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TO STUDY SERUM MAGNESIUM LEVELS IN TYPE 2 DIABETES MELLITUS PATIENTS AND ITS CORRELATION WITH MODERATELY INCREASED ALBUMINURIA

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ABSTRACT

Aim: The aim of this study was to evaluate serum magnesium levels in patients with type 2 diabetes mellitus and investigate their correlation with moderately increased albuminuria.

Methods: This cross-sectional study was conducted in the Department of Medicine at Patna Medical College & Hospital, Patna, between March 2020 and October 2021, with a total of 100 patients enrolled using convenience sampling..

Results: This study investigated the relationship between serum magnesium levels and albuminuria in diabetic patients. A total of 100 participants, aged 30 to 70 years (mean age 55.24 ± 8.10 years), with a mean diabetes duration of 11.08 ± 5.26 years, were included. The cohort consisted of 63 males and 37 females, with the highest proportion in the 51–60 age group. Serum magnesium levels were low (<1.6 mg/dL) in 26% of patients and normal (1.6–2.4 mg/dL) in 74%, with a mean level of 1.91 ± 0.34 mg/dL. Microalbuminuria was observed in 38% of patients, while 62% had normoalbuminuria, with a mean microalbumin level of 60.54 mg/dL. Male predominance was noted in both groups, with 76.3% in the microalbuminuria group and 54.8% in the normoalbuminuria group. A statistically significant difference (p = 0.03) in serum magnesium levels was found between the two groups, with higher levels in the normoalbuminuria group (2.05 ± 0.26 mg/dL) compared to the microalbuminuria group (1.6 ± 0.32 mg/dL). These results indicate an association between lower serum magnesium levels and microalbuminuria, emphasizing the importance of monitoring magnesium to mitigate early renal complications in diabetic patients.

Conclusion: Serum magnesium levels were significantly reduced in patients with type 2 diabetes mellitus and showed an inverse correlation with urinary microalbumin. Hypomagnesemia was associated with poor glycemic control, and patients with low magnesium levels had higher mean microalbuminuria compared to those with normal magnesium levels. Thus, hypomagnesemia should be recognized as a risk factor for developing microalbuminuria in the early stages of diabetes mellitus. Furthermore, it was also significantly linked to the presence of diabetic retinopathy.

Keywords: Serum magnesium levels, type 2 diabetes mellitus patients, correlation, increased albuminuria

1. INTRODUCTION

Diabetes is poised to become one of the major global health challenges of the 21st century. By 2030, one in ten adults will have diabetes, with the number of people living with the condition projected to increase from 366 million in 2011 to 552 million if no urgent interventions are implemented. This equates to nearly three new cases every ten seconds, or almost ten million annually[1]. Chronic hyperglycemia in diabetes can eventually impair vital organs, particularly the heart, kidneys, blood vessels, nerves, and eyes. In addition to elevating the risk of coronary heart disease, diabetes increases the incidence of cerebrovascular events. It is also the leading cause of acquired blindness and accounts for approximately one-quarter of end-stage renal disease cases, as well as half of all non-traumatic lower limb amputations[2].

The adult human body (approximately 70 kg) contains 21 to 28 grams of magnesium, the fourth most abundant cation in the body and second only to potassium within cells. About 60% of magnesium is stored in bone, 20% in skeletal muscle, 19% in other cells, and 1% in extracellular fluid. Magnesium exists in protein-bound, complexed, or free forms and plays a crucial role in carbohydrate metabolism. It serves as a cofactor for all enzymatic reactions involving kinases[3]. Magnesium (Mg) is essential in various fundamental biological processes, including metabolism and DNA synthesis. Mg deficiency has been linked to endothelial dysfunction, inflammation, and oxidative stress—key contributors to atherosclerosis[4].

Hypomagnesemia has long been associated with diabetes mellitus. In diabetic patients, serum magnesium levels are directly related to cellular glucose utilization, independent of insulin secretion. Sufficient magnesium levels enhance tissue sensitivity to insulin, while magnesium deficiency is connected to diabetic microvascular complications. A deficiency of magnesium may contribute to complications such as retinopathy, thrombosis, and hypertension. Several studies have demonstrated that serum magnesium concentrations are lower in individuals with type 2 diabetes compared to healthy controls. Hypomagnesemia has also been confirmed in patients with diabetic retinopathy, with low magnesium levels predicting an increased risk of severe diabetic retinopathy[5].

