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Original article

Anaemia, Dyslipidaemia and Electrolytes Imbalance in Type 2 Diabetes Mellitus: An analytical Cross-Sectional Study

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ABSTRACT

Type 2 diabetes mellitus (T2DM) is characterized by chronic hyperglycaemia resulting from defects in insulin secretion and/or insulin action and metabolic disorders of protein and lipids. Diabetic dyslipidaemia is a risk factor of the early development of coronary heart disease (CHD). Electrolyte imbalance also are common in diabetic patients and may be associated with increased morbidity and mortality. Furthermore, Anaemia in diabetic patient has a significant adverse effect on quality of life. Therefore, early detection of anaemia, dyslipidaemia and electrolyte imbalance may reduce the prevalence of complications in T2DM. This study was carried out to assess the prevalence and correlation of anaemia, dyslipidaemia, electrolyte imbalance in T2DM. A number of 50 T2DM patients' demographic, biochemical and clinical data was collected from Zliten Medical Centre, Diabetes and Endocrinology Centres in Alkhoms & Zliten and Bin Haider Medical Laboratory. The raw data was classified and then analysed by the SPSS software. The results show that hypomagnesaemia is found to be prevalent pattern of electrolyte imbalance in T2DM patients (42/50) 84%. Hypertriglyceridemia (25/50) 50%, high VLDL (25/50) 50% and high LDL-cholesteraemia (20/50) 40%. Anaemia is shown to be endemic in T2DM patients which was determined by Hb level and found to be (39/50) 78%. Furthermore, T2DM was found to be uncontrolled in almost all of the study's patients (49/50) 98%. In conclusion, anaemia, dyslipidaemia is very common in our study and high electrolyte imbalance is only represented by hypomagnesaemia.

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a complex disorder that involves multiple organ systems. The pathophysiology of T2DM has been linked to several systems besides the pancreas. Reduced skeletal muscle glucose reuptake, increased hepatic glucose production in the liver, decreased gut incretin effect (metabolic hormone that promotes a reduction in blood glucose levels), increased pancreatic α cell glucagon secretion, increased fat cell lipolysis, increased kidney glucose retention, and even brain hypothalamic insulin resistance are contributing to pathology of T2DM (1).

Electrolytes are essential for numerous bodily functions, including blood coagulation, neuronal transmission, muscle contraction, acid-base balance (pH), and fluid regulation. It takes calcium, sodium, and potassium to maintain the right electrolyte balance. Patients with type 2 diabetes frequently have electrolyte imbalances. The aetiology is typically complex, but insulin insufficiency leads to hyperglycaemia and diabetic ketoacidosis (2).

One of the most frequent and widespread blood-related disorders that affects diabetic patients is anaemia. It mainly affects those with diabetes who also have renal impairment. However, the early onset of anaemia in diabetic patients who do not have renal impairment, indicate that anaemia can also have other causes (3).

High triglyceride levels and reduced high-density lipoprotein (HDL) cholesterol are hallmarks of the dyslipidaemias associated with type 2 diabetes (T2DM), and these changes are seen years before clinically significant hyperglycaemias manifests. It has been postulated that low HDL cholesterol may be a an independent risk factor for both the onset of diabetes and cardiovascular disease (4). Hypertriglyceridemia plays a significant role in the acceleration of atherosclerosis in diabetes mellitus and insulin-resistant diseases, together with elevated small dense LDL cholesterol and low HDL cholesterol levels (5).

The failure of the kidney to produce appropriate erythropoietin is an essential cause of the existence of anaemia among T2DM patients. For this reason, anaemia is more prevalent in T2DM patients with renal impairment (6). In addition, anaemia in T2DM patients can be a result of chronic low-grade inflammation which can affect bone marrow to produce normal levels of blood (7). Anaemia is commonly unrecognized in a considerable number of T2DM patients as both diseases share similar symptoms like pale skin, and shortness of breath (8).

