Original Research

CORRELATION OF GLYCEMIC CONTROL AND SERUM MAGNESIUM WITH URINE ALBUMIN CREATININE RATIO IN TYPE 2 DIABETES MELLITUS

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ABSTRACT

Introduction: In India diabetes is the major public health concern. Hypomagnesemia is a major finding seen in multiple studies of poorly controlled diabetes category patients. There is an association between hypomagnesemia and insulin resistance in diabetes patients and metabolic syndrome. **Aim:** To evaluate the correlation between serum magnesium levels, HbA1c, and urine ACR in T2DM patients and assess its potential role as a prognostic marker for early diabetic nephropathy detection. **Materials and Methods:** A cross-sectional study was conducted on 85 patients diagnosed with T2DM at a tertiary care hospital. Fasting blood glucose (FBS), HbA1c, serum magnesium, serum creatinine (S. CR), and urine ACR were measured. Patients were categorized based on serum magnesium levels (normal: >1.8 mg/dL; low: ≤1.8 mg/dL). Glycemic control was classified as good (HbA1c ≤ 7.5%) or poor (HbA1c > 7.5%). Statistical analysis was performed using IBM SPSS version 22.0 software (SPSS Inc, Chicago, USA). In mean comparison between more than two groups, ANOVA test was used. Spearman rank correlation coefficient was used to study the relationship between parameters. **Results:** There is a statistically significant moderate positive correlation between Urine ACR and HbA1c (r =.300, p = 0.014), and a moderate negative correlation between Urine ACR and magnesium (r = –0.370, p = 0.040) which is statistically significant. A significant association (p < 0.001) exists between HbA1c levels and Urine ACR status - poor glycemic control is linked to higher rates of macro albuminuria, while good diabetes control shows more normal Urine ACR values. **Conclusion**: In our study 88.2% of participants had poor glycemic control (high HbA1c), Serum magnesium is more prevalent in low category (90.6%) as compared to normal (9.4%), Kidney damage is prevalent - Nearly all participants (97.6%) showed evidence of kidney damage, with macroalbuminuria (63.5%) being more common than microalbuminuria (34.1%). Study reveals the relationship between glycemic control, urinary albumin excretion, and magnesium levels in diabetic patients.

INTRODUCTION

In India, 2025, projections indicate a significant elevation in the number of cases of diabetes people increases around 69.9 million[1]. Among Diabetes patients Type 2 Diabetes Mellitus contributes around 80% to 90% of cases. Diabetes nephropathy is the one of the major complications of Type 2 diabetes mellitus. Diabetic kidney disease which is defined by elevated urine albumin excretion or reduced glomerular filtration rate (GFR) or both – is a serious complication that occurs in 20% to 40% of all diabetics[2]. Diabetic kidney disease (DKD) complication that take place in 20% to 40% of all diabetic patients.

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The major cause of End Stage Kidney Disease in western world is diabetic kidney disease[3]. The prevalence of diabetic nephropathy ranges in India from 0.9% to 62.30%[4]. There was an incidence of 2.62 million cases related to CKD and DM globally[5]. Hypomagnesemia in diabetes mellitus patients have been reported in multiple studies[6]. Magnesium deficiency may play a role in the development of endothelial dysfunction and altered insulin function[7]. Oxidative stress is one of the major contributor in the mechanism of diabetic nephropathy. Oxidative stress which reduces TRPM6 activity and thereby, reduces magnesium reabsorption and ultimately to hypomagnesemia in diabetic patients[8]. Hyperglycaemia in diabetic patients results in hyper-filtration and increased renal urinary flow[9]. Increased urine volume in diabetic patient's results into dilution of magnesium concentration in the urine thereby disturbing the trans-epithelial magnesium gradient between the

tubule and the interstitium resulting in increased magnesium excretion. Thus, magnesium reabsorption in Thick Ascending Limb (TAL) and DCT is inversely correlated with the urine volume in diabetic patients. One of the other possible mechanisms explaining the relation between MA and Mg deficiency is insulin resistance.Mg can act as a mild calcium antagonist. In patients with Mg deficiency, intracellular calcium is increased. Increased calcium may interrupt response of skelatal muscles and adipocytes to insulin and lead to insulin resistance[10]. Intracellular Mg plays a role in regulating insulin action, insulin-dependent glucose uptake, and vascular tone. Deficiency of Mg can reduce tyrosine-kinase activity, postreceptorial activity and eventually it may contribute to the development of insulin resistance[11,12]. On the
Other hand, insulin deficiency and resistance can effect tubular reabsorption of Mg[13].
Only very few studies are there in literature till date regarding the correlation of serum magnesium levels and diabetes status of the patients.

