International Journal of Advances in Medicine
Wahid A et al. Int J Adv Med. 2017 Apr;4(2):311-316
http://www.ijmedicine.com
pISSN 2349-3925 | eISSN 2349-3933
DOI: http://dx.doi.org/10.18203/2349-3933.ijam20170614

Original Research Article

Study of serum magnesium level in patients with type 2 diabetes mellitus and it's correlation with glycosylated hemoglobin and diabetic complications

Abdul Wahid*, Girish C. Verma, C. P. Meena, A. R. Pathan

Department of Medicine, Government Medical College, Kota, Rajasthan, India

Received: 27 January 2017
Accepted: 11 February 2017

***Correspondence:**
Dr. Abdul Wahid,
E-mail: dr.wahidqureshi80@gmail.com

ABSTRACT

Background: Hypomagnesemia has been proposed as a novel factor implicated in the pathogenesis of poor glycemic control and diabetic complications. Aim of the present study is to study serum magnesium level in patients with type 2 DM and to find the correlation between serum magnesium levels, HbA1c and diabetic complications.
Methods: 100 patients with Type 2 DM (50 males and 50 females) who were diagnosed on the basis of ADA criteria or taking treatment for Diabetes were included in the study. All patients underwent tests for serum magnesium level, fasting blood sugar, postprandial blood sugar, HbA1c and also target organ evaluation for Diabetes. A detailed history and examination was also done.
Results: There was significant difference in the prevalence of hypomagnesemia (34% versus 6%) and serum magnesium levels (1.59±0.187 versus 1.78±0.126, p <0.0001) between diabetics and control group. FBS (172.17±30.55 versus 137.06±37.76, p<0.0001), PPBS (243±61.21 versus 195.84±59.1, p = 0.0003) and HbA1C (8.42±1.292 versus 7.04±0.956, p<0.0001) were significantly higher in hypomagnesemic diabetics as compared to normomagnesemic diabetics. Significant proportion of hypomagnesemic diabetics were suffering from retinopathy as compared to normomagnesemic diabetics (47.06% versus 19.70%, p = 0.0042). Diabetic nephropathy, neuropathy, hypertension and IHD were also higher in hypomagnesemic diabetics as compared to normomagnesemic diabetics, but insignificant.
Conclusions: Prevalence of hypomagnesemia in Type 2 diabetics was 34%. Diabetics with hypomagnesemia had poor glycemic control. Hypomagnesemia was significantly associated with diabetic retinopathy.

Keywords: Diabetic retinopathy, Glycosylated haemoglobin, Hypomagnesemia, Type 2 DM

INTRODUCTION

The term diabetes mellitus (DM, derived from Greek words meaning - Siphon and sweet) refers to a group of common metabolic disorders that share the phenotype of hyperglycemia which results from reduced insulin secretion and/or action, decreased glucose utilization, and increased glucose production. Incidence of diabetes is increasing worldwide due to population ageing and growth, obesity, unhealthy diets and sedentary life style. Microvascular and macrovascular complications of diabetes increase as a function of the duration of hyperglycemia. So, a reduction of chronic hyperglycemia prevents or delays these complications.[1]

Magnesium is an essential element and has a fundamental role in carbohydrate metabolism in general and in the insulin action in particular. Magnesium is a cofactor in

both glucose transport mechanism of the cell membranes and for various intracellular enzymes involved in carbohydrate oxidation.[2,3] Magnesium is involved in multiple levels in insulin secretion, binding and activity. Cellular magnesium deficiency can alter the activity of the membrane bound Na+K+ ATPase, which is involved in the maintenance of gradients of sodium and potassium and in glucose transport.

