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Glycaemicparameters, Dyslipidaemia and Thyroid Hormone: An exploratory study of their interrelationship in Type 2 Diabetes Mellitus patients

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ABSTRACT

Background*:* Diabetes mellitus and thyroid disorders may coexist and impacting each other. The thyroid gland function (hypo- and hyper-function) may affect the metabolism of carbohydrates. Both conditions have an impact on the lipid profile since insulin resistance or insufficiency alters important enzymes and pathways involved in lipid metabolism. Lipid abnormalities are common in diabetes mellitus. The purpose of this study is to determine how diabetes mellitus, hypothyroidism, and dyslipidaemia are related.

Method: The study included 300 participants, 150 of whom were healthy controls and 150 of whom had diabetes mellitus and hypothyroidism. 150 people with diabetes were further divided into 75 people who had dyslipidemia and 75 people who did not. Serum lipid profiles and blood sugar levels were measured using the Mindray BS240 analyzer. Triiodothyronine [T3], thyroxine [T4], and thyroid stimulating hormone [TSH] were measured using chemiluminescence immunoassay.

Result: The study found that female subjects with diabetes had a higher prevalence of dyslipidaemia. The TSH differences between the study and control groups were more significant (OR 3.147, P Value0.001*). Notable were the T4 (OR 1.734, P Value0.001*) and T3 (OR 2.031, P Value0.001*), mean differences as well. Higher levels of FBS, PPBS, and RBS were observed. The lipid profile total cholesterol (OR 3.120, P Value0.001*), triglycerides (OR 1.592, P Value0.001*), HDL (OR 2.173, P Value0.001*), LDL (OR 2.110, P Value0.001*), and VLDL (OR 2.194, P Value0.001*) is also significant compared to controls.

Conclusion: This study shows that T2DM significantly affect thyroid function especially in female. It is crucial to take thyroid function into account in diabetic patients because changes in thyroid hormone levels may be caused by insulin resistance and altered glucagon levels.The results suggest a significant association between hypothyroidism and diabetes with dyslipidaemia.

Keywords: *Hypothyroidism, diabetes mellitus, Dyslipidaemia.*

1. INTRODUCTION

Type 2 diabetes mellitus (T2DM), a complicated metabolic disease that results in chronic hyperglycemia, is characterized by insulin resistance and impaired insulin secretion (1). Type 2 diabetes mellitus (T2DM) affects more than 460 million people globally, and its prevalence has increased to alarming proportions. Moreover, type 2 diabetes often coexists with thyroid dysfunction and dyslipidemia, which further complicates management (2).Dyslipidemia, a disorder characterized by

abnormal lipid profiles that increases the risk of cardiovascular disease, is common in patients with type 2 diabetes (3). Thyroid hormone, a major regulator of metabolism, has also been connected to the pathophysiology of type 2 diabetes (4, 5). In particular, it has been shown that hyperthyroidism can exacerbate insulin resistance, while hypothyroidism affects insulin sensitivity and glucose metabolism (6).Although type 2 diabetes, dyslipidemia, and thyroid dysfunction have been connected, their precise relationship is still unclear. The majority of current research focuses on the relationships between T2DM, dyslipidemia, and thyroid dysfunction separately; few studies look at the intricate relationships between these three conditions. This knowledge gap emphasizes the need for additional research on the connection between thyroid hormones, dyslipidemia, and glycemic parameters in patients with type 2 diabetes. The purpose of this exploratory study is to look into the relationships among dyslipidemia, thyroid hormone, and glycemic parameters in people with type 2 diabetes. By providing a comprehensive understanding of the relationships between thyroid hormone, dyslipidemia, and glycemic parameters in people with type 2 diabetes, this study will advance our understanding. The results of the study will have important implications for the treatment of type 2 diabetes, highlighting the need for a multidisciplinary approach that takes into account the complex connections between these conditions.

AIM:

The aim of this study is to look into the relationships among dyslipidaemia, thyroid hormone, and glycaemic parameters in people with type 2 diabetes.

2. MATERIALS AND METHODS:

This cross-sectional study, designed to explore the relationship between Type 2 diabetes mellitus, thyroid dysfunction, and dyslipidemia.It was conducted at Department of Biochemistry, Pacific Medical College and Hospital, Pacific Medical University, Udaipur, Rajasthan, India.

According to the American Diabetes Association, a fasting plasma glucose level of 126 mg/dL (7.0 mmol/L) and a random plasma glucose level of 200 mg/dL were used to diagnose type 2 diabetes.

Sample Size: Sample size was calculated on the basis of this formula, Sample Size (n) = $\frac{z^2_{1-\alpha/2}\, P(1-p)}{E^2}$ Where, p= expected prevalence, α= level of significance, Z= the Z score corresponding to degree of confidence E=desired precision. The minimum required sample size is 200 for this study but considering the complexity of the study we recruited 300 participants. Out of 300 participants, 150 were healthy individuals and 150 were T2DM cases.

InclusionCriteria:

1. Age: Patients aged 30-70 years.
2. Clinically confirmed cases of diabetes with hypothyroidism.
3. Individuals willing to provide informed consent.

Exclusioncriteria:

1. Patients with Type 1 Diabetes Mellitus.
2. Pregnant or lactating women.
3. Patients with severe illness, such as cancer, liver disease, or kidney disease.
4. Thyroid Cancer: Patients with thyroid cancer.
5. Patients taking medications that affect thyroid function, such as amiodarone or lithium.
6. Patients who have undergone thyroid surgery or radioactive iodine treatment.

Method of Analysis: The participant's medical history was collected to record their age, gender, height, weight, duration of diabetes and hypothyroidism, as well as details about any medications they were using.Venous blood samples were subjected to thyroid function tests (FT4, FT3, T3, T4, and TSH) and other biochemical analyses (FPG, HbA1C, and lipid profile). TSH (normal range: 0.3-5.3 µIU/ml), T4 (normal range: 5.2-12.45 µg/dl), and T3 (normal range: 0.60-1.78 ng/ml) were measured using the Chemiluminescence Assay method. FPG (normal range 70-110 mg/dl), HbA1c (normal range 4.2-6.2%), serum cholesterol (normal range 150-200 mg/dl), serum triglycerides (normal range 100-150 mg/dl), serum HDL (normal range 35-48 mg/dl), serum LDL (normal range <130), and serum VLDL (normal range 5-35 mg/dl) were all measured using a fully automated clinical chemistry analyzer (Mindray BS240 analyzer).

Statistical Analysis:

The statistical analysis was performed by using SPSS version 23. Data were expressed as mean ± standard deviation. The independent t-test was used to compare the variables. A p-value <0.05 was considered statistically significant.

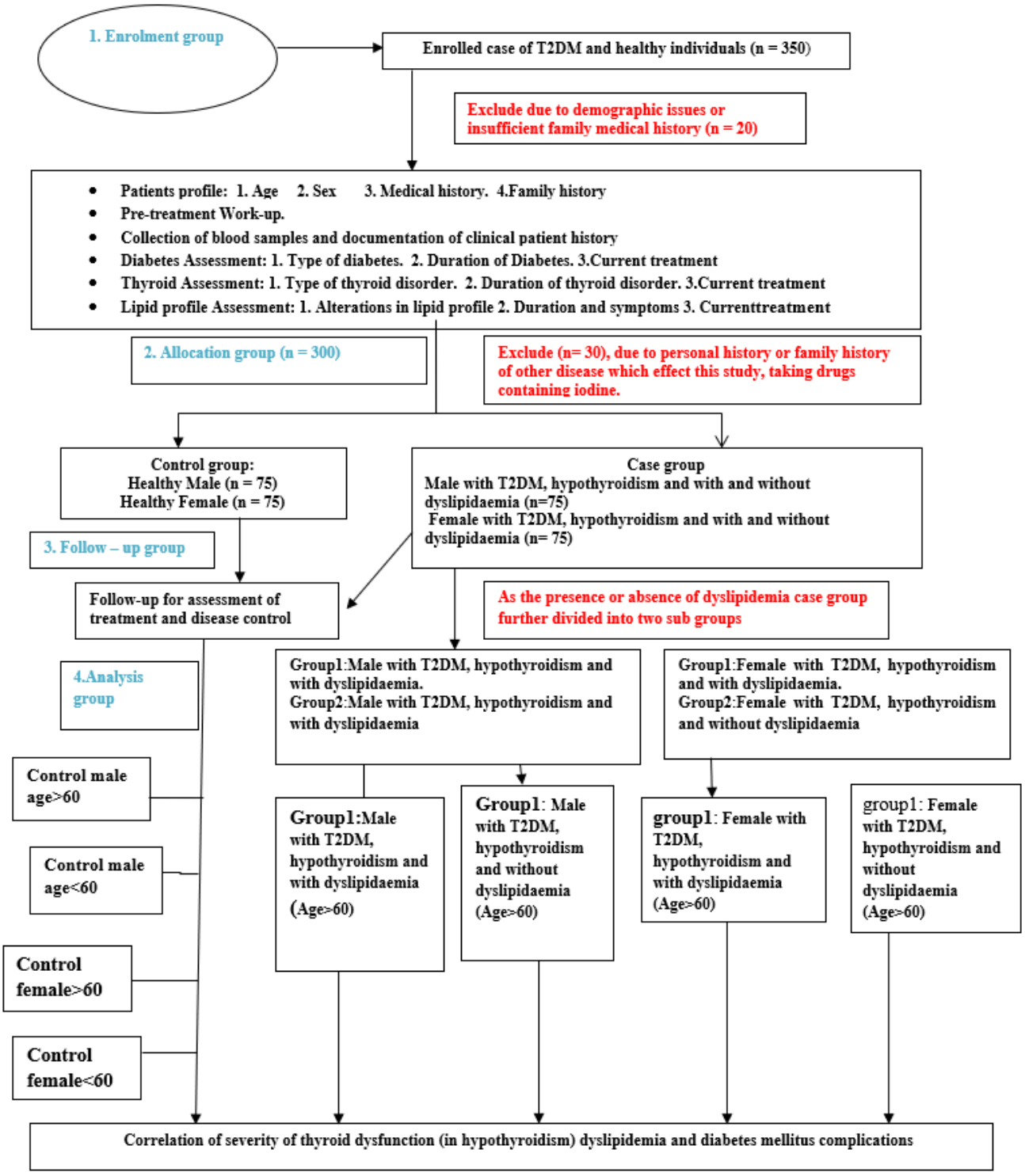

Figure no1: Study Design

3. RESULTS

The study included 300 participants, 150 case with type 2 diabetes mellitus and 150 healthy male and female subjects in the same age range who were admitted to or attending the outpatient at Pacific Medical College and hospitals, Pacific Medical University, Udaipur, Rajasthan. The case group's mean T3(OR 2.031, P 0.001**), T4 (OR 1.734, P 0.001**), and TSH (OR 3.147, P 0.001**) values were abnormally high, according to the thyroid profile results. Female's thyroid profiles in the case group are significantly (0.001**) more aberrant than men's.

