INTRODUCTION

Magnesium is second most common intracellular cation and fourth most common cation in the body.\(^1\) It serves as a cofactor in more than 320 enzymatic reactions involving energy metabolism and particularly in insulin action.\(^2,3\) In this regard we have studied the serum magnesium levels to know its relationship with type 2 diabetes mellitus (type 2 DM) and also to evaluate its association with the glycemic control.

MATERIALS AND METHODS

A total of one hundred and fifty subjects in the age group of 35-60 years attending medical OPD of Rajarajeswari Medical College and Hospital, Bengaluru were included in the study. Hundred, diabetic patients were divided into two groups; group I-consisting of fifty subjects with poor glycemic control and group II-fifty subjects with good glycemic control. Fifty, non-diabetic apparently healthy volunteers were considered as group III.

Serum FBS and PPBS was estimated by GOD-POD method, Glycosylated Hemoglobin (HbA\(_{1c}\)) by particle enhanced immunoturbidimetric method and Serum Magnesium by Xylidil blue spectrophotometric method.

RESULTS

Mean serum magnesium level was 1.97 ± 0.43 mg/dl and 2.0 ± 0.22 mg/dl in type 2 DM patients and non-diabetic healthy volunteers respectively. Though there was no significant difference in serum magnesium levels between the three study groups, incidence of hypomagnesemia was high (38%) in diabetic group compared to non-diabetic healthy volunteers (12%). Group I subjects had high incidence of hypomagnesemia (40%) than group II (36%).

CONCLUSION

Hypomagnesemia is common among type 2 diabetics irrespective of glycemic control. This incidence is multifactorial and needs further investigation in larger population.

KEYWORDS: Type 2 DM; Serum Mg\(^{2+}\); glycemic control; hypomagnesemia.
Hemoglobin (HbA1c) was estimated by particle enhanced immunoturbidimetric method (kits supplied by Mindray). HbA1c is determined directly without measurement of total hemoglobin. Principle: Total hemoglobin and HbA1c in hemolysed blood bind with the same affinity to particles in latex buffer. The amount of binding is proportional to the relative concentration of both substances in the blood. Mouse anti-human HbA1c monoclonal antibody binds to particle bound HbA1c. Goat anti-mouse IgG polyclonal antibody interacts with the monoclonal mouse anti-human HbA1c antibody and agglutination takes place. The measured absorbance is proportional to the HbA1c bound to particles, which in turn is proportional to the percentage of HbA1c in the sample. Expected range: Nondiabetic: 4.0-6.0%, good control: <7%, poor control: >7.0%. Serum magnesium was estimated by XyliDil blue spectrophotometric method (Accucare kits). Magnesium in the serum reacts with XyliDil blue to form a colored compound in alkaline solution.

**STATISTICS**

This is a descriptive study. The data obtained was analyzed statistically using One way Anova calculator for independent measures. Pearson’s correlation coefficient was used to find out the correlation.

**RESULTS**

One hundred and fifty subjects in three groups were studied. We observed equal number of male and female subjects with average age of 45-55 years in each study group (table No.1).

### Table No. 1: Age distribution among cases and controls.

<table>
<thead>
<tr>
<th>Age in Years</th>
<th>Type II DM</th>
<th>Non-diabetic healthy volunteers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group I (Poor glycemic control)</td>
<td>Group II (Good glycemic control)</td>
</tr>
<tr>
<td>30-39 Years</td>
<td>13 HbA1c &gt;7mg/dl</td>
<td>06 HbA1c &lt;7mg/dl</td>
</tr>
<tr>
<td>40-49 years</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>50-59 years</td>
<td>09</td>
<td>12</td>
</tr>
<tr>
<td>60-70 years</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Total Study subjects</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

Mean FBS and PPBS levels in three study groups was as follows (table No. 2). There was significant difference in FBS, PPBS and HbA1c levels among the three study groups at p<0.001.

### Table No. 2: FBS and PPBS among the study groups.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Type II DM</th>
<th>Non-diabetic healthy volunteers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group I</td>
<td>Group II</td>
</tr>
<tr>
<td>FBS</td>
<td>204.54 ± 77.04</td>
<td>127.82 ± 45.05</td>
</tr>
<tr>
<td>PPBS</td>
<td>310.7 ± 83.36</td>
<td>208 ± 80.96</td>
</tr>
<tr>
<td>HbA1C</td>
<td>8.179 ± 0.89</td>
<td>6.078 ± 0.639</td>
</tr>
</tbody>
</table>

Mean serum magnesium level in hundred type 2 DM patients and fifty non-diabetic healthy controls was 1.97 ± 0.43 mg/dl and 2.05 ± 0.22 mg/dl respectively. Mean serum Mg$^{2+}$ levels in group I and II with p values are as follows (table No. 3).

### Table No. 3: Serum magnesium levels among the three study groups.

<table>
<thead>
<tr>
<th>Type II DM</th>
<th>Healthy volunteers (50 subjects)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum Mg$^{2+}$ levels in mg/dl</td>
<td>2.05</td>
<td>0.88</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>1.972 ± 0.43</td>
<td>0.35</td>
</tr>
<tr>
<td>Group I (50 subjects)</td>
<td>1.96 ± 0.43</td>
<td></td>
</tr>
<tr>
<td>Group II (50 subjects)</td>
<td>1.98 ± 0.43</td>
<td>0.22</td>
</tr>
<tr>
<td>Group I and II</td>
<td>0.79</td>
<td></td>
</tr>
</tbody>
</table>

p value >0.1 not significant, p <0.05 moderately significant, p<0.001 highly significant
Serum Mg$^{2+}$ was in the lower limit of reference range (1.9-2.5mg/dl) in both the diabetic groups. Even though there was no significant difference in serum magnesium level among the study groups, high incidence (38%) of hypomagnesemia (serum Mg$^{2+}$ < 1.9mg/dl) was observed in diabetics compared to healthy volunteers (12%). Incidence of hypomagnesemia was high in group I (40%) subjects compared to group II (36%) subjects. (Refer figure No. 2).