The concentrations of magnesium in serum of healthy people are remarkably constant, whereas 25-39% of diabetics have low concentrations of serum magnesium.[4-6] Hypomagnesemia in diabetics can be due to: osmotic renal losses from glycosuria, decreased intestinal magnesium absorption and redistribution of magnesium from plasma to red blood cells caused by insulin effect. Mc Nair P et al indicated that the net tubular reabsorption (in the thick ascending loop of Henle or more distally) of magnesium is decreased in diabetic patients in presence of hyperglycemia, leading to hypermagnesuria and hypomagnesemia.[17]

Magnesium depletion has a negative impact on glucose homeostasis and insulin sensitivity in patients with type 2 diabetes as well as on the evolution of complications such as retinopathy, arterial atherosclerosis and nephropathy.[7-11] Moreover, low serum magnesium is a strong, independent predictor of development of type 2 diabetes. In the atherosclerosis risk in communities (ARIC) Study, a dose response inverse relation between serum magnesium concentrations and the incidence of type 2 diabetes was observed amongst white participants.[12]

Several subsequent large prospective cohort studies have reported a statistically significant reduction in risk of type 2 diabetes associated with increased magnesium intake. In humans, several experimental metabolic studies have suggested that magnesium supplementation has beneficial effects on glucose metabolism, insulin action and⁄or insulin sensitivity.[13-15] In addition, cross-sectional studies have found an inverse association between magnesium intake and fasting insulin concentrations, a good marker of insulin resistance.[18]

High concentration of glucose can increase the glycation of hemoglobin, forming Glycosylated hemoglobin (HbA1c). It is a simple and economical way for assessment of long term glycemic control (6-8 weeks).[16] American Diabetes Association recommends twice per year measurements for patients who are meeting treatment goals and quarterly measurements for those whose therapy has changed or who are not meeting treatment goals.

The present study was undertaken with an aim to estimate prevalence of hypomagnesemia in patients with type 2 Diabetes mellitus and to correlate the serum magnesium concentrations with glycosylated hemoglobin (glycemic control), and with microvascular and macrovascular complications of diabetes.

METHODS

The subjects were selected from the cases presenting with diabetes mellitus in the OPD and ward of department of medicine, in MBS Hospital, Kota, Rajasthan. The study population consisted of 100 Diabetic (type 2) and 50 non-diabetic subjects. All the patients in the diabetic group were confirmed diabetics as per ADA criteria or were receiving treatment for diabetes mellitus. A detailed history was taken and examination done. Age- and sex-matched healthy volunteers without a history of diabetes were considered to be control subjects. All subjects were informed about the objectives of the study and an informed written consent was taken.

The study excluded patients with diabetes mellitus other than type2, critically ill patients (patients with significant hepatic and renal disease, haematological malignancy, chronic kidney disease, acute cerebrovascular accidents, acute myocardial infarction etc.), pregnant women with diabetes mellitus, patients receiving magnesium supplements or magnesium containing antacids, patients on diuretics, patients with history of alcohol abuse, malabsorption or chronic diarrhea, patients refusing to give informed consent for the study.

Blood samples were collected from all the 150 subjects. They were kept on overnight fast at least for 8 hrs before blood collection. 5 ml of venous blood was taken in dry disposable syringe under aseptic conditions in sterile, dry vial for biochemical analysis. Calmagite dye method was used for quantitative estimation of serum magnesium. FBS, PPBS, HbA1c, cholesterol, triglycerides, HDL, LDL, VLDL, blood urea, serum creatinine, SGOT and SGPT, were determined on semi-automated clinical chemistry analyzer.

Statistical analysis

The results were expressed as mean±SD of each variable. Student t test is used to compare parametric data. Chi square test used to compare groups wherever applicable. P value of <0.05 has been considered significant.

RESULTS

Prevalence rate of hypomagnesemia was 34% in the study group. The clinical and laboratory characteristics of the study patients according to the presence or absence of hypomagnesemia are showed in Table 1.

There was significant difference in respect to serum magnesium levels between the cases and controls, with low value in the case group (1.59±0.187 versus 1.78±0.126, $p<0.0001$) (Table 2).

