To determine the correlation of Triglyceride levels with HbA1c values in type 2 Diabetic patients.

[1]Dr S Moogaambiga [2]Dr S R RangaBashyam [3]Dr Nisha S [4]Dr Vandana Sanjoy Mishra

1. Professor, Department of General Medicine, Vinayaka Mission's Medical College and Hospitals, Vinayaka Mission's Research Foundation (DU), Salem, Tamil Nadu, India
2. Professor, Department of General Medicine, Vinayaka Mission's Medical College and Hospitals, Vinayaka Mission's Research Foundation (DU), Salem, Tamil Nadu, India
3. Postgraduate, Department of General Medicine, Vinayaka Mission's Medical College and Hospitals, Vinayaka Mission's Research Foundation (DU), Salem, Tamil Nadu, India
4. Postgraduate, Department of General Medicine, Vinayaka Mission's Medical College and Hospitals, Vinayaka Mission's Research Foundation (DU), Salem, Tamil Nadu, India

Abstract

Introduction: HbA1c could be used as a viable biomarker for predicting dyslipidemia and cardiovascular disease (CVD).Lipid abnormalities are common in diabetic population irrespective of insulin deficiency (or) resistance. The most common abnormality noted is hypertriglyceridemia.

Objectives: To determine the correlation of Triglyceride levels with HbA1c values in Diabetic patients.

Materials and Methods: The study is an observational study. The sample size will be 100 patients for evaluation of triglyceride levels and HbA1c (by satisfying inclusion and exclusion criteria) after informed written consent. Triglyceride levels and HbA1c levels will be checked for the patients who are selected, and the statistical test will be done to determine the correlation between them.

Results: The participants were grouped into three categories based on HbA1c levels, participants with excellent control, good control and poor control. The mean and standard deviation of lipid parameters was higher in poorly controlled group. Positive correlation observed between triglyceride and HbA1c (r=0.257).

Conclusion: Poorly controlled HbA1c has been found to be strongly linked to hypertriglyceridemia and also places them at high risk for cardiovascular disease. HbA1c levels can be used as an ideal marker for prediction of dyslipidemia. It can be used to screen high-risk diabetic patients for timely lipid-lowering medication intervention, averting unfavourable cardiovascular event

Introduction:

The prevalence of hyperglycaemia in the absence of therapy characterises and distinguishes a set of metabolic illnesses known as diabetes. Defects in insulin secretion, insulin action, or both, as well as changes in carbohydrate, lipid, and protein metabolism, are among the several aetiopathologies.[1] Diabetes is predicted which shows that it can affect 463 million people worldwide in the year 2019, which accounts for 9.3% of the adult global population (20–79 years). In the year 2030, this number is believed to rise to 578 million (10.2 %) and 700 million (10.9 %) by 2045. Prediction of diabetes is that it may affect 9.0 percent of female population and 9.6 percent of male population in2019. Diabetes prevalence increases with age, that it exists in a range of 19.9% (111.2 million) in adults aged from 65 to 79 years. Its prevalence ranges from 1.2% to 14.6% in the Asian population.[2] In comparison to Caucasians, Asians have a higher prevalence of diabetes. Sedentary lifestyle practices, growing urbanisation, and the

adoption of an industrialised food culture, all of which lead to obesity and insulin resistance, are major contributors to this alarming prevalence.In Indian population, the prevalence of diabetes when adjusted for age is 9.6% in 2021 which tends to increase to 10.8% by 2045.The percentage of mortality in diabetic people under 60 years tends to be about 2.8%.[3]

Cholesterol is now one of the most well-known biological macromolecules in human biology, owing to its direct link to atherosclerotic vascular disease. Cheese, eggs, butter, ghee, fish, hog, poultry, and goat meat are the most common sources of cholesterol. Cholesterol is absorbed from the diet and generated by the body's cells, particularly those in the liver and intestine. HMG Co-A reductase catalyses the conversion of HMG Co-A to Mevalonate, which is the rate-determining step and is heavily regulated by cholesterol supply, hence several drugs target this process for the treatment of hypercholesterolemia.[4]

Diabetes is linked to both microvascularcomplications and macrovascular complications, such as retinopathy, nephropathy, and neuropathy (microvascular) and ischemic heart disease, peripheral vascular disease, and cerebrovascular disease (macrovascular), resulting in organ and tissue damage in one-third to one-half of diabetics.[5]In India, the percentage of diabetics with nephropathy, neuropathy and retinopathy tends to be 5.9%,10.6% and 0.8% respectively. The percentage of diabetic population with macrovascular complications like coronary artery disease, cerebrovascular disease and heart failure is estimated to be 2.5%,0.3% and 0.2% respectively.[3]Glycaemic management markers include fasting blood glucose (FBG), postprandial blood glucose (PPBG), and glycated haemoglobin (HbA1c). HbA1c is a glycaemic control biomarker that is measured throughout the previous 8-12 weeks. In diabetics, glycated haemoglobin (HbA1c) levels are frequently evaluated to assess glycaemic management. It is utilised as a marker for glycaemic management, disease progression, and the emergence of problems in diabetic patients. The goal is to lower the rate to below 7%. Multiple factors, including as sugar intake, exercise, and medication adherence, might alter HbA1c levels.

