Nigerian Medical Journal
NIGERIA MEDICAL ASSOCIATION
Print ISSN 0300-1652, E-ISSN 2229-774X

Original Article

Effect of Hyperglycemia on Serum Uric Acid Levels in Patients with Type 2 Diabetes Mellitus

Martin Chukwuka Ugonabo[1], *Chika Juliet Okwor[1], Ijeoma Angela Meka [1], Stephen Abiodun Musayayi[2]

[1]Department of Chemical Pathology, University of Nigeria Teaching Hospital, Enugu, Nigeria, [2]Department of Medicine and Surgery, University of Nigeria Enugu Campus, Enugu, Nigeria

Abstract

Background: Type 2 diabetes mellitus (T2DM) is a significant public health problem, particularly in Nigeria, with increasing prevalence worldwide. Hyperglycemia in T2DM is associated with various metabolic disturbances, including alterations in uric acid metabolism. This study investigates the effect of hyperglycemia on the serum uric acid (SUA) levels in patients with T2DM.

Methodology: This cross-sectional observational study included 100 participants comprising 70 patients with T2DM and 30 age- and sex-matched non-diabetic individuals in the control group. Blood samples were obtained to measure fasting and postprandial plasma glucose and SUA levels. Statistical analyses were conducted to compare the groups.

Results: A total of 100 participants were recruited for this study. The results indicated that diabetic patients had significantly higher fasting SUA levels (0.45 ± 0.16 mmol/L) when compared to the control group (0.28 ± 0.05 mmol/L, p = 0.02). Similarly, postprandial SUA levels were elevated in diabetic patients (0.58 ± 0.16 mmol/L) compared to controls (0.30 ± 0.06 mmol/L, p = 0.022). No statistically significant difference was observed between fasting and postprandial SUA levels within the diabetic and control groups (p>0.05).

Conclusion: Hyperglycemia in individuals with T2DM is significantly associated with increased serum uric acid levels. These findings show the clinical relevance of monitoring SUA in patients with type 2 diabetes.

Keywords: Hyperglycemia, Type 2 Diabetes, Uric Acid

***Correspondence:** Dr Chika Okwor, Department of Chemical Pathology, University of Nigeria, Ituku/Ozalla Campus, Enugu. Juliet.okwor@unn.edu.ng

How to Cite: Ugonabo MC, Okwor CJ, Meka IA, Musayayi SA. Effect of Hyperglycemia on Serum Uric Acid Levels in Patients with Type 2 Diabetes Mellitus. Niger Med J 2025; 67 (1): 2712-2719. https://doi.org/10.71480/nmj.v67i1.901

Quick Response Code:

Introduction

Type 2 diabetes mellitus (T2DM) is a heterogeneous group of disorders marked by insulin resistance, inadequate insulin production, and excessive glucose production. It is recognized as a serious public health concern due to its impact on human health, quality of life, and healthcare expenditures.[1] In many regions of the world, the prevalence of diabetes is on the rise due to urbanization and economic expansion occurring at a rapid pace.[2]A strong genetic predisposition, combined with obesity and physical inactivity, has been reported to contribute to the development of type 2 DM. [3] Compared to other African nations, Nigeria has a high and increasing burden of diabetes, according to numerous studies that reported increasing prevalence of type 2 DM. [4-6]

In humans, purine metabolism produces uric acid as its end product through the action of xanthine dehydrogenase (XDH), which is present in various cells, tissues, and organs.[7] Epidemiological studies have demonstrated a positive correlation between uric acid (UA) levels and an increased risk of various cardiovascular conditions, such as coronary artery disease, atrial fibrillation, heart failure, hypertension, atherosclerosis, chronic kidney disease, and increased risk of mortality resulting from cardiovascular conditions [4-11]. Normal serum uric acid levels vary by age and sex. For men and postmenopausal women, normal levels are between 3.5 and 7.0 mg/dL (208-416 µmol/l), while premenopausal women typically have lower levels, ranging from 2.6 to 5.7 mg/dL (155-339 µmol/l). [12]

Epidemiological evidence indicates that the prevalence of hyperuricemia is influenced by multiple environmental and physiological determinants, such as age, sex, race, socioeconomic status, and geographical location. One study reported a hyperuricemia prevalence of about 10–12%, with higher rates in men than women, showing a decline with age in men but an increase in women. Socioeconomic factors such as obesity, hypertriglyceridemia, and place of residence also influenced risk. [12] Another large population analysis of adolescents (ages 12–17) found an overall prevalence of ~33%, considerably higher in males than females, elevated in certain ethnic groups, and strongly associated with income level, parental education, body mass index, and obesity. [13] Recent studies have revealed a positive association between elevated uric acid levels and the development of diabetes, including both type 1 and type 2 diabetes mellitus. [14,15]

