Evaluation of Serum Magnesium in Uncontrolled and Controlled Diabetes Mellitus

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Abstract

Introduction: Diabetes mellitus has increased incidence because of changing pattern of dietary and life style changes and stress. This metabolic disorder is associated with altered serum electrolyte levels like magnesium which may lead to serious complications if not detected early. **Objective:** To estimate and compare serum magnesium levels in uncontrolled and controlled diabetic groups. **Materials and Methods:**The study was conducted on 30 uncontrolled diabetic subjects with glycated haemoglobin ($HbA_1 c$) more than 7 and 30 controlled diabetic subjects with good glycemic control, $HbA_1 c$ less than 7. Serum magnesium levels were estimated in both the groups. Statistical analysis was done by using Graphpad Quickcalcs calculator. Student's unpaired t-test was done to compare between two groups and statistical significance was determined and expressed as P-value. **Results:**Serum magnesium levels expressed as mean ± S.D. was 1.440± 0.271 in uncontrolled diabetic group when compared to 2.033 ± 0.385 in controlled diabetic group. The decrease in serum magnesium levels in poorly controlled diabetics than in those diabetics with good glycemic control has a p-value < 0.0001 which is of extreme statistical significance. **Conclusion:**To conclude there was decreased serum magnesium in uncontrolled diabetics when compared to well controlled diabetics. This warrants the need for correction of hypomagnesemia in diabetics to prevent associated complications and morbidity.

Key Words: Diabetes mellitus, Glycated haemoglobin ($HbA_1 c$), Serum magnesium, Hypomagnesemia, Diabetes associated complications

Introduction

Diabetes mellitus is a chronic, non-communicable disease characterised by increased blood glucose levels or hyperglycemia which may be because of defective insulin secretion or increased resistance to insulin. There is alarming increase in diabetic case load in India. Apart from genetic causes, other contributing factors are obesity, changing dietary habits, sedentary life style, increased stress in day to day life. The estimates in 2019 showed that 77 million individuals had diabetes in India, which is expected to rise to over 134 million by 2045. [1] Also, there is increased morbidity and mortality associated with diabetes mainly because of consequent complications like nephropathy, neuropathy, retinopathy, involving microvascular and macrovascular changes. The scenario is not so dim. Diabetes be kept under control by following healthy lifestyle like taking proper diet restricting calories,regular exercise, doing yoga and meditation. This is apart from taking prescribed medications appropriately and following regular medical check-ups.

Glycated haemoglobin (HbA_1c) is most widely used investigation for evaluation of diabetes. It is superior to fasting blood glucose and post-prandial blood glucose which give information regarding blood glucose levels of prior 24 hrs. Glucose which is bound to haemoglobin present in RBC is more reliable parameter.The life-span of RBC being 120 days, HbA_1c or Glycated haemoglobin gives information about glucose control over past few months.

Diabetes being metabolic disorder is associated with alterations in lipid profile, certain minerals or electrolytes especially magnesium. It was found that insulin regulates magnesium levels in blood and hypomagnesemia associated with diabetes,[2,3,4,5,6] aggravates the related complications. Also magnesium effects the functioning of insulin. In the present study, serum magnesium levels were estimated in diabetic patients with uncontrolled glucose levels and compared with diabetics having good glycemic control.

Materials and methods

The study subjects were selected based on inclusion and exclusion criteria. Informed consent was taken from all the subjects following ethical quidelines.

Inclusion criteria : The study was conducted on 60 type -2 diabetic patients of atleast 5 years duration, 30 of them were grouped into uncontrolled diabetics, with glycated haemoglobin (HbA$_1$c) more than 7. Another 30 of them were grouped into controlled diabetics with good glycemic control, HbA$_1$c being less than 7.

Exclusion criteria:

1)Patients on magnesium supplementation or antacids containing magnesium.

2) Renal disorders

3) Gastrointestinal disorders

4) Endocrinal disorders

5) Hypertension

6) Those on diuretic therapy.