MATERIALS AND METHODS

Study design:

A cross sectional study conducted in a tertiary care centre at Sree Gokulam Medical College and Research Foundation,Trivandrum,kerala. Statistical analysis was performed using IBM SPSS version 22.0 software (SPSS Inc, Chicago, USA). Sample size calculated using correlation value.

$$n = \frac{\left[Z_{1-\beta} + Z_{1-\frac{\alpha}{2}}\right]^2}{\left[\frac{r^2}{1-r^2}\right]}$$

Statistics and reports

Categorical variables were expressed using frequency and percentage. Numerical variables were presented using mean and standard deviation. Chi square with continuity correction was used to test the statistical significance of the association of all categorical variables between groups. Independent sample t test was used to study the statistical significance of the difference in the mean values of all continuous variables between groups. In the case of mean comparison between more than two groups, ANOVA test was used. Spearman rank correlation coefficient was used to study the relationship between parameters. A p value of <0.05 was considered to be statistically significant

Aim: To evaluate the correlation between serums magnesium levels, HbA1c, and urine ACR in T2DM patients and assess its potential role as a prognostic marker for early diabetic nephropathy detection.

METHODOLOGY

A cross-sectional study was conducted on 85 patients diagnosed with T2DM at a tertiary care hospital. Fasting blood glucose (FBS), HbA1c, serum magnesium, serum creatinine (S CR), and urine ACR were measured. Patients were categorized based on serum magnesium levels (normal: >1.8 mg/dL; low: ≤1.8 mg/dL). Glycemic control was classified as good (HbA1c ≤ 7.5%) or poor (HbA1c > 7.5%).

Table No 1 Distribution of HbA1c Group

HbA1c Group	Frequency	Percent
Good	10	11.8%
Poor	75	88.2%
Total	85	100.0%

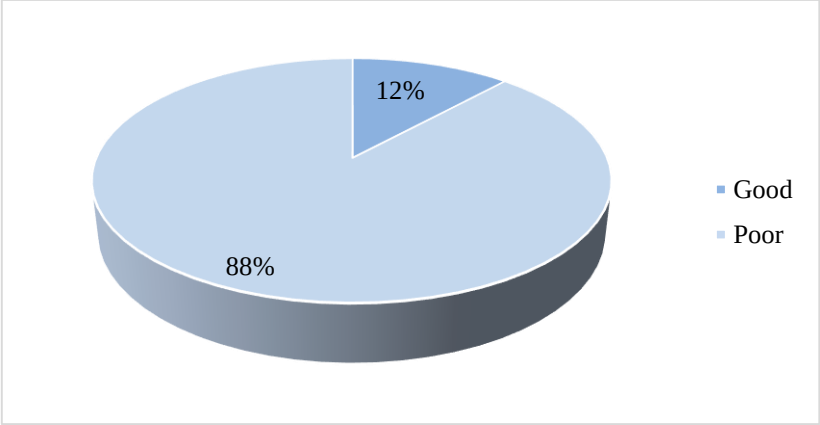

Figure No 1 Distribution of HbA1c Group

The majority (88.2%) of participants fall in the Poor HbA1c group, while only 11.8% fall under the good category.

Table No 2 Distribution of Serum Mg2+

S.MG2 Group	Frequency	Percent
Low	77	90.6
Normal	8	9.4
Total	85	100

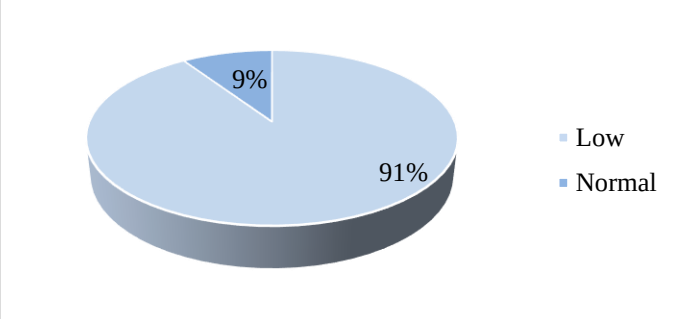

Figure No 2 Distribution of Serum Mg2+

Almost 91% subjects have low serum magnesium and less than 9% shows normal serum magnesium levels in distribution.