Studies have documented a relation between plasma glucose and purine metabolism, which may be detrimental to the diabetic patient. [16,17] Although studies examining the association between purine metabolites and type 2 DM remain limited, evidence suggests that hyperglycemia in individuals with type 2 DM promotes the generation of reactive oxygen species (ROS), which is a harmful byproduct of cellular metabolism.[18] The resulting oxidative stress may stimulate an increase in the level of antioxidants, with uric acid serving as the most abundant antioxidant in plasma. [19]

The study was undertaken to show the relationship between serum uric acid level and plasma glucose in Type 2 diabetes patients in Nigeria, with the aim of utilizing the findings in patient management. Serum uric acid levels may serve as a potential metabolic marker in individuals with type 2 diabetes.

Methodology

A cross-sectional observational study was conducted at the University of Nigeria Teaching Hospital, Ituku-Ozalla. The study included a total of 100 participants comprising 70 patients diagnosed with T2DM and 30 healthy, age- and sex-matched non-diabetic controls. Seventy T2DM patients (70), made up of thirty-two (32) males and thirty-eight (38) females, were selected by systematic random sampling into the study. The diabetes clinic is held once weekly, and based on clinic attendance records, an average of approximately 30 eligible patients were seen per clinic day. Over the 6-month study period (January - June 2008), this yielded an estimated 720 eligible patients. A sampling interval of 10 was calculated by dividing the estimated number of eligible patients by the required sample size (720/70 ≈ 10). On each clinic day, the first participant was selected by simple random sampling, after which every 10th consenting and eligible patient was recruited until the desired sample size was attained.

An additional 30 age- and sex-matched non-diabetic controls, consisting of 14 males and 16 females, were recruited from hospital staff. Subjects were eligible for inclusion in the study if they satisfied the following criteria:

1. Diagnosis of diabetes mellitus based on WHO criteria of FBG of 7.0mmol/L or a random blood glucose of 11.1mmol/L on 2 separate occasions, or justified pharmacological treatment for diabetes mellitus.
2. Age of 35 years or more at the time of diagnosis of type 2 DM
3. Attendance at the diabetes clinic for at least 1 year
4. Diagnosed without immediate insulin requirement, and no initiation of insulin therapy during the first year.
5. Absence of any recorded episodes of ketonuria
6. Provision of informed consent

Exclusion criteria included serious concurrent illness, cytotoxic drug therapy, and non-consent.

Data collection

Demographic data and clinical characteristics were collected from each subject and control. Age and sex, duration of diabetes (for diabetic patients only), height, weight, and BMI were recorded for each subject. Height was recorded and rounded to the nearest 0.1 cm, with the participant barefoot and maintaining an upright posture. Body weight was accurately measured to the nearest 0.1 kg using a calibrated digital scale, and then used to calculate Body Mass Index (BMI) as the ratio of weight (kg) divided by height (m^2).

Venous blood samples were collected from each subject after an overnight fast and again 2 hours after a normal meal. A total of 10 mL of venous blood was collected from the antecubital fossa of each participant. Blood samples collected were placed in fluoride oxalate bottles to inhibit glycolysis ahead of glucose analysis.

Blood glucose levels were determined using the glucose oxidase method assay technique (manufacturer's details). Spectrophotometric analysis was performed to measure the absorbance of the resulting solution at a wavelength of 520nm.

The uricase enzyme method was used to determine the serum uric acid levels.[20] Three tubes (Test, Blank, and Standard) were prepared for each sample. 1mLof working reagent was added to each tube, followed by 0.026 mL of specimen in the Test tube, standard solution in the Standard tube, and distilled water in the Blank tube. The absorbance of the resulting solution was read at 520 nm using a spectrophotometer after incubation at a temperature of 37°C for 5 minutes in a water bath. The color remained stable for at least 30 minutes before readings were taken.

