The Correlation Between Serum Lipids and Glycemic Control Parameters in Patients with Type 2 Diabetes Mellitus

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Abstract-
Background: A pronounced increase in prevalence, coupled with vascular complications, has made diabetes mellitus type II a worldwide health problem. Diabetes established patients are commonly monitored through the measurement of glycated hemoglobin (HbA1c).
Objective: The study objective was to determine whether lipid profile in serum correlated with the level of HbA1c in patients with type II diabetes mellitus.
Methods: There were 80 diabetic participants in the present cross-sectional observational study, 40 of them men and 40 of them women, ranging in age from 27 to 75 years.
The HbA1c value was used to classify patients into 2 groups: those with a HbA1c ≤ 7% (good glycemic control) and those with a HbA1c >7% (poor glycemic control). An analysis of glucose, HbA1c, and lipid profile concentrations was conducted.
Results: A group of participants with good glycemic control had significantly lowed glucose concentrations, TAG levels, and the ratio of TAG to HDLc. A significant difference between patient groups with good and poor glycemic control was noted in the Castelli 1 and Castelli 2 indexes, in comparison with low glycemic control ($p = 0.004$).
Conclusion: The HbA1c-TAG ratio and HbA1c-TAG/HDL-cholesterol ratio was statistically significantly positively correlated in our study.
Keywords: Type II diabetes mellitus, lipid profile, glycemic control, HbA1c, LDL, HDL.

I. Introduction

Diabetes was recognized as a worldwide pandemic disease and contagious disease by the United Nations in 2006, making it an important issue for medical and public health.[1] Diabetes occurs when an overproduction of insulin, or a defect in insulin action, results in hyperglycemia.[2] There are many organ systems affected by chronic hyperglycemia, including diabetic complications. Typically, chronic complications become apparent in the second decade of hyperglycemia because of the increasing duration of hyperglycemia.[3] Mortality and morbidity associated with diabetes mellitus are largely caused by cardiovascular disease (CVD).[4,5]
There are several types of diabetes mellitus, but the ones common to the majority are characterized by hyperglycemia due to insulin dysfunction and/or deficiency. Dyslipidemia, defined as an abnormal concentration of lipids in the blood, is a major risk factor for cardiovascular disease (CVD) in T2DM patients. Diabetic hyperglycemia is associated with microvascular and macro vascular complications over the long term.
The relationship between serum lipid profile and glycemic control parameters in T2DM participants has been widely studied.[6–8] Studies have also shown that T2DM participants with poor glycemic control have a higher risk of CVD equated to those with good glycemic control.[9]
The impact of different interventions on lipid profiles and glycemic control in patients with T2DM as well as the mechanisms underlying this association are discussed. The metabolic disorder type 2 diabetes mellitus (T2DM) is characterized by hyperglycemia and dyslipidemia. Mortality and morbidity are among their leading causes worldwide. Hyperglycemia, the primary feature of T2DM, is the result of insulin resistance and/or inadequate insulin secretion. Another common complication of T2DM is dyslipidemia. Triglycerides (TG) increase as high-density lipoprotein cholesterol (HDL-C) decreases and low-density lipoprotein cholesterol (LDL-C) increases. In people with diabetes mellitus, the HbA1c test shows that blood glucose levels have been controlled over a long period of time. In the HbA1c test, plasma glucose concentration can be determined since red blood cells are no longer present after 3–4 months. In this test, the control of diabetes mellitus over the past two to three months is evaluated. Certain medical conditions may result in falsely increased HbA1c. Chronic excessive alcohol consumption, uremia (kidney failure), and hypertriglyceridemia are among these conditions. In addition to acute disease may falsely lower HbA1c levels.[10,11]
Dyslipidemia is common because of poor glycemic control, whose serum lipid levels are affected dramatically.[12] As part of the metabolic syndrome, dyslipidemia is described as an abnormality of lipoprotein metabolism, including excessive production or deficiency of lipoproteins, among others.[13] There are not only triglyceridemia and decreased HDL cholesterol levels that are primary changes, but also abnormalities in the structure of lipoprotein particles. LDL cholesterol is primarily composed of small, dense particles when someone has diabetes. The smaller the LDL particles, the more likely it is to cause atherosclerosis since the smaller particles are more likely to penetrate the arterial wall

and form strong bonds with it.[14] Those patients with diabetes who also have hyperlipidemia and elevated HbA1c values are at an increased risk of cardiovascular disease.[15]

The aim of this study was to investigate the relationship between serum lipid profiles and hemoglobin A1C levels in people with type 2 diabetes mellitus.