Table 1-Showing the Glycaemic parameters, serum lipid profile and serum thyroid profile in case and control group

SNo.	Parameters	Controls (n=150) Mean ± SD	Case (n =150) Mean ± SD	OR	P-value
1	T3 (ng/ml)	1.34 ± 0.34	0.61 ± 0.3	2.031	0.001**
2	T4 (ug/dl)	8.5 ± 1.76	4.65 ± 1.12	1.734	0.001**
3	TSH (uIU/L)	2.8 ± 1.12	12.58 ± 2.46	3.147	0.001**
4	T. CHO	170 ± 32.90	289.1 ± 42.55	3.120	0.001**
5	TG	86.6 ± 18.1	205.1 ± 46.8	1.592	0.001**
6	HDL	50.2 ± 5.9	28.7 ± 4.08	2.173	0.001**
7	LDL	77.65 ± 13.61	140 ± 24.87	2.110	0.001**
8	VLDL	17.33 ± 6.8	48.1 ± 13.8	2.194	0.001**
9	Creatinine	0.74 ± 0.15	1.05 ± 0.25	1.00	0.0006*
10	Urea	29.63 ± 5.9	33.12 ± 8.1	0.792	0.004*
11	Uric Acid (UA)	5.13 ± 1.5	6.3 ± 2.02	1.392	0.001**
12	T. Bilirubin	0.69 ± 0.12	1.4 ± 0.38	0.129	0.18
13	Conjugated bilirubin	0.16 ± 0.08	0.21 ± 0.1	0.650	0.0073**
14	Unconjugated bilirubin	0.46 ± 0.7	0.65± 0.9	0.192	0.00 1**
15	SGPT	31.92 ± 6.9	35.95 ± 8.4	0.176	0.34
16	SGOT	28.97 ± 6.37	33.12 ± 7.3	0.129	0.12
17	ALP	93.76 ± 14	96.76 ± 16.9	0.212	0.52
18	TP	7.32 ± 0.69	7.21 ± 0.71	0.229	0.24
19	Albumin	4.5± 0.60	4.32 ± 0.59	0.271	0.029
20	Globulin	2.7± 0.46	2.85± 0.53	0.117	0.36

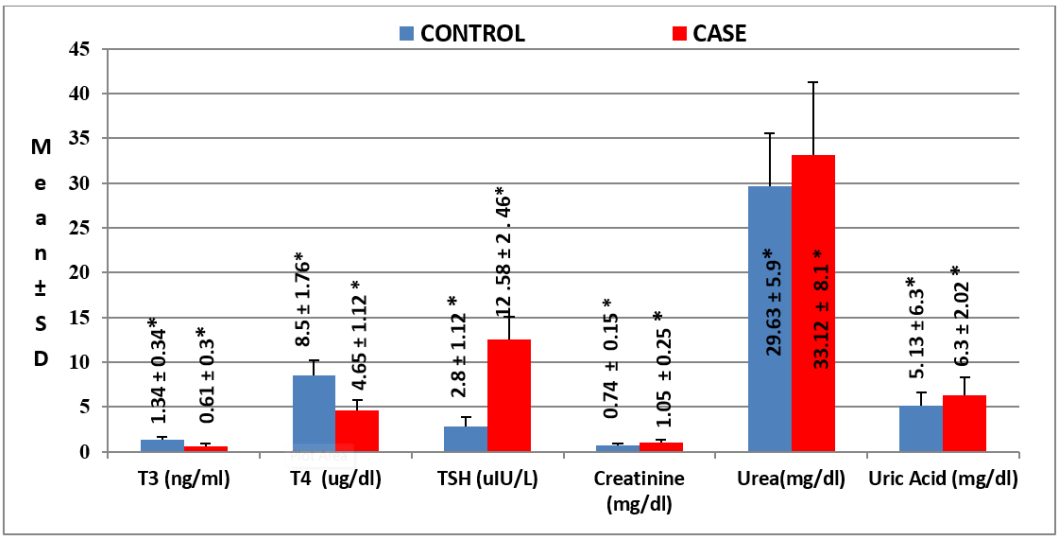

Figure1 (A): Showing the Thyroid profile and RFT in case and control group

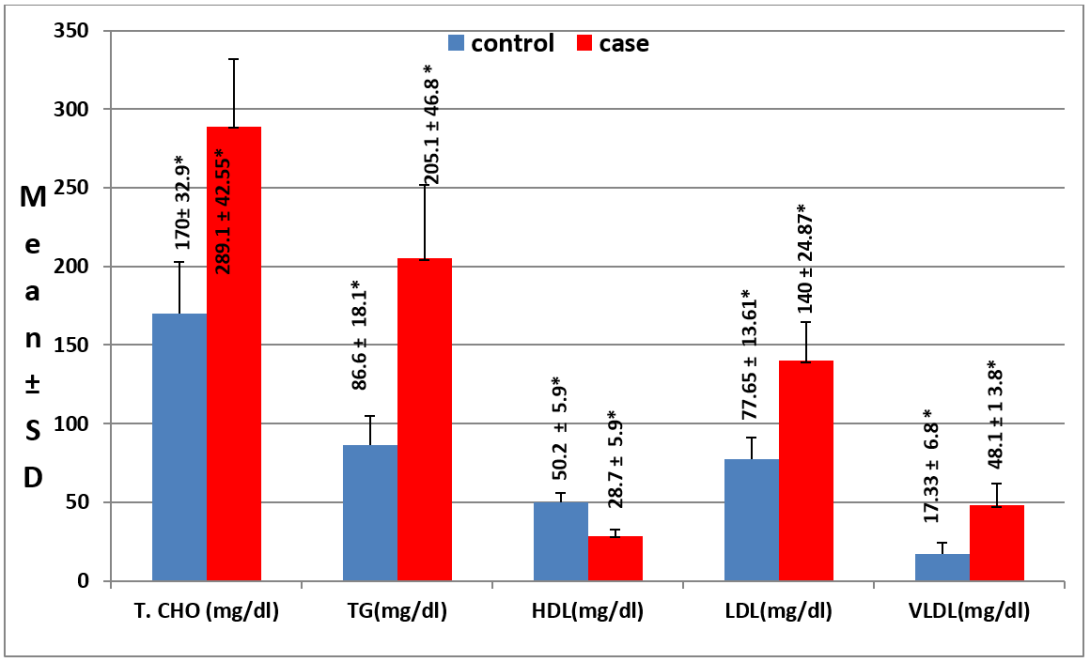

Figure 1(B): Showing the Lipid profile comparison in case and control

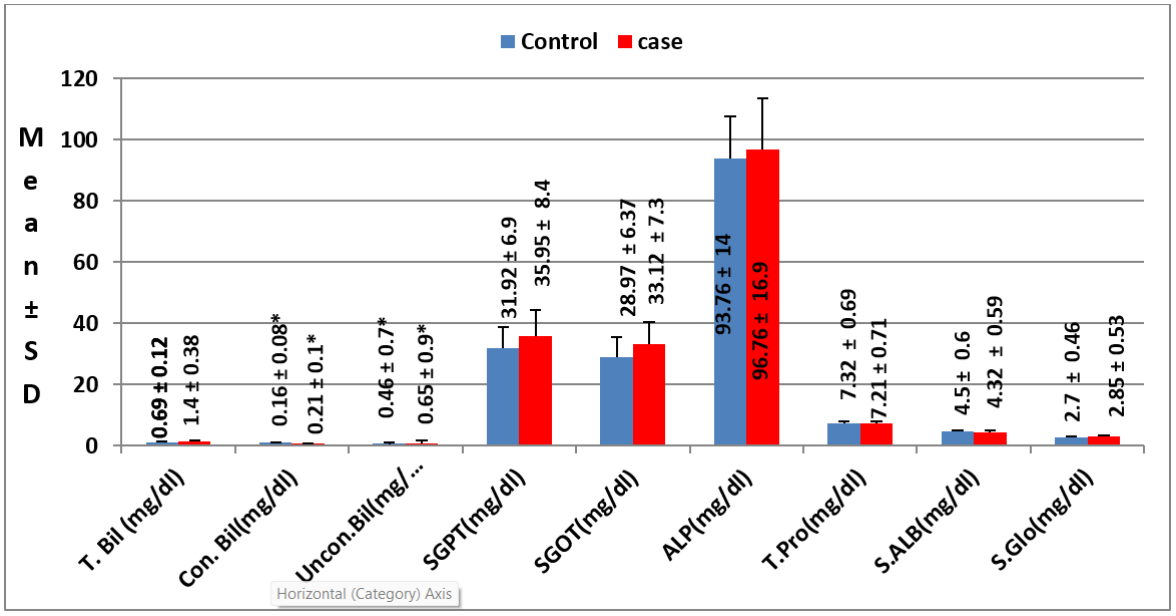

Figure 1(c): Showing the LFT in case and control group

Table 1 compares the thyroid profile, serum lipid profile, and glycemic parameters between cases and controls using mean ± SD, odds ratio (OR), and P-values.TSH was higher in cases (12.58 ± 2.46 vs. 2.8 ± 1.12; OR = 3.147, P < 0.001 for all) than in controls (1.34 ± 0.34 and 8.5 ± 1.76), but T3 and T4 levels were significantly lower in cases (0.61 ± 0.3,OR = 2.031, P < 0.001 and 4.65 ± 1.12, OR = 1.734, P < 0.001). T CHO (OR = 3.120, P < 0.001), TG (OR = 1.592, P < 0.001), LDL (OR = 2.110, P < 0.001), and VLDL (OR = 2.194, P < 0.001), levels were higher in cases, but HDL levels were lower (28.7 ± 4.08 vs. 50.2 ± 5.9; (OR = 2.173, P < 0.001).Creatinine (OR = 1.00, P < 0.006), urea (OR = 0.792, P < 0.004), and uric acid (OR = 1.392, P < 0.001) levels were higher in cases (P < 0.05).While total bilirubin (OR = 0.129, P < 0.18), did not differ significantly. conjugated (OR = 0.650, P < 0.0073), and unconjugated bilirubin (OR = 0.192, P < 0.001) were significantly higher in cases.Except for slightly lower albumin levels (OR = 0.271, P = 0.029), in cases,SGPT (OR = 0.176, P =0.34),SGOT (OR = 0.129, P =0.12),ALP (OR = 0.212, P = 0.52), TP (OR = 0.229, P = 0.24), andglobulin(OR = 0.117, P = 0.36), levels were comparable and did not differ significantly.

