"CORRELATION BETWEEN TRIGLYCERIDE GLUCOSE INDEX AND MICROVASCULAR COMPLICATIONS IN TYPE 2 DIABETES MELLITUS"

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With reference to the above, we wish to inform you that your proposed research project titled **"CORRELATION BETWEEN TRIGLYCERIDE GLUCOSE INDEX AND MICROVASCULAR COMPLICATIONS IN TYPE 2 DIABETES MELLITUS."** is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee.

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LIST OF ABBREVIATIONS

ADA	American Diabetes Association
BMI	Body mass index
CCM	Corneal confocal microscopy
CKD	Chronic kidney disease
CI	Confidence interval
CV	Cardiovascular
eGFR	Estimated glomerular filtration rate
DKD	Diabetic nephropathy
DPN	Diabetic peripheral neuropathy
DR	Diabetic retinopathy
ESRD	End stage renal disease
FBS	Fasting blood sugar
GBM	glomerular basement membrane
HbA1c	Glycated hemoglobin
HDL	High density cholesterol
HR	Hazard ration
IDF	International Diabetes Federation
LDL	Low density cholesterol

MNSI	Michigan Neuropathy Screening Instrument
NPDR	non-proliferative diabetic retinopathy
OR	Odds ratio
PDR	Proliferative diabetic Retinopathy
RR	Relative risk
SD	Standard deviation
T2DM	Type 2 diabetes mellitus
TCNS	Toronto Clinical Neuropathy Score
TG	Triglyceride
TyG	Triglyceride glucose index
UACR	Urine Albumin-to-Creatinine Ratio
UKST	United Kingdom Screening Test

ABSTRACT

Background: Diabetes micro vascular complications such as diabetic retinopathy, diabetic neuropathy and renal complications are among the important causes of mortality and morbidity among patients diagnosed with diabetes mellitus and results in significant healthcare and overall economic burden. The triglyceride glucose Index (TyG Index), is a key indicator of insulin resistance. It is associated with cardiovascular diseases and Type 2 diabetes mellitus. The objective was to evaluate the relationship between Triglyceride Glucose index and microvascular complications of type 2 Diabetes Mellitus.

Methods: The present cross sectional study was conducted in the Department of General Medicine, K.L.E's Dr. Prabhakar Kore Hospital and Medical Research Centre, Belagavi from January 2023 to December 2023. All patients aged ≥ 18 years of age diagnosed with type 2 DM were included. Following a signed informed consent, a detailed information on demographics, patient history and laboratory parameters were recorded.

Results: A total of 136 patients were enrolled. The mean ± SD age was 59.8 ±13.2 years, 58.8% were males. Overall, 74 patients had at least one microvascular complication including diabetic retinopathy, diabetic nephropathy, or diabetic neuropathy. The mean ± SD TyG Index of the study population was 9.3±0.5. Overall, significant association was noted between TyG index and overall microvascular complications, diabetic retinopathy, diabetic nephropathy and diabetic neuropathy (p=0.000 for each). Similar associations were noted between HbA1c, TG levels and microvascular complications.

Conclusion: The results of this study emphasize the importance of adapting the useful, easily calculated TyG index in routine follow up during treatment of patients with Type 2 DM to assess the risk of microvascular complications.

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INTRODUCTION

Diabetes Mellitus is a global public health crisis affecting over 537 million adults worldwide, lead to 6.7 million deaths in 2021[1]. Diabetes microvascular complications such as diabetic retinopathy, diabetic neuropathy and renal complications are among the important causes of mortality and morbidity among patients diagnosed with diabetes mellitus and results in significant healthcare and overall economic burden [2]. Identifying cost effective strategies related to prevention and delaying micro vascular complications, is need of the hour. Achieving controlled serum glucose levels through medications has been identified as an important factor in preventing microvascular and macrovascular complications. Additionally, guidelines by the American Diabetes Association emphasise on the importance of lifestyle modifications in controlling type 2 diabetes mellitus [3].

Despite guideline based optimal treatment of diabetes mellitus, cardiovascular event risk is relatively higher in patients with diabetes as compared to those without diabetes [4]. Hence, it is vital to screen individuals who are at increased risk of developing micro or macrovascular complications. Metabolic Syndrome (Met S) is a series of metabolic abnormalities,whose clinical features are based on central obesity, insulin resistance, hypertension, high triglycerides and low high-density lipoprotein cholesterol (HDL). Hypertriglyceridemia is an important component of metabolic syndrome and is often associated with an increased risk of cardiovascular diseases.

The abnormal plasma triglyceride levels in metabolic disorders and cardiovascular diseases is secondary to the interaction between triglycerides and elevated glucose levels in body tissues [5, 6]. A positive correlation between elevated

triglycerides and progression of diabetic retinopathy [7] and risk of increased albuminuria [8] in diabetic patientshas been reported previously. In another study among patients with mild-to-moderate neuropathy, Wiggin et at, reported progressive myelinated fibre density loss among patients with elevated triglyceride levels. This association was independent of factors including age, disease duration or glycemic control [9, 10].

Based on results from previous studies, the triglyceride glucose Index (TyG Index), has been considered as a key indicator of insulin resistance in clinical practice [11, 12]. TyG index is a non-insulin-based Insulin resistance index which can be calculated from routinely available biochemical tests. The TyG index serves as a straightforward, precise and dependable marker for evaluating insulin resistance. It can be calculated as: Ln [Fasting serum triglyceride (mg/dL) * fasting glucose (mg/dL)/2]

A positive correlation between TyG index and cardiovascular risk including carotid atherosclerosis, hypertension, metabolic syndrome and coronary artery calcification has been studied [13, 14, 15]. Further, a correlation between TyG index and incidence of Type 2 diabetes mellitus has also been reported [16]. However, studies demonstrating the relationship between TyG index and microvascular complications in type 2 Diabetes Mellitus are limited.

Hence, the present hospital based cross sectional study was planned to study the relationship between TyG index and microvascular complications in type 2 Diabetes Mellitus.

AIM AND OBJECTIVES

- To study the correlation between Triglyceride Glucose index and microvascular complications in type 2 Diabetes Mellitus.

REVIEW OF LITERATURE

Diabetes Mellitus, a commonly occurring metabolic syndrome is characterized by hyperglycemia, a physiological state having increased glucose levels in the body than the recommended normal levels. Hyperglycemia can either occur from insufficient insulin secretion or inadequate function of insulin in the body and manifests as carbohydrate, fat and protein metabolic dysfunction.

Incidence and Prevalence

Diabetes mellitus is a severe chronic disease, is the largest global emergencies, ranking among the top 10 leading causes of mortality worldwide. The estimated overall prevalence of diabetes is over 0.5 billion among adult population globally. According to International Diabetes Federation (IDF), the estimated prevalence is expected to rise to approximately 0.6 billion and 0.7 billion by 2030 and 2045, respectively [1]. In 2021, the mortality rate of diabetes was 6.7 million worldwide [1]. According to World Health Organization, the prevalence of diabetes is increasing, particularly in developing and underdeveloped countries where 3 in 4 adults live with diabetes [1, 17]. Asia is the epicenter of diabetes with approximately 60% of patients live with diabetes. The estimated prevalence and incidence rate of diabetes in India are 77 million and 9.6%, respectively, with a projected upward increase to 134 million and 10.9%, respectively by 2045 [18, 19]. Asian Indians migrated and living worldwide are at an increased likelihood of developing diabetes as compared to the indigenous community. Previous study has conferred that Indians develop type 2 diabetes much earlier in life, with a lower BMI due to genetic makeup as well as due to behavioural

and environmental factors including diet, sedentary lifestyle and rapid urbanization [20].

Types of diabetes

Diabetes mellitus can be categorized to different types based on etiology and pathogenesis of disease, which will further assist in clinical assessment and management (Figure 1) [21].

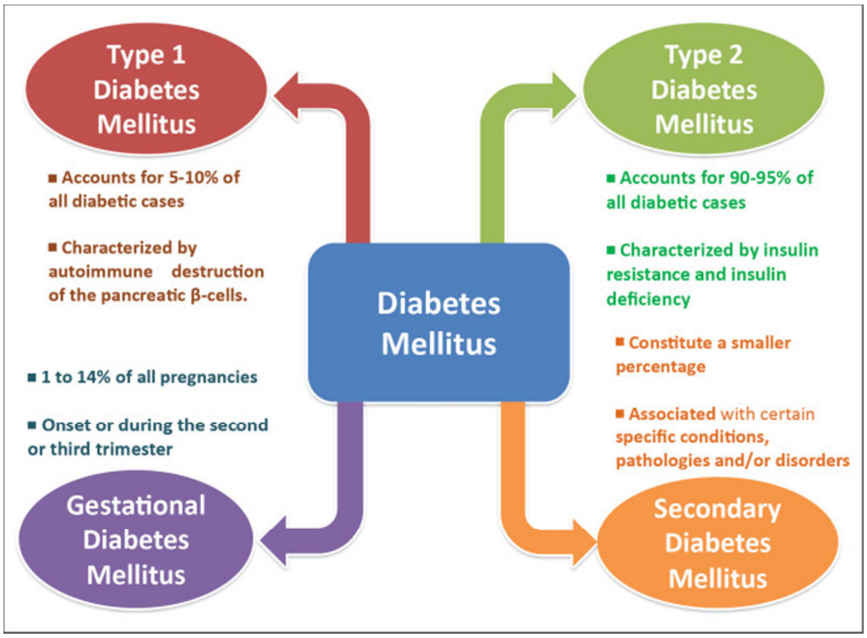


Figure 1: Types of diabetes mellitus

Risk factors

Etiology of diabetes is multifactorial. In India, total disease burden was mainly due to aggregation of risk factors, including poor dietary habits, excess weight, hypertension, elevated blood glucose and lipids, increased tobacco use and decreased consumption of fruits, nuts, seeds, and whole grains. In general, diabetes risk factors are classified as alterable (modifiable) and unalterable (non-modifiable) [22, 23].

The inherent risk factors:

- Hereditary predisposition of diabetes
- Race/ethnicity
- Age >45 years

Modifiable risk factors

- Physical inactivity
- Obesity
- Poor nutrition
- Stress/depression
- Altered intrauterine environment
- Environmental pollutants
- Inadequate sleep

Impact of Diabetes

Diabetes and its complications are among the leading causes of death. Elevated blood sugar levels (hyperglycemia) and related disruptions in carbohydrate, fat and protein metabolism impact various organs, leading to abnormal bodily functions. Chronicity of the disease with sustained hyperglycemia and its associated anomalies affect the normal structure and function of vasculature. The untreated, uncontrolled diabetes leads to diabetes-related complications including macro vascular and micro vascular complications, organ damage and dysfunction and ultimately resulting in organ failure and death. The most common complications include diabetic retinopathy, which can lead to blindness; nephropathy, which can result in renal failure; cardiac issues such as hypertension and coronary heart disease;

neuropathy; and atherosclerotic cardiovascular disease, encompassing cerebrovascular disease, coronary heart disease and peripheral arterial disease [21,24]. Additionally, diabetes is also correlated to other disease states including mental health disorders, malignancy, disability and liver diseases [25]. Diabetic complications are significantly related to premature morbidity and mortality among patients which further leads to reduced life expectancy, increased healthcare related costs and increased burden on national healthcare system. The relatively high prevalence of diabetic complications and associated outcomes could be attributed to presence of comorbidities, delay in diagnosis, inadequate healthcare system and higher medicinal cost leading to poor disease control [19]. Figure 2 illustrates the course of diabetes in relation to vasculopathy, highlighting the development of both macrovascular and microvascular complications.

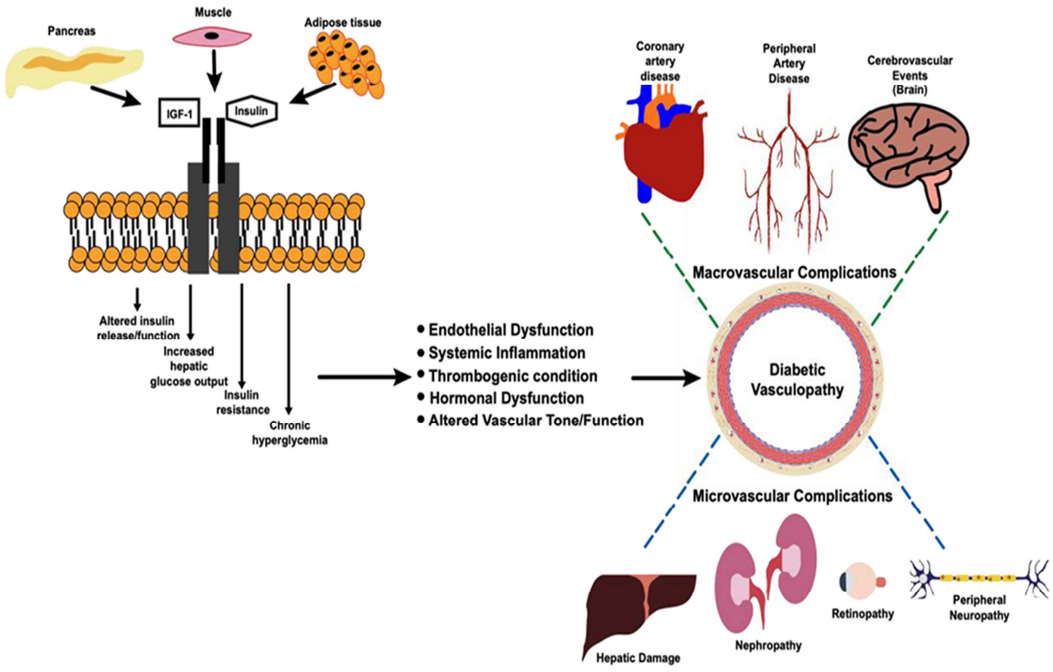


Figure 2: Progression of Diabetes and Macro and Micro vascular complications

[26]

Diabetic Retinopathy

Diabetic retinopathy is a prevalent microvascular complication of diabetes, affecting around 30% of individuals. It is complex multifactorial diabetic complication and is directly linked to endothelium system injury and chronic damage. The findings of retinopathy include micro aneurisms secondary to neo angiogenesis in the retina, blurry vision, blindness, macular damage, macular edema, cataract and glaucoma. The International Clinical Diabetic Retinopathy Society classified retinopathy as [27],

- No apparent retinopathy
- Mild non-proliferative diabetic retinopathy (NPDR)
- Moderate NPDR
- Severe NPDR
- Proliferative diabetic Retinopathy (PDR)

Diagnosis can involve retinal imaging techniques such as color fundus photography and fluorescein angiography. Recent advancements encompass optical coherence tomography, ultra-wide field retinal imaging and optical coherence tomography angiography [28].

Diabetic Nephropathy

Diabetic Nephropathy, a prominent microvascular complication of diabetes, stands as a significant contributor to chronic kidney disease and end-stage renal disease. It affects around 40% of individuals diagnosed with diabetes. Tervaert et al, [29] in 2010, has published classification of diabetic nephropathy based on hierarchical glomerular lesions into:

Class	Description and criteria
I	Mild or nonspecific changes on light microscopy and confirmed glomerular basement membrane (GBM) thickening proven by electron microscopy: GBM > 395 nm (female), GBM > 430 nm (male).
IIa	Mild mesangial expansion in >25% of the observed mesangium; area of mesangial proliferation < area of capillary cavity.
IIb	Severe mesangial expansion in >25% of the observed mesangium. Area of mesangial proliferation < area of capillary cavity.
III	At least one convincing nodular sclerosis (Kimmelstiel-Wilson lesion).
IV	Advanced diabetic glomerulosclerosis in >50% of glomeruli.

Diabetic nephropathy diagnosis relies on specific criteria including a decline in renal function, the presence of diabetic retinopathy, proteinuria and a decrease in glomerular filtration rate. Early diagnosis of nephropathy will aid in early interventions preventing the complications [30].

Common biomarkers of interest are:

- Microalbuminuria is the gold standard biomarker in diagnosis of renal changes.
- Glomerular biomarkers including transferrin, immunoglobulin G, ceruloplasmin, Type IV collagen, Laminin, Glycosaminoglycans, vascular endothelial growth factors etc

- Tubular biomarkers include alpha 1 microglobulin, neutrophil gelatinase associated lipocalin, angiotensinogen, Advanced glycation products etc
- Inflammatory biomarkers including Tumour necrosis factor alpha
- Oxidative stress biomarkers
- Newer biomarkers such as retinol binding protein, microRNA among others.

Albuminuria is linked to a heightened risk of complications and worsening kidney disease. The Urine Albumin-to-Creatinine Ratio (UACR) measures the 24-hour urine albumin excretion, calculated as urine albumin (mg/dL) divided by urine creatinine (g/dL). UACR is akin to albumin excretion in mg/day. UACR <30 mg/g excretion is considered normal. UACR of between 30 and 300 is considered micro albuminuria and if excretion rate is over 300 mg/g, is considered overt nephropathy [31].

Diabetic Neuropathy

Diabetic Neuropathy, a frequent complication in both type 1 and type 2 diabetes mellitus, impacts about half of all patients. It is a sensory neuropathy with autonomic nervous system involvement, most common in advances stage of diabetes. It is a prevalent reason behind non-traumatic amputations of the lower limbs and impaired balance, gait, diabetic foot ulceration. Clinical assessment of neuropathy can be made with assessment tools including [32]

- Michigan Neuropathy Screening Instrument (MNSI)
- Toronto Clinical Neuropathy Score (TCNS)
- the United Kingdom Screening Test (UKST)

The TCNS consists of 3 parts with a maximum score of 19.

- Symptom scores (pain, numbness, tingling sensation, weakness, ataxia, upper limb symptoms)
- Reflex test scores (Right and left ankle and knee reflexes)
- Sensory test scores (pin prick, temperature, light touch and vibration)

Based on the score the patients are stratified as no diabetic neuropathy, mild diabetic neuropathy, moderate diabetic neuropathy and severe diabetic neuropathy.

Diagnosis of neuropathy can be based on nerve conduction studies. Bedside tests such as the 10g monofilament, the Ipswich Touch Test and assessing vibration perception threshold using a tuning fork are commonly utilized. Early stage and subclinical neuropathy diagnosis is made possible with point of care devices such as the NeuroQuick, NeuroPAD, NC-Stat DPN-Check, Corneal Confocal Microscopy (CCM) and Sudoscan [32, 33].

Identification and prevention of Micro vascular Complications in Diabetes Mellitus

Micro vascular complications of diabetes with its diverse presentation and increased mortality risk remain a significant clinical challenge. Among patients with early-onset diabetes, microvascular complications were reported in approximately 50% to 80% of patients after 9 and 15 years of follow-up, respectively [34]. It typically develops over several years, but it can also manifest at the time of diabetes diagnosis. The presence of microvascular complications is associated with an increased risk of cardiovascular disease. Therefore, identifying patients at increased risk of microvascular complications and implementing early prevention measures are of

paramount importance. While, hyperglycemia is considered the root cause of complications, however, the exact etiology is not clear. Prior research has indicated a synergistic effect of hypertension, dyslipidaemia, smoking and duration of diabetes on the development and progression of microvascular complications in diabetes [35].

Primary prevention of microvascular complications entails intensive management of modifiable risk factors, adopting lifestyle modifications, implementing systematic screening measures and promoting education and awareness. Regular screening and timely follow up of patients diagnosed with diabetes is essential to identify micro vascular complications. Secondary prevention involves consistent monitoring and proactive management of risk factors to prevent and mitigate the progression of disease. The following considerations can be taken to account to monitor and prevent micro vascular complications [36]:

- Individualized glycemic monitoring and target setting are vital for managing microvascular complications of diabetes. This can be accomplished through the use of glucose-lowering medications, which can be tailored to maintain optimal blood sugar levels.
- A target blood pressure of less than 140/90 mmHg should be aimed.
- Engaging in lifestyle modifications and increasing physical activity can facilitate weight loss, which is beneficial for managing dyslipidemia.
- Cessation of smoking.

Risk factors of Micro vascular Complications in Diabetes

Common risk factors of development of diabetic complications include [37]:

- Blood pressure
- Changes in lipid profile (Total cholesterol, high-density lipoprotein [HDL], low-density -lipoprotein [LDL] and triglycerides)
- Obesity
- HbA1c levels

Long-term variability, characterized by fluctuations in risk factors beyond normal ranges, has been demonstrated to be associated with the development of diabetic complications. Previous studies have established an association between variability in HbA1c and lipids and the occurrence of diabetic complications [38].

Glycemic variability in Diabetic Micro Vascular complications

HbA1c remains the gold standard to assess the glycemic control among diabetic patients. However, it is not a complete representation of glycemic status. Glycemic variability constitutes a fundamental aspect of glucose homeostasis, representing the fluctuations in glucose and associated parameters within a given interval. Increased glycemic variability is linked to a heightened risk of cardiovascular events. Previous studies have shown that, increased fluctuations of mean HbA1c was associated with increased risk of albuminuria, kidney disease progression and progression of diabetic nephropathy. Additionally, glycemic variability is correlated with the severity of peripheral neuropathy and serves as a significant risk factor for the development of diabetic neuropathy. Moreover, HbA1c is regarded as an independent risk factor for the development of diabetic retinopathy. Glucose variability is associated with both

hyperglycemia and hypoglycemia, contributing to the development of both macrovascular and microvascular complications over time [39-41]. Mechanisms of glycemic variability are described in figure 3.

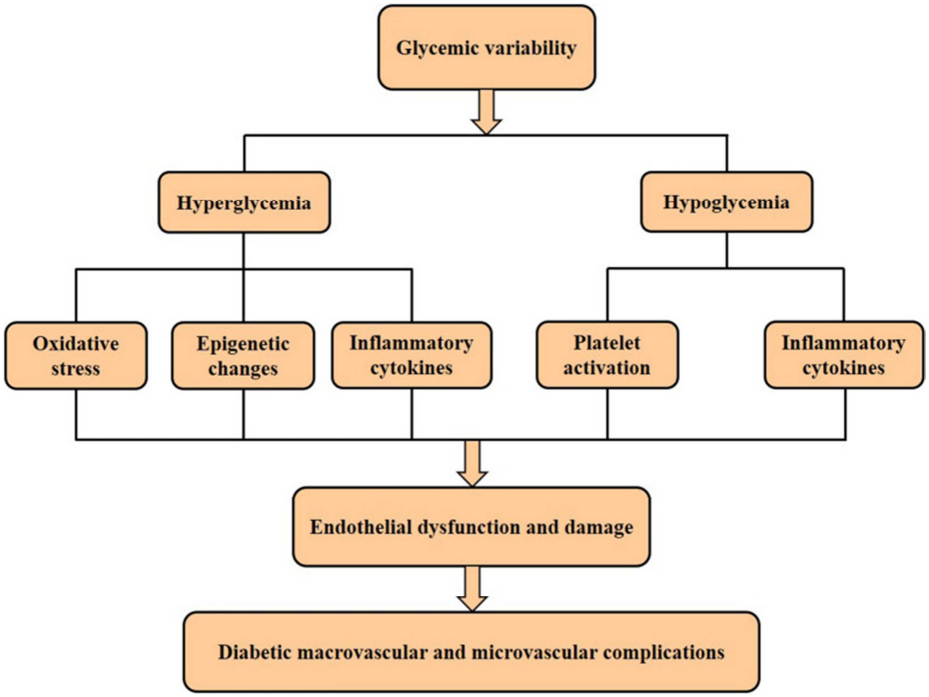


Figure 3: Mechanisms of Glycemic Variability and Diabetic Complications [42]

Dyslipidemia in Diabetes

Lipid abnormalities significantly contribute to the heightened risk of atherosclerotic cardiovascular disease in individuals with diabetes. Termed as Diabetic Dyslipidemia, these alterations encompass elevated levels of total cholesterol, very low-density lipoprotein (VLDL), low-density lipoprotein (LDL) and triglycerides (TG), alongside reduced concentrations of high-density lipoprotein (HDL). Diabetic dyslipidemia exhibits a close association with microvascular complications. While previous studies have established a correlation between lipid profiles and these complications [43], ongoing research aims to elucidate further, the

impact of lipid profiles on diabetic complications. Enhancing our comprehension of lipid profiles is pivotal for effectively managing dyslipidemia and mitigating cardiovascular risk in diabetic patients. Numerous studies have highlighted the occurrence of elevated triglyceride (TG) levels and increased ratios of TG to high-density lipoprotein cholesterol (HDL) among individuals with diabetic complications [44-46].

