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Factors Associated with Glycemic Control among Type 2 Diabetic Patients Attending Primary Health Care Centers in Qatar, a Cross-Sectional Study

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Abstract

Introduction/Aim: Type 2 diabetes mellitus is a major global public health problem affecting huge number of the population with multiple complications that decrease the quality of life and contribute to earlier mortality. A lot of evidence suggests a link between poor glycemic control, diabetic complications and poor patient's outcome. Therefore, it is critical for us to identify factors associated with poor glycemic control among type 2 diabetes mellitus patients as we aimed by this study.

Materials and Methods: A cross sectional study was conducted and included 510 type 2 diabetic patients attending non-communicable disease clinics at nine primary health care centers in Qatar aiming to explore some associated factors of poor glycemic control among them. A stratified cluster sampling technique with proportional allocation was utilized. HbA1c level >7% was considered as poor control, while HbA1c ≤ 7% was categorized as good control. The level of significance was set at $p < 0.05$. Pre-coded structured interviewing questionnaire was utilized. Review of medical records was done to collect the required information.

Results: About two thirds (63.7%) of patients had poor glycemic control was high. Poor glycemic control was higher among patients with duration of diabetes of ≥ 10 years (73.4%) compared to those with duration of < 5 years (51.9%) and the difference was found to be statistically significant ($\chi 2 = 14.498$, $p = 0.001$). also, the differences were statistically significant regarding the management strategies of diabetes and the self-monitoring of blood glucose. The relation between the number of diabetic complications and glycemic control was statistically significant with poor control of 100% among patients had > 3 complications. Patients who were on diet, oral hypoglycemic drugs and insulin had 6.90 times higher risk of having poor glycemic control compared to those who were on diet and oral hypoglycemic drugs only (OR = 6.90, CI = 3.60-13.20). Finally, patients who don't practice self-monitoring of blood glucose had 3.66 more risk of having poor glycemic control compared to those practicing self-monitoring of blood glucose (OR = 3.66, CI = 2.40-5.60).

Conclusion: Based on the findings of the study, it can be concluded that about two thirds of patients with T2DM in Qatar had a poor glycemic control with HbA1c level of > 7%. Comorbidities were highly prevalent among them and about 25% of them were developed one or more complications of diabetes. The duration of T2DM, the strategy used in management and the self-monitoring of blood glucose are critical factors in glycemic control.

Keywords: Glycemic control; Factors; Type 2 diabetes mellitus; Primary health care; Qatar

Introduction

Type 2 Diabetes Mellitus (T2DM) is a worldwide major public health problem. It is a global crisis that threatens the health and economy of all nations, particularly developing countries. It is one of the main chronic diseases currently affecting humankind, regardless of socioeconomic status and geographic location. It is the fourth or fifth leading cause of death in most high-income countries and there is a substantial evidence that it is changing into an epidemic in many low- and middle-income countries. Diabetes is certain to be one of the most challenging health problems in the 21st century [1].

The increasing prevalence of Diabetes Mellitus (DM) worldwide has led to a situation where approximately 360 million people had DM in 2011, of whom more than 95% had T2DM. This number is estimated to increase to 552 million by 2030 and it is thought that about half of those will be unaware of their diagnosis [2].

The states of The Co-operation Council for the Arab States of the Gulf (GCC) including Qatar have some of the highest rates of T2DM in the world. Five of the International Diabetes Federation's (IDF's) 'top 10' countries for diabetes prevalence in 2010 and in 2030 are in this region [3]. In December 2011, the IDF showed that the prevalence of diabetes among adults aged 20 to 79 years in Qatar was 20.2% [2]. Also in Qatar, risk factors associated with diabetes were examined in a population-based study. As expected, obesity, hypertension, metabolic syndrome, and heart disease were found to increase the likelihood of having diabetes. In addition, smoking habits and family history of diabetes were major contributors to diabetes [4].