Diabetic patients with hypomagnesemia did not differ from normomagnesemic diabetics in terms of age, sex, duration of diabetes and BMI. However, diabetic patients with hypomagnesemia had higher values of fasting

plasma glucose (Table 3), post prandial plasma glucose (Table 4) and HbA1c (Table 5) in comparison with the diabetic patients with normomagnesemia. Significantly higher proportion of diabetic patients with hypomagnesemia have found to be suffering from retinopathy as compared to normomagnesemic diabetics (47.06% versus 19.7%, p = 0.0042) (Table 6). Prevalence of diabetic neuropathy, nephropathy, hypertension and IHD were more in hypomagnesemic diabetics when compared with normomagnesemic diabetics, but found statistically insignificant.

Table 1: Clinical and laboratory characteristics of the study patients.

	Diabetic subjects with hypomagnesemia (n=34)	Diabetic subjects with normomagnesemia (n=66)	P value
Age (years)	59.7±9.37	54.21±9.84	0.085
Males/Females number (%)	19(55.8%)/15(44.1%)	31(46.9%)/35(53%)	0.3984
Duration of diabetes (years)	5.73±3.48	5.71±3.48	0.9797
Body mass index (Kg/m2)	31.36±4.67	30.92±5.5	0.6914
Fasting plasma glucose (mg/dl)	172.17±30.55	137.06±37.76	<0.0001
Post prandial plasma glucose(mg/dl)	243±61.21	195.84±59.1	0.0003
HbA1c (%)	8.42±1.292	7.04±0.956	<0.0001
Total cholesterol (mg%)	172.17±42.86	165.1±32.98	0.3625
HDL cholesterol (mg%)	39.82±10.44	40.83±9.69	0.6317
LDL cholesterol (mg%)	102.32±33.49	94.71±22.86	0.1835
Triglycerides (mg%)	151.14±46.28	148.51±48.29	0.7942
Serum magnesium (mEq/l)	1.39±0.077	1.69±0.139	<0.0001
Diabetics with complications (50)	22 (44%)	28 (56%)	0.0347
Diabetics without complications (50)	12 (24%)	38 (76%)	0.0347
Hypertension (yes) number (%)	9 (26.47%)	15 (22.73%)	0.6783
Retinopathy (yes) number (%)	16 (47.06%)	13 (19.7%)	0.0042
Nephropathy (yes) number (%)	7 (20.59%)	10 (15.15%)	0.4929
Neuropathy (yes) number (%)	10 (29.41%)	18 (27.27%)	0.8213
Coronary artery disease (yes) number (%)	7 (20.59%)	11 (16.67%)	0.6285
Values are given as mean±SD			

Table 2: Serum mg level in case and control groups.

Serum Mg	Group		t value	P value	Significance
	Diabetic	Control			
Mean±SD	1.59±0.187	1.78±0.126	6.4811	<0.0001	Highly significant

Table 3: Fasting blood glucose in case group subjects.

Parameter	Mean±SD		t value	P value	Significance
	Hypo magnesemia	Normo magnesemia			
FBS	172.17±30.55	137.06±37.76	4.6856	<0.0001	Significant

Table 4: Post prandial Blood glucose in case group subjects.

Parameter	Mean±SD		t value	P value	Significance
	Hypo magnesemia	Normo magnesemia			
PPBS	243±61.21	195.84±59.1	3.7346	0.0003	Significant

Table 5: Glycated haemoglobin in case group subjects.

Parameter	Mean±SD		t value	P value	Significance
	Hypo magnesemia	Normo magnesemia			
HbA1C	8.42±1.292	7.04±0.956	6.0481	<0.0001	Significant

Prevalence of hypomagnesemia in diabetics with microvascular complications was significantly higher when compared to diabetics with no complications (44% versus 24%). This difference was statistically significant ($\chi 2$ value is 4.456 and P value is 0.0347 at DF of 1) (Table 7).

