Original Article

Metabolic control targets in Sudanese adults with type 1 diabetes: A population-based study

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Abstract

Background: Type 1 diabetes is a challenging metabolic disorder for health authorities in Sudan. The objective of this study was to assess the level of glycemic control and to determine the prevalence of dyslipidemia and complications among individuals with type 1 diabetes in Sudan. **Materials and Methods:** Individuals with type 1 diabetes, who were having the disease for at least 1 year, were invited to participate in this study. Data were collected from two diabetes centers, in the Capital Khartoum and Atbara City, North of Sudan. Participants were interviewed using standardized pretested questionnaire to record medical history, sociodemographic data, and life style characteristics. Blood pressure, body mass index, and waist circumference were measured. Blood samples were taken for measurement of lipid profile and glycosylated hemoglobin. **Results:** A total of eighty individuals with type 1 diabetes volunteered to participate in this study, 37.5% of males and 62.5% of females. Majority of the patients were aged between 40 and 70 years old. There was poor glycemic control (glycosylated hemoglobin >7%), in 83.8%. Age and sex were significant factors associated with poor glycemic control in this cohort. High cholesterol, triglyceride, and low density lipoprotein were seen in 76.2%, 27.5%, and 48.8% of participants, respectively. Low high density lipoprotein was seen in 33.8%. Hypertension was determined in 21.3%. Peripheral neuropathy, visual impairment, diabetic foot, and myocardial infarction were seen in 50%, 48.8%, 18.8%, and 2.5% of patients, respectively. **Conclusion:** Sudanese adults with type 1 diabetes have poor glycemic control, high prevalence of dyslipidemia, and long-term complications.

Keywords: Dyslipidemia, Sudan, type 1 diabetes

Introduction

Sudan is part of the Middle East and North Africa (MENA) region, and this region has the highest prevalence of diabetes worldwide.[1] For instance, in a cross-sectional epidemiological study in MENA in 14 countries, the prevalence of diabetes was estimated to be around 25% of the total population.[1] This was attributed to the increased urbanization in Africa, low physical activity and excessive intake of carbohydrate. It is estimated that by the year 2030, diabetes will affect double the current number of patients.[2-4] The estimated total global prevalence of diabetes is around 8.3% (382 million people) and the number is expected to increase beyond 10.1% (592 million) by the year 2035.[5] Alarmingly, the global estimation of undiagnosed cases of diabetes is around 175 millions.[5]

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Glycemic control constitutes a great challenge in the management of type 1 diabetes mellitus (T1DM). For Instance, in China the median glycosylated hemoglobin (HbA1c) level was 8.5% (7.5%, 10.2%) and only one-fifth of participants had HbA1c levels <7%.[6] The same result was also seen in Finland, as only one-fifth of participants had HbA1c levels <7% and less than half of them had low density lipoprotein cholesterol (LDL-c) levels within the target range.[7] Despite intensive treatment for T1DM in the UK for 10 years, majority of people HbA1c remained above the target.[8] In Morocco, only 22.2% of type 1 diabetes can achieve the target of HbA1c of <7%.[9] Factors associated with poor diabetes control in type 1 are: (i) longer duration of diabetes (ii) lack of motivation (iii) psychological and emotional factors.[10] The complexity of management of T1DM had lead many experts in the field of diabetes to suggest special management in addition to insulin therapy. For instance, structured education, multidisciplinary clinics, risk factors management, psychological and self-management support and dietary and life style changes.[10-15]

There is no previous data concerning glycemic control among adults with T1DM in Sudan. Therefore, we conducted this study to evaluate the glycemic and metabolic control and to assess diabetes complications and associated risk factors among Sudanese adults with T1DM.

Materials and Methods

Study design

This cross-sectional hospital based study that carried out at two diabetes centers.

Setting and population

Individuals who attended two diabetes centers in Khartoum (Gaber Abo-Elezz Center), Khartoum state and in Atbara city, River Nile state were included in this study. Inclusion criteria included adults over 18 years, being on diabetes type I, and on treatment for at least one year.

Data collection tools

A validated, pretested, interviewer-administered questionnaire was used to obtain demographic data, diabetes related enquiries, in addition to physical measurements including anthropometric measurements and biochemical tests were done through standard techniques.

Laboratory methods

Fasting levels of plasma glucose, cholesterol, triglycerides (TGs), high density lipoprotein (HDL), LDL, and HbA1c were measured using standardized laboratory techniques in a fully-automated chemistry analyzer.