The goal of treatment in T2DM is to achieve and maintain optimal Blood Glucose (BG), lipid, and Blood Pressure (BP) levels to prevent or delay chronic complications of diabetes [5]. A patient's glycosylated hemoglobin (HbA_{1c}) level is an indicator of the status of glycemic control over the previous 3 months. A cut-off point of < 7% indicates optimal glycemic control. Each percentage point reduction in HbA_{1c} was associated with a 35% reduction in micro-vascular complications and a 7% reduction in all-cause mortality [6]. Glycemic control was found to be associated with many factors such as age, race/ethnicity, duration of diabetes, type and number of medications taken, obesity, psychological variables, and family support [7].

Promotion of Physical Activity (PA) is one of the most important and effective strategies for reducing the risk of several chronic diseases including T2DM, Cardiovascular Diseases (CVD), osteoporosis, obesity and some types of cancer [8].

Compliance of diabetic patients with medical advice is essential for controlling the disease; it is affected by many factors related to the patient, the disease, the physician and the family [9].

During recent decades T2DM became a major public health problem affecting huge number of the population with multiple complications that decrease the health-related quality of life and contribute to suboptimal physical and mental functioning and earlier mortality. Poor glycemic control is associated with higher rate of complications and worse prognosis among diabetic patients. Identification of factors associated with poor glycemic control may help in planning for more comprehensive strategy of care, and better quality of life of diabetic patients.

Based on the above, this work is essential to propose an appropriately tailored and culturally relevant approach for intervention. The main goal of this study is identifying some of the most relevant factors associated with poor glycemic control among diabetic patients attending Primary Health Care Centers in Qatar.

Materials and Methods

Study design and settings

A cross-sectional approach was utilized in this study. The study was conducted at non-communicable disease (NCD) clinics in health centers related to the Primary Health Care Corporation (PHCC).

Study population and data collection

Participants were adults diagnosed with T2DM and registered in the NCD clinics. Inclusion criteria included being adult aged 18 years or more, with history T2DM and willing to participate. Patients with communication problems (unable to answer the questions as those with dementia, dysarthria, and hearing impairment) were excluded.

Different tools have used in data collection included pre-coded structured interviewing questionnaire, anthropometric measurements and review of medical records.

Sample size calculation and sampling technique

Initial sample size calculated was 335. After adding a design effect, the total sample size became 510. Stratified cluster sample technique with proportional allocation was utilized. Simple random sampling conducted to select nine health centers; three from each geographical region covered the country. A systematic random sampling technique utilized to recruit the participants.

Definitions of Study Variables

Dependent variable

Glycemic Control measured by HbA_{1c} percent which indicates the glycemic control during the past three months. A HbA_{1c} level >7% categorized as poor control, while $HbA_{1c} \leq 7\%$ categorized as good control [10,11]. The last HbA_{1c} reading within the medical record of the participant was used.

Independent variables

Glycemic control relation with several independent variables were assessed within this study. The list of these variables included duration of diabetes mellitus, adherence to (diet, medication, and follow up at the clinic), management strategy, Comorbidities (frequency and type) based on documented diagnosis, blood pressure control (less than 140/80 mmHg or less than 130/80 in presence of nephropathy was considered as controlled), [12] blood lipid control (desirable/undesirable) (low density lipoprotein cholesterol "LDL-C", high density lipoprotein cholesterol "HDL-C", Triglyceride level), body mass index (BMI), and diabetic complications (frequency and type) based on documented diagnosis.

LDL-C level of <70 mg/dL (<1.8 mmol/L) in very high risk diabetic patients (DM, combined with documented CVD, sever chronic kidney disease or with one or more cardiovascular risk factors and/or target organ damage) or <100 mg/dL (<2.5 mmol/L) in high risk diabetic patients (without any other CVD risk factor and free of target organ damage) was considered as desirable. HDL-C level of >40 mg/dL (> 1.03 mmol/L) among men and > 50 mg/dL (> 1.29 mmol/L) among women was considered as desirable. Triglycerides level of <150 mg/dL (< 1.7 mmol/L) was considered as desirable [13,14].

The WHO adult cutoff points of BMI were used: < 18.5 as underweight, 18.5-24.9 as normal weight, 25-29.9 as overweight and 30-34.9 as class I obesity, 35-39.9 as class II obesity and ≥ 40 as class III obesity [15].