Initially, hypomagnesemia in diabetes was attributed to (1) osmotic renal losses due to glycosuria, (2) reduced intestinal magnesium absorption, and (3) redistribution of magnesium from plasma into red blood cells via insulin's action. Recently, a specific tubular defect affecting magnesium reabsorption in diabetes has been proposed. Hypomagnesemia primarily results from impaired tubular absorption of magnesium[6]. Magnesium deficiency has been linked to poor glycemic control, while magnesium supplementation has been shown to improve insulin sensitivity[7].

The objective of this study was to assess serum magnesium levels in patients with type 2 diabetes mellitus and explore their correlation with moderately to severely increased albuminuria.

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MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Medicine at Patna Medical College & Hospital, Patna, from March 2020 to October 2021, involving 100 patients selected through convenience sampling.

Inclusion Criteria
Patients with type 2 diabetes mellitus (T2DM)
Age above 30 years

Exclusion Criteria
Type 1 diabetes mellitus
Long-term diuretic use
Malabsorption or chronic diarrhea
Bedridden patients
Patients on dialysis
History of chronic kidney disease
Acute myocardial infarction within the past 6 months
History of alcohol abuse
Patients on magnesium supplements or magnesium-containing antacids

Methodology
The study was initiated after obtaining approval from the Ethics Committee of Patna Medical College & Hospital, Patna. A total of 100 patients with T2DM attending the hospital's Medicine Department between March 2020 and October 2021 were included. A detailed history was collected from all participants, covering presenting complaints, symptoms, disease duration, complications, current medications, and associated conditions such as systemic hypertension and ischemic heart disease. Personal history, including alcohol consumption, smoking, exercise, and other addictions, was also recorded.

Blood samples were collected aseptically, with 5 ml drawn from the median cubital vein. The samples were left to clot for 30 minutes in a clean, dry test tube and then centrifuged for 20 minutes to separate the serum. The serum was stored at -80°C until analysis. Fasting blood sugar (FBS) and postprandial blood sugar (PPBS) were measured using the hexokinase method, and HbA1c was assessed via nephelometry. Serum magnesium levels were determined using the Calmagite dye method, with a reference range of 1.6–2.5 mg/dL.

Albuminuria was evaluated by calculating the urine Albumin-Creatinine Ratio (ACR) as follows:
ACR = Concentration of Albumin / Concentration of Creatinine (µg Albumin/g Creatinine)
<30 µg/g – Normal to mildly increased albuminuria (normoalbuminuria)
30–300 µg/g – Moderately increased albuminuria (microalbuminuria)

Statistical Analysis
Data were coded and entered into an MS Excel spreadsheet for consistency checks and verification. Any outliers were thoroughly reviewed. The final dataset was analyzed using SPSS (Statistical Package for the Social Sciences) version 19.0. Results were presented using frequency tables, cross-tabulations, and figures. Categorical data were expressed as frequencies

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and percentages, while continuous variables with normal distribution were reported as mean ± standard deviation. Chi-square tests were used to compare categorical variables, and independent unpaired t-tests and Pearson correlation coefficients were employed to analyze differences in mean levels. A p-value <0.05 was considered statistically significant.

2. RESULTS

Table 1: Demographic data

Age Group (years)	Frequency	Percentage
30-40 years	4	4.0
41-50 years	25	25.0
51-60 years	43	43.0
61-70 years	28	28.0
Mean Age	55.24±8.10	
Sex		
Male	63	63.0
Female	37	37.0
Duration of Diabetes		
<5 years	8	8.0
5-10 years	38	38.0
>10 years	54	54.0
Mean Duration	11.69±4.28	

The age of all patients included varied between 30-70 years with a mean age of 55.24±8.10 years. Maximum numbers of patients were in the age group of 51-60 i.e. about 43% of patients, followed by 28% between 61-70 years, 25% between 41-50 years and 4% patients between 30-40 years. Regarding sex distribution we found out of a total number of 100 cases, 63 were male and 37 were female. While analysing the duration of diabetes we found the mean duration of diabetes was 11.08±5.26 years among study subjects.