T2DM is associated with a two- to fourfold excess risk of atherosclerosis, particularly coronary heart disease (CHD) and peripheral arterial disease. Dyslipidaemia may lead to the early development of CHD (4). Electrolyte imbalance is commonly present in T2DM patients. Insulin deficiency in diabetic ketoacidosis and hyperglycaemia is usually the result of loss of body fluids and electrolytes (9). Electrolyte imbalance are common in diabetic patients and may be associated with increased morbidity and mortality (10). This study was designed to evaluate electrolytes imbalance, dyslipidaemia and anaemia in T2DM.

METHODS

Study design

This analytical cross-sectional study was conducted during the period of January 28th to June 17th 2020. The raw data of 50 T2DM was collected in a collection form. Secondary data was obtained Zliten Medical Centre, Diabetes and Endocrinology Centres in Alkhoms & Zliten and Bin Haider Medical Laboratory.

Data collection

Information related to T2DM patients' data namely, demographic data (age, gender, residence, occupation & level of Education), medical history (hypertension, smoking & duration of T2DM, DM medication, other medications, DM family history and DM complications) and laboratory data (FBS, HbA1c, Na, K, Cl, Mg, LDL, HDL, TC, VLDL, TG & CBC) were obtained from their file registry.

Statistical analysis

Statistical Analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 24 (SPSS for Windows, Chicago, IIIinois). Descriptive analysis was used to analyse the data. Then, Pearson's correlation coefficient test was used to find the association between the variables. A *p-value <0.05* was considered to be statistically significant and a *p-value <0.05* was considered to be strongly significant.

RESULTS

Clinical and Biochemical Description of T2DM Patients

As shown in Table 1 a total of 50 T2DM patients were involved and analysed, out of which (21 /50) 42% were female, (29/50) 58% were male, (25/50) 50% patients were hypertensive and (11/50) 22% were smokers. T2DM medications, patients on Insulin medication were (22/50) 44% while those on Metformin medication were (24/50) 48% and combination of Insulin and Metformin medication was found to be (4/50) 8%. DM family history was found in (25/50) 50% of T2DM patients. Complications of T2DM were found as following: visual impairment was found in (15/50) 30% T2DM patients, renal failure was found in (2/50) 4% T2DM patients while both heart disease & visual impairment were found in (1/50) 2% T2DM patients.

The information on quantitative parameters of study show that the mean age was 56.02±15.027 years, the mean for duration of diabetes was 8.84±5.97. Mean fasting blood glucose was 165.60±45.44 and the mean for HbA1c was

9.83±1.52. Amongst electrolytes, mean serum potassium was 3.88±0.45, mean serum sodium was 138.75±3.14, while the mean chloride was 101.22±3.86 and the mean magnesium was 1.08±0.35. For lipid profile, mean TC was 218.03±35.72, mean TG was 156.35±40.85, mean HDL-c was 51.14±2.89, mean LDL-c was 135.57±33.72 and mean VLDL-c was 31.27±8.17. For the CBC parameters, mean of WBCs was 7.26±2.73, mean of RBCs was 4.16±0.69, mean of Hb was 11.31±1.88, mean of HCT was 31.01±4.72, mean of MCV was 75.23±4.70, mean of lymphocyte was 30.29±9.81 and mean of neutrophils was 60.15±10.47.