Anthropometric measurements

Anthropometric measurements were taken using standardized and calibrated equipment, body mass index (BMI) was calculated using the formula; weight in kilogram divided by height per squired meter. BMI was classified according National Institute of Health of the USA as follows: BMI less 18.5 is under weight, between 18.5 and 24.9 is normal, between 25 and 29.9 is overweight, 30–34.9 is Class 1 obesity, from 35 to 39.9 is Class 2 obesity and BMI of 40 or more is Class 3 or morbid obesity.[16]

Waist circumference

Waist circumference was measured by a tape at the level of the umbilicus. A waist circumference of 94 cm or more in males and 80 cm or more in females defines central obesity.[16]

Ethical clearance

A written consent was obtained from all participants before enrollment. The following information was given during data collection, to insure that participants had the information need to make the informed consent. The participation was optional and without a penalty for refusal. A complete description of the aims of this study, potential benefits and risks, assurance of confidentiality, and any other additional information requested by participants were provided during data collection. A formal ethical approval was obtained from the ethical committees of the Faculty of Medicine of both UMST and NVU.

Statistical analysis

The collected data were analyzed by using Statistical Package for Social Sciences (SPSS) version 21 (IBM Statistics, Chicago, IL, USA). The frequencies, mean, and standard deviation were calculated. Pearson Chi-square test was used to compare between proportions. The level of significance was considered if the value of $P < 0.05$.

Results

Sociodemographic variables

In this study, eighty individuals with type 1 diabetes were included. Their age range was 20–75 years. Males were 30 (37.5%) and females were 50 (62.5%). The majority were living in urban areas (72.5%) and 70% were married. Hypertension was found in 21%. The sociodemographic characteristics and duration of diabetes were displayed in Table 1. Optimal diabetes control was identified in 16.2% of participants only, whereas uncontrolled diabetes (HbA1c > 7%) was identified in 83.8% [Table 2]. High cholesterol, TG, and LDL were seen in 76.2%, 27.5%, and 48.8%, respectively. Low HDL was seen in 70% [Table 3].

Factors and complications associated with uncontrolled diabetes

Peripheral neuropathy, visual impairment, diabetic foot, and myocardial infarction were seen in 50%, 48.8%, 18.8%, and 2.5%, respectively [Table 3]. Poor glycemic control was only significantly associated with age and sex in our cohort ($P < 0.072$, 0.039) [Table 4].

Table 1: Sociodemographic characteristics of Sudanese individuals with type 1 diabetes

Characteristic	Variable	*n* (%)
Sex	Male	30 (37.5)
	Female	50 (62.5)
Age group	20-30	25 (31.3)
	31-40	18 (22.5)
	41-50	19 (23.8)
	51-60	11 (13.8)
	61-70	7 (8.8)
	>70	0
Marital status	Married	56 (70.0)
	Single	17 (21.3)
	Divorced	3 (3.8)
	Widow	4 (5.0)
Educational level	Illiterate	15 (18.8)
	Basic	14 (17.5)
	Secondary	35 (43.8)
	College and above	16 (20.0)
Residence	Urban	58 (72.5)
	Rural areas	22 (27.5)
Duration of DM at the time of study (years)	0-5	14 (17.5)
	6-11	21 (26.3)
	12-20	23 (28.8)
	>20	22 (27.5)
Hypertension	Yes	17 (21.3)
	No	63 (78.8)

DM: Diabetes mellitus

Table 2: Complications among Sudanese individuals with type 1 Diabetes (*n*=80)

Complication	*n* (%)
Peripheral neuropathy	
Yes	40 (50.0)
No	40 (50.0)
Visual problem	
Yes	39 (48.8)
No	41 (51.3)
Diabetic foot	
Yes	15 (18.8)
No	65 (81.3)
Myocardial infarction	
Yes	2 (2.5)
No	78 (97.5)

Table 3: Lipid profile and glycosylated hemoglobin level among Sudanese individuals with type 1 diabetes

Variable	Normal/abnormal	*n* (%)
Cholesterol (mg/dl)	Normal <155	19 (23.8)
	abnormal >155	61 (76.2)
Triglycerides (mg/dl)	Normal <150	58 (72.5)
	Abnormal >150	22 (27.5)
LDL (mg/dl)	Normal <100	41 (51.2)
	Abnormal >100	39 (48.8)
HDL (mg/dl)	Normal >40	53 (66.2)
	Abnormal <40	27 (33.8)
HbA1c	<7 good	13 (16.3)
	>7 poor	67 (83.8)

