e-ISSN: 0976-822X, p-ISSN:2861-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2023; 15(6); 146-157

Original Research Article

Study of Pattern of Serum Electrolytes and Lipid Profile Level in type 2 Diabetic Patient Attending Tertiary Care Hospital AGMC and GBPH

Rajib Debbarma[1], Dilip Kumar Das[2], Asis Debbarma[3], Swapan Sarkar[4]

[1]Postgraduate Trainee, Department of Biochemistry, Agartala Government Medical College (AGMC and GBPH), Tripura, India.

[2]Associate Professor, Department of Biochemistry, Agartala Government Medical College (AGMC and GBPH), Tripura, India.

[3]Associate Professor, Department of Biochemistry, Agartala Government Medical College (AGMC and GBPH), Tripura, India.

[4]Associate Professor, Department of General Medicine, Agartala Government Medical College (AGMC and GBPH), Tripura, India.

Received: 15-03-2023 / Revised: 22-04-2023 / Accepted: 29-05-2023

Corresponding author: Dr. Dilip Kumar Das

Conflict of interest: Nil

Abstract

Background: Poor glycemic control diabetes mellitus patient experiences dyslipidemia and serum electrolyte imbalance. The relationship between glycemic control, serum electrolyte and lipid profile is complex and is related to a number of factors like age, BMI, associated conditions. Tripura has the highest prevalence of diabetes and pre diabetes among the north-eastern state of India. This study was planned to assess the pattern of serum electrolyte and lipid profile and their relationship with HbA1c in type 2 diabetes patients attending tertiary care hospital Agartala Government medical college and GBPH, in Tripura.

Methodology: HbA1c, serum electrolyte (sodium, potassium, calcium) and lipid profiles (Cholesterol, triglyceride, HDL-C, LDL-C) were determined in 164 type2 diabetic patients between the age group 30 to 70 years. It was a hospital based cross-sectional study.

Result: Descriptive statistics were expressed as mean and standard deviation. The study shows decrease in the mean of serum sodium (p value = 0.006) and potassium (p value = 0.010) and increase in the mean of serum calcium (p value = 0.001) with different label of HbA1c (i.e. group I = < 7%, group II = 7 to 8 %, group III = >8) and it was found to be statistically significant. The present study also revealed statistically significant increase in the mean of serum triglyceride (p value = 0.014) and decrease in the mean of HDL-C (p value < 0.001) with different level of HbA1c. Whereas increase in the mean of serum cholesterol (p=0.258) and LDL-C (p=0.111) with HbA1c level were not statistically significant. Pearson's correlation analysis was performed and found that serum cholesterol (r = 0.301, p<0.01), triglyceride (r = 0.275, p<0.01), LDL-C (r = 0.359, p<0.01) and serum Calcium (r = 0.449, p <0.01) showed direct and significant correlation with HbA1c. Whereas HDL-C (r = -0.467, p<0.01), Serum Sodium (r = -0.363, p <0.01) and Serum Potassium (r = -0.285, p< 0.01) showed inverse significant correlation with HbA1c.

Conclusion: This study provides an overview and enriched our knowledge regarding electrolytes imbalance and dyslipidemia in type 2 diabetes and highlight for early detection of complications of type 2 diabetes mellitus which will be very much helpful for the prompt management and better outcome.

Keywords: LDL-C, HDL-C, HbA1c, Serum Electrolytes Imbalance.

Introduction

Diabetes is a modern pandemic disease. According to WHO there are about 422 millions people worldwide with Diabetes mellitus in the year 2014, the majority of them are living in low and middle income countries. In 2019, diabetes was the 9th leading cause of death with an estimated 1.5 million deaths directly caused by diabetes. Diabetes is a growing challenge for our country India with 7.8% diabetic population in the age group of 20 and 70 years.[1] Our small hilly state Tripura is also not left behind from the touch of this modern pandemic disease. In Tripura the prevalence of diabetes and prediabetes were 9.4% and 14.7% respectively, which is higher than the other North Eastern state of India.[2]

The reason behind the rising prevalence of diabetes and other non-communicable diseases is a combination of factors like– rapid urbanization, sedentary lifestyles, unhealthy diets, tobacco use and increasing life expectancy. Obesity and overweight are the most important risk factors responsible for diabetes.[1]

It has been observed that diabetic patients frequently develop an array of electrolyte disorders. These disturbances are particularly common in decompensated diabetics, especially in the context of diabetic ketoacidosis or non-ketotic hyperglycaemic hyperosmolar syndrome.[3] Sodium and chloride ions are the main electrolytes in the extracellular fluid whereas potassium, magnesium and phosphate are the main electrolytes in the intracellular fluid. Diffusion of cellular K+ out of cell and Na+ into cells is caused by trans-membrane electrical gradients. Sodium-potassium ion (Na+- K+) pump, which is stimulated by insulin and catecholamines hormones, reverse the movement of these electrolytes in order to maintain their extracellular and intracellular homeostasis. Alterations of the levels of insulin and catecholamine affect the serum electrolytes level. Changes in the total amount of extracellular solute, osmotic dieresis, intake of water driven by thirst and influences from associated conditions are the mechanism that have been considered by which fluid and solute abnormalities occur in hyperglycaemic patient.[4,5,6]