Figure 4: illustrates the mechanism of lipid alterations and development of diabetic micro vascular complications.

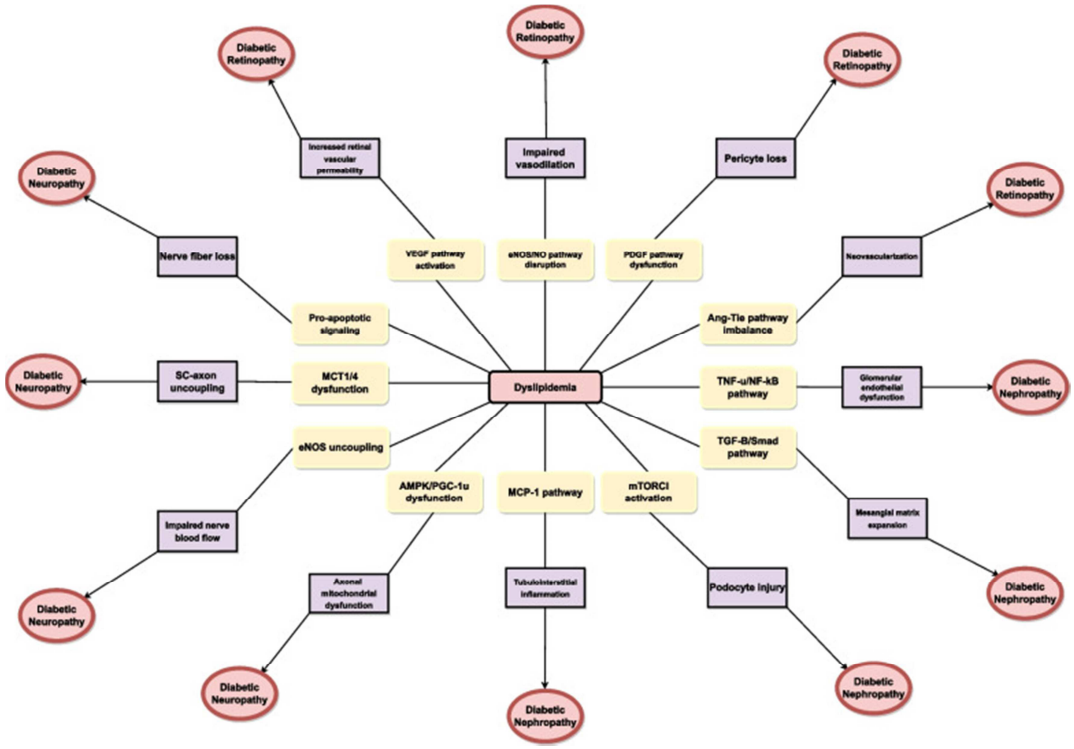


Figure 4: Impact of lipid alterations and mechanism of development of diabetic microvascular complications [47]

Triglyceride levels in diabetes complications

In individuals with diabetes at risk of vascular injury, elevated triglyceride levels can accumulate within the lumen of the vascular system. Increased levels of serum Triglycerides might impact renal function by inducing detrimental lipid disruptions, inflammatory process, oxidative stress and affect the normal renal function. Elevated levels of triglycerides are recognized to stimulate the production of inflammatory mediators and exert a pro-apoptotic influence on the endothelium of the kidney [48]. Fasting serum triglyceride level if <150 mg/dl is considered normal. Values 150-199 are considered borderline high levels and values >200 are considered high elevation and TG levels of at least 500 is categorized as very high [49].

The triglyceride glucose Index (TyG Index)

Insulin resistance is associated with Metabolic syndrome and type 2 DM. Among the many methods to measure the insulin resistance, TyG index is also now commonly used. Previous studies have demonstrated an association between the TyG index and insulin resistance and is significantly elevated among patients with T2DM. Recent studies, have also shown association of TyG index in diabetes mellitus cases with microvascular and macrovascular complications. TyG index is a non-insulin-based Insulin resistance index, which can be calculated from routinely available biochemical tests. The TyG index serves as a straightforward, precise and reliable marker for evaluating insulin resistance.

It can be calculated as: Ln [Fasting serum triglyceride (mg/dL) * fasting glucose (mg/dL)/2]

The Homeostasis Model Assessment for insulin resistance (HOMA-IR) index is another widely used marker of insulin resistance in clinical practice. Recent studies, have identified TyG index as a dependable index with better sensitivity as compared to homeostasis model assessment [59]. This index is useful to assess metabolic syndrome, non-alcoholic fatty liver disease, atherosclerosis and T2DM. While TyG index has emerged as a marker for assessing the risk of microvascular complications, the TyG index can be confounded by diet, lifestyle, patient medications including hypoglycaemic agents and lipid lowering drugs [50, 51].

Related Studies

In a prospective observational study conducted across multiple hospitals, **Stratton, et al (2000), [52]** examined the correlation between glycemic exposure over time and the risk of macrovascular or microvascular complications, in patients with Type 2 diabetes mellitus. The study analysed data from a total of 4585 patients for incidence, with 3642 patients included in the analysis of relative risk. Their findings revealed, a statistically significant association between glycemic levels and the incidence of clinical complications. For every 1% decrease in HbA1c levels, there was a 21% reduction in the risk of diabetic complications, a 21% decrease in mortality risk, a 14% reduction in myocardial infarction risk and a 37% decrease in microvascular complications. The authors concluded that, diabetic complications are strongly linked to hyperglycaemia status and lowering HbA1c levels can significantly mitigate the risk of complications.

Nazimek-Siewniak B, et al (2002), [53] conducted a retrospective study, aiming to identify risk factors associated with the development of long-term complications in Type 2 diabetes. The study included 2175 patients newly diagnosed with T2DM, who

visited an outpatient diabetes clinic between 1980 and 1994. The researchers recorded the time from T2DM diagnosis to the occurrence of complications, along with various risk factors such as fasting plasma glucose, total cholesterol, triglycerides, blood pressure and body mass index (BMI). They found that higher levels of fasting plasma glucose and mean blood pressure, significantly increased the risk of developing nephropathy and proliferative retinopathy. Additionally, elevated mean arterial blood pressure was linked to a higher incidence of stroke and cardiovascular disease. High total cholesterol levels was associated with an increased risk of coronary artery disease and proliferative retinopathy. The authors concluded that, increased blood pressure is a risk factor for macrovascular complication and the combined risk factors such as, increased blood pressure and elevated fasting plasma glucose, are significantly associated with microvascular complications in patients with T2DM.

Pradeepa R, et al (2010), [54] conducted a population-based study, to examine the risk factors for microvascular complications and the interrelation between different microvascular complications in diabetes. They enrolled 1736 patients in the study, out of which, 1608 individuals provided complete information for analysis. Diabetic retinopathy was classified according to the Early Treatment Diabetic Retinopathy Study grading system. A urinary albumin-to-creatinine ratio (UACR) of more than 30 mg/g, was set as the threshold for diagnosing nephropathy. The study found that diabetic retinopathy, neuropathy, overt nephropathy and microalbuminuria were present in 282 (17.5%), 414 (25.7%), 82 (5.1%) and 426 (26.5%) patients, respectively. The risk of nephropathy and neuropathy was significantly higher among patients with diabetic retinopathy, compared to those without diabetic retinopathy, with odds ratios of 5.3 and 2.9, respectively ($p < 0.0001$ for each). Risk factors for microvascular complications included age, glycated hemoglobin levels, duration of

diabetes and serum triglycerides levels. After eliminating all confounders, diabetic retinopathy was associated with an increased risk of nephropathy, with an odds ratio of 2.1 ($p = 0.005$).

Shang J, et al (2019), [55] conducted a nested case-control study, to investigate the associations and potential thresholds between the triglyceride-glucose (TyG) index and the risk of new-onset biopsy proven diabetic nephropathy, in patients with Type 2 diabetes mellitus (T2DM). They selected 950 biopsy-proven diabetic nephropathy cases and compared with 4750 age and gender-matched treated T2DM patients, as controls. Logistic regression analysis of this study, revealed a nonlinear relationship between the TyG index and newly diagnosed biopsy-proven diabetic nephropathy, with a threshold TyG index of 9.05-9.09. Similar associations were noted with fasting glucose and triglyceride levels. The authors concluded that, a TyG index above the threshold of 9.05-9.09, could serve as a prognostic indicator to identify patients at risk of developing diabetic nephropathy.

Su WY, et al (2019), [56] conducted a longitudinal retrospective study, to evaluate the role of the TyG index in cardiovascular (CV) events in patients with T2DM and to assess the predictive ability of occurrence of CV events, using TyG index. They included, 3524 patients diagnosed with T2DM in 2009 and followed them up until 2015. During the follow-up period of 5.93 years, 215 (6.1%) CV events were recorded. Based on multivariable stepwise analysis, high fasting glucose (hazard ratio [HR] 1.01; $p < 0.001$) and a high TyG index (HR 1.52; $p = 0.004$) were associated with higher rate of CV events. Adding fasting glucose and the TyG index to the basic model, significantly improved the predictive ability of the occurrence of CV events ($p < 0.001$ and $p = 0.018$, respectively). The authors concluded that, fasting glucose and

the TyG index are useful parameters and stronger predictive factors for CV events, offering an additional prognostic benefit in patients with Type 2 diabetes mellitus.

Da Silva A, et al (2020), [57] conducted a systematic review and meta-analysis of 13 cohort studies, to evaluate the TyG index's predictive value for identifying adults and older individuals, who are at risk of Type 2 diabetes mellitus. They obtained relevant articles with cohort designs that assessed T2DM incidence through hazard ratios (HR), relative risks (RR), or odds ratios (OR) from search engines such as PubMed, Cochrane, Scopus and Lilacs. The meta-analysis included 70,380 adults and older population of both sexes. Out of 13 studies, 10 showed a significant association between the TyG index and the risk of developing T2DM (HR: 2.4, 95% CI: 2.2-2.8). Among nine studies, a significant association was noted between the TyG index and T2DM risk (RR: 3.1, 95% CI: 2.3-4.2). However, high heterogeneity was observed in all analyses, confirmed by I^2 and visual inspection of funnel plots. The authors concluded that, due to its positive and significant association with T2DM, the TyG index may be considered applicable for identifying individuals at risk of developing T2DM, though further studies are warranted to address the high heterogeneity.

In a cross-sectional observational study, **Srinivasan et al. (2020),** [58] investigated the relationship between the TyG index, diabetic retinopathy and nephropathy. Their study enrolled 1413 patients, who were newly diagnosed or known to have Type 2 diabetes mellitus (T2DM). Patients were categorized into four groups based on TyG quartiles: Q1 (≤7.3), Q2 (>7.3 to ≤ 7.5), Q3 (>7.5 to ≤ 8.0) and Q4 (>8.0) for analysis. They utilized, stepwise binary logistic regression analysis to assess the association between variables and diabetic retinopathy or nephropathy. Their findings revealed that, a higher TyG index (odds ratio [OR]: 1.5; p = 0.001) and a longer duration of

diabetes (OR: 1.1; $p < 0.001$) were associated with diabetic retinopathy. Similarly, a higher TyG index (OR: 1.7; $p < 0.001$), advanced age (OR: 1.0; $p < 0.001$), insulin use (OR: 1.8; $p = 0.033$), higher systolic blood pressure (OR: 1.0; $p < 0.001$) and the presence of diabetic retinopathy (OR: 3.1; $p < 0.001$) were associated with nephropathy. Moreover, a higher TyG index correlated with the severity of DR ($p = 0.024$), nephropathy ($p = 0.001$), age ($p < 0.001$) and diastolic blood pressure ($p = 0.006$). The authors concluded that, there is a recognized association between TyG index and the presence of diabetic complications, including retinopathy and nephropathy in T2DM patients. They suggested that, the TyG index could serve as a monitoring tool for the metabolic status in such patients.

In a cross-sectional study, **Liu et al. (2021),** [59] examined the association between the TyG index and diabetic nephropathy, in patients with Type 2 diabetes mellitus (T2DM). They included, 682 adult patients with T2DM, hospitalized between January 2007 and December 2009 in their analysis. Among these patients, 232 (34%) had diabetic neuropathy. Among the patients with diabetic neuropathy, there was significant increase in the disease duration, body weight, blood pressure, HbA1c, TG levels, total cholesterol, serum uric acid, 24-hour urinary albumin, TyG index and homeostatic model assessment 2 for insulin resistance (HOMA2-IR) as compared to patients without neuropathy. Using a cutoff of 9.66, the TyG index exhibited a higher area under the receiver operating characteristic curve (AUC) of 0.67 compared to HOMA2-IR (AUC: 0.61) for identifying diabetic neuropathy. The TyG index demonstrated positive correlations with metabolic indicators and urinary albumin-to-creatinine ratio (UACR). Multiple regression analysis identified, TyG index as an independent risk factor for diabetic neuropathy.

Pan et al. (2021), [50] conducted a study, from January 2015 to November 2020 and enrolled a cohort of 4,721 hospitalized Chinese patients. They assessed the relationship between, TyG index and the risk of both macrovascular and microvascular complications. They evaluated brachial-ankle pulse wave velocity and ankle-brachial index to assess macrovascular complications. Urine microalbuminuria and fundus examination were used to detect diabetic nephropathy and retinopathy respectively. The association between the TyG index and diabetes complications was examined using logistic regressions. Higher TyG index values were found to be associated with significantly increased risk of urine microalbumin (odds ratio [OR]: 1.4) and ankle-brachial index (OR=1.3), with a p-value less than 0.002. This significance persisted, even after adjusting for confounding factors. The authors noted stronger TyG index associations in elderly patients and inpatients, with poor glycemic control. Based on their findings, Pan and colleagues concluded that, hospitalized patients with elevated TyG index levels are at a heightened risk of diabetic complications. Thus, emphasizing the importance of close monitoring in this population.

Gao YM, et al (2023), [60] conducted a study, to assess the correlation between TyG index and the risk of end-stage renal disease (ESRD) in patients diagnosed with Type 2 diabetes mellitus (T2DM) and Chronic Kidney Disease (CKD). Over the period spanning from 2013 to 2021, a total of 1,936 patients with T2DM and CKD, who were hospitalized at Peking University Third Hospital in Beijing, China, were enrolled in the study. ESRD was defined as an estimated glomerular filtration rate (eGFR) of less than 15 mL/min/1.73 m^2 or the initiation of dialysis or renal transplantation. Following a median follow-up duration of 41 months, 105 (5.42%) participants developed ESRD. The unadjusted and fully adjusted analyses revealed, a

1.50-fold (95% confidence interval [CI]: 1.17-1.93; p=0.001) and 1.49-fold (95% CI: 1.12-1.99; p=0.006) increased risk for ESRD, per one unit rise in the TyG index. Additionally, with a TyG index cut-off value of 9.5, significant risk stratification was noted (p=0.003). The authors concluded, a notable positive correlation between elevated TyG index levels and the risk of ESRD. Their study highlighted, the clinical significance of utilizing the TyG index to monitor the decline in renal function, among individuals with T2DM and CKD.

Jabeen WM, et al (2023), [61] conducted a cross-sectional study and aimed at assessing the role of the TyG index and TG:HDL ratio, as predictors of insulin resistance and glycemic control, in patients diagnosed with Type 2 diabetes mellitus (T2DM). The study included, a total of 56 patients aged between 30 and 75 years. In comparison to patients with good glycemic control, those with uncontrolled glucose levels exhibited significantly higher mean TyG index (17.8 vs. 7.3; p=0.01) and TG:HDL ratio (3.84 vs. 1.2; p=0.01). Furthermore, the TyG index and TG:HDL ratio demonstrated, significant associations with HbA1c, fasting blood glucose and HOMA-IR (p=0.01 for each). Both the TyG index and TG:HDL ratio were also found to significantly increase the risk of cardiovascular diseases and nephropathy. The authors concluded that, both the TyG index and TG:HDL ratio possess strong associations and predictive capabilities, for identifying insulin **resistance and detect the development and progression of T2DM.**

Kassab HS, et al (2023), [62] conducted a cross-sectional study, to examine the relationship between the TyG index and microvascular complications, among 500 patients diagnosed with Type 2 diabetes mellitus (T2DM). These patients were recruited from the outpatient clinic of the Diabetes and Metabolism Unit, at

Alexandria Main University Hospital. Microvascular complications were diagnosed according to the criteria established by the American Diabetes Association (ADA). The study found that, among T2DM patients, the TyG index was significantly higher in those with diabetic retinopathy, diabetic kidney disease and diabetic peripheral neuropathy ($p<0.001$). Additionally, a statistically significant positive correlation was observed between the TyG index and the duration of diabetes and between the ratio of triglycerides to high-density lipoprotein ($p<0.001$). Based on these findings, the authors concluded that the TyG index serves as an accessible, inexpensive and readily available **marker for detecting microvascular complications in patients with T2DM.**

Li J, et al (2023), [46] conducted a retrospective cross-sectional study, to investigate the relationship between lipid profiles and microvascular complications, in patients diagnosed with Type 2 diabetes mellitus (T2DM). The study included 1096 T2DM patients, who were categorized into groups based on existing diabetic complications. The groups included the Control group (diabetic patients without microvascular complications) and patients with microvascular complications. Comparisons of lipid profiles between both the groups were made and logistic regression analysis was applied. The study found that, the rate of dyslipidemia was higher among patients with microvascular complications, compared to the control group. Additionally, an increased level of triglycerides (TG) was significantly associated with a higher number of complications. Elevated TG levels were linked with an increased risk of complications, with odds ratios of 2.4, 2.3 and 2.3 for DKD, DR and DPN, respectively. Furthermore, the risk of DKD, DR and DPN was found to be even higher, among patients with high TG values, those aged over 55 years (OR=2.2, 2.1 and 1.8, respectively), with a disease duration of over 10 years (OR=2.4, 2.1 and 1.4,

respectively) and those with an HbA1c level of ≥7 (OR=2.1, 2.0 and 1.4, respectively).The authors concluded that, elevated TG levels increase the risk of microvascular complications, particularly among older patients, those with elevated HbA1c levels and amongst patients with longer duration of disease.

Sartore G, et al (2023), [63] conducted a meta-analysis, aiming to assess the relationship between variability in HbA1c levels and the risk of macrovascular and microvascular complications in Type 2 diabetes mellitus (T2DM). The meta-analysis included 23 relevant articles published between 2015 and July 2022. Their analysis revealed a significant association between HbA1c levels and all macrovascular and microvascular complications, except neuropathy. Specifically, the risk of stroke (HR: 1.4; 95% CI: 1.3-1.5, p<0.0001), transient ischemic attack, coronary heart disease, myocardial infarction (HR: 1.3; 95% CI: 1.3-1.4, p<0.0001) and peripheral arterial disease (HR: 1.3; 95% CI: 1.1-1.6; p=0.0007), was significantly associated with higher HbA1c levels. Similarly, the risk of microvascular complications, including nephropathy (HR: 1.3; 95% CI: 1.2-1.4, p<0.0001) and retinopathy (HR [95% CI]: 1.2 [1.1-1.2], p<0.0001), was also higher with increased HbA1c levels. However, the risk of neuropathy (HR [95% CI]: 1.0 [1.0-1.1], p=0.14) was not found to be significant. Furthermore, in patients with higher HbA1c levels, both all-cause mortality and cardiovascular mortality rates were elevated, with HRs exceeding 1.0. In conclusion, the authors highlighted a positive association between HbA1c variability and the incidence of macrovascular and microvascular complications, as well as higher mortality rates, in patients with T2DM.

Zhou J, et al (2023) conducted a meta-analysis, aiming to explore the relationship between the TyG index and the prevalence of diabetic retinopathy. The researchers screened all relevant articles published until June 2023. They included 10 observational studies, comprising 13,716 patients diagnosed with Type 2 diabetes mellitus (T2DM). Patients with a higher TyG index have an increased risk of diabetic retinopathy, with an odds ratio (OR) of 2.3 (95% CI: 1.3-4.2; $p<0.05$). Similar results were obtained when the TyG index was evaluated as a continuous variable, with an OR of 1.5. In conclusion, the meta-analysis suggested that the TyG index might be associated with an elevated prevalence of diabetic retinopathy in patients with T2DM.

Karimi MA, et al (2024), conducted a systematic review, to investigate the impact of lipid variability on microvascular complications in patients with diabetes. The review included seven studies published between 2012 and 2022, involving patients aged 45 to 84 years with a diabetes history ranging from 7 to 12 years. Their findings revealed that, increased levels of LDL, HDL and TG variability were associated with an elevated risk of microvascular complications, particularly diabetic nephropathy and neuropathy. Changes in the lipid profile were linked to the development of albuminuria and decline in glomerular filtration rate (GFR), leading to nephropathy. Additionally, reduced levels of HDL were found to have a protective effect against microalbuminuria. However, no significant relationship between lipid variability and retinopathy was identified. Based on their findings, the authors concluded that healthcare providers and policymakers should remain vigilant regarding lipid variation in the general population, given its association with diabetic complications.

MATERIAL AND METHODS

Source of Data

The present study was conducted in the Department of General Medicine, K.L.E's Dr. Prabhakar Kore Hospital and Medical Research Centre, Belagavi.

Study design

Cross-sectional study

Study period

One year from January 2023 to December 2023

Sample size: 135 patients

According to the IDF, 8.8% of the adult population have diabetes, with men having slightly higher rates (9.6%) than women (9.0%). Based on the incidence rate of 8.8%, incidence formula was used to calculate sample size.

The sample size n and margin of error E are given by:

$x = Z(c/100)2r(100-r)$

$n = N\ x/((N-1)E2 + x)$

$E = Sqrt[(N - n)x/n(N-1)]$

Where,

N is the population size; N=20000,

r is the fraction of responses; r=8.8%,

Z(c/100) is the critical value for the confidence level c; Z=1.96.

By inputting the values in the above formula, the sample size of 123 patients with type-2 diabetes mellitus, at a confidence interval of 95% and 80% power of the study was obtained.

Further, considering an attrition rate of 10%, a sample size of **135** patients with type-2 diabetes mellitus was calculated.

Sampling method

Convenient sampling method

Selection Criteria

Inclusion Criteria

- All patients aged ≥ 18 years of age
- Diagnosis of Type 2 Diabetes Mellitus according to ADA criteria [64]

Exclusion criteria

- Any Febrile Illness
- Chronic Renal Disease
- Heart Failure
- Autoimmune Disease
- Hypertension
- Malignancy
- Liver Disease
- Radiculopathy And Inflammatory Neuropathy
- Peripheral Vascular Disease
- Obstructive Uropathy

Methodology

All patients fulfilling the inclusion criteria and willing to participate in the study, were enrolled in the study after taking written informed consent. A proforma was used to record comprehensive details about patient demographics, medical history and treatment history in order to detect the existence of microvascular complications. Vital signs were recorded and a thorough physical examination was performed.

Laboratory investigations included Fasting blood sugar (FBS), glycosylated hemoglobin (HbA1c), Complete blood counts, Renal function tests, liver function and fasting lipid profile. The serum level of creatinine and albumin were measured by an automatic biochemical analyzer.