5ml of early morning venous blood sample was drawn from antecubital vein under strict aseptic conditions. Half of the sample is taken in test-tube containing EDTA which is used to estimate HbA$_1$c. The other half of the sample is centrifuged at the rate of 3000 rpm for 10minutes, and the separated serum is used to estimate serum magnesium by photocalorimetry method.

Statistical analysis of the obtained data was done using Graphpad Quickcalcs calculator and results were expressed as mean ± S.D. Statistical significance was determined by student's unpaired t-test to compare between the 2 groups and expressed as p-value.

Results:

The diabetics with HbA$_1$c less than 7 were included in controlled diabetics group. Their mean age was 52.03± 8.72 and estimated serum

magnesium was 2.033+0.385. The diabetics with HbA$_1$c more than 7 were grouped as uncontrolled diabetics, their mean age being 56.90±9.32 and serum magnesium was 1.440±0.271. It's evident that uncontrolled diabetics had lower serum magnesium Levels when compared to the diabetics with good glycemic control, and this decrease was statistically significant with a p -value of < 0.0001.

Table-1. Mean age in controlled and uncontrolled diabetic groups

Age	Controlled Diabetes Mellitus	Un Controlled Diabetes Mellitus
Mean±S.D	52.03±8.72	56.90±9.32
Minimum	41	40
Maximum	70	80

Table-2. Serum magnesium in controlled diabetic group and uncontrolled diabetic group

Serum Magnesium	Controlled Diabetes Mellitus	Uncontrolled Diabetes Mellitus	P-Value
Mean±S.D	2.033±0.385	1.440±0.271	<0.0001
Minimum	1.1	1	
Maximum	2.5	1.9	
95% C.I	1.889-2.177	1.339-1.541	

Graph-1. Serum magnesium in un controlled vs controlled diabetics
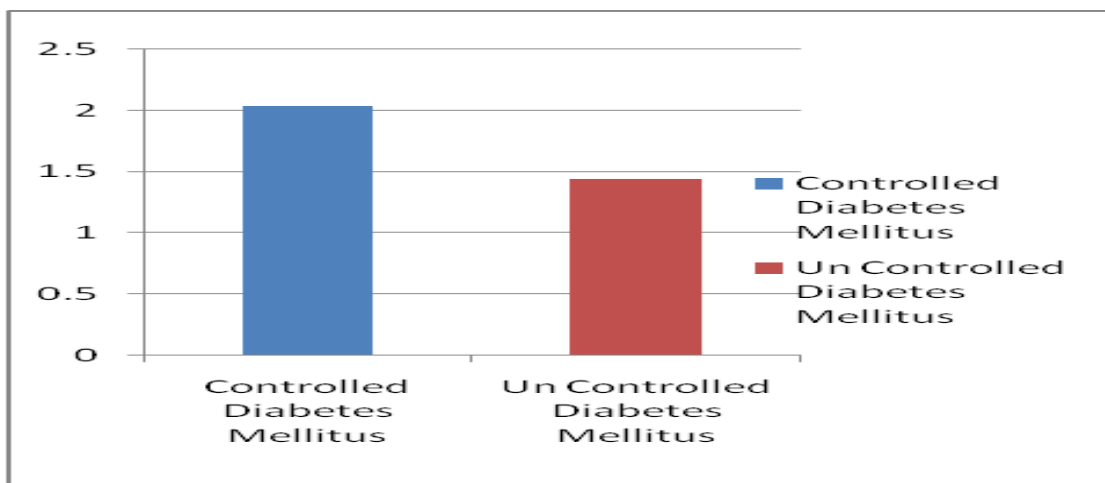
Discussion

Magnesium acts as co-factor for various enzymatic reactions and plays important role in energy metabolism. Insulin is one of the several factors regulating plasma and intracellular magnesium. Ingestion of glucose load was followed by insulin mediated shift of magnesium from extracellular to intracellular space thus decreasing plasma magnesium and increasing erythrocyte magnesium content.[7]