Table 2: Serum Magnesium Level and Urine Albumin Level

Serum Magnesium Level	Frequency	Percentage
<1.6 mg/dl (Hypomagnesemia)	26	26.0
1.6-2.4 mg/dl (Normal)	74	74.0
Mean ±SD	1.91±0.34	
Urine Albumin Level		
Normoalbuminuria <30 mg/l	62	62.0
30-300 mg/l	38	38.0

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It was observed that 26 (26%) had low level (<1.6 mg/dl) and 74(74%) had normal level (1.6-2.4). The mean serum magnesium level was found 1.91±0.34 mg/dl. It was observed that 38 (38%) patients had microalbuminuria and 62 (62%) had normoalbuminuria. The mean microalbumin level was found 60.54 mg/dl.

Table 3: Comparison of Urine Albumin level according to Sex

Sex	**Normoalbuminuria (n=62)**		**Microalbuminuria (n=38)**	
	Frequency	Percentage	Frequency	Percentage
Male	34	54.8	29	76.3
Female	28	45.2	9	23.7
Total	62	100.0	38	100.0
Statistical Inference	Chi- Square- 4.662		p Value-0.03	

It was observed that majority of the patients 76.3% in microalbuminuria group were male and it is 54.8% in normoalbuminuria group. The difference was statistically significant (p value=0.03) between two group.

Table 4: Comparison of Urine Albumin level according to Serum Magnesium Level

Serum Magnesium Level	**Normoalbuminuria (n=62)**		**Microalbuminuria (n=38)**	
	Frequency	Percentage	Frequency	Percentage
<1.6 mg/dl (Hypomagnesemia)	10	16.1	16	42.1
1.6-2.4 mg/dl (Normal)	52	83.9	22	57.9
Total	62	100.0	38	100.0
Statistical Inference	Chi- Square- 8.262		p Value-0.004	

It was observed that 10 (16.1%) patients had low serum magnesium in normoalbuminuria group and 16 (42.1%) in microalbuminuria group. The mean serum magnesium was found 2.05±0.26 mg/dl in normoalbuminuria and 1.6±0.32 mg/dl in microalbuminuria group. The difference was statistically significant (p value=0.004) between two groups.

Table 5: Comparison of various parameters according to urine albumin level

Variables	**Normoalbuminuria (n=62)**		**Microalbuminuria (n=38)**		**p value**
	Mean	±SD	Mean	±SD	
FBS (mg/dl)	135.61	±11.22	161.57	±21.66	<0.001
PPBS (mg/dl)	177.98	±17.82	239.34	±52.62	<0.001

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HbA1c (%)	6.98	±0.44	8.40	±0.94	<0.001
Serum Magnesium (mg/dl)	2.05	±0.26	1.60	±0.32	0.009
ACR (mg/g)	18.14	±7.72	150.83	±74.50	<0.001

It shows mean FBS (mg/dL) in normoalbuminuria and microalbuminuria were 135.61 ± 11.22 and 177.98 ± 21.66 (p value =< 0.001), and mean PPBS (mg/dl) in microalbuminuria were 161.7 ± 17.82 and 239.34 ± 52.62, respectively (p value =< 0.001). The mean HbA1c (%) in normoalbuminuria and microalbuminuria were 6.98 ± 0.44 and 8.40 ± 0.94, respectively (p value =< 0.001). The mean serum magnesium was found 2.05±0.26 mg/dl in normoalbuminuria and 1.6±0.32 mg/dl in microalbuminuria group. The mean SUACR (mg/g) in normoalbuminuria and microalbuminuria were 18.14± 7.72 and 150.83 ± 74.50(p value =< 0.001).

Table 6: Association of Hypomagnesemia with Retinopathy

Retinopathy	**Hypomagnesemia (n=26)**		**Normal Magnesium (n=74)**	
	Frequency	Percentage	Frequency	Percentage
Present	22	84.6	17	23.0
Absent	4	15.4	57	77.0
Total	26	100.0	74	100.0
Statistical Inference	Chi- Square- 30.7305		p Value- <0.0001	

In hypomagnesemia group 84.6% patients had retinopathy whereas in patients with normal magnesium level only 23% had diabetic retinopathy. There was significant difference among these two groups.