To assess diabetic nephropathy, the urinary microalbuminuria: creatinine ratio (UACR) was calculated. A UACR value of <30mg/g was considered normal and value of ≥30 mg/g was considered as microalbuminuria suggestive of diabetic nephropathy.

Further, a comprehensive eye examination by fundoscopy was done to confirm diabetic retinopathy. Based on The International Clinical Diabetic Retinopathy Severity Scale, retinopathy was categorized as [27],

- No apparent retinopathy
- Mild non-proliferative diabetic retinopathy (NPDR)
- Moderate NPDR
- Severe NPDR
- Proliferative diabetic retinopathy (PDR)

Neuropathy was confirmed based on Toronto clinical neuropathy score [33]. Based on this, neuropathy was categorized as

- No neuropathy (score 0-5)
- Mild neuropathy (score 6-8)
- Moderate neuropathy (score 9-11)
- Severe neuropathy (score ≥12)

The Triglyceride Glucose index was calculated using the following formula Ln [fasting triglycerides (mg/dL) × fasting glucose (mg/dL)/2].

Patients were categorized based on the score as

- A: <9.3
- B: 9.3-<9.5
- C: 9.5-10
- D: >10

Data collection

The following data were collected and entered in a case history proforma

- Demographics including age and sex
- Fasting blood sugar
- Glycated haemoglobin (HbA1c) levels
- Serum triglycerides
- TyG index
- Fundoscopy findings: normal, mild NPDR, moderate NPDR, severe NPDR and PDR

- TCNS
- UACR
- Complete blood counts
- Renal function tests- Serum creatinine and urea levels
- Liver function tests

Ethical considerations

Institutional ethical clearance was obtained prior to initiation of the study. The details of the study were explained to the patients and an informed consent was obtained from all patients

Data handling

The collected data were entered in Microsoft excel and the related records were stored safety with no access to other study personnel.

Statistical analysis

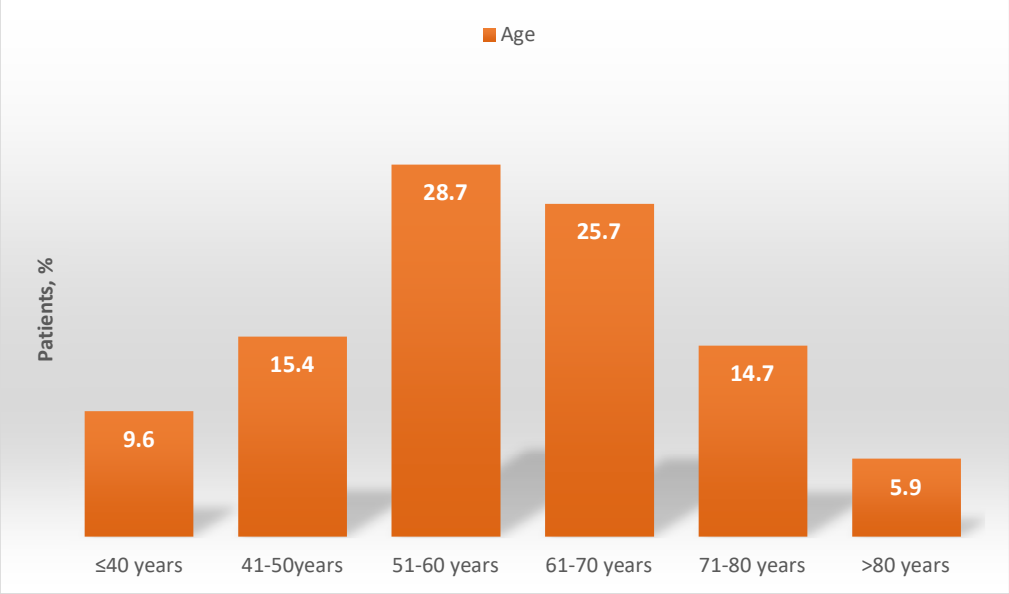
All data was entered in the Microsoft excel sheet and then imported to SPSS version 22 software for statistical analysis. Categorical variables were summarized as frequency and percentages. Continuous variables were presented as Mean and standard deviation. Chi-square test or Fisher exact test was used to check the association between triglyceride levels, HbA1c, TyG index and micro vascular complications among categorical variables. Comparison of continuous variables was done using ANOVA test. P-value less than or equal to 0.05 indicates statistical significance.

RESULTS

A total of 136 patients diagnosed with type 2 Diabetes Mellitus, aged between 30-88 years were included in the study. The mean ± SD age of the study population was 59.8 ±13.2 years and median age was 60 years. Most of the patients belonged to the age group of 51-60 years (n=39, 28.7%), followed by 61-70 years (n=35, 25.7%). The descriptive statistics and age distribution are presented in Table 1 and Graph 1.

Table 1: Distribution of patients based on age

Age group	Frequency	Percentage (%)
≤40 years	13	9.6
41-50years	21	15.4
51-60 years	39	28.7
61-70 years	35	25.7
71-80 years	20	14.7
>80 years	8	5.9
Total	**136**	**100.0**

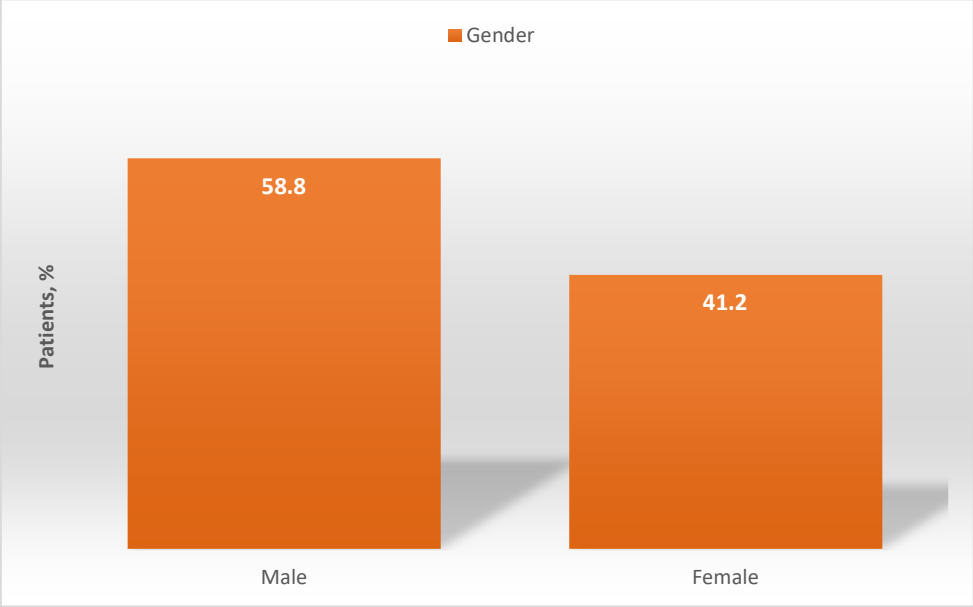


Graph 1: Bar diagram showing age distribution of study population

Overall, 80 (58.8%) patients were male and 56 (41.2%) were female. Gender distribution of patients based is shown in Table 2 and Graph 2

Table 2: Distribution of patients based on gender

Gender	Frequency	Percentage
Male	80	58.8
Female	56	41.2
Total	136	100.0

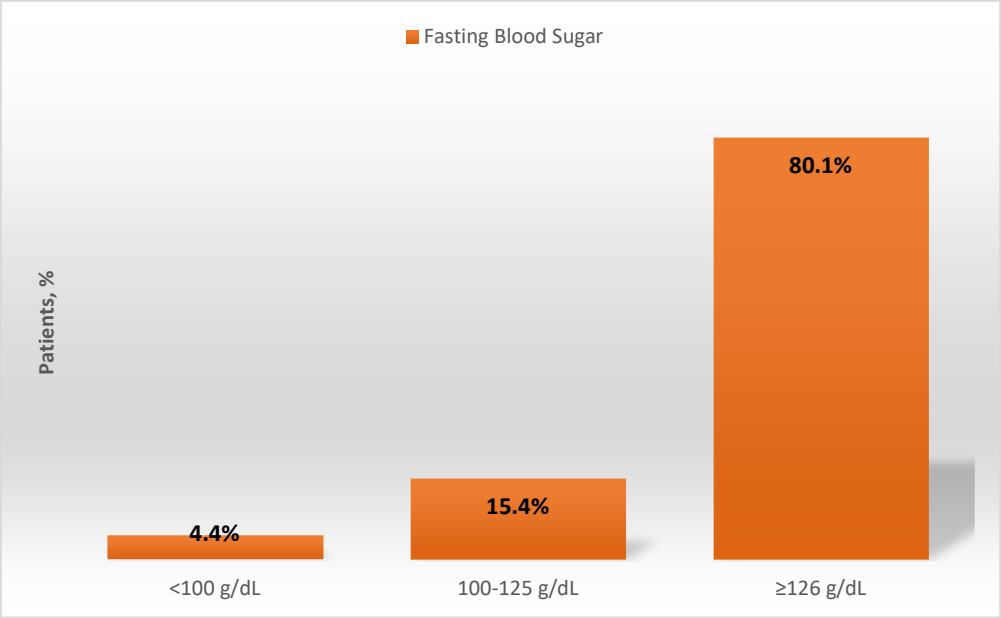


Graph 2: Bar diagram showing gender distribution of study population

The mean ± SD FBS levels of the study population was 167.3±51.9 g/dL and median FBS was 152.5 g/dL. FBS levels were in normal range among 6 (4.4%) patients. 21 (15.4%) and 109 (80.1%) patients has prediabetes and diabetes, respectively (Table 3 and Graph 3).

Table 3: Patient distribution based on FBS levels

FBS	Frequency	Percentage
Normal, <100 g/dL	6	4.4
Prediabetes, 101-125 g/dL	21	15.4
Diabetes, ≥126 g/dL	109	80.1
Total	**136**	**100.0**

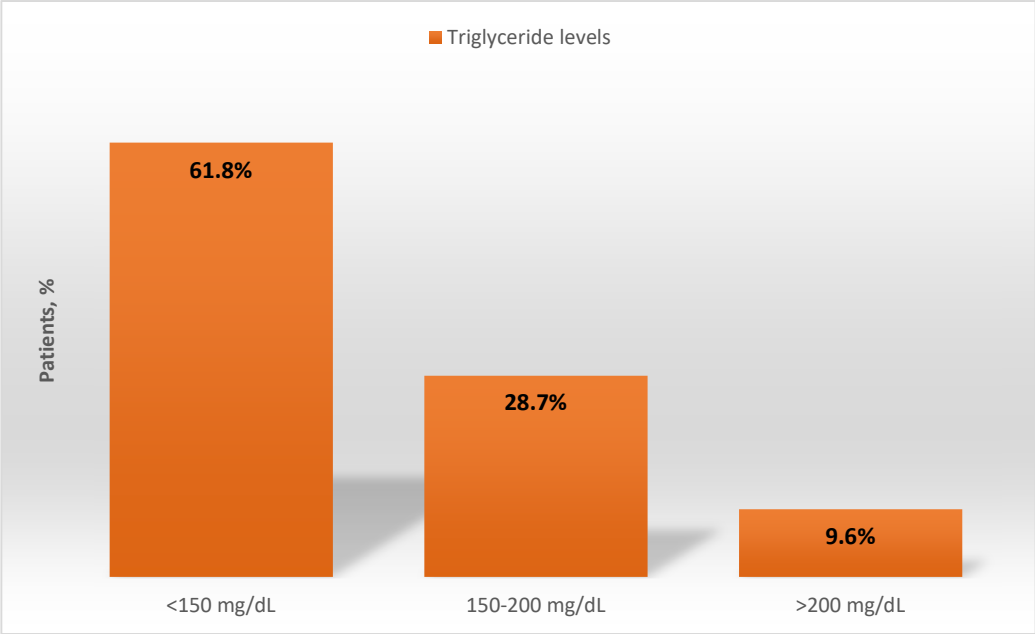


Graph 3: Bar diagram showing distribution of patients based on FBS levels

The mean ± SD serum TG levels of the study population was 140.6±47.2 and median serum TG was 136.0. Serum TG levels were normal in 84 (61.8%) patients and increased in 52 (38.2%) patients (Table 4 and Graph 4).

Table 4: Patient distribution based on serum TG levels

TG	Frequency	Percentage
<150 mg/dL	84	61.8
150-200 mg/dL	39	28.7
>200 mg/dL	13	9.6
Total	**136**	**100.0**

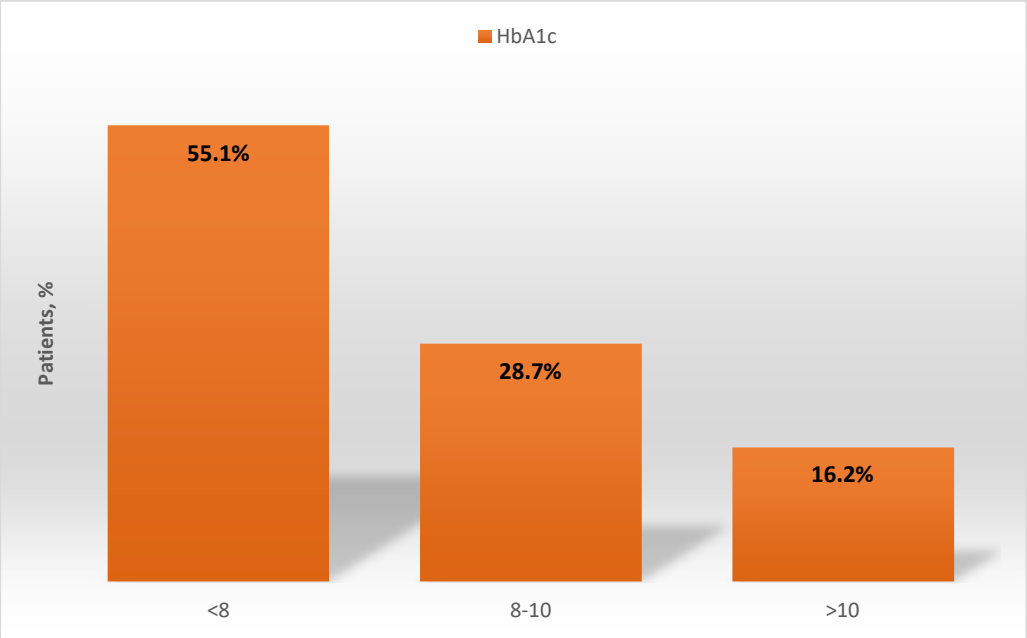


Graph 4: Bar diagram showing distribution of patients based on serum TG levels

The mean ± SD serum HbA1c levels of the study population was 8.3±2.1 and median serum HbA1c was 7.6. Serum HbA1c levels were <8 in 5.1% patients, 8-10 in 28.7% and >10 in 16.2% of patients (Table 5 and Graph 5)

Table 5: Patient distribution based on HbA1c levels

HbA1c	Frequency	Percentage
<8	75	55.1
8-10	39	28.7
>10	22	16.2
Total	**136**	**100.0**

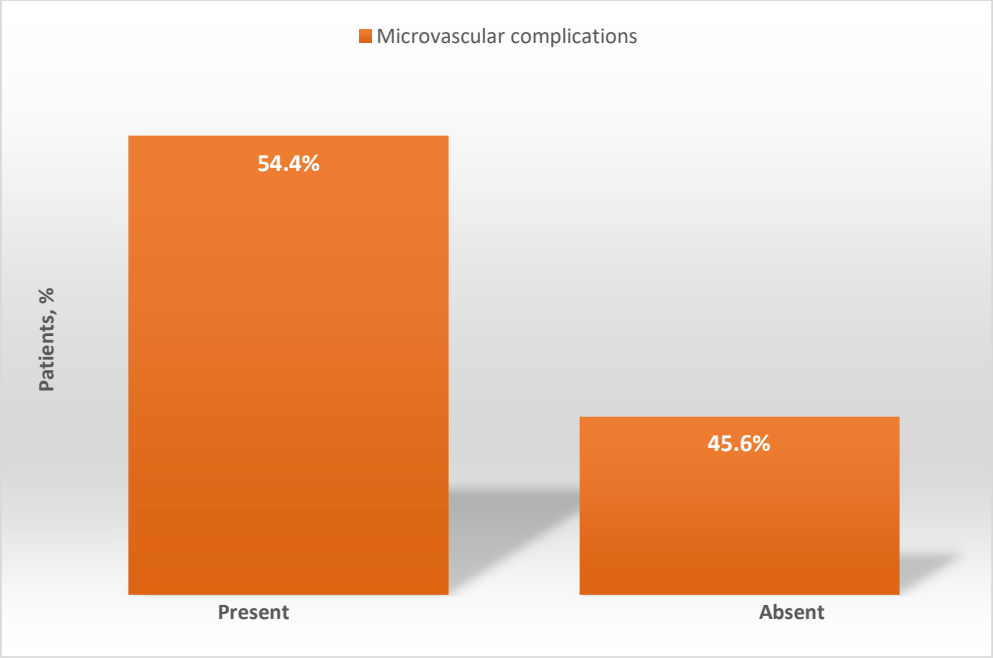


Graph 5: Bar diagram showing distribution of patients based on HbA1c levels

A total of 136 patients diagnosed with T2DM were included in the analysis. A total of 74 patients had at least one microvascular complication including diabetic retinopathy, diabetic nephropathy or diabetic neuropathy. Distribution of patients based on presence and absence of microvascular complications is shown in Table 6 and Graph 6.

Table 6: Microvascular complications in the study population

Microvascular complications	Frequency	Percentage
Present	74	54.4
Absent	62	45.6
Total	**136**	**100.0**

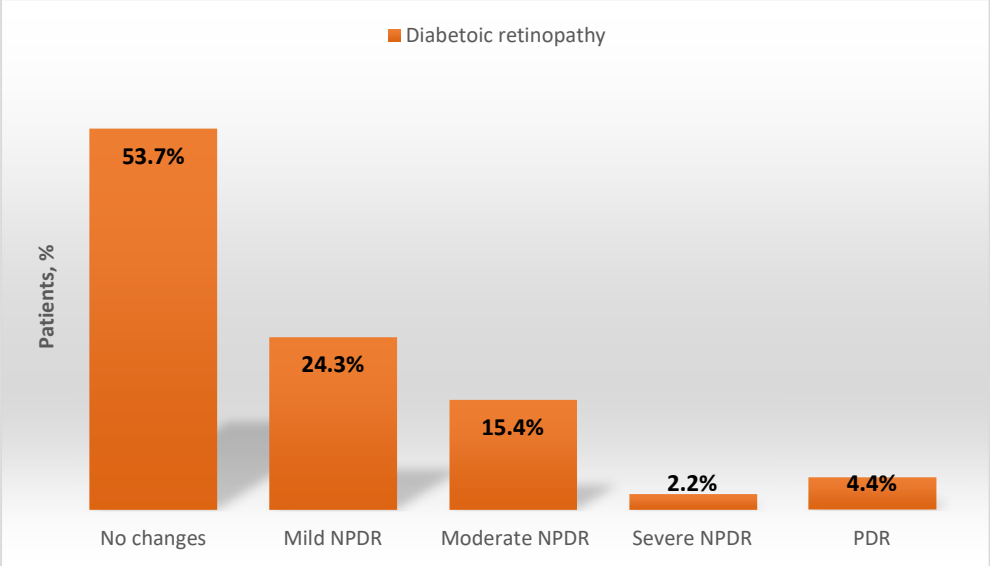


Graph 6: Bar diagram showing patient distribution based on microvascular complications

Diabetic retinopathy was assessed using fundoscopy and patient distribution based on retinal findings are summarised in Table 7 and Graph 7. A total of 73 patients did not show any signs of Diabetic Retinopathy. Mild NPDR, moderate NPDR and severe NPDR was noted in 33, 21 and 3 patients, respectively and 6 patients had PDR.

Table 7: Diabetic Retinopathy based on fundoscopy findings

Fundoscopy findings	Frequency	Percentage
No changes	73	53.7
Mild NPDR	33	24.3
Moderate NPDR	21	15.4
Severe NPDR	3	2.2
PDR	6	4.4
Total	136	100

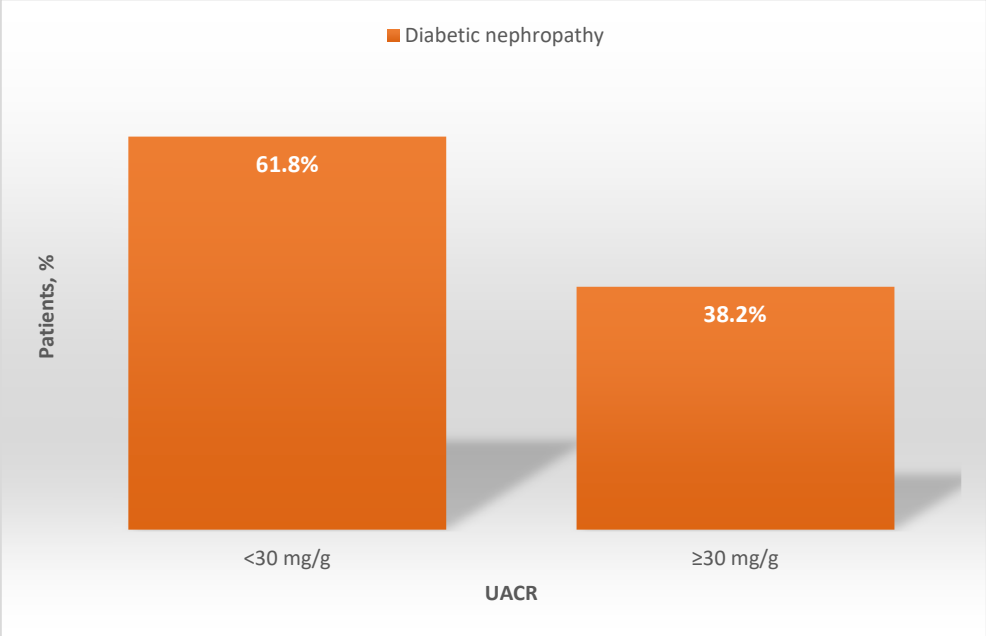


Graph 7: Bar diagram showing patient distribution based on Diabetic Retinopathy

Overall, 84(61.8%) patients had UACR <30 mg/g suggestive of normal renal function. Whereas, 52 (38.2%) patients had UACR >30 mg/g suggestive of microalbuminuria. Among these 2 patients had UACR >300mg/g suggestive of overt nephropathy. Distribution of patients based on diabetic nephropathy is summarised in Table 8 and graph 8.

