Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(5), 2670-2676 | ISSN:2251-6727

Correlation of Serum Magnesium with Clinical Markers of Nephropathy in Patients with Type 2 Diabetes Mellitus

Dr. D Selvakumar[1], Dr. Pavana A [2*], Dr Veluri Ganesh[3], Dr. Gnanadesigan Ekambaram[4]

1 Assistant Professor, Department of Biochemistry, PES Institute of Medical Sciences and Research, Kuppam, Chittoor, Andhra Pradesh, India-517425.

*2*Assistant Professor, Department of Biochemistry, Sri Siddhartha Institute of Medical Sciences, T Begur, Karnataka, India-562123.*

3 Assistant Professor, Department of Biochemistry, PES University Institute of Medical Sciences and Research, Electronic City, Bengaluru, Karnataka -560100.

4 Associate Professor, Department of Physiology, Nootan Medical College and Research Centre, Sankalchand Patel University, Visnagar, India -384315.

(Received: 25 August 2025 Revised: 27 September 2025 Accepted: 14 October 2025)

KEYWORDS

Type 2 Diabetes Mellitus, Nephropathy, Serum Magnesium, Urinary Albumin Creatinine Ratio and eGFR.

ABSTRACT:

Introduction: The type 2 diabetes mellitus clinical disease is typified by hyperglycemia, or elevated blood glucose levels, brought on by insufficient or ineffective (incompetent) insulin. The magnesium is the fourth most prevalent cation and has numerous essential biological functions, such as DNA synthesis and metabolism.

Objectives: The present study aimed to correlate the Serum Magnesium and Clinical Markers of Nephropathy in Patients with Type 2 Diabetes Mellitus.

Methods: The present study included 150 T2DM patients and 75 age, gender matched healthy controls, the T2DM cases classified into two groups based on their microalbumin levels. For all the patients routine biochemical, clinical and serum magnesium was analysed.

Results: The serum magnesium had shown significant reduced levels in patients with T2DM when compared to controls. These levels significantly negatively correlated with blood sugars, glycated haemoglobin, dyslipidaemia, urinary ACR and these levels positively correlated with HDL and GFR. The ROC curve analysis also shown the serum magnesium has significant at area under the curve, also has highest sensitivity and specificity than urinary ACR and eGFR.

Conclusions: This study suggests to monitor serum magnesium might be useful for to detect early onset of nephropathy in patients with T2DM and controls.

1. Introduction

Type 2 diabetes Mellitus is a clinical condition due to hyperglycemia. When insulin resistance is present, a gradual failure in insulin production leads to type 2 diabetes [1-2]. Complications from type 2 diabetes might include retinopathy, polyneuropathy, nephropathy, and cardiovascular disease [3]. About 40% of people with diabetes go on to develop nephropathy. A primary cause of end-stage renal disease (ESRD) and one of the most significant microvascular consequences of diabetes is diabetic nephropathy (DN) [4-5]. High intracellular glucose levels have been proposed as a necessary condition for the development of DN-typical kidney morphological and functional alterations [6-8]. Increased perfusion resulting in elevated glomerular filtration and intraglomerular pressure is a characteristic of the diabetic kidney. First, microalbuminuria, which develops into more extensive proteinuria, glomerular filtration rate (GFR) decline, and finally end-stage renal disease (ESRD) are caused by pathological alterations [9]. One of the pathogenic factors for diabetes complications, such as nephropathy, has been identified

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(5), 2670-2676 | ISSN:2251-6727

as oxidative stress. Hyperglycemia-induced oxidative stress raises the production of ROS, which in turn causes cellular damage and malfunction and, eventually, diabetic micro and macrovascular problems [10-11].