Data analysis

The statistical packages SPSS 22 software was used in data analysis. A descriptive analysis in the form of means and Standard Deviation (SD) was used whenever appropriate. Frequencies and percentages were carried out according to the type of data. Chi-square (X^2) test, Pearson correlation coefficient and multivariate logistic regression were used as needed. The level of significance was set at $p < 0.05$ (two tailed).

Ethical considerations

Acquired approvals have been taken. An informed written consent was obtained from each participant. Privacy of participants and confidentiality of data were assured. Results of the completed questionnaires were communicated with the patients and treating physician for the possibility for further actions.

Results

Figure 1 shows distribution of patients with T2DM according to HbA_{1c} level. It indicates that more than one third of the patients (36.3%) had good glycemic control with a $HbA_{1c} \leq 7\%$. HbA_{1c} level of 8-8.9% found among 20% of participants, followed by 16.8% had a level of 7.1-7.9%. HbA_{1c} level of ≥ 10% found in 15.0% of subjects.

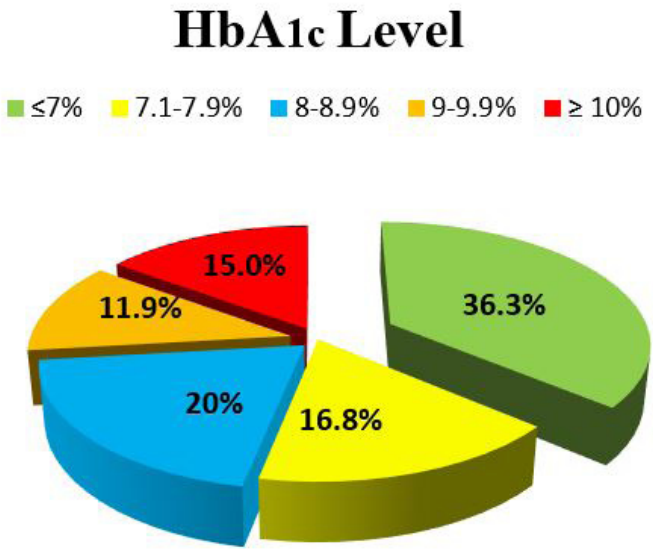

Figure 1: Distribution of type 2 diabetic patients according to HbA1c level, Primary Health Care Centers, Qatar, 2014.

Table 1 shows the relation between poor glycemic control and different factors. The difference was found to be statistically significant in case of the duration of diabetes, management strategy, and self-monitoring of blood glucose.

Variable	Glycemic control				Total	χ^2 (p – value)
	Good ($HbA_{1c} \leq 7\%$)		Poor ($HbA_{1c} > 7\%$)			
	No.	(%)	No.	(%)		
Duration of DM						
< 5	64	(48.1)	69	(51.9)	133	14.498
5 -	79	(36.1)	140	(63.9)	219	**(0.001)****
10 +	42	(26.6)	116	(73.4)	158	
Management strategy						
Diet and oral hypoglycemic drugs	173	(44.7)	214	(55.3)	387	49.311
Diet, oral hypoglycemic drugs and insulin	12	(9.8)	111	(90.2)	123	**(0.001)****
Adherence to diet						
Adherent	87	(39.7)	132	(60.3)	219	3.017
Partially adherent	78	(35.3)	143	(64.7)	221	(0.221)
Non-adherent	20	(28.6)	50	(71.4)	70	
Adherence to medication						
Adherent	178	(36.9)	305	(63.1)	483	1.623
Partially adherent	7	(25.9)	20	(74.1)	27	(0.444)
Adherence to follow up at the clinic						
Adherent	167	(35.6)	302	(64.4)	469	1.122
Partially adherent	18	(43.9)	23	(56.1)	41	(0.289)
Self-monitoring of blood glucose						
Yes	143	(47.4)	159	(52.6)	302	39.301
No	42	(20.2)	166	(79.8)	208	**(0.001)****
$^{**}p < 0.01$						

Table 1: Relationship between duration of diabetes, management strategy, adherence, self-monitoring of blood glucose, and glycemic control (HbA_{1c} level) among type 2 diabetic patients, Primary Health Care Centers, Qatar, 2014.

The results demonstrated a significant positive correlation between HbA_{1c} level and the duration of diabetes ($r = 0.153$, $p = 0.001$).