DISCUSSION

In developing countries, the rising prevalence of type 2 diabetes mellitus (T2DM) has led to increased morbidity and significant socioeconomic impact. In India, T2DM has become a silent epidemic, with over 60 million individuals estimated to be affected[8]. Although many studies on diabetes management have emerged, the latest treatment approaches may not be accessible to everyone, emphasizing the need for research focused on prevention and primary care[8]. Magnesium (Mg), the fourth most abundant cation in the human body, plays a vital role in fundamental biological processes, including metabolism and DNA synthesis. Mg deficiency has been associated with endothelial dysfunction, inflammation, and oxidative stress, which are key contributors to atherosclerosis[9].

In this study, the participants' ages ranged from 30 to 70 years, with a mean of 55.24 ± 8.10 years. Out of 100 cases, 63 were male, and 37 were female. The mean duration of diabetes was 11.08 ± 5.26 years, aligning with findings by Nayyar SB et al.[10], who reported similar results in their study. They observed that the study group's age varied between 40 and 70 years, with a mean age of 57.86 ± 9.55 years, while the control group ranged from 40 to 85 years, with a mean age of 59.20 ± 14.39 years. In Nayyar's study, the distribution of males

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and females was equal in the study group (50% each), while the control group consisted of 38% males and 62% females. They also found the mean duration of diabetes to be 11.08 ± 5.26 years in the study group compared to 8.80 ± 5.79 years in the control group, with a statistically significant difference (p = 0.042).

In our study, 26% of participants had low magnesium levels (<1.6 mg/dL), while 74% had normal levels (1.6–2.4 mg/dL), with a mean magnesium level of 1.91 ± 0.34 mg/dL. Shaikh MK et al.[11] reported a mean serum magnesium level of 1.34 ± 0.53 mg/dL, with hypomagnesemia detected in 14.5% of patients with type 1 diabetes and 85.5% of those with type 2 diabetes (p = 0.02). Similarly, Ferdousi S et al.[12] found that serum magnesium levels were significantly lower (p < 0.001) in type 2 diabetic patients compared to healthy controls, likely due to increased urinary excretion. In this study, 38% of patients had microalbuminuria, while 62% had normoalbuminuria, with a mean microalbumin level of 60.54 mg/dL. Xu B et al.[13] observed a lower prevalence of microalbuminuria (11.37%) in their population.

Our findings showed that 16.1% of patients in the normoalbuminuria group had low magnesium levels, compared to 42.1% in the microalbuminuria group. The mean serum magnesium levels were 2.05 ± 0.26 mg/dL in the normoalbuminuria group and 1.6 ± 0.32 mg/dL in the microalbuminuria group, with a statistically significant difference (p = 0.004). These results align with those of Rao PP et al., Anesh T et al., and T. Nasreen et al.[14–16]. We also observed that patients with microalbuminuria had poorer glycemic control. Significant differences in FBS, PPBS, HbA1c, and ACR were noted between the normoalbuminuria and microalbuminuria groups, with a significant negative correlation (r = -0.476, p < 0.05) between serum magnesium and urinary microalbumin levels.

Diabetic retinopathy, a leading cause of blindness, is associated with decreased visual acuity due to maculopathy or proliferative complications. Hypomagnesemia has been reported to occur more frequently in type 2 diabetic patients than in non-diabetics[17]. In our study, we found a significant association between serum magnesium levels and diabetic retinopathy (p < 0.001). Similar results were reported by Kundu et al.[18] and Kauser et al.[19], who observed that serum magnesium levels were significantly lower in diabetic patients with retinopathy compared to those without complications.
The terms microalbuminuria and normoalbuminuria have been updated for clarity. Microalbuminuria is now moderately increased albuminuria (ACR 30–300 mg/g), and normoalbuminuria is normal to mildly increased albuminuria (ACR <30 mg/g). These changes, recommended by KDIGO and ADA, aim to improve terminology, support early intervention, and enhance care for kidney and cardiovascular risks [20].

CONCLUSION

Serum magnesium levels were found to be significantly reduced in patients with type 2 diabetes mellitus and showed an inverse correlation with urinary microalbumin. Hypomagnesemia was associated with poor glycemic control, with higher mean microalbuminuria levels observed in patients with low magnesium compared to those with normal levels. Thus, hypomagnesemia should be considered a risk factor for the development of microalbuminuria in early-stage diabetes. Additionally, hypomagnesemia was strongly linked to diabetic retinopathy, highlighting the need for regular ophthalmic evaluations in affected patients. In conclusion,

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further large-scale studies and clinical trials are required to explore the impact of magnesium supplementation on diabetic complications and its potential role in mitigating microalbuminuria.

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