The human body contains magnesium, the fourth most abundant cation, which is essential for many basic biological functions, such as DNA synthesis and energy metabolism [12-13]. Additionally, it has a variety of roles in the binding, activity, and secretion of insulin. Endothelial cell failure, inflammation, and oxidative stress have all been linked to magnesium shortage [14-15]. Type 2 diabetes is closely linked to magnesium shortage. Insulin resistance or insufficiency in diabetic patients may contribute to magnesium loss at the thick ascending limb of the Henle loop [16]. Magnesium shortage has been proposed as a major contributor to the pathophysiology of diabetes complications, such as nephropathy. The present study aimed to correlate between the serum magnesium and urinary microalbumin in different stages of kidney diseases in patients with type 2 diabetes mellitus.

2. Methods

This cross-sectional study recruited 150 type 2 diabetes mellitus attended to the general medicine OPD at PES University Institute of Medical Sciences, Bangalore, Karnataka. Additionally, 75 age and gender matched healthy controls included and considered as group 1. The T2DM patients sub grouped based on their microalbumin levels shown in figure 1. The study approved by institutional ethics committee and the participants recruited after obtained informed consent form. The subject's age should 30-70 years, the T2DM patients diagnosed according to american diabetic association criteria [17] and kidney disease improvement global outcomes criteria [18] are included in the present study. The subjects had history of other types of diabetes mellitus, kidney diseases, thyroid diseases, liver diseases, pancreatic diseases; cardio vascular diseases and subjects who are on magnesium supplementation were excluded.

Sample collection

Five (5) ml of fasting venous blood sample collected from all the subjects. One (1) ml transferred into sodium fluoride, one ml transferred into ethylenediamine tetraacetic acid (EDTA) tube and remaining sample transferred into serum separation tube. The plasma and serum separated. Additionally, urine a spot fasting urine sample also collected and separated. The separated into properly labelled aliquots and stored into -80ºC until analysis will be done.

Statistical analysis

The date was expressed mean ± standard deviation and comparison between the variables done by analysis of variance. The correlation between the study variables done by pearson's correlation. The ROC curve analysis done between the serum magnesium and clinical parameters of nephropathy. The statistical analysis done by using SPSS version 20.0.

3. Results

The table 1 illustrates that comparison of base line characteristic between the study groups. The age and BMI shown statically significant between type 2 diabetes mellitus and controls (P-0.001**). The FBS TGL TC VLDL, LDL and HbA1c significantly increased in type 2 diabetes patients and controls (P-0.001**). The urinary albumin creatinine ratio significantly elevated in type 2 diabetes patients and controls (P-0.001**). The serum magnesium and eGFR significantly decreased in type 2 diabetes patients and controls (P-0.001**).

The table 2 illustrates that comparison of base line characteristic between the both groups of type 2 diabetes mellitus and controls groups. The age and BMI shown statically significant between both the groups of type 2 diabetes mellitus and controls (P-0.001**). The FBS TGL TC VLDL, LDL and HbA1c significantly increased in both the groups of type 2 diabetes patients and controls (P-0.001**). The urinary albumin creatinine ratio significantly elevated in both groups of type 2 diabetes patients and controls (P-0.001**). The serum magnesium and eGFR significantly decreased in both the groups of type 2 diabetes patients and controls (P-0.001**).

The table 3 illustrates correlation of serum magnesium with other study variables. The serum magnesium negatively correlated with age, BMI, FBS, HbA1c, TC, TGL, VLDL, LDL and urinary albumin creatinine ratio (P=0.001**) and positively correlated with eGFR and HDL. (P=0.001**).

Table 4 shows ROC curve analysis between serum magnesium and urinary ACR, eGFR. The urinary ACR

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(5), 2670-2676 | ISSN:2251-6727

and eGFR not shown significant at AUC and have low sensitivity and specificity (P=0.344,0.471). the serum magnesium shown significant at AUC and have highest sensitivity and specificity (P<0.0001**).

Figure 1 shows scatter plots between serum magnesium and eGFR, urinary ACR there was a significant positive correlation between serum magnesium and eGFR. The serum magnesium negatively correlated with urinary ACR.