Table No 3 Distribution of Urine ACR

Urine ACR Group	Frequency	Percent
Microalbuminuria	29	34.1%
Macroalbuminuria	54	63.5%
Normal	2	2.4
Total	85	100.0%

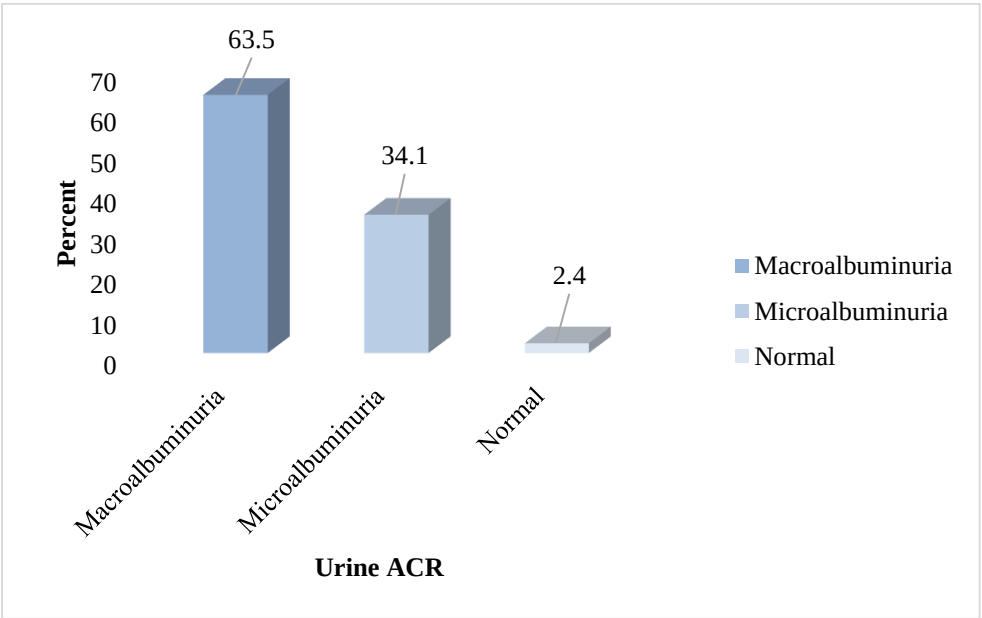

Figure No 3 Distribution of Urine ACR

Macroalbuminuria is more prevalent (63.5%) than microalbuminuria (34.1%) and normal (2.4%) in the population.

Table No 4 Correlation between Urine ACR and HbA1c, Serum Mg2+

Nonparametric Correlations – Spearman's Rho (n = 85)

Variables	HbA1c (r Value)	MG2+ (r Value)

URINE ACR	0.300	-0.370
Sig. (2-tailed)	0.014	0.040

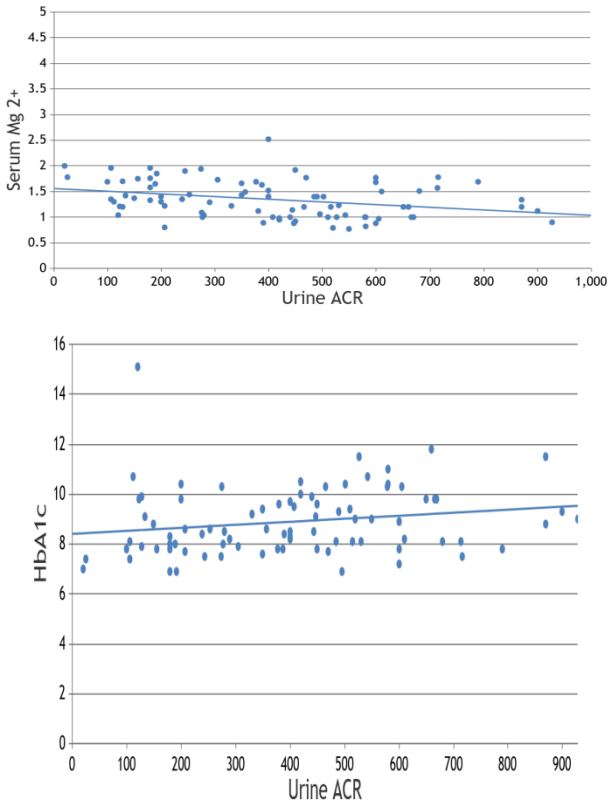

Figure No 4 Correlation between Urine ACR and HbA1c, Serum Mg2+

There is a statistically significant moderate positive correlation between Urine ACR and HbA1c (r = .300, p = 0.014), and a moderate negative correlation between Urine ACR and magnesium (r = – 0.370, P = 0.040) which is statistically significant.

