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Endocrinology

Serum Magnesium and Glycemic Status in Newly Diagnosed T2DM Patients in Tertiary Care Hospital of Bangladesh

Atikur-Rahman M[1*], Emon-Jarin[2], Fazlul-Hoque[3], Kamrul-Hasan ABM[4], Debasish-Ghosh[5], Shahjada-Selim[6], Fariduddin M[7], Hasanat MA[8]

[1]Junior Consultant, OSD-Directorate General of Health Services (DGHS), Working Deputation to Bangladesh National Parliament Secretariat Medical Centre, Department of Endocrinology, Dhaka, Bangladesh
[2]Junior Consultant, Kurmitola General Hospital, Department of Ophthalmology, Dhaka, Bangladesh
[3]Lecturer, Department of Community Medicine, Shahid Syed Nazrul Islam Medical College, Kishoregonj, Bangladesh
[4]Assistant Professor, Department of Endocrinology, Mymensingh Medical College, Mymensingh, Bangladesh
[5]Assistant Professor of Endocrinology, Khulna Medical College, Khulna, Bangladesh
[6]Associate Professor, Department of Endocrinology, BSMMU, Dhaka, Bangladesh
[7]Professor and Chairman, Department of Endocrinology, BSMMU, Dhaka, Bangladesh
[8]Professor and Course Co-ordinator, Department of Endocrinology, BSMMU, Dhaka, Bangladesh

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***Corresponding author:** Atikur-Rahman M
Junior Consultant, OSD-Directorate General of Health Services (DGHS), Working deputation to Bangladesh National Parliament Secretariat Medical Centre, Department of Endocrinology, Dhaka, Bangladesh

Abstract **Original Research Article**

Background: Diabetes mellitus is a major global health issue. Trace elements play important role as co-factors for various events in this context. Recently, an inverse relationship between serum magnesium and glycemic control has been observed and magnesium is thought to be low in with type-2 diabetes mellitus (T2DM). ***Objective:*** This study aimed to see serum magnesium and HbA_1c in newly diagnosed T2DM. ***Methodology:*** This cross-sectional study included 100 newly detected diabetes subjects (age: 40.65±11.65 years, mean ± SD; m/f: 35/65) diagnosed according to American Diabetic Association (ADA) 2016 diagnostic criteria for diabetes. 5 ml of blood was collected for serum magnesium and HbA_1c measurement by utilizing atomic absorption Spectrometricanalysis and NGSP certified Bio-Rad D-10™ Hemoglobin A_1c Program 220-0101 USA. All data were analyzed by SPSS (version 22.0). ***Results:*** Magnesium and HbA1c were 1.99±0.23 mg/dl and 8.65±2.18% (mean±SD). About 9% were hypomagnesemic and 91% eumagnesemic. Socioeconomically 50% were middle income group, family history was present in 48% and 11% had history of smoking. Magnesium (mean±SD) was statistically similar between males and females (1.99±0.22 vs. 1.99±0.24 mg/dl, p=0.974), urban and rural subjects (1.98±0.24 vs. 1.99±0.22 mg/dl, p=0.754), subjects with or without family history of diabetes (1.95±0.22 vs. 2.02±0.23 mg/dl, p=0.117), in subjects with BMI <25 Kg/m^2 and ≥25 Kg/m^2 (2.01±0.25 vs. 1.98±0.22 mg/dl, p= 0.526) as well as among various HbA1c cut-off values (<6.5 vs. 6.5− 9 vs. >9%: 2.08 ±0.15 vs. 1.98±0.24 vs. 1.99±0.23; p=0.257). However, magnesium level was statistically and significantly different among the age groups (<25 yrs vs. 25-34 yrs vs. 35-44 yrs vs. 45-54 yrs vs. ≥55 yrs: 1.91±0.28 vs. 2.00±0.23 vs. 1.93±0.20 vs. 1.96±0.26 vs. 2.16±0.13 mg/dl, mean±SD; p= 0.018). None of the variables showed any correlation with magnesium except age (r=0.220, p=0.028) nor any was significant independent predictor for hypomagnesemia. ***Conclusions:*** It is concluded that magnitude of derangement of magnesium in newly detected diabetes in Bangladesh may not remarkable. Glycemic status correlated poorly with serum magnesium. However, it has a inverse relationship with BMI and HbA1c. Large scale prospective studies are required before any conclusive comment is made.
Keywords: Type-2 diabetes mellitus (T2DM), serum magnesium level, glycemic status.

