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Original Research

Dyslipidemia and Atherogenic Index of Plasma among Type 2 Diabetes Mellitus in Dhamar, Yemen

Abdulqawi Ali Al-Shammakh[1*], Abdulelah H. Al-Adhroey[2], Mohammed A. Al-Kholani[2], Abdullatif D. Ali[1], Haidar M. Haidar[3], Saif N. Alaiwi[3], Yacup I. Alhamzi[3], Maljum S. Almonifi[3], Mokaram A. Alshawish[3]

[1]Department of Biochemistry, Faculty of Medicine and Health Sciences, Thamar University, Dhamar, Yemen
[2]Department of Community Medicine, Faculty of Medicine and Health Sciences, Thamar University, Dhamar, Yemen
[3]Medical laboratories Graduated Students, Al-Hikma University, Dhamar, Yemen

For correspondence:
Abdulqawi Ali Al-Shammakh*
Department of Biochemistry, Faculty of Medicine and Health Sciences, Thamar University, Dhamar, Yemen
Tel: +967 774 485 970; Email: aqawi54@gmail.com

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Abstract

Background: Dyslipidemia is a recognized major risk factor leading to atherosclerotic cardiovascular disease (CVD) in patients with type2 diabetes mellitus(T2DM). Atherogenic index of plasma (AIP) is expected to be excellent lipid index for predicting CVD.

Aim: This study was aimed to evaluate the prevalence of dyslipidemia and determine atherogenic index of plasma (AIP) among T2DM patients in Dhamar city, Yemen

Methods: This was a cross- sectional study carried out on T2DM patients visiting the outpatient's clinics at public and private hospitals in Dhamar city during the study time. A total of 365 patients were enrolled in this study. Sociodemographic and clinical data were obtained using pretested questionnaire. Blood samples were withdrawn after overnight fast; blood sugar and lipid profiles were spectrophotometrically analyzed.

Results: The overall prevalence of dyslipidemia was found to be 68.5 %. An elevated serum total cholesterol (TC), triglycerides (TG), low density lipoprotein (LDL), low high-density lipoprotein (HDL) and High non-HDL-C were detected in 32.1 %, 38.6 %, 18.6 %, 26.6% and 36.8% of study subjects, respectively. Multivariable logistic regression revealed significant independent association between dyslipidemia and male diabetic patients (AOR = 1.98; CI = 1.11-3.53; *P* = 0.021), unemployed (AOR = 2.077; CI% = 1.15-3.77; *P* = 0.016) and patients with mean FBS >180 mg/dl (AOR = 2.39; CI% = 1.29-4.42; *P* = 0.005), respectively. Regarding of AIP, the results showed that 78.36 % of diabetic patients had high risk, 10.68% had a moderate risk and 10.96 % had low risk levels of AIP. Accordingly, AIP was found to be positively correlated with BMI (r = 0.105; *P* = 0.044), LDL-C (r = 0.138; *P* = 0.008), and non-HDL-C (r = 0.316; *P* < 0.001).

Conclusion: The prevalence of dyslipidemia is high among type2 diabetic patients and the majority are at high risk level of AIP. Therefore, an effective screening and therapeutic processes is required to manage dyslipidemia and to protect its serious complication in diabetic patients.

Keywords: Diabetes, Dyslipidemia, Atherogenic index, Yemen

1. Introduction

Diabetes mellitus prevalence has increased steadily throughout the world and expected to further increase to 9.9% representing 628.6 million individuals by the year 2045 [1]. Atherosclerotic cardiovascular disease remains the principal cause of death and disability among patients with diabetes mellitus. It has been reported that atherosclerosis in patients with type 2 diabetes mellitus occurs earlier with greater severity compare to individuals without diabetes mellitus [2,3]. Multiple

factors include obesity, hypertension, dyslipidemia, oxidative modification of lipoproteins and insulin resistant contribute to the accelerated atherosclerosis in diabetes [4].

Dyslipidemia is defined as abnormality in any one of the serum lipids profile including TC, LDL-C, HDL-C, and TG. It is a modifiable risk factor for cardiovascular disease and commonly associated with Diabetes mellitus. Previous study found that lipid abnormalities affecting 60% to 70% of type 2 diabetes mellitus (T2DM) [5]. The mechanism of dyslipidemia in T2DM is mediated by insulin resistance causes increased free fatty-acid release from fat cells into the liver which in turn stimulates triglyceride production and secretion of apolipoprotein B (Apo-B) and very low-density lipoprotein cholesterol (VLDL-C) [6]. Combination of Hypertriglyceridemia and increased VLDL-C particles alter the lipid exchange between VLDL-C and high-density lipoprotein cholesterol (HDL.C) leading to increased production of atherogenic small dens LDL.C and small size HDL-C [7,8].