Table 1. Description of clinical and biochemical parameters

Parameters		Female	Male	Total
Age		53.95± 13.67	57.52±16.01	56.02±15.027
Gender		(21/50) 42%	(29/50) 58%	(50/50) 100%
Hypertension	**Hypertensive**	(9/21) 42.9%	(16/29) 55.2%	(25/50) 50%
	Non-hypertensive	(12/21) 57.1%	(13/29) 44.8%	(25/50) 50%
Smoking	**Smokers**	(0/21) 0%	(11/29) 37.9%	(11/50) 22%
	Non-smokers	(21/21) 100%	(18/29) 62.1%	(39/50) 78%
T2DM Medications	**Insulin**	(9/21) 42.9%	(13/29) 44.8%	(22/50) 44%
	Metformin	(9/21) 42.9%	(15/29) 51.7%	(24/50) 48%
	Insulin + Metformin	(3/21) 14.3%	(1/29) 3.4%	(4/50) 8%
DM Family History	**DM Family History**	(10/21) 47.6%	(15/29) 51.7%	(25/50) 50%
	No DM Family History	(11/21)52.4%	(14/29) 48.3%	(25/50) 50%
T2DM Complications	**Not Applicable (NA)**	(3/21) 14.3%	(1/29) 3.4%	(4/50) 8%
	No Complications	(12/21)57.1%	(16/29) 55.2%	(28/50) 56%
	Visual Impairment	(6/21) 28.6%	(9/29) 31%	(15/50) 30%
	Renal Failure	(0/21) 0.0%	(2/29) 6.9%	(2/50) 4%
	Heart Disease & Visual Impairment	(0/21) 0.0%	(1/29) 3.4%	(1/50) 2%
T2DM Duration		8.48±5.29	9.1±6.51	8.84±5.97
FBS		174.81±57.04	158.93±34.35	165.60±45.44
HbA1c		9.84±1.52	9.83±1.55	9.83±1.52
Potassium		3.87 ±0.26	3.88±0.56	3.88±0.45
Chloride		102.23 4.43	100.49±3.27	101.22±3.86
Magnesium		1.05±0.34	1.10±0.36	1.08±0.35
Sodium		138.42±3.27	138.99±3.08	138.75±3.14
TC		220.00±32.97	216.60±38.10	218.03±35.72
TG		151.43±27.67	159.92±48.40	156.35±40.85
HDL-c		50.15±2.50	51.86±2.99	51.14±2.89
LDL-c		139.54±30.74	132.69±35.98	135.57±33.72
VLDL-c		30.29±5.54	31.98±9.68	31.27±8.17
Bilirubin		0.51±0.26	0.44±0.22	0.47±0.24
WBC		6.42±2.62	7.87±2.70	7.26±2.73
RBC		3.70±0.39	4.49 ±0.68	4.16±0.69
Platelets		288.00±83.65	254.10±59.95	268.34±72.08
Hb		9.59 ±0.97	12.56±1.28	11.31±1.88
HCT		26.75±2.33	34.09±3.41	31.01±4.72
MCV		73.38±4.56	76.57±4.40	75.23±4.70
Lymphocyte		30.04±12.12	30.47±7.97	30.29±9.81
Neutrophils		59.64±12.71	60.52±8.72	60.15±10.47

Hyperglycaemia is shown to be extremely high in T2DM patients (43/50) 86% and T2DM was found to be uncontrolled in almost all of the study's patients (49/50) 98%. Hypomagnesemia is shown to be prevalent pattern of electrolyte

imbalance in T2DM patients (42/50) 84%. While, hypokalaemia was shown to be less common in T2DM patients (10/50) 20%. The overall Electrolyte Imbalance was found to be 18%. Dyslipidaemia pattern was determined in T2DM patients by hypercholesteraemia (33/50) 66% hypertriglyceridemia (25/50) 50%, high VLDL (25/50) 50% and high LDL-cholesteraemia (20/50) 40%. The overall Dyslipidaemia pattern was found to be 50.5%. Anaemia is shown to be endemic in T2DM patients which was determined by Hb level and found to be (39/50) 78%. The classified anaemia pattern in T2DM patients was found as mild anaemia (17/50) 34% and moderate anaemia (21/50) 42% as shown in figure 1. The prevalence of low haematocrit level, low MCV and erythrocytopenia are (43/50) 86%, (23/50) 46% and (30/50) 60%, respectively.