The relationship between comorbidities (by number and type) and glycemic control presented in Table 2.

Comorbidity	Glycemic control				Total	χ^2 (p-value)
	Good ($Hb_{A1c} \leq 7\%$)		Poor ($Hb_{A1c} > 7\%$)			
	No.	(%)	No.	(%)		
Number						
0	15	(35.7)	27	(64.3)	42	0.374
1-2 complications	103	(37.5)	172	(62.5)	275	(0.829)

3+ complications	67	(34.7)	126	(65.3)	193	
Type						
Hypertension						
Yes	117	(35.5)	213	(64.5)	330	0.272
No	68	(37.8)	112	(62.2)	180	(0.602)
Dyslipidemia						
Yes	134	(35.4)	244	(64.6)	378	0.430
No	51	(38.6)	81	(61.4)	132	(0.512)
Obesity						
Yes	98	(36.3)	172	(63.7)	270	0.000
No	87	(36.3)	153	(63.7)	240	(0.991)
Others**						
Yes	25	(33.8)	49	(66.2)	74	0.232
No	160	(36.7)	276	(63.3)	436	(0.630)
*Mainly thyroid dysfunction and vitamin D deficiency						

Table 2: Relationship between comorbidities and glycemic control (HbA_{1c} level) among type 2 diabetic patients, Primary Health Care Centers, Qatar, 2014.

Table 3 reveals that poor glycemic control was more common among patients who had three complications or more (100%) compared to those who have one or two complications and those who do not have (71.3%, 61.1% respectively) and the difference in glycemic control as regards the number of complications was statistically significant ($\chi^2 = 7.264$, p-value = 0.026).

Diabetic complications	Glycemic control				**Total**	χ^2 ***(p*-value)**
	Good ($Hb_{A1c} \leq 7\%$)		**Poor** ($Hb_{A1c} > 7\%$)			
	No.	(%)	No.	(%)		
Number						
0	154	(38.9)	242	(61.1)	396	7.264

1-2 complications	31	(28.7)	77	(71.3)	108	(0.026)*
3+ complications	0	(0.0)	6	(100.0)	6	
Type						
Nephropathy						
Yes	5	(23.8)	16	(76.2)	21	1.472
No	180	(36.8)	309	(63.2)	489	(0.225)
Retinopathy						
Yes	15	(30.0)	35	(70.0)	50	0.944
No	170	(37.0)	290	(63.0)	460	(0.331)
Neuropathy						
Yes	3	(15.8)	16	(84.2)	19	3.583
No	182	(37.1)	309	(62.9)	491	(0.058)
Ischemic heart disease						
Yes	15	(30.6)	34	(69.4)	49	0.752
No	170	(36.9)	291	(63.1)	461	(0.386)
Others**						
Yes	0	(0.0)	3	(100.0)	3	1.718
No	185	(36.5)	322	(63.5)	507	(0.190)

* $p < 0.05$; **: Peripheral arterial disease and Diabetic foot

Table 3: Relationship between diabetic complications and glycemic control (HbA_{1c} level) among type 2 diabetic patients, Primary Health Care Centers, Qatar, 2014.

Table 4 demonstrates the relation between lipid profile and blood pressure with glycemic control of the participants. It revealed that poor glycemic control was more common among diabetic patients who had undesirable triglycerides (70.0%) compared to those who had desirable triglycerides (59.3%) and the difference was found to be statistically significant (χ^2= 6.136, p= 0.013). However, the differences in glycemic control as regards LDL cholesterol, HDL cholesterol and blood pressure were not statistically significant.

Variable	Glycemic control				Total	χ^2 (*p*-value)
	Good (HbA_{1c}≤7%)		Poor (HbA_{1c}>7%)			
	No.	**(%)**	**No.**	**(%)**		
Low density lipoprotein						
Desirable	78	(37.3)	131	(62.7)	209	0.168
Undesirable	107	(35.5)	194	(64.5)	301	(0.682)
High density lipoprotein						
Desirable	88	(40.6)	129	(59.4)	217	2.991
Undesirable	97	(33.1)	196	(66.9)	293	(0.084)

Triglycerides						
Desirable	121	(40.7)	176	(59.3)	297	6.136
Undesirable	64	(30.0)	149	(70.0)	213	**(0.013)****
Blood pressure						
Controlled	140	(36.0)	249	(64.0)	389	0.058
Uncontrolled	45	(37.2)	76	(62.8)	121	(0.810)
**p<0.01						

Table 4: Relationship between metabolic, blood pressure, and glycemic control (HbA_{1c} level) among type 2 diabetic patients, Primary Health Care Centers, Qatar, 2014.