The contribution of lipid abnormalities and atherosclerosis have long been studied. Several studies found association between cholesterol, LDL-C, and low HDL-C with atherosclerosis [9,10]. On the other hand, epidemiological and clinical studies have shown that elevation of TG and decreasing HDL-C level in association with elevated Apo-B and small dense LDL-C particles, is strongly predictive of coronary heart diseases (CHD) [11,12]. Recently an increasing number of studies have found that Lipid ratios or atherogenic indices such as Castelli's Risk Index-I and II (CRI-I &II), atherogenic index of plasma (AIP), atherogenic coefficient (AC), and non-HDL-C fraction (non-HDL-C) are valuable predictors of CVD risk better than traditional lipid profiles measurement [13,14,15]. Among those atherogenic indices, AIP which is defined as logarithm [log] of the ratio of plasma concentration of TG to HDL-C was demonstrated to be a sensitive marker associated with HDL-C, LDL-C, and VLDL-C particle sizes and predicted the CVD risk [16,17].

Given the fact that diabetic dyslipidemia has received much attention over the last two decades worldwide. There is also high prevalence of dyslipidemia in developing countries due to urbanization, changing lifestyle, and food habits. In Yemen, this issue has not been dealt with in depth. Additionally, no previous study, to the best of our knowledge, has studied burden of AIP among type 2 diabetes. Therefore, this study was designed to evaluate the prevalence of dyslipidemia and determine the patterns of atherogenic index of plasma (AIP) among type 2 diabetes mellitus patients in Dhamar city, Yemen.

2. Methods

Study design

This was a cross sectional study carried out in Dhamar City, Dhamar Governorate, located 100 km away to the south from Sana'a, capital of Yemen. The study was conducted on T2DM patients attending outpatient clinics in Dhamar General Hospital, Dr. Mohammed Almusaly Hospital and Taiba Consultative Hospital, during a period from February to July 2019. Patients participated in this study were already diagnosed during their previous routine visit, as type 2 diabetic based on American Diabetic Association (ADA) criteria [18]. A total of 365 diabetic patients were selected randomly. All subjects were informed of study proposes and written consents were obtained from them. The sample size was calculating based on 39% global prevalence of hypercholesterolemia [19]. Confidence level of 95% with margin of error of 5% and significance level of 0.05 were considered in this study. The including criteria was T2DM patients (male and female) willing to participate in the study. Patients with type 1 diabetes, cardiac failure, renal failure and those who are not willing to participates were excluded.

Data collection

A semi-structured questionnaire was used to collect data on sociodemographic characteristics, life style, and clinical history of the patients. The patients were requested to present the FBS reports of the previous three months. Anthropometric measurements including body weight, height, and blood pressure were carried out by trained nurses. Body mass Index (BMI) was calculated as weight in kg/(height in meters)^2. Subjects were categorized according to their BMI as the criteria of World Health Organization (WHO) and cut-off point for obesity is accepted as BMI > 29.9 kg/m2 [20]. Blood pressure was measured in sitting position after 10 minutes rest on right arm using standard mercury sphygmomanometer [21].

Serum Lipid and glucose analysis

Blood samples were collected from all participants after an overnight fasting. Fasting blood sugar, TC, HDL-C and TG were measured using commercially available reagents on COBAS INTEGRA 400 analyzer Roche Diagnostics. LDL cholesterol was calculated according to Friedewald's formula [22].

Definition of variables

Lipid abnormalities were defined as TC >200 mg/dl, TG >150 mg/dl, LDL-C >130 mg/dl, HDL-C <40 mg/dl and non-HDL-C < 150 mg/dl according to the criteria set by the National Cholesterol Education Program-Adult Treatment Panel III (NCEP ATP III) [23]. Atherogenic index was calculated by using the following formula: $\log_{10}$ (TG/HDL-C). It can be classified according to the risk predictions of CVD as: low risk (<0.1), medium risk (0.1 to 0.24) and high risk (> 0.24) [24]. Physical activity was defined as > 90 minutes per week of regular exercise or occupational physical activity [25].