INTRODUCTION

Diabetes mellitus (DM) is a major noncommunicable disease, ranking as a leading cause of death and disability worldwide [1]. It is a metabolic disorder of multiple etiologies, characterized by chronic hyperglycemia together with disturbance of carbohydrate, fat and protein metabolism resulting from defects of insulin secretion, insulin action or both [2]. Many endocrine-related diseases including Diabetes mellitus (DM) have associations with magnesium deficiency or reduced dietary magnesium intake although the specific underlying mechanisms remain undefined [3]. Among these endocrinopathies, diabetes mellitus type II and metabolic syndrome have been highly correlated to low magnesium levels [4]. Type I (T1DM) and type2 (T2DM) both involve hypomagnesaemia, hypermagnesuria, and lower magnesium levels within tissues. More research has been conducted on T2DM, since 90-95% of diagnosed cases of diabetes are T2DM [3]. Numerous causes for low magnesium levels in diabetics can be listed including diets low in magnesium, osmotic diuresis that leads to high renal excretion of magnesium, insensitivity to insulin that affects intracellular magnesium transport and causes increased loss of extracellular magnesium, usage of loop and thiazide diuretics that promote magnesium wasting, diabetic autonomic neuropathies and reduced tubular reabsorption due to insulin resistance. Additionally, continuous magnesium deficiency correlates to higher levels of TNFα, which may also contribute to post-receptor insulin resistance [5].

Besides, HbA1c has now been recommended by an International Committee and by the ADA as a means to diagnose diabetes and reflects average plasma glucose over the previous eight to twelve weeks [6]. According to International Expert Committee diagnosis of diabetes can be made if the HbA1c level is 6.5%. Diagnosis should be confirmed with a repeat HbA1c test, unless clinical symptoms and plasma glucose levels >11.1mmol/l (200 mg/dl) are present in which case further testing is not required. Levels of HbA1c just below 6.5% may indicate the presence of intermediate hyperglycemia.

Objective

This study aimed to see serum magnesium and HbA1c in newly diagnosed T2DM.

METHODOLOGY

Study Design: Observational Cross-sectional study.

Place of Study: Department of Endocrinology, BSMMU.

Study period: December, 2015 to April, 2017.

Study Population:

Newly detected patients with type 2 diabetes mellitus attending the department of Endocrinology, BSMMU and on referral basis.

Sample Size Determination:

Sample size is determined by using the following formula,

$n = Z^2 p q / d^2$

Here, n = Minimum number of sample to be studied.

Z = Value of standard normal distribution (Z distribution) at a given level of Significance or at given confidence level (1.96% at level of 95% Confidence interval, which is constant).

p = Proportion or percentage of prevalence based on previous studies (66).

d = Margin of error over the prevalence (15% of 66).

q = 1- p = 100 – 66 = 34

So, using above formula, $n = [(1.96)^2 \times 66 \times 34] / [(15 \times 66) / 100]^2$

= 87.95 = 88

So intended sample size (n) = 88

For this study 100 subjects was enrolled.

Sampling Method:

Sample was collected consecutively from the day of commencement of the study till fulfilling required number.

Data Collection Technique: Prescribed data collection sheet (Appendix II).

Screening Method: Subjects was screened and diagnosed by ADA 2016 criteria for diagnosis of Diabetes.

Inclusion and Exclusion Criteria:

Inclusion criteria:

- Newly detected type 2 diabetes mellitus patients and
- Age ≥18 years.

Exclusion criteria:

- Patients with prediabetes, type 1 DM
- Patients on antidiabetic agents
- Patient received magnesium supplementation or taken drug that can modify magnesium metabolism e.g.Tetracycline's, Quinolones, Amiloride, ACE Inhibitors, Thiazide diuretics.
- Pregnant and lactating women.
- Persons suffering from chronic diseases e.g. Chronic diarrhoea, malabsorption syndrome, chronic liver disease, chronic kidney disease, cardiac failure, thyroid disorders, malignancy, alcoholics.

Study Protocol:

Subjects, recruited on the basis of ADA 2016 criteria for diagnosis of DM

↓

Before sampling written consent taken from the subjects after explained the steps and purpose of the study

↓

Data was collected using structured questionnaires and through

physical examination

↓

5 ml of venous blood taken from each subjects

↓

Serum was separated and stored in the department of Biochemistry,

BSMMU under – 20 ^{0} C until assay
↓
Assay of HbA1c of collected samples done in Department of Biochemistry and serum magnesium in Nutritional Biochemistry Laboratory, ICDDR, B at the convenience without causing any harm to quality
↓
Data was analyzed using computer based SPSS program (version 22.0)
↓
Observation, result and discussion
↓
Summary and conclusion.