Table 8: Diabetic Nephropathy based on UACR

UACR	Frequency	Percentage
<30 mg/g	84	61.8
≥30 mg/g	52	38.2
Total	**136**	**100.0**

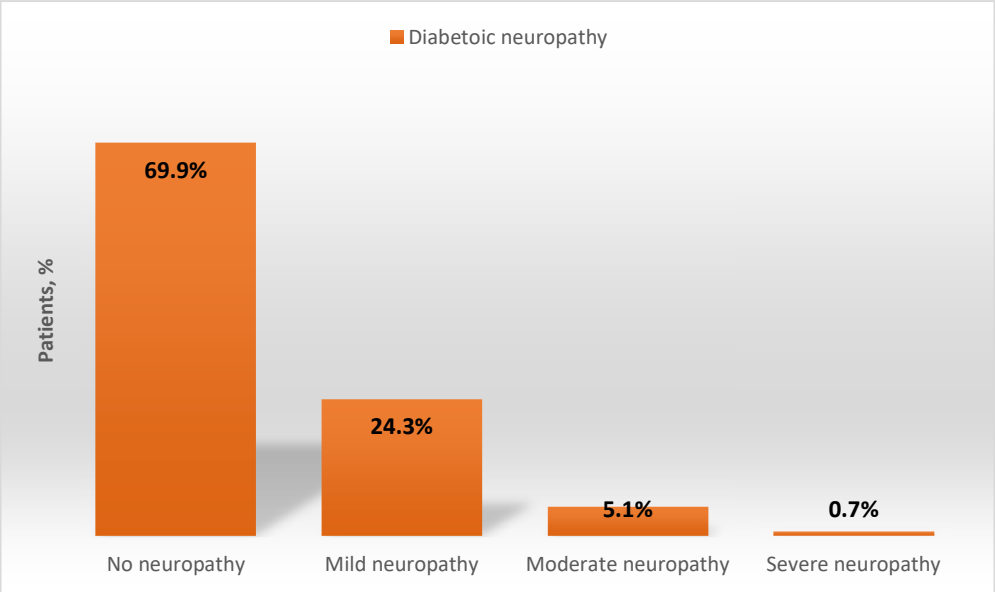


Graph 8: Bar diagram showing patient distribution based on Diabetic Nephropathy

Diabetic Neuropathy was assessed base on TCNS. Distribution of patients based on diabetic neuropathy is shown in Table 9 and Graph 9. Overall, 95(69.9%) patients had no neuropathy. Mild, moderate and severe neuropathy were seen in 33 (24.3%), 7(5.1%) and 1 (0.7%) patients, respectively.

Table 9: Patient distribution based on Diabetic Neuropathy

Diabetic Neuropathy	Frequency	Percentage
No neuropathy	95	69.9
Mild neuropathy	33	24.3
Moderate neuropathy	7	5.1
Severe neuropathy	1	0.7
Total	**136**	**100.0**

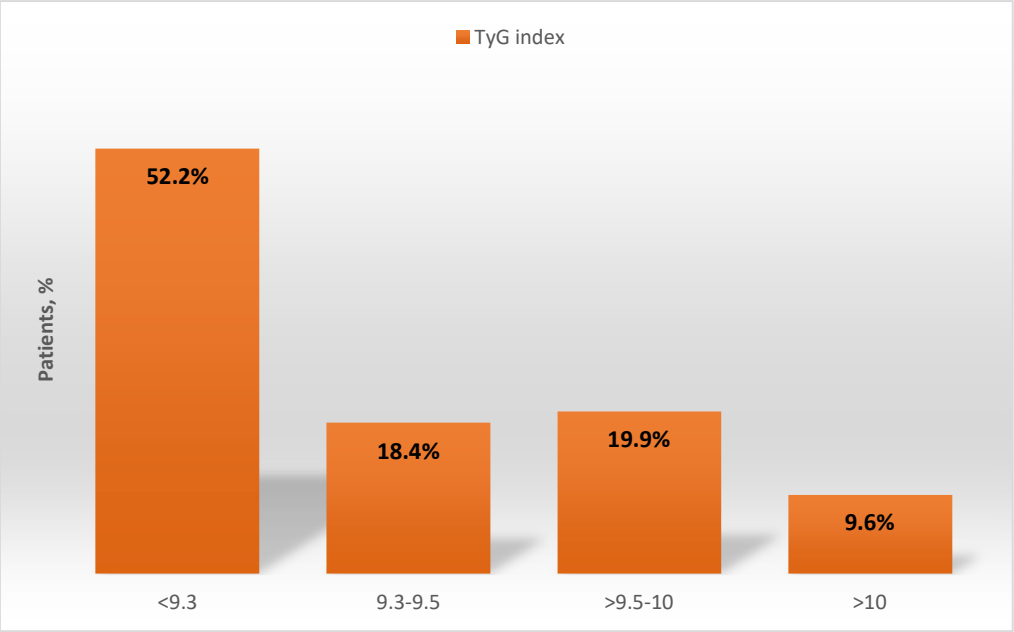


Graph 9: Bar diagram showing patient distribution based on Diabetic Neuropathy

The mean ± SD TyG Index of the study population was 9.3±0.5 and median TyG Index was 9.3. Majority of patients had TyG index <9.3 (n=71, 52.2%), followed by >9.5-10 (n=27, 19.9%). The distribution of patients based on TyG index is presented in Table 10 and Graph 10.

Table 10: Distribution of patients based on TyG Index

TyG Index	Frequency	Percentage
<9.3	71	52.2
9.3-9.5	25	18.4
>9.5-10	27	19.9
>10	13	9.6
Total	**136**	**100.0**

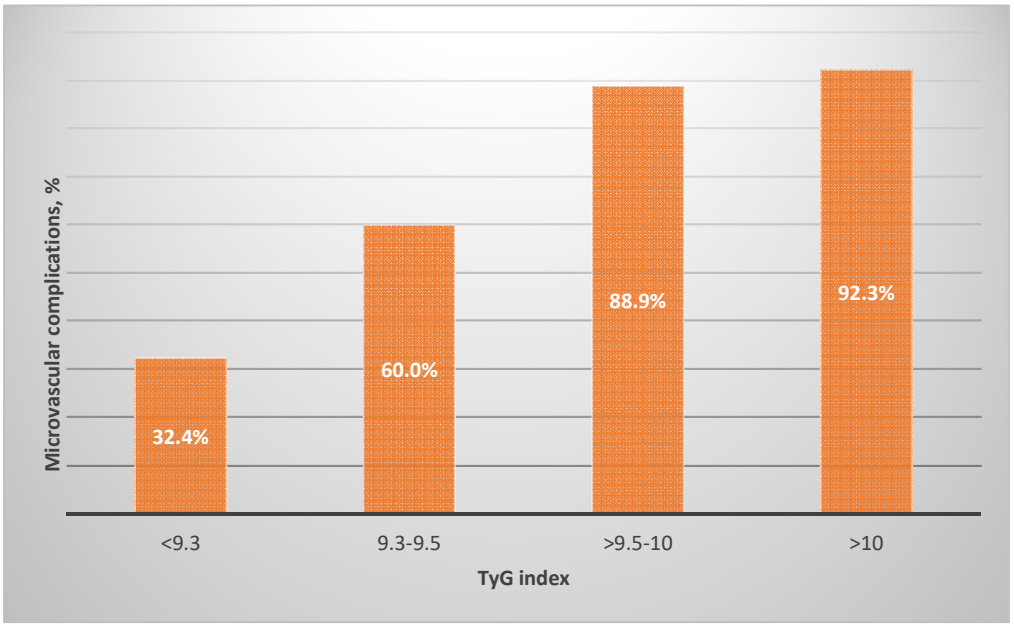


Graph 10: Bar diagram showing patient distribution based on TyG index

Association between TyG index and overall microvascular complications is shown in Table 11 and Graph 11. Frequency of microvascular complications increased with increased TyG index. Overall, significant association was noted between TyG index and microvascular complications (p=0.000)

Table 11: Association of TyG index with microvascular complications

Variable, n(%)		Microvascular complications		P value
		Present	Absent	
TyG Index	**<9.3**	23(32.4%)	48(67.6%)	0.000
	9.3-9.5	15(60.0%)	10(40.0%)	
	>9.5-10	24(88.9%)	3(11.1%)	
	>10	12(92.3%)	1(7.7%)	

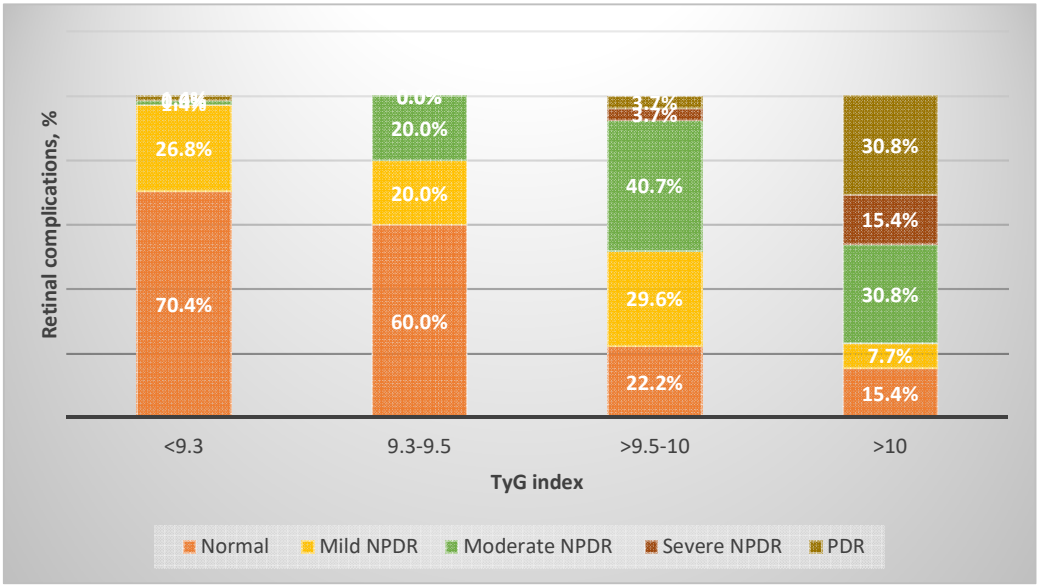


Graph 11: Bar diagram showing association of TyG index with microvascular complications

Association between TyG index and Diabetic Retinopathy is shown in Table 12 and Graph 12. Frequency of retinal complications increased with increased TyG index. Overall, significant association was noted between TyG index and retinal complications (p=0.000)

Table 12: Association of TyG index with Diabetic Retinopathy

Variable, n(%)		Diabetic Retinopathy					P value
		Normal	Mild NPDR	Moderate NPDR	Severe NPDR	PDR	
TyG Index	<9.3	50 (70.4%)	19(26.8%)	1(1.4%)	0(0.0%)	1(1.4%)	0.000
	9.3-9.5	15(60.0%)	5(20.0%)	5(20.0%)	0(0.0%)	0(0.0%)	
	>9.5-10	6(22.2%)	8(29.6%)	11(40.7%)	1(3.7%)	1(3.7%)	
	>10	2(15.4%)	1(7.7%)	4(30.8%)	2(15.4%)	4(30.8%)	

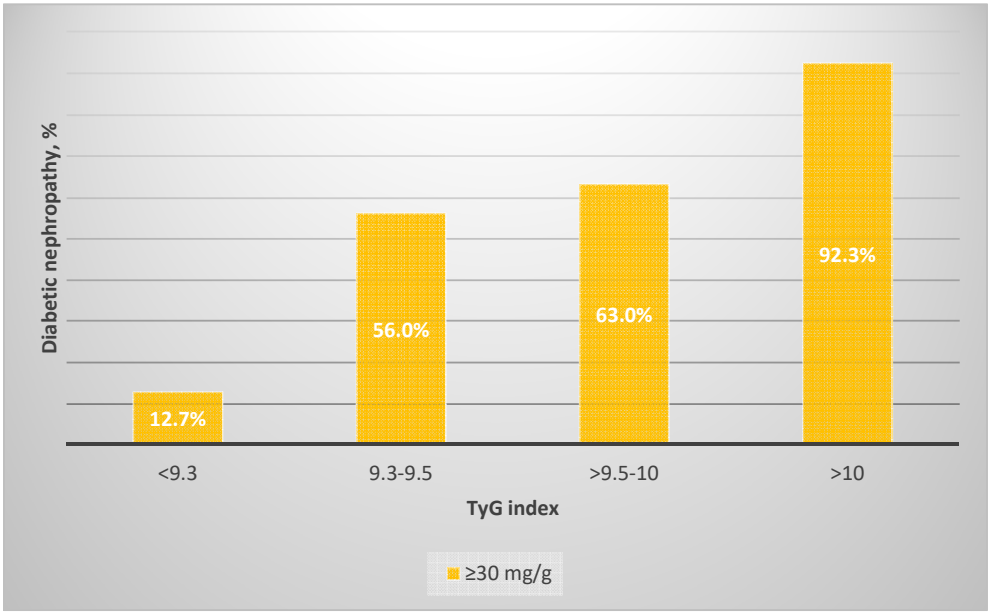


Graph 12: Bar diagram showing association of TyG index with Diabetic Retinopathy

Association between TyG index and diabetic nephropathy is shown in Table 13 and Graph 13. Frequency of microalbuminuria increased with increased TyG index. Overall, significant association was noted between TyG index and diabetic nephropathy (p=0.000).

Table 13: Association of TyG index with Diabetic Nephropathy

Variable, n (%)		Diabetic Nephropathy		P value
		<30 mg/g	≥30 mg/g	
TyG Index	<9.3	62 (87.3%)	9(12.7%)	0.000
	9.3-9.5	11(44.0%)	14(56.0%)	
	>9.5-10	10(37.0%)	17(63.0%)	
	>10	1(7.7%)	12(92.3%)	

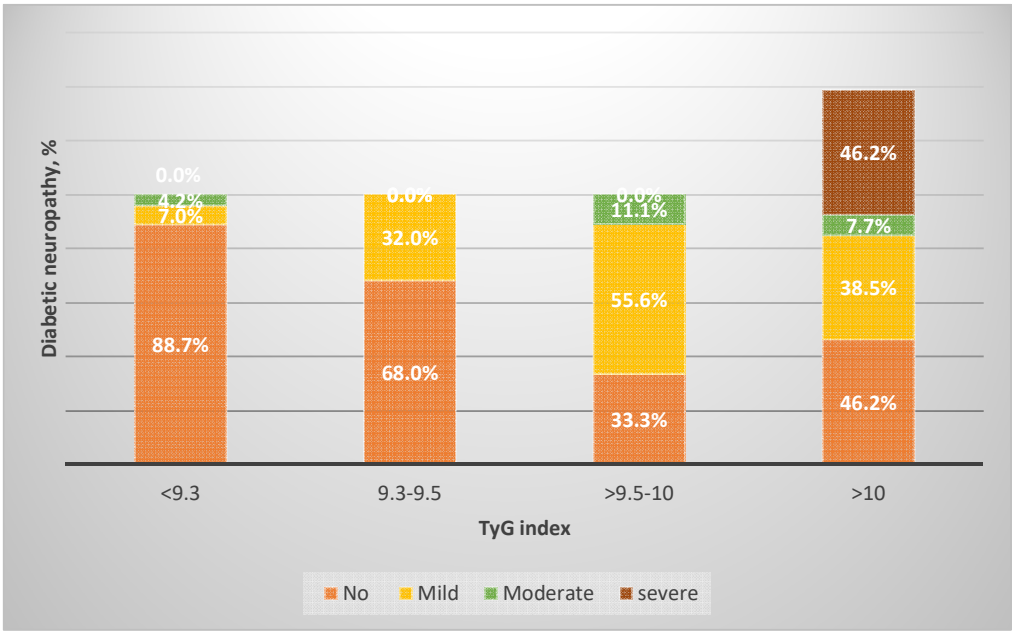


Graph 13: Bar diagram showing association of TyG index with Diabetic Nephropathy

Association between TyG index and diabetic neuropathy is shown in Table 14 and Graph 14. Frequency and severity of neuropathy increased with increased TyG index. Overall, significant association was noted between TyG index and diabetic neuropathy (p=0.000).

Table 14: Association of TyG index with Diabetic Neuropathy

Variable, n (%)		Diabetic Neuropathy				P value
		No	Mild	Moderate	severe	0.000
TyG Index	<9.3	63(88.7%)	5(7.0%)	3(4.2%)	0(0.0%)	
	9.3-9.5	17(68.0%)	8(32.0%)	0(0.0%)	0(0.0%)	
	>9.5-10	9(33.3%)	15(55.6%)	3(11.1%)	0(0.0%)	
	>10	6(46.2%)	5(38.5%)	1(7.7%)	1(7.7%)	

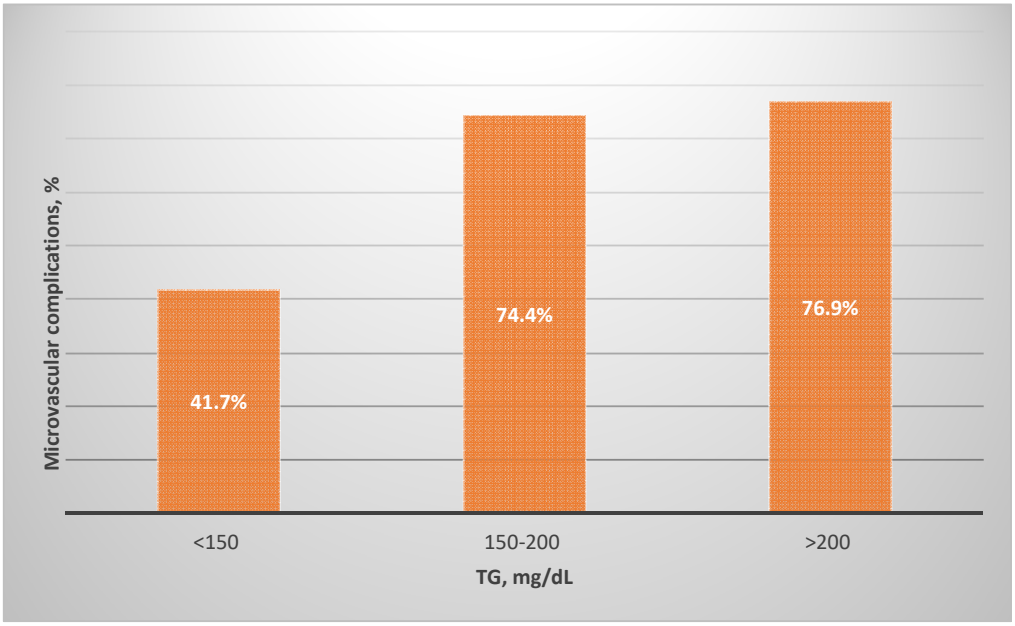


Graph 14: Bar diagram showing association of TyG index with Diabetic Neuropathy

Association between serum TG and overall microvascular complications is shown in Table 15 and Graph 15. Frequency of microvascular complications increased with increased TG levels. Overall, significant association was noted between TG levels and microvascular complications (p=0.001)

Table 15: Association of serum TG with microvascular complications

Variable, n(%)		Microvascular complications		P value
		Present	Absent	
TG	<150 mg/dL	35(41.7%)	49(58.3%)	0.001
	150-200 mg/dL	29(74.4%)	10(25.6%)	
	>200 mg/dL	10(76.9%)	3(23.1%)	

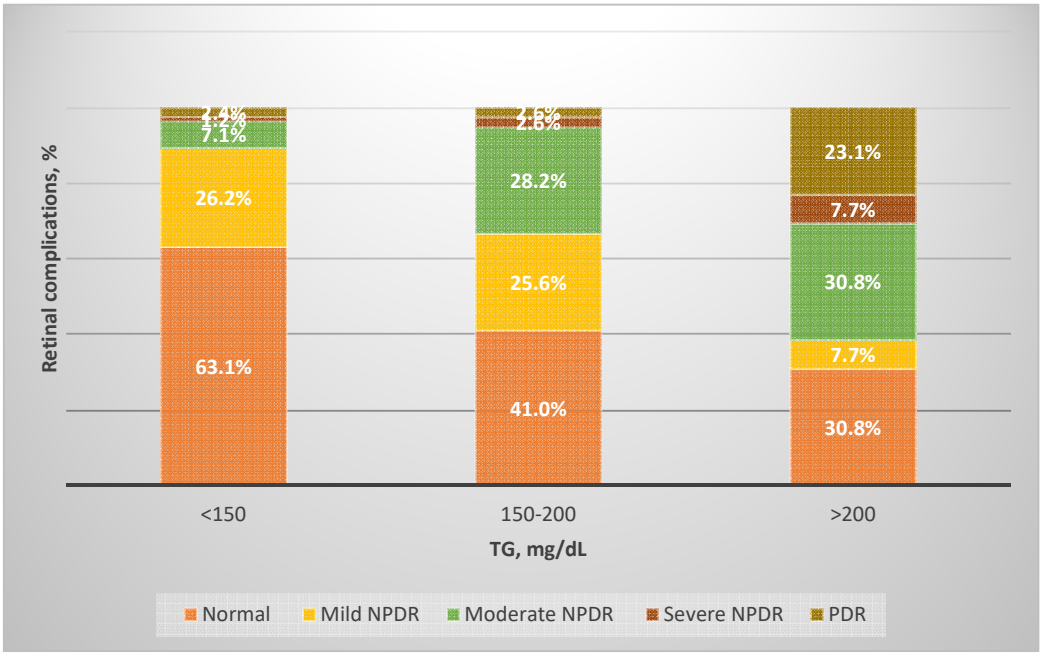


Graph 15: Bar diagram showing association of serum TG with microvascular complications

Association between serum TG and diabetic retinopathy is shown in Table 16 and Graph 16. Significant association was noted between serum TG levels between different diabetic retinopathy groups (p=0.000)

Table 16: Association of serum TG with Diabetic Retinopathy

Variable, n (%)		Diabetic Retinopathy					P value
		Normal	Mild NPDR	Moderate NPDR	Severe NPDR	PDR	
TG	<150 mg/dL	53(63.1%)	22(26.2%)	6(7.1%)	1(1.2%)	2(2.4%)	0.000
	150-200 mg/dL	16(41.0%)	10(25.6%)	11(28.2%)	1(2.6%)	1(2.6%)	
	>200 mg/dL	4(30.8%)	1(7.7%)	4(30.8%)	1(7.7%)	3(23.1%)	

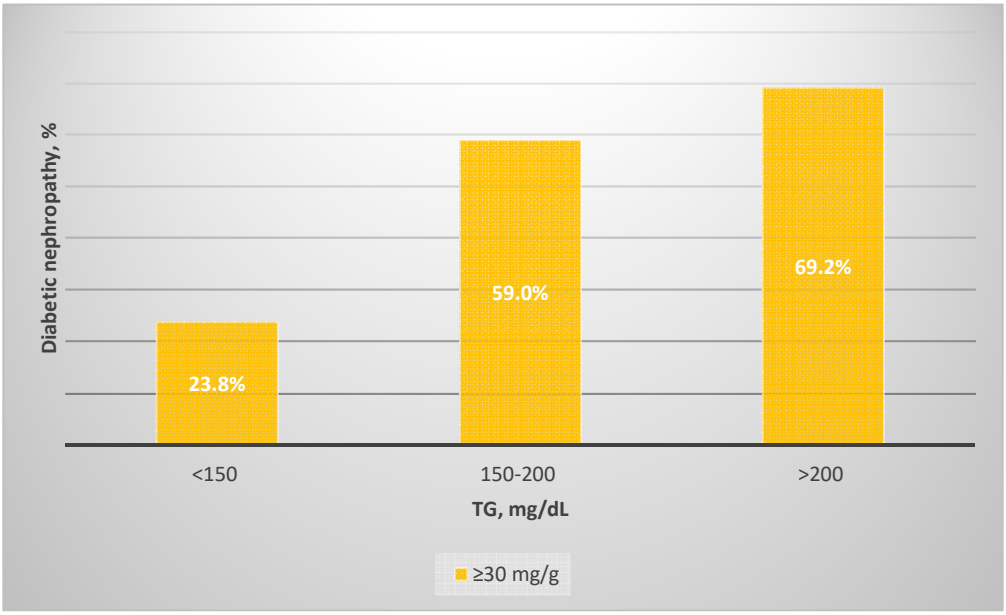


Graph 16: Bar diagram showing association of serum TG with Diabetic Retinopathy

Association between serum TG and diabetic nephropathy is shown in Table 17 and Graph 17. Frequency of microalbuminuria increased with increased TG levels. Overall, significant association was noted between serum TG and diabetic nephropathy (p=0.000)