Table 5 reveals that patients who were on diet, oral hypoglycemic drugs and insulin had 6.90 times higher risk of having poor glycemic control compared to those who were on diet and oral hypoglycemic drugs only (OR = 6.90, CI = 3.60-13.20).

Variables	Adjusted Odds Ratio	95% Confidence interval	*p*-value
Management strategy Diet and oral hypoglycemic drugs	1	3.60 - 13.20	0.001**
Diet, oral hypoglycemic drugs and insulin	6.90		
Self-monitoring of blood glucose Yes	1	2.40 - 5.60	0.001**
No	3.66		
Triglycerides Desirable	1	1.09 - 2.50	0.02*
Undesirable	1.65		
Duration of DM < 5	1	1.03 - 2.57	0.03*
≥ 5	1.63		
*p < 0.05; **p < 0.01			

Table 5: Multivariate logistic regression of variables associated with poor glycemic control among type 2 diabetic patients, Primary Health Care Centers, Qatar, 2014.

The table also demonstrates that patients who don't practice self-monitoring of blood glucose had 3.66 more risk of having poor glycemic control compared to those practicing self-monitoring of blood glucose (OR = 3.66, CI = 2.40-5.60).

It can be shown that patients who had undesirable triglycerides had 1.65 higher risk of having poor glycemic control compared to those who had desirable triglycerides (OR = 1.65, CI = 1.09-2.50).

The tables also reveals that patients with duration of diabetes of five years or more had increased risk of poor glycemic control by 1.63 times compared to those of less than five years duration (OR = 1.63, CI = 1.03-2.57).

Discussion

Type 2 diabetes mellitus is a progressive disease in which the risks of myocardial infarction, stroke, micro-vascular complications and mortality are all strongly associated with hyperglycemia [16]. Achieving glycemic control is the main therapeutic goal for the prevention of organ damage and other complications of diabetes [17].

Many studies from different countries have shown variable results regarding poor glycemic control among type 2 diabetic patients. This variation could be partially explained by different cutoff points used for categorization of poor glycemic control among these patients enrolled in studies. In Jordan, the prevalence

of poor glycemic control was 65.1% using a cutoff point of HbA_{1c} ≥ 7% [17]. In Kuwait, the prevalence of poor glycemic control was 66.7% using a cutoff point of HbA1c ≥ 8%. On the other hand, the prevalence of poor glycemic control was 46.7% in Pakistan using a cutoff point of HbA_{1c} > 7.5% [18,19].

In the present study, the level of HbA_{1c} > 7% was utilized as an indicator for uncontrolled glycaemia according to European DM guidelines, American diabetes association, and Primary Health Care National Guidelines in Qatar [10,13,20]. The results of the present study, revealed a prevalence of uncontrolled glycaemia of 63.7%. Different studies have used same indicator as our study and revealed different outcome such as two studies from KSA (76.4%, and 78%.) [18,21].

In addition to the use of different cutoff points of HbA_{1c} level, differences in the degree of glycemic control in different studies may reflect variability in the quality of services provided in different countries, including availability of certain medications, guidelines, patient's education and motivation, and the degree of understanding of the importance of glycemic control and self-management practices [22]. Moreover, differences may reflect variability in participants characteristics included in the study.

Longer duration of diabetes was reported to be associated with poor glycemic control, possibly because of progressive impairment of insulin secretion with time because of β-cell failure, which makes the response to diet alone or oral agents unlikely [6]. The present study also supported this fact. This finding is consistent with that reported by other studies; like the study done among middle-aged and older adults in USA, in addition to another study conducted in India [7,23].