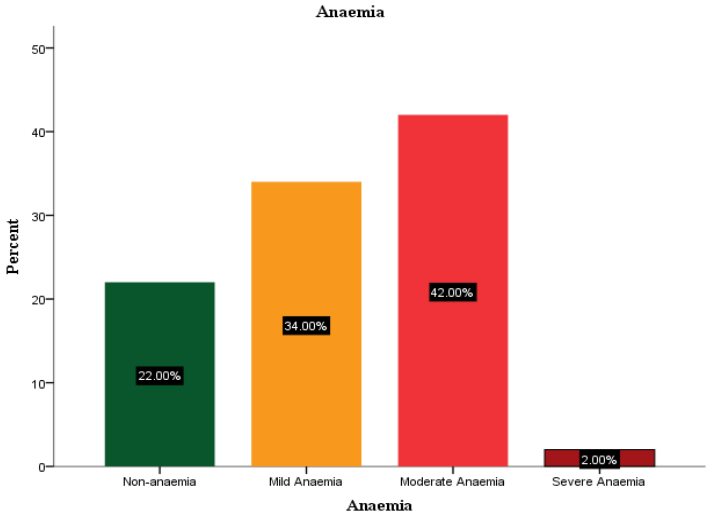

Figure 1. Anaemia Groups in T2DM

The Correlation between Variables of the Study in T2DM Patients

Correlation between Diabetic Control & Glycaemia and Different Variables of the Study in T2DM Patients

FBS was found to have significant positive correlation with age (r =.403**, p=0.004), Age Groups (r =.439**, p=0.001), DM duration (r =.406**, p=0.003), LDL (r =.364**, p=0.009) and TC (r =.364**, p=0.009). While HbA1c was found to have significant positive correlation with FBS (r =0.656**, p=0.000), LDL (r =0.407**, p=0.003) and TC (r =0.406**, p=0.003) (Table 2).

Table 2. Correlation between HbA1c & FBS and different variables of the study in T2DM patients.

Variables	Correlation	Age	Age Groups	FBS	DM Duration	LDL	TC
FBS	**Pearson Correlation**	.403**	.439**	-	.406**	.364**	.364**
	p-value	0.004	0.001	-	0.003	0.009	0.009
HbA1c	**Pearson Correlation**	-		0.656**	-	.407**	.406**
	p-value	-		0.000	-	0.003	0.003

Correlation between Electrolytes and Different Variables of the Study in T2DM Patients

Chloride was found to have significant positive correlation with Mg (r =0.328*, p=0.020) and significant negative correlation with HDL (r = -0.284*, p=0.045). While, magnesium was found to have significant positive correlation with chloride (r =0.328*, p=0.020) and significant negative correlation with LDL (r =0.329*, p=0.020) (Table 3).

Table 3. Correlation between Cl & Mg and different variables of the study in T2DM patients.

Variables	Correlation	Cl	Mg	LDL	HDL
Cl	**Pearson Correlation**		0.328*		-0.284*
	p-value		*0.020*		*0.045*
Mg	**Pearson Correlation**	0.328*		-0.329*	
	p-value	*0.020*		*0.020*	

Correlation between CBC Parameters and Different Variables of the Study in T2DM Patients

WBCs was found to have significant positive correlation with RBCs (r =.376**, p=0.007), Hb (r =.443**, p=0.001) and HCT (r = .474**, p=0.001). While, RBCs was found to have significant positive correlation with VLDL (r =.489**, p=0.000), TG (r = - 0.490**, p=0.000), Hb (.643**, 0.000) and HCT (.691**,0.000). Whereas, HCT was found to have significant positive correlation with Hb (r =0.935**, p=0.000) and MCV (r =0.336*, p=0.017) (Table 3).

Table 4. Correlation between CBC parameters and different variables of the study in T2DM patients

Variables	Correlation	VLDL	TG	WBC	RBCs	HB	MCV	HCT	Lymp	Neut
WBC	**Pearson Correlation**	-	-	-	.376**	.443**	-	.474**	-	-
	p-value	-	-	-	0.007	0.001	-	0.001	-	-
RBCs	**Pearson Correlation**	.489**	.490**	.376**	-	.643**	-	.691**	-	-
	p-value	0.000	0.000	0.007	-	0.000	-	0.000	-	-
Hb	**Pearson Correlation**	-	-	.443**	.643**		.450**	.935**	-	-
	p-value	-	-	0.001	0.000		0.001	0.000	-	-
MCV	**Pearson Correlation**	-	-	-	-	.450**	-	.336*	-	-
	p-value	-	-	-	-	0.001	-	0.017	-	-
HCT	**Pearson Correlation**	-	-	.474**	.691**	.935**	.336*	-	-	-
	p-value	-	-	0.001	0.000	0.000	0.017	-	-	-
Lymph	**Pearson Correlation**	-	-	-	-	-	-	-		-.885**
	p-value	-	-	-	-	-	-	-		0.000
Neut	**Pearson Correlation**	-	-	-	-	-	-	-	-.885**	
	p-value	-	-	-	-	-	-	-	0.000	