It has been reported that there is an inverse relationship between serum sodium (Na+) and potassium (K+) levels in diabetic patients. Moreover, hypokalemia has been clearly shown to be associated with increased risk of hyperglycemia. [7,8]

Calcium plays an important role in biological functions, in recent decades; insulin resistance and its secretion have been reported to be dependent on calcium homeostasis.[9] Any alterations in calcium flux can have adverse effects on β -cell secretory function and may interfere with normal insulin release, especially in response to a glucose load. The elevated level of cytosolic calcium is associated with an increased risk for type 2 diabetes.[10]

Individuals with Diabetes mellitus who have poor glycemic control experience a dyslipidemic state such as an increase in triglyceride (TG), low density lipoprotein cholesterol (LDL-C), and a decrease in high density lipoprotein cholesterol (HDL-C). Individuals with diabetes accompanied by the coexistence of metabolic syndrome (Hypertension, Dyslipidemia, abdominal obesity, Hyperglycemia) have a very high risk for the occurance of a cardiovascular complication.[11,12]

The pathogenesis of dyslipidemia in type 2 Diabetes mellitus is a decrease in activity of lipoprotein lipase due to insulin

deficiency or resistance. Under the action of insulin, enzyme lipoprotein lipase metabolizes lipid in healthy individual. In type 2 Diabetes mellitus the relative insulin deficiency and decreased adiponectin causes decrease lipoprotein lipase activity resulting in high levels of triglyceride, low density lipoprotein cholesterol, and low levels of high density lipoprotein cholesterol.[14]

Serum lipids and electrolytes play a dominant role in the normal functioning of the body. So, any Imbalance in them may result in development of complications. Therefore, any changes in the concentrations of lipids or electrolytes provide indications of disease progression in DM.

Hence, there is a direct association of serum electrolyte and lipid profile with diabetes mellitus and the relation between glycemic control, serum electrolyte and lipid profile is complex which is related to number of the factors like age, sex, duration of disease, BMI, associated conditions .

From this perspective, we would like to investigate the electrolyte disturbance and dyslipidemia and their association with glycemic status in type 2 diabetes patients attending tertiary care hospital Agartala Government Medical College and GBPH, in Tripura. Moreover, this type of study was not conducted in Agartala Government Medical College and GBPH as well as in Tripura till today. This study may highlight for early detection of complications of type 2 diabetes mellitus which will be very much helpful for the prompt management and better outcome.

Materials & Methods

The present study was an observational study with Cross-sectional model for one and half year duration. Sample Size was 164 diagnosed type-2 diabetic patient between the age 30 to 70years. The study population includes type 2 diabetes mellitus patients fulfilling the inclusion and exclusion criteria attending the diabetic clinic, in the department of Medicine and study was conducted in the Department of Biochemistry, Agartala Government Medical College and GBP hospital, Agartala, Tripura . Approval was taken by research and ethics committee and informed consent was obtained from individuals who are willing to participates in this study.

Inclusion criteria: Individual whose age is above 30 years and ≤70 years, irrespective of sex, caste and creed, diagnosed case of type 2 Diabetes Mellitus as per American Diabetic Association and who are willing to participate were included in the study.

Diagnostic criteria for Diabetes Mellitus

As per American Diabetes Association (ADA) include the following:

1. Glycohemoglobin is ≥ 6.5%, which is the preferred diagnostic method. So, value of ≥ 6.5% at any one time means patient is suffering from diabetes.
2. Fasting plasma glucose ≥ 126mg/dl on more than one occasion.
3. 2 hours glucose after meal ≥ 200mg/dl, even on one occasion.
4. If both fasting and 2-hour values are above the normal levels on same occasion.
5. Random plasma glucose ≥ 200mg/dl on 2 occasions.[15]

Exclusion criteria:

1. Patients with age less than 30 and above 70years.
2. Pregnant women.
3. 3.Patients on lipid lowering agent.
4. Chronic alcohol abuse
5. 5.Patients with condition like anaemia, haemoglobinopathies, chronic renal disease, other chronic illness.
6. Those unwilling to participate in the study.

Complete physical examination including anthropometry measurement was done for all the participants. Among laboratory investigations serum electrolytes (sodium,

potassium & calcium), lipid profile ((total cholesterol, triglyceride, LDL-C, HDL-C), FBS, PPBS and HbA1C levels were done.

HbA1C was measured by HPLC method in BIORAD D-10 analyser. Serum Sodium and Potassium was measured by ISE based Electrolyte auto analyzer. Lipid profile (total cholesterol, triglyceride, LDL-C, HDL-C), FBS, PPBS and serum calcium were assayed in XL 640 Fully automated clinical chemistry analyzer. All the data so collected were analysed by using SPSS version 26 for windows. Descriptive statistics like mean, standard deviation, frequency, percentage was used. ANOVA test was used to analyze the difference between the means of more than two groups. Pearson correlation test was used for correlating biochemical markers. P value < 0.05 was taken as significant.