II. MATERIAL AND METHODS

The Liaquat University of Medical & Health Sciences Jamshoro conducted a six-month cross-sectional observational study. We studied 80 patients with at least five years' history of type II diabetes mellitus (40 females and 40 males). Participants in the current study were divided into two groups based on their blood glucose levels. Group 1 (HbA1c ≤7%): patients with good glycemic control (43 patients, 24 females, and 19 males, aged 32–75). Group 2 (HbA1c >7%): patients with poor glycemic control. There were 37 patients, aged 27–70, in Group 2 of the study, of whom 16 were female and 21 were male.

Medical records, laboratory tests, and patient interviews were used to collect data. The following information was collected from patients: age, gender, duration of diabetes, current treatment, and any other relevant medical history. The medical record was reviewed for information on HbA1c, fasting blood glucose, and any other diabetes-related parameters

The following laboratory tests were performed on all patients: lipid profile (total cholesterol, LDL, HDL, and triglycerides) and HbA1c. In the hospital's laboratory, blood samples were collected following an overnight fast. Instantly after collection, the blood samples were frozen at +4°C in empty tubes. Biochemical analyses were performed the same day. All patients were informed about the study and were provided written informed consent before participating. Patient confidentiality was maintained throughout the study.

Statistical analysis

SPSS for Windows application (version 22.0) was used for statistical analysis of the data obtained. When presenting numeric variables in descriptive statistics, the mean was accompanied by the standard deviation, or the mean was accompanied by the standard error of the mean. According to Pearson's test, there is a relationship among HbA1c and glucose, as well as HbA1c and the ratio of TAG/HDL-c. Based on Pearson's test of correlation, HbA1c and TAG were correlated. In this study, an independent t-test was used to compare two normally distributed groups. We determined that the P-value was statistically significant at ≤0.05.

III. RESULTS

A total of 80 people with type II diabetes were involved in the present study, 40 of whom were males and 40 of whom were females. The table shows the comparison of various parameters between patients with HbA1c levels <7 (n=43, 53.7%) and those with HbA1c >7% (n=37, 46.25%). The results show that the mean age of participants with HbA1c ≤7 is 66±13.77 years, while the mean age of participants with HbA1c >7 is 58.5±11.3 years. The difference in age is statistically significant (P-value=0.012).

The glucose levels in patients with HbA1c ≤7 are 7.88 ± 1.54 mmol/l, while the glucose levels in patients with HbA1c levels >7 are 12.52 ± 5.67 mmol/l. The difference in glucose levels is statistically significant (P-value=0.004).

The total cholesterol levels between the 2 groups are not statistically significant (p-value=0.124). The triglycerides levels in patients with HbA1c ≤7 are 1.39 (1.14-2.33), while the triglycerides levels in patients with HbA1c >7 are 3.14 (1.5-3.43). The difference in triglycerides levels is statistically significant (P-value=0.04).

The low-density lipoprotein cholesterol levels among the two groups are not statistically significant (P-value=0.105). In both groups, no statistically significant differences in HDL cholesterol levels were found (P-value =0.213). The Castelli risk index 1 levels among the two groups are not statistically significant (P-value=0.062). The Castelli risk index 2 levels among the two groups are not statistically significant (P-value=0.065).

The atherogenic index of plasma in participants with HbA1c ≤7 is 1.64 ± 0.18, while the atherogenic index of plasma in participants with HbA1c >7 is 2.87 ± 0.36. The difference in the atherogenic index of plasma is statistically significant (p-value=0.014).

It was found that serum glucose concentrations and glycated hemoglobin concentrations were significantly correlated (r = 0.450) in patients with T2DM (Figure 1). Furthermore, serum triglyceride levels and glycated hemoglobin concentrations are significantly correlated (r = 0.264) (Figure 2). TAG/HDL-c (r = 0.224) shows a significant positive relationship with the concentration of glycated hemoglobin (Figure 3).

Table 1. The following biochemical parameters are categorized by the patient's glycemic control level (HbA1c) (n=80).