Table 6: Distribution of retinopathy and serum mg in case group subjects.

Retinopathy	Group I Hypomagnesemia		Group II Normomagnesemia	
	No.	%	No.	%
Present	16	47.06	13	19.70
Absent	18	52.94	53	80.30
Total	**34**	**100**	**66**	**100**

$\chi 2 = 8.159$; d.f.= 1; P:0.0042; Significant

Table 7: Prevalence of hypomagnesemia and diabetic complications.

Complication	No. of patients	Hypomagnesemia	%
Only retinopathy +	13	8	61.54
Only nephropathy +	2	1	50
Only neuropathy +	16	4	25
Retinopathy and nephropathy +	7	3	42.86
Retinopathy and neuropathy +	4	3	75
Neuropathy and nephropathy +	3	1	33.33
Retinopathy, neuropathy and nephropathy +	5	2	40
With complications	50	22	44
Without complications	50	12	24

$\chi 2 = 4.456$; P value= 0.0347; DF=1.

DISCUSSION

In the present study, serum magnesium concentrations were below the reference range in 34 (34%) patients with type2 diabetes (case group) and in 6% of control group. This confirms to the reported prevalence of low plasma magnesium status in type-2 diabetics in several studies, which ranged from 25 to 39%.[4-6] Walti MK et al, reported a prevalence of hypomagnesemia in type 2 diabetics as 37.6% versus 10.9% in nondiabetic controls in a study conducted in Zurich, Switzerland.[19]

The reasons for the high prevalence of magnesium deficiency in diabetes are not clear, but may include increased urinary loss, lower dietary intake, or impaired absorption of magnesium compared to healthy individuals. Recently a specific tubular defect in magnesium reabsorption in thick ascending loop of Henle is postulated. This defect results in reduction in tubular reabsorption of magnesium and consequently hypomagnesemia. Increased urinary magnesium excretion due to hyperglycemia and osmotic diuresis may contribute to hypomagnesemia in diabetes. Insulin treatment has been shown to correct renal magnesium loss in diabetics.[17]

Our results confirm to the recent reports that have not shown any significant associations between sex, age, duration of diabetes and obesity with serum magnesium levels.[19-21] (Table 1) Walti MK et al and present study reported that diabetes treatment (insulin or OHA) did not significantly predict hypomagnesemia.[19]

Serum levels of magnesium have been found by several investigators to correlate inversely with fasting blood glucose concentration, post prandial blood glucose and the percentage of HbA1C.[8,20,22-25] The present study also revealed that patients with low serum magnesium levels had poor glycemic control. There was statistically significant association between low serum magnesium levels and higher FBS, PPBS and HbA1C%.

Hypomagnesemia is reported to be both a cause and result of poor glycemic control. In addition, magnesium deficiency has been shown to promote insulin resistance in multiple studies.[27-29] Nadler et al. have reported that insulin sensitivity decreases even in nondiabetic individuals after induction of magnesium deficiency.[7] Conversely, hyperglycemia and osmotic diuresis may lead to increased urinary magnesium excretion and hypomagnesemia in diabetics.[17]

Atherosclerosis risk in communities study, a cohort of 15,792 subjects were studied over 7 years and an increasing relative risk of coronary artery disease with decreasing serum magnesium was reported.[30] However, in present study no significant relationship was found

between hypomagnesemia and hypertension/IHD/lipid profile.