Correlation between Lipid Profile and Different Variables of the Study in T2DM Patients

LDL was found to have significant positive correlation with HDL (r =0.320*, p=0.024), TC (.968**, 0.000) and significant negative correlation with Mg (r = -0.-.329*, p=0.020). While, HDL was found to have significant positive correlation with TC (r =.412*, p=0.003) and significant negative correlation with Cl (r =-.284*, p=0.045). Whereas, VLDL was found to have significant positive correlation with TG (r =1.000**, p=0.000) and RBCs (r =.489*, p=0.000). Moreover, VLDL was found to have significant positive correlation with RBCs (r =.490*, p=0.000) (Table 5).

Table 5. Correlation between HbA1c & FBS and different variables of the study in T2DM patients.

Variables	Correlation	Cl	Mg	LDL	HDL	TC	VLDL	TG	RBCs
LDL	**Pearson Correlation**		-.329*		.320*	.968**			
	p-value		0.020		0.024	0.000			
HDL	**Pearson Correlation**	-.284*		.320*		.412**			
	p-value	0.045		0.024		0.003			
TC	**Pearson Correlation**			.968**	.412**				
	p-value			0.000	0.003				
VLDL	**Pearson Correlation**	-	-	-	-	-		1.000**	.489**
	p-value	-	-	-	-	-		0.000	0.000
TG	**Pearson Correlation**	-	-	-	-	-	1.000**		.490**
	p-value	-	-	-	-	-	0.000		0.000

DISCUSSION

This study shows that the overall electrolyte imbalance was found to be 18%. Particularly, hypomagnesaemia is shown to be most of electrolyte imbalance pattern in T2DM patients (42/50) 84%. In addition, hypokalaemia was shown to be

less common in T2DM patients (10/50) 20%. A systemic review study was published in 2014, concluded that hypomagnesaemia occur at an increased frequency among T2DM patients (11). Recently, meta-analysis of 19 studies including 4192 T2DM patients showed that the global prevalence of hypomagnesaemia in T2DM was 32% (12). Oost LJ and his colleagues suggested that insulin resistance is required to hypomagnesaemia in in T2DM patients (13). It has been reported that T2DM patients with hypomagnesaemia had a high prevalence of microvascular complications (retinopathy, nephropathy, and neuropathy). Further, significant negative correlation was observed between hypomagnesaemia with TC, TG and LDL (14, 15). However, this study shows only significant negative correlation between hypomagnesaemia and LDL. meta-analysis with 12 A randomised controlled trial (RCTs) revealed that the LDL level in T2DM patients is significantly lowered by Mg supplementation (16). These finding emerge the role of hypomagnesaemia in the development of dyslipidaemia in T2DM patients.

In addition, this study also shows moderate prevalence of dyslipidaemia (50.5%). A recent study was conducted in Saudi Arabia showed that (266/400) 66.5% had a minimum of one abnormal lipid level (dyslipidaemia) (17). Moreover, A systematic review and meta-analysis includes 14 articles with 3662 participants revealed that diabetic dyslipidaemia is prevalent in uncontrolled diabetes (18).

Anaemia is shown to be endemic (39/50) 78% in T2DM patients in the current study. Furthermore, all T2DM females were anaemic (21/21) 100% whereas anaemia in male T2DM patients were (18/29) 62.1%. In contrast, results of a study was conducted in Brack -Alshati (South Libya) on 198 T2DM patients stated that anaemia is a mild health problem as it was found in only 10.1% (19). This discrepancy may be explained by the difference of glycaemic control of the T2DM patients in the both studies. Sharif and his colleagues reported that anaemia is highly associated with uncontrolled diabetes as it was found in 49% of poorly controlled T2DM, compared to 13.5% of controlled T2DM (20). A recent systematic review and meta-analysis of 24 studies with a total number of 19,118 participants showed that approximately one in four patients with T2DM develops anaemia (7).