Results and Analysis

Total 164 subjects have been included in this study matching inclusion and exclusion criteria. Among them 104 were male and 60 were female. Maximum number of patient belongs to 40-60years age group which is 68.9%. Majority of the patient i.e. 49.4% patients had duration of type 2 DM between 5 and 10 years and 45.1% patients had duration of type 2 DM more than 10 years. Mean BMI of diabetic patient in our study was 26.91 kg/m2 and 50.60 % diabetic patient were having hypertension.

The study population was divided into three group depending upon HbA1C level (group I = < 7%, group II = 7 to 8 % & group III = >8%).

Following table 2 shows comparison between different Serum Electrolyte level (Sodium, potassium, calcium) and HbA1c level groups using ANOVA.

Table 1: Lipid Descriptives

Lipid Parameter	HbA1c	N	Mean	SD	Std Error
Cholesterol	<7	32	194.68	44.18	7.81
	7 – 8	32	196.65	51.70	9.14
	>8	100	207.24	41.19	4.11
Triglyceride	<7	32	165.56	66.76	11.80
	7 – 8	32	173.90	75.98	13.43
	>8	100	205.54	81.69	7.87
HDL-C	<7	32	55.90	11.26	1.99
	7 – 8	32	53.34	12.68	2.24
	>8	100	46.93	11.08	1.10
LDL-C	<7	32	105.62	37.43	6.61
	7 – 8	32	109.06	38.34	6.77
	>8	100	120.34	38.67	3.01

Lipid parameters	Comparison of Groups	Sum of squares	Mean of squares	F	Sig.
Cholesterol	Between groups Within groups	5284.319 311390.3	2642.159 1934.101	1.366	0.258
Triglyceride	Between groups Within groups	51144.828 931517.4	25572.414 5785.823	4.420	0.014*
HDL-C	Between groups Within groups	2415.81 21100.44	1207.90 131.05	9.21	0.000*
LDL-C	Between groups Within groups	6576.652 237217.7	3288.326 1473.402	2.23	0.111
ANOVA test					

*P value <0.05, statistically significant.

Above table (table no. 1 & ANOVA test) Shows the comparative analysis between mean of serum Cholesterol, triglyceride, HDL-C and LDL-C with HbA1c level group using ANOVA. Serum Cholesterol level was highest (207.24 ±41.19) mg/dl in HbA1c group of >8% and lowest (194.68±44.18)mg/dl in HbA1c group<7%. The different was not statistically significant (p = 0.258). The patients in group >8% HbA1c (mean TG, 205.54±81.61 mg/dl) and group 7 – 8% HbA1c (mean TG, 173.90 ±75.98 mg/dl) had significantly higher Triglyceride levels as compared to group <7% HbA1c (mean TG 165.56±66.76 mg/dl) (ANOVA *F*= 4.420, *P*=0.014). The patients in group >8% HbA1c (mean HDL-C, 46.93±11.08 mg/dl) and group 7 – 8% HbA1c (mean HDL-C, 53.34±12.68 mg/dl) had significantly lower HDL-C levels as compared to group <7% HbA1c (mean HDL-C, 55.90±11.26 mg/dl) (ANOVA *F*= 9.21, *P*=0.000). Serum LDL-C level was highest (120.34±38.67) mg/dl in HbA1c group of >8% and lowest (105.62±37.43)mg/dl in HbA1c group<7%. The different was not statistically significant (p = 0.111).

Following table 2 shows comparison between different Serum Electrolyte level (Sodium, potassium, calcium) and HbA1c level groups using ANOVA.

Table 2: Electrolyte Descriptives

Electrolytes	HbA1c	N	Mean	SD	Std Error
Sodium	<7	32	138.13	3.83	0.67
	7 – 8	32	138.03	4.08	0.72
	>8	100	135.72	4.80	0.48
Potassium	< 7	32	4.44	0.61	0.11
	7 – 8	32	4.46	0.46	0.08
	>8	100	4.14	0.69	0.06
Calcium	< 7	32	8.99	0.65	0.11
	7 – 8	32	9.20	0.77	0.13
	>8	100	9.49	0.66	0.06

Electrolytes	Comparison of Groups	Sum of squares	Mean of square	F	Sig.
Sodium	Between groups Within groups	217.14 3254.62	108.57 20.21	5.37	0.006**
Potassium	Between groups Within groups	3.78 64.78	1.89 0.40	4.70	0.010*
Calcium	Between groups Within groups	6.92 74.16	3.46 0.46	7.52	0.001*
ANOVA test					

*P value <0.05, statistically significant.