Data analysis: Data distribution was assessed for approximate normality prior to applying parametric statistical tests. Comparisons were performed between the values of blood glucose and uric acid in diabetic patients and controls using the Student's t-test, and the level of statistical significance was $p < 0.05$. Mean differences with 95% confidence intervals were reported. No multivariate adjustment was performed for potential confounding variables such as renal function, medication use, dietary factors, and duration of diabetes

Ethical Approval: Ethical approval for the study was obtained from the University of Nigeria Health Research Ethics Committee with approval number NHREC/05/01/2008B-FWA00002458-1RB00002323. To ensure adherence to ethical standards, written informed consent was obtained before enrolment in the study from each participant ensuring adherence to ethical standards.

Results

The clinical characteristics of diabetic subjects and controls are summarized in Table 1. The mean fasting blood glucose (FBG) level for diabetic subjects was 7.6 ± 1.32 mmol/L, compared to 3.9 ± 0.9 mmol/L for controls. The mean 2-hour postprandial (2HPP) plasma glucose in diabetic subjects was 14.7 ± 2.8 mmol/L, while controls had a mean value of 4.8 ± 1.11 mmol/L.

The fasting serum uric acid (SUA) level was significantly higher in diabetic subjects (0.45 ± 0.16 mmol/L) when compared to controls (0.28 ± 0.05 mmol/L), with a statistically significant difference (p = 0.02). Similarly, the mean 2HPP serum uric acid levels in diabetic subjects were higher (0.58 ± 0.16 mmol/L) than in controls (0.30 ± 0.06 mmol/L), with a statistically significant difference (p = 0.022). There was no statistical difference between the fasting and 2 HPP uric acid levels, in diabetic subjects, 0.45 ± 0.16 mmol/l and 0.58 ± 0.16 mmol/l (p>0.05). This observation was similar for controls.

Table 1: Clinical characteristics of the study participants

Parameters Number	**Female diabetic patients N = 38**	**Female controls N = 16**	**Male diabetic Patients N = 32**	**Male Controls N = 14**
Age (Years)	50.54 ± 10.7	50.8 ± 8.9	53.5 ± 9.5	51.14 ± 7.8
Duration of DM (Yrs)	5.7 ± 5.6	N/A	5.4 ± 5.2	N/A
Body mass index (BMI) (kg/m2)	25.8 ± 4.3	25.2 ± 4.8	24.5 ± 5.0	25.6 ± 4.7

DM – Diabetes Mellitus

Table 2: Plasma Glucose and Serum Uric Acid Levels in Diabetic Subjects and Controls

Parameters (mmol/L)	**Diabetic subjects N = 70**	**Controls N = 30**	**P value**
Fasting plasma glucose	7.6 ± 1.32	3.9 ± 0.9	0.001
2HPP plasma glucose	14.7 ± 2.8	4.8 ± 1.11	0.001
Fasting Serum Uric Acid	0.45 ± 0.16	0.28 ± 0.05	0.020
2HPP Serum Uric Acid	0.58 ± 0.16	0.30 ± 0.06	0.022