Daily magnesium intake should be 350mg/day in men and 300 mg/day in women. This intake was found to be below recommended dietary allowance in western countries. India is no way different from this condition. Hypomagnesemia found in diabetes mellitus impairs the action of insulin by causing defective tyrosine kinase activity at the insulin receptor level which further worsens insulin resistance. [8] Increased urinary losses of magnesium were reported in diabetic patients. Increased magnesium intake was associated with significant decrease in incidence of diabetes.[9] Magnesium is involved in insulin secretion, binding and action. Cellular deficiency of magnesium can effect even Na-K pump which is important for maintaining gradient of important ions like sodium and potassium and even glucose, ultimately influencing their transport across the cell membrane. [5,10]

The present study included 30 uncontrolled type 2 diabetics whose serum magnesium levels (1.440 ± 0.271) were lower than 30 controlled diabetics (2.033 ± 0.385). This study is in agreement with certain other studies, where serum magnesium in control group varied from 2.077 ± 0.27 to 2.30 ± 0.32 [2, 11, 12] and in uncontrolled diabetics varied from 118±0.22 to 1.94±0.05 [2, 11, 12]

It was concluded that serum magnesium level of poorly controlled diabetic patients was lower than that of well controlled diabetic patients. [12,13] These results suggest that magnesium deficient state can be one of the causes of insulin resistance.

In another study, done by Dipankar Kundu et al, serum magnesium levels in type 2 diabetic patients without retinopathy, with retinopathy and in healthy individuals were found to be (2.02±0.29), (1.38±0.39) and (2.03±0.25). [3]

In of the study conducted by Prabodh S et al [4] the mean magnesium levels in diabetic nephropathy cases (1.60±0.32) were significantly lower than healthy control group (2.14±0.16) with a p-value < 0.05.

Ranjith Kumar et al in their study [10] observed that serum magnesium in patients with and without diabetic nephropathy were 1.31 mg/dl and 2.08 mg/dl respectively which were statistically significant with p-value <0.0001

Hypomagnesemia has negative impact on insulin sensitivity in type 2 diabetic patients. It has been associated with greater risk for diabetic retinopathy and nephropathy.The more the deficiency, the more is the risk for serious complications. It was implicated in vasospasm, hypertension, altered platelet activity and in genesis of arrhythmias [14,15]

Hypomagnesemia seen in uncontrolled diabetes may be attributed to decreased dietary intake, comparatively impaired absorption of magnesium and increased urinary loss. [16] It was found that in type-1 and 2 diabetes, there was increased urinary excretion of magnesium. [17,18,19,20] Correlation between glycemic control and urinary magnesium loss was also reported. [19] Lesser the glycemic control, more is the urinary magnesium loss. It is a vicious cycle where decreased magnesium levels causes diabetes and diabetes leads to decreased magnesium levels.

This emphasises the need for maintaining normal magnesium levels apart from glycemic control in diabetics so that associated serious complications can be prevented.

Conclusion

To put it in nutshell, magnesium deficient state causes decreased insulin sensitivity or   increases insulin resistance. Hypomagnesemia when accompanies diabetes, leads to complications like diabetic retinopathy and nephropathy. Early detection and prompt correction of this electrolyte disturbance of hypomagnesemia can prevent or relieve diabetic associated complications. Magnesium supplementation and increased intake of magnesium rich foods in diabetics with hypomagnesemia prevents serious ontoward complications decreasing the associated morbidity and mortality, thus improving the quality of life in diabetics. Even in prediabetics correction of hypomagnesemia may prevent the incidence of diabetes by increasing insulin sensitivity combating insulin resistance.

Conflict of interest: There are no conflicts.

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References

1. *Rajendra Pradeepa and Viswanathan Mohan*. Epidemiology of type 2 diabetes in India. Indian J Ophthalmol. 2021 Nov; 69(11): 2932–2938.

2. *Nadler JL, Malayan S, Luong H, Shaw S, Natarajan RD & Rude RK*. Intracellular free magnesium deficiency plays a key role in increased platelet reactivity in type II diabetes mellitus. Diabetes Care. 1992 Jul;15(7):835-41.