Main Outcome Variables:

- Serum magnesium level
- HbA1c

Checklist of Variables:
Clinical Variables:
Height Weight Waist circumference Hypertension
Dyslipidemia Ischemic heart disease Cerebrovascular disease
Retinopathy Neuropathy Nephropathy

Biochemical Variables:
Fasting plasma glucose (FPG)
Plasma glucose 02-hr after 75 g glucose load
HbA1c
Serum magnesium
Serum creatinine
SGPT

Procedures of preparing and organizing materials:

Prior to commencement of the study ethical clearance was obtained from institutional review board (IRB) of BSMMU. Patients who fulfill the inclusion criteria and in the absence of exclusion criteria were included in the study. Samples were collected from Endocrine outpatient department of Bangabandhu Sheikh Mujib Medical University (BSMMU) after complete explanation of the steps and purpose of the study and taken written consent from patient. Data was collected in questionnaire after completion of history, physical examination. Then 5 ml blood was taken from each subject in two separate test tubes maintaining all aseptic precaution. Serum was separated and stored at Biochemistry department under – 20 ^{0} C for magnesium assay while HbA1c assay was done on the same day.

Analytic Method:
Assay of HbA1c:

HbA1c was measured using the NGSP certified Bio-Rad D-10^{TM} Hemoglobin A_1c Program 220-0101, USA. This is intended for the percent determination of hemoglobin A1c in human whole blood using ion-exchange high performance liquid chromatography (HPLC). The Bio-Rad D-10 Hemoglobin A_1c Program is intended for in vitro diagnostic use.

Principles of the test:

- The D-10 Hemoglobin A_1c Program utilizes principles of ion-exchange high-performance liquid chromatography (HPLC).
- The samples were automatically diluted on the D-10 and injected into the analytical cartridge.
- The D-10 delivers a programmed buffer gradient of increasing ionic strength to the cartridge, where the hemoglobins are separated based on their ionic interactions with the cartridge material.
- The separated hemoglobins then passed through the flow cell of the filter photometer, where the changes in the absorbance at 415 nm are measured.
- The D-10 performs reduction of raw data collected from each analysis.
- Two-level calibration is used for quantitation of the HbA1c values.
- A sample report and a chromatogram are generated for each sample.
- The A_1c peak is shaded. This area is calculated using an exponentially modified Gaussian (EMG) algorithm that excludes the labile A_1c and carbamylated peak areas from the A_1c peak area.

Assay of magnesium:

Serum magnesium was measured using Atomic Absorption Spectrometric Analysis (AASA). Atomic Absorption Spectrometry is generally accepted method for analysis of many metals. In a typical AASA method, sample were aspirated into a flame, where ions within the liquid are reduced to the atomic state. The metals in the atomic state can then quantitatively absorb light at the wavelengths characteristic of their resonance frequencies. Alternatively, the ions may either be chemically reduced by a cold vapor technique or be thermally reduced in a graphic furnace before analysis.

Atomic Absorption Spectroscopy may be defined as a method for determining the concentration of an element in a sample by measuring the intensity of external radiation absorbed by atoms produced from a sample at a wavelength characteristic for that element.

Features:

Atomic absorption refers to absorption of light at a specific wavelength by atoms or by an atomic vapor. These aggregates scatter a beam of light passed through the sample.

The amount of light absorbed at the characteristic wavelength will increase as a number of atoms of the selected elements in the light path increase.

The relationship between the amount of light absorbed and the concentration of the element present in known standards can be used to determine unknown concentrations of the sample (such as soil and plant extracts/ digest, fertilizer solution or water sample).

Digestion of the samples:

The samples were digested with concentrated nitric acid at low temperature for a relatively longer period of time for complete oxidation. When the contents became almost dry to dry water was added after cooling the beaker and the content was then filtered through filter paper of whatman No. 42. The absorption reading was taken in AAS (VARIAN).

Statistical Analysis:

Data was analyzed using computer based SPSS program (version 22.0). All data were expressed as frequencies and mean (±SD or ± SE). Comparison of magnesium and HbA1c between subgroups was done by Student's unpaired t-test or by One-way ANOVA. Pearson's correlation test was used to see correlation among different variables. P values ≤0.05 will be considered as significant.

The present study measured serum magnesium level in 100 newly diagnosed type 2 diabetic patients [age: 40.65±11.65years, (mean ± SD); Sex (m/f): 35/65)] recruited consecutively from the department of Endocrinology of BSMMU. Demographic characteristics of the participants are shown in Table-1. Of the total subjects, 54% were housewife, 14% service holder, 11% businessman and 5% unemployed. Socioeconomically 34% were in low income group, 50% average income and 16% from high income group. Family history of diabetes was present in 48% while 11% had history of smoking.