According to several research, HbA1c could be used as a viable biomarker for predicting dyslipidemia and cardiovascular disease (CVD). [6]Microvascular problems were linked to higher HbA1c levels. Our findings support the use of a HbA1c cut-off point of 6.6 to 7.0 percent for diabetes diagnosis. Individuals with mild and severe retinopathy were best identified using cut-off values in this range. At these cut-off values, any retinopathy, chronic kidney disease, albuminuria, and peripheral neuropathy are less well recognised.[7]Lipid abnormalities are common in diabetic population irrespective of insulin deficiency (or) resistance. To be more precise, rather than hypercholesterolemia, the most common abnormality noted is hypertriglyceridemia and low level of High Density Lipoprotein (HDL).[8]Even in non-diabetics, increased HbA1c has been identified as an independent risk factor for CVD.[9]Abnormal lipid profiles are defined as total cholesterol levels of 200 mg/dl, triglyceride levels of 150 mg/dl, HDL levels of 40 mg/dl in males and 50 mg/dl in females, and LDL levels of 100 mg/dl, according to the American diabetic association (ADA). The Adult Treatment Panel (ATP) III of the National Cholesterol Education Programme (NCEP) has identified these LDL particles as a key risk factor for chronic heart disease (CHD). Diabetes is linked to an increase in TG and apo B, as well as a decrease in HDL component, all of which contribute to the establishment of atherosclerosis.[10]In diabetes mellitus, alterations in lipid parameters are caused by an increase in free fatty acid flux as a result of insulin resistance.[2]

This study aims to determine correlation of HbA1c values with triglyceride levels in diabetic patients.

Materials And Methods

Study setting:

This study was conducted in Department of General Medicine, Vinayaka Missions Kirupananda Variyar Medical College, Salem.

Study population:

All diabetic patients above 18 years of age upto 75 years coming to VMKV Medical College and Hospital, Salem will be taken up for the study for one-year duration.

Study sample:100 cases

Inclusion criteria:

Patient with diabetes mellitus, male and female, both between 18 to 75 years of age.

Exclusion criteria:

Patient with history of cardiovascular disease taking lipid lowering drugs like statins.

Patient with history of stroke & on medication with lipid lowering drugs.

Patient with diabetes already on statins.

Study design:

The study is an observational study. The sample size will be 100 patients for evaluation of triglyceride levels and HbA1c (by satisfying inclusion and exclusion criteria) after informed written consent.

Data collection procedure:

After proper history taking and thorough clinical examination, these patients will be subjected for checking triglyceride levels and HbA1c in patient who are fitting in the study (after screening for inclusion and exclusion criteria) will be considered selected for the study purpose.

Triglyceride levels and HbA1c levels will be checked for the patients who are selected, and the statistical test will be done.

STATISTICAL ANALYSIS

Descriptive Statistics:

Mean, Median, Mode and standard deviation are used to represent numerical variables.Frequencies and Percentagesare used to represent categorical variables.. Pie charts and bar diagrams are used at appropriate places.

Inferential statistics:

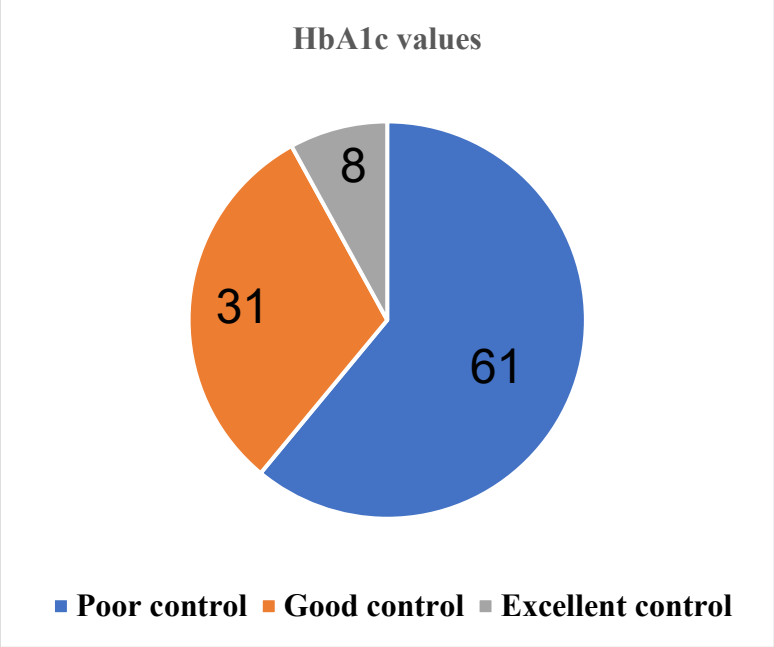
Correlation is used to analyse the relationship between triglycerides and HbA1c. Data was entered in MS excel sheet and analysed using SPSS software version 16.