Table 2: Showing the Gender wise comparison of thyroid profile, lipid profile and renal function test in Control and Case

S. N	Parameters	Mean ± SD Healthy male	Mean ± SD Healthy female	Mean ± SD Diabetic male	Mean ± SD Diabetic Female	OR	P-value
1	T3 (ng/ml)	1.38 ± 0.21	1.30 ± 0.28	0.68 ± 0.9	0.54 ± 0.3	2.19	0.001**
2	T4 (ug/dl)	7.9 ± 1.7	7.1 ± 1.5	4.9 ± 0.71	4.25 ± 0.2	1.734	0.001**
3	TSH (uIU/L)	2.6 ± 1.2	3.0 ± 0.9	11.48 ± 4.37	13.68 ± 5.74	3.147	0.001**
4	T. CHO	155.5 ± 31.92	185 ± 30.1	249 ± 35	269.2 ± 68	3.120	0.001**
5	TG	85.62 ± 15.1	87.76 ± 14.3	238 ± 62.6	261 ± 67.46	1.592	0.001**
6	HDL	49.86 ± 5.6	53.1 ± 4.9	26.3 ± 4.8	22 ± 4.08	2.173	0.001**
7	LDL	72.13 ± 13.6	80 ± 15.1	178.1 ± 20.1	241 ± 28.48	2.110	0.001**
8	VLDL	21.1 ± 6.6	25.1 ± 5.1	41.9 ± 21.4	61.85 ± 23.2	2.194	0.001**
9	Creatinine	0.74 ± 0.16	0.72 ± 0.10	1.9 ± 0.25	0.83 ± 0.21	1.00	0.048**
10	Urea	29.48 ± 6.16	31.1 ± 10.4	39.63 ± 12	35.60 ± 14.64	0.792	0.29
11	UA	3.6 ± 1.8	4.1 ± 1.3	7.2 ± 5.3	5.91 ± 1.9	1.392	0.35
12	T. Bilirubin	0.59 ± 0.11	0.39 ± 0.2	0.76 ± 0.35	1.0 ± 0.23	0.129	0.39
13	Conjugated bilirubin	0.23 ± 0.3	0.26 ± 0.7	0.36 ± 0.06	0.87± 0.34	0.650	0.21
14	Unconjugated bilirubin	0.32 ± 0.1	0.29 ± 0.3	0.60 ± 0.3	0.57± 0.7	0.192	0.83
15	SGPT	28.5 ±12.7	26.1 ±10.8	29.75 ± 28	31.6± 24.9	0.176	0.56
16	SGOT	26.1 ± 13.1	21.1 ± 18.1	35.5 ± 31	28.4± 22.7	0.129	0.67
17	ALP	91.2 ± 35.1	93.7 ± 27.2	91 ± 39	102.8 ± 46	0.212	0.43
18	TP	7.9 ± 0.6	6.8 ± 1.1	9.1 ± 0.6	7.3 ± 0.6	0.229	0.12
19	Albumin	3.7 ± 0.5	3.9 ± 0.3	4.1 ± 0.53	4.4± 0.53	0.271	0.70
20	Globulin	2.1 ± 0.13	2.1 ± 0.38	2.7± 0.5	2.8 ± 0.57	0.117	0.21

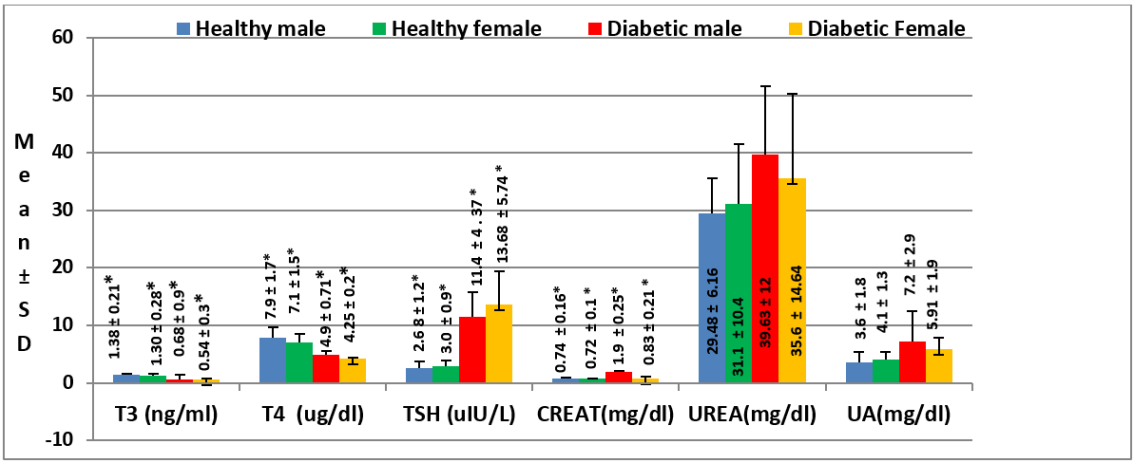

Figure 2:(A) Showing the Gender wise comparison of thyroid profile, and renal function test in Control and Case

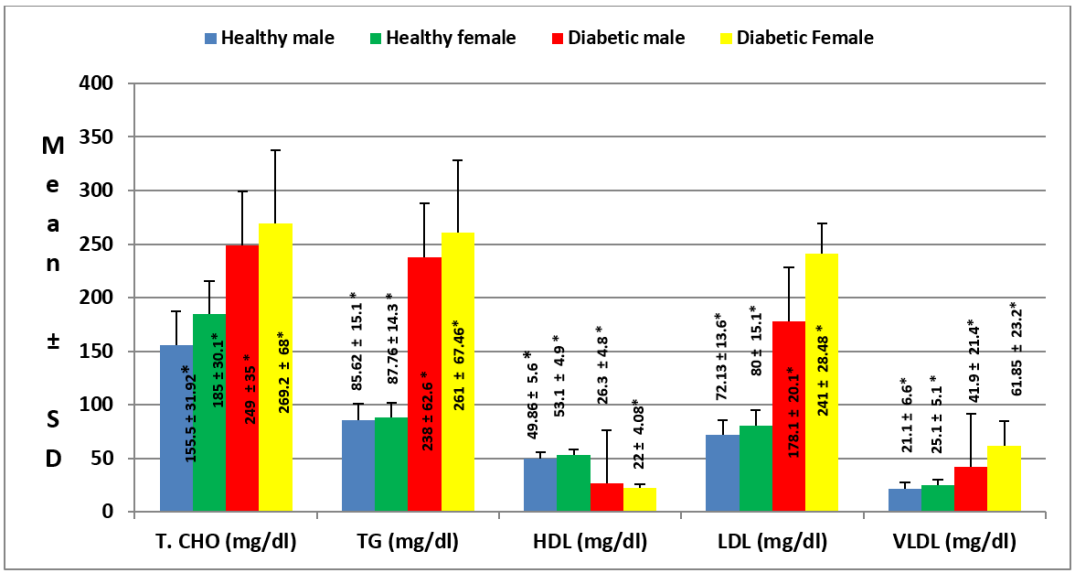

Figure 2(B)Showing the Lipid profile in case and control group.

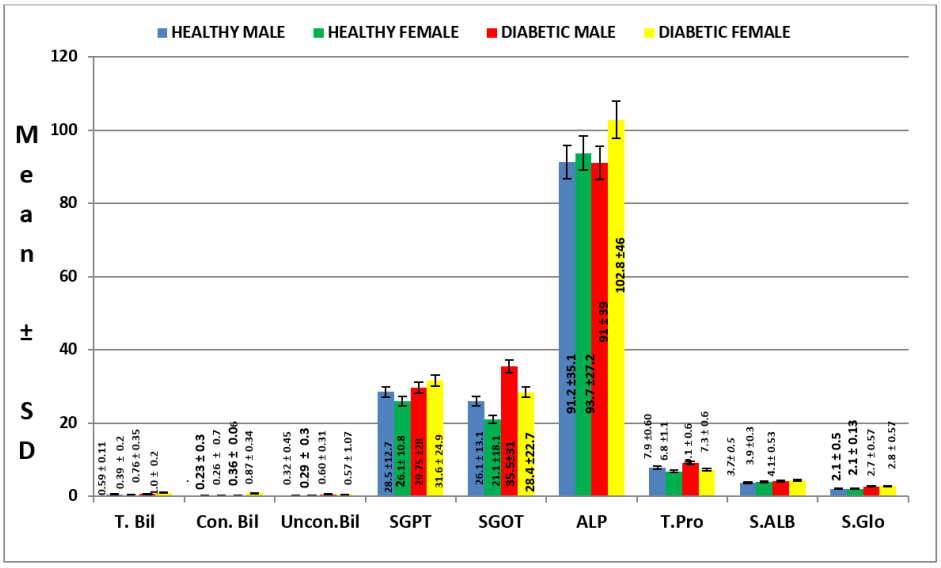

Figure 2(C):Showing the LFT in case and control group

Table 2 shows that diabetes has little effect on liver enzymes and protein levels but has a major effect on thyroid function, lipid profile, and renal function. Compared to healthy people, diabetics have significantly lower levels of T3 (OR= 2.19, P = 0.001). and T4 (OR= 1.734, P = 0.001). Diabetics have significantly higher TSH, which may be a sign of subclinical hypothyroidism (OR= 3.147, P = 0.001). Diabetics have significantly higher levels of triglycerides (TG) (OR= 1.592, P = 0.001) and total cholesterol (T. CHO) (OR= 3.120, P = 0.001). Diabetics have significantly lower levels of HDL (OR 2.173, P = 0.001). Diabetics have significantly higher levels of bad cholesterol (LDL and VLDL) (OR= 2.110, P = 0.001) and (OR = 2.194, P = 0.001)respectively. Male diabetics have significantly higher creatinine, which may indicate renal involvement (OR= 1.00, P = 0.048). Group differences in urea are not statistically significant. There were no appreciable variations in the groups for bilirubin and liver enzyme levels (SGPT, SGOT). Albumin and globulin levels varied slightly, but not significantly.