Above table (Table no.2 & ANOVA test) Shows the comparative analysis between mean plot of serum Sodium, Potassium and Calcium with HbA1c level group using ANOVA. The patients in group >8% HbA1c (mean Sodium, 135.72 ±4.80 mEq/L) had significantly lower Sodium levels as compared to group <7% HbA1c (mean Sodium, 138.13±3.83 mEq/L) (ANOVA *F*= 5.37, *P*=0.006). The patients in group >8% HbA1c (mean Potassium, 4.14±.69 mEq/L) had significantly lower Potassium levels as compared to group <7% HbA1c (mean Potassium, 4.44±.61 mEq/L) (ANOVA *F*= 4.70, *P*=0.010). The patients in group >8% HbA1c

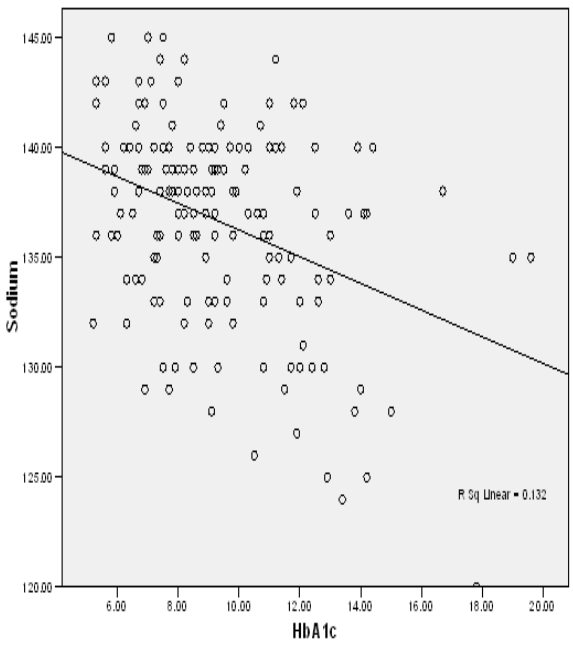
(9.09±0.66mg/dl) and group 7 – 8% HbA1c (mean Calcium, 9.20±0.77mg/dl) had significantly lower Calcium levels as compared to group <7% HbA1c (mean Calcium, 8.99±0.65mg/dl) (ANOVA *F*= 7.52, *P*=0.001).

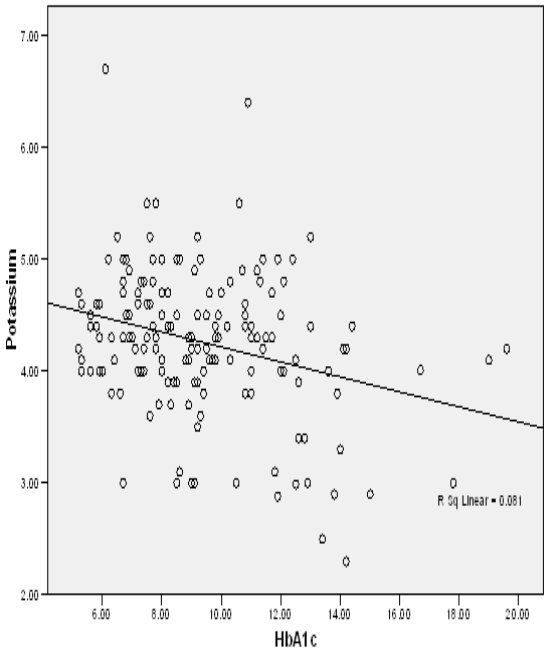
Table 3: Pearson's Correlation of fasting blood sugar, serum Electrolytes and Lipid Profile with HbA1c

Parameter	HbA1c	
	'r'	'p'
FBS	0.658**	0.000
Sodium	-0.363**	0.000
Potassium	-0.285**	0.000
Calcium	0.449**	0.000
Cholesterol	0.301**	0.000
Triglyceride	0.275**	0.000
HDLc	-0.467**	0.000
LDLc	0.359**	0.000

**** Correlation is significant at the 0.01 level.**

In our study, Pearson correlation analysis shows positive correlation of HbA1c with FBS (r = 0.658, p<0.01), serum cholesterol (r = 0.301, p<0.01), triglyceride (r = 0.275, p<0.01), LDL-C (r = 0.359, p<0.01) and serum Calcium (r = 0.449, p <0.01). However, HbA1c is negatively correlated with HDL-C (r = -0.467, p<0.01), Serum Sodium (r = -0.363, p <0.01) and Serum Potassium (r = -0.285, p< 0.01). All the correlation are statistically highly significant. (Table No. 3 and Graph No. 1-7)