RESULTS:

Table 1: Distribution of HbA1c levels of the participants (n=100)

Characteristics		Frequency	Percentage
HbA1c	4% to 6% (Excellent control)	8	8%
	7% and 8% (Good control)	31	31%
	Above 8% (Poor control)	61	61%

Figure 1: Distribution of the participants by HbA1c levels (n=100).



The above table 1 and figure 1 shows distribution of HbA1c levels of the participants. HbA1c levels 0f 4 to 6% were regarded as excellent control, levels of 7 and 8 % were considered as good control and levels above 8 % were considered as poor control. Among the study population, majority of the participants had poor control of HbA1c (61%) whereas 31% and 8% of the participants had good and excellent control of HbA1c respectively.

Table2: Distribution of total cholesterol levels of the participants (n=100)

Characteristics		Frequency	Percentage
Total cholesterol	(<200 mg/dl) Desirable	69	69%
	200-239 mg/dl (Borderline high)	20	20%
	≥ 240 mg/dl (High)	11	11%

Figure2: Distribution of the participants by total cholesterol levels (n=100)

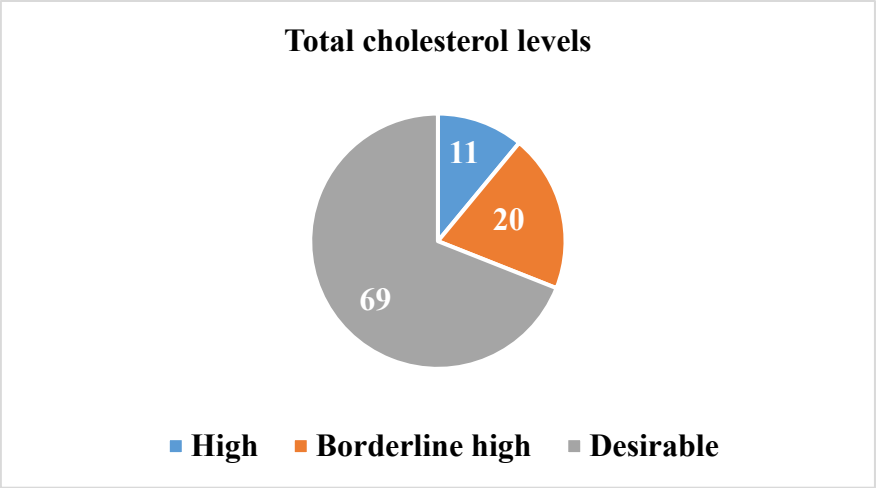
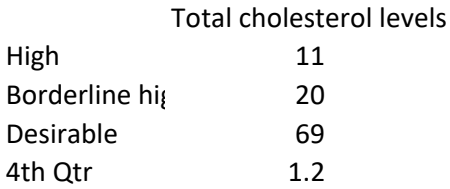


Figure 3: Histogram of distribution of total cholesterol levels of participants (n=100)



The above table 2 and figures 2 and 3 shows distribution of total cholesterol levels of the participants. Cholesterol levels of less than 200 mg/dl are considered as desirable, levels between 200 to 239 mg/dl were considered as borderline high and levels above it were

considered as high (≥ 240 mg/dl). Among the study population, majority of the participants had desirable cholesterol levels (69%) whereas 20 % and 11 % of the participants had borderline high and high cholesterol levels respectively. The mean cholesterol levels of the study population was 190.57 with standard deviation of 30.89.

Table3: Distribution of triglyceride levels of the participants (n=100)

Characteristics		Frequency	Percentage
Triglyceride levels	<150 mg/dl (Desirable)		41%
	150-199 mg/dl (Borderline high)	44	44%
	(200-499 mg/dl) High	15	15%
	≥ 500 mg/dl (Very high)	0	0%

Figure 41: Distribution of the participants by triglyceride levels (n=100)