Table 3: Showing the comparison of healthy control and case according to age

S.N.	Parameters	Mean ± SD Control < 60year	Mean ± SD Control > 60year	Mean ± SD Diabetic case < 60year	Mean ± SD Diabetic Case> 60 year	OR	P-value
1	T3 (ng/ml)	1.32 ± 0.21	1.22 ± 0.28	0.56 ± 0.9	0.49 ± 0.5	7.0	0.01*
2	T4 (ug/dl)	8.2± 0.14	7.6± 1.5	4.12 ± 0.31	3.1 ± 0.29	1.734	0.01*
3	TSH (uIU/L)	2.68 ± 1.2	2.42 ± 0.9	12.1 ± 22.4	10.1 ± 19.2	3.147	0.01*
4	T. CHO	138.1 ± 36	152± 39	180 ± 41	203.24 ± 49	3.120	0.001**
5	TG	83.1± 19	88 ± 25	124.46 ± 45	156.38 ± 48	1.592	0.008*
6	HDL	52 ± 8.7	46 ± 6.2	28.1 ± 11	15 ± 1.5	2.173	0.001**
7	LDL	63 ± 18	66.5 ± 19	105 ± 22	132 ± 28	2.110	0.001**
8	VLDL	33.1 ± 12	52.1 ± 18.5	38.1 ± 15.7	44.3 ± 19.2	2.194	0.001**
9	Creatinine	0.71 ± 0.12	0.75 ± 0.10	0.89 ± 0.35	1.21 ± 0.40	1.00	0.048
10	Urea	29.48 ± 6.16	38.1 ± 10.2	31.1 ± 10.4	37.1 ± 9.7	0.792	0.29
11	UA	3.6 ± 1.8	4.1 ± 1.3	7.2 ± 2.9	5.91 ± 1.9	1.392	0.35
12	T. Bilirubin	0.62 ± 0.27	0.69 ± 0.32	0.76 ± 0.35	1.9 ± 0.21	0.129	0.31
13	Conjugated Bilirubin	0.13 ± 0.12	0.16 ± 0.08	0.36 ± 0.06	0.82± 0.31	0.650	0.24
14	Unconjugated Bilirubin	0.42 ± 0.21	0.46 ± 0.24	0.60 ± 0.31	0.51± 1.1	0.192	0.69
15	SGPT	35.1 ± 22.1	31.92 ± 26.9	29.75 ± 28	17.5± 8.2	0.176	0.032
16	SGOT	31.1 ± 12.2	28.97 ± 11.37	35.5 ± 11.67	22.1± 9.25	0.129	0.67
17	ALP	94.1±1.2	93.76 ± 24	91 ± 22	102.8 ± 27	0.212	0.43
18	TP	6.31 ± 0.61	6.5 ± 0.69	9.1 ± 0.60	8.1 ± 0.6	0.229	0.14
19	Albumin	5.5± 0.43	5.1± 0.63	4.7 ± 0.53	4.9 ± 0.53	0.271	0.81
20	Globulin	2.1± 0.41	2.7± 0.46	2.3 ± 0.55	2.1 ± 0.57	0.117	0.27

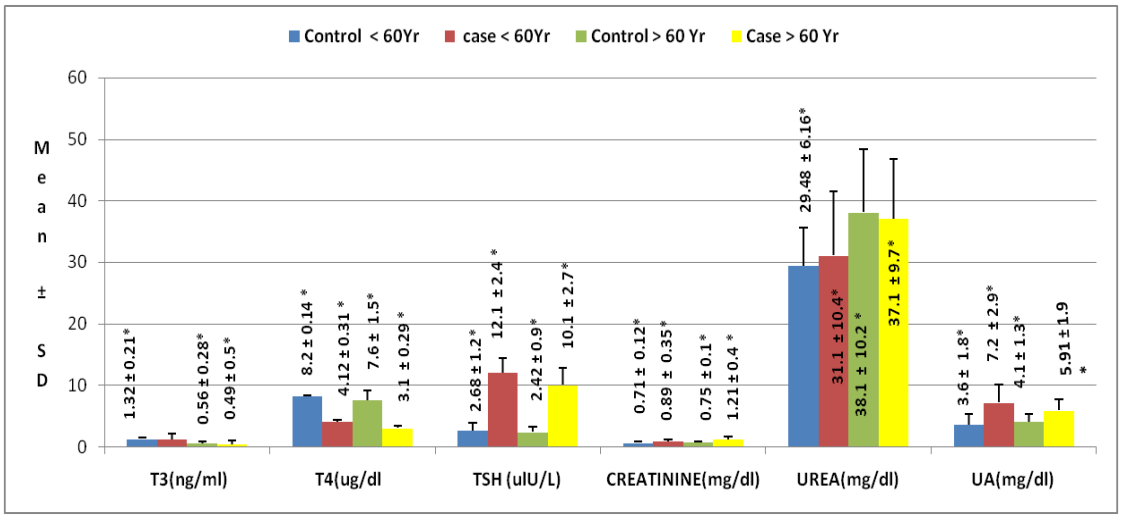

Figure 3(A): Showing the Thyroid profile and RFT in control and case group.

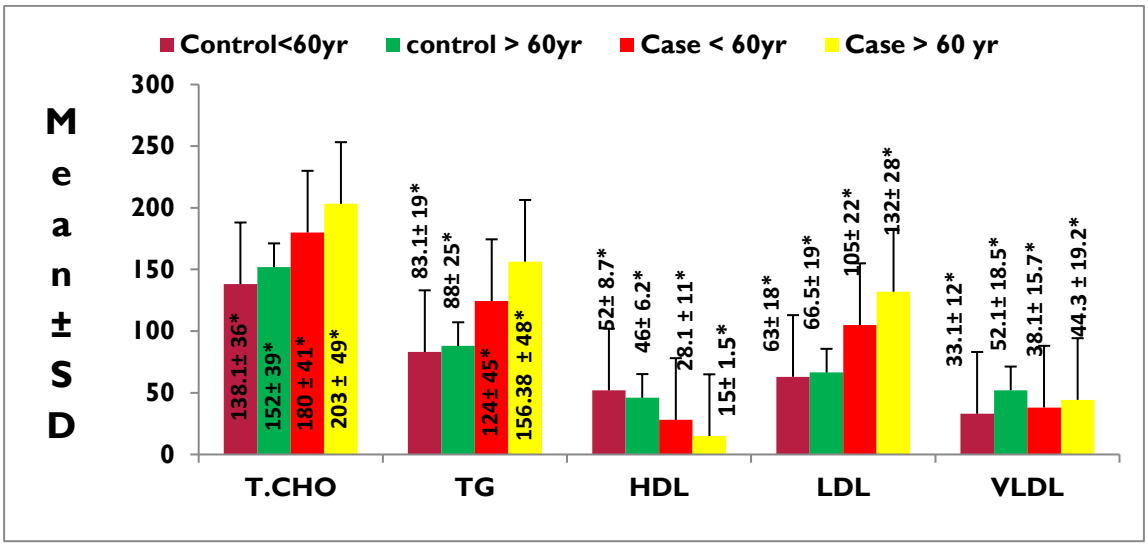

Figure3 (B):Showing the Lipid profilein control and case group.

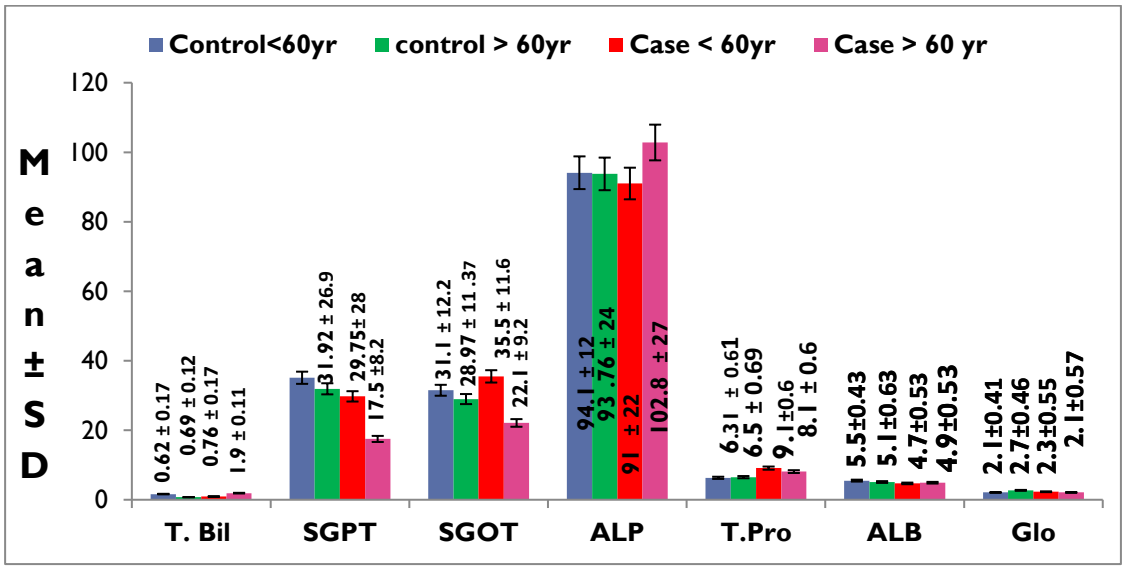

Figure3 (C): Showing the LFT Panel in control and case group.

Table 3 shows that Diabetic patients show significant alterations in thyroid function, lipid profiles, and kidney function markers. Older diabetic patients (>60 years) show more pronounced derangements, particularly in lipid metabolism and renal markers.Diabetic cases have significantly lower levels of T3 and T4 than controls, with ORs of 7.0 and 1.734, and p-values <0.01, indicating hypothyroidism affinities in diabetics.TSH(OR = 3.147, p <0.01) levels was Elevated in diabetics (especially <60 years), suggesting subclinical or overt hypothyroidism. Total cholesterol (T. CHO) (OR = 3.120, p <0.01), triglycerides (TG) (OR = 1.592, p = 0.008), LDL (OR = 2.110, p <0.01), and VLDL (OR = 2.194, p <0.01) are higher in diabetics, especially those >60 years, with significant p-values.HDL (good cholesterol) is significantly lower in diabetics, with a strong p-value of <0.001 and OR 2.173.Creatinine levels are elevated in diabetic cases, particularly in those >60 years (p=0.048, OR = 1.00), indicating declining renal function.While parameters like SGPT, SGOT, and ALP show slight variations, the significance is not as pronounced except for SGPT (OR = 0.176, p=0.032). No significant differences are observed for total and conjugated bilirubin (p > 0.05), except for a slight trend in diabetic cases >60 years.