CONCLUSION

Our results show a notable prevalence of anaemia, dyslipidaemia and high electrolyte imbalance represents only by hypomagnesaemia in T2DM patients. The correlation of HbA1c with LDL and TC was positively significant, thereby highlighting the important link between glycaemic control and dyslipidaemia. Also, there was a strong positive correlation of RBCs with TG and VLDL. Further, electrolytes imbalance which represented by low level of Mg has a strong negative correlation LDL. To conclude, this study recommends that lipid profile, CBC and electrolytes tests should be frequently checked to avoid their complications.

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Conflicts of Interest

The authors declare no conflicts of interest

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دراسة مقطعية تحليلية لاعتلال الألكتروليتات و فقر الدم وعسر الدهون لمرضى النوع الثاني من السكري

إسماعيل الحويج[1]*،علي أبورخيص[2] ،عبدالحكيم الحاج [3] ، إسراء بالنور[3] ، منصور غازي[3] ، محمد أبو ودن[3] ، زهور منصور[3]

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[2]قسم المختبرات الطبية، كلية التقنية الطبية، جامعة الزيتونة، ليبيا.
[3]قسم التخدير، كلية التقنية الطبية، جامعة المرقب، ليبيا.

المستخلص

يتميز داء السكري من النوع الثاني بارتفاع سكر الدم المزمن الناتج عن عيوب في إفراز الأنسولين و/ أو عمل الأنسولين واضطرابات التمثيل الغذائي للبروتينات والدهون. يعد عسر دهون الدم السكري أحد عوامل الخطر للتطور المبكر لأمراض القلب التاجية. اعتلال الألكتروليتات أيضًا شائع لدى مرضى السكري وقد يترافق مع زيادة معدلات امراضية السكري ومعدل الوفيات. علاوة على ذلك ، فإن فقر الدم لدى مرضى السكري له تأثير سلبي كبير على حياة المرضى. لذلك ، فإن الاكتشاف المبكر لفقر الدم ، وعسر دهون الدم ، اعتلال الألكتروليتات قد يقلل من انتشار المضاعفات لمرضى السكري. أجريت هذه الدراسة المقطعية التحليلية لإظهار انتشار فقر الدم ، وعسر دهون الدم ، و اعتلال الألكتروليتات لمرضى السكري من النوع الثاني. تم جمع عدد من البيانات الديموغرافية والكيميائية الحيوية والسريرية لـــ 50 مريض بالسكري من مركز زليتن الطبي ومراكز السكري والغدد الصماء ومختبر بن حيدر الطبي في بلديتي الخمس وزليتن. صنفت البيانات الأولية ثم حللت بواسطة برنامج الحزمة الإحصائية للعلوم الاجتماعية. أظهرت نتائج هذه الدراسة أن نقص المغنسيوم في الدم هو النمط السائد من اعتلال الألكتروليتات لمرضى السكري حيث كانت النسبة 84% (50/42).كذلك نسبة ارتفاع الدهون الثلاثية في الدم كانت 50% (50/25) ، ارتفاع الدهون البروتينة المنخفضة جدا ايضاً 50% (50/25)، وارتفاع الكولسترول الكلي في الدم 40% (50/20). أظهرت هذه الدراسة ايضاً أن فقر الدم منتشر بشكل كبير جدا في مرضى السكري والذي تم تحديده بواسطة مستوى الهيموجلوبين والذي كانت نسبته 78% (50/39). علاوة على ذلك ، وجد أن السكري غير مسيطر عليه لجميع مرضى الدراسة تقريبًا 98% (50/49). في الختام ، فإن فقر الدم ، وعسر دهون الدم شائعان جدًا في دراستنا اما اعتلال الألكتروليتات فان نقص مغنسيوم الدم هو السائد.

الكلمات المفتاحية. فقر الدم، اعتلال الألكتروليتات، عسر الدهون، يتميز داء السكري من النوع الثاني.