Table 17: Association of serum TG with Diabetic Nephropathy

Variable, n(%)		Diabetic Nephropathy		P value
		<30 mg/g	**≥30 mg/g**	0.000
TG	**<150 mg/dL**	64 (76.2%)	20(23.8%)	
	150-200 mg/dL	16(41.0%)	23(59.0%)	
	>200 mg/dL	4(30.8%)	9(69.2%)	

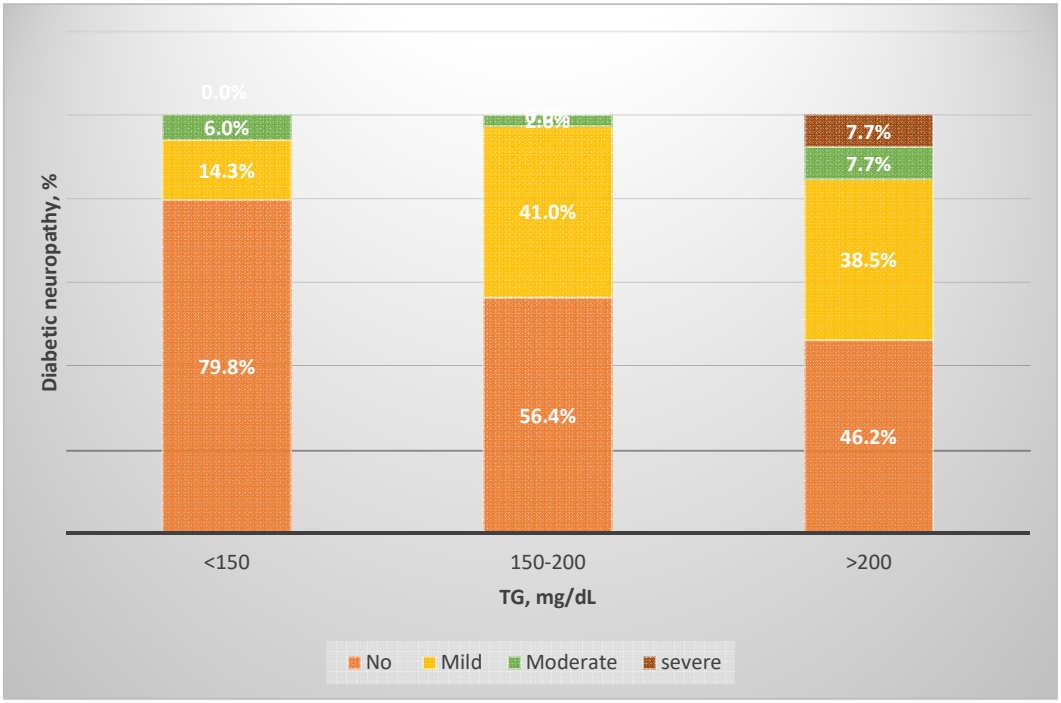


Graph 17: Bar diagram showing association of serum TG with Diabetic Nephropathy

Association between serum TG and diabetic neuropathy is shown in Table 18 and Graph 18. Frequency and severity of neuropathy increased with increased TG levels. Overall, significant association was noted between TG and diabetic neuropathy (p=0.001)

Table 18: Association of serum TG with Diabetic Neuropathy

Variable, n (%)		Diabetic Neuropathy				P value
		No	Mild	Moderate	severe	0.001
TG	<150 mg/dL	67(79.8%)	12(14.3%)	5(6.0%)	0(0.0%)	
	150-200 mg/dL	22(56.4%)	16(41.0%)	1(2.6%)	0(0.0%)	
	>200 mg/dL	6(46.2%)	5(38.5%)	1(7.7%)	1(7.7%)	

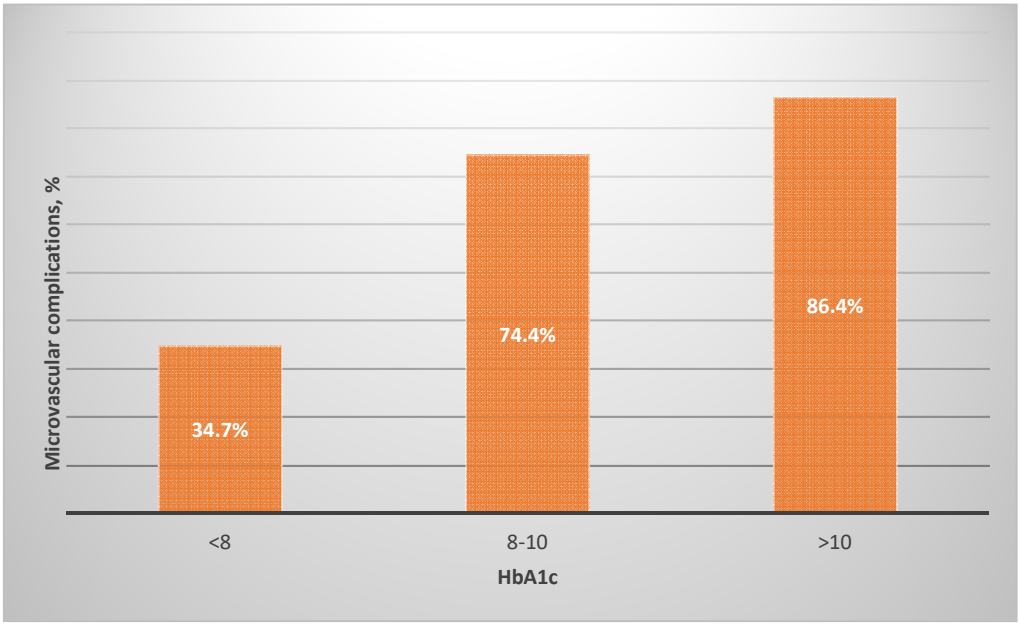


Graph 18: Bar diagram showing association of serum TG with Diabetic Neuropathy

Association between HbA1c and overall microvascular complications is shown in Table 19 and Graph 19. Frequency of microvascular complications increased with increased HbA1c. Overall, significant association was noted between HbA1c and microvascular complications (p=0.000)

Table 19: Association of HbA1c with microvascular complications

Variable n(%)		Microvascular complications		P value
		Present	Absent	
HbA1c	<8	26(34.7%)	49(65.3%)	0.000
	8-10	29(74.4%)	10(25.6%)	
	>10	19(86.4%)	3(13.6%)	

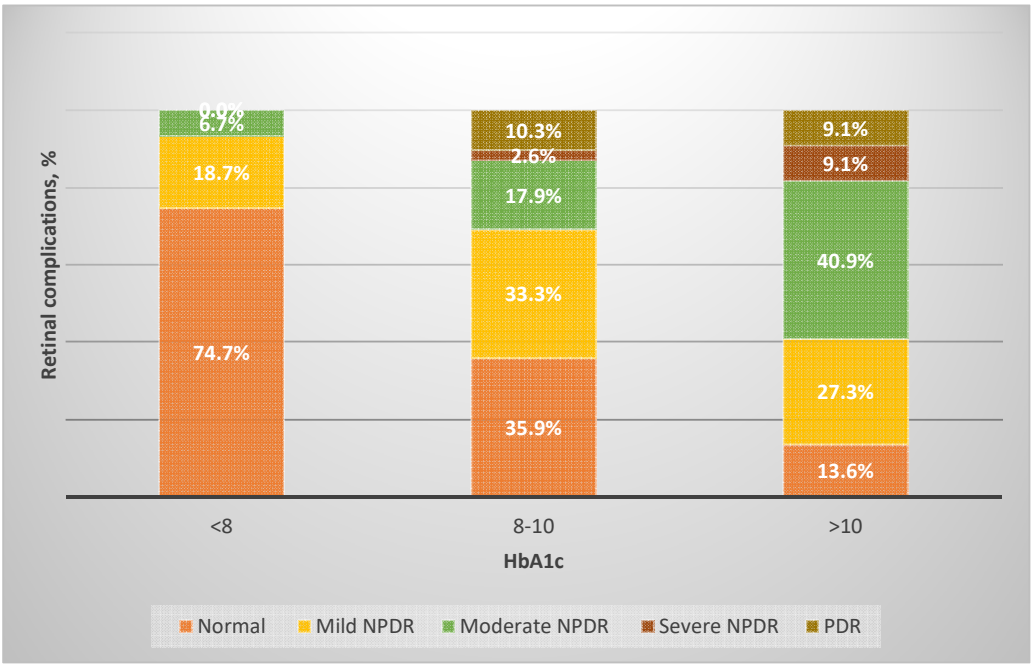


Graph 19: Bar diagram showing association of HbA1c with microvascular complications

Association between HbA1c and diabetic retinopathy is shown in Table 20 and Graph 20. Frequency of Diabetic Retinopathy increased with increased HbA1c. Overall, significant association was noted between HbA1c and Diabetic Retinopathy (p=0.000)

Table 20: Association of HbA1c with Diabetic Retinopathy

Variable, n (%)		Diabetic Retinopathy					P value
		Normal	Mild NPDR	Moderate NPDR	Severe NPDR	PDR	
HbA1c	<8	56(74.7%)	14(18.7%)	5(6.7%)	0(0.0%)	0(0.0%)	0.000
	8-10	14(35.9%)	13(33.3%)	7(17.9%)	2(2.6%)	4(10.3%)	
	>10	3(13.6%)	6(27.3%)	9(40.9%)	2(9.1%)	2(9.1%)	

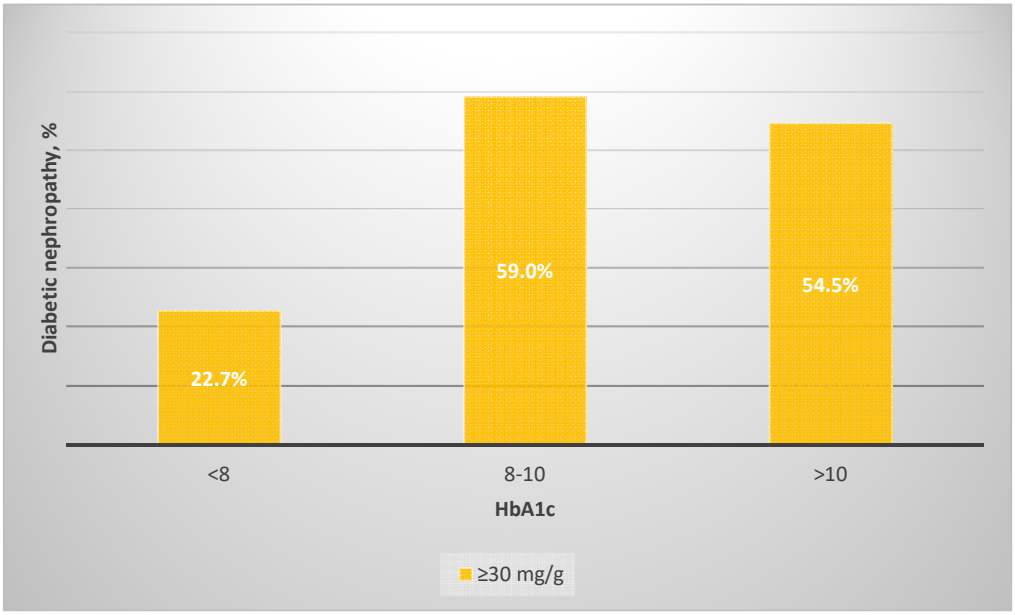


Graph 20: Bar diagram showing association of HbA1c with Diabetic Retinopathy

Association between HbA1c and diabetic nephropathy is shown in Table 21 and Graph 21. Frequency of microalbuminuria increased with increased HbA1c. Overall, significant association was noted between HbA1c and diabetic nephropathy (p=0.000)

Table 21: Association of HbA1c with Diabetic Nephropathy

Variable, n(%)		Diabetic Nephropathy		P value
		<30 mg/g	**≥30 mg/g**	0.000
HbA1c	**<8**	58 (77.3%)	17(22.7%)	
	8-10	16(41.0%)	23(59.0%)	
	>10	10(45.5%)	12(54.5%)	

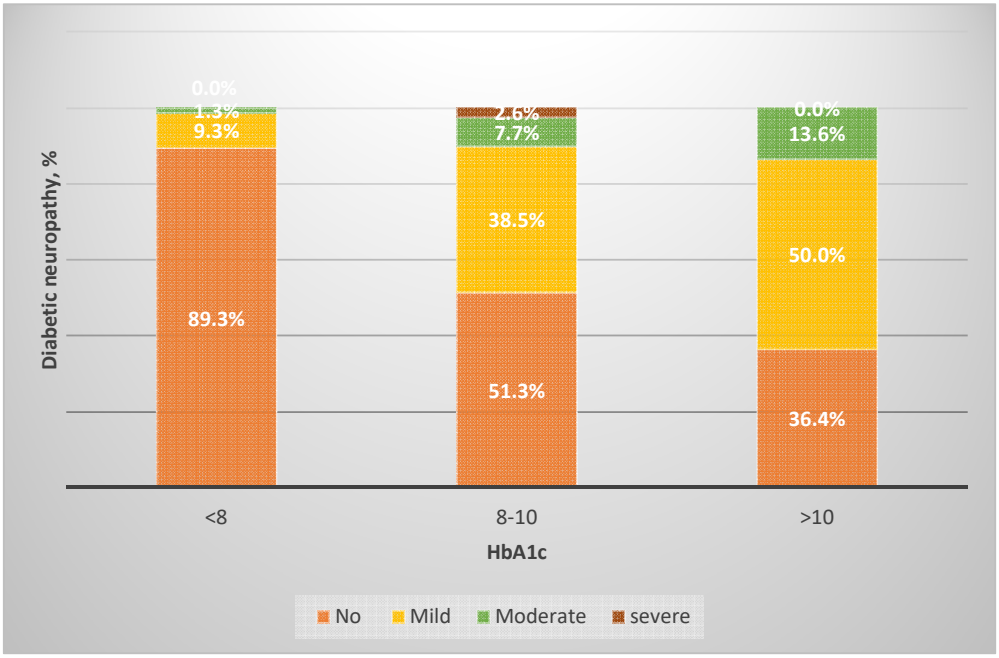


Graph 21: Bar diagram showing association of HbA1c with Diabetic Nephropathy

Association between HbA1c and diabetic neuropathy is shown in Table 22 and Graph 22. Frequency and severity of neuropathy increased with increased HbA1c. Overall, significant association was noted between HbA1c and diabetic neuropathy (p=0.000)

Table 22: Association of HbA1c with Diabetic Neuropathy

Variable, n (%)		Diabetic Neuropathy				P value
		No	Mild	Moderate	severe	0.000
HbA1c	<8	67(89.3%)	7(9.3%)	1(1.3%)	0(0.0%)	
	8-10	20(51.3%)	15(38.5%)	3(7.7%)	1(2.6%)	
	>10	8(36.4%)	11(50.0%)	3(13.6%)	0(0.0%)	

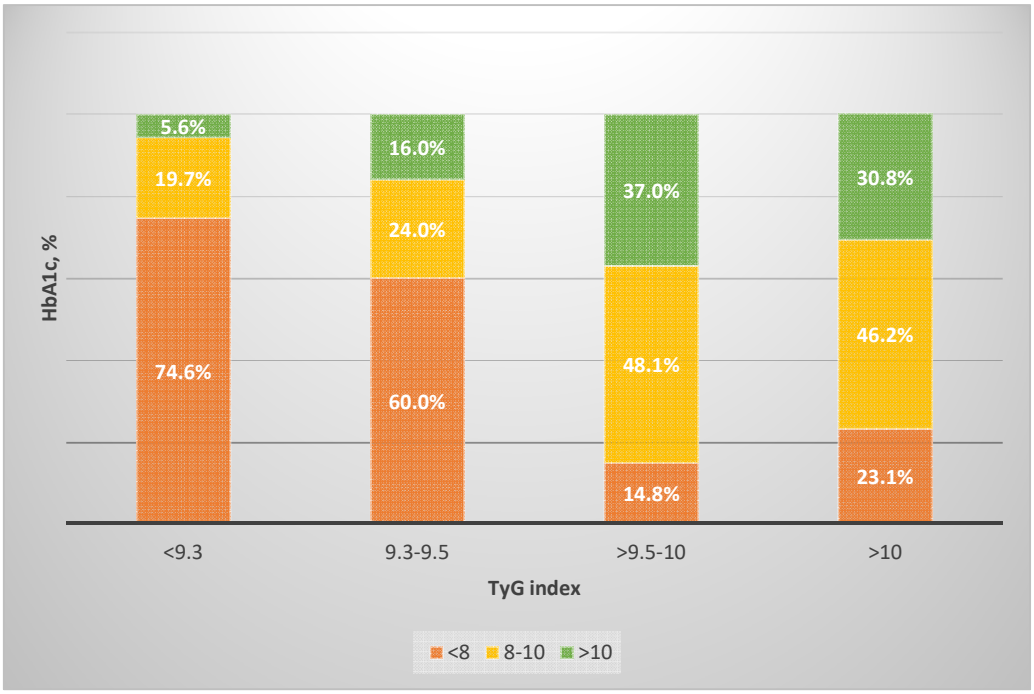


Graph 22: Bar diagram showing association of HbA1c with Diabetic Neuropathy

Association between TyG index and HbA1c shown in Table 23 and Graph 23. Frequency of patients with higher HbA1c levels increased with increased TyG index. Overall, significant association was noted between TyG index and HbA1c (p=0.000)

Table 23: Association of serum TyG index with HbA1c

Variable, n (%)		HbA1c			P value
		<8	**8-10**	**>10**	0.000
TyG Index	**<9.3**	53(74.6%)	14(19.7%)	4(5.6%)	
	9.3-9.5	15(60.0%)	6(24.0%)	4(16.0%)	
	>9.5-10	4(14.8%)	13(48.1%)	10(37.0%)	
	>10	3(23.1%)	6(46.2%)	4(30.8%)	

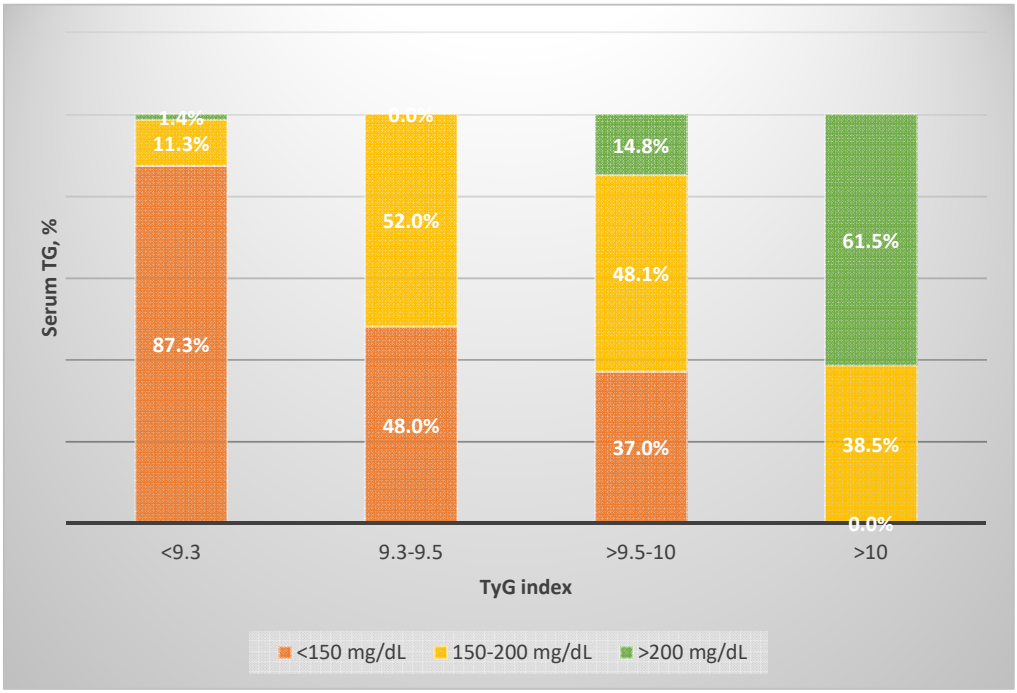


Graph 23: Bar diagram showing association of serum TyG index with HbA1c

Association between TyG index and serum TG shown in Table 24 and Graph 24. significant association was noted between TyG index and serum TG (p=0.000)

Table 24: Association of serum TyG index with serum TG

Variable, n (%)		TG			P value
		<150 mg/dL	**150-200 mg/dL**	>200 mg/dL	0.000
TyG Index	**<9.3**	62(87.3%)	8(11.3%)	1(1.4%)	
	9.3-9.5	12(48.0%)	13(52.0%)	0(0.0%)	
	>9.5-10	10(37.0%)	13(48.1%)	4(14.8%)	
	>10	0(0.0%)	5(38.5%)	8(61.5%)	

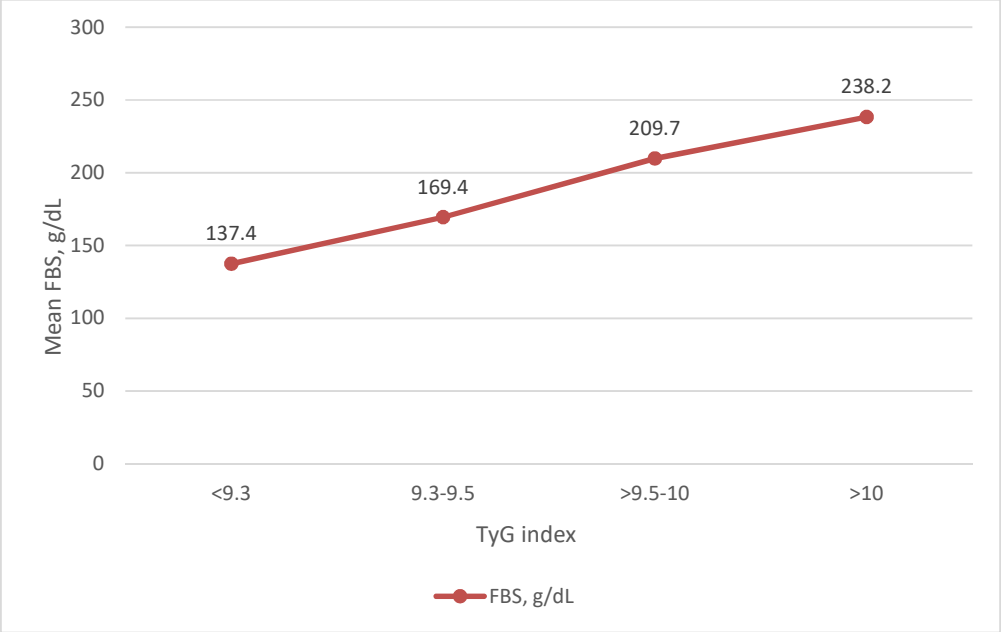


Graph 24: Bar diagram showing association of serum TyG index with serum TG

Comparison of mean FBS with TyG index is summarised in Table 25 and graph 25. The mean±SD FBS among patients with TyG index <9.3 137.4±30.9 which increased proportionately with increased TyG index with highest mean±SD FBS of 238.2±46.0 g/dL among patients with TyG index > 10. The difference was statistically significant (p=0.000).