Table 4: Showing the Comparison of control and case according to gender

Parameters	Mean ± SD Control male>60year (n=37)	Mean ± SD Control female >60year (n=40)	Mean ± SD Diabetic male > 60year (n=65)	Mean ± SD Diabetic female>60 year (n=75)	OR	P-value
T3 (ng/ml)	1.13± 0.30	1.06± 0.27	1.4± 0.9	1.1± 0.3	1.14	0.001**
T4 (ug/dl)	5.64 ± 1.50	5.42 ± 1.57	2.1 ± 1.4	1.8 ± 1.3	1.39	0.001**
TSH (uIU/L)	2.34 ± 1.28	2.67 ± 1.21	38.1 ± 2.4	44.7 ± 1.2	4.26	0.001**
T. CHO	91 ± 32.52	101 ± 32.53	280 ± 26.34	318.4 ± 23.1	3.120	0.001**
TG	36 ± 32.3	40.0 ± 35.29	320 ± 47.34	341 ± 41	1.592	0.001**
HDL	40.7 ± 5.7	42 ± 5.9	29 ± 10	17.1 ± 13.1	2.173	0.001**
LDL	13.4 ± 3.1	20 ± 5.7	61 ± 9.68	67 ± 10.9	2.110	0.001**
VLDL	17.3± 6.4	18 ± 7.08	53 ± 10.7	78.1 ± 14.7	2.194	0.001**
Creatinine	0.46 ± 0.13	0.51 ± 0.14	0.59 ±.0.17	0.63 ± 0.19	1.00	0.07
Urea	21 ± 5.4	20 ± 6.1	22.1± 7.12	36.1 ± 9.5	0.792	0.42
UA	3.0 ± 0.39	3 ± 0.57	3.4± 0.65	4.1 ± 0.69	1.392	0.21
T. Bilirubin	0.69 ± 0.06	0.28 ± 0.07	0.42 ± 0.09	0.72 ± 0.12	0.129	0.10

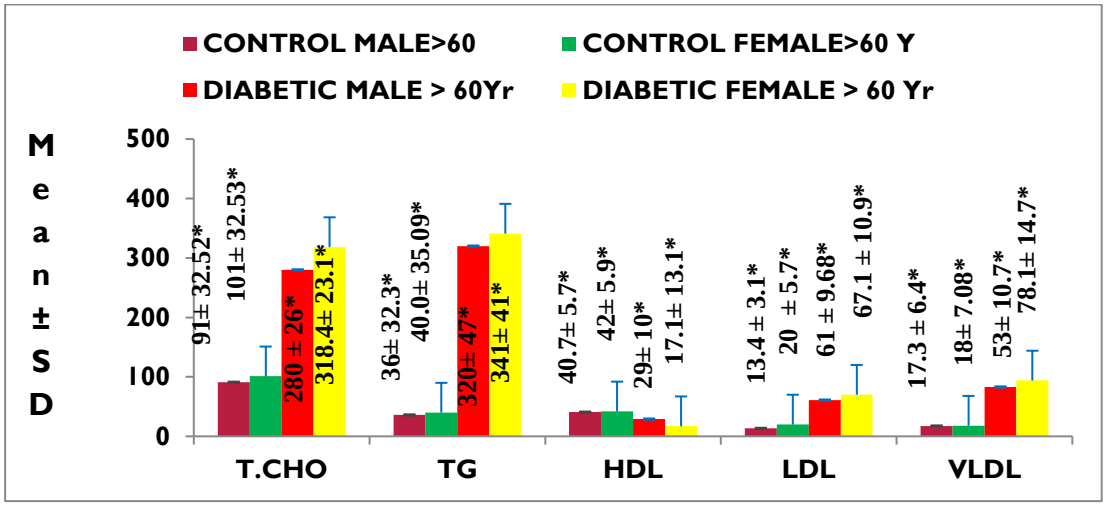

Figure 4 (A): Showing the comparison of Lipid profile in case and control group.

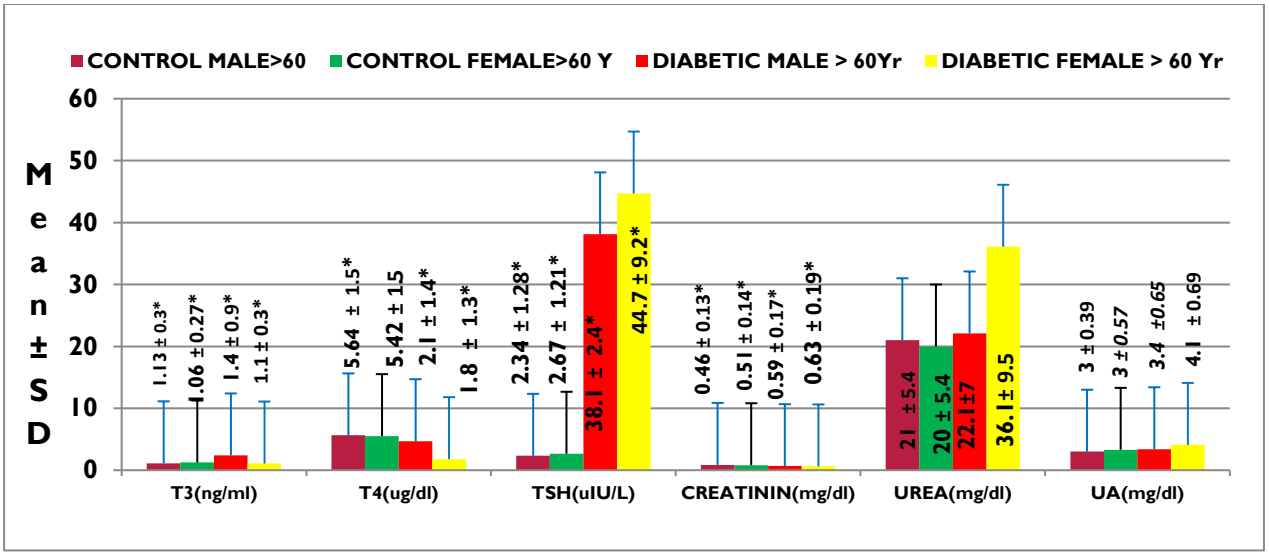

Figure 4(B) Showing the Thyroid profile and RFT in case and control group

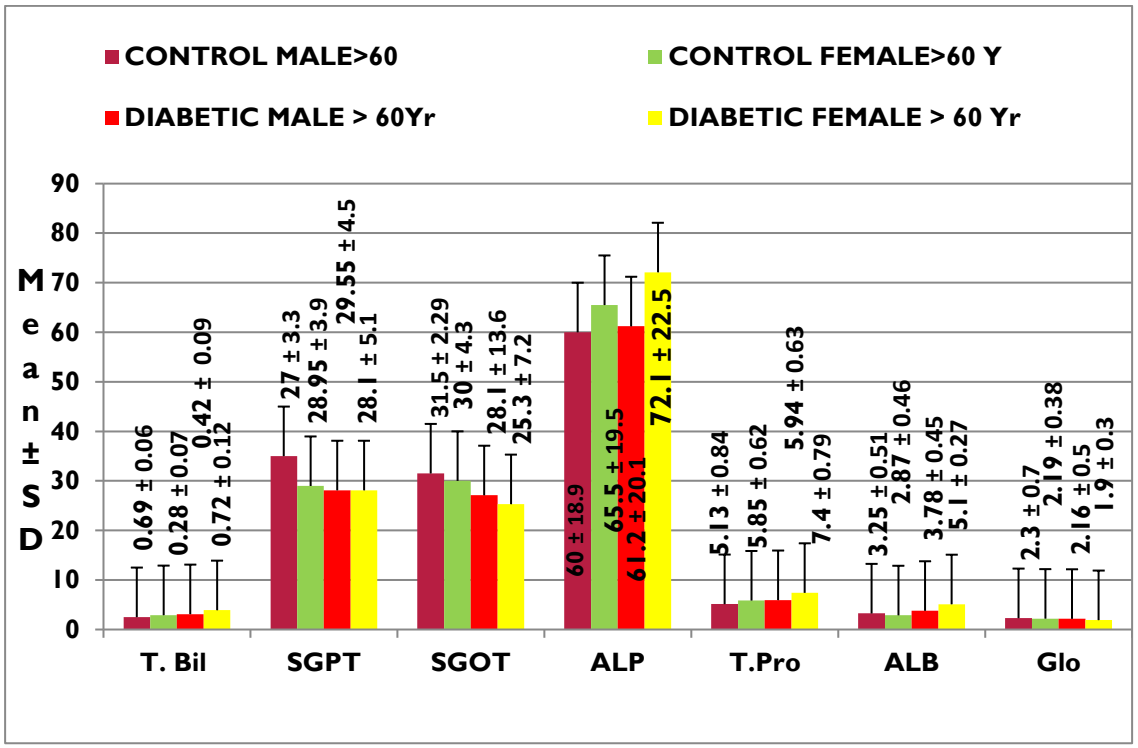

Figure 4 (C)Showing the LFT in case and control group

Figure 4: Comparison of Lipid profile(A), Thyroid Profile, RFT(B) and LFT (C) in case and control group.

Table 4 shows a significant change in thyroid function in diabetic groups compared to controls. T3 and T4 levels are lower in diabetics, especially women, which may indicate hypothyroid trends ($p < 0.001$). TSH is substantially elevated in diabetics (OR = 4.26, $p < 0.001$), suggesting a close association with hypothyroidism. Diabetics have significantly higher levels of total cholesterol (T. CHO), with females having the highest levels (318.4 ± 23.1; OR = 3.12; $p < 0.001$). Triglycerides (TG) were higher in diabetics, particularly women (OR = 1.592, $p < 0.001$). HDL was considerably lower in diabetics, especially in women (17.1 ± 13.1; OR = 2.173; $p < 0.001$). Significant correlations ($p < 0.001$) were observed between elevated LDL(OR = 2.110, $p < 0.001$) and VLDL (OR = 2.194, $p < 0.001$) in diabetics. The creatinine levels of diabetics were marginally higher, but this difference was not statistically significant (OR = 1.00,$p = 0.07$). Urea levels were higher in female diabetics, but the difference was not statistically significant (OR = 0.792, $p = 0.42$). The levels of bilirubin (T. bilirubin(OR

= 0.129, p = 0.1), conjugated(OR = 0.650, p = 0.37), and unconjugated (OR = 0.192, p = 0.61) did not significantly differ between the groups (p > 0.1). SGPT(OR = 0.176, p = 0.1), SGOT(OR = 0.129, p = 0.72), and ALP (OR = 0.212, p = 0.09) group differences were not statistically significant (p > 0.1). Total protein (TP)(OR = 0.229, p = 0.51) and albumin (OR = 0.271, p = 0.31) levels are higher in female diabetics, but these differences are not statistically significant (p > 0.05). Diabetics, especially women over 60, have significant dyslipidemia (higher cholesterol and triglycerides, lower HDL and thyroid dysfunction is common in diabetics, as evidenced by markedly elevated TSH (OR = 4.26, p <0.001) and decreased T3(OR = 1.14, p < 0.001) andT4(OR = 1.39, p<0.001).