Table-1: Characteristics of the Newly Detected Type 2 Diabetes Subjects

Parameter	Values
N	100
Age (Years, mean ± SD)	40.65±11.65
Gender [N (%)]	
Male	35 (35%)
Female	65 (65%)
Occupation [N (%)]	
Service holder	14 (14%)
House wife	54 (54%)
Business	11 (11%)
Unemployed	55 (55%)
Others	16 (16%)
Socioeconomic status [N (%)]	
Low	34 (34%)
Middle	50 (50%)
High	16 (16%)
Family history of diabetes [N (%)]	48 (48%)
History of smoking [N (%)]	11 (11%)

Figure depicts the mean (1.99±0.23, mg/dl; mean±SD) and range (1.51 – 2.54 mg/dl) of magnesium. As shown in Figure-3, HbA1c level of the study subjects at the time of diagnosis was 8.65 (SD±2.18) and ranged from 5.8% to 14.5%. Figure-4 shows the magnesium status of the newly detected type 2 diabetes. Among the respondents 9% were hypomagnesemic and 91% were eumagnesemic.

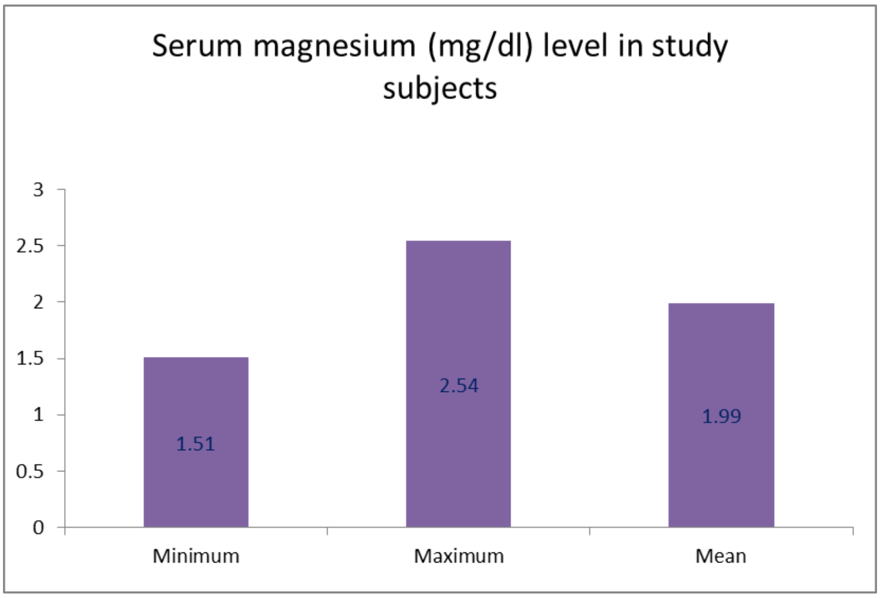


Figure-1: Magnesium level (mg/dl) of the newly detected type 2 diabetes subjects (N= 100) (mean±SD = 1.99±0.23, mg/dl)

Figure shows the magnesium status of the newly detected type 2 diabetes. Among the respondents 9% were hypomagnesemic and 91% were eumagnesemic.

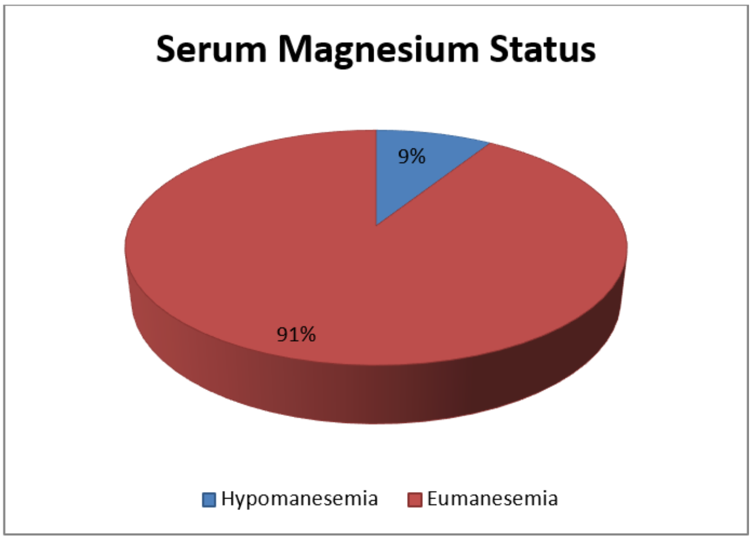


Figure-2: Serum magnesium status of the study subjects (N=100)

HbA1c level of the study subjects at the time of diagnosis was 8.65 (SD±2.18) and ranged from 5.8% to 14.5%.