Data analysis

Data were analyzed using Statistical Package for Social

Science (SPSS) version 23. Categorical variables were expressed as frequencies and percentages. Continuous variables were presented as mean ±S.D. and were compared using one-way ANOVA. Multiple logistic regression analysis was used to find out independent association between dyslipidemia and various risk factors. Adjusted odds ratio (AOR) and 95% confidence intervals were calculated. Pearson correlation was used to evaluate the correlation between AIP and other variables. P <0.05 was considered to be statistically significant.

3. Results

General characteristics of the study population

General characteristics of diabetic patients participated in this study are shown in Table 1.

Table 1: General characteristics of the type 2 diabetes mellitus (T2DM) patients participated in this study (n=365)

Variable	Frequency (%)
Age (year)	
<50	146 (40.0)
≥ 50	219 (60.0)
Resident	
Urban	287 (78.6)
Rural	78 (21.4)
Gender	
Male	177 (48.5)
Female	188 (51.5)
Occupation	
Employed	154 (42.2)
Unemployed	211 (57.8)
Hypertension	
Yes	131 (35.9)
No	234 (64.1)
Diabetic duration/ year	
<5	258 (69.3)
>5	112 (30.7)
Mode of treatment	
Diet	70 (19.2)
OAHGA	295 (80.8)
FBS status (mg/dl)	
<126	137 (37.5)
126-180	121 (33.2)
>180	107 (29.3)
BMI (Kg/m2)	
Normal	138 (37.8)
Over weight	143 (39.2)
Obesity	84 (23.0)
Diabetic State	
<180	198 (54.2)
≥ 180	167 (45.8)
Physical activity	
Active	133(36.4)
Inactive	232 (63.6)
Smoking	
Yes	150 (41.1)
No	215 (58.9)

The mean age was 51.3±12, about half (51.5%) of the study participants were female, 60% were ≥ 50 years, 78.6% were urban, 57.8% were unemployed, 35.9% were hypertensive patients, 69.3% were with diabetic duration <5 years and 80.8% were using oral antihyperglycemic agents. The distribution of BMI of the study population were 37.8% normal, 39.2% overweight and 23.0% obese. Status of FBS was calculated as a mean of results obtained through last three months. Based on the mean of FBS levels, 37.5% of the diabetic patients had normal levels (<126 mg/dl), 33.2% had levels between 126 and 180 mg/dl and 29.3 % had mean FBS above 180 mg/dl. About two third of the participants were physically inactive and 41.1% were smokers.

Prevalence and patterns of dyslipidemia among diabetic patients

The overall prevalence of dyslipidemia (at least one lipid profile abnormal) among T2DM patients in this study was 68.49% Figure 1. The patterns of dyslipidemia as shown in the Figure 2 indicating that 32.1% of diabetic patients were presented with hypercholesterolemia, 38.6 were having hypertriglyceridemia, 18.6 were having high LDL.C 26.6% were having low HDL.C, and 36.8% of the study population had high non-HDL-C. The highest lipid abnormalities in type 2 diabetes were triglyceride, followed by non-HDL-C and the lowest was LDL.C.