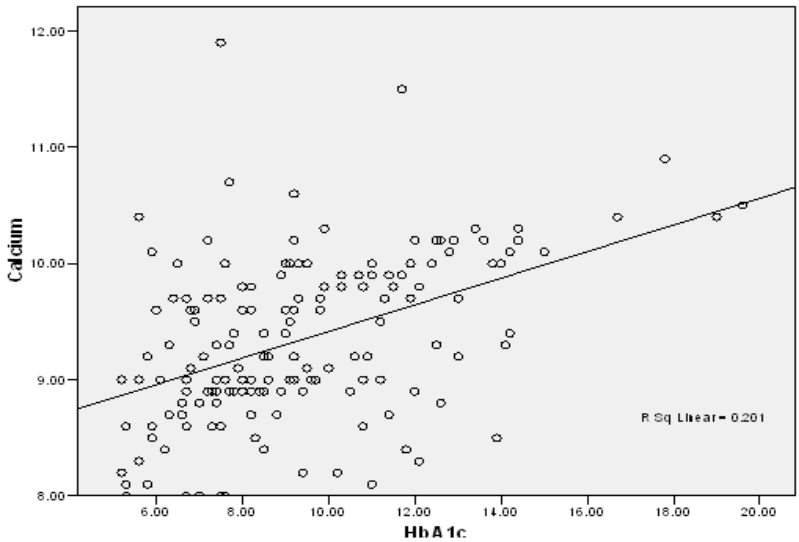


Figure 1: Scatter plot between Sodium, potassium, calcium & HbA1C

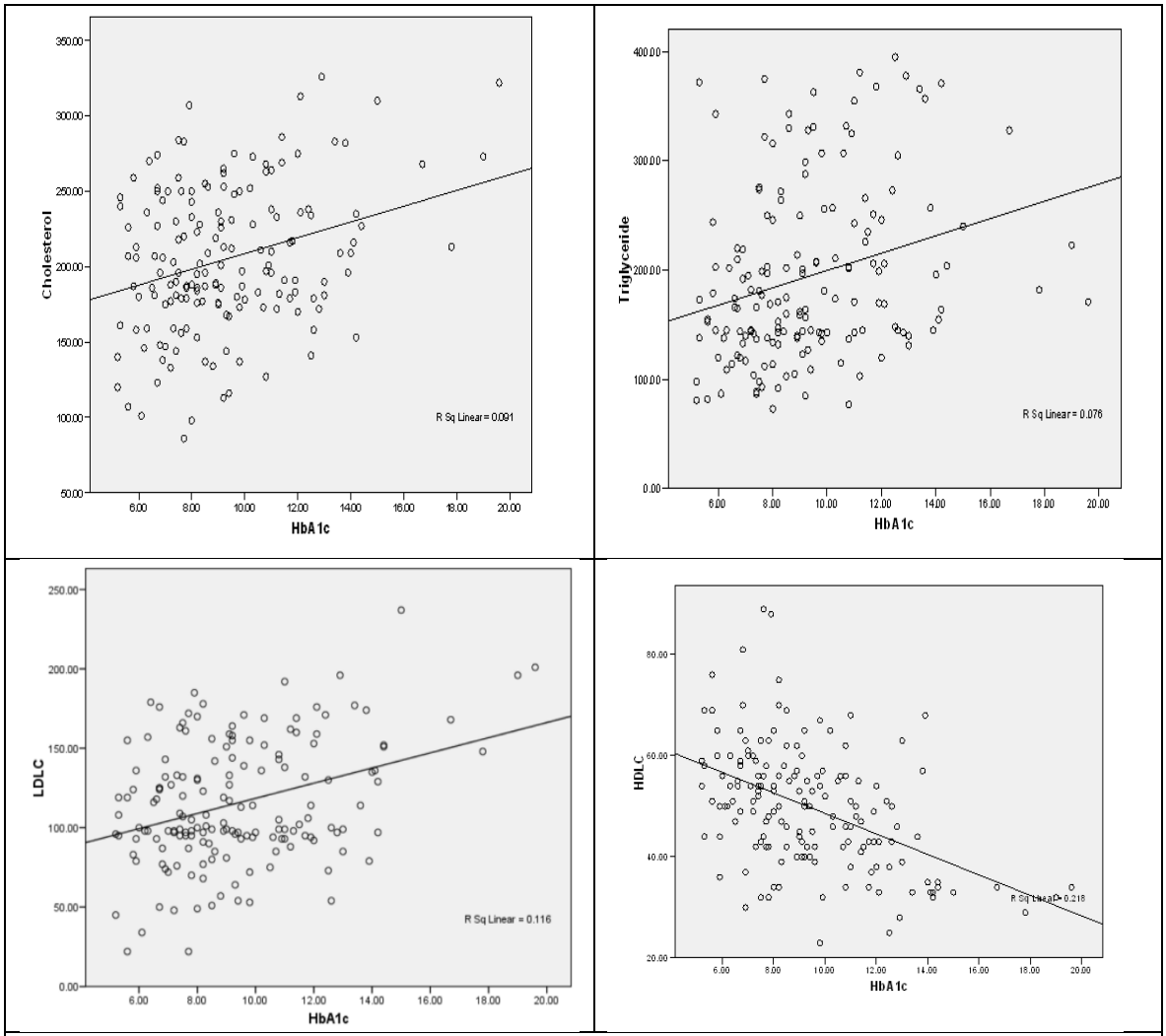


Figure 2: Scatter plot between Lipid profile & HbA1C

Discussion

The present study shows decrease in the mean of serum sodium (p value = 0.006) and potassium (p value = 0.010) and increase in the mean of serum calcium (p value = 0.001) with different label of HbA1c (i.e. group I = < 7%, group II = 7 to 8 %, group III = >8) and it was found to be statistically significant. This finding was in consistent with the result of Hasona NA et al[16], in their study among 100 diabetic patient they found that the serum electrolytes level, sodium and potassium shows a very highly significant ($p < 0.001$) decrease. While serum Calcium levels exhibited a very highly significant ($p < 0.001$) increase. Similarly, in another study conducted by Wang S et al[17] showed that serum sodium and potassium level decreases among the diabetes, whereas the level of serum calcium increases. Ramadan RH et al[18] conducted a study where they found that the mean serum level of sodium and potassium in Type 2 diabetes patients was significantly decreased. But, in a study conducted by Siddiqui A.M et al[19] showed that there was a significant increase in serum potassium, although serum sodium was found to be significantly decreases. The result of Sarguru et al[20] disagree with our study finding where they showed significantly elevated sodium and mildly elevated potassium level among type 2 diabetic patient.