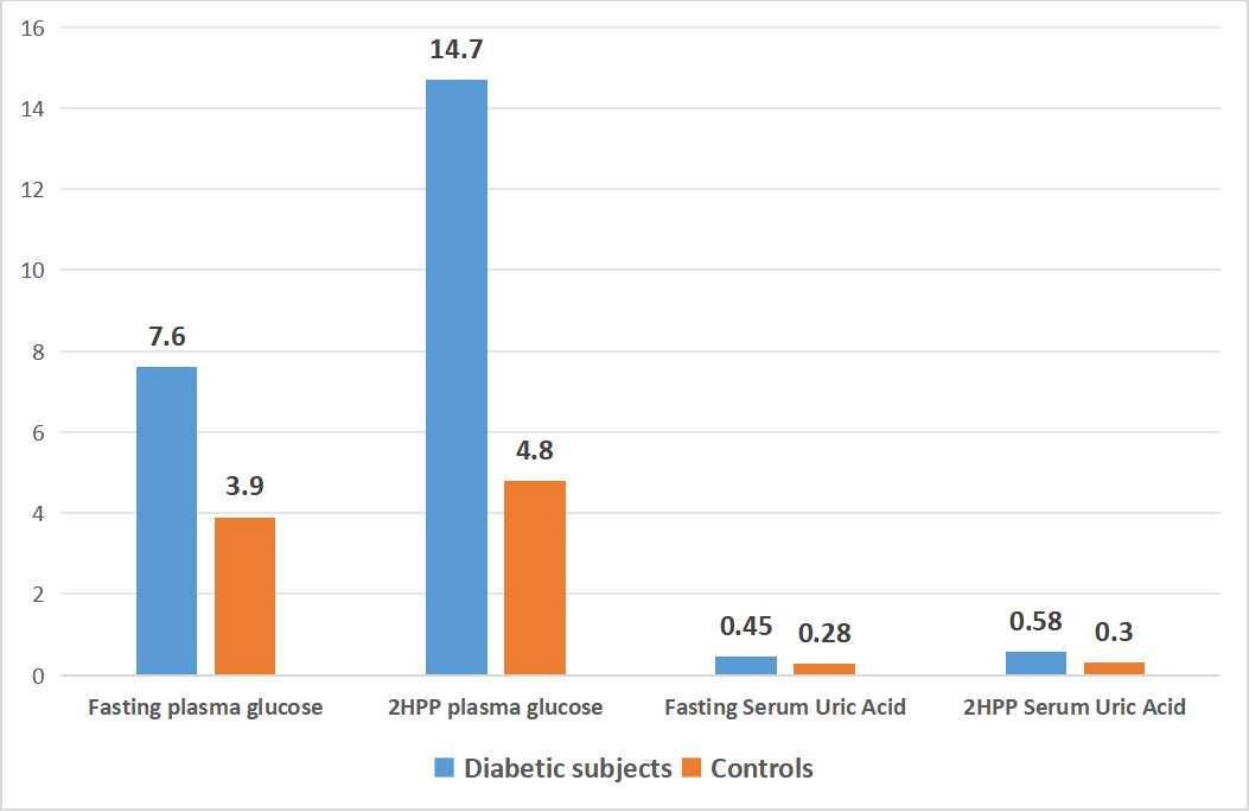

Figure 1: Comparison of Fasting and Postprandial Serum Uric Acid Levels Between Diabetic Subjects and Controls

Discussion

The present study on the effect of hyperglycemia on serum uric acid levels in patients with type 2 DM was carried out in the University of Nigeria Teaching Hospital, Ituku-Ozalla. The present study demonstrated elevated serum uric acid levels among patients with T2DM compared with non-diabetic controls. These findings showed a significant association between hyperglycemia and elevated serum uric acid levels in patients with T2DM.

This observation is similar to results from earlier studies, which also documented a high plasma uric acid level in diabetic patients compared with non-diabetic controls.[21-23] More recent studies have reported that serum uric acid levels are significantly higher in individuals with type 2 diabetes compared with non-diabetic controls, and are associated with adverse metabolic characteristics, including dyslipidemia and reduced renal function.[24] Elevated SUA has also been observed to correlate with glycemic indices and microvascular complications such as retinopathy in T2DM patients.[25]

Consistent with the present findings, previous studies have demonstrated an association between SUA and hyperglycemia in T2DM. Karim *et al* [26] reported that individuals with poor glycemic control had significantly higher SUA levels compared to those with better control. Sumanth & Jain also found that elevated SUA levels were significantly associated with higher fasting blood glucose, post-prandial glucose, and HbA1c levels, suggesting that SUA may serve as a biomarker of inadequate glycemic control in T2DM. These findings support the observed relationship between elevated SUA and hyperglycemia in individuals with established T2DM, consistent with the results of this present study.[27]

This association between hyperuricemia and T2DM is believed to be mediated through mechanisms related to insulin resistance and renal impairment. [28] Experimental and mechanistic studies propose that elevated serum uric acid has been linked to insulin resistance through multiple molecular pathways, including oxidative stress, endothelial dysfunction, inflammation, mitochondrial impairment, and altered adipokine regulation.[29] Large cross-sectional

studies conducted in diabetic populations have similarly demonstrated significant associations between hyperuricemia, insulin resistance, and dyslipidemia, with some reports suggesting that uric acid may partially be responsible for some metabolic abnormalities.[30] Recent clinical studies have shown that higher serum uric acid levels correlate with adverse metabolic profiles and reduced renal function in individuals with diabetes.[31] Although causal relationships cannot be established due to the cross-sectional nature of these studies, the accumulating evidence suggests that serum uric acid may serve as an important metabolic marker in patients with type 2 diabetes. These may explain the mechanism underlying the association between elevated SUA levels and hyperglycemia in T2DM patients.