Table 5: Comparison of diabetic dyslipidaemia and diabetic non dyslipidaemia group

Parameters	Mean ± SD Diabetic non dyslipidaemia	Mean ± SD Diabetic dyslipidaemia	OR	P value
T3 (ng/ml)	1.69 ± 0.10	0.32± 0.09	3.07	0.001**
T4 (ug/dl)	3.18 ± 0.38	2.73 ± 0.21	2.56	0.001**
TSH (uIU/L)	7.1 ± 1.1	12.12 ± 1.90	3.07	0.001**
Creatinine	0.63 ± 0.13	0.68 ± 0.15	5.65	0.031
Urea	29 ±4.16	31 ± 6.4	1.21	0.004
UA	5.1 ± 1.1	6.3 ± 1.3	2.1	0.001**
T. Bilirubin	0.81 ± 0.13	1.1 ± 0.19	5.90	0.71
Conjugated bilirubin	0.19 ± 0.02	0.31 ± 0.01	1.712	0.01
Unconjugated bilirubin	0.27± 0.17	0.39± 0.21	8.451	0.14
SGPT	32.12 ± 2.7	34.83 ± 3.8	1.24	0.27
SGOT	30 ±2.3	35 ± 2.5	0.165	0.31
ALP	102.8±16.2	111.3±17.4	0.275	0.52
TP	7.2±0.9	8.3±1.2	3.235	0.12
Albumin	4.4±0.67	4.5±0.61	3.0274	0.70
Globulin	2.3±0.47	2.1±0.41	3.301	0.23

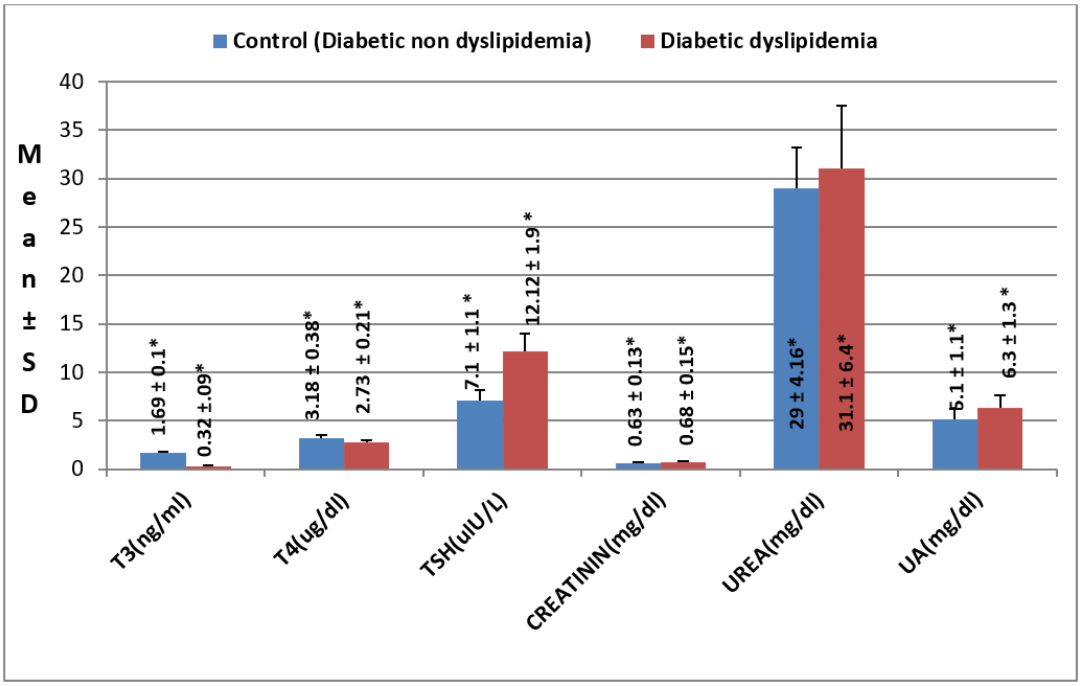

Figure 5(A): Showing the Thyroid profile and RFT of Diabetic non - dyslipidaemia and Diabeticdyslipidaemia group

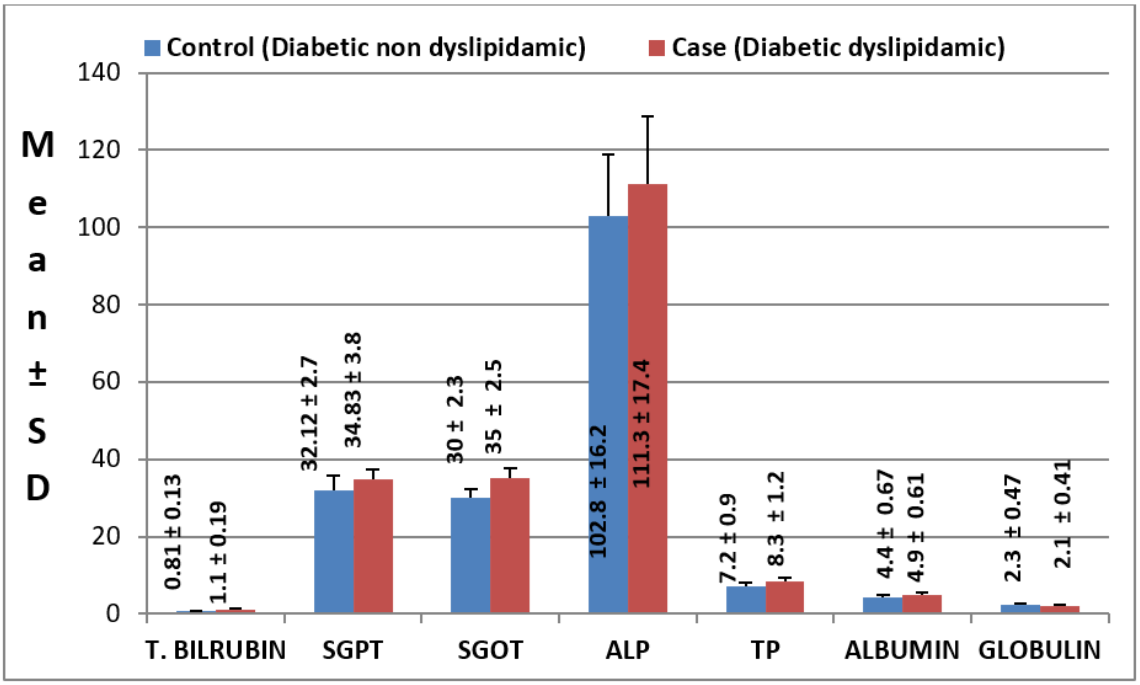

Figure 5 (B): Showing the LFT Panel of Control (Diabetic non – dyslipidaemia) and Case (Diabetic dyslipidaemia) group

Table 5 shown that that T3 levels are significantly lower in dyslipidaemia diabetics (0.32 ± 0.09 ng/ml) than in non-dyslipidaemia diabetics (1.69 ± 0.10 ng/ml); OR = 3.07, p = 0.001, Additionally, there is a significant correlation (p = 0.001**) between the dyslipidaemia group and lower T4 (OR = 2.56, p = 0.001) levels. TSH levels in dyslipidaemia diabetics are significantly higher (12.12 ± 1.90 uIU/L) than in non-dyslipidaemia diabetics (7.1 ± 1.1 uIU/L), OR = 3.07, p = 0.001). The creatinine level was marginally higher in the dyslipidaemia group (0.68 ± 0.15 mg/dl, OR = 5.65, p = 0.031), and this difference was statistically significant. Moreover, urea levels were higher in dyslipidaemia diabetics (31 ± 6.4 mg/dl), with a statistically significant difference (OR = 1.21, p = 0.004). In comparison to the non-dyslipidaemia group (5.1 ± 1.1 mg/dl), the dyslipidaemia group's UA levels (6.3 ± 1.3 mg/dl) are significantly higher(OR = 2.1, p = 0.001). The levels of total and conjugated bilirubin in the dyslipidaemia group are marginally higher, but they differ in statistical significance: Conjugated bilirubin is significant (OR = 1.712, p = 0.01). Unconjugated bilirubin does not differ statistically significantly (OR = 8.451, p = 0.14). SGPT (OR = 0.176, p = 0.1) and SGOT(OR = 0.129, p = 0.72) are marginally higher in the dyslipidaemia group, but the differences are not statistically significant (p > 0.05). ALP(OR = 0.212, p = 0.09) is marginally higher in dyslipidaemia diabetics, but this difference is not statistically significant (p >0.05). TP (OR = 3.235, p = 0.12) levels are higher in the dyslipidaemia group, but the difference is not statistically significant. The albumin levels do not differ significantly (OR = 3.0274, p = 0.7). The globulin level lower in dyslipidaemia diabetics, but the difference is not significant (OR = 3.301, p = 0.23). Significantly lower thyroid hormone levels (T3, T4) with higher TSH, slightly impaired renal function (elevated creatinine and urea), strongly correlated elevated uric acid levels, and no observable changes in liver enzymes (SGPT, SGOT) or proteins (TP, albumin) are all present in dyslipidaemia diabetics.

Table 6: Comparison of control group (healthy male >60 year and healthy female>60Year) and case group (diabetic dyslipidaemia male >60 year and diabetic dyslipidaemia female > 60 year).