4. Discussion

Type 2 diabetes mellitus is a chronic metabolic disease linked to insulin resistance and hyperglycaemia results decreased antioxidants and increased oxidative stress. Most of the T2DM patients suffering with nephropathy and it is started with microalbuminuria and end up with end stage renal disease [19-20]. The microalbumin is a common clinical available marker for detection of kidney damage in T2DM patients. But recent studies are opposing the microalbumin cannot be served as a marker for nephropathy due to its flows. Many of the T2DM with microalbuminuria patients revert back to normoalbuminuria and many of the normoalbuminuria patients showed a advanced renal pathophysiology. Along with that it is elevated in other disease conditions [21-24].

The present study focused on the serum magnesium can have capability to serve as a marker for both T2DM and nephropathy. The physiological properties of magnesium are insulin sensitizing and antioxidant properties. The present study found significant and drastically decreased levels of serum magnesium in T2DM with microalbuminuria and normoalbuminuria patients when compared to controls. Intracellular magnesium is essential for controlling vascular tone, insulin action, and insulin-mediated glucose uptake. Decreased intracellular magnesium levels cause diabetes patients' insulin resistance to worsen and their tyrosine kinase activity to be impaired postreceptorily [25-26]. Some of the previous studies indicated that the overall prevalence of microalbuminuria was 36.3%, and normoalbuminuria had 11.37% [27-28]. Some of recent studies are reported the T2DM population had a significant and drastically reduced levels of serum magnesium when compared to controls [29-30].

Additionally, we also found the serum magnesium shown significant negative correlation with blood sugars, glycated haemoglobin, lipid profile and the urinary ACR. These levels were positively correlated with HDL, eGFR (P=0.001**). Another study also reported, the microalbuminuria group had lower mean magnesium levels than the normoalbuminuria group, the pearson's correlation test was serum magnesium levels and urinary microalbumin levels in patients with type 2 diabetes mellitus were negatively correlated in the current study. Another, study reported i.e the incidence of microalbuminuria was inversely correlated with serum magnesium levels [31]. To ascertain whether treating magnesium shortage with medication or dietary changes could effectively lower the incidence of microalbuminuria. Better glycaemic control and fewer diabetic complications may result from screening for serum magnesium levels in Type 2 diabetes and correcting any deficiencies.

5. Conclusion

According to this study, type 2 diabetic patients with and without nephropathy had noticeably lower serum magnesium levels than healthy people. Serum magnesium levels were found to significantly correlate positively with estimated GFR and negatively with fasting blood glucose, HbA1c, serum creatinine, and urine ACR in both type 2 diabetes individuals with and without nephropathy. The monitoring of serum magnesium might be used as a early detectible marker for nephropathy than the microalbumin.

References

1. Xu MR, Wang AP, Wang YJ, Lu JX, Shen L, Li LX. Serum Magnesium Levels Are Negatively Associated with Obesity and Abdominal Obesity in Type 2 Diabetes Mellitus: A Real-World Study. Diabetes Metab J. 2024 Nov;48(6):1147-1159.
2. Veluri G, Mannangatti M. Urinary Nephrin is a Sensitive Marker to Predict Early Onset of Nephropathy in Type 2 Diabetes Mellitus. J Lab Physicians. 2022 26;14(4):497-504.
3. Ganesh, V., Murugan, M., Goud, V. G., & Gangannagari, V. K. (2022). Correlation of urinary nephrin with albubinuria to predict early onset of nephropathy in patients with type 2 diabetes

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(5), 2670-2676 | ISSN:2251-6727

mellitus. International Journal of Health Sciences 2022; 6(S3): 4621-4630.