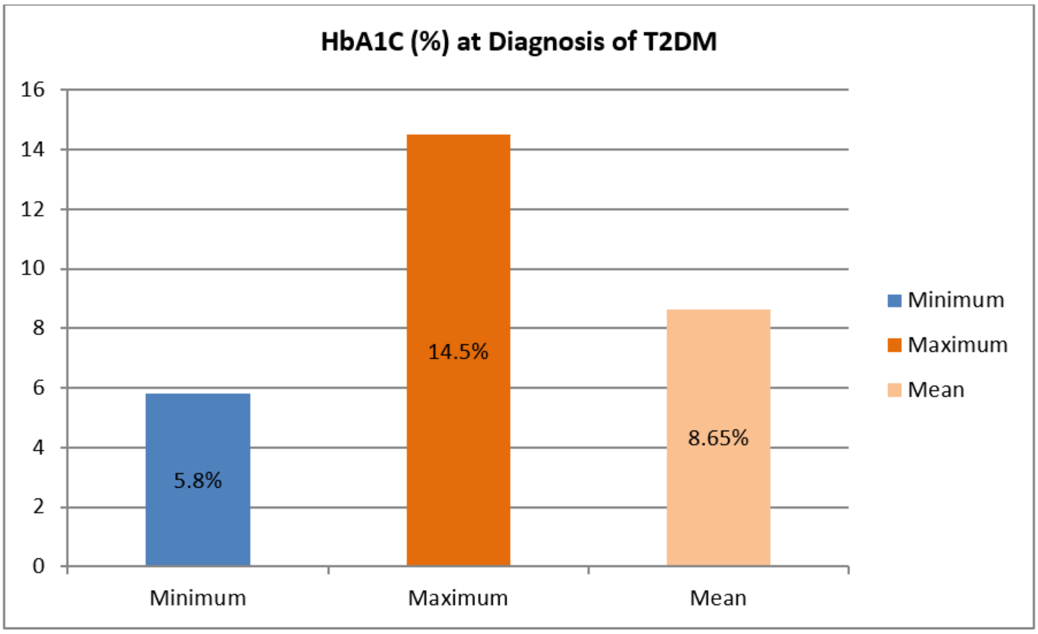


Figure-3: HbA1c of the newly detected type 2 diabetes subjects (N= 100)

Serum magnesium levels of females and males are shown separately in Table. There was no statistically difference for magnesium between male and females (1.99±0.22 vs. 1.99±0.24 mg/dl, mean±SD; p=0.974).

Table-2: Magnesium level (mg/dl) in newly detected type-2 diabetes: Gender difference

Gender	Magnesium Level (mean ± SD)	t , p
Male	1.99±0.22	t=0.033 p=0.974
Female	1.99±0.24	
Total	**1.99±0.23**	

By Student's t-test

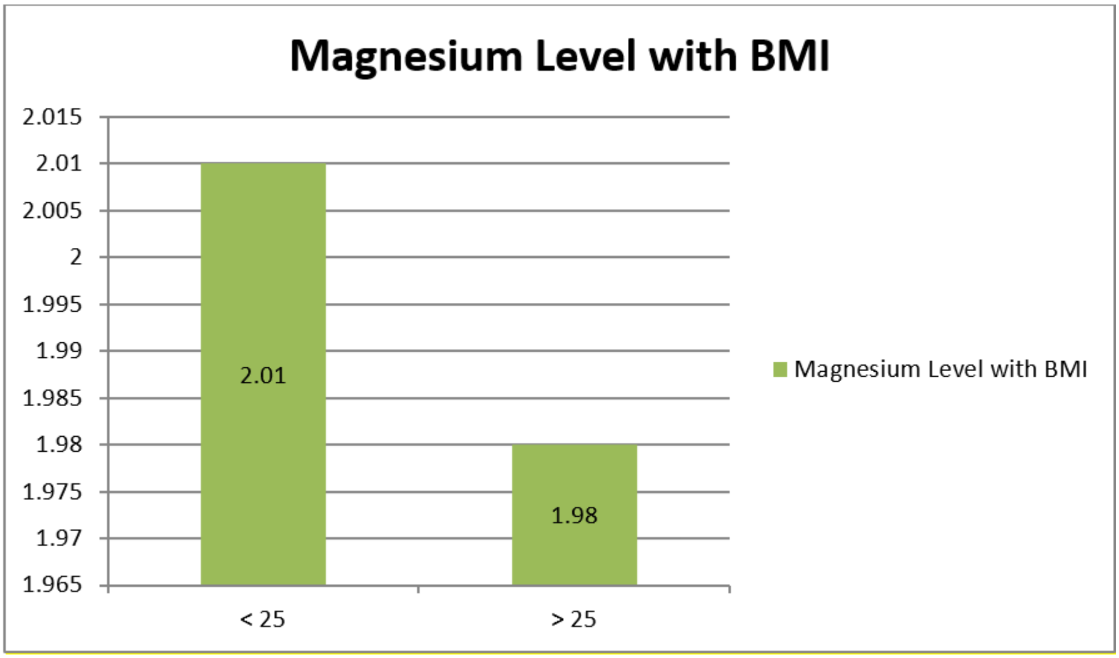
Magnesium level was statistically and significantly different among the age groups (<25 yrs vs. 25-34 yrs vs. 35-44 yrs vs. 45-54 yrs vs. □ 55 yrs: 1.91 ± 0.28 vs. 2.00±0.23 vs. 1.93 ± 0.20 vs. 1.96±0.26 vs. 2.16 ± 0.13 mg/dl, mean □ SD; p= 0.018).