Our study also shows negative correlation of HbA1c with Sodium (r = - 0.363) and Potassium (r = -0.285) and positive correlation with Calcium (r = .449) in the pearson's correlation test. This result was in consistent with Wang S et al.[17] They showed that serum sodium was negatively correlated with HbA1c (Pearson's $r=-0.25$; $P < 0.01$) and calcium was positively correlated with HbA1c (Pearson's $r=0.17$; $P < 0.05$).

Simillarly, in another study conducted by Rahiman NB et al[21] showed negative correlation of HbA1c with sodium (r = -0.386, p =0.000) and Potassium (r = -0.438, p = 0.000). Al Jamil N et al[22] conducted a study where they also found that sodium (r = -0.210, p = 0.042) was negatively correlated with HbA1c but unlike our study potassium showed insignificant association with HbA1c (r = 0.02, p = NS).

The common causes for disorder of electrolyte balances among diabetes mellitus includes insulin deficiency, hyperglycemia, and hyperketonemia. In Diabetes mellitus, primarily hyperglycemia is limited to the extracellular space. As a result of which water moves from the intracellular to the extracellular compartment diluting plasma sodium. Hence, the plasma sodium concentration may be artificially lowered. But during the accompanying osmotic diuresis, water is generally lost in excess of sodium until the water balance is maintain between extracellular and intracellular compartments. Hyperglycemia-induced osmotic dieresis is thought to be a primary mechanism underlying the decreased serum concentrations of sodium observed in response to hyperglycemia.[23]

In kidney, Calcium is mainly reabsorbed in the proximal tubule. Its reabsorption is coupled to sodium absorption. However, In the distal convoluted tubule, Calcium absorption is regulated independently of sodium. But instead, numerous other factors such as calcitonin, parathyroid hormone, and vitamin D, can have marked effects on Calcium reabsorption and secretion.[24] On the other hand, the serum potassium levels were reduced because of diuretics and the diabetic ketoacidosis (increased loss in the urine). It has been observed that cellular membrane electrolyte transporter Na+K+ATPase dysfunction in diabetic subjects can be secondary to hyperglycemia.[25] Moreover, the functions of Ca2+Mg2+ATPase,

Na+/Ca2+ exchanger, and Ca2+ pump, which are located in the cell membrane, mitochondria or endoplasmic reticulum, have been shown to be impaired in diabetes.[26]

The present result revealed statistically significant increase in the mean of serum triglyceride (p value = 0.014) and decrease in the mean of HDL-C (p value < .001) with different levell of HbA1c (i.e. group I = < 7%, group II = 7 to 8 %, group III = >8). Whereas increase in the mean of serum cholesterol (p=0.258) and LDL-C (p=0.111) with HbA1c level were not statistically significant. This result was partly consistent with the study done by Khan HA et al.[27] In their study they showed the impact of glycaemic control on various lipid parameters in which the diabetic patients were categorized into 3 groups according to their HbA1c levels. Though there was no significant differences in LDL–C level in 3 groups with regard to glycaemic control, alterations in other lipid parameters were statistically significant in three different groups. Severity of dyslipidemia increases in patients with higher HbA1c value.

In our study, Pearson correlation analysis shows positive correlation of HbA1c with serum cholesterol (r = 0.301, p<0.001), triglyceride (r = 0.275, p<0.001) and LDL-C (r = 0.359, p<0.001) and negative correlation with HDL-C (r = -0.467, p<0.001). This result was in consistent with the study done by Khan HA et al[27], where they found statistically significant correlation of HbA1c with lipid profile i.e. TC (r = 0.127, p = .000), TG (r = 0.153, p = .000), LDL-C (r =0.142, p = .001) and HDL-C (r = -0.128, p=.002) and suggested the importance of good management of diabetes in controlling dyslipidaemia . Our result is also in agreement with the findings of Ko GT et al,[28] Chan WB et al[29] and Faulkner MS et al[30] who reported significant correlations between HbA1c and lipid profiles and suggested the importance of good management of diabetes in controlling dyslipidaemia. Mahato R V et al[31] conducted a study where they found statistically significant positive correlation of HbA1c with TC (p = 0.017) and LDL-C (p = 0.015), which are consistent with our finding. Although in there report they showed HbA1c had positive correlation with TG (p =0.169) and negative correlation with HDL-C (p= 0.596) . But unlike our study, correlation was not statistically significant.