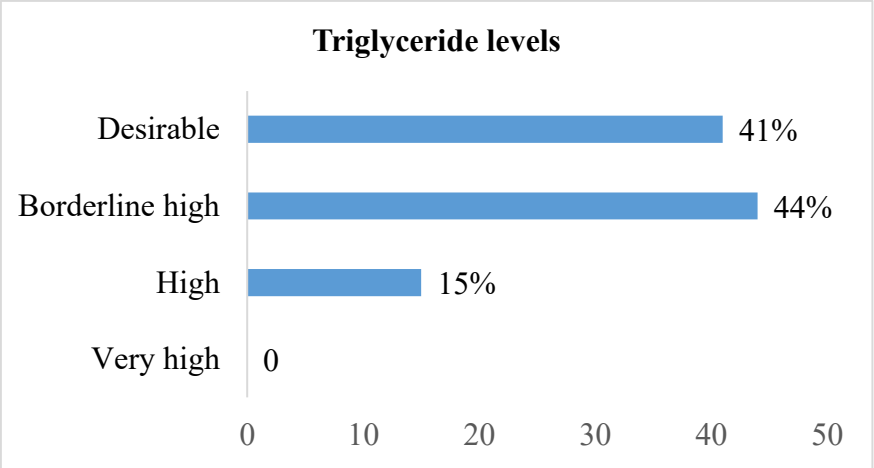
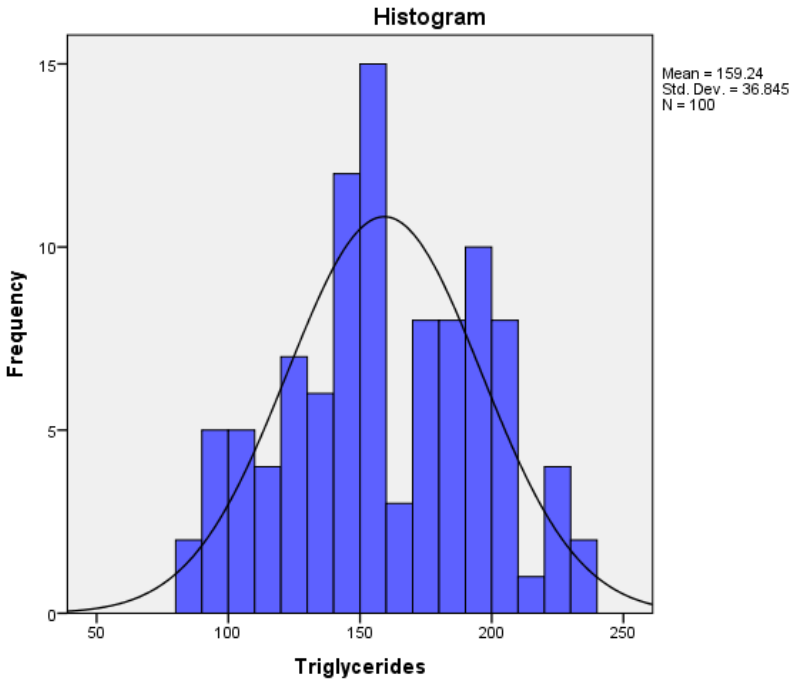


Figure5: Histogram of distribution of triglyceride levels of participants (n=100)



The above table 3 and figures 4 and 5 shows distribution of triglyceride levels of the participants. Triglyceride levels of less than 150 mg/dl are considered as desirable, levels between 150 to 199 mg/dl were considered as borderline high and levels between 200 to 499 mg/dl were considered as high and levels above it (≥ 500 mg/dl) were considered as very high. Among the study population, majority of the participants had borderline high triglyceride levels (44%) whereas 41% of the participants had desirable triglyceride levels. Of the participants, 15% had high triglyceride levels. The mean triglyceride levels of the study population was 159.24 with standard deviation of 36.84.

Table4: Distribution of parameters for male and female patients with T2DM (n=100).

Parameters	Males (n=51)			Females (n=49)		
	Mean ± Standard deviation	Minimum	Maximum	Mean ± Standard deviation	Minimum	Maximum
Age	50.51 ± 12.35	29	70	51.18 ± 12.31	30	73
FBS	142.20 ± 40.40	76	245	146.45 ± 39.76	77	255
PPBS	217.94 ± 63.46	140	420	221.45 ± 59.57	140	420
HbA1c	7.6 ± 1.18	5.7	10.2	7.8 ± 1.21	5.7	10.4
Total cholesterol	192.67 ± 29.64	140	252	188.55 ± 32.21	136	261
Triglycerides	161.37± 37.19	86	235	157.20 ± 36.76	89	221
VLDL	28.427± 9.61	11.4	49.7	28.54 ± 9.14	12.4	46.4
HDL	44.76 ± 6.77	30	61	48.37 ± 10.74	35	72
Non HDL	143.82 ± 38.13	87	256	282 ± 143.88	94	282
LDL	164.14 ± 22.99	120	204	170.39 ± 21.77	119	210