Hypomagnesemia has been reported in patients with diabetic retinopathy, with lower magnesium levels predicting a greater risk of severe diabetic retinopathy.[9,31] In our study there was a significant difference in prevalence of retinopathy between hypomagnesemic and normomagnesemic diabetics (47.06% versus 19.70%; P = 0.0042). Grafton et al. have proposed the inositol transport theory to explain this association, but the exact reason remains obscure.[3]

With reference to other diabetic microangiopathies, no significant association was found between prevalence of hypomagnesemia and diabetic neuropathy or diabetic nephropathy. Corsonello et al demonstrated significantly lower serum magnesium in type 2 diabetics with nephropathy compared to a normoalbuminuric group.[25,26] Pham PC et al demonstrated that lower (Mg2+) is associated with a faster renal function deterioration rate in type2DM patients.[32] Present study also found higher prevalence of diabetic nephropathy in hypomagnesemic diabetics compared to in normomagnesemic diabetics (20.59% versus 15.15%), but difference was statistically insignificant.

CONCLUSION

Prevalence of hypomagnesemia in type 2 diabetics is 34%. Hypomagnesemia is significantly associated with poor glycemic control. Hypomagnesemia is significantly associated with diabetic retinopathy. Hence, diabetic patients with hypomagnesemia must undergo frequent ophthalmic check-ups to rule out retinopathy. Thus according to our study Hypomagnesemia in diabetics can predict the poor glycemic control and diabetic Retinopathy.

ACKNOWLEDGEMENTS

Authors would like to thanks the help of MBS hospital laboratory and medicine ward nursing staff for their cooperation in the study.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Harrison's Principles of Internal Medicine; 18th Edition. McGraw Hill; 2011:2968-3002.
2. Garfinkel D. Role of magnesium in carbohydrate oxidation. Magnesium. 1988;7:249-61.
3. Grafton G, Baxter MA, Sheppard MC. Effects of magnesium on sodium dependent inositol transport. Diabetes. 1992;41:35-9.
4. Nadler JC, Rude RK. Disorders of magnesium metabolism. Endocrinol Metab Clinic North Am. 1995;24:623-41.
5. Ma J, Folsom AR, Melnick SL, Eckfeldt JH, Sharret AR, Nabulsi AA, et al. Associations of serum and dietary magnesium with cardiovascular disease, hypertension, diabetes, insulin and carotid arterial wall thickness. The atherosclerosis risk in communities (ARIC) study. J Clin Epidemiol. 1995;48:927-40.
6. Rude RK. Magnesium deficiency and diabetes mellitus - causes and effects. Postgrad Med J. 1992;92:217-24.
7. Nadler JL, Buchnan T, Natarajan R, Antonipillai I, Bergman R, Rude RK. Magnesium deficiency produces insulin resistance and increased thromboxane synthesis. Hypertension. 1993;21:1024-9.
8. Schlinger JL, Grunenberger F, Maier EA, Simon C, Chabrier G, Leroy MJF. Disturbances of plasma trace elements in diabetes - relations with glycemic control. Presse Med. 1988;17:10769.
9. McNair P, Christiansen C, Madsbad S, Lauritzen E, Faber O, Binder C, et al. Hypomagnesemia - a risk factor in diabetic retinopathy. Diabetes. 1978;27:1075-7.
10. Mather HM, Levin GE, Nisbet JA. Hypomagnesemia and ischemic heart disease in diabetes. Diabetes Care. 1982;5:452-3
11. Andrea C, Ricardo L, Michele B, Domenico C, Vittorio NM, Salvatore M, et al. Serum ionized magnesium levels in type-2 diabetic patients with microalbuminuria or clinical proteinuria. Am J Nephrol. 2000;20:187-92.
12. Kao WH, Folsom AR, Nieto FJ, Mo JP, Watson RL, Brancati FL. Serum and dietary magnesium and the risk for type 2 diabetes mellitus: The Atherosclerosis Risk in Communities Study. Arch Intern Med. 1999;159:2151-9 .
13. De Lordes Lima M, Cruz T, Pousada JC, Rodrigues LE, Barbosa K, Cangucu V. The effect of magnesium supplementation in increasing doses on the control of type 2 diabetes. Diabetes Care. 1998;21:682-6.
14. Garland HO. New experimental data on the relationship between diabetes mellitus and magnesium. Magnes-Res. 1992;5:193-202.
15. De Valk HW, Verkaaik R, Van Rijn HJM. Oral magnesium supplementation in insulin requiring type 2 diabetes mellitus. Diabet Med. 1998;15:503-7.
16. Sack DB, Bruns De, Goldstein DE, Maclaren NK, Mcdonald JM, Parott M. Guidelines and recommendations for laboratory analysis in the diagnosis and management of diabetes mellitus. Clin Chemis. 2002;48(3):436-72.
17. McNair P, Christiansen MS, Christiansen C, Madsbad S, Transbiol I. Renal hypomagnesemia in human diabetes mellitus: its relation to glucose homeostasis. European J Clin Invest. 1982;12:81-5.