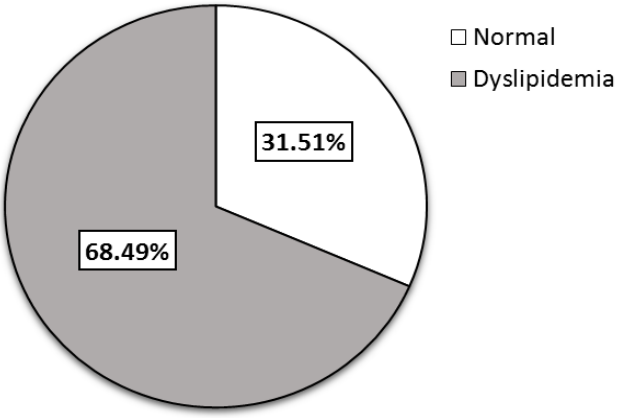

Figure 1: Prevalence of dyslipidemia among T2DM patients in Dhamar city, Yemen

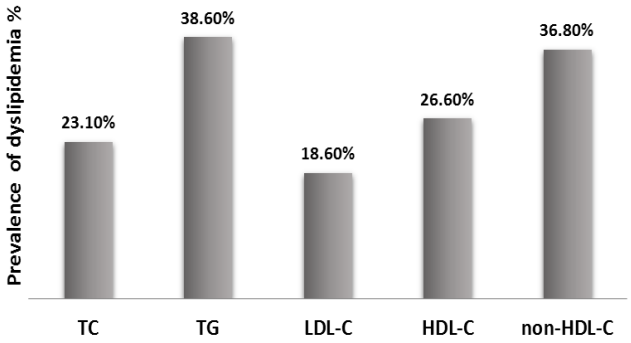

Figure 2: Patterns of dyslipidemia among type2 diabetic patients in Dhamar city, Yemen

Associations of socio-demographic characteristics and cardiovascular disease risk factors with dyslipidemia

Associations of socio-demographic characteristics and cardiovascular disease risk factors with dyslipidemia is

shown in Table 2. Multivariate logistic regression exhibited the independent risk factors associated with dyslipidemia. The results indicated that diabetic patients being male (AOR = 1.98; CI = 1.11-3.53; *P* = 0.021), unemployed (AOR = 2.08; CI = 1.15-3.77; *P* = 0.016) and with mean FBS more than 180 mg/dl (AOR = 2.39; CI=1.29-4.42; *P* = 0.005) were significantly associated with higher prevalence of dyslipidemia. Diabetic patients with mean FBS 126-180 md/dl and patients were not using oral antihyperglycemic agent and depend on diet for controlling their blood sugar were more likely to develop dyslipidemia (AOR = 1.36; CI = 0.78-2.38; *P* = 0.29 and AOR = 1.60; CI = 0.85- 3.00; *P* = 0.145, respectively). Patients with duration of diabetes more than five years (AOR = 0.41; CI = 0.24-0.70; *P* =0.001) and overweight diabetic patient (AOR = 0.53; CI = 0.31-0.91; *P* = 0.020) seemed to have significant less probability of developing dyslipidemia. Hypertension, smoking and physical activity were found to be not associated with dyslipidemia in this study population.

Level of lipid profiles and AIP based on glycemic status of diabetic patients

Level of lipid profiles and AIP in different glycemic status are summarized in Table 3. In comparison with diabetic patients having mean FBS less than 126 mg/dl, those with mean FBS more than 180 mg/dl were presented with high total cholesterol (189 ± 60, *P*= 0.001), high LDL-C (102 ±52; *P* = 0.012) and high non-HDL-C (132 ± 57; *P* = 0.006). In contrast, TC, TG, LDL-C, non-HDL-C, AIP in diabetic patient's category with FBS between 126 and 180 mg/dl were not showing significantly higher levels in compression to patients with mean FBS less than 126 mg/dl. Accordingly, all lipid profiles except TC and HDL-C were not statistically differ among diabetic patients in the categories mean FBS 126-180 and >180 mg/dl.

Patterns of atherogenic index of plasma (AIP) among type2 diabetes mellitus patients

Atherogenic index of plasma is shown in the Figure 3. According to the concentration of AIP patients were classified into three categories. Low risk (AIP < 0.10), medium risk (AIP = 0.10-0.24) and high risk (AIP > 0.24). The results showed that 78.36 % of diabetic subjects had high risk level of AIP, 10.68% had a moderate risk level of AIP and 10.96 % had low risk level of AIP.

Table 2: Associations of socio-demographic characteristics and cardiovascular disease risk factors with dyslipidemia

