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A Study on Serum Magnesium Levels and their Association with Glycemic Status in Patients with Type 2 Diabetes Mellitus An Observational study

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ABSTRACT

The aim of the present study was to find the status of Serum magnesium in patients of type 2 diabetes mellitus (type 2 DM). This investigation was conducted as an observational cross-sectional study for a period of 10 months, after approval from the institutional ethics committee. All individuals previously diagnosed with type 2 diabetic mellitus (type 2 DM) and who received a diagnosis upon admission were included in the study. The research had 50 patients who willingly participated and visited for regular blood examinations. Out of the total, 32 individuals, accounting for 64% of the sample, fell within the age range of 41-60 yrs. Additionally, 10 individuals, representing 20% of the sample, were between the ages of 19 and 40 yrs. The remaining 8 individuals, making up 16% of the sample, were aged between 61 and 80 yrs. The gender distribution consisted of 46% men and 54% females. Out of the total, 24 individuals (48%) had been diagnosed with diabetes for a duration of 11-20 yrs, 16 individuals (32%) had been diabetic for 0-10 yrs, 8 individuals (16%) had been diabetic for 21-30 yrs and 2 individuals (4%) had been diabetic for more than 30 years. The laboratory reports indicated a statistically significant difference in the average total leukocyte count, Serum glutamic pyruvic transaminase (SGPT), serum glutamic oxaloacetic transaminase (SGOT), K+, Random blood sugar (RBS) and HbA1c levels between patients with hypomagnesemia and patients with normomagnesemia ($p < 0.05$). There were no notable disparities in any laboratory data between the two groups. The disparity in serum magnesium levels in relation to HbA1c was found to be statistically significant. The current investigation has demonstrated that hypomagnesemia is associated with impaired glycemic control, hence increasing the risk of diabetes complications. Early identification via the use of oral magnesium supplements as a treatment method may prevent this: nevertheless, further study is needed to determine the potential impact of magnesium therapy in preventing the development of diabetic complications.

INTRODUCTION

Type 2 diabetes accounts for 90% of all instances of diabetes[1]. The estimated global prevalence is projected to reach 439 million by 2030[2]. According to the International Diabetes Federation and WHO, the prevalence of diabetes is 10% and more than 19% of the world's diabetic population consists of Indians[3,4]. Diabetes is a significant public health issue that is marked by long-term high blood sugar levels, resulting in problems such as damage to small blood vessels in the eyes (retinopathy), kidneys (nephropathy), heart (coronary artery disease) and brain (stroke)[5]. Magnesium is the second most prevalent positively charged ion found inside the cells of the body. It has a crucial function in several metabolic pathways, particularly in glucose metabolism, by serving as a cofactor for multiple enzymes. It has a crucial function in the production of insulin, the binding of insulin and the maintenance of homeostasis[6]. Insufficient amounts of magnesium have been shown to impair the function of tyrosine kinase activity and receptors that are crucial for signalling[7]. Type 2 diabetes mellitus is linked to deficiencies in both intracellular and extracellular magnesium[8].

Hypomagnesemia has been seen in 25%-38% of individuals with type 2 diabetes and is linked to higher rates of illness and death[10,11]. Hypomagnesemia has been linked to glucose intolerance, elevated blood sugar levels, reduced sensitivity to insulin, problems of diabetes and high levels of lipids in the blood[12]. Hypomagnesemia is a prevalent condition in diabetes individuals that is often not recognised properly. Recent research has shown that diabetes has the ability to directly cause hypomagnesemia and in turn, hypomagnesemia may trigger or exacerbate the development of diabetes mellitus[12].

Hypomagnesemia disrupts the function of Na+ K+ ATPase, a crucial enzyme involved in insulin-dependent glucose transport, post-receptor insulin activity and the exacerbation of insulin resistance. Possible causes of magnesium insufficiency include increased urine excretion, reduced food consumption, poor magnesium absorption. In comparison to those who are in good health[13]. The study revealed a significant correlation between inadequate glycemic management, insulin resistance and low magnesium levels and an elevated incidence of microalbuminuria[14]. The unfavourable correlation between magnesium consumption and diabetes mellitus may be attributed to the significant role played by systemic inflammation and insulin resistance. Therefore, the objective was to determine the level of serum magnesium in individuals diagnosed with type 2 diabetic mellitus (type 2 DM).

MATERIAL and METHODS

This investigation was conducted as an observational cross-sectional study over a period of 10 months, after approval from the institutional ethics committee. Only those who had previously been diagnosed with type 2 diabetic mellitus (type 2 DM) and were diagnosed upon admission were included in the study. The trial had 50 patients who voluntarily participated and visited for regular blood examinations.