Of the 100 participants, 51% were males and 49% were females. The mean age of the participants was 50.51 years and 51.18 years with standard deviation of 12.35 and 12.31 respectively. The mean value of HbA1c in females was 7.8 ± 1.21 which is slightly higher than males having mean HbA1c value of 7.8 ± 1.21.Similarly the mean level of FBS is 146.45 ± 39.76 which is slightly higher than males whose mean FBS value is 142.20 ± 40.40.The mean value of PPBS for females is 221.45 ± 59.57 which is slightly higher than males whose mean PPBS value is 217.94 ± 63.46. The mean value of total cholesterol for males is 192.67 ± 29.64 which is slightly higher than females whose mean cholesterol value is 188.55 ± 32.21. The mean value of triglyceride for males is 161.37± 37.19 which is slightly higher than females whose mean triglyceride value is 157.20 ± 36.76. The mean value of HDL for males is 44.76 ± 6.77 which is slightly lower than females whose mean HDL value is 48.37 ± 10.74. The mean value of LDL for males is 164.14 ± 22.99 which is slightly lower than females whose mean LDL value is 170.39 ± 21.77. The mean value of VLDL for males and females was almost similar. The mean value was found to be 28.427± 9.61 for males and 28.54 ± 9.14 for females. The mean value of Non HDL for males is 143.82 ± 38.13 which is lower than females whose mean Non HDL value is high(282 ± 143.88

Table5: Biochemical parameters categorised for HbA1c 4 to 6 % (excellent control) (n=100).

Parameters	HbA1c (4 to 6 %) (n=8)		
	Mean ± Standard deviation	Minimum	Maximum
Age	54.63 ± 13.60	37	72
FBS	84.63 ± 5.99	76	95
PPBS	156.25 ± 13.70	140	169
Total cholesterol	168.25 ± 19.49	140	191
Triglycerides	121.88 ± 19.61	95	149
VLDL	20.138 ± 6.34	12.4	31.4
HDL	38.50 ± 3.20	35	45
Non HDL	113 ± 13.67	96	130
LDL	139.75 ± 14.72	120	159

Table 6: Biochemical parameters categorised for HbA1c 7 and 8 % (good control) (n=100)

Parameters	HbA1c (7 % and 8%) (n=31)		
	Mean ± Standard deviation	Minimum	Maximum
Age	49.87 ± 11.31	29	69
FBS	132.97 ± 12.18	110	156
PPBS	199.65 ± 12.82	170	220
Total cholesterol	190.03 ± 34.76	136	260
Triglycerides	161.48 ± 38.14	93	230

VLDL	26.68 ± 9.01	12.4	44.6
HDL	45.61 ± 9.48	35	72
Non HDL	134.23 ± 30.91	88	205
LDL	161.10 ± 18.55	119	189

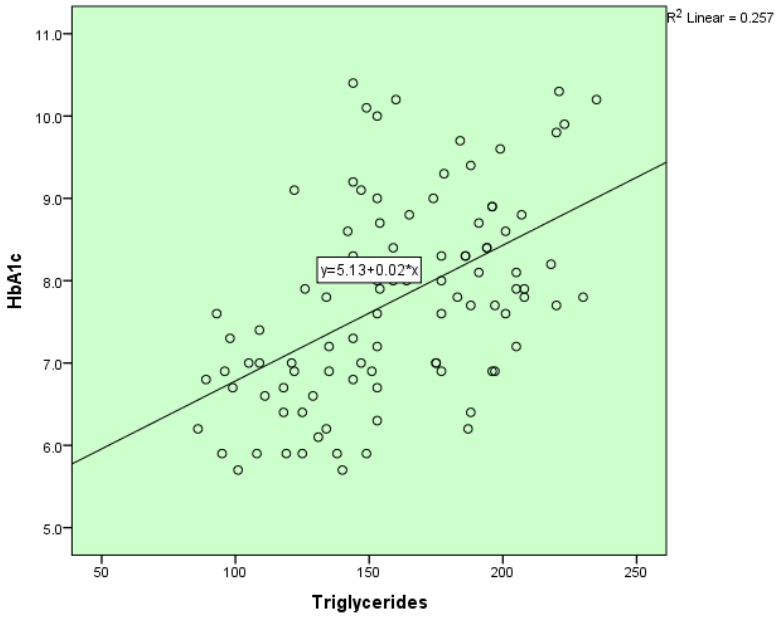
Table 7 : Biochemical parameters categorised for HbA1c >8% (poor control) (n=100)

Parameters	**HbA1c (>8%) (n=61)**		
	Mean ± Standard deviation	**Minimum**	**Maximum**
Age	50.85 ± 12.67	29	73
FBS	158 ± 42.67	85	255
PPBS	238.26 ± 70.61	165	420
Total cholesterol	193.77 ± 29.13	140	261
Triglycerides	163 ± 35.56	86	235
VLDL	30.50 ± 9.12	11.4	49.7
HDL	48.16 ± 8.96	30	72
Non HDL	152.79 ± 41.32	87	282
LDL	174.11 ± 21.65	125	210