Table-3: Magnesium level (mg/dl) in different age groups of the participants

Age group	Magnesium Level (mean ± SD)	95% CI	F, p
<25	1.91±0.28	1.65-2.17	F=3.139 P=0.018
25 – 34	2.00±0.23	1.90-2.10	
35 - 44	1.93±0.20	1.85-2.00	
– 54	1.96±0.26	1.84-2.08	
≥ 55	2.16±0.13*	2.09-2.23	
Total	**1.99±0.23**		

Data were expressed as mean±SD; p values was calculated by One- way ANOVA followed by post hoc test (LSD).

Figure shows serum magnesium level in diabetes under BMI categories divided at cut off 25 kg/m^2. There was no statistically significant difference for magnesium between the two groups (2.01±0.25 vs. 1.98±0.22 mg/dl, mean ± SD; p= 0.526).



By Student's t-test; t=0.636, p= 0.526

Figure-3: Magnesium level (mg/L) in newly detected type 2 diabetes: BMI group

There was no statistically significant difference for magnesium level among the various HbA1c cut off values (<6.5 vs. 6.5− 9 vs. >9%: 2.08 ±0.15 vs. 1.98±0.24 vs. 1.99±0.23; mean±SD; p=0.257).

Table-4: Magnesium level (mg/dl) in newly detected type 2 diabetes: HbA1c group

HbA1c %	Magnesium Level (mean ± SD)	F, p
<6.5	2.08 ±0.15	F= 0.658 P= 0.520
6.5-9	1.98±0.24	
>9	1.99±0.23	

By One-way ANOVA

Table depicts magnesium level of the subjects with or without existing comorbidities. There could be found no statistically significant difference of magnesium level for the comorbidities of (smoking positive vs. negative: 1.98±0.21 vs. 1.99±0.23, p=0.964), hypertension (2.00±0.23 vs. 1.99±0.24, p=0.690), dyslipidemia (2.01±0.23 vs.1.98±0.23; p=0.393), IHD (1.99±0.22 vs. 1.99±0.23, p=0.643), Diabetic retinopathy (2.04±0.30 vs. 1.98±0.22, p=0.696), Diabetic nephropathy (2.00±0.37 vs. 1.99±0.23, p=0.944), Diabetic neuropathy (2.00±0.33 vs. 1.99±0.22, p=0.933) (mean±SD).

Table-5: Magnesium level: relation with risk and co-morbidities

Risk factors	Magnesium Level (mean ± SD)		P
N=100	Positive	Negative	
Smoking	1.98± 0.21(n=11)	1.99±0.23(n=89)	0.964
Hypertension	2.00±0.23(n=22)	1.99±0.24(n=78)	0.690
Dyslipidemia	2.01±0.23(n=30)	1.98±0.23(n=70)	0.393
IHD	1.99±0.22(n=12)	1.99±0.23(n=88)	0.643
CVD	0	1.99±0.23(n=100)	
Diabetic retinopathy	2.04±0.30(n=6)	1.98±0.22(n=94)	0.696
Diabetic nephropathy	2.00±0.37(n=4)	1.99±0.23(n=96)	0.944
Diabetic Neuropathy	2.00±0.33(n=18)	1.99±0.22(n=82)	0.933

By Student's t-test; IHD= Ischemic heart disease, CVD= Cardiovascular disease

Table shows the correlations of magnesium with other variables. Age of the patients positively correlated with magnesium (r=0.220, p=0.028). However none of the other variables as: BMI (r=-0.095, p=0.347); FPG (r=-0.074, p=0.466); 2H PG (r=-0.098, p=0.331); HbA1c (r=-0.042, p=0.680); Serum creatinine (r=0.055, p=0.584); SGPT (r=-0.172, p=0.088). None of the variables showed any correlation with magnesium level.