Parameters	Mean ± SD Control male (> 60 yr)	Mean ± SD Control female (> 60 yr)	Mean ± SD Case (Diabetic dyslipidaemia)male > 60 yr	Mean ± SD Case (Diabetic dyslipidaemia) female> 60 yr	OR	P-value
T3 (ng/ml)	1.13 ± 0.30	1.78 ± 0.27	0.41 ± 0.11	0.37 ± 0.12	6.12	0.001**
T4 (ug/dl)	5.64 ± 1.50	5.52 ± 1.57	1.73 ± 0.21	1.2 ± 0.2	4.29	0.001**
TSH (uIU/L)	1.64 ± 0.28	2.9 ± 0.12	12.12 ± 2.37	13.4 ± 3.12	8.61	0.001**

Creatinine	0.91 ± 0.3	0.82 ± 0.2	0.68 ± 0.1	0.39 ± 0.21	4.12	0.29
Urea	22 ± 4.3	23 ± 4.29	31.1 ± 3.4	27. ± 3.1	3.52	0.13
UA	4.7 ± 1.5	4.2 ± 1.9	6.3 ± 1.3	6.2 ± 1.4	4.15	0.17
T. Bilirubin	1.3 ± 0.38	1.2 ± 0.34	1.6 ± 0.42	2.1 ± 0.92	2.71	0.80
Conjugated bilirubin	0.73 ± 0.11	0.8 ± 0.13	0.18 ± 0.010	0.15 ± 0.03	3.25	0.01
Unconjugated bilirubin	0.46 ± 0.13	0.51 ± 0.12	0.39 ± 0.21	0.87 ± 0.29	4.12	0.19
SGPT	21 ± 5.4	20 ± 6.1	32.12 ± 7.2	33.1 ± 6.7	1.37	0.27
SGOT	30.2 ± 3.39	32.2 ± 3.57	32.29 ± 5.4	32.7 ± 5.2	2.19	0.31
ALP	109.3 ± 20.5	106.3 ± 19.6	111.3 ± 27.6	114.3 ± 22.4	3.17	0.49
TP	7.1 ± 0.12	6.5 ± 0.85	5.1 ± 0.32	6.1 ± 0.28	4.19	0.12
Albumin	4.2 ± 0.09	4.4 ± 0.09	3.1 ± 0.9	2.9 ± 0.72	8.13	0.24
Globulin	2.7 ± 0.7	2.9± 0.8	2.1 ± 0.9	3.1 ± 0.62	3.41	0.14

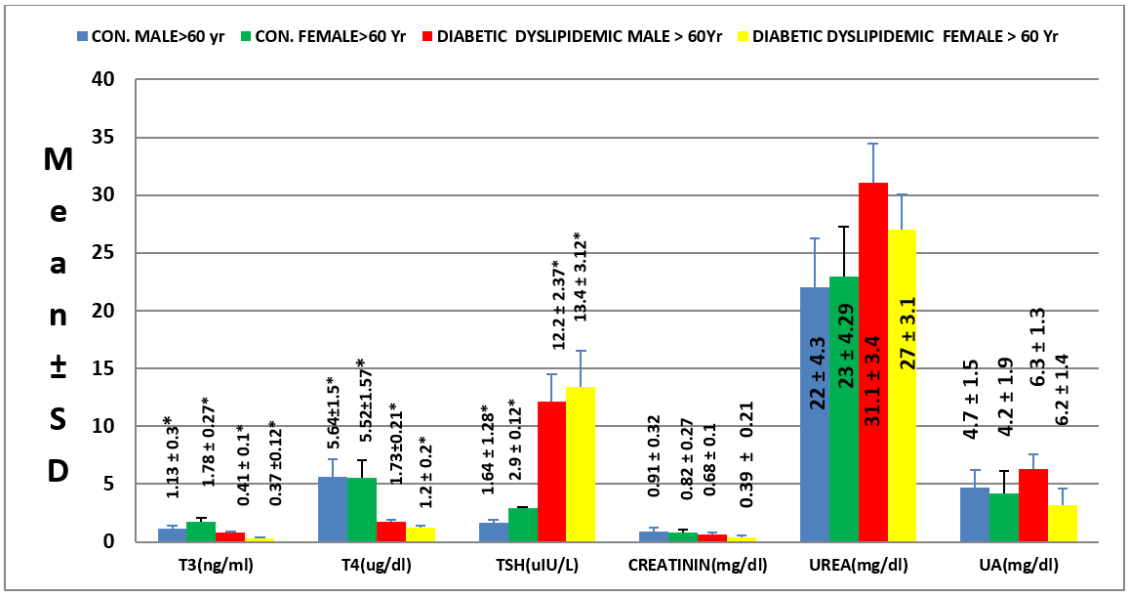

Figure6 (A):Showing the Thyroid Profile in control and case group

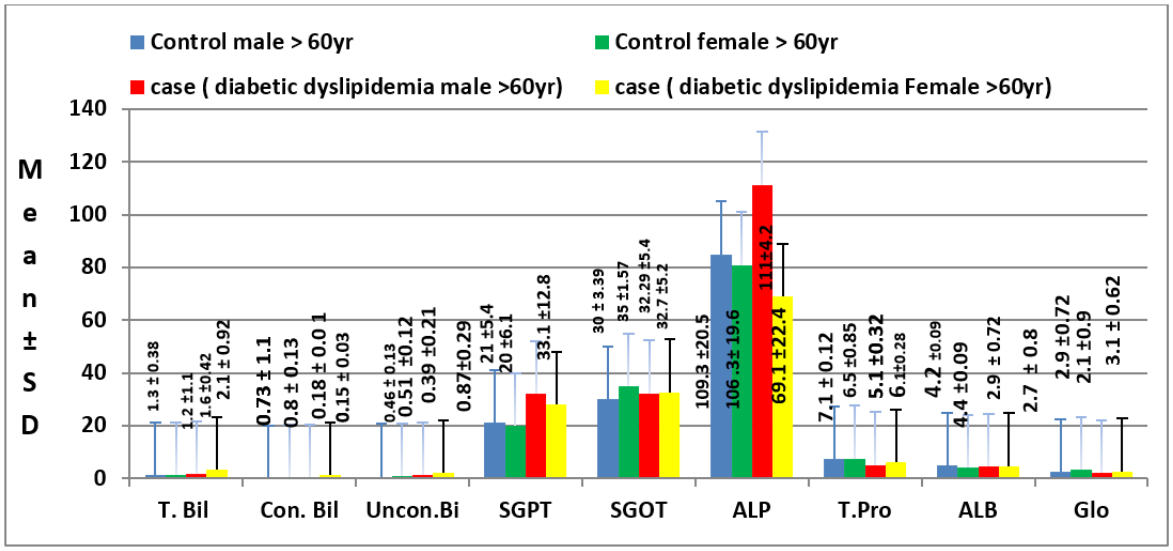

Figure 6 (B): Showing the LFT in control and case (>60 Yr) group

Figure 6: Comparison of Thyroid profile and RFT (A) and LFT (B) in control group (healthy male and healthy female) and case group (diabetic dyslipidaemia male and diabetic dyslipidaemia female)

Table 6 demonstrates that T_3(OR= 6.12,p=0.001) and T_4 (OR= 4.29,p=0.001) levels are significantly lower in patients with diabeticdyslipidaemia than in controls, with female patients having the lowest levels. Significant thyroid dysfunction is indicated by significantly higher TSH (OR= 8.61,p=0.001) levels in diabetic dyslipidaemia cases when compared to controls. Although not statistically significant, diabetic dyslipidaemia females have lower creatinine (OR= 4.12,p=0.29)levels than controls. Although urea levels in diabetic dyslipidaemia cases (OR= 3.52,p= 0.13)are higher than in controls, the difference is not statistically significant. Although not statistically significant(p=0.17), diabeticdyslipidaemia cases had elevated UA (OR = 4.15,p= 0.17)when compared to controls. While there is no significant difference in totalbilirubin (OR= 2.71,p= 0.80) or unconjugated bilirubin(OR=4.12, p=0.19)levels, diabetic dyslipidaemia cases have significantly lower conjugated bilirubin (OR= 3.25,p= 0.01) levels than controls. There are no discernible variations in SGPT(OR= 1.37,p= 0;27), SGOT (OR= 2.19,p= 0.31), and ALP(OR=3.17,p= 0.49)levels between groups. Although not statistically significant, total protein (TP)(OR= 4.19,p= 0.12)and albumin levels(OR= 8.13,p= 0.24)are lower in diabetic dyslipidaemia cases, particularly in females. Regarding globulin, (OR= 3.41,p= 0.14)there is no discernible variation between the groups. While other parameters show less noticeable changes, this analysis emphasizes the strong correlation between thyroid dysfunction and changed bilirubin levels in diabetic dyslipidaemia patients.

Table No. 7. Comparison of control group (healthy male and healthy female) and case group (diabetic dyslipidaemia male anddiabetic dyslipidaemia female).

Parameters	Mean ± SD Control male	Mean ± SD Control female	Mean ± SD Diabetic dyslipidaemia male	Mean ± SD Diabetic dyslipidaemia female	OR	P-value
T3 (ng/ml)	0.92 ± 1.1	1.13 ± 0.28	0.7 ± 0.1	0.2 ± 0.01	0.32	0.01**
T4 (ug/dl)	5.85 ± 1.75	5.19 ± 1.6	2.6 ± 1.91	0.98 ± 0.2	0.12	0.01**
TSH (uIU/L)	0.48 ± 1.19	0.51 ± 1.1	12.1 ± 11.2	13.1 ± 19.4	0.51	0.01**
Creatinine	0.37 ± 0.16	0.41 ± 0.14	0.51 ± 0.12	0.39 ± 0.21	0.59	0.035
Urea	20 ± 6.02	20 ± 5.7	35 ± 8.1	27. ± 3.1	5.23	0.069
UA	3 ± 1.4	3 ± 1.36	3.9 ± 0.74	3.2 ± 0.12	3.41	0.21
T. Bilirubin	0.2 ± 0.03	0.2 ± 0.04	0.28 ± 0.04	0.31 ± 0.05	1.25	0.71
Conjugated bilirubin	0.6 ± 0.05	0.05 ± 0.04	0.9 ± 0.017	0.5 ± 0.012	1.9	0.01
Unconjugated bilirubin	0.14 ± 0.02	0.15 ± 0.50	0.17 ± 0.02	0.47 ± 0.03	1.3	0.19
SGPT	26 ± 8.9	13 ± 9.2	23.1± 8.2	28.1 ±12.8	2.1	0.27
SGOT	30 ± 7.2	32 ± 6.1	36.4±19.1	32.7 ±16.2	2.7	0.31
ALP	51 ± 11.4	61.1 ± 39.5	63.1 ±1.7	69.1 ± 14.4	3.51	0.52
TP	4.43 ± 0.82	5.12 ± 0.78	4.9 ± 0.21	6.1 ± 0.28	1.43	0.12
Albumin	2.63 ± 0.6	2.87 ± 0.5	3.1 ± 1.2	2.9 ± 0.72	0.71	0.24
Globulin	2.78 ± 0.24	2.8 ± 0.24	2.9 ± 0.28	2.7 ± 0.22	0.53	0.74

