

Original Research Article

STUDY OF SERUM FERRITIN AND MICROVASCULAR COMPLICATION IN TYPE 2 DIABETES MELLITUS IN TERTIARY CARE HOSPITAL, BAREILLY

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) remains a major global health challenge, with microvascular complications representing a significant cause of morbidity and disability. Serum ferritin, a marker of body iron stores and systemic inflammation, has been increasingly linked to the development and progression of diabetes and its associated vascular complications. **Aims and Objectives:** The present study aimed to evaluate the association between serum ferritin levels and the occurrence of microvascular complications in patients with T2DM. Specific objectives included quantifying serum ferritin levels, determining the prevalence of diabetic complications—namely nephropathy, neuropathy, and retinopathy—and analyzing their correlation with ferritin concentrations.

Materials and Methods: A cross-sectional study was conducted on 96 patients with T2DM attending a tertiary care hospital in Bareilly. Serum ferritin and HbA1c were measured, and microvascular complications were assessed using standard clinical and laboratory protocols. Statistical analysis involved descriptive statistics, Pearson's correlation, and logistic regression to evaluate associations and predictive relationships.

Results: Microvascular complications were highly prevalent among participants—neuropathy in 85.4%, nephropathy in 84.4%, and retinopathy in 80.2%. Elevated serum ferritin levels (>100 ng/ml) were observed in 54.17% of patients. Serum ferritin showed a significant positive correlation with retinopathy ($r = 0.45$) and nephropathy ($r = 0.34$). Logistic regression analysis identified serum ferritin as an independent predictor of microvascular complications, significantly increasing the risk of retinopathy (OR = 1.1, $p < 0.001$), nephropathy (OR = 1.07, $p = 0.002$), and neuropathy (OR = 1.05, $p = 0.022$).

Conclusion: Elevated serum ferritin levels are strongly associated with an increased risk of microvascular complications in T2DM, suggesting its potential role as a biomarker for early detection and preventive management.

Keywords: Serum Ferritin, Type 2 Diabetes Mellitus, Microvascular Complications, Diabetic Retinopathy, Diabetic Nephropathy.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) has emerged as a major global health concern, affecting populations

worldwide with a rising incidence in low- and middle-income countries. Once considered primarily a disease of affluent nations, T2DM now contributes significantly to global morbidity and mortality,

particularly due to its vascular complications. The disease is associated with both macrovascular complications, such as coronary artery disease and stroke, and microvascular complications, including diabetic retinopathy, nephropathy, and neuropathy.^[1] Microvascular complications are progressive and often irreversible, underscoring the importance of early detection and preventive strategies. Despite advances in therapeutic interventions, the burden of these complications remains high, especially in resource-limited settings where access to adequate chronic care is often constrained. Beyond clinical consequences, diabetes imposes substantial social and economic costs, reducing productivity, increasing absenteeism, and placing financial strain on families and healthcare systems. Addressing this burden requires integrated strategies encompassing clinical care, lifestyle modification, public health education, and improved access to healthcare services.^[2]

Among the emerging strategies for early detection and risk stratification, identifying reliable biomarkers has gained considerable attention. Serum ferritin, a protein complex responsible for intracellular iron storage and functioning as an acute-phase reactant, has been suggested as a potential predictor of diabetes complications. Elevated ferritin levels are associated with insulin resistance, chronic inflammation, and components of metabolic syndrome, all of which contribute to the pathogenesis of T2DM.^[3] Excess iron can catalyze the production of reactive oxygen species, leading to oxidative stress and subsequent endothelial dysfunction, which is central to the development of microvascular injury. This mechanistic link has prompted investigations into the association of ferritin with diabetic retinopathy, nephropathy, and neuropathy, with several studies reporting that higher ferritin levels correspond to an increased risk of microvascular complications.^[4]

Oxidative stress, resulting from an imbalance between free radicals and antioxidant defenses, plays a critical role in vascular injury in diabetes. Excess iron exacerbates oxidative damage by generating reactive oxygen species that impair blood vessels, nerves, and renal tissue.^[5] As a result, elevated serum ferritin not only reflects iron overload but also serves as a marker of systemic inflammation and metabolic stress, making it a potential biomarker for predicting microvascular complications in T2DM. Understanding this relationship is particularly important in populations with high disease prevalence and limited resources, where early identification of high-risk individuals could significantly reduce the burden of complications.^[6,7] The present study was designed to evaluate the association between serum ferritin levels and microvascular complications in patients with T2DM at a tertiary care hospital in Bareilly, India. This region experiences a rising prevalence of diabetes, reflecting broader national trends driven by urbanization, lifestyle changes, and population

growth. Investigating this relationship in a local setting allows consideration of environmental, genetic, and lifestyle factors that may influence disease progression and complication patterns. By establishing whether serum ferritin correlates with microvascular injury in this population, the study aims to identify a practical, inexpensive, and clinically actionable biomarker for early risk assessment.^[8]