Type 2 diabetes is a progressive disease in which β-cell function continually declines and eventually falls, ultimately recurring nearly all patients to be placed on insulin therapy. An increasing body of evidence suggests that early intensive glycemic control reduces long-term vascular outcomes and potentially may prolong β-cell life-span and function [24].

Related to the above finding, the present study demonstrated that patients with poor glycemic control were significantly more likely to be prescribed a combination of diet, oral hypoglycemic drugs and insulin, which may indicate that physicians are attempting multi-drug therapy to provide better disease control. Moreover, those patients who were on diet, oral hypoglycemic drugs and insulin had nearly seven times higher risk of having unachieved target glycemic control compared to those on diet and oral hypoglycemic drugs only. This association going with the results of other studies; including a study from Saudi Arabia, and another conducted on 822 diabetic patients in the primary care settings in USA [25,26]. This finding reflects the fact that with deterioration of diabetes over time, the need for higher doses or additional medications increases. Therefore, patients who were treated by combination therapy of diet, oral hypoglycemic drugs and insulin had more progressive disease which required more aggressive treatment to provide glycemic control.

An important factor linked to the success of any management strategy is the patient's adherence to diet, medication and to follow up. This factor improves diabetic management and avoids long term complications [27,28].

Studies from KSA and Jordan demonstrated that non-adherence to appropriate diet and medication is associated with poor glycemic control [17,29]. Our study support this finding. However, the difference was not statistically significant. Also, a study from Ethiopia revealed that study participant's adherence to insulin regimen, self-care and lifestyle didn't show significant difference between good and poor glycemic control [30].

A good counseling and health education on regular basis can be vitally important in helping diabetic patients to understand the importance of adherence to diet and medication. However, tackling non-adherence is a multifactorial process and might include cost, health belief, dosing frequency and complexity, personality disorders and patient-provider relationships [31].

Contrary to adherence to diet and medication, the present study demonstrated that those who were adherent to follow up at the clinic had insignificantly higher level of poor glycemic control than those who were non-adherent. This unexpected result was in contrast with other studies from KSA and Jordan which found that poor adherent to regular follow up was significantly associated with poor control [17,29].

Some studies showed that the major reasons given for not complying with follow up at the clinic were forgetting, being out of town on day of appointment, financial problems and work/school commitments [32,33].

In standard care, Self-Monitoring of Blood Glucose (SMBG) is recommended for all newly diagnosed people with T2DM as an integral part of self-management education. Different studies and recommendations revealed that SMBG in T2DM is associated with HbA_{1c} reduction, improvement of glycemic variability, visualization of highly glycemic episodes and improvements in lifestyle and medication adherence [34,35]. The present study revealed that poor glycemic control was significantly more common among patients who were not practicing SMBG.

Moreover, those patients who were not practicing SMBG have nearly four times the risk of poor glycemic control compared to those who were practicing it. These results are consistent with what was found in other studies; including a study from USA on diabetic patients from 34 primary health care settings, and another study conducted in UK [36,37]. However, the study done

in Iran among diabetic female patients found that controlled and uncontrolled patients did not differ significantly with respect to SMBG [38].

Comorbidities are very common among T2DM [39]. So, it is important to determine if comorbidity increases the difficulty to manage the disease and to achieve good glycemic control [40]. The present study revealed that neither the number nor the type of the comorbidities had significant association with the glycemic control. This is consistent with the results of other studies which found no association between the number of comorbidities and glycemic control; including the study in Dar Essalaam Tanzania, the study among urban African Americans with type 2 diabetes USA, and in a study at primary care center in Canada [22,39,41]. Moreover, another study at 20 primary health care centers in USA 2002 found that the presence of multiple chronic conditions was not a factor limiting the achievement of a good glycemic control, even after taking into account the severity of the coexistent diseases. The authors explained this by the fact that diabetic patients with elevated HbA_{1c} receive a closer attention in primary care encounters. Therefore, in the presence of multiple comorbid conditions, diabetic patients may receive better care [42]. On the other hand, other studies found an association between comorbidity and glycemic control; e.g. 2 studies from USA [43,44].