Table-6: Correlation of magnesium with other variables:

Variables	r	p
Age and Serum Magnesium	0.220	**0.028**
BMI and Serum Magnesium	-0.095	0.347
FPG and Serum Magnesium	-0.074	0.466
Plasma Glucose 2 Hours and Serum Magnesium	-0.098	0.331
HbA1c and Serum Magnesium	-0.042	0.680
Serum creatinine and Serum Magnesium	0.055	0.584
SGPT and Serum Magnesium	-0.172	0.088

DM= Diabetes Mellitus; FPG= Fasting Plasma Glucose; HbA1c= Glycated Hemoglobin A1c; SGPT= Serum glutamic pyruvic transaminase by Pearson's correlation.

Table shows regression analysis for hypomagnesemia for multiple clinic-biochemical characters presence of microvascular complication or comorbidities. None [age (p=0.065), BMI (p=0.931), FPG (p=0.352), 2H PG (p=0.539), HbA1c (p=0.533), HTN (p=420), dyslipidemia (p= 0.998), IHD (p=0.528), retinopathy (p=0.484) , neuropathy (p=0.626) , nephropathy (p=0.213)] of the factors were shown to be statistically significant independent predictor for hypomagnesemia.

Table-7 Regression statistics of variables that influenced serum magnesium level (mg/dl) in newly detected type 2 diabetes patients

Independent variables	*β*	SE	P
Constant	1.354	0.500	0.008
Age	0.005	0.003	0.065
BMI	0.001	0.007	0.931
FPG	- 0.016	0.017	0.352
2H PG	0.001	0.002	0.539
HbA1c	- 0.006	0.026	0.533
HTN	-0.059	0.073	0.420
Dyslipidemia	.000	0.071	0.998
IHD	-0.062	0.097	0.528
Retinopathy	0.098	0.139	0.484
Neuropathy	-0.043	0.088	0.626
Nephropathy	0.213	0.170	0.213

BMI= Body mass index, FPG= Fasting plasma glucose, 2H PG= 2 hour after intake 75 gram glucose plasma glucose, HTN= Hypertension, IHD= ishcaemic heart disease

DISCUSSION

Magnesium level was found to be 1.99±0.23mg/dl (mean±SD). There was no statistically significant difference of magnesium level between different genders, rural and urban inhabitants, various BMI groups and educational levels, among subjects with or without family history of DM, nor even between the groups with or without various comorbidities. However, there were some differences among the age groups and with increment of age level of magnesium was found to increase and correlate positively and significantly though all age groups except few showed normal level of magnesium. Of the total, 9 (9%) subjects were found hypomagnesemic and rest 91 (91%) were eumagnesemic. Moreover, subjects having risk factors (smoking, HTN, dyslipidaemia) and complications of DM (IHD, CVD, retinopathy, nephropathy and neuropathy) showed magnesium level within normal limit. These findings are similar to findings by some investigators. 7-8 while does not match, rather contradict with findings by other group of investigators who concluded that low magnesium is common in type2 DM [9].

Type2 DM is a progressive disorder. There is progressive deterioration of glycemic control with increasing duration of the disease due to progressive beta cell failure and it accounts for the inadequacy of the treatment. Along with changes of glycemic status, other components and trace elements are suspected to show some changes of their concentration. Some investigators in our group have studied recently zinc level in newly diagnosed type2 diabetes; there was found no deficiency for zinc in newly diagnosed type2 diabetes (except a few) in that study [10]. In the present study, level of magnesium is studied; and except a few, most of the newly diagnosed type2 diabetic subjects had normal level of magnesium. Therefore, to understand the status of trace elements like magnesium and others, it seems wise to follow up the status of these trace elements over longitudinal period to assess whether with the elapse of time and increase of diabetes duration as well as derangement of glycemic control status, there are alterations of status of these trace elements. In this context, it is noted that though not significant and sample size was not adequate for such assessment, HbA1c was found inversely related with magnesium. Fasting and postprandial glucose levels do not truly reflect the overall status of control of diabetes. Therefore, glucose level should not be emphasized much in the context of such assessment of trace elements in diabetes. It should also be kept in mind that age and magnesium level was found positively and significantly correlated which should be taken into account while assessing the status of magnesium in diabetes. Thus, if any control group is taken in any study for assessing over trace elements, that should be age matched.