Routine measurement of serum ferritin could potentially enable clinicians to identify individuals at higher risk of developing complications, allowing for timely interventions such as tighter glycemic control, lifestyle modifications, and targeted monitoring for retinopathy, nephropathy, and neuropathy.^[9] Early detection and risk stratification could mitigate the progression of microvascular complications, improve patient outcomes, and optimize healthcare resource utilization. Furthermore, findings from this study may provide region-specific insights, contributing to the development of tailored preventive and therapeutic strategies that address the unique demographic and lifestyle factors affecting the local diabetic population.^[10]

T2DM represents a complex global health challenge with escalating rates of microvascular complications that significantly impact morbidity, quality of life, and economic productivity. Serum ferritin, as an indicator of iron metabolism, oxidative stress, and inflammation, holds promise as a predictive biomarker for these complications. Investigating its role in a local population provides an opportunity to enhance early detection, guide clinical management, and inform public health strategies. The study's outcomes could facilitate proactive interventions, reduce the burden of complications, and improve long-term outcomes for patients with T2DM, ultimately advancing both clinical practice and public health responses to the diabetes epidemic.^[11,12]

The study aimed to investigate the association between serum ferritin levels and the development of microvascular complications in patients with Type 2 Diabetes Mellitus (T2DM) at a tertiary care hospital in Bareilly. Specifically, it involved measuring serum ferritin levels in T2DM patients, identifying the prevalence of microvascular complications such as diabetic nephropathy, neuropathy, and retinopathy within the cohort, and assessing the correlation between serum ferritin levels and the severity of these complications.

MATERIALS AND METHODS

This prospective observational study was conducted at the Department of General Medicine, Rajshree Medical Research Institute, located in Bareilly, Uttar Pradesh, India from October 2024 to June 2025. Ethical approval has been obtained from the Ethical Approval Committee of Rajshree Medical Research Institute, located in Bareilly, Uttar Pradesh, India.

Study Population: The study population included adults aged 18 years and above of either gender with a confirmed diagnosis of Type 2 Diabetes Mellitus who were receiving standard treatment (lifestyle modification and/or pharmacotherapy) and provided written informed consent. Excluded were patients with Type 1 Diabetes, LADA, other specific diabetes types, pregnancy, acute infections, hematological disorders, advanced chronic kidney or liver disease, malignancy, or recent significant alcohol or substance abuse.

Data Analysis: All collected data were entered into a structured Microsoft Excel sheet using a double-entry method to ensure accuracy, and the cleaned dataset was analyzed using IBM SPSS Statistics Version 25. Descriptive statistics summarized categorical variables as frequencies and percentages, and continuous variables as mean \pm SD or median (IQR) based on distribution. Pearson's or Spearman's correlation assessed relationships, while t-test,

ANOVA, Chi-square, and logistic regression determined group differences and predictive associations. A p-value <0.05 was considered significant.

RESULTS

Among the 96 study participants with Type 2 Diabetes Mellitus, the majority (32.29%) were aged 51–60 years, followed by 21.88% in the 41–50 years group, indicating a higher prevalence among middle-aged individuals. Younger age groups (21–40 years) constituted fewer cases, while 15.63% were above 60 years. Males comprised 72.92% of the study population compared to 27.08% females, suggesting male predominance possibly due to lifestyle, occupational, and behavioral risk factors influencing diabetes occurrence.

Table 1: Serum Ferritin levels among T2DM patients

Ferritin Level	Frequency	Percentage
<100 ng/ml	44	45.83
>100 ng/ml	52	54.17

More than half of the T2DM patients (54.17%) had elevated serum ferritin levels (>100 ng/ml), while 45.83% had lower levels, indicating a high prevalence of increased ferritin that may reflect

inflammation, oxidative stress, and a potential role in the development of diabetic microvascular complications.

