

# Clinical profiles, comorbidities and complications of type 2 diabetes mellitus in patients from United Arab Emirates

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## ABSTRACT

**Objective** To assess clinical profiles of patients with type 2 diabetes in the United Arab Emirates (UAE), including patterns, frequencies, and risk factors of microvascular and macrovascular complications.

**Research design and methods** Four hundred and ninety patients with type 2 diabetes were enrolled from two major hospitals in Abu Dhabi. The presence of microvascular and macrovascular complications was assessed using logistic regression, and demographic, clinical and laboratory data were collected. Significance was set at  $p < 0.05$ .

**Results** Hypertension (83.40%), obesity (90.49%) and dyslipidemia (93.43%) were common type 2 diabetes comorbidities. Most of the patients had relatively poor glycemic control and presented with multiple complications (83.47% of patients had one or more complication), with frequent renal involvement. The most frequent complication was retinopathy (13.26%). However, the pattern of complications varied based on age, where in patients <65 years, a single pattern presented, usually retinopathy, while multiple complications was typically seen in patients >65 years old. Low estimated glomerular filtration rate in combination with disease duration was the most significant risk factor in the development of a diabetic-associated complication especially for coronary artery disease, whereas age, lipid values and waist circumference were significantly associated with the development of diabetic retinopathy.

**Conclusions** Patients with type 2 diabetes mellitus in the UAE frequently present with comorbidities and complications. Renal disease was found to be the most common comorbidity, while retinopathy was noted as the most common diabetic complication. This emphasizes the need for screening and prevention program toward early, asymptomatic identification of comorbidities and commence treatment, especially for longer disease duration.

## INTRODUCTION

Type 2 diabetes mellitus is one of the major chronic disease burdens with a prevalence of 422 million patients worldwide.<sup>1</sup> Type 2 diabetes is expected to be the seventh most common cause of death in the world by 2030, primarily due to its rapid rise in

## Significance of the study

### What is already known about this subject?

In the United Arab Emirates (UAE), the prevalence for type 2 diabetes is 23%, with hypertension, obesity, and dyslipidemia as common type 2 diabetes comorbidities.

### What are the new findings?

Few studies have been reported on Arab population regarding type 2 diabetes and its complication, and we have found that more than 80% of patients with type 2 diabetes in UAE have one or more complication with retinopathy (13.26%), being the most frequent single complication.

### How might these results change the focus of research or clinical practice?

We report that levels of estimated glomerular filtration rate (eGFR) and disease duration are the most significant risk factors for complications. A regular test of eGFR might be an essential for early prediction of type 2 diabetes complications outcome for nephropathy.

middle-income and low-income countries.<sup>2</sup> In addition, type 2 diabetes is a leading cause of severe morbidities and disabilities (blindness, chronic renal impairment, cardiovascular events, and lower limb amputation).

Within the Gulf region, the prevalence of type 2 diabetes and associated risk factors and comorbidities is one of the highest in the world.<sup>3–5</sup> In the United Arab Emirates (UAE), specifically, the prevalence of prediabetes and type 2 diabetes were reported to be 30% and 23%, respectively,<sup>6</sup> with 6.6%–14.6% of UAE residents remaining undiagnosed.<sup>7,8</sup> A screening among Emirati children and adolescents showed that 5.4% are already in the prediabetes state,<sup>9</sup> indicating that type 2 diabetes constitutes a considerable future challenge in this country. In addition, UAE has high rates of overweight,

obesity, dyslipidemia, and hypertension (32%, 35%, 44%, and 23.1%, respectively), which contributes further to the risk of type 2 diabetes and its complications.<sup>10–12</sup> Over the next decade, the economic burden of prediabetes and diabetes in the UAE is estimated to be in the order of US\$8.52 billion if current trends continue with medical costs escalating to US\$1.04 billion by 2020 (UnitedHealth Group/Ingenix (2020) Diabetes in the United Arab Emirates: Crisis or Opportunity? United Health Group, Minnetonka, Minnesota).