Inclusion criteria: Patients with type 2 DM of age 18 yrs and above, who gave written informed consent, were included in the study.

Exclusion criteria: Patients receiving diuretics, those with chronic diarrhea, malabsorption syndrome, sepsis and those who were not willing to participate in the study were excluded.

Methods: The diagnosis of Type 2 DM was established according to the diagnostic criteria provided by the American Diabetes Association[15]. Diabetic retinopathy (DR) was detected by the use of fundus examination[16]. The diagnosis of diabetic nephropathy (DN) was established by identifying the presence of either macroalbuminuria or microalbuminuria. Microalbuminuria is characterised by an Albumin to creatinine ratio (ACR) ranging from 30-300 mg g^{-1}. Macroalbuminuria was characterised by an albumin to creatinine ratio (ACR) over 300 mg g^{-1}[17]. The diagnosis of diabetic neuropathy was established by the identification of clinical manifestations, including tingling and numbness. The serum magnesium (S.Mg) level was estimated using the Xylidyl blue colorimetric technique[18]. A level of 1.8-2.6 mg dL^{-1} was deemed to be within the usual range. Hypomagnesemia was defined as a concentration below 1.8 mg dL^{-1}.

A comprehensive medical history was obtained from the individuals and a thorough examination was conducted to identify microvascular problems associated with diabetes. Laboratory analyses were conducted to corroborate the outcomes of the evaluation. Every patient had a comprehensive evaluation including tests for complete blood count, urine analysis, microalbuminuria, fasting blood glucose, postprandial blood glucose, haemoglobin A1c (HbA1c), blood urea, serum creatinine, serum magnesium, abdominal ultra sonography and fundus examination. Additional diagnostic tests, including electrocardiography, 2D echocardiography and serum sodium and potassium measurements, were performed based on the specific medical indications.

Statistical analysis: The statistical analysis was conducted using IBM's Statistical Package for the Social Sciences (SPSS) version 24.0. The Pearson correlation coefficient was used to determine the link between the amount of serum magnesium (S. Mg) and diabetes control. The odds ratio was computed to determine the correlation between serum magnesium levels and diabetic retinopathy, as well as the correlation between serum magnesium levels and diabetic nephropathy.

RESULTS

Out of the total, 32 individuals, accounting for 64% of the sample, fell within the age range of 41-60 years. Additionally, 10 individuals, representing 20% of the sample, were between the ages of 19 and 40 yrs. The remaining 8 individuals, making up 16% of the sample, were aged between 61 and 80 yrs. The gender distribution consisted of 46% men and 54% females. Out of the total, 24 individuals (48%) had been diagnosed with diabetes for a duration of 11-20 yrs, 16 individuals (32%) had been diabetic for 0-10 yrs, 8 individuals (16%) had been diabetic for 21-30 yrs and 2 individuals (4%) had been diabetic for >30 yrs.

The laboratory reports indicated a statistically significant difference in the average total leukocyte count, Serum glutamic pyruvic transaminase (SGPT), serum glutamic oxaloacetic transaminase (SGOT), K+, Random blood sugar (RBS) and HbA1c levels between patients with hypomagnesemia and patients with normomagnesemia ($p<0.05$). There were no notable disparities in any laboratory data between the two groups. The difference of S. Mg level in relation to HbA1c was statistically highly significant.

Table 1: Demographic characteristics of the study participants

Variables	Sub-groups	N	Percentage
Gender	Male	23	46
	Female	27	54
Age groups	19-40 yrs	10	20
	41-60 yrs	32	64
	61-80 yrs	8	16
Duration of diabetes	0-10 yrs	16	32
	11-20 yrs	24	48
	21-30 yrs	8	16
	>30 yrs	2	4
Age (Mean ± SD)			53.27 ± 12.118

Table 2: Laboratory reports of the study population

	Mean±SD		
Laboratory report	Normo magnesemia	Hypo magnesemia	P
Hemoglobin	10.34±2.38	10.28±1.96	0.935
Total count	7542.78±2380.12	8426.14±2574.96	0.048
Platelets	2.04±0.86	2.12±0.84	0.512
Urea	36.82±16.54	43.08±25.75	0.64
Creatinine	1.26±0.94	1.56±1.34	0.150
SGPT	34.46±27.93	44.07±33.67	0.036
SGOT	32.28±21.43	45.43±28.63	0.001
Total bilirubin	1.12±0.83	1.23±0.68	0.412
Na+	135.32±3.77	135.74±2.86	0.432
K+	3.97±0.53	4.16±0.32	0.007
Cl	98.22±3.06	98.42±1.68	0.090
RBG	232.88±62.06	258.82±71.69	0.007
HemoglobinA1C	7.32±1.22	8.72±1.58	<0.001