Table 25: Comparison of FBS with TyG index

Variable, n (%)		FBS, g/dL	P value
		Mean ± SD	
TyG Index	**<9.3**	137.4±30.9	0.000
	9.3-9.5	169.4±39.0	
	>9.5-10	209.7±46.8	
	>10	238.2±46.0	

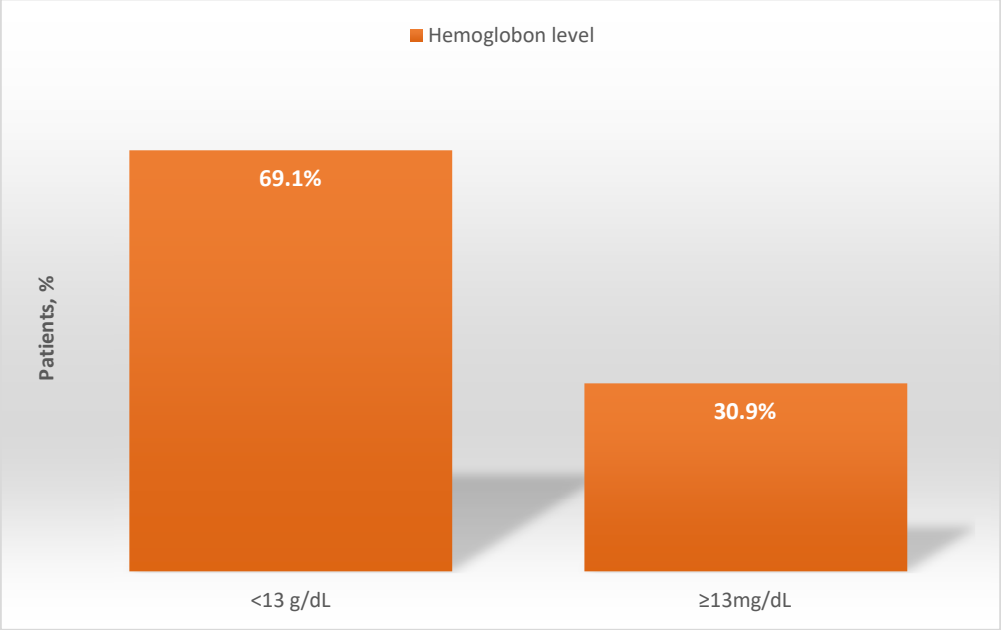


Graph 25: Line diagram showing mean FBS among different TyG index groups

The mean ± SD hemoglobin level of the study population was 12.0 ±1.9 g/dLand median hemoglobin level was 11.9 g/dL. Overall, 94 (69.1%) patients had low hemoglobin levels of <13 g/dL. Distribution of patients based on hemoglobin levels is shown in Table 26 and Graph 26.

Table 26: Patient distribution based on hemoglobin levels

Hemoglobin	Frequency	Percentage
Low (<13g/dL)	94	69.1
Normal (≥13mg/dL)	42	30.9
Total	**136**	**100.0**

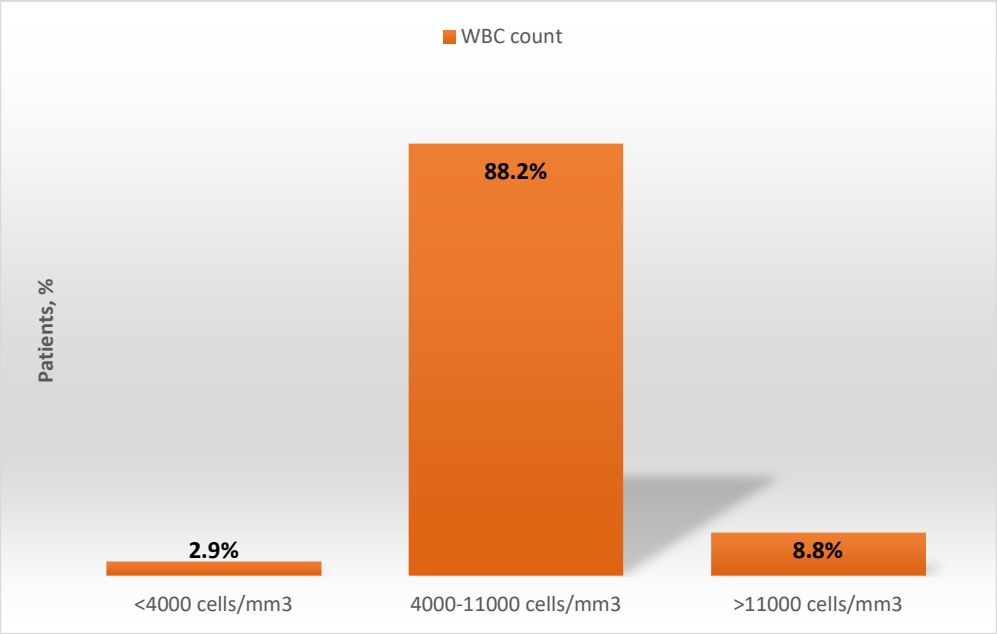


Graph 26: Bar diagram showing distribution of patients based on hemoglobin levels

The mean ± SD WBC count of the study population was 8938.2 ±2153.2 cells/mm^3 and median WBC count was 8200 cells/mm^3. Overall, 120 (88.2%) patients normal WBC counts and only 2(2.9%) and 12(8.8%) patients had leucopenia and leucocytosis, respectively (Table 27 and Graph 27).

Table 27: Patient distribution based on WBC counts

WBC counts	Frequency	Percentage
<4000 cells/mm^3	4	2.9
4000-11000 cells/mm^3	120	88.2
>11000 cells/mm^3	12	8.8
Total	**136**	**100.0**

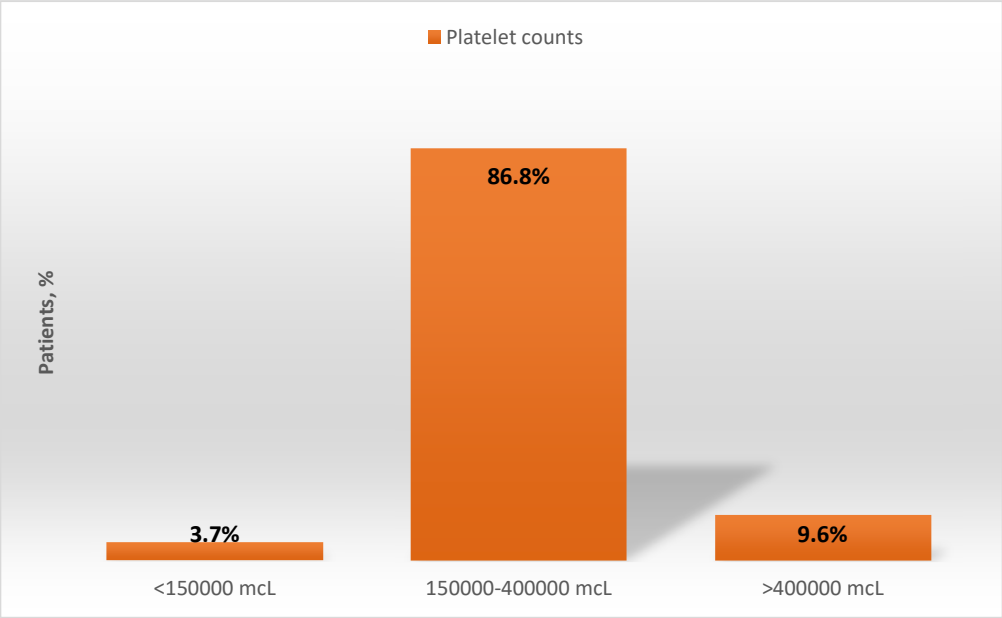


Graph 27: Bar diagram showing distribution of patients based on WBC count

The mean ± SD platelet count of the study population was 274014.7±97235.0 mcL and median platelet count was 265000 mcL. Overall, 118 (86.8%) patients had normal platelet counts, and only 5(3.7%) and 13(9.6%) patients had thrombocytopenia and thrombocytosis, respectively (Table 28 and Graph 28).

Table 28: Patient distribution based on platelet counts

Platelet count, mcL	Frequency	Percentage
<150000 mcL	5	3.7
150000-400000 mcL	118	86.8
>400000 mcL	13	9.6
Total	**136**	**100.0**

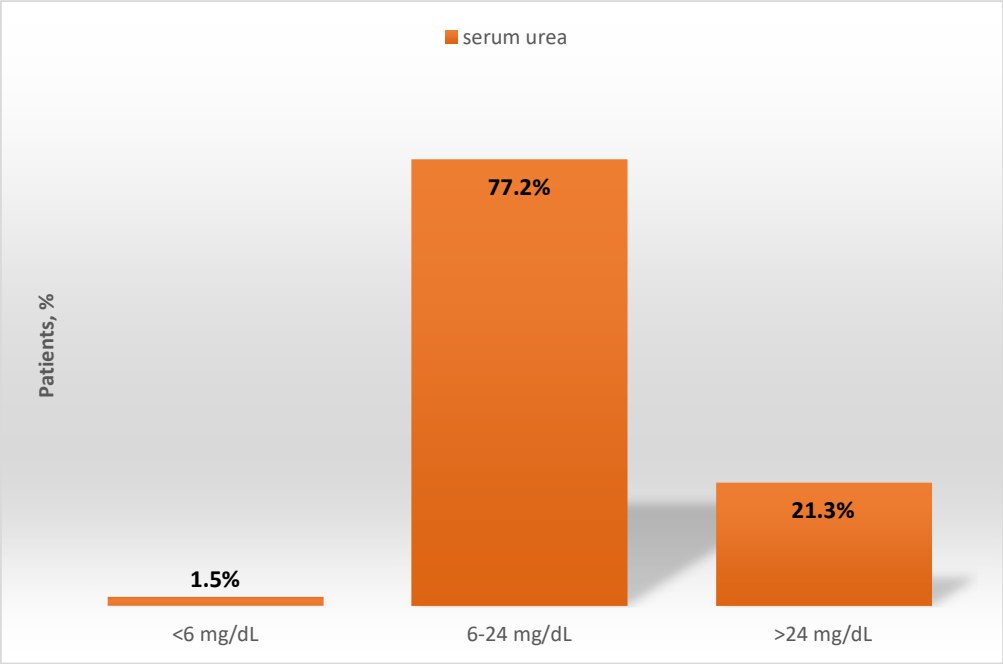


Graph 28: Bar diagram showing distribution of patients based on platelet count

The mean ± SD serum creatinine levels of the study population was 0.8±0.2 mg/dL and median serum creatinine was 0.8 mg/dL. Serum creatinine levels of all patients was within normal range. The mean ± SD serum urea levels of the study population was 17.8±10.4 mg/dL and median serum creatinine was 15.2 mg/dL. Urea levels were decreased and increased in 2 (1.5%) and 29 (21.3%) patients, respectively (Table 29 and Graph 29).

Table 29: Patient distribution based on urea levels

Urea levels	Frequency	Percentage
decreased, <6 mg/dL	2	1.5
Normal, 6-24 mg/dL	105	77.2
Increased, >24 mg/dL	29	21.3
Total	**136**	**100.0**

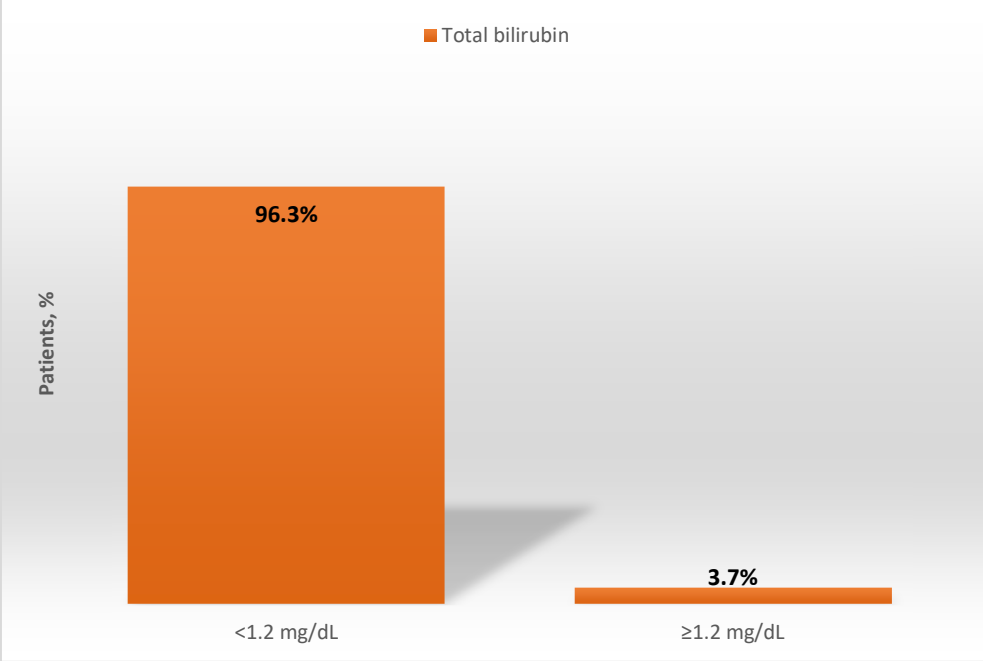


Graph 29: Bar diagram showing distribution of urea levels among patients

The mean ± SD serum total bilirubin levels of the study population was 0.7±0.2 mg/dL and median serum total bilirubin was 0.6 mg/dL. Serum total bilirubin levels were in normal range among 131 (96.3%) patients and increased in 5 (3.7%) patients. Distribution of patients based on total bilirubin levels is shown in Table 30 and Graph 30.

Table 30: Patient distribution based on total bilirubin levels

Total bilirubin	Frequency	Percentage
Normal, <1.2 mg/dL	131	96.3
Increased, ≥1.2 mg/dL	5	3.7
Total	**136**	**100.0**

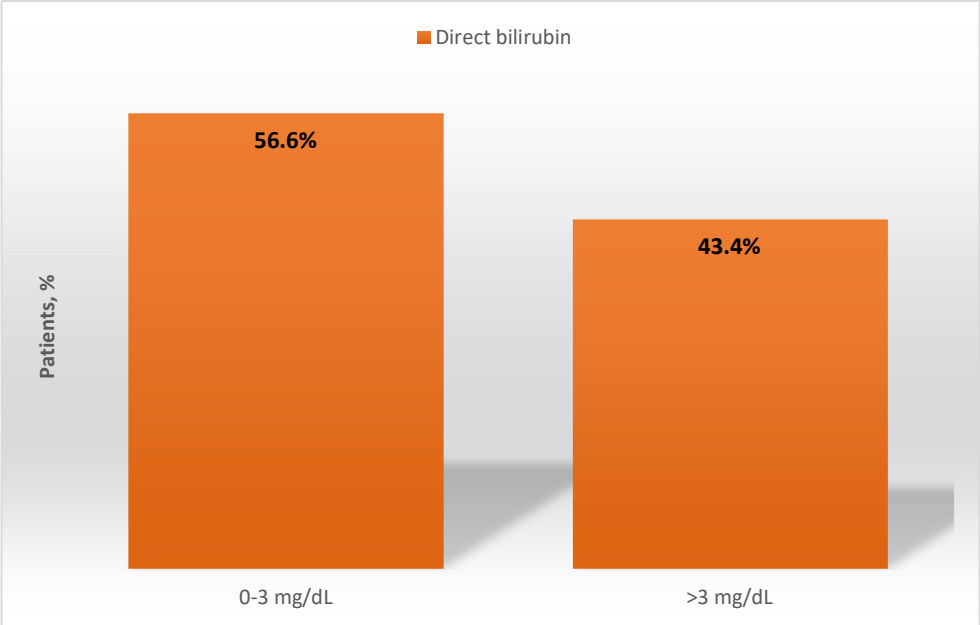


Graph 30: Bar diagram showing distribution of patients based on total bilirubin

The mean ± SD serum direct bilirubin levels of the study population was 0.3±0.2 mg/dL and median serum direct bilirubin was 0.3 mg/dL. Serum direct bilirubin levels were in normal range among 77 (56.6%) patients and increased in 59 (43.4%) patients (Table 31 and Graph 31).

Table 31: Patient distribution based on direct bilirubin levels

Direct bilirubin	Frequency	Percentage
Normal, 0-3 mg/dL	77	56.6
Increased, >3 mg/dL	59	43.4
Total	**136**	**100.0**

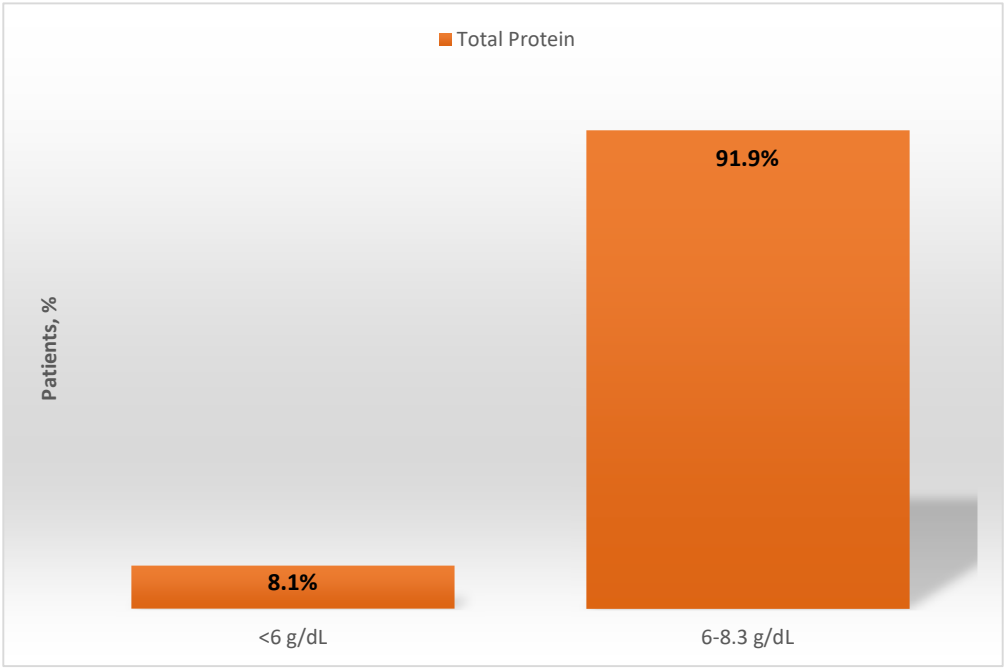


Graph 31: Bar diagram showing distribution of patients based on direct bilirubin

The mean ± SD serum total protein levels of the study population was 6.7±0.6 g/dL and median serum total protein was 6.8 g/dL. Serum total protein levels were in normal range among 125 (91.9%) patients and decreased in 11 (8.1%) patients (Table 32 and Graph 32).

Table 32: Patient distribution based on total protein levels

Total protein	Frequency	Percentage
Decreased, <6 g/dl	11	8.1
Normal, 6-8.3 g/dl	125	91.9
Total	**136**	**100.0**

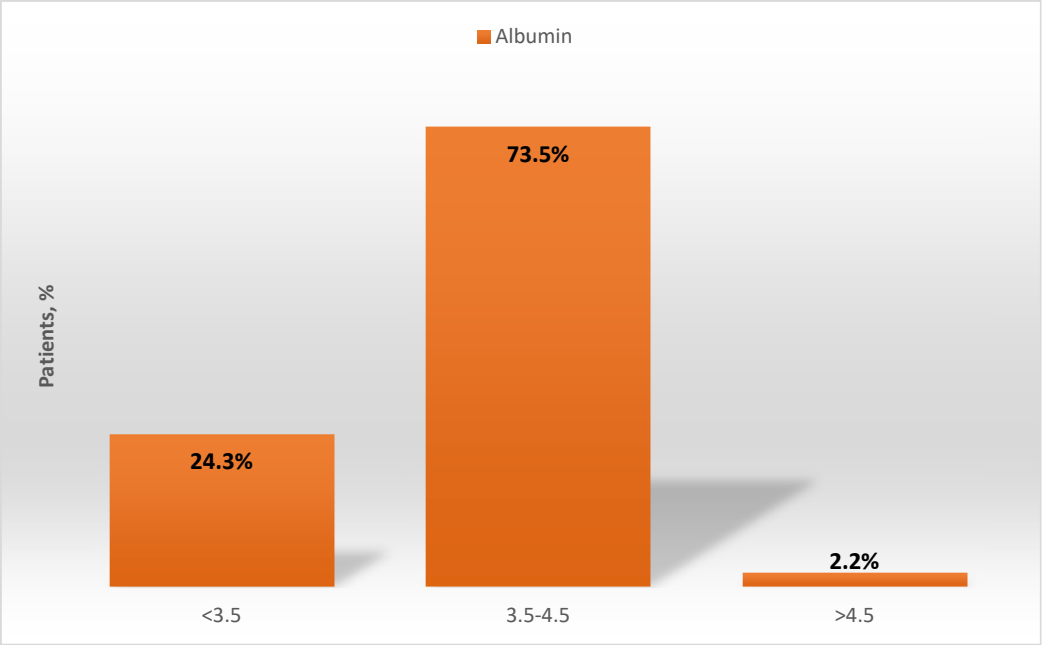


Graph 32: Bar diagram showing distribution of patients based on total protein levels

The mean ± SD albumin levels of the study population was 3.8±0.4 g/dL and median serum albumin was 3.8 g/dL. Serum albumin levels were in normal range among 100 (73.5%) patients, increased in 3(2.2%) and decreased in 33 (24.3%) patients (Table 33 and Graph 33).

Table 33: Patient distribution based on albumin levels

Albumin	Frequency	Percentage
Decreased, <3.5	33	24.3
Normal, 3.5-4.5	100	73.5
Increased, >4.5	3	2.2
Total	**136**	**100.0**

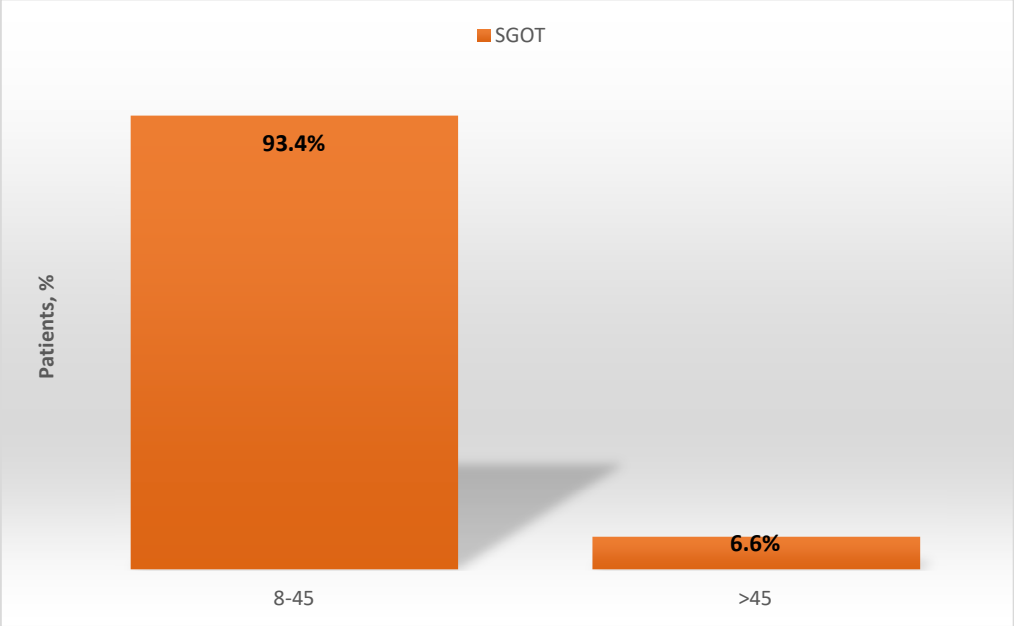


Graph 33: Bar diagram showing distribution of patients based on albumin levels

The mean ± SD serum SGOT levels of the study population was 24.8±11.7 and median serum SGOT was 22.0. Serum SGOT levels were in normal range among 127 (93.4%) patients and increased in 9 (6.6%) patients (Table 34 and Graph 34).