Variables	HbA1c ≤7 n=43 (53.7%)	HbA1c >7 n=37 (46.25%)	P-value
Age (years)	66±13.77	58.5±11.3	0.012*
Glucose (mmol/l)	7.88±1.54	12.52±5.67	0.004*
Total cholesterol (mmol/l)	6.13±1.30	6.45±1.47	0.124
Triglycerides (mmol/l)	1.39 (1.14–2.33)	3.14 (1.5–3.43)	0.04*
Low-density lipoprotein cholesterol (mmol/L)	2.11±1.17	2.21±1.46	0.105
High-density lipoprotein cholesterol (mmol/L)	1.11 (0.71–1.25)	1.0 (0.70–1.87)	0.213
Castelli risk index 1 (TC/HDL-cholesterol)	4.97±1.79	5.48±2.31	0.062
Castelli risk index 2 (LDL/HDL-cholesterol)	3.01±1.44	3.38±1.86	0.065
Atherogenic index of plasma (log[TAG/HDL-cholesterol])	1.64±0.18	2.87±0.36	0.014*

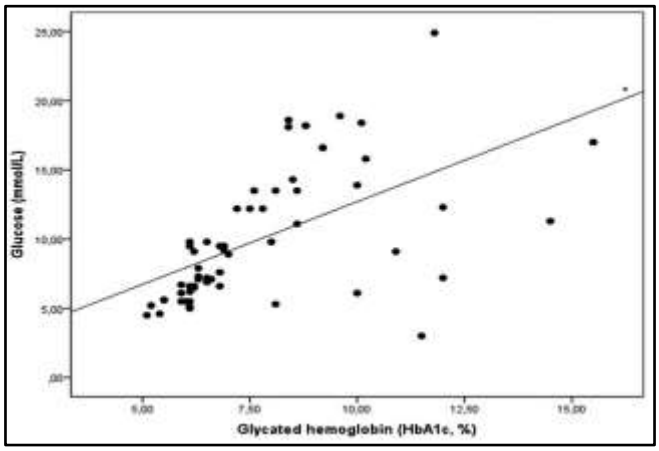

Figure 1. glycated hemoglobin and serum glucose concentrations are correlated (*r=0.450, p<0.0004).

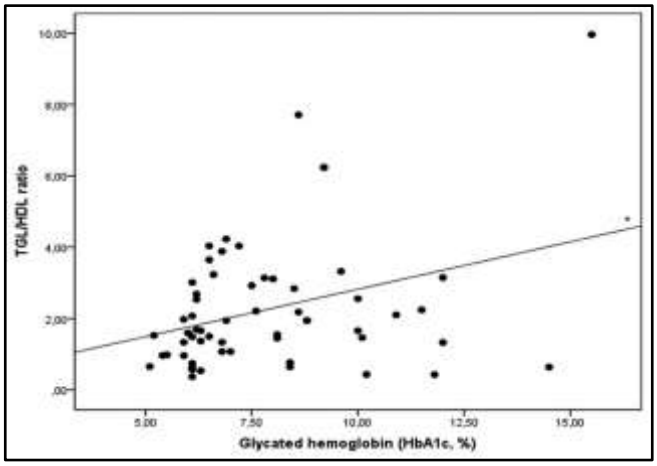

Figure 2. The relationship between serum triglyceride and glycated hemoglobin concentrations (*r=0.187, p=0.012).

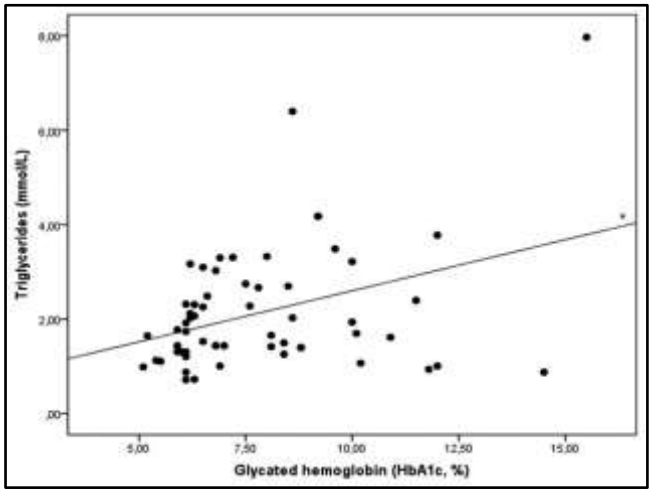

Figure 3. The relationship between triglycerides and HDL cholesterol and blood glucose levels (*r=0.224, P=0.008).