Table 2: Descriptive statistics of Serum Ferritin among T2DM patients

Parameters	Value
Mean	98.98
Standard Error	1.23
Median	102.36
Mode	96.36
Standard Deviation	12.08
Sample Variance	146.00
Kurtosis	0.19
Skewness	-0.85
Range	48.80
Minimum	68.79
Maximum	117.59
Sum	9502.47
Count	96.00
Largest(1)	117.59
Smallest(1)	68.79
Confidence Level(95.0%)	2.45

Serum ferritin levels among T2DM patients showed a mean of 98.98 ng/ml and a median of 102.36 ng/ml, with moderate variability (SD = 12.08) and slight negative skewness, indicating values clustered around 100 ng/ml and a near-normal distribution, suggesting ferritin's stability as a potential biomarker for metabolic and microvascular risk assessment.

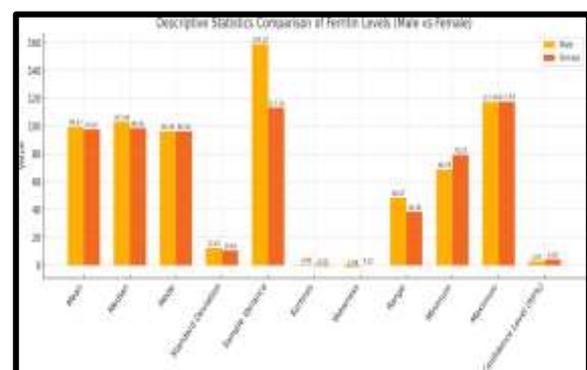


Figure 1: Comparative statistics comparison of Ferritin level among Male and Female

Male T2DM patients showed slightly higher mean serum ferritin levels (99.47 ng/ml) than females (97.67 ng/ml), with greater variability and a wider range among males, suggesting marginal gender differences possibly linked to variations in iron metabolism, inflammation, or diabetes-related risk profiles.

Among the T2DM patients studied, the majority exhibited poor glycemic control, with 46.9% having HbA1c levels between 9–10.49% and 38.5% between 7.5–8.99%. Only 7.3% of patients had relatively well-controlled levels between 6–7.49%, while

another 7.3% showed severely uncontrolled diabetes with HbA1c $\geq 10.5\%$. Overall, more than 85% of patients had HbA1c values above 7.5%, indicating suboptimal glycemic regulation. This pattern emphasizes the high prevalence of inadequate diabetes control in the cohort and highlights the need for enhanced management strategies, regular glycemic monitoring, and lifestyle or pharmacological interventions to achieve better control and minimize the risk of diabetes-related complications.

Table 3: Comparison of Hb1Ac level with biochemical parameter among T2DM patients

	Hb1Ac	n	Mean	Std. Deviation	Median	Range	Minimum	Maximum	Confidence Level (95.0%)
Ferritin (ng/m)	6 - 7.49	7	79.02	10.36	77.46	6.11	68.79	96.30	10.87
	7.5 - 8.9	37	96.39	12.03	98.56	48.57	68.79	117.36	4.01
	9 - 10.49	45	103.08	9.71	105.23	48.80	68.79	117.59	2.92
	10.5 \geq	7	105.16	5.49	104.23	15.15	99.21	114.36	5.08
C-Reactive Protein (CRP)	6 - 7.49	7	6.26	2.60	5.23	6.11	4.01	10.12	2.40
	7.5 - 8.9	37	6.43	1.88	5.69	6.08	4.23	10.31	0.63
	9 - 10.49	45	6.74	1.76	5.78	5.46	4.23	9.69	0.53
	10.5 \geq	7	5.64	0.63	5.89	1.95	4.36	6.31	0.58
SBP (mmHg)	6 - 7.49	7	113	2.16	113	6	110	116	1.99
	7.5 - 8.9	37	123.05	5.05	125	17	112	129	1.68
	9 - 10.49	45	125.82	0.58	126	21	111	132	1.18
	10.5 \geq	7	127.57	1.51	128	4	125	129	1.39
DBP (mmHg)	6 - 7.49	7	76.71	6.16	78	16	70	86	5.69
	7.5 - 8.9	37	75.49	3.37	75	11	71	82	1.12
	9 - 10.49	45	76.98	0.45	78	9	71	80	0.91

As HbA1c levels increased, serum ferritin and systolic blood pressure rose significantly, indicating strong associations with poor glycemic control, metabolic stress, and cardiovascular risk, while CRP levels remained elevated but non-linear, and diastolic pressure showed minimal variation, suggesting ferritin and SBP as more sensitive indicators of worsening diabetes status.