4. Ganesh V, M M, Palem SP. Adiponectin Can Be an Early Predictable Marker for Type 2 Diabetes Mellitus and Nephropathy. Cureus. 2022; 26:14(7):e27308.
5. Ganesh V, M M, Gk VG, Gangannagari VK. Linking adiponectin expression and kidney dysfunction among Indian patients with and without diabetic nephropathy. Bioinformation. 2022;31:18(10):876-883.
6. Găman MA, Dobrică EC, Cozma MA, Antonie NI, Stănescu AMA, Găman AM, Diaconu CC. Crosstalk of Magnesium and Serum Lipids in Dyslipidemia and Associated Disorders: A Systematic Review. Nutrients. 2021 Apr 22;13(5):1411.
7. Maqrashi NA, Busaidi SA, Al-Rasbi S, Alawi AMA, Al-Maqbali JS. Effect of Magnesium Supplements on Improving Glucose Control, Blood Pressure and Lipid Profile in Patients With Type 2 Diabetes Mellitus: A systematic review and meta-analysis. Sultan Qaboos Univ Med J. 2025 May 2;25(1):382-394.
8. Li W, Jiao Y, Wang L, Wang S, Hao L, Wang Z, Wang H, Zhang B, Ding G, Jiang H. Association of Serum Magnesium with Insulin Resistance and Type 2 Diabetes among Adults in China. Nutrients. 2022 Apr 25;14(9):1799.
9. Díaz-Tocados JM, Lloret MJ, Domínguez-Coral JD, Tinoco Aranda AP, Fayos de Arizón L, Massó Jiménez E, Bover J, Valdivielso JM, Rodríguez-Ortiz ME. Magnesium Balance in Chronic Kidney Disease: Mineral Metabolism, Immunosuppressive Therapies and Sodium-Glucose Cotransporter 2 Inhibitors. Int J Mol Sci. 2025 Jun 13;26(12):5657.
10. Drenthen LCA, de Baaij JHF, Rodwell L, van Herwaarden AE, Tack CJ, de Galan BE. Oral magnesium supplementation does not affect insulin sensitivity in people with insulin-treated type 2 diabetes and a low serum magnesium: a randomised controlled trial. Diabetologia. 2024 Jan;67(1):52-61.
11. Hariri M, Sohrabi M, Gholami A. The effect of magnesium supplementation on serum concentration of lipid profile: an updated systematic review and dose-response meta-analysis on randomized controlled trials. Nutr J. 2025 Feb 4;24(1):24.
12. Piuri G, Zocchi M, Della Porta M, Ficara V, Manoni M, Zuccotti GV, Pinotti L, Maier JA, Cazzola R. Magnesium in Obesity, Metabolic Syndrome, and Type 2 Diabetes. Nutrients. 2021 Jan 22;13(2):320.
13. Rizk DV, Silva AL, Pergola PE, Toto R, Warnock DG, Chin MP, Goldsberry A, O'Grady M, Meyer CJ, McCullough PA. Effects of Bardoxolone Methyl on Magnesium in Patients with Type 2 Diabetes Mellitus and Chronic Kidney Disease. Cardiorenal Med. 2019;9(5):316-325.
14. Ferrè S, Li X, Adams-Huet B, Maalouf NM, Sakhaee K, Toto RD, Moe OW, Neyra JA. Low serum magnesium is associated with faster decline in kidney function: the Dallas Heart Study experience. J Investig Med. 2019 Aug;67(6):987-994.
15. Huang JH, Lu YF, Cheng FC, Lee JN, Tsai LC. Correlation of magnesium intake with metabolic parameters, depression and physical activity in elderly type 2 diabetes patients: a cross-sectional study. Nutr J. 2012 Jun 13;11:41.
16. Sakaguchi Y. The emerging role of magnesium in CKD. Clin Exp Nephrol. 2022 May;26(5):379-384.
17. Xiong C, Shi S, Cao L, Wang H, Tian L, Jia Y, Zeng M, Wang J. Association of early postoperative serum magnesium with acute kidney injury after cardiac surgery. Ren Fail. 2023 Dec;45(1):2170244.
18. Vermeulen EA, Vervloet MG. Magnesium Administration in Chronic Kidney Disease. Nutrients. 2023 Jan 20;15(3):547.
19. Mazza E, Maurotti S, Ferro Y, Castagna A, Pujia C, Sciacqua A, Pujia A, Montalcini T. Magnesium: Exploring Gender Differences in Its Health Impact and Dietary Intake. Nutrients. 2025 Jul 4;17(13):2226.
20. Azem R, Daou R, Bassil E, Anvari EM, Taliercio JJ, Arrigain S, Schold JD, Vachharajani T, Nally J, Na Khoul GN. Serum magnesium, mortality and disease progression in chronic kidney disease. BMC Nephrol. 2020 Feb 12;21(1):49.
21. Sakaguchi Y, Shoji T, Hayashi T, Suzuki A, Shimizu M, Mitsumoto K, Kawabata H, Niihata K, Okada N, Isaka Y, Rakugi H, Tsubakihara Y.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(5), 2670-2676 | ISSN:2251-6727