Variable	Dyslipidemia Prevalence n (%)	Univariate Analysis		Multivariable Analysis	
		OR (CI%)	*P*	OR (CI%)	*P*
Age (years)					
< 50	103 (70.5)	Ref.		Ref.	
≥ 50	147 (67.1)	0.85 (0.54-1.34)	0.490	0.82 (0.49-1.36)	0.438
Resident					
Rural	127 (71.8)	Ref.		Ref.	
Urban	193 (67.2)	0.76 (0.43-1.32)	0.327	0.87 (0.48-1.59)	0.653
Gender					
Female	123 (65.4)	Ref.		Ref.	
Male	127 (71.8)	1.34 (0.86-2.09)	0.194	1.98 (1.11-3.53)	0.021*
Occupation					
Employed	102 (66.2)	Ref.		Ref.	
Unemployed	148 (70.1)	1.20 (0.77-1.87)	0.428	2.08 (1.15-3.77)	0.016*
Hypertension					
No	162 (69.7)	Ref.		Ref.	
Yes	88 (67.2)	0.91 (0.58-1.44)	0.685	0.82 (0.49-1.37)	0.447
Mode of treatment					
AHGA	198 (67.1)	Ref.		Ref.	
Diet	52(74.3)	1.42 (0.79-2.55)	0.247	1.60 (0.85-3.00)	0.145
FBS (mg/dl)					
< 126	86 (62.8)	Ref.		Ref.	
126 -180	82 (67.8)	1.25 (0.75-2.09)	0.401	1.36 (0.78-2.38)	0.285
> 180	82 (76.6)	1.95; 1.10-3.43)	0.021*	2.39 (1.29-4.42)	0.005*
Diabetic duration (years)					
< 5	184 (72.7)	Ref.		Ref.	
> 5	66 (58.9)	0.54 (0.34-0.86)	0.009*	0.41 (0.24-0.70)	0.001*
Physical activity					
Active	89 (66.9)	Ref.		Ref.	
Inactive	161 (69.4)	1.12 (0.71-1.77)	0.624	1.17 (0.71-1.93)	0.541
BMI					
Normal	104 (75.4)	Ref.		Ref.	
Over weight	86 (60.1)	0.49 (0.30-0.82)	0.007*	0.53 (0.31-0.91)	0.020*
Obesity	60 (71.4)	0.82 (0.44-1.51)	0.518	0.97 (0.51-1.85)	0.925
Smoking					
Non smoker	147(68.4)	Ref.		Ref.	
Smoker	103 (68.7)	1.01 (0.65-1.59)	0.952	0.96 (0.59-1.57)	0.869

FBS: Fasting Blood Sugar; BMI: Body Mass Index; AHGA: Oral Antihyperglycemic Agents
*Significant association (*P* <0.05); OR (CI%): Odd Ratio (Confidence Interval%)

Table 3: Fasting blood sugar status and lipid profiles in the study population

Parameters	Glycemic status			Significance level
mean ± SD	<126 mg/dl	126-180 mg/dl	>180 mg/dl	
TC	168 ±45	185 ± 48	189 ± 60	P^a = 0.560, P^{b*} = 0.001, P^{c*} = 0.007
TG	142 ±73	152 ±76	153 ±72	P^a = 0.883, P^b = 0.223, P^c = 0.270
LDL.C	86 ± 46	94 ±48	102 ±52	P^a = 0.218, P^{b*} = 0.012, P^c = 0.197
HDL.C	53 ± 28	60 ± 29	56 ± 25	P^a = 0.250, P^b = 0.351, P^{c*} = 0.029
non-HDL.C	114 ± 47	124 ± 47	132 ± 57	P^a = 0.218, P^b = 0.006*, P^c=0.120
AIP	0.43 ± 0.29	0.41 ± 0.29	0.43 ± 0.26	P^a = 0.332, P^b = 0.954, P^c = 0.330

P^a= difference between <126 mg/dl and 126-180 mg/dl categories
P^b = difference between <126 mg/dl and >180 mg/dl categories
P^c = difference between 126-180 mg/dl and >180 mg/dl categories
*Significant difference (P <0.05)

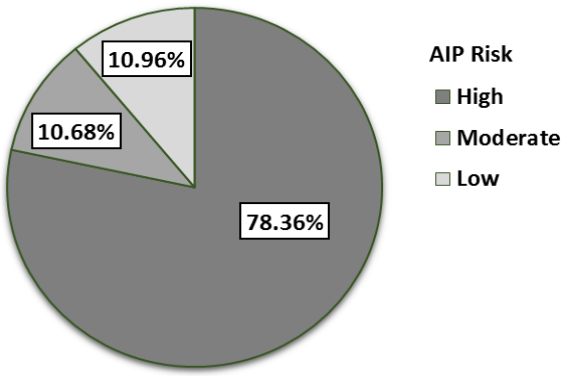

Figure 3: Patterns of Atherogenic Index of Plasma (AIP) among T2DM Patients in Dhamar, Yemen

Correlation of AIP with dyslipidemia and CVD risk factors

Correlation analysis revealed that AIP was positively correlated with BMI (r=0.105; P = 0.044), LDL-C (r=0.138; P = 0.008) and non-HDL-C (r=0.316; P < 0.001). On the other hand, this study found that there was no significant correlation of AIP with patients age, duration of diabetes mellitus and status of FBS.