Several factors are responsible for the development of dyslipidemia in diabetics: the most important of which is insulin deficiency. Insulin effects on liver apoprotein production, regulates action of lipoprotein lipase (LpL), cholesteryl ester transfer protein (CETP), and it has also peripheral actions on muscle and adipose tissue. Hepatic lipase is an enzyme synthesized by hepatocytes that hydrolyzes phospholipids and triglycerides on HDL and remnant lipoproteins. Some studies suggest that this enzyme is reduced due to insulin deficiency. One effect of hepatic lipase deficiency is the decrease in clearance of remnant lipoproteins.[32,33]

LpL is the major enzyme responsible for conversion of lipoprotein triglyceride into free fatty acids.[34] Several steps in the production of biologically active LpL may be altered in diabetes mellitus.[35,36]

There are several reasons for low HDL in diabetic patient. It may be due to insulin resistace, augmented very low-density lipoprotein production and increased activities of cholesteryl ester transfer protein (CETP) and endothelial lipase. Increased concentrations of plasma VLDL drive the exchange of triglyceride from VLDL for the cholesteryl esters found in HDL.[37]

Conclusion

The increase in Total Cholesterol, Triglyceride, LDL-C, and decrease in HDL-C with increase in the level of HbA1c shows that the glycemic control has impact on lipid metabolism at

lipoprotein levels. Thus hyperlipidemia of diabetic patients may be correctable by improving glycemic control i.e. blood sugar level. Though, the causes of electrolyte imbalance are multifactorial, its abnormalities are now predominantly common in diabetes patients. Our study shows that the electrolyte abnormalities has relation with increase in HbA1c level. Sodium and potassium imbalance is significantly present in patients with uncontrolled diabetes mellitus.

In our study, it has been observed that the diabetic patients having raised HbA1c were showing more dyslipidemia and electrolyte imbalance.

Our study concluded that the differences found in the lipid profile and serum electrolyte levels in Type 2 DM subjects can be used as a diagnostic tool in our daily practices. Early diagnosis of dyslipidemia and electrolyte imbalances can be used to prevent complications in Type 2 DM patients

Bibliography

1. Web reference : health-topics/diabetes.
2. Anjana RM, Deepa M, Pradeepa R, Mahanta J, Narain K, Das HK, Adhikari P, Rao PV, Saboo B, Kumar A, Bhansali A. Prevalence of diabetes and prediabetes in 15 states of India: results from the ICMR–INDIAB population-based cross-sectional study. The lancet Diabetes & endocrinology. 2017 Aug 1;5(8):585-96.
3. Liamis G, Liberopoulos E, Barkas F, Elisaf M. Diabetes mellitus and electrolyte disorders. World Journal of Clinical Cases: WJCC. 2014 Oct 16; 2(10):488.
4. Woyesa SB, Gebisa WC, Anshebo DL. Assessment of Selected Serum Electrolyte and Associated Risk Factors in Diabetic Patients. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy. 2019;12:2811.
5. Bhave G, Neilson EG. Volume depletion versus dehydration: how understanding the difference can guide therapy. American journal of kidney diseases. 2011 Aug 1;58(2):302-9.
6. Ashraf R, Naikoo NA, Bashir H, Farooq I, Koul RK, Majid S, et al. Electrolyte imbalance in the patients admitted to the emergency department of the tertiary care hospital of smhs hospital, Srinagar. International journal of current Research. 2018; 10(04): 67854-67857
7. Parmar SK, Singh S, Singh GK. Role of hyperglycemia in the pathogenesis of Na±/K±disturbance. Int J Res Med Sci. 2016 Apr 4;4(4):1167-71.
8. Siddiqui K, Bawazeer N, Scaria Joy S. Variation in macro and trace elements in progression of type 2 diabetes. The scientific world journal. 2014 Aug 5; 2014.
9. Becerra-Tomás N, Estruch R, Bulló M, Casas R, Díaz-López A, Basora J, Fitó M, Serra-Majem L, Salas-Salvadó J. Increased serum calcium levels and risk of type 2 diabetes in individuals at high cardiovascular risk. Diabetes Care. 2014 Nov 1;37(11):3084-91.
10. Pittas AG, Lau J, Hu FB, Dawson-Hughes B. The Role of Vitamin D and Calcium in Type 2 Diabetes. A Systematic Review and Meta-Analysis. J Clin Endocrinol Metab. 2007; 92(6):2017–2029.
11. Artha IM, Bhargah A, Dharmawan NK, Pande UW, Triyana KA, Mahariski PA, et al. High level of individual lipid profile and lipid ratio as a predictive marker of poor glycemic control in type-2 diabetes mellitus. Vascular Health and Risk Management. 2019;15:149.
12. Rosediani M, Azidah AK, Mafauzy M. Correlation between fasting plasma glucose, post prandial glucose and glycated haemoglobin and fructosamine. The Medical journal of Malaysia. 2006 Mar;61(1):67-71.
13. Ginsberg HN, Elam MB, Lovato LC, et al. ACCORD study group. Effects of combination lipid therapy in type 2

