of FBSs and serum creatinine levels**

| FBS/Serum creatinine Mean±SD | Cases | Controls | *P* value |
|---|---|---|---|
| FBS (mg/dl) | 206.33±54.89 | 94.86±11.78 | 0.0001 |
| Serum creatinine (mg/dl) | 0.96±0.34 | 0.90±0.20 | 0.0725 |

FBS: Fasting blood sugar

**Table 4: Serum magnesium levels in cases and controls**

| Serum magnesium (*n*=1.8-2.5 mg/dl) | Cases | Controls |
|---|---|---|
| Range (Min-Max) | 1.1-2.7 | 1.5-2.7 |
| Mean±SD | 1.88±0.28 | 2.1±0.29 |
| 95% CI | 1.81-2.00 | 2.00-2.20 |
| *P* | <0.003 | |

SD: Standard deviation, CI: Confidence interval

**Table 5: Comparison of serum magnesium levels between cases and controls**

| Serum magnesium (mg/dl) | Cases *n*=75 (%) | Controls *n*=35 (%) |
|---|---|---|
| <1.8 | 29 (38.6) | 1 (2.9) |
| 1.8-2.5 | 45 (60.0) | 32 (91.4) |
| □2.5 | 1 (1.4) | 2 (5.7) |

**Table 6: Effect of level of control of DM on serum magnesium**

| Serum magnesium | Controlled (*n*=37) | Uncontrolled (*n*=38) |
|---|---|---|
| Range (Min-Max) | 1.5-2.7 | 1.1-2.1 |
| Mean±SD | 2.04±0.29 | 1.73±0.23 |
| 95% CI | 1.94-2.13 | 1.65-1.81 |
| *P* | □0.001 | |

SD: Standard deviation, CI: Confidence interval, DM: Diabetes mellitus

**Table 7: Effect of type of treatment on serum magnesium**

| Serum magnesium | Insulin (*n*=12) | OHAs (*n*=33) |
|---|---|---|
| Mean (Min-Max) | 1.4-2.0 | 1.5-2.4 |
| Mean±SD | 1.72±0.22 | 1.99±0.31 |
| 95% CI | 1.58-1.87 | 1.88-2.10 |
| *P* | 0.013 | |

SD: Standard deviation, CI: Confidence interval, OHA: Oral hypoglycemic agent

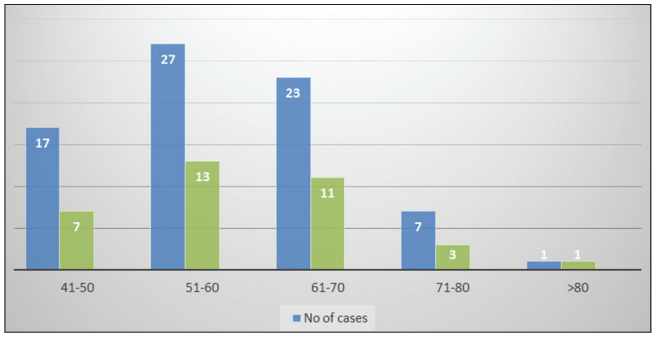


**Figure 1: Age distribution among cases and controls**

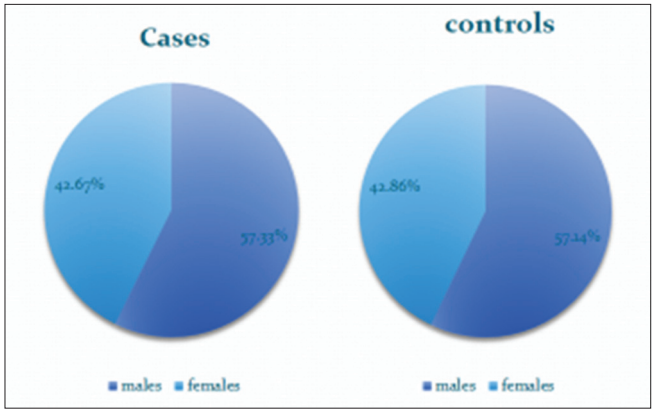


**Figure 2: Gender distribution among cases and controls**

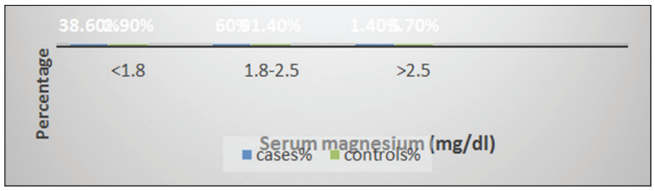


**Figure 3: Comparision of serum magnesium levels in cases and controls**

## CONCLUSION

1. Serum magnesium levels were low in Type 2 diabetics when compared to controls
2. Levels of serum magnesium were further lower in uncontrolled Type 2 diabetics than those in whom diabetes was controlled
3. Hypomagnesemia was associated with diabetic retinopathy and diabetic nephropathy
4. No correlation was found in respect to neuropathy and ischemic heart disease
5. More the duration of diabetes and the levels of FBS, lower was the serum magnesium levels
6. Patients on insulin had lower levels of serum magnesium as compared to patients on OHAs
7. Hypomagnesemia is a factor in Type 2 diabetes and associated with various complications. Hence, it is worth measuring serum magnesium levels in patients with type DM and probably correlates their relationship with various complications.

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