In the present investigation, statistically significant difference for magnesium level was found only among age groups. No statistically significant difference for magnesium was observed either among glycemic status groups, residence groups, socioeconomic classes or between genders or BMI groups. Apropos with this, level of magnesium showed no significant correlation with any of the factors as BMI, glycemic status, creatinine and SGPT but positively correlated with age of the participants. In this context, it can be mentioned that Zargar *et al.,* (1998) compared the levels of copper, zinc and magnesium in type-2 diabetes mellitus between diabetic and non-diabetic subjects [8]. They observed that age, sex, duration and control of diabetes did not influence the serum copper, zinc and magnesium concentrations. Their results were in agreement with observation in this study. However, as all the patients in the present study were newly diagnosed DM, influence of duration of DM over magnesium level could not be assessed. In context to our findings, Riaz *et al.,* (2012) at BIRDEM observed that the level of magnesium was lower in diabetic subjects; but they included diabetic patients who were admitted in hospital and were suffering from several other comorbidities. As mentioned earlier, HbA1c was inversely related with magnesium level though not statistically significant highlighting over the matter that glycemic control might be a related factor for the status of magnesium. This can be validated by large scale studies only.

The reasons explained by McNair P *et al.,* (1982) for their observance of high prevalence of magnesium deficiency in chronic and complicated diabetics are not clear. They put forward some reasons as: increased urinary loss, lower dietary intake or impaired absorption of magnesium compared to healthy individuals as the factors for such observation. 11 Tubular defect in magnesium reabsorption may also affect andresults in reduction in tubular reabsorption of magnesium and consequently hypomagnesemia. This area should be more extensively studied. 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 [12].

According to our study 35% of the study subjects had HbA1c > 9.0% though the magnesium level was within normal limit but lower than that in the group who had HbA1c< 6.5. Walti *et al.,* (2003) found that hypomagnesaemia was common in type2 DM but did not have any significant correlation with HbA1c. In contrast El-said *et al.,* (2015) and others found statistically significant negative correlation between serum magnesium levels and HbA1c. These debates need follow up studies to reach any conclusive inference [12].

About 66% of our subjects were overweight and obese. But this study couldn't find any risk relationship between parameter of BMI and serum magnesium level. However, it should be mentioned here that magnesium level was substantially lower in the group of our patients with BMI ≥25 kg/m^2 than that of BMI <25 kg/m^2 though not significantly different. Regarding family history, we found 48% of our patient had family history of diabetes. But important to observe that there was no statistically significant difference for magnesium level between groups with and without family history of diabetes. Neither between rural and urban nor among socioeconomic status there was any statistically significant difference of magnesium in this study. It needs be mentioned that all our patients were newly diagnosed type2 diabetic subjects.

On evaluation of relationship between risk factors and magnesium level, we found no significant differences in serum magnesium level among the persons who were positive for risk factors in comparison to negative for risk factors. Regarding comorbidities we observed no significant relationship with serum magnesium. Similarly no significant relationship was found between hypomagnesemia and hypertension, IHD, lipid profile by other study these results were in agreement with observation in this study [12].

Only age of the patients positively correlated with serum magnesium level. However, none of the other variables showed any correlation with magnesium level. In our study we did not find any correlations between serum magnesium levels and fasting lipids. In contrast, Mishra *et al.*, (2012) found negative correlation between serum magnesium with triglycerides and positive correlation with HDL [13]. Also Hamid *et al.*, (2008) reported negative correlations between serum magnesium with total cholesterol and LDL and didn't find any correlations between TG and HDL. The association between hypomagnesaemia and lipid abnormalities needs further investigation; because, previous studies were mainly done to detect the effect of magnesium supplementation on the lipid profile of diabetic patients [14].

We have not included any nondiabetic subjects. Magnesium level was considered in light of the reference normal range. It was found that majority (91%) of the subjects had normal magnesium level. Thus, the factor responsible for the contradictory findings of ours and by different investigators remains to be explored further by including control subjects and keeping the discussed point above in consideration.

In conclusion, small number (9%) of newly diagnosed diabetic patients were found to have magnesium level below normal. Magnesium level was statistically and significantly different among the age groups. But though not statistically significant, magnesium level was comparatively lower in group with higher HbA1c group. There was no statistically significant difference for magnesium level in urban and rural participants, different socioeconomic classes and between gender or BMI groups. Subjects having risk factors like smoking, HTN, dyslipidaemia and complications of DM at diagnosis as IHD, CVD, retinopathy, nephropathy and neuropathy showed normal level of magnesium.

Conclusion

In conclusion, it can be stated that majority of our newly detected diabetic subjects have eumagnesemia and glycemic status correlated poorly with serum magnesium level. However, large scale prospective studies are required before any comment could be made on the causal relationship between development of DM and serum magnesium level.

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