Hypertension and diabetes are commonly associated diseases as showed in the present study. The Skara Hypertension and Diabetes Project observed worse glucose control in patients with type 2 diabetes alone compared with hypertensive diabetic patients in the primary health care outpatient clinics in Sweden [45]. However, the present study didn't find significant association between the presence of hypertension and glycemic control as found in other studies; like the study in Dar Essalaam Tanzania, and a study done in India [22,46]. The present study also didn't reveal relation between blood pressure control and glycemic control.

There was no association between obesity and glycemic control in the current study. This is consistent with the outcomes of 2 studies conducted in USA [47,48]. However, a study from Jordan found that overweight and obesity were risk factors for poor glycemic control [49].

On the other hand, the study done in Tanzania found that patients with normal BMI had double the risk of having poor glycemic control compared to overweight patients. The authors explained this by the fact that patients with poor control have lost weight due to disease process, while improved glycemic control is associated with weight gain. This explanation is consistent with the UKPDS findings indicating that intensive glycemic control caused 2 to 5 kg weight gain [6,22].

Dyslipidemia is highly prevalent among T2DM patients. However, intensive glycemic control in DM patients may lead to overall improvement of the lipid profile of the patients and hence reduction in the associated cardiovascular risk [50].

The present study showed that three quarters of the patients had dyslipidemia. It also revealed that unachieved target glycemic control was more common among patients with diagnosed dyslipidemia than those without dyslipidemia. Similarly, poor glycemic control was more common among patients with undesirable LDL and HDL levels. However, all the above-mentioned relations between dyslipidemia and glycemic control was not statistically significant. Similar findings were observed in other studies from Ethiopia [51,52].

On the other hand, the present study demonstrated significantly higher level of poor glycemic control and undesirable triglyceride level. Moreover, the logistic regression analysis revealed that those with undesirable triglyceride level had 1.65 higher risk of having poor glycemic control compared to those who had desirable triglycerides. This finding is supported by results of other studies; like a study done in India, and a study done in Ethiopia [46,51].

In general diabetes has the effect of lowering HDL and increasing LDL and triglyceride levels. Cholesterol accumulation on the other hand may contribute to β-cell dysfunction in T2DM. Poor glycemic control and increased serum lipids are considered as risk factors for micro-vascular and macro-vascular complications in T2DM. It is possible that both glycemic control and lipid concentration are markers for the quality of diabetes care [22].

Given the already increased risk of cardiovascular disease in diabetes, the association between glycemic control and lipid levels reinforces that cardiovascular health requires an optimization of dyslipidemia in addition to correction for the hyperglycemia. Good glycemic control could result in improvement in the lipid profile and the patients could be spared from the high cardiovascular risk [52].

The burden of diabetic complications is significant. In the United States, diabetes is the leading cause of end-stage renal disease, polyneuropathy, non-traumatic amputations, and in adults age 20-64, it is the most common cause of new blindness [53].

The present study revealed that near to one quarter of the patients had diabetic complications. This is much lower than what found in as a study where about 83% of type 2 diabetic patients had at least one diabetic complication [51]. This low number of complications in the present study may be explained by the fact that 69% of the patients had DM of less than 10 years in duration.

The complications of diabetes mellitus are far less common and less sever in people who have good glycemic control. The present study showed that there was a significant association between increasing in the number and of diabetic complications

and glycemic control. Different other studies had demonstrated a significantly higher level of both micro-vascular and macro-vascular complications among those with poor glycemic control [51,54]. Different reasons for the poor control were postulated including a change in insulin sensitivity and clearance in the presence of renal impairment. In addition, various cardiovascular drugs such as diuretics and beta blockers may affect beta cell function adversely leading to more poor glycemic control [55].

It seems that glycemic control is multifactorial; some factors are modifiable, others are not. Improving glycemic control among type 2 diabetic patients is a challenge. Intensive effort should be offered by the healthcare system, health care providers, the patients and their families, to achieve better glycemic control and hence decrease diabetic complications and improve patient's outcome.

Conclusion

Based on the findings of the study, it can be concluded that about two thirds of patients with T2DM in Qatar had a poor glycemic control with HbA_{1c} level of > 7%. Comorbidities were highly prevalent among them and about 25% of them were developed one or more complications of diabetes. The duration of T2DM, the strategy used in management and the self-monitoring of blood glucose are critical factors in glycemic control.

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