Table 3: Status of magnesium level according to hemoglobinA1C

HbA1c	Normo-magnesemia	Hypo-magnesemia
Optimal (<7%)	18	4
Uncontrolled (>7%)	12	16
Total	30	20
p-value	<0.001	

DISCUSSIONS

Magnesium (Mg) is the second most prevalent cation found inside cells, behind potassium. It has the potential to affect the control of blood glucose metabolism by altering the production and activity of insulin.8 Hence, changes in the metabolism of this mineral might impact these activities, hence contributing to the development of obesity and insulin resistance[19,20]. Research and understanding of the correlation between diabetes and magnesium levels are increasing. Type 2 diabetes patients (T2DM) often have hypomagnesemia[21].

Diabetes mellitus is an endocrine disorder characterised by elevated metabolic stress and oxidative damage. Several trace elements and minerals play a crucial role in maintaining the proper functioning of our body. Prior research has highlighted the significance of serum magnesium and zinc in the pathophysiology and progression of magnesium levels in diabetes and carbohydrate metabolism[22]. Out of the total, 32 individuals, accounting for 64% of the sample, fell within the age range of 41-60 yrs. Additionally, 10 individuals, representing 20% of the sample, were between the ages of 19 and 40 yrs. The remaining 8 individuals, making up 16% of the sample, were aged between 61 and 80 yrs. The gender distribution consisted of 46% men and 54% females. Out of the total, 24 individuals (48%) had been diagnosed with diabetes for a duration of 11-20 yrs, 16 individuals (32%) had been diagnosed with diabetes for a duration of 0-10 yrs, 8 individuals (16%) had been diagnosed with diabetes for a duration of 21-30 yrs and 2 individuals (4%) had been diagnosed with diabetes for a duration of >30 yrs. Magnesium is crucial in the process of carbohydrate metabolism since it controls the activity of key enzymes that are involved in glycolysis, glucose regulation and insulin function. This includes the response of insulin receptors (tyrosine kinases) and the cascade of events triggered by insulin signalling. Magnesium has a role in controlling cellular glucose metabolism and the release of insulin. Additional metabolic processes that use magnesium as a cofactor or directly include lipid metabolism, as well as protein and nucleic acid synthesis. Magnesium has a stabilising function in proteins, nucleic acids and cellular membranes[23]. Given its participation in several metabolic processes: magnesium (Mg) may have a significant role in the development of problems. The research population's high incidence of hypomagnesemia may be attributed to the inclusion of individuals with type 2 diabetes lasting for a minimum of 5 yrs. In research conducted in Iraq, Saeed *et al*[24] found that the frequency of hypomagnesemia among diabetics was just 5%. The much lower occurrence seen in this study may be attributed to variations in race or dietary factors. The laboratory reports indicated a significant disparity in the average total leukocyte count, Serum glutamic pyruvic transaminase (SGPT), serum glutamic oxaloacetic transaminase (SGOT), K+, Random blood sugar (RBS) and HbA1c levels between patients with hypomagnesemia and patients with normomagnesemia ($p<0.05$). There were no notable disparities in any laboratory data between the two groups. The disparity in serum magnesium levels in relation to HbA1c was found to be statistically significant. Furthermore, there was a notable inverse relationship between S. Mg and HbA1c level ($r = -0.499$, $P = 0.001$), consistent with the findings of Aksit *et al*[25] ($r = 0.332$, $p<0.001$) and Yossef *et al*[26] ($r = 0.569$, $p<0.0001$).

The studies undertaken by Siddique *et al* and Al-Osali *et al* have similarly shown a negative association between them[27,28]. Hypomagnesemia impairs glycemic control by modifying cellular glucose transport, reducing pancreatic insulin secretion, interfering with post-receptor signalling and affecting the interaction between insulin and its receptor[29]. Additionally, it contributes to the development of microvascular problems associated with diabetes, such as progressive retinopathy, foot ulcers and nephropathy. Marhelle *et al.*[30] performed research which found an inverse relationship between blood magnesium levels and dyslipidaemia and hypertension. While several prospective cohort studies and meta-analyses have shown that magnesium intake reduces the occurrence of diabetes, the results remain inconclusive, necessitating more investigation to validate this relationship[31].

CONCLUSION

The current investigation has revealed that hypomagnesemia is associated with impaired glycemic control, resulting in the development of diabetes complications. Early identification via the use of oral magnesium supplements as a treatment method may prevent this: nevertheless, further study is needed to determine the potential impact of magnesium therapy in preventing the development of diabetic complications.

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