In our study, the 100 participants were grouped into three categories based on HbA1c levels, participants with excellent control (n=8), good control (n=31) and poor control (n=61) which has been given in tables .Of the participants with excellent control of HbA1c the mean age of the participants was 54.63 with standard deviation of 13.60 years. The mean age of the participants was 49.87 and 50.85 with standard deviation of 11.31 and 12.67 years for participants with good control and poor control respectively. The mean FBS value of the participants with excellent control was 84.63 ± 5.99 mg/dl which was lower than participants with good and poor control who had mean FBS values as 132.97± 12.18 and 158 ± 42.67 respectively. The mean PPBS value of the participants with excellent control was 156.25 ± 13.70mg/dl which was lower than participants with good and poor control who had mean PPBS values as 199.65 ± 12.82 and 238.26 ± 70.61 respectively. The mean total cholesterol value of the participants with excellent control was 168.25 ± 19.49 mg/dl which was slightly lower than participants with good and poor control who had mean total cholesterol values as 190.03 ± 34.76 and 193.77 ± 29.13 respectively. The mean triglyceride value of the participants with excellent control was 121.88 ± 19.61 mg/dl which was lower than participants with good and poor control who had mean total triglyceride values as 161.48 ± 38.14 and 163 ± 35.56 respectively. The mean VLDL values of the participants with excellent control was 20.138 ± 6.34 mg/dl which was lower than participants with good and poor control who had mean total triglyceride values as 26.68 ± 9.01 and 30.50 ± 9.12 respectively. The mean HDL values of the participants with excellent control was 45.61 ± 9.48 mg/dl which was similar for participants with good and poor control whose mean HDL values is 45.61 ± 9.48 and 48.16 ± 8.96 respectively. The mean non HDL values of the participants with excellent control was 113 ± 13.67 mg/dl which was lower than participants with good and poor control who had mean non HDL values as 134.23 ± 30.91 and 152.79 ± 41.32 respectively. The mean LDL values of the participants with excellent control was 139.75 ± 14.72 mg/dl which was lower than participants

with good and poor control who had mean LDL values as 161.10 ± 18.55 and 174.11 ± 21.65 respectively.

Figure 6: Scattered plot showing correlation between triglyceride levels and HbA1c in type 2 diabet es mellitus patients (n=100).



Pearson's correlation coefficient was done to find correlations between triglycerides and glycosylated hemoglobin(HbA1c) . Results of the univariate analysis revealed that HbA1c is positively correlated with high triglyceride values (r=0.257) which shows that HbA1c levels can be used as a marker for dyslipidaemia particularly hypertriglyceridemia besides as a marker for glycaemic control. A scattered plot showing correlation between glycosylated hemoglobin (HbA1c) and high triglyceride DISCUSSION

The link between diabetes and cardiovascular disease is well established, and it has been widely debated over the last few decades. 14 Both the lipid profile and the diabetes mellitus (DM) have been proven to be key predictors of metabolic disorders such as dyslipidemia, hypertension, cardiovascular disease, and hyperinsulinemia. When compared to people without diabetes, people with T2DM have a greater rate of cardiovascular morbidity and mortality, and they are disproportionately affected by CVD. Early detection and treatment of dyslipidemia linked with diabetes mellitus may be one step toward lowering the risk of cardiovascular disease.[40]

In our study, majority of the participants were in the age group of above 40 years. As per distribution of HbA1c of the participants, majority had poor control of diabetes (61%) and their HbA1c values were above 8%. Hypercholesterolemia was present in 31% of the participants. Hypertriglyceridemia was present in 59% of the participants with majority (44%) of them at borderline high levels.HDL was low in 11% of the participants. In majority of the individuals (94%), LDL levels were high. Elevated VLDL was present in 45% of the participants. Non HDL was elevated on 54% of the participants. The mean levels of FBS, PPBS, HbA1c, VLDL, HDL.Non HDL, LDL was almost equal in both sexes with slightly higher levels among females. The mean levels of Total Cholesterol and Triglycerides was higher in males. There was positive correlation between triglycerides and HbA1c among the study population.

In a study done among 931 subjects by Sheth et al[41], that comprised 430 type 2 diabetic patients and 501 non diabetic controls, higher mean fasting plasma glucose and HbA1c was observed in diabetic patients when compared to non-diabetic control subjects. Dyslipidemiawas observed in 50.27% of the diabetic subjects. Hypercholesterolemia was present in 19.76% of type 2 diabetes and 20.56% of the control subjects. Hypertriglyceridemia was more in type 2 diabetic subjects. Further the study also evaluated the prevalence of obesity in diabetic and control subjects. It was found that higher central obesity and peripheral obesity was seen in T2DM than non-diabetics. There was no significant correlation between hypertriglyceridemia and HbA1c.Significant linear association of central and peripheral obesity with dyslipidemia was present. This study had less prevalence of hypercholesterolemia and other lipid parameters among the study subjects. Predominance of individuals over 40 years may be the reason for the higher prevalence of dyslipidemic individuals in our study.Further,in our study, there was significant correlation between triglycerides and HbA1c.