IV. DISCUSSION

Developing as well as developed countries are experiencing a rapid rise in diabetes prevalence.[4] Hemoglobin A1c is also a useful indicator of long-term glycemic control, which is related to complications related to diabetes.[16] Between people with type 2 diabetes mellitus, CVD is the leading cause of death. Atherosclerosis is caused by atherogenic plaque that accumulates inside the arteries.[13] Up to 97% of diabetes patients suffer from dyslipidemia, a condition highly associated with atherosclerosis.[17] Patients with higher HbA1c values have a greater risk of dyslipidemia, according to Khan and associates.[18]

This study examined the relation among serum lipid parameters and glycemic status in patients with diabetes mellitus type II. Al Lawati and colleagues reported similar findings, showing that younger Omani diabetics have worse glycemic control than older diabetics.[19] The Hawaiian study showed that patients under 35 had a significantly higher risk of sustained poor glycemic control than patients between 50 and 64.[20] According to the Roy et al., study, patients older than 40 years were seen to have poorer glycemic control than their younger counterparts.[21,22] The study found that patients who had good glycemic control had significantly lower serum glucose and TAG levels than those who had poor glycemic control. In patients with good glycemic control, TC levels were lower than those with poor glycemic control, but they were not significantly different. The LDL cholesterol levels of Participants with good glycemic control were lower, and the HDL cholesterol levels were higher, but the variances were not statistically significant. Participants with uncontrolled type II diabetes mellitus had deranged lipid fractions in a cohort study.[23]

Female patients had lower serum glucose, TC, TAG, and LDL-cholesterol concentrations, and HbA1c and HDL-cholesterol values when compared to male participants, but the differences were not statistically significant. A minor difference existed between the ages of female and male participants, but it was not significant. A comparable study conducted by Al-Alawi found female participants had higher levels of HDL cholesterol than male patients.[24] We found conflicting results in Samantha's and her colleagues' studies. The average age of male participants was mildly higher than that of female patients. A significant difference in cholesterol levels was not observed among male and female patients, but glucose, TC, TAG, LDL-cholesterol, and HDL-cholesterol levels were higher in males. The difference in serum values for TC between male and female may be because of estrogens, which impact lipid metabolism. As a result, women are more aware and educated than men about the importance of health and wellness, as well as how to prevent disease. CVD develops seven to ten years later in women than in men, according to studies.[21] Besides quantitative estimates of serum cholesterol concentrations, the size of LDL-cholesterol particles plays a critical role in predicting vascular complications in type 2 diabetes mellitus. A reliable, indirect, and workable way to measure the particle size of LDL cholesterol is to use the ratio TAG/HDL cholesterol.[25] Although serum absorptions of LDL cholesterol are low, high ratios of TAG to HDL cholesterol are associated with cardiovascular events.[26] Present study found that participants with good glycemic control and females had significantly lowed ratios

of TAG and HDL cholesterol. Normal lipid profiles are associated with coronary heart disease in patients with type 2 diabetes mellitus. It is therefore recommended that AIP, Castelli risk indexes 1 & 2, be determined in order to predict and monitor coronary heart disease.[27]

Recently, extensive research has been conducted on the relationship between serum lipid profiles and glycemic control variables in patients with type II diabetes mellitus (T2DM). T2DM management and progression have been investigated in several studies examining the effect of these two factors. In the Journal of Clinical and Diagnostic Research, researchers found that low-density lipoprotein cholesterol (LDL) levels were significantly associated with hemoglobin A1c levels in patients with type II diabetes.[28] There was a significant correlation between triglyceride levels and HbA1c levels, but not between LDL cholesterol levels and HbA1c levels, according to another study published in the International Journal of Diabetes in Developing Countries in 2018.[29] HDL cholesterol levels and HbA1c levels, however, did not appear to have a significant correlation according to a 2019 study published in the Journal of Diabetes Research.[30]

We found that patients with good glycemic control had a lower AIP value than those with poor glycemic control, and the difference was significantly smaller than the difference for poor control patients. The AIP values in patients with coronary heart disease and diabetes mellitus were significantly higher than those without coronary heart disease, according to Patil et al.[31] Previous studies have revealed that diabetes patients with high serum lipid profiles and atherosclerosis should maintain good glycemic control. It is possible to prevent CVD in these patients by early diagnosis of dyslipidemia.[31]

In addition, a study published in the Journal of Diabetes and Metabolic Disorders in 2022 found that LDL cholesterol levels were significantly linked to HbA1c levels, but not triglyceride levels.[32]

V. CONCLUSION

The HbA1c-TAG ratio and HbA1c-TAG/HDL-cholesterol ratio were statistically significantly positively correlated in our study, suggesting HbA1c is not only a glycemic control parameter but also a measure of dyslipidemia in patients with type II diabetes mellitus. This patient population may benefit significantly from improved glycemic control, thereby reducing the risk of cardiovascular events.

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