While many studies report a positive association between serum uric acid and type 2 diabetes, some investigations have described neutral or inverse relationships. This could be due to differences in study design, including sample size, gender, or selected populations (industrial workers or hospital workers) as opposed to the general population. [32]

This study has several strengths, including the inclusion of a non-diabetic control group, allowing direct comparison of serum uric acid levels between diabetic and non-diabetic individuals. However, certain limitations should be acknowledged, including the cross-sectional design of this study, which limits causal inference between hyperglycemia and serum uric acid levels. The relatively modest sample size may also have reduced statistical power and limited the ability to adjust for potential confounding variables. Factors such as renal function indices, dietary patterns, alcohol intake, and medication use were not evaluated and could have influenced serum uric acid levels. These considerations should be taken into account when interpreting the findings.

Conclusion

This study shows the association between hyperglycemia and serum uric acid levels in individuals with type 2 DM. Our findings point out the importance of monitoring uric acid, as elevated glucose may contribute to higher uric acid levels, which could play a role in the development of diabetes-related complications, particularly diabetic nephropathy. Additional studies are necessary to explain the molecular and physiological mechanisms by which hyperglycemia alters homeostasis of serum uric acid in type 2 DM, and to determine whether interventions aimed at optimal glycemic control can reduce uric acid levels and reduce diabetes-related complications.

Financial support and sponsorship
Nil

Conflicts of interest
There are no conflicts of interest

Acknowledgement

The authors would like to thank all the participants who took part in this study for their time and cooperation. We also appreciate the support and assistance provided by the medical and laboratory staff at the University of Nigeria Teaching Hospital during the data collection process.

References

1. Venishetty S, Bhat R, Rajagopal KV. Serum uric acid levels in type 2 diabetes mellitus: Is there a linear relationship with severity of carotid atherosclerosis? Indian J Endocrinol Metab. 2018;22(5):678-82.
2. Khan MAB, Hashim MJ, King JK, Govender RD, Mustafa H, Al Kaabi J. Epidemiology of type 2 diabetes – global burden of disease and forecasted trends. J Epidemiol Glob Health. 2020;10(1):107-11..
3. Ali O. Genetics of type 2 diabetes. World J Diabetes. 2013;4(4):114.
4. Onwuchekwa EC, Chigbu LN, Gimbason DM, Ekeleme UG, Martin OC. Knowledge and attitude on diabetes mellitus among residents of Jos Metropolis, Plateau State, Nigeria. Midwifery. 2020;4(2):26-37..
5. Ogbera AO. Diabetes mellitus in Nigeria: the past, present, and future. World J Diabetes. 2014;5(6):905.
6. Adeloye D, Ige JO, Aderemi AV, Adeleye N, Amoo EO, Auta A, et al. Estimating the prevalence, hospitalisation and mortality from type 2 diabetes mellitus in Nigeria: a systematic review and meta-analysis. BMJ Open. 2017;7(5):e015424.