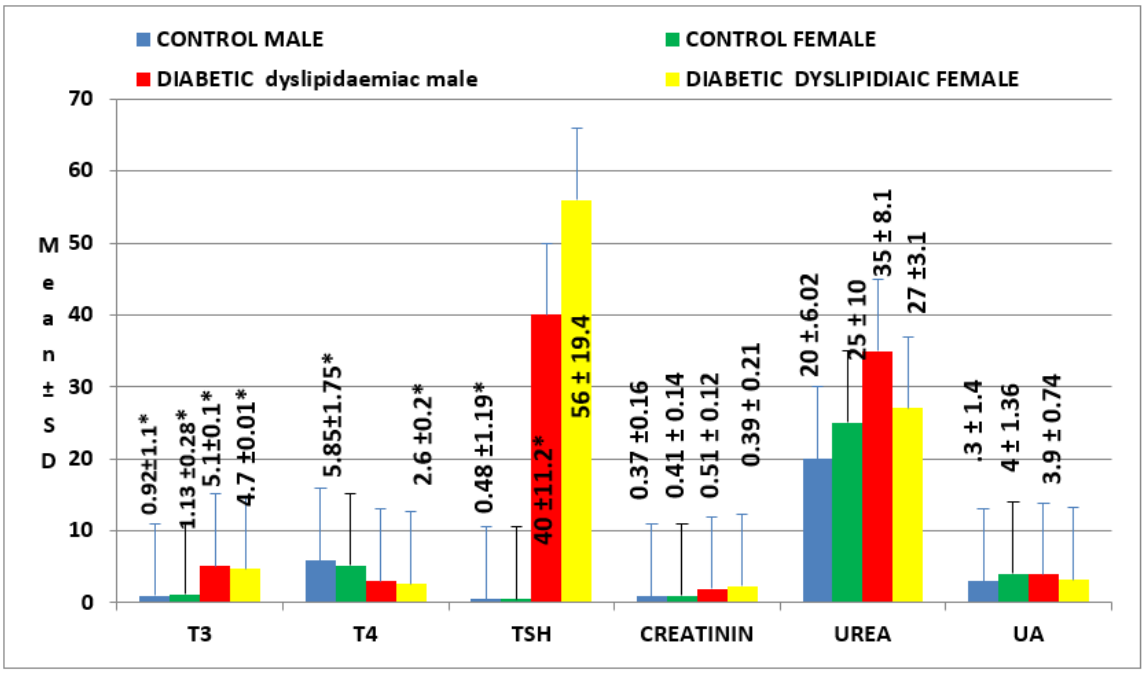

Figure 7(A)Showing the Thyroid Profile and RFT in control and case

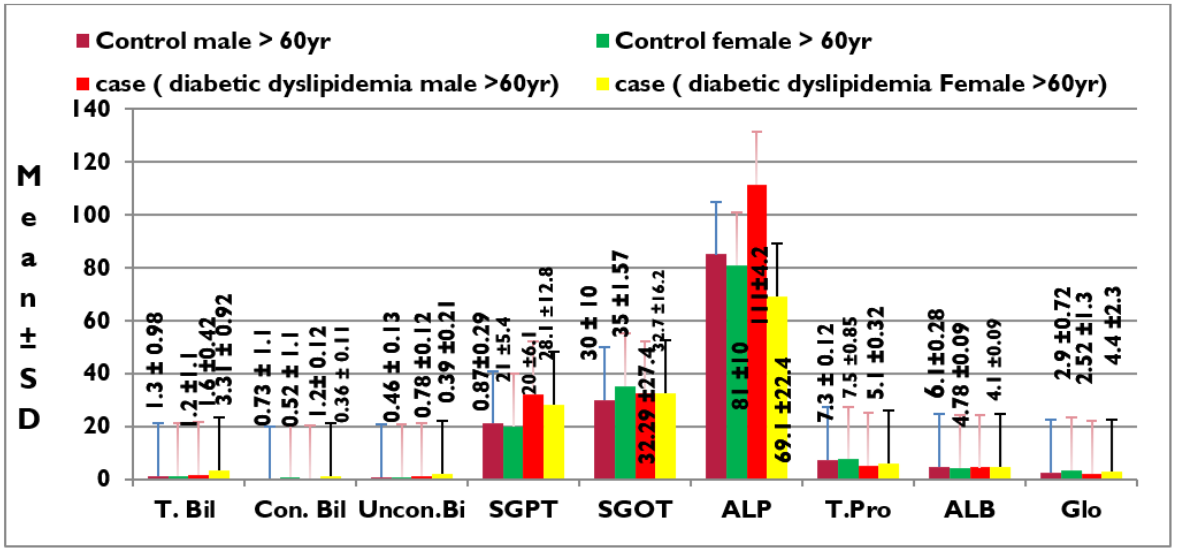

Figure7 (B): LFT in control group (healthy male and healthy female) and case group

Figure7: Showing the Comparison of TFT, KFT (A) and LFT (B) in control group (healthy male and healthy female) and case group (diabetic dyslipidaemia male and diabetic dyslipidaemia female)

Table 7 demonstrates that thyroid dysfunction is indicated by significantly lower T3 (OR = 0.32, P =0.01) and T4(OR = 0.12, P =0.01) levels in diabetic dyslipidaemia individuals, especially in females, when compared to controls (p=0.01). When compared to controls, diabetic dyslipidaemia individuals had elevated TSH levels (OR = 0.51, P =0.01), which is consistent with hypothyroidism. Creatinine, Lower in females and slightly higher in males with diabetic dyslipidaemia than in controls (OR = 0.59, P=0.035), indicating mild renal impairment. Males with diabetes and dyslipidaemia had higher urea levels, but there was no discernible difference (OR = 5.23, P =0.069). Compared to controls, diabetic dyslipidaemia cases had higher levels of conjugated bilirubin (OR = 1.9, P =0.01). Compared to other groups, diabetic dyslipidaemia females had slightly higher levels of total protein (TP) (OR = 0.32, P =0.01) (p=0.12). Uric acid (OR = 3.41, P =0.21), totalbilirubin(OR = 1.25, P =0.71)and unconjugated bilirubin (OR =1.3, P =0.19), liver enzymes SGOT (OR = 2.7, P =0.31)SGPT (OR = 2.1, P = 0.27)ALP (OR = 3.51, P =0.52), Total proteins (OR = 1.43, P =0.12), albumin (OR = 0.71, P =0.24) , and globulin(OR = 0.53, P =0.74) are among the other parameters that exhibit non-significant fluctuations.

4. DISCUSSION

This study assesses the dyslipidaemia pattern in individuals with hypothyroidism and diabetes mellitus (DM). One important risk factor for cardiovascular diseases is dyslipidaemia, which can be difficult to manage when hypothyroidism and diabetes mellitus coexist [16,17]. Patients with diabetes mellitus and hypothyroidism had significantly higher levels of glycaemic parameters, such as fasting blood sugar (FBS), postprandial blood sugar (PPBS), and random blood sugar (RBS), than the control group ($p < 0.001$ for all) [18,19,44]. These results imply that hypothyroidism has a compounding effect on glycaemic control. By reducing insulin secretion and sensitivity, hypothyroidism is known to disrupt glucose metabolism and exacerbate hyperglycaemia in diabetic patients [20]. This emphasizes the need for strict glycaemic control in this patient subgroup [21, 22]. The group with DM and hypothyroidism had significantly higher TSH levels than the control group, according to thyroid function tests, with a p-value <0.001 [23]. This is consistent with the diagnosis of hypothyroidism. However, there was no statistically significant difference in T3 and T4 levels, which could be due to the variable severity of hypothyroidism or the impact of continuous thyroid hormone replacement therapy [24,25]. The combination of diabetes and thyroid dysfunction creates a metabolic environment that is conducive to dyslipidaemia and poor glycaemic outcomes [26, 27,44]. The study showed a clear pattern of dyslipidaemia in DM patients with hypothyroidism; the DM with hypothyroidism group had higher levels of total cholesterol (T. CHO, TG, LDL, and VLDL) than the controls (p-value <0.001) [28]. Triglyceride (TG) levels were significantly higher in the DM with hypothyroidism group than in the control group (p-value <0.001) [29–31].

These results demonstrate how diabetes and hypothyroidism affect lipid metabolism in tandem. Diabetes impairs lipoprotein clearance, which raises triglyceride and LDL levels, while hypothyroidism decreases LDL receptor activity and hepatic cholesterol metabolism [32,44]. Patients who exhibit this pattern are more likely to experience cardiovascular problems [33, 34]. High-density lipoprotein (HDL) levels, on the other hand, did not significantly differ between the two groups ($p = 0.74$), suggesting that the co-occurrence of DM and hypothyroidism may have less of an impact on HDL metabolism [35,36]. Nonetheless, the wide range of HDL levels in the group of people with diabetes mellitus who also had hypothyroidism points to individual variations impacted by the length of the illness, adherence to treatment, or other variables [37-39].

A significant risk of cardiovascular complications arises from the combined effects of diabetes mellitus and hypothyroidism on lipid metabolism [40,41]. A pro-atherogenic state is produced by the combined effects of hyperglycaemia, elevated LDL, and VLDL levels, highlighting the significance of thorough lipid management in lowering cardiovascular morbidity [42 - 44]. To reduce cardiovascular risk, a comprehensive strategy that incorporates pharmacological treatments like fibrates and statins with lifestyle changes is essential [45,46].

5. STRENGTHS AND LIMITATIONS:

This study clarifies how diabetes mellitus, hypothyroidism, and dyslipidaemia interact. Its cross-sectional design, however, makes it more difficult to prove causation. Additionally, a number of variables that might have affected the observed lipid profile were not thoroughly investigated, including the length of time that the patient had diabetes and hypothyroidism, treatment compliance, and the effect of thyroid hormone replacement therapy.

6. CONCLUSION:

The study identifies a noteworthy pattern of dyslipidaemia, which is defined by elevated levels of total cholesterol, triglycerides, LDL, and VLDL, in DM patients with hypothyroidism. In order to address the dual metabolic burden of diabetes and hypothyroidism and lower the related cardiovascular risks, these findings highlight the significance of integrated management approaches.

7. ADDITIONAL INFORMATION

Disclosures:

Human subjects: Consent for treatment and open access publication was obtained or waived by all participants in this study. Ethical approval for the project approved by Institutional ethics committee, Pacific Medical College and Hospital, Udaipur, Rajasthan, India. Informed written patient consent form for treatment and publication in open access journal has been obtained from each study participant prior to enrollment in study and sample collection.

Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue.

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work.

Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other relationships: All authors have declared that there are no other relationships or activities that could appear to have

influenced the submitted work.

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