In a study by Meenu et al[42],done among 150 non obese non hypertensive patients of diabetes mellitus, the mean levels of HbA1c,FBG and other lipid parameters was higher in females. In our study, total cholesterol and triglycerides was higher in males but it was almost equal to females. In the former study, the study subjects were categorised into two groups based on HbA1c value of 7%,with the mean values of all variables higher in the poorly controlled group and the difference between the two groups was significant for all variables other than HbA1c and FBS.In a study by Prabavathi et al[43]done among 130 type 2 diabetic patients, mean HbA1c was more in females and when analysed by age categorized groups, older patients had more levels of HbA1c,FBS and lipid profile.HbA1c showed significant and direct correlation with triglycerides, cholesterol and LDL. Even our study showed positive

correlation with other lipid parameters except for HDL.The univariate analysis done in the former study suggested HbA1c as good predictor level of circulating lipids. When serum biochemistry was categorized by gender, all parameters except for triglycerides was higher in females. In a study done among 60 diabetic subjects and 60 controls, by Charitha et al [44]HbA1c showed positive correlation with all lipid parameters other than HDL.These findings were similar to our study. Poorly controlled diabetic patients had higher lipid levels which also replicates our study.

In a study done among 50 participants by Dharmesh et al[45]which constitute 66% of male participants and 34% of female participants.70% of male participants and 53 % of the female participants had poor glycemic control. LDL levels were high in 46% of the participants.52% of the participants had HDL levels below 40mg/dl. Hypertriglyceridemia was present in 26% of the participants. Participants with hypercholesterolemia constitute 38%. Further the study also revealed that all the lipid parameters are increased in people with increasing duration of diabetes. Compared to our study, the former study had decreased prevalence of hypertriglyceridemia whereas participants having increased LDL levels constitute only 46%. Prevalence of hypercholesterolemia was almost similar in both the studies.

In a study conducted by Sirsikar et al[46]done among 150 subjects in which 75 diabetic subjects were compared with 75 controls. Positive correlation of HbA1c with all lipid parameters except for HDL were present in the study. These findings were similar to our study. The correlation between HbA1c and blood sugar values, lipid parameters were significant for all variables except for VLDL.Similar results were also found in another study done among 35 type 2 diabetic patients by Valarmathi et al[47].In a study by Shreshtha et al[48],

The lipid parameters and blood sugar values increased in the poorly HbA1c controlled group when compared to the well-controlled group. The lipid parameters except for HDL was increased in both the groups but the HDL values did not significantly differ between the two groups.In a cross sectional study done by Thambiah et al[23]in Malaysia when HbA1c value is less than 6.5%,it reduces macro and microvascular complications. It is a retrospective study done among 214 type 2 diabetes patients. Here patients were categorised into poor glycemic control when HbA1c value is more than or equal to 6.5%, in whom the lipid parameters were high. HbA1c,non-HDL,LDL/HDL and TC/HDL ratio was lower in patients when they were on treatment with statins and this was significantly associated ($p<0.05$).The study also emphasized the relationship between poor glycemic status and dyslipidemia and elaborated the potential role of HbA1c as a predictor of cardiovascular risk in type 2 diabetic patients.[23]

In a cross sectional study among 5822 participants in China.FBG, TG, TC, HDL-C & LDL-C had metabolic control percentage of 27.50,73.10,28.10,64.20 and 44.80% respectively. The odds ratios and 95% confidence intervals of TG, TC, HDL-C & LDL-C in the fourth model with the greatest confounding factors were 0.989,0.862,0.987 and 2.173 respectively. With diverse confounding factors taken into account, TC & HDL-C was statistically significant while TG & LDL-C were not. Finally, FPG was found to be strongly linked with HDL and TC but not with LDL or TG. Our findings suggested that in the management of T2DM health, TC and HDL should be prioritized. [24]

In a study done by Regmi et al[49]among 144 diabetic individuals and 56 healthy controls,the mean values of blood sugar values and lipid parameters are increased in the diabetic study group when compared to healthy controls.Diabetic dyslipidemia is likely caused by a number of variables, including insulin's impact on apoprotein synthesis in the liver and lipoprotein lipase control (LpL), cholesteryl ester transfer protein (CETP) activity, and

peripheral impacts of insulin on muscle and adipose tissue. Hepatic lipase is an enzyme that is produced in the liver.HDL and lipoproteins that are remnant have phospholipids and triglycerides that are hydrolysed by hepatic lipase which are produced by hepatocytes. Insulin deficiency reduces the activity of this enzymes. So the clearance of remnant lipoproteins will be reduced due to the reduced activity of this enzyme. Lipoprotein lipase (Lpl) will be the majoer enzyme that promotes the formation of free fatty acids from lipoprotein triglyceride. This production of LpL will be hindered in conditions like diabetes mellitus. [50][51]