Hypomagnesemia in type 2 diabetic nephropathy: a novel predictor of end-stage renal disease. Diabetes Care. 2012 Jul;35(7):1591-7.

22. Zhang Y, Li Q, Xin Y, Lv W, Ge C. Association between serum magnesium and common complications of diabetes mellitus. Technol Health Care. 2018;26(S1):379-387.
23. Futrakul N, Futrakul P. Biomarker for early renal microvascular and diabetic kidney diseases. Ren Fail. 2017 Nov;39(1):505-511.
24. Zhang H, Yang J, Cao Y, Shan X, Yang L. Study on the Dose-Response Relationship between Magnesium and Type 2 Diabetes of Childbearing Women in the China Adult Chronic Disease and Nutrition Surveillance 2015. Nutrients. 2024 Mar 31;16(7):1018.
25. Ratiu IA, Moisa C, Marc L, Olariu N, Ratiu CA, Bako GC, Ratiu A, Fratila S, Teusdea AC, Ganea M, Indries M, Filip L. The Impact of Hypomagnesemia on the Long-Term Evolution After Kidney Transplantation. Nutrients. 2024 Dec 27;17(1):50.
26. Ledeganck KJ, De Winter BY, Van den Driessche A, Jürgens A, Bosmans JL, Couttenye MM, Verpooten GA. Magnesium loss in cyclosporine-treated patients is related to renal epidermal growth factor downregulation. Nephrol Dial Transplant. 2014 May;29(5):1097-102.
27. Garnier AS, Duveau A, Planchais M, Subra JF, Sayegh J, Augusto JF. Serum Magnesium after Kidney Transplantation: A Systematic Review. Nutrients. 2018 Jun 6;10(6):729.
28. Holzmacher R, Kendziorski C, Michael Hofman R, Jaffery J, Becker B, Djamali A. Low serum magnesium is associated with decreased graft survival in patients with chronic cyclosporin nephrotoxicity. Nephrol Dial Transplant. 2005 Jul;20(7):1456-62.
29. Miura K, Nakatani T, Asai T, Yamanaka S, Tamada S, Tashiro K, Kim S, Okamura M, Iwao H. Role of hypomagnesemia in chronic cyclosporine nephropathy. Transplantation. 2002 Feb 15;73(3):340-7.
30. Peled Y, Ram E, Lavee J, Tenenbaum A, Fisman EZ, Freimark D, Klempfner R, Sternik L, Shechter M. Hypomagnesemia is associated with new-onset diabetes mellitus following heart transplantation. Cardiovasc Diabetol. 2019 Oct 11;18(1):132.
31. Van Laecke S, Vermeiren P, Nagler EV, Caluwe R, De Wilde M, Van der Vennet M, Peeters P, Randon C, Vermassen F, Vanholder R, Van Biesen W. Magnesium and infection risk after kidney transplantation: An observational cohort study. J Infect. 2016 Jul;73(1):8-17.