HDL: High density lipoprotein; LDL: Low density lipoprotein; HbA1c: Glycosylated hemoglobin

Discussion

In this study, the poor glycemic control (HbA1c >7%) among Sudanese individuals with type 1 DM was found to be (83.8%). Age and sex were associated with poor glycemic control in this cohort. High cholesterol, TG, and LDL were seen in 76.2%, 27.5%, and 48.8%, respectively. Low HDL was seen in 33.8% and hypertension 21.3%. Peripheral neuropathy, visual impairment, diabetic foot, and myocardial infarction were seen in 50%, 48.8%, 18.8%, and 2.5%, respectively. Elbagir *et al.* in 1995 have shown that the glycemic control in Sudan was adequate in only 12.5% of patients, and in this study, it is only adequate in 16.2%.[17] The high prevalence of inadequate diabetes control may be attributed, in part, to the high prevalence of diabetes; as recent estimation suggested this could be around 19% of the population.[16] Despite the fact that self-monitoring of blood glucose was significantly associated with better glycemic control in Sudanese, as assessed by HbA1c ($P = 0.02$) and blood glucose at clinic visits ($P \leq 0.0001$), unfortunately, in more than 75% of individuals with type 1 diabetes in Sudan never self-monitored blood glucose.[18]

Glycemic control for type 1 DM is very difficult even for developed countries. This is also proved to be challenging in a large epidemiological study in which data were obtained from (324,501) individuals with type 1 DM from the following countries/regions: Western Australia, Austria, Denmark, England, Champagne-Ardenne (France), Germany, Epirus, Thessaly and Thessaloniki (Greece), Galway (Ireland), several Italian regions, Latvia, Rotterdam (The Netherlands), Otago (New Zealand), Norway, Northern Ireland, Scotland, Sweden, Volyn (Ukraine), USA and Wales from population or clinic-based registries. The proportions with HbA1c 58 mmol/mol (<7.5%) varied from 15.7% to 46.4% among 44,058 people aged <15 years, from 8.9% to 49.5% among 50,766 people aged 15–24 years and from 20.5% to 53.6% among 229,677 people aged ≥25 years and being male or female have no impact on glycemic control.[19] This study showed that about one-sixth of patients had glycemic control (HbA1c <7%). In China, Finland, and Morocco almost one-fifth can achieve glycemic control with HbA1c <7.[6,7,9] Despite intensive treatment for T1DM in the UK for 10 years, majority of people HbA1c remained above the target.[8] Further research is needed to confirm whether availability and compliance with insulin therapy, disease awareness and education and poor health system are contributing factors in high prevalence of poor glycemic control in our study.

In this study, we have shown that high cholesterol, TG and LDL were seen in 76.2%, 27.5%, and 48.8%, respectively. Low HDL was seen in 33.8% and hypertension 21.3%. The Coronary Artery Calcification in Type 1 Diabetes study showed a higher HbA_1c

Table 4: Relationship between glycosylated hemoglobin and serum lipid level in type 1 diabetic Sudanese patients (*n*=80)