18. Song Y, Buring JE, Manson JE, Liu S. Dietary magnesium intake in relation to plasma insulin levels and risk of type 2 diabetes in women. Diabetes Care. 2004;27(1):59-65.
19. Walti MK, Zimmermann MB, Hurrell RF. Low plasma magnesium in type 2 diabetes. Swiss Med Wkly. 2003;133:289-92.
20. Hamdan TK, Abbas MR, Ghassan AA. Hypomagnesemia and obesity in relation to insulin resistance and glycemic control in type 2 diabetic patients. Iraqi J Med Sci. 2011;9(2).
21. Lal J, Vasudev K, Kela AK, Jain SK. Effect of oral magnesium supplementation on lipid profile and blood glucose of patients with type 2 diabetes mellitus. JAPI. 2003;51:37-42.
22. Sales CH, Campos Pedrosa LF, Lima JG. Influence of magnesium status and magnesium intake on the blood glucose control in patients with type 2 diabetes. Clin Nutr. 2011;30(3):359-64.
23. Yajnik CS, Smith RF, Hockaday TD, Ward NI. Fasting plasma magnesium concentrations and glucose disposal in diabetes. BMJ. 1984;288:1032-4.
24. Alzaida A, Dinnean SF, Moyer TP, Rizza RA. Effects of insulin on plasma magnesium in non-insulin dependent diabetes mellitus: evidence of insulin resistance. J Clin Endocrinol Metab. 1995;80:1376-81.
25. Corica F, Corsonello A, Ientile R, Cucinotta D. Serum ionized magnesium levels in relation to metabolic syndrome in type 2 diabetic patients. J Am Col Nutr. 2006;25(3):210-5.
26. Serum ionized magnesium levels in type 2 diabetic patients with microalbuminuria or clinical proteinuria. Am J Nephrol. 2000;20(3):187-92.
27. Nagase N. Hypertension and serum magnesium in the patients with diabetes and coronary heart disease. Hypertens Res. 1996;19:65-8.
28. Tosiello L. Hypomagnesemia and diabetes mellitus. A review of clinical implications. Arch Intern Med. 1996;156:1143-8.
29. Dzurik R, Stetikova K, Spustova V. The role of magnesium deficiency in insulin resistance- an invitro study. J Hypertens. 1991;9(6):S312-3.
30. Liao F, Folsom AR, Brancati FL. Is low magnesium concentration a risk factor for coronary heart disease? The ARIC study. Am Heart J. 1998;136:480-90.
31. Hatwal A, Gujral AS, Bhatia RP, Agarwal JK, Bajpai HS. Association of hypomagnesemia with diabetic retinopathy. Acta Ophtalmol. 1989;67:714-6.
32. Pham PC, Pham PM, Pham PA, Miller JM, Yanagawa N. Lower serum magnesium levels are associated with more rapid decline of renal function in patients with diabetes mellitus type 2. Clin Nephrol. 2005;63(6):429-36.

Cite this article as: Wahid A, Verma GC, Meena CP, Pathan AR. Study of serum magnesium level in patients with type 2 diabetes mellitus and it's correlation with glycosylated hemoglobin and diabetic complications. Int J Adv Med 2017;4:311-6.