Table 1: Comparison of base line characteristics between the study subjects

Parameters	Controls			Type 2 Diabetes Mellitus			P-Value
	Mean	±	SD	Mean	±	SD	
Age (Years)	46.25	±	8.34	50.14	±	9.30	0.001**
BMI (kg/m2)	24.10	±	1.61	33.58	±	8.23	0.001**
FBS (mg/dL)	85.02	±	10.26	161.89	±	30.14	0.001**
eGFR (ml/min)	93.36	±	9.62	43.15	±	37.83	0.001**
CHOL (mg/dl)	162.45	±	17.08	251.70	±	65.42	0.001**
TGL (mg/dl)	115.70	±	22.79	186.50	±	50.54	0.001**
HDL (mg/dl)	47.27	±	8.71	34.46	±	7.94	0.001**
VLDL (mg/dl)	25.26	±	5.96	39.68	±	11.31	0.001**
LDL (mg/dl)	93.22	±	11.06	182.13	±	61.72	0.001**
HbA1c (%)	6.58	±	2.76	8.62	±	2.47	0.001**
Albumin Creatinine Ratio (mg/g creatinine)	19.15	±	7.09	336.78	±	323.83	0.001**

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(5), 2670-2676 | ISSN:2251-6727

Serum Magnesium (mg/dL)	0.72	±	0.21	0.61	±	0.18	0.001**

Table 2: Comparison of study variables both the groups of type 2 diabetes mellites patients and controls

Parameter	Control			Type 2 Diabetes Mellitus with Normo albuminuria			Type 2 Diabetes Mellitus with Micro albuminuria			P-Valve
	Mean	±	SD	Mean	±	SD	Mean	±	SD	
Age (Years)	46.25	±	8.34	44.05	±	6.41	52.22	±	6.67	0.001**
BMI (kg/m2)	24.10	±	1.61	26.15	±	1.95	36.59	±	3.81	0.001**
FBS (mg/dL)	85.92	±	10.25	136.82	±	15.29	157.58	±	16.72	0.001**
eGFR (ml/min)	93.36	±	9.59	92.70	±	8.75	23.82	±	7.14	0.001**
CHOL (mg/dl)	162.45	±	17.08	174.15	±	16.67	273.50	±	25.96	0.001**
TGL (mg/dl)	115.70	±	22.79	136.20	±	20.56	198.52	±	21.77	0.001**
HDL (mg/dl)	47.27	±	8.71	40.72	±	5.46	38.18	±	3.33	0.001**
VLDL (mg/dl)	25.26	±	5.96	27.66	±	6.59	42.22	±	4.99	0.001**
LDL (mg/dl)	93.21	±	10.06	108.83	±	13.85	203.36	±	26.29	0.001**
HbA1c (%)	6.58	±	0.75	8.69	±	0.48	9.79	±	1.18	0.001**
Albumin Creatinine Ratio (mg/g creatinine)	19.15	±	7.05	20.09	±	5.91	232.59	±	39.89	0.001**
Serum Magnesium (mg/dL)	1.74	±	0.21	0.76		0.14	0.68	±	0.15	0.001**

Table 3: Correlation of serum magnesium with other study variables

Parameters	r-Value	P-Value
AGE	0.322	0.001**
BMI (kg/m2)	-0.461	0.001**
FBS (mg/dL)	-0.374	0.001**
eGFR (ml/min)	0.572	0.001**
CHOL (mg/dl)	-0.738	0.001**
TGL (mg/dl)	-0.647	0.001**
HDL (mg/dl)	0.734	0.001**
VLDL (mg/dl)	-0.639	0.001**
LDL (mg/dl)	-0.835	0.001**
HbA1c (%)	-0.734	0.001**
Albumin Creatinine Ratio (mg/g creatinine)	-0.846	0.001**

Table 4: ROC curve analysis between serum magnesium and urinary ACR, eGFR.

Parameter	AUC	95% CI for Value	Cut off Value	Sensitivity	Specificity	P Value

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(5), 2670-2676 | ISSN:2251-6727

Urinary ACR (mg/g creatinine)	0.562	0.447 to 0.673	0.200	97.50	22.50	0.344
eGFR (ml/min)	0.548	0.433 to 0.660	0.275	90.00	37.50	0.471
Serum Magnesium (mg/dL)	1.000	0.955 to 1.000	1.000	100.00	100.0	<0.0001

Figure 1: Scatter plots between serum magnesium and eGFR, urinary ACR