Serum lipid (mg/dl)	Cut off value (mg/dl)	HbA1c		*P*
		<7 good, *n* (%)	>7 poor, *n* (%)	
Sex	Male	2 (6.7)	28 (93.3)	0.072
	Female	11 (22.0)	39 (78.0)	
Age group	20-30	8 (32.0)	17 (68.0)	0.039
	31-40	1 (5.6)	17 (94.4)	
	41-50	1 (5.3)	18 (94.7)	
	51-60	3 (27.3)	8 (72.7)	
	61-70	0	7 (100.0)	
Marital status	Married	12 (21.4)	44 (78.6)	0.283
	Single	1 (5.9)	16 (94.1)	
	Divorced	0	3 (100.0)	
	Widow	0	4 (100.0)	
Educational level	Illiterate	2 (13.3)	13 (86.7)	0.415
	Basic	4 (28.6)	10 (71.4)	
	Secondary	6 (17.1)	29 (82.9)	
	College and above	1 (6.2)	15 (93.8)	
Residence	Urban	11 (19.0)	47 (81.0)	0.285
	Rural areas	2 (9.1)	20 (90.9)	
Duration of DM at the time of study (years)	0-5	2 (14.3)	12 (85.7)	0.621
	6-11	5 (23.8)	16 (76.2)	
	12-20	4 (17.4)	19 (82.6)	
	>20	2 (9.1)	20 (90.9)	
Hypertension	Yes	1 (5.9)	16 (94.1)	0.192
	No	12 (19.0)	51 (81.0)	
Peripheral neuropathy (numbness)	Yes	7 (17.5)	33 (82.5)	0.762
	No	6 (15.0)	34 (85.0)	
Visual problem (diabetic retinopathy)	Yes	5 (12.8)	34 (87.2)	0.417
	No	8 (19.5)	33 (80.5)	
Septic foot (diabetic foot)	Yes	1 (6.7)	14 (93.3)	0.264
	No	12 (18.5)	53 (81.5)	
Myocardial infarction (ischemic heart disease)	Yes	0 (0.0)	2 (100.0)	0.528
	No	13 (16.7)	65 (83.3)	
Cholesterol (mg/dl)	Normal <155	3 (15.8)	16 (84.2)	0.950
	Abnormal >155	10 (16.4)	51 (83.6)	
Triglycerides (mg/dl)	Normal <150	10 (17.2)	48 (82.8)	0.696
	Abnormal >150	3 (13.6)	19 (86.4)	
LDL (mg/dl)	Normal <100	9 (22.0)	32 (78.0)	0.156
	Abnormal >100	4 (10.3)	35 (89.7)	
HDL (mg/dl)	Normal >40	10 (18.9)	43 (81.1)	0.374
	Abnormal <40	3 (11.1)	24 (88.9)	
Type of drug	Insulin	12 (18.2)	54 (81.8)	0.309
	Oral hypoglysemic	1 (7.1)	13 (92.9)	

HDL: High density lipoprotein; LDL: Low density lipoprotein; HbA1c: Glycosylated haemoglobin; DM: Diabetes mellitus

was associated with significantly worse levels of the lipids total cholesterol, LDL-c, TG, and non-HDL-c.[20]

Type 1 diabetes is known as condition associated with disturbance in metabolism of TG, HDL, and LDL.[15] The prevalence of dyslipidemia among 239 T1DM in Brazil was found to be 72.5%. High cholesterol in 56.7%, low HDL 21.7%, high LDL 44%, and high TG 11.8%.[21] Hypercholesterolemia was found to be the most common dyslipidemia in T1DM in about 54.6%, whereas other study found that low HDL was also most common dyslipidemia.[22,23]

We have shown in this study that peripheral neuropathy, retinopathy, diabetic foot, and myocardial infarction were seen in 50%, 48.8%, 18.8%, and 2.5%, respectively. Elbagir *et al.* in 1995 have shown that the prevalence of diabetes complications in Sudan such as retinopathy was 43%, nephropathy 22% cardiovascular disease 28%, peripheral vascular disease 10%, cerebrovascular accidents 5.5%, and neuropathy 37%.[24] Despite the fact that in this study HbA1c was not significantly linked to any diabetic complication [Table 3], it is possible to say that the higher prevalence of uncontrolled diabetes is likely associated with these complications. Bos and Agyemang have showed in

their systemic review that diabetes in North Africa was associated with the high prevalence of chronic diabetes complications ranged from 8.1% to 41.5% for retinopathy, 21% to 22% for albuminuria, 6.7% to 46.3% for nephropathy, and 21.9% to 60% for neuropathy.[4] In systemic review about diabetes in MENA, it was shown that macro- and micro-vascular complications were observed in 9%–12% and 15%–54% of population with diabetes, respectively.[25] Another possible factor for high prevalence of diabetes complications that not researched in this study is late referral to specialist centers to deal with complications beside lack of modern equipment and well-trained health practioners.[20] These are common challenges for the management of diabetes in Africa. Renzaho suggested several challenges for diabetes control in Africa, for example, poor documentation of risk factors, demographic transitions (rapid urbanization and aging), poorly regulated food and beverage industry and the urgent need to direct resources, policies, and implementation strategies hold the key to an effective response to diabetes in African countries.[26]

Limitation of this study is related to cross-sectional design of the study and hence we could not take account of the temporal relationship between potential risk factors and outcomes. Another limitation is relatively small sample and short duration of the study. Despite these factors, we believe that this study is novel and its findings reflect the trend of increasing prevalence of poor glycemic control and dyslipidemia in Sudanese individuals with Type 1 diabetes.

Conclusion

High prevalence of uncontrolled diabetes (83.8%) and dyslipidemia is noted in Sudanese adults with type 1 diabetes.

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Conflicts of interest

There are no conflicts of interest.

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