Table No 5 Comparison between Urine ACR Group and Mg2+ among HbA1c Group

HbA1c	URINE ACR GROUP	N	Mean Mg2+	SD	p Value
Good	**Macroalbuminuria**	3	1.54	0.415	0.512
	Microalbuminuria	5	1.92	0.047	
	Normal	2	1.89	0.155	
Poor	**Macroalbuminuria**	51	1.09	0.186	0.163
	Microalbuminuria	24	1.16	0.168	

In patients with Good glycemic control, Patients with microalbuminuria had the highest mean Mg2+ levels (1.920mg), those with normal had intermediate levels (1.890 mg), and those with macroalbuminuria ACR had the lowest Mg2+ levels (1.540 mg). These differences were not statistically significant (P = 0.512)

In patients with Poor glycemic control, Patients with microalbuminuria had slightly higher mean Mg2+ levels (1.16 mg) than those with macroalbuminuria (1.09 mg). This difference was not statistically significant (P = 0.163).

Table No 6 Association between HbA1c and Urine ACR

HbA1c Group	Urine ACR Group				p Value
	Microalbuminuria	Macroalbuminuria	Normal	Total	
Good	5 (50.0%)	3 (30.0%)	2 (20.0%)	10	<0.001
Poor	24 (32.0%)	51 (68.0%)	0 (0%)	75	
Total	29 (34.1%)	54 (63.5%)	2 (2.4%)	85	

There is a statistically significant association between HbA1c levels (Good vs. Poor glycemic control) and Urine ACR status (Normal, Microalbuminuria, Macroalbuminuria), as indicated by a p-value < 0.001.

This suggests that poorer glycemic control (high HbA1c) is strongly associated with a higher prevalence of Macroalbuminuria and a complete absence of normal urine ACR levels. Conversely, individuals with good glycemic control had a more balanced distribution, including a proportion with normal ACR.

DISCUSSION

In our study 85 diabetes patients were enrolled and categorised as 2 groups, good glycemic and poor glycemic controlled category. Most of the patients have found hypomagnesemia. Macroalbuminuria is more prevalent than microalbuminuria in the study population. There is a statistically significant moderate positive correlation between Urine ACR and HbA1c ($r = .300$, $p = 0.014$), and a moderate negative correlation between Urine ACR and magnesium ($r = –0.370$, $p = 0.040$) which is statistically significant.

In CARDIA Study (Coronary Artery Risk Development in young Adults) conducted by Kim et al showed an inverse relationship between Mg intake and the incidence of diabetes[14]. Zargar et al suggested that glycemic control and presence of microalbuminurea did not affect serum Mg levels[15]. A study conducted by Kumar P et al., (2019) observed that 110 (44%) out of 250 patients have hypomagnesemia and found that hypomagnesemia was associated with poor glycaemic control and increased risk of diabetic retinopathy[16].

CONCLUSION

This study reveals several important findings about the relationship between glycemic control, urinary albumin excretion and magnesium levels in diabetic patients:

Glycemic control is poor in most patients - 88.2% of participants had poor glycemic control (high HbA1c), Serum magnesium is more prevalent in low category (90.6%) as compared to normal (9.4%), Kidney damage is prevalent - Nearly all participants (97.6%) showed evidence of kidney damage, with macroalbuminuria (63.5%) being more common than microalbuminuria (34.1%).

In comparison group, serum magnesium levels varied among urine ACR groups, but differences were not statistically significant in either good or poor glycemic control status patients. There is a moderate positive correlation between Urine ACR and HbA1c and a moderate negative correlation between Urine ACR and serum magnesium, both statistically significant. A significant association ($p < 0.001$) exists between HbA1c levels and Urine ACR status - poor glycemic control is linked to higher rates of macroalbuminuria, while good diabetes control shows more normal Urine ACR values.

In summary, these findings indicate a significant association between glycemic control, magnesium homeostasis and renal function in individuals with diabetes. Furthermore, magnesium metabolism appears to vary in accordance with the level of glycemic control and the extent of renal involvement.

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