3. *Dipankar Kundu et al*. Serum magnesium levels in patients with diabetic Retinopathy, J Nat Sci Biol Med. 2013 Jan;4(1):113-6.

4. *S. Prabodh et al*. Status of Copper and Magnesium Levels in Diabetic Nephropathy Cases: a Case-Control Study from South India: Biol Trace Elem Res. 2011 Jul;142(1):29-35.

5. *Ranjith Kumar GK, Santhosh P*. Study of Serum Magnesium Levels in Type 2 Diabetics. *Int J Med Res Rev.*2015;3(7):699-705.

6. *C. Anjani Kumar, Sumanas Gopal Datta Kolli, Seetha Katta and Shubha katta*. Serum magnesium levels in Type 2 Diabetes patients and its relation with diabetic nephropathy.International Journal of Medical Research and Health Sciences, 2018,7(7):90-94

7. *Paolisso G, Sgambato S, Passariello N et al*. Insulin induces opposite changes in plasma and erythrocyte magnesium concentration in normal man. Diabetologia 1986; 29: 644-647

8. *Giuseppe Paolisso, Mario Barbagallo*. Hypertension, Diabetes Mellitus and Insulin Resistance; The role tranellulet magnesium. American Journal of Hypertension, Volume Issue 3, March 1997 10, Pages 346-355.

9. *Colditz GA, Manson JAE, Stampfer M J et al*. Diet and risk of clinical diabetes in women. Am J Clin Nutr 1993; 55: 1018-1023.

10. *Nadler JL & Rude RK*. Disorders of magnesium metabolism. Endocrinol Metab Clin North Am. 1995 Sep; 24(3): 623-41.

11. *Jain AP, Gupta NN, Kumar A*. Some metabolic facets of magnesium in diabetes mellitus. J Assoc Physicians India. 1976 Dec;24(12):827-31.

12. *Nagase N et al.* Hypertension and Serum Mg in the Patients with Diabetes and Coronary Heart Disease: Hypertens Res. 1996 Jun;19 Suppl 1:S65-8.

13. *Paolisso G, Scheen A, D' Onfrio F, Lefebvre P*. Magnesium and glucose. Diabetologia. 1990 Sep; 33(9):511-4.

14. *Sasaki S, Oshima T, Mtsuura H, et al.* Abnormal magnesium status in patients with cardiovascular diseases. Clin Sci (Lond). 2000 Feb;98(2):175-81.

15. *Ma J, Folsom AR, Melnick SL, Eckfeldt JH, Sharrett AR, Nabulsi AA, Hutchinson RG & Metcalf PA*. Associations of serum and dietary magnesium with cardiovascular disease, hypertension, diabetes, insulin, and carotid arterial wall thickness: the ARIC study.Atherosclerosis Risk in Communities Study. J Clin Epidemiol. 1995 Jul;48(7):927-40.

16. *Monika KW, Michael BZ, Giatgen AS*. Richard FH, Low plasma magnesium in type 2 diabetes. Swiss Med Wkly. 2003 May 17;133(19-20):289-92.

17. *Johannson G, Danielson BG, Ljunghall S & Wibell L.* Evidence for a disturbed magnesium metabolism in diabetes- mellitus. Magnes Bull 1981; **2**: 178-180.

18. *Fujii S, Takemura T, Wada M, Akai T & Okuda K.* Magnesium levels in plasma, erythrocyte and urine in patients with diabetes mellitus. Horm Metab Res. 1982 Mar;14(3):161-2

19. *McNair P, Christensen MS, Christiansen C, Madsbad S & Transbol I.* Renal Hypomagnesaemia in human diabetes mellitus: its relation to glucose homeostasis. Eur J Clin Invest. 1982 Feb;12(1):81-5

20. *Sjögren A, Floren CH & Nilsson A.* Magnesium, potassium and zinc deficiency in subjects with type II diabetes mellitus. Acta Med Scand. 1988;224(5):461-6.