**Table No. 4: Serum magnesium levels among the Hypomagnesemia patients of the three study groups.**

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of patients with hypomagnesemia</th>
<th>Serum Mg$^{2+}$ levels (Mean ± SD in mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>20</td>
<td>1.54 ± 0.27</td>
</tr>
<tr>
<td>Group II</td>
<td>18</td>
<td>1.58 ± 0.24</td>
</tr>
<tr>
<td>Group III</td>
<td>6</td>
<td>1.7 ± 0.014</td>
</tr>
</tbody>
</table>

Even in subjects with hypomagnesemia, there was no significant difference in serum magnesium levels among the three study groups.

The Pearson correlation co-efficient is used to measure the strength of a linear association between two variables, where the value $r = 1$ means a perfect positive correlation and the value $r = -1$ means a perfect negative correlation. The value nearer to the zero, weaker is the relationship.

**Figure No. 4: Correlation graph between HbA$\text{_{1c}}$ and serum Mg$^{2+}$ levels in Group I and Group II. (Variables: X = HbA$\text{_{1c}}$ values, Y = serum Mg$^{2+}$ values).**

A weak negative correlation was observed between HbA$\text{_{1c}}$ and serum Mg$^{2+}$ level among the two diabetic groups with $r = -0.0726$ and $r = -0.2387$ respectively.

A weak negative correlation was observed between HbA$\text{_{1c}}$ and serum Mg$^{2+}$ level even in subjects with hypomagnesemia of two diabetic groups with $r = -0.2684$ and $r = -0.1953$ respectively.
DISCUSSION

Type 2 diabetes mellitus and its complications are increasing alarmingly worldwide. Hence the disease has to be treated meticulously, considering every potential complicating factor. Type 2 DM is characterized by insulin resistance and relative insulin deficiency.

Intracellular magnesium (Mg²⁺), a macro mineral plays a key role in regulating insulin action and in glucose uptake via insulin receptor mediated tyrosine kinase activity. In addition Mg²⁺ is a cofactor for several enzymes of carbohydrate metabolism. Magnesium deficiency thus contributes to insulin resistance. Impaired metabolism of Mg²⁺ may have a contributory role in the progression of DM and its complications.

In this study, mean serum Mg²⁺ level was within the reference range in all the three study groups and the serum Mg²⁺ level among the diabetics was towards the lower limit of the reference range. Though there was no significant difference in serum Mg²⁺ level among the three study groups, we observed high incidence of hypomagnesemia in type 2 DM patients (irrespective of the glycemic control) compared to non-diabetic healthy volunteers. Hypomagnesemia has been reported to occur with increasing frequency among diabetics. The reasons for magnesium deficiency in diabetes are not very clear. This could be due to higher urinary loss (glomerular hyperfiltration) and lower dietary intake/impaired absorption.

In addition, increased gastrointestinal loss as a result of autonomic dysfunction, osmotic diuresis due to glycosuria, hereditary factors, altered insulin metabolism, recurrent metabolic acidosis, hypophosphataemia, hypokalaemia, concomitant use of diuretics and hypolipidemic drugs may all contribute to hypomagnesaemia in diabetic patients. Renal function is said to be the major regulator of the serum Mg²⁺ level. Rude R K et al in his study says that approximately one-third of patients with type 2 diabetes have hypomagnesemia, mainly caused by enhanced renal excretion.

Similar to our study findings, few authors found no significant difference in serum magnesium level in diabetic patients as compared to controls. Contrary to our findings, majority of the researchers observed statistically significant decrease in serum Mg²⁺ levels in diabetics. This observation may be due to differences in the selection of the study subjects like socioeconomic status, duration of the disease, glycemic control. Literature search shows that hypomagnesemia is linked to poor control of type 2 diabetes mellitus and depletion of serum magnesium occurs exponentially with duration of disease and also magnesium supplementation improves insulin sensitivity.

Though there was no significant difference in serum magnesium levels among group I and II, we observed hypomagnesemia in 40% of subjects in group I and 36% of subjects in group II. Even among these subjects we did not observe significant difference in the serum magnesium levels, but we observed a weak negative correlation between HbA1c and serum magnesium level. Whether hypomagnesemia is a cause or consequence of diabetes is still debatable, but literature search reveals that it contributes to the development and progression of diabetic complications. Hypomagnesemia is potential cause of hypocalcemia in diabetics. Unlike hypomagnesemia, hypocalcemia is well recognized and treated condition in clinical practice. Since “Mg²⁺” is a cofactor for several enzymes of carbohydrate metabolism. Magnesium deficiency thus contributes to insulin resistance. Impaired metabolism of Mg²⁺ may have a contributory role in the progression of DM and its complications.

CONCLUSION

Hypomagnesemia is common among type 2 diabetics, irrespective of glycemic control. This incidence is multifactorial and needs further investigation in larger population. It may be judicious in clinical practice to do routine surveillance and regular monitoring of serum magnesium to delay the complications associated with it.

LIMITATION OF THE STUDY

It is a cross sectional study with small sample size.

ACKNOWLEDGEMENTS

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REFERENCES

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