HbA1c levels were linked to LDL, triglycerides, total cholesterol, high-density lipoprotein, very-low-density lipoprotein, high-density lipoprotein C, and low-density lipoprotein C levels in a study by Mahajan et al.[52] In individuals with T2DM, a cross-sectional study conducted in Bangladesh found a strong relationship between lipid profile characteristics and HbA1c levels. They came to the conclusion that HbA1c is a better measure for predicting the occurrence and prevalence of dyslipidemia in T2DM patients.[39]

Furthermore, according to Anand et al., serum HbA1c levels, adequate glycemic control, and lipid profile screening help to identify high-risk patients for timely diagnosis of hyperlipidemia, which reduces the incidence of cardiovascular diseases and peripheral vascular complications by implementing appropriate interventions.[53]

The lipid profile and its correlation with HbA1c levels in the incidence of myocardial infarction were investigated in a study from the north eastern population, which concluded that 60 percent of patients with myocardial infarction had poor glycemic control and also found that the serum HbA1c level has a direct relationship with the serum lipid profile and also identified its indirect relationship with levels of HDL cholesterol. [54]HbA1c was found to be a sign of abnormalities in the lipid profile of patients with T2DM in a similar study from Chidambaram, Tamil Nadu. They also discovered an increase in HDL-C concentration in T2DM patients, as well as an increase in all other lipid profile parameters in both T1DM and T2DM patients.[47]

In a study by Vinod et al,Total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C) and LDL-C ratio, non-HDL-C, and TC/HDL-C ratio all showed positive and substantial relationships with HbA1c. In comparison to patients with HbA1c 7.0 percent, patients with HbA1c > 7.0 percent had significantly higher values of TC, Triacylglycerol (TAG), LDL-C, LDL-C/HDL-C ratio, non-HDL-C, and TC/HDL-C ratio. However, there was no statistically significant difference in HDL-C values between the two groups. In addition to glycemic management, HbA1c can be used as a possible biomarker for predicting dyslipidemia in type 2 diabetes patients.[55] The decrease in HDL found in diabetic patients can be attributed to a number of factors. Increased plasma VLDL concentrations cause the triglyceride from VLDL to be exchanged for the cholesteryl esters present in HDL.[56]Low-density lipoprotein (LDL) is not frequently elevated in diabetics. This could be due to a balance of factors that influence LDL generation and catabolism. The hydrolysis of VLDL by LpL is a necessary step in the formation of LDL. LDL production is reduced when this phase is reduced due to LpL shortage or increased surface apoprotein. [57]VLDL generation is higher in diabetic patients, particularly type 2.Insulin resistance is thought to play a key role in the development of diabetic dyslipidemia. Increased free fatty acid release from insulin-resistant fat cells is one of the causes. 23 These free fatty acids boost TG synthesis, which further stimulates Apolipoproteins (Apo-B) and very low density lipoprotein (VLDL) if glycogen levels are sufficient.[58]

Dyslipidemia was shown to be greater in females than males in our study.Women's hyperlipidemia may be due to the impact of sex hormones on body fat distribution, resulting in changes in lipoprotein composition.[59] Our high-carbohydrate diet could be a contributing

element in our population's hypertriglyceridemia.[60] Increased levels of tiny dense LDL, which is thought to be extremely atherogenic, have been linked to high TG levels. The main causes of dyslipidemia in our population are a high-fat, high-calorie diet and a lack of physical activity. Our diets are high in saturated fats, according to research. In addition, it involves overcooking food, which destroys nutrients like folate, as well as deep frying and refrying in the same oil, which results in the development of trans-fatty acids, which may contribute to the rise in dyslipidemia in our population.[61]

Conclusion:

Poorly controlled HbA1c has been found to be strongly linked to hypertriglyceridemia and also places them at high risk for cardiovascular disease.

Since there is a positive correlation between HbA1c and triglyceride levels, HbA1c levels can be used as an ideal marker for prediction of dyslipidemia.

Apart from its primary purpose in monitoring long-term glycemic management, the extent of circulating lipids is also important. As a result, HbA1c's dual biomarker capacity (glycaemic control and lipid profile indicator) could be used to screen high-risk diabetic patients for timely lipid-lowering medication intervention, averting unfavourable cardiovascular events.

Better glycaemic management, as measured by HbA1c, would also indicate a healthier lipidemic condition. Achieving the goal HbA1c will help to improve lipid levels, which will help to reduce diabetes complications in type 2 diabetic patients.

So periodic check-ups should encompass measurement of total cholesterol and triglycerides in the management of type 2 Diabetes Mellitus.

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