Table 4: Correlation of AIP with lipid profiles and CVD risk factors

Risk factors	AIP Pearson Correlation (r)	P value
Age	-0.051	0.335
Diabetic duration	-0.057	0.277
BMI	0.105	0.044*
FBS	-0.030	0.565
TC	-0.052	0.325
LDL-C	0.138	0.008*
non-HDL-C	0.316	< 0.001*

*Significant correlation (P < 0.05)

4. Discussion

Dyslipidemia is a recognized major risk factor leading to atherosclerotic cardiovascular disease (CVD) and its treatment has been shown to reduce the incidence of CVD morbidity and mortality. The present study revealed a critical information on the patterns of dyslipidemia and AIP among T2DM patients in Dhamar, Yemen. The present study showed that the overall prevalence of dyslipidemia among Yemeni T2DM patients in Dhamar was 68.49%. This result is lower than studies carried out in Jordan(90%) [26] and Thailand (88.9%) [27]. On the other hand, the prevalence of dyslipidemia in this study was comparable to the data from Emirates (72.5%) [28] and China (67.1%) [29]. Concerning the patterns of dyslipidemia, this study indicated that 38.6% of study population had hypertriglyceridemia, 32.1% had hypercholesterolemia, 26.6 % had low HDL-C, 18.6% had high LDL-C and 36.8 % had High non-HDL-C. The prevalence of hypercholesterolemia in this study was consistent with rate reported in Thailand (35.1%), Bangladesh (35.69%), UAE (36%), Kuwait (37%), Oman (35%) and higher than Qatar (29%) and previously reported in Yemen (12%) [27,30,31].

Hypertriglyceridemia is common manifest of type 2 diabetes patients [6]. In this study hypertriglyceridemia (38.6%) was comparable with data from other studies [27,29,30]. High LDL-C in this study (18.6%) was lower than that reported from Ethiopia (43.8 %) [32], Bangladesh (72.92%) [30] and Thailand (56.5%) [27]. The low level of HDL-C (26.6%) among the study population was comparable with the results reported from Indonesia (23%), and lesser than that in Saudi Arabia (48.7%) Thailand 47.1% Philippines (71.3%) and Jorden (83.9%) [26,27,33].

The variations between the present study and those studies may have been due to socioeconomic status, lifestyle, race/ethnic and genetic factors. Previous study among Iranian population indicated that the prevalence of hypercholesterolemia was 11.4%, hyper-low-density lipoprotein cholesterol was 9.6%, hypertriglyceridemia was 25% and hypo-high-density lipoprotein was 34.3% [34]. A report of the National Health and Examination Survey (NHANES) from 2003–2006 estimated that 53% of U.S. adults have dyslipidemia, 27% have high LDL-C, 23 % have low HDL-C, and 30% have high TG) [35]. Furthermore, the dyslipidemia in Western populations is predominantly characterized by high levels of LDL-C, while in Asia and the Middle East population there is evidence of a predominance of low levels of HDL-C, as well as an increased prevalence of hypertriglyceridemia [33].

The multivariate analysis showed significant independent association between dyslipidemia with sociodemographic. Male diabetic patients, unemployed, and patient with FBS > 180mg/dl were significantly associated with higher prevalence of dyslipidemia. Association of gender with dyslipidemia have been reported in many studies. Prevalence of the hyperlipidemia is reported to be more in male populations than female population [28]. Our findings appear to be well controverted by previous systemic

review conducted on adult population of gulf countries from 1999 to 2004 reported that hypercholesterolemia was higher in females [31]. Unemployed diabetic patient in this study were found to be more disposed to dyslipidemia. The reasons for high dyslipidemia prevalence in these patients can be explained by stress, sedentary life style and level of education which plays an important role in disease management for those people.

Consistent with previous study fasting plasma glucose > 180 mg/dl was found to be risk factor of dyslipidemia. Abundant epidemiological data support the association between hyperglycemia, dyslipidemia and increased risk of cardiovascular diseases [5,6]. Hyperglycemia is intrinsically linked to insulin resistance, which facilitates hyperlipidemia by converting excess carbohydrates into free fatty acids (FAs) and TG which finally leads to increased production of VLDL-C and other atherogenic subtypes of lipoproteins [6,7]. Obesity has been reported to be one of risk factors for dyslipidemia [26-28]. Different mechanism behind the obesity and abnormalities in lipid metabolism; Increased visceral and subcutaneous waist adipose tissues, insulin resistance and poor physical activity among diabetic obese patients are associated with abnormal lipoprotein levels [28]. Unlike other research carried out in this area our result shows that overweight diabetic patients are significantly less likely to have dyslipidemia.