Table 34: Patient distribution based on SGOT levels

SGOT	Frequency	Percentage
Normal, 8-45	127	93.4
Increased, >45	9	6.6
Total	**136**	**100.0**

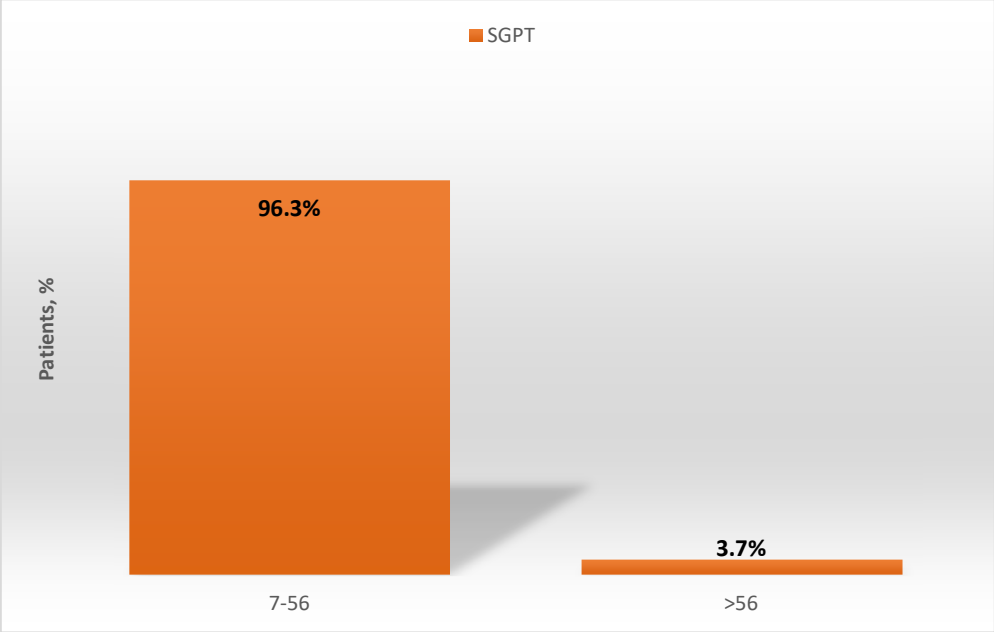


Graph 34: Bar diagram showing distribution of patients based on SGOT levels

The mean ± SD serum SGPT levels of the study population was 22.0±12.1 and median serum SGPT was 19.0. Serum SGPT levels were in normal range among 131 (96.3%) patients and increased in 5(3.7%) patients (Table 35 and Graph 35)

Table 35: Patient distribution based on SGPT levels

SGPT	Frequency	Percentage
Normal, 7-56	131	96.3
Increased, >56	5	3.7
Total	**136**	**100.0**



Graph 35: Bar diagram showing distribution of patients based on SGPT levels

DISCUSSION

Diabetic microvascular complications lead to significant morbidity and mortality with reduction in quality of life and increased economic burden. Therefore, identifying patients with diabetes mellitus who are at increased risk of microvascular complications is of paramount importance. Recently, TyG index has been used as a marker to identify patients at risk of developing microvascular and macrovascular complications in type 2 diabetes mellitus. The present study, was carried out to evaluate the relationship between TyG index and specific microvascular complications including diabetic retinopathy, diabetic nephropathy and diabetic neuropathy.

The study population comprised of 136 patients aged 30-88 years, diagnosed with type 2 diabetes mellitus. Majority of patients (75.0%) were over 50 years of age, males (58.8%). This is in concordance with previous studies which show that incidence of diabetes is common among males [65]. Previous studies have suggested that increasing age, longer duration of disease, lack of physical exercise, increased level of HbA1c, elevated FBS and total cholesterol are risk factors for developing diabetic complications. Studies have also suggested, serum triglyceride levels and blood pressure values are independent risk factors of microvascular complications [66, 67]. In our study, the mean serum HbA1c values were 8.3%, mean FBS values were 167.3 g/dL and serum TG levels were increased in 38% patients.

In this study, microvascular complications such as diabetic retinopathy, diabetic nephropathy and diabetic neuropathy were assessed. Retinal changes were assessed using fundoscopy and based on International Clinical Diabetic Retinopathy

classification, patients were categorized as mild NPDR (n=33), moderate NPDR (n=21) and severe NPDR (n=3) and PDR (n=6) [27]. Microalbuminuria is an important factor in determining diabetic nephropathy and is widely used [31]. In this study, UACR was used to assess diabetic nephropathy. An UACR of >30 mg/g was indicative of microalbuminuria. In this study 38% patients had microalbuminuria. Amongst them, 2 patients had overt nephropathy with UACR >300 mg/g. TCNS was used for clinical assessment of neuropathy in this study [32]. In this study, Mild, moderate and severe neuropathy were seen in 24.3%, 5.1% and 0.7% patients, respectively. The frequency of patients with complications is in accordance with previously reported data. In a study by Pradeepa R, et al, Diabetic retinopathy, neuropathy, overt nephropathy and microalbuminuria was present in 17.5%, 25.7%, 5.1% and 26.5% patients, respectively [54]. Liu et al [59], reported diabetic neuropathy among 34% of patients.

TyG index is an indicator calculated from commonly available laboratory tests, such as fasting triglyceride and FBS. It is a simple marker to assess insulin resistance and is also strongly associated with diabetes mellitus, metabolic syndrome, cardiovascular diseases. Gao et al, reported that, with every increase in one unit rise of TyG, there was 1.5-fold increase in risk of renal complications [60]. In the present study, the mean TyG index was 9.3 which was lower than TyG index of 17.8, reported by Jabeen Wm et al [61]. Majority of patients had TyG index <9.3 (52.2%), followed by >9.5-10 (19.9%). Previous studies have used different cut off values to evaluate the TyG index, in specific microvascular complications. In a study by Shang J et al [55], a threshold of 9.05-9.09, was considered a prognostic cut off value to identify patients at risk of diabetic nephropathy. Liu L et al [59], reported a cut off value of 9.66 to identify diabetic neuropathy. Further, Gao YM, et al [60], reported a

significant positive correlation between ESRD risk at a TyG index cut off value of 9.5.

However, there is lack of consensus on cut off values of TyG index. This is due to lack of data in literature, regarding the sensitivity and specificity of this index. Therefore, in this study the patients were categorized based on quartiles into 4 groups, to evaluate the relationship between TyG index and various microvascular complications. There was significant association between TyG index and microvascular complications (p=0.000). The frequency of microvascular complications was directly proportional with TyG index. This result was further supported by, occurrence of individual complications such as diabetic retinopathy, diabetic nephropathy and diabetic neuropathy, which showed significant association with TyG index individually. Frequency of severity of individual complications was directly proportional to TyG index.

Similar association between TyG index and microvascular complications have been reported previously. In a cross-sectional study by Srinivasan et al, patients were categorized into quartiles from <7.3 to >8.0 for analysis. Similar to our results, they reported a proportionate relationship between TyG index and diabetic retinopathy and higher TyG index correlated with disease severity [58]. Pan Y et al [50], reported that higher TyG index was associated with significantly increased risk of microalbuminuria. According to study by Zhou J et al, patients with increased TyG index was associated with increased risk of developing diabetic retinopathy [64].

HbA1c, TG and FBS are considered as significant risk factors for the development of microvascular complications [66, 67]. Our study supported this fact, by showing a significant association between HbA1c and microvascular complications.

Similar positive association was also observed between serum TG and overall microvascular complications.

Further, association of TyG index with individual risk factors contributing to development of diabetic complications, such as HbA1c, TG and FBS was evaluated. We noticed, a significant positive association between TyG index and HbA1c levels, which increased proportionately with increasing HbA1c levels. Similarly, a significant association between TyG index and increasing serum TG levels was observed. The mean FBS was slightly lower among patients with TyG index <9.3 and increased proportionately with increasing TyG index. Highest mean FBS was noted among patients with TyG index greater than 10. These findings are in accordance with studies conducted by Jabeen WM, et al [61] and Kassab HS et al, [62] where a significant association was reported ,between TyG index and increasing HbA1c.

Prevention and management of diabetes and its associated complications, in developing countries like India is challenging, due to several barriers in the healthcare sector. Lack of access to healthcare, affordability of medicines, lack of education related to diabetes and its complications, poor compliance to medications and inadequate follow up during treatments, are the challenges faced by the treating physician. Therefore, health promotion and primary prevention of diabetes at both individual level and community level should be added in the agenda of diabetes care by Health authorities and apex bodies. TyG is an easy index, which can be calculated by using the common laboratory tests, that are done routinely during evaluation and follow up. The physicians should take advantage of this easy index, to screen the patients at risk of diabetic microvascular complications and manage the patient effectively. However, there are limited studies which has evaluated the specific cut off

values of TyG index which can determine the risk. Further studies are warranted to assess the sensitivity, specificity and area under the curve values for TyG index.

LIMITATIONS OF THE STUDY

- This was a cross-sectional observational study limiting the establishment of causal relationship.
- Although we found significant relationship between TyG index and microvascular complications, however, a specific cut off value was not used in the study. Further studies are warranted to evaluate a cut off value of TyG index, with better understanding of sensitivity and specificity of this index.
- Single centre study, with smaller sample size is another limitation as patients are limited to specific area only.
- Convenient method of sampling could result in selection bias. A further population-based studies are warranted to evaluate the TyG index as a screening method.

CONCLUSION

- In the present study, a statistically significant association between TyG index and overall microvascular complications including diabetic retinopathy, diabetic nephropathy and diabetic neuropathy were observed.
- The risk of microvascular complications increased with increasing TyG index.
- A statistically significant association between HbA1c levels and microvascular complications including diabetic retinopathy, diabetic nephropathy and diabetic neuropathy were observed.
- Poor diabetic control was associated with severe complications.
- Further, the association between serum triglyceride levels and microvascular complications including diabetic retinopathy, diabetic nephropathy and diabetic neuropathy was statistically significant.
- The results of our study emphasize the importance of adapting this useful, easily calculated TyG index in routine follow up during treatment of patients with Type 2 DM, to assess the risk of microvascular complications.

SUMMARY

The present cross sectional study was conducted in the Department of General Medicine, K.L.E's Dr. Prabhakar Kore Hospital and Medical Research Centre, Belagavi from January 2023 to December 2023. All patients aged ≥ 18 years of age diagnosed with type 2 DM according to ADA criteria were enrolled. Patients with any febrile illness, chronic renal disease, heart failure, autoimmune disease, hypertension, cancer, liver disease, radiculopathy and inflammatory neuropathy, peripheral vascular disease and obstructive uropathy were excluded. After obtaining a written informed consent, a detailed patient history and demographic data were documented. A detailed examination to screen for microvascular complications was done. Basic laboratory parameters including FBS, HbA1c and serum triglycerides were sent.

For diabetic nephropathy, a value of ≥30 mg/g was considered as microalbuminuria. Diabetic retinopathy was categorized based on the International Clinical Diabetic Retinopathy Severity Scale and diabetic neuropathy was categorized based on Toronto clinical neuropathy. The TyG index was calculated with formula: Ln [fasting triglycerides (mg/dL) × fasting glucose (mg/dL)/2]. Association between TyG index and microvascular complications were assessed using Chi-square test or Fisher exact test. P-value less than or equal to 0.05 indicates statistical significance.

A total of 136 patients diagnosed with T2DM were included in the analysis, of which 74 patients had at least one microvascular complication including diabetic retinopathy, diabetic nephropathy, or diabetic neuropathy. Mild NPDR, moderate NPDR and severe NPDR was noted in 33, 21 and 3 patients, respectively and 6

patients had PDR. 52 (38.2%) patients had UACR >30 mg/g suggestive of microalbuminuria. Mild, moderate and severe neuropathy were seen in 33 (24.3%), 7(5.1%) and 1 (0.7%) patients, respectively.

The mean ± SD TyG Index of the study population was 9.3±0.5. Overall, significant association was noted between TyG index and overall microvascular complications, diabetic retinopathy, diabetic nephropathy and diabetic neuropathy (p=0.000 for each). Frequency and severity of microvascular complications increased with increased TyG index. Overall, significant association was noted between HbA1c and microvascular complications, diabetic retinopathy, diabetic nephropathy and diabetic neuropathy (p=0.000) were observed. Frequency and severity of microvascular complications increased with increased HbA1c. Overall, significant association was noted between TG levels and microvascular complications (p=0.001), diabetic retinopathy and nephropathy (p=0.000, each) and diabetic neuropathy (p=0.001).

The mean ± SD age of the study population was 59.8 ±13.2 years. Overall, 80 (58.8%) patients were male and 56 (41.2%) were female. Summary of Mean ± SD laboratory parameters are as follows: hemoglobin level, 12.0 ±1.9 g/dL; WBC count, 8938.2 ±2153.2 cells/mm^3; platelet counts, 274014.7±97235.0 mcL; serum creatinine, 0.8±0.2 mg/dL; serum urea, 17.8±10.4 mg/dL; serum total bilirubin 0.7±0.2 mg/dL; serum direct bilirubin, 0.3±0.2 mg/dL; total protein, 6.7±0.6 g/dL; albumin levels, 3.8±0.4 g/dL; serum SGOT levels 24.8±11.7; serum SGPT levels 22.0±12.1; HbA1c levels 8.3±2.1; FBS levels 167.3±51.9 g/dL and serum TG levels 140.6±47.2 mg/dL.

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ANNEXURE I

INFORMED CONSENT FORM

Dear Mr. /Mrs. /Dr. _____, you are kindly requested to enroll yourself in a research study tilted, **"CORRELATION BETWEEN TRIGLYCERIDE GLUCOSE INDEX AND MICROVASCULAR COMPLICATIONS IN TYPE 2 DIABETES MELLITUS"** being conducted by REG NO: BG0121021, a post graduate student in M.D. General Medicine, Department of General Medicine, Jawaharlal Nehru Medical College, Belgaum.

You have been requested to participate in this as you fit into the laid-out criteria for a study 'subject'/ participant.

Your participation in study is voluntary. During the study you will be asked some questions and you are supposed to answer to the best of your knowledge. Your decision whether to participate in the study will not affect your treatment in any form. If you decide to participate you are free to withdraw at any time.

TITLE OF THE STUDY:

TO STUDY THE RELATIONSHIP BETWEEN TRIGLYCERIDE GLUCOSE INDEX AND MICROVASCULAR COMPLICATIONS IN TYPE 2 DIABETES MELLITUS

"**PURPOSE OF THE STUDY:** To correlate triglyceride glucose index with MICROVASCULAR COMPLICATIONS in patients with TYPE 2 DIABETES MELLITUS

PROCEDURES INVOLVED: If you agree to enroll yourself in my study, you will be interviewed regarding your present, past and family history then you will be clinically examined in detail and investigated accordingly.

Then you will be subjected to a few blood investigations, namely FBG, total cholesterol (TC), serum TG, high-density lipoprotein- cholesterol, and low-density lipoprotein-cholesterol, serum level of creatinine, urinary level of creatinine, and albumin

Fundoscopy will be done

Neuropathy according to Toronto clinical neuropathy will be evaluated

RISKS AND BENEFITS: There are no potential risks involved in this study.

Benefits of taking part in this research: By taking part in this study, prognosis, and risk of development of MICROVASCULAR COMPLICATIONS in diabetes can be detected

VOLUNTARY PARTICIPATION / WITHDRAWAL FROM THE STUDY: Taking part in the study is voluntary. You may choose not to enroll yourself in this study and may choose to leave the study anytime in between.

ALTERNATIVES: Your decision regarding participation in study will not change present or future health care services offered to you at KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum. You would simply be excluded from the study if you wish to, and all your details shall be kept confidential and you will get the routine line of management.

PRIVACY AND CONFIDENTIALITY: All data collected or disclosed by you during the course of participation of study, will be kept fully confidential. If however during the course it becomes necessary for the progress of the course to disclose the identity, it would be done so only after your informed & written consent. The only people to know that you are a research subject are members of the research team. No information about you will be disclosed to other without your written permission except:

In emergency to protect your rights AND welfare.

If required by law.

AUTHORIZATION TO PUBLISH RESULT: The results of the study may be used to publish an article. When the results of research published or discussed, in a conference, no information will be displayed that would

disclose your identity. Any information obtained in connection with this study and that can be identified with you will remain confidential.

FINANCIAL INCENTIVES FOR PARTICIPATION: No additional costs shall be incurred upon you for the purpose of this study. It is purely being done with the idea of research and all the cost of study will be borne by the investigator.

COMPENSATION: In the event that you become injured as a result of taking part in this study, treatment will be offered to you at KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum, or you will be given information about where to receive medical care. However, no reimbursement, compensation or free medical care will be given.

QUESTIONS/CONTACT DETAILS: You shall be free to contact the below mentioned name & addresses anytime during the study period for any clarification or help as you may desire for.

PRINCIPAL INVESTIGATOR:

REG NO: BG0121021, MD (Post Graduate Student), Department of General Medicine, Jawaharlal Nehru Medical College, Nehru Nagar, KLE Hospital Road, Belagavi 590010**,** Mobile - 8197329220

CONSENT FORM

I, voluntarily agree to take part in this study by signing below. I may withdraw at any time. I am not giving up any of my legal rights by signing this form. My signature below indicates that I have read this consent form, or it has been read to me, this consent form and have had all the questions answered.

……..…….. …..……

Name of the Participant Signature of the participant

or Left-Hand Thumb impression

…… ……

Name of Investigator Signature of investigator

or Left-Hand Thumb impression

……. ……..

Name of Witness Signature of Witness

or Left-Hand Thumb impression

Date:

ANNEXURE II

PROFORMA

CASE NO:	**IP NO.:**
NAME: **AGE** **SEX: M / F** **ADDRESS:** **OCCUPATION:**	
Chief Complaints :	

Past history : DIABETES On OHA/ Insulin : HTN Others **Treatment history:**
Family history:
Personal history: SMOKER ALCOHOLIC
Diagnosis:

PHYSICAL EXAMINATION: GENERAL CONDITION:

- PALLOR- YES/NO
- ICTERUS-YES/NO
- LYMPHADENOPATHY-YES/NO
- CYANOSIS- YES/NO
- CLUBBING-YES/NO
- EDEMA-YES/NO

VITALS:

- TEMPERATURE:
- PULSE:
- RESPIRATORY RATE:
- BLOOD PRESSURE:

SYSTEMIC EXAMINATION

R. S.: C.V.S.: C.N.S.: P.A.:	

Table 1

The components of the original Toronto Clinical Neuropathy Score (TCNS)

Symptom scores	**Sensory test scores**	**Reflex scores**
Foot pain	Pinprick	Knee reflexes
Numbness	Temperature	Ankle reflexes
Tingling	Light touch	
Weakness	Vibration	
Ataxia	Position sense	
Upper limb symptoms		

Symptom scores	**Sensory test scores**	**Reflex scores**
Symptom scores graded as	Sensory test scores graded as	Reflexes graded as
0 = absent	0 = normal	0 = normal
1 = present	1 = abnormal	1 = reduced
		2 = absent

Maximum TCNS is 19 points.

Diabetes severity graded according to the results of the TCNS. Out of a total score of 19, the grades are defined as follows: 0–5 = no neuropathy; 6–8 = mild neuropathy; 9–11 = moderate neuropathy; ≥ 12 = severe neuropathy.

INVESTIGATIONS

Sl no	Test	Date_____	
	Complete Blood counts		
1	Haemoglobin (g/dl)		
2	TLC($x10^3/\mu l$)		
3	Platelets($x10^3/\mu l$)		
	Renal Profile		
4	Urea(mg/dl)		
5	Creatinine (mg/dl)		
	Liver Function Test		
6	Total Bilirubin (mg/dl)		
7	Direct Bilirubin(mg/dl)		
8	Total Protein(g/dl)		
9	Albumin(g/dl)		
10	Globulin (g/dl)		
11	ALT (SGPT) (U/l)		
12	AST (SGOT) (U/l)		
13	ALK. Phosphatase (U/l)		
	LIPID PROFILE		
14	Cholesterol (mg/dl)		
15	LDL(mg/dl)		
16	HDL(mg/dl)		
17	TG(mg/dl)		
18	LDL/HDL RATIO		
19	HbA1c (%)		
20	FBS(mg/dl)		

21	Fundoscopy	
22	TRIGLYCERIDE GLUCOSE INDEX(TyG)	
23	eGFR	
24	Urinary albuminuria: creatinine ratio	
25	Toronto Clinical Neuropathy Scoring	

INTERPRETATION

ANNEXURE III – MASTERCHART

Sl No	IP No	NAME	AGE	SEX	HAEMOGLOBIN	WBC	PLATELET	CREATININE	UREA	TB	DB	TOTAL PROTEIN	ALBUMIN	SGOT	SGPT	HBA1C	FBS	Sr TRIGLYCERIDES	TyG INDEX	FUNDOSCOPY	UACR	TCNS
1	10045641	ANJALI BHAURAO	50	F	10.4	9.2	414	0.62	22	0.23	0.12	7.6	3.6	14	15	15.3	289	183	10.15	MODERATE NPDR	135.45	0
2	10044225	BIBI FARZANA	43	F	9.6	8.5	467	0.57	17	0.3	0.1	7.2	4	11	12	6.6	110	110	8.7	NORMAL	16	2
3	10045405	NAGAWA BHAGANNA	88	F	13.8	11.9	252	0.88	23	0.38	0.16	6.3	3.3	9	19	6.7	140	150	9.25	MILD NPDR	86	7
4	10044491	BHARATHI MALLUR	35	F	9	9.1	439	0.52	12	0.6	0.4	7	4	16	10	6.6	120	90	8.5	NORMAL	13	3
5	10044283	SUNIL BEKWAD	51	M	10.2	8.6	232	0.8	14	0.2	0.16	7.5	3.6	27	21	7.1	140	160	9.32	NORMAL	110	4
6	10044889	DEEPAK MASTHIHOLIMATH	69	M	10.4	8.8	326	1.13	35	0.77	0.41	6.6	4.2	21	29	7.2	160	130	9.24	MILD NPDR	75	9
7	10044351	MANDAKINE TALWAR	75	F	12	11.6	306	0.86	27	0.22	0.07	6.8	3.7	25	58	7	150	124	9.13	MILD NPDR	20	5
8	10045341	PRABHAVATI UDAKEKAR	62	F	12.2	7.9	271	0.58	11.2	0.3	0.15	6.8	4	25	19	8	185	148	9.52	MILD NPDR	120	11
9	10044629	VISHNU CHOUGLE	65	M	17.9	10.1	450	1.03	26	1.1	0.2	7	4	20	25	7	140	76	8.57	NORMAL	10	3
10	10045394	SITARAM SUKVE	55	M	11.3	7	205	0.68	15	0.4	0.2	6.6	3.1	41	58	6.6	60	60	8.18	NORMAL	10	0
11	10044121	SHANTA BADIGER	75	F	11.1	10.1	275	0.61	28	0.4	0.1	6	3.1	20	24	7.2	150	110	9.01	NORMAL	25	2
12	10045536	SUSHILA PATIL	58	F	12	5.5	289	0.53	19	0.45	0.2	7.1	4.1	20	18	7	150	156	9.36	NORMAL	35	3
13	10045729	MARUTI PUJERI	42	M	9.4	8.1	173	0.76	20	1.16	1.01	7.2	3.5	12	20	6.8	138	253	9.7	NORMAL	25	4
14	10007892	HANUMANTH	45	M	10	9	250	0.9	20	0.9	0.3	6.9	3.6	20	25	8.4	126	102	8.76	MILD NPDR	604	10
15	10005812	SHANKAR	77	M	10.6	8	190	0.8	25	1.1	0.8	7	4	16	20	8.4	170	142	9.3	MODERATE NPDR	76	7
16	10008212	SHAMEEM	55	F	11	10	250	0.7	14	0.2	0.16	6.8	3.6	30	35	7.7	145	168	9.4	NORMAL	10.73	2
17	10007990	SANTHOSH	55	M	12.6	7	260	0.6	16	0.3	0.15	6	3.5	15	11	6.6	128	88	8.63	NORMAL	14.2	0
18	10008202	SHIVAGANGAVVA	72	F	11.4	7	350	0.68	22	0.66	0.21	7.1	4	20	22	6.1	110	120	8.8	NORMAL	20	0
19	10006556	ANITA	52	F	10	6.6	245	0.9	25	0.6	0.4	6.9	3.7	35	22	7.6	243	98	9.38	MILD NPDR	22	8
20	10007683	BHIMAPPA	65	M	12.6	8.3	278	0.5	23	1.1	0.8	7.2	3.8	27	20	9.7	220	221	9.7	MODERATE NPDR	45	8