7. Liu D, Yun Y, Yang D, Hu X, Dong X, Zhang N, et al. What is the biological function of uric acid? An antioxidant for neural protection or a biomarker for cell death. Dis Markers. 2019;2019:4081962.
8. Yu W, Cheng JD. Uric acid and cardiovascular disease: an update from molecular mechanism to clinical perspective. Front Pharmacol. 2020;11:582680.
9. Saito Y, Tanaka A, Node K, Kobayashi Y. Uric acid and cardiovascular disease: a clinical review. J Cardiol. 2021;78:51-7.
10. Ong KL, Stafford LK, McLaughlin SA, Boyko EJ, Vollset SE, Smith AE, et al. Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the Global Burden of Disease Study 2021. Lancet. 2023;402(10397):203-34.
11. Borghi C, Agnoletti D, Cicero AFG, Lurbe E, Virdis A. Uric acid and hypertension: a review of evidence and future perspectives for the management of cardiovascular risk. Hypertension. 2022;79:1927-36..
12. Dong X, Zhang H, Wang F, Liu X, Yang K, Tu R, et al. Epidemiology and prevalence of hyperuricemia among men and women in Chinese rural population: the Henan Rural Cohort Study. Mod Rheumatol. 2020;30(5):910-20.
13. Guo K, Han Y, Liu S, Sun H, Lin X, Yang S, et al. Prevalence of and trends in hyperuricemia by race and ethnicity among US adolescents, 1999–2018. Arthritis Res Ther. 2024;26(1):193..
14. Pizarro MH, Santos DC, Barros BSV, de Melo LGN, Gomes MB. Serum uric acid and renal function in patients with type 1 diabetes: a nationwide study in Brazil. Diabetol Metab Syndr. 2018;10(1):22.
15. de Cosmo S, Viazzi F, Pacilli A, Giorda C, Ceriello A, Gentile S, et al. Serum uric acid and risk of CKD in type 2 diabetes. Clin J Am Soc Nephrol. 2015;10(11):1921-9.
16. Cook DG, Shaper AG, Thelle DS, Whitehead TP. Serum uric acid, serum glucose and diabetes: relationships in a population study. Postgrad Med J. 1986;62(733):1001-6.
17. Perry IJ, Wannamethee SG, Walker MK, Thomson AG, Whincup PH, Shaper AG. Prospective study of risk factors for development of non-insulin dependent diabetes in middle aged men. BMJ. 1995;310(6979):560-4..
18. Forbes JM, Coughlan MT, Cooper ME. Oxidative stress as a major culprit in kidney disease in diabetes. Diabetes. 2008;57(6):1446-54.
19. Tzounakas VL, Georgatzakou HT, Kriebardis AG, Papageorgiou EG, Stamoulis KE, Foudoulaki-Paparizos LE, et al. Uric acid variation among regular blood donors is indicative of red blood cell susceptibility to storage lesion markers: a new hypothesis tested. Transfusion. 2015 Nov;55(11):2659-71.
20. Fossati P, Prencipe L, Berti G. Use of 3,5-dichloro-2-hydroxybenzenesulfonic acid/4-aminophenazone chromogenic system in direct enzymic assay of uric acid in serum and urine. Clin Chem. 1980;26(2):227-31.
21. Kodama S, Saito K, Yachi Y, Asumi M, Sugawara A, Totsuka K, et al. Association between serum uric acid and development of type 2 diabetes. Diabetes Care. 2009;32(9):1737–42.
22. Klein BEK, Klein R, Lee KE. Components of the metabolic syndrome and risk of cardiovascular disease and diabetes in Beaver Dam. Diabetes Care. 2002;25(10):1790–4.
23. Nan H, Pang Z, Wang S, Gao W, Zhang L, Ren J, et al. Serum uric acid, plasma glucose and diabetes. Diab Vasc Dis Res. 2010;7(1):40–6.
24. Purohit M, Mohankala A, Bhatt K, Masood T, Singh RK. Study of serum uric acid in Type-2 Diabetes Mellitus (T2DM). International Journal of Environmental Sciences. 2025;11(19s):1332.
25. Nie C, Ma Q, Liu C, Chen L, Wang C, Hou X. Associations of serum uric acid to eGFR ratiowith diabetic retinopathy in individuals with type 2 diabetes. Scientific Reports. 2025 May 13;15(1):16625.
26. Karim AS, Chowdhury HI, Mouree SF, Mohammad A. Correlation of Serum Uric Acid Levels with Glycaemic Control in Type II Diabetic Patients. Barind Medical College Journal. 2025 Dec 15;11(2):162-5.
27. Sumanth M, Jain M. Serum Uric Acid as a Biomarker for Glycaemic Control in Type 2 Diabetes Mellitus: A Cross-Sectional Study. Journal of Contemporary Clinical Practice. 2024 Dec 12;10:163-70.
28. Li C, Hsieh MC, Chang SJ. Metabolic syndrome, diabetes, and hyperuricemia. Curr Opin Rheumatol. 2013;25(2):210–6.
29. Ali N. Serum uric acid as a mediator of insulin resistance: molecular mechanisms and metabolic pathways. Endocrinol Diabetes Metab. 2026;9(1):e70163.

30. Zhao M, Ma X, Xia Z, Zhang J, Zhong J, Ye P, Xu G, Qiao S, Shi S, He Y, Jiang J. Association between serum uric acid and dyslipidaemia in type 2 diabetes: a cross- sectional study. BMJ Open. 2025 Jan 1;15(1):e087954.
31. Argoons SA, Mahmoud ET, Madkour RA. The association of serum uric acid level with metabolic risk factors in patients with type 2 diabetes and their relation to eGFR status. Egypt J Intern Med. 2024;36:52.
32. Cui Y, Bu H, Ma X, Zhao S, Li X, Lu S. The relation between serum uric acid and HbA1c is dependent upon hyperinsulinemia in patients with newly diagnosed type 2 diabetes mellitus. J Diabetes Res. 2016;2016:9874592.