For many years research has tended to focus on LDL-C levels as objective to prevent atherothrombosis and plaque rupture, which portend high CV morbidity and mortality rather than other types and subtractions which recently have also been implicated in the atherogenic process. The ratio of triglycerides to HDL-cholesterol ratio (TG/HDL-c) correlates inversely with the plasma level of small, dense LDL and HDL-C subtraction. Moreover, recent evidence demonstrated that atherogenic index of plasma (AIP) strongly predicting the risk of cardiovascular diseases and extensive coronary heart disease among all the lipid variables examined [16,36]. In our study we found that 78.36% of diabetic subjects had high risk level of AIP, 10.68% had a medium risk level of AIP and 10.96% had low risk level of AIP. It has been reported that individuals with high AIP have a higher risk of coronary heart disease (CHD) than those with low AIP. The close association of the AIP and cardiovascular risk has been mainly explained by lipoprotein particle size, insulin resistance, and metabolic syndrome, all of which are important risk factors for cardiovascular disease [37]. It has been reported that AIP can be used as a stand-alone index for cardiac risk estimation [38]. The finding of this study of high-risk level of AIP among type 2 diabetic patient is in agreement with previous study carried out in Iran which indicated that all diabetic participants and 90 % of person with impaired fasting glucose were in AIP increased risk category [39]. In Yemen, people suffering catastrophic consequences because of the country's conflict, and nowhere is that more visible than in the health care system. All of such circumstances leading to lack of medicines for chronic diseases like high blood pressure and diabetes as well as reducing the panel of diabetic investigation in public hospitals. Therefore, most diabetic patient's incapable to do their regular investigation and poorly control their diabetes. Although most patients with poorly controlled diabetes develop hypertriglyceridemia, this reflect the higher proportion of diabetic patient at a high-risk category of AIP.

The results of the current study also identified the mean differences of lipid profiles according to the status of FBS. We found that people with high level of mean FBS (> 180 mg/dl) had significant higher levels of TC, LDL-C and non-HDL-C. These findings are in agreement with previous studies that showed strong association between abnormalities of blood lipoproteins and FBS [5,6]. It is understandable that diabetic patients with poor glycemic control have determined higher level of atherogenic particles such as TC, LDL and non-HDL-C. Furthermore, it is well known that non–HDL-C is a measure of all potentially atherogenic lipoprotein particles (LDL, VLDL, intermediate-density lipoprotein, and lipoprotein[a]) which more accurate predictor of CHD risk [40].

The correlation analysis of AIP and cardiovascular risk factors revealed that AIP was positively correlated with BMI, LDL-C and non-HDL-C. This finding was in agreement with study carried out by Bo et al. [41]. AIP has been reported to be associated with HDL, LDL, and VLDL particle sizes and predicted the CVD risk [16]. On the other hand, positive correlation of AIP with Non-HDL-C which is a strong predictor of CVD reflect the important clinical significance of AIP. Generally, this study did have some limitations. Firstly, some of the clinical history of the patients such as diabetic duration, previous FBS, and physical activity were self-reported by the patients. Secondly, LDL-C was calculating using Friedewald's formula, we belief it would be better if it was estimated directly using commercially kit.

5. Conclusion

Dyslipidemia is one of the major risk factors for developing CVD in diabetic patients. The present study provides for the first time reliable epidemiological information regarding dyslipidemia and associated risk factors among the T2DM patients in Dahmar city, Yemen. The study reveals high prevalence of dyslipidemia and the most predominant lipid abnormality is TG followed by non-HDL-C. Majority of diabetic patients are having a high-risk level of AIP. Gender, sedentary life style, hyperglycemia, diabetic duration and BMI are independent risk factors for dyslipidemia. This study indicates a significant positive correlation between AIP and LDL-C, non-HDL-C, and BMI. The results are expected to be useful to develop appropriate strategies for controlling the identified risk factors in order to reduce

the prevalence of dyslipidemia and its complication in diabetic patients.

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Competing interests
The authors declare that they have no competing interests.

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