A high prevalence of microvascular complications was observed among T2DM patients, with neuropathy (85.4%), nephropathy (84.4%), retinopathy (80.2%), hypertension (87.5%), and dyslipidemia (85.4%), all showing highly significant associations ($p < 0.0001$), highlighting the substantial

comorbidity burden and the need for early detection and integrated management strategies.

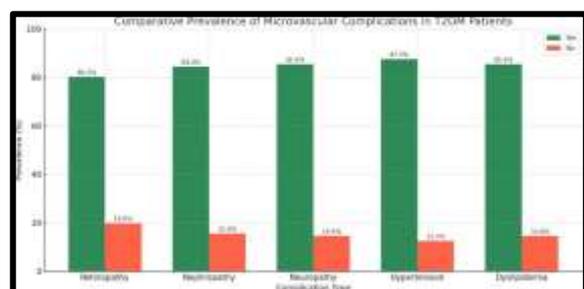


Figure 2: Prevalence of microvascular complications

Table 4: Correlation of Microvascular Complications Serum Ferritin

Microvascular Complications	Correlation with Serum Ferritin
Diabetic Retinopathy	0.45
Diabetic Nephropathy	0.34
Diabetic Neuropathy	0.24
Hypertension	0.17

Serum ferritin levels showed a moderate positive correlation with diabetic retinopathy ($r = 0.45$) and

nephropathy ($r = 0.34$), a weaker correlation with neuropathy ($r = 0.24$), and a very weak association

with hypertension ($r = 0.17$), indicating a stronger link between elevated ferritin and microvascular

complications, especially retinopathy and nephropathy.

Table 5: Logistic regression of Microvascular Complications with Serum Ferritin

Complication	Odds Ratio	95% CI (Lower–Upper)	p-value
Diabetic Retinopathy	1.1	1.05 – 1.15	0.0001
Diabetic Nephropathy	1.07	1.03 – 1.12	0.002
Diabetic Neuropathy	1.05	1.01 – 1.10	0.0218
Hypertension	1.04	0.99 – 1.09	0.112

Logistic regression showed that higher serum ferritin significantly increased the odds of diabetic retinopathy (OR 1.1, $p < 0.001$), nephropathy (OR 1.07, $p = 0.002$), and neuropathy (OR 1.05, $p = 0.022$), while its association with hypertension was not significant, indicating ferritin as a strong predictor of microvascular complications in T2DM.

DISCUSSION

Type 2 diabetes mellitus (T2DM) represents a growing global health challenge, imposing substantial burdens on individuals and healthcare systems due to chronic hyperglycemia and its vascular consequences. Prolonged hyperglycemia damages small blood vessels, leading to microvascular complications such as retinopathy, nephropathy, and neuropathy, which contribute significantly to morbidity in affected patients. While glycemic control mitigates these complications, patients with comparable glycemic levels often exhibit markedly different risks of developing microangiopathy, suggesting additional pathophysiological factors influence complication susceptibility.^[13]

Serum ferritin has emerged as a potential factor in this context. Primarily an intracellular iron-storage protein, ferritin also functions as an acute-phase reactant, rising in response to inflammation and oxidative stress. Excess iron catalyzes reactive oxygen species formation, exacerbating endothelial dysfunction, insulin resistance, and beta-cell impairment, which together increase cardiometabolic risk.^[14] Butler AE, et. al; 2021, linked elevated ferritin with higher HbA1c and longer diabetes duration, although evidence regarding its association with microvascular complications remains inconsistent. Butler AE, et. al; 2021, reported that diabetic patients with microangiopathy have higher ferritin, while others find no significant correlation, likely due to differences in population characteristics, control of inflammatory confounders, or comorbidities such as hepatic disease.^[15]

Given the scarcity of consistent data, particularly in Indian populations, investigating this association locally is imperative. Bareilly's tertiary care hospital offers access to a diverse patient base, providing an opportunity to assess whether serum ferritin can serve as a risk marker for microvascular damage in T2DM patients.^[16] Alqahtani N, et. al; 2022, aimed to evaluate the relationship between serum ferritin levels and the presence and severity of microvascular

complications, as well as to examine associations with clinical parameters such as HbA1c, diabetes duration, and other laboratory indices.^[17]

Our study revealed that the majority of T2DM patients were aged 51–60 years (32.29%), suggesting that middle-aged individuals bear a greater disease burden. Diabetes frequency increased with age, peaking in midlife, before declining after 60 years, indicating that cumulative metabolic stress and declining insulin sensitivity drive complications during this period. Sharma P, et. al; 2024, who reported peak T2DM incidence at 55–59 years in males and 65–69 years in females, highlighting age- and gender-related metabolic vulnerability.^[18] Sahakyan G, et. al; 2022, found elevated ferritin positively correlated with microalbuminuria in T2DM, supporting its role in oxidative stress-mediated endothelial dysfunction and early microvascular injury.^[19]