diabetes mellitus. N Engl J Med. 2010;362(17):1563–1574.
14. Sarfraz M, Sajid S, Ashraf MA. Prevalence and pattern of dyslipidemia in hyperglycemic patients and its associated factors among Pakistani population. Saudi Journal of Biological Sciences. 2016 Nov 1;23(6):761-6.
15. Book: Vasudevan DM, Sree Kumari S, Kannan Vaidyanathan, Regulation of Blood glucose, Insulin &Diabetes Mellitus. Textbook of Biochemistry for Medical student. 9th ed Jaypee Brother medical publishers; 2019; P 164.
16. Hasona NA, Elasbali A. Evaluation of electrolytes imbalance and dyslipidemia in diabetic patients. Medical sciences. 2016 Jun;4(2):7.
17. Wang S, Hou X, Liu Y, Lu H, Wei L, Bao Y, . Serum electrolyte levels in relation to macrovascular complications in Chinese patients with diabetes mellitus. Cardiovascular diabetology. 2013 Dec 1;12(1):146.
18. Ramadan RH, Abdullah AM. Assessment of Serum Electrolyte Levels & HbA1C Levels among Type 2 Diabetic Sudanese Patients with Macrovascular Complications in Khartoum State. Open Access Library Journal. 2020 Mar 5;7(3):1-9.
19. Siddiqui A. M., & Choudhary S. K. Study of Serum Electrolyte Levels in Type 2 Diabetes Mellitus. International Journal of Innovative Research in Medical Science, 2019; 4(06): 370 to 371.
20. Datchinamoorthi S, Vanaja R, Rajagopalan B. Evaluation of serum electrolytes in type II diabetes Mellitus. Int J Pharm Sci Rev Res. 2016; 40(1): 251-253.
21. Rahiman NB, Bangera S, Hameed SS. Assessment of serum lipid profile and electrolyte levels in Type II diabetes mellitus–A comparative study based on glycosylated haemoglobin levels. National Journal of Physiology, Pharmacy and Pharmacology. 2019; 9(7):617-20.
22. Al-Jameil N. Estimation of serum electrolytes in diabetes patients of Saudi region. Life. Sci. J. 2014;11(7):378-80.
23. Kitabchi, A.E.; Umpierre, G.E.; Murphy, M.B.; Kriesberg, R.A. Hyperglycemic crisis in adult patients with diabetes: A consensus statement from the American diabetes association. Diabetes Care 2006, 29, 2739–2748.
24. Book: Guyton, A.; Hall, J. Textbook of Medical Physiology; Elsevier Saunders: Philadelphia, PA, USA, 2006; 348–381.
25. Shahid, S.M.; Rafique, R.; Mahboob, T. Electrolytes and sodium transport mechanism in diabetes mellitus. Pak. J. Pharm. Sci. 2005; 18: 6–10.
26. Mikaelian, N.P.; Gurina, A.E.; Terent'ev, A.A. Dysfunction of membrane-receptor system of blood cells and kidney tissue in experimental diabetes mellitus. Bull. Exp. Biol. Med. 2013, 154, 610–613.
27. Khan HA, Sobki SH, Khan SA. Association between glycaemic control and serum lipids profile in type 2 diabetic patients: HbA1c predicts dyslipidaemia. Clinical and experimental medicine. 2007 Mar; 7(1): 24-9.
28. Ko GT, Chan JC, Woo J et al. Glycated hemoglobin and cardiovascular risk factors in Chinese subjects with normal glucose tolerance. Diabet Med. 1998; 15:573–578.
29. Chan WB, Tong PC, Chow CC, So WY, Ng MC, Ma RC, Osaki R, Cockram CS, Chan JC. Triglyceride predicts cardiovascular mortality and its relationship with glycaemia and obesity in Chinese type 2 diabetic patients. Diabetes/metabolism research and reviews. 2005 Mar;21(2):183-8.
30. Faulkner MS, Chao WH, Kamath SK, Quinn L, Fritschi C, Maggiore JA, Williams RH, Reynolds RD. Total homocysteine, diet, and lipid profiles in type 1 and type 2 diabetic and

nondiabetic adolescents. The Journal of cardiovascular nursing. 2006; 21(1): 47.
31. Vinod Mahato R, Gyawali P, Raut PP, Regmi P, Singh KP, Pandeya DR, Gyawali P. Association between glycaemic control and serum lipid profile in type 2 diabetic patients: Glycated haemoglobin as a dual biomarker. Biomedical Research (0970-938X). 2011 Jul 1;22(3).
32. Ruotolo G, Parlavecchia M, Taskinen MR, et al. Normalization of lipoprotein composition by intraperitoneal insulin in IDDM. Role of increased hepatic lipase activity. Diabetes Care 1994; 17:6-12.
33. Taylor KG, Galton DJ, Holdsworth G. Insulin independent diabetes: a defect in the activity of lipoprotein lipase in adipose tissue. Diabetologia 1979; 16:313-317.
34. Goldberg IJ. Lipoprotein lipase and lipolysis: central roles in lipoprotein metabolism and atherogenesis. J Lipid Res 1996; 37:693–707.
35. Tavangar K, Murata Y, Pedersen ME, Goers JF, Hoffman AR, Kraemer FB. Regulation of lipoprotein lipase in the diabetic rat. J Clin Invest 1992; 90:1672-8.
36. Semenkovich CF, Wims M, Noe L, Etienne J, Chan L. Insulin regulation of lipoprotein lipase activity in 3T3–L1 adipocytes is mediated at posttranscriptional and posttranslational levels. J Biol Chem 1989; 264:9030-8.
37. Hayek T, Azrolan N, Verdery RB, et al. Hypertriglyceridemia and cholesteryl ester transfer protein interact to dramatically alter high density lipoprotein levels, particle.