21	10005315	YALLAPPA	37	M	13.5	4.5	275	0.9	16	0.6	0.4	7.9	4.1	26	31	8.1	187	124	9.3	NORMAL	7.9	2
22	10045667	LAXMAN	58	M	14.7	10.1	391	0.8	15	1.57	0.21	7	4.4	23	23	6.6	112	156	9.07	MILD NPDR	11	1
23	10045473	NARAYAN CHANAPUDI	48	M	15.9	11	299	0.9	25	1.07	0.46	7.4	4.4	30	27	6.6	84	102	8.3	NORMAL	20	0
24	10041316	KRISHNA PATIL	78	M	16.1	7.6	224	1.11	30	0.89	0.37	6.7	3.3	26	20	7.3	250	148	9.83	MODERATE NPDR	45	4
25	10045082	RAMGOUDA PATIL	75	M	15.9	10	268	0.87	33	0.6	0.3	7	4.1	21	22	10.8	140	214	9.6	MODERATE NPDR	22	6
26	10045121	IRAPPA WALI	56	M	13.2	6.3	168	0.77	18	0.52	0.18	7.1	3.6	29	40	8.1	130	209	10.2	SEVERE NPDR	45	7
27	10044306	MARUTHI SURVE	70	M	10.7	9.1	388	1.1	43.7	0.72	0.33	6.6	3.3	50	61	6.8	265	271	10.48	NORMAL	40	2
28	10044381	KASTURI KARADI	45	F	9.7	5.3	206	0.41	9.3	0.16	0.08	6.8	3.6	25	28	10.3	258	176	10.05	SEVERE NPDR	228	6
29	10045192	PARSU SATTIKAR	68	M	12.3	6	291	0.9	12	0.9	0.4	6.4	4	15	10	9.1	234	271	10.3	MODERATE NPDR	92	5
30	10045865	FAKEERAGOUDA	78	M	13	7.1	171	1.1	16	0.99	0.66	6.5	4.1	15	16	6.3	141	151	9.2	NORMAL	25	0
31	10045901	PARVATI GUDIGOPPA	60	F	12.4	8.2	284	0.58	12.7	0.58	0.26	6.8	4	10	15	7.3	217	93	9.2	NORMAL	6.12	6
32	10042051	MEHABUB	65	M	11	10	284	0.76	14	0.45	0.2	6.6	3.6	18	15	8	172	140	9.39	NORMAL	133	3
33	10046635	KEMPANNA KOLI	67	M	12.5	7.6	195	0.87	19	1.1	0.6	7.8	4	19	15	13.6	316	102	9.6	MILD NPDR	47	7
34	10046372	IRAVVA	58	F	10.8	6.5	258	0.98	88	1.18	0.9	6.6	3.1	37	53	8.3	212	168	9.7	NORMAL	171	6
35	10046354	SHOBHA	75	F	9.6	9	185	1	45	0.9	0.66	7.3	3.7	20	22	13.6	275	128	9.7	SEVERE NPDR	75	9
36	10044491	BHARATI MALLUR	35	F	11.4	9.1	331	0.52	12	0.78	0.45	6.6	3.8	12	10	6.9	97	110	8.47	NORMAL	10	1
37	10044532	MUBARAK	46	M	12.9	11	325	1.07	11	0.18	0.1	7	3.4	47	39	7.1	120	100	8.7	NORMAL	14	0
38	10007564	NASIR HUSSAIN	53	M	11	6.8	196	0.9	26	0.87	0.33	6.4	3	14	19	11.1	200	147	9.59	NORMAL	28	4
39	10007112	KRISHNA PATIL	75	F	10.5	7.5	200	1	12	0.7	0.3	6.6	4	32	20	6.7	155	151	9.36	MILD NPDR	113	2
40	10008189	RAM BILAASH	49	M	13.6	6	285	0.9	26	0.9	0.5	7.5	4.2	16	10	7.2	157	78	8.7	NORMAL	16	1
41	10008464	NILAMMA	85	F	10.6	10	157	0.46	30	0.6	0.4	6.8	3.6	20	25	6.5	104	95	8.5	NORMAL	28	2
42	10046656	SURESH YADAHALLI	55	M	12	7.7	262	1	30	0.25	0.09	6.9	3.7	16	25	6.8	180	237	9.96	MODERATE NPDR	50	7
43	10047173	MAHADEVI MUDALAGI	58	F	11	9	247	0.6	14	0.66	0.3	7	4	28	20	7	110	120	8.79	NORMAL	15	2
44	10046721	ABDUL GAFAR	75	M	9	10	165	1	30	1.1	0.5	6.6	3.6	16	14	9.5	200	87	9.07	MILD NPDR	99	9
45	10046631	MAMTAZ KHAN	61	F	13	6.9	185	1.03	33	0.7	0.55	7.2	3.9	29	38	6.5	90	140	8.74	NORMAL	3.64	0
46	10044061	MD HANIF	40	M	12.4	7.6	225	0.56	12	0.9	0.65	6.4	3.5	24	20	10	180	150	9.51	MILD NPDR	4.56	6
47	10046343	HANAMANTH KUTRI	68	M	9.4	10	198	1.1	35	0.3	0.1	6.9	4.1	36	30	8.4	224	250	10.23	PDR	489	12
48	10046324	CHANDU KILARE	50	M	8.6	6.1	117	0.9	22	0.6	0.3	6.7	3.9	16	12	7.4	193	381	10.95	MILD NPDR	148	4
49	1001842	KEMPAYYA	57	M	10	11	321	1.07	33	0.7	0.45	7	4	26	22	9.6	140	110	8.94	NORMAL	4.5	0
50	10045051	SHNAKARAPPA	52	M	11.5	7.6	254	0.9	22	0.87	0.55	6.5	3.4	15	20	7	120	120	8.8	NORMAL	10	0
51	10045043	YALLAWWA	71	F	12.1	7.2	304	0.84	25.7	0.34	0.16	6.8	4	22	16	8.2	164	130	9.24	MILD NPDR	40	2
52	10045724	SHANTA BADIGER	55	F	10.9	11.2	374	1.05	24	0.45	0.2	7.1	3.8	28	34	8.3	200	170	9.74	MODERATE NPDR	158	6
53	10044880	TUSHSAR BALEKUNDRI	42	M	16.65	10	211	0.89	19.6	1.04	0.45	6.8	4	23	15	7.1	120	123	8.8	NORMAL	13	0
54	10045783	MD HANIF ISMAIL	62	M	11.1	10	489	1	26	0.9	0.6	6.9	3.7	22	18	6.9	130	80	8.55	NORMAL	10	0
55	10046004	ZAHID SHAIK	65	M	10.8	105	331	0.75	30	0.6	0.44	7.2	3.8	29	20	7.6	188	143	9.48	NORMAL	3	2

56	10027872	LOHAR GOPAL	45	M	12.9	11	328	0.71	25.8	0.4	0.1	8.1	4.3	30	49	8.6	350	114	9.86	PDR	78	0
57	10027842	SUBHASH	76	M	9.79	6.6	294	0.87	18	0.23	0.1	7.5	4.2	25	26	8.9	208	107	9.2	MILD NPDR	35	0
58	10028709	RAJESHWARI PUJARI	45	F	10.9	8.1	162	0.41	21	0.26	0.1	7.5	4.5	12	27	6.8	114	78	8.39	NORMAL	4.3	0
59	10008444	BASAVARAJ HIREMATH	43	M	12.7	11.4	147	1.01	46.3	0.39	0.2	5.6	3.1	34	20	6.7	140	79	8.61	MILD NPDR	9.4	3
60	10024796	RAVASAB B N	59	M	13.1	3.9	199	0.55	22	0.6	0.4	6.8	3.9	36	20	13.4	321	79	9.46	MODERATE NPDR	47.6	7
61	10006991	NAGOJ PARASHURAM	52	M	14.3	11.1	220	1.07	24	1.05	0.6	6.7	4.2	20	25	9.1	214	143	9.66	MILD NPDR	14	0
62	10007766	CHIDANANDAPPA	60	M	16	12.5	253	0.99	20.1	0.97	0.3	7.9	4.6	28	28	8.8	150	182	9.51	NORMAL	6.2	2
63	1124265	KRISHNA KAMBLE	72	M	10.3	8.8	163	1.1	18	0.36	0.09	7.3	4.1	15	18	9.5	210	100	9.25	MILD NPDR	36	6
64	1196587	HANAMATH	36	M	12.4	10.1	487	0.7	20	0.6	0.34	6.4	3.3	28	26	8.4	196	225	10.02	NORMAL	7.2	2
65	10008430	FAYAZ	40	M	9.8	7.1	265	1	11	0.9	0.66	7.2	4.2	16	18	7.6	145	100	8.8	NORMAL	15	0
66	10008686	SHAHEBI	71	F	11.1	7.6	278	0.6	16	0.56	0.12	6.5	3.9	18	18	6.9	135	113	8.9	NORMAL	6.1	1
67	10045798	DULHANBI MATTE	65	F	10.4	9	400	0.7	20	0.3	0.11	7.4	4.1	15	14	11.2	290	193	10.23	MODERATE NPDR	125.4	8
68	10045759	NINGULI PATIL	45	F	9.6	8.5	400	0.6	20	0.5	0.2	7.2	4.1	11	12	6.6	110	112	8.7	NORMAL	16	2
69	10045976	ANAND BHAJANTRI	53	M	11.6	10	252	0.88	21	0.4	0.16	6.3	3.4	19	9	6.8	140	153	9.31	MODERATE NPDR	86	7
70	100447578	VIDYA BADIGER	50	F	13.7	6.6	277	0.65	18	0.6	0.2	6.9	4.3	14	16	7	120	123	8.9	NORMAL	15	2
71	1108190	SHRIKANT BHIMANNAVA	78	M	11.6	5.7	123	0.94	9.34	1.13	0.52	6.7	3.6	25	66	8	110	100	8.61	NORMAL	21	0
72	1107458	MANINGAPPA MASTHIHOLI	77	M	10.7	12.6	194	1.1	14	0.56	0.09	7.2	3.5	21	14	8.2	121	160	9.17	MILD NPDR	9.6	1
73	1107356	SHIVAPPA JAMMANAKAR	52	M	10.5	5.8	163	0.64	15.4	0.75	0.38	6.2	3.5	21	14	7.6	187	173	9.29	NORMAL	11	2
74	1106849	OMPRAKASH NAIK	70	M	14.6	11.1	178	0.73	8.41	1.18	0.41	6.8	4.5	34	30	6.5	210	200	9.95	MODERATE NPDR	45	7
75	1108189	SANGAPPA LAKKUNUR	61	M	12	4.6	180	1	25	0.51	0.31	5.7	3	21	17	10.9	203	107	9.21	MODERATE NPDR	27	8
76	1108089	SHAKUNTALA ARVIND	76	F	12.1	9.6	309	0.84	11.21	0.45	0.1	7	3.7	40	45	8.1	110	120	8.8	NORMAL	17	0
77	1105798	SALEEMBAIG SHAHAPURI	56	M	14.4	9.7	285	0.75	11.68	0.35	0.12	7.5	3.9	10	12	12.8	88	128	8.63	NORMAL	11.6	0
78	1104449	DAYANAND KAMBLE	60	M	13.7	10.7	276	0.65	11.21	0.47	0.14	7.2	4.4	49	19	7.7	152	170	9.46	NORMAL	21	3
79	1107970	SANJANA BASRGE	49	F	12.4	11	307	0.94	16.81	0.39	0.13	7.9	4.3	15	23	14.7	150	152	9.34	MODERATE NPDR	70.1	7
80	1108842	NINGANGOUDA PATIL	83	M	11.6	10.8	238	1.09	18.21	0.6	0.14	6.8	3	29	14	6.9	140	76	8.57	NORMAL	12	2
81	1018662	LAXMAN KASE	82	M	13.1	6.8	217	1.17	18	0.54	0.32	5.7	3	28	16	9.7	185	148	9.52	MILD NPDR	79	8
82	1049665	LAXMI KARIGAR	40	F	13.5	8.9	191	0.45	10.74	0.38	0.12	6.6	3.4	14	11	6.9	110	110	8.7	NORMAL	22	2
83	1045223	MALU KOPARDE	54	M	11.5	11	165	0.81	13.08	0.23	0.09	6	3.1	11	12	14.1	145	155	9.32	MILD NPDR	77	7
84	1039356	DAYANAND SHEMI	68	M	12.9	6.6	168	0.79	8.65	0.29	0.15	6.8	4.2	13	21	8.4	120	90	8.5	NORMAL	11	1
85	1041268	GUNDU JYOTIBAKOCHERI	70	M	11.8	8.9	313	1	8.54	0.28	0.14	6.3	3.5	22	12	6.7	162	142	9.35	NORMAL	84	4
86	1047260	SHANMUKAPPA SIDNAL	85	M	9.7	6.6	290	0.7	6.54	0.62	0.42	5.5	3.3	14	10	7.1	160	133	9.24	MILD NPDR	71	4
87	1022535	APPASAHEB PATIL	62	M	13.3	11.3	303	1.01	8.24	0.64	0.23	7.7	4.1	46	14	10.1	124	155	9.13	MILD NPDR	16	3
88	1020454	LAXMAN MANNURKAR	54	M	14.6	4.5	150	0.77	8.87	0.72	0.32	7	4.6	20	41	7.8	142	78	8.57	NORMAL	6	0
89	1018666	PRAKASH SUNAGAR	68	M	13.4	7.7	369	0.78	10.74	0.38	0.26	7.2	4.1	18	16	7.6	280	173	10.09	MODERATE NPDR	101	0
90	1024394	PREMA KULKARNI	67	F	9.6	3.7	162	0.86	6.2	0.96	0.72	6.4	4.2	26	25	6.6	120	96	8.5	NORMAL	15	1

91	1031885	KAMALABAVI T SHRINGARI	65	F	10.8	4.6	473	0.67	8.87	0.22	0.1	6.4	3.8	13	9	7.5	93	210	9.18	NORMAL	7.5	3
92	1034384	SIDDAWA MELAVANKI	60	F	14.8	9.9	129	0.67	5.24	0.39	0.11	5.1	2.5	46	50	8.3	205	163	9.69	NORMAL	143	7
93	1034451	ISHWAR KODOLI	45	M	13.6	9.8	311	1.09	8.2	0.62	0.48	6.4	4.2	21	12	8.2	160	145	9.35	MILD NPDR	21	2
94	1026447	MAHABUBAI BELAVADI	51	F	12.7	7.3	309	0.74	8.64	0.9	0.41	7.8	3.6	15	11	6.5	130	113	8.9	NORMAL	3.6	2
95	1116166	MOHAN KESARKAR	59	M	9.9	6.5	356	1	6.22	0.63	0.22	7.6	3.6	37	21	6.5	153	112	9.05	NORMAL	7	0
96	1041066	SUSHILA ARBINWADI	65	F	13.1	11	341	0.52	10.61	0.63	0.1	7.4	4.3	14	11	9.7	214	143	9.61	MODERATE NPDR	12	6
97	1031022	GURURAJ HOSAMANI	58	M	9.3	9.4	146	0.96	9.24	0.39	0.22	6.6	3.2	91	17	6.5	150	140	9.19	NORMAL	21	1
98	1024495	SHOBHA MORE	56	F	9.4	7.4	575	1.1	9.28	0.47	0.3	6.7	3.3	23	17	8.1	162	150	9.4	NORMAL	37	2
99	1036974	SHAMASHABEGUM ATTAR	65	F	9.3	11.6	553	0.83	7.64	0.86	0.62	6.4	3.8	21	12	14.2	208	167	9.75	MILD NPDR	67	6
100	1041066	SUSHILA R ARBINWADI	65	F	13.1	11	341	0.52	9.32	0.63	0.17	7.4	4.3	34	11	9.7	155	110	9.05	MILD NPDR	11	2
101	1048058	SHOBHA S DESAI	60	F	15	7.6	280	0.48	4.26	0.42	0.23	7.3	3.8	17	9	10.2	183	172	9.66	MODERATE NPDR	7	3
102	1048814	SHIVALEELA BELLANKIMATH	64	F	12.2	6.4	160	0.7	14.2	0.38	0.08	6	3.3	15	13	9.2	142	153	9.23	NORMAL	3.6	0
103	1043639	YALLAMMA MADIWALAR	73	F	11.2	3.6	323	0.42	11.68	1.1	0.47	6.7	4.4	24	16	7.2	157	113	8.9	NORMAL	33	3
104	1042841	JYOTHI SIDDANNAVAR	38	F	12.9	7.2	184	0.6	12.48	0.3	0.25	6	3.5	63	75	6.4	140	92	8.77	NORMAL	5.7	0
105	1030237	SHANTA BAILWAD	62	F	9.2	8.5	160	0.65	14.2	0.39	0.2	6.2	3.7	26	11	6.4	123	86	8.57	NORMAL	6.8	2
106	1029502	MOHAMMAD BEPARI	58	M	11.7	8.4	253	0.98	9.1	0.22	0.1	6.2	3	40	29	8.5	243	210	10.14	PDR	113	8
107	1026542	MURAGEPPA DALAWAI	68	M	10.4	6.7	163	1.05	22.1	1.63	0.81	6.2	3.2	39	19	6.4	181	97	9.06	MILD NPDR	6.2	3
108	1026456	SANNADEVAPPA KARATAGI	80	M	12.5	8.1	327	0.69	24.2	0.74	0.24	6	3.4	34	26	7.1	166	106	9.08	NORMAL	3.5	0
109	1040524	LAXMI NAIK	61	F	9.6	11.7	234	0.8	30.2	0.84	0.5	6	3	29	35	7.9	153	123	9.15	MILD NPDR	7.8	2
110	1006173	LAXMAN UPPAR	68	M	13.2	9.6	171	0.54	22.1	1.37	0.4	6.6	4.3	16	13	6.8	138	112	8.95	NORMAL	3.1	1
111	1037317	SHARADA KALANGADE	70	F	11.6	8.6	197	1.02	32.8	1.83	0.94	5.8	3	41	20	6.8	179	139	9.43	NORMAL	26.3	3
112	1032444	LATA KOTARAGI	38	F	11.6	7.7	512	0.85	20.8	0.3	0.14	6.1	3.5	24	20	9.4	164	132	9.28	MILD NPDR	9.6	1
113	1041939	SHIVANAND MAREPPA	70	M	9.7	5.3	189	0.92	10.2	0.82	0.13	6.2	3.3	40	15	6.5	140	103	8.88	NORMAL	3.7	0
114	977378	SHANTA PATIL	60	F	11.3	11	561	1.1	10.9	0.9	0.68	6.3	4.1	28	16	7	193	115	9.3	MILD NPDR	37.3	6
115	912299	GEETA KAMBLE	46	F	9.8	6.9	303	0.84	11.2	0.8	0.72	6.4	4.8	20	16	7.2	140	163	9.33	NORMAL	113.1	4
116	1013541	SARASWATHI AVAREKARE	51	F	11	8.1	513	0.78	10.2	0.68	0.32	6.8	4.2	42	36	6.5	132	110	8.89	NORMAL	7.7	0
117	1051610	GEETA REGI	46	F	15.8	6.6	240	0.81	10.3	0.48	0.28	7	4.2	22	24	8.8	175	137	9.39	MODERATE NPDR	71	6
118	1032020	SHANTHA JADHAV	82	F	10.9	10.1	288	0.91	11.2	0.56	0.28	6.6	3.9	18	11	8.7	145	122	9.08	NORMAL	15	2
119	1035357	SAKKAR NAIK	88	M	13.4	9.6	240	1	11.2	0.84	0.57	7.7	3.4	23	11	6.8	120	90	8.6	NORMAL	4.8	1
120	1013574	SHRIKANTH PATTAR	65	M	13	4.2	313	1	14.1	0.71	0.1	6.8	3.4	54	15	8.9	273	185	10.13	PDR	117.3	7
121	1024663	SHIVAJI SAVANT	58	M	13.4	9.2	273	0.99	10.2	1.28	0.46	5.4	2.9	23	12	10.3	202	143	9.58	MILD NPDR	17	3
122	1037562	RAMESH PANDIT	55	M	10.7	10.5	324	0.67	8.6	0.23	0.19	5.8	2.9	16	9	6.9	133	152	9.22	MILD NPDR	9.3	1
123	1008761	NILIMA NAIK	50	F	9.6	9.7	166	1	8.8	0.84	0.68	6.8	4.2	22	16	9.4	210	193	9.91	MODERATE NPDR	33	7
124	1020812	BASALINGAPPA WALAD	65	M	16	10.1	237	0.77	8	0.63	0.26	6.9	4	20	19	11.4	222	210	10.05	RIGHT EYE PDR	115	10
125	1067377	MAHESH KUKADOLLI	31	M	13.8	4.6	158	0.88	18.2	0.98	0.42	6.5	4.1	31	33	12.8	175	190	9.7	MODERATE NPDR	221	9

126	1067708	SHAHIRABANU AGATTI	32	F	12.3	6.9	177	0.87	6.8	0.96	0.76	7.2	4.3	23	31	6.7	130	110	8.87	NORMAL	9	0
127	1074387	SARDAR MOHDINSAB DESAI	73	M	10.6	5.2	232	0.7	8.2	0.51	0.25	7	3.5	25	27	10	201	173	9.75	NORMAL	73	6
128	1136944	THAGAVVA PATIL	84	F	13.2	7.7	243	0.8	12.2	0.7	0.6	7.1	3.6	20	12	7.1	145	160	9.35	NORMAL	13.1	0
129	1136933	PRATHIBHA HALYAL	38	F	12.2	3.6	345	0.6	10.2	0.4	0.3	5.5	3.8	22	14	7.6	151	116	9.07	NORMAL	4.6	0
130	1136327	MANJUNATH LAVAKUMAR	30	M	15.5	7.8	440	0.8	17.2	0.78	0.3	6.2	4.2	56	34	11.6	243	178	9.99	MODERATE NPDR	22.6	4
131	10064963	JIVABA	60	M	12.2	6.7	280	0.68	11.1	0.5	0.4	6.4	3.7	18	12	10.9	198	110	9.29	BOTH EYE PDR	27.6	6
132	10063033	SOMASHEKAR	62	M	13.6	4	345	0.7	9	1.1	0.3	6.5	4	25	20	6.7	144	116	9.03	MILD NPDR	17.6	0
133	10068586	ANJALI	45	F	14	5.5	265	0.66	14	0.6	0.3	5.6	3.7	14	20	14	165	135	9.31	NORMAL	13.3	2
134	10069012	PADMAKAR	55	M	13.8	6.3	300	1	15	0.8	0.56	7	4.1	32	30	11.1	215	189	9.9	MILD NPDR	45	6
135	10067926	MAHADEV	60	M	11	4.3	256	0.5	18.2	0.63	0.19	6.6	3.5	22	17	7.5	147	152	9.32	NORMAL	17.5	2
136	10068482	IRAPPA KOUJALGI	62	M	14.2	8.2	388	0.66	11	0.78	0.6	5.4	3	19	13	6.7	150	155	9.36	NORMAL	3.4	0