Pradeepa R, et. al; 2023 demonstrated a clear male predominance (72.92%), reflecting either higher disease prevalence or greater healthcare-seeking among men, potentially influenced by lifestyle, occupational stress, and metabolic risk differences. This is consistent with Kautzky-Willer A, et. al; 2023, who observed higher diabetes prevalence and earlier onset in men globally, underscoring the need for gender-sensitive prevention and management strategies.^[20,21]

More than half of the participants (54.17%) had serum ferritin >100 ng/ml, indicating elevated iron stores, chronic inflammation, and oxidative stress, which contribute to microvascular injury. These findings are corroborated by Shang X, et. al; 2022, who reported associations between hyperferritinemia and diabetic retinopathy or microalbuminuria, reinforcing ferritin as a risk marker rather than an epiphenomenon.^[22] Mean ferritin was 98.98 ng/ml with moderate variability (SD 12.08), a slight negative skew (-0.85), and near-normal kurtosis (0.19), indicating clustering near the upper-normal range, in agreement with Bayih A, et. al; 2024, who observed elevated ferritin in T2DM correlated with HbA1c and fasting glucose, reflecting metabolic and inflammatory stress.^[23]

Ferritin levels were slightly higher in males (99.47 ng/ml) than females (97.67 ng/ml) with greater variability, consistent with previous studies suggesting minimal gender differences in iron-related metabolic stress, supporting ferritin as a reliable biomarker across sexes (18,19). Most patients exhibited poor glycemic control, with 46.9%

having HbA1c 9–10.49%, reflecting chronic hyperglycemia and heightened microvascular risk. Ling J, et. al; 2025, similarly reported widespread suboptimal glycemic control and a strong link between elevated HbA1c and retinopathy, confirming hyperglycemia as a driver of oxidative stress and vascular injury.^[24]

Serum ferritin increased progressively with HbA1c, from 79.02 ng/ml (HbA1c 6–7.49%) to 105.16 ng/ml (HbA1c $\geq 10.5\%$), paralleling rises in systolic and diastolic blood pressure and elevated CRP, indicating chronic inflammation and cardiovascular strain. Bayih A, et. al; 2024, who reported ferritin's positive correlation with HbA1c, systolic blood pressure, and lipid parameters, reinforcing its role as a marker of metabolic and vascular stress.^[23]

Microvascular complications were highly prevalent: retinopathy (80.2%), nephropathy (84.4%), neuropathy (85.4%), hypertension (87.5%), and dyslipidemia (85.4%), all statistically significant ($p < 0.0001$), consistent with Shang X, et. al; 2022, emphasizing ferritin's contribution to endothelial injury and oxidative inflammation. Pearson correlation showed moderate associations of ferritin with retinopathy ($r = 0.45$) and nephropathy ($r = 0.34$), and weaker associations with neuropathy ($r = 0.24$) and hypertension ($r = 0.17$), corroborating its role in microvascular damage. Logistic regression confirmed ferritin as a significant predictor of retinopathy, nephropathy, and neuropathy, further supporting its utility as an integrative biomarker for early detection and risk stratification.^[22]

Chawla R, et. al; 2019, elevated serum ferritin in T2DM patients is closely linked with poor glycemic control and high prevalence of microvascular complications, particularly retinopathy and nephropathy. Ferritin reflects the cumulative impact of oxidative stress, inflammation, and metabolic dysregulation, serving as a practical and cost-effective biomarker to identify high-risk patients, guide early interventions, and improve long-term vascular outcomes in T2DM populations.^[25]

CONCLUSION

The study enrolled 96 diagnosed T2DM patients using a consecutive sampling method and employed comprehensive demographic profiling, clinical examinations, and standardized laboratory investigations. Key variables included serum ferritin (measured via Chemiluminescent Immunoassay), glycemic control (HbA1c via HPLC), and microvascular complications—retinopathy (fundoscopy), nephropathy (urine albumin-to-creatinine ratio), and neuropathy (clinical and nerve conduction assessments). Data were analyzed using descriptive statistics, Pearson's correlation, and binary logistic regression, revealing significant associations between elevated ferritin, poor glycemic control, and the presence and severity of microvascular complications, underscoring ferritin's

clinical relevance as a potential predictive biomarker in T2DM.

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