Early screening and prevention program can reduce the incidence of type 2 diabetes and its coexisting conditions.<sup>13</sup> The co-occurrence of type 2 diabetes associated complications have not been extensively investigated for specific ethnic groups especially in the Gulf countries despite the significant social and economic burden and requires further study in order to implement appropriate, culturally sensitive early detection and prevention plans.<sup>13</sup>

The current study had two main objectives: (1) to determine the prevalence of type 2 diabetes complications in a cohort of UAE nationals with type 2 diabetes recruited from two major hospitals in Abu Dhabi; and (2) to investigate the prevalence of diabetes comorbidities and associations among the various risk factors including obesity, kidney disease, hypertension and dyslipidemia.

## RESEARCH DESIGN AND METHODS

### Study type

Prospective cross-sectional study of Emirati patients from Abu Dhabi with type 2 diabetes.

### Subjects

Four hundred and ninety (274 females and 216 males), unrelated patients with type 2 diabetes were enrolled in this study during routine visits to the endocrinology and cardiology clinics at Shaikh Khalifa Medical Centre (SKMC) and Mafraq Hospital between July 2014 and May 2015. Both hospitals are major tertiary hospitals in the UAE.

### Diagnosis of type 2 diabetes mellitus

Inclusion in the study required patients to have been diagnosed with type 2 diabetes. The presence of diabetes-associated complications was confirmed by a qualified physician, based on the criteria outlined by the WHO consultation group report.<sup>14</sup>

### Inclusion and exclusion criteria

Inclusion criteria were: UAE-born national, diagnosed with type 2 diabetes mellitus, able to give consent, and above 18 years of age at the time of enrollment in the study. Exclusion criteria were: current pregnancy, not able to give consent and presence of other pathophysiology such as cancer or psychosis.

### Clinical variables and laboratory data

Laboratory tests were performed at the time of enrollment. Blood pressure was taken on two different occasions, 48 hours apart and the average taken. Hypertension was defined as systolic blood pressure >130 mm Hg, diastolic blood pressure >80 mm Hg, or taking antihypertensive medications. Dyslipidemia was diagnosed as a total cholesterol >6.2 mmol/L, low-density lipoprotein (LDL)-cholesterol >3.3 mmol/L, and or triglycerides >2.2 mmol/L.

### Complications

The major complications of type 2 diabetes considered in this study were coronary artery disease (CAD), nephropathy, peripheral neuropathy, and retinopathy.

Diagnosis of cardiovascular disease (CVD) was obtained from the medical records and verified by the consulting physician.

Diagnosis of peripheral neuropathy was determined according to presence of (1) foot ulcers, (2) loss of sensation/numbness/burning/tingling in the feet, (3) loss of toe, foot or leg due to diabetes, (4) claudication, or (5) peripheral vascular disease as determined by ultrasound.<sup>15</sup>

Diagnosis of nephropathy was set by a urine albumin level >30 µg/min for microalbuminuria, and >200 µg/min for macroalbuminuria, or estimated glomerular filtration rate (eGFR) >60 mL/min/1.73 m<sup>2</sup>.

Diagnosis of retinopathy was defined as either white or red lesions (non-proliferative or proliferative retinopathy) or both present in the retina according to WHO criteria.<sup>16</sup>

### Statistical analysis

Demographic data, clinical measurements (such as height, weight, and waist circumference), and measured laboratory values were all summarized as means±SD. To determine the association between complications (as dependent variables) and clinical and laboratory data (as independent variables), a stepwise logistic regression analyses were performed including all risk factors for development of complications (complications outcome vs no complications, CAD vs no CAD, retinopathy vs no retinopathy, nephropathy vs no nephropathy, and neuropathy vs no neuropathy) using R statistical program (V.3.3.1). The best model (the model with the minimum Akaike information criterion value) from each stepwise analysis was further selected for input to a multivariate logistic regression model to exclude the effects of confounding factors, using the same software. The findings were presented as estimates, standard errors, and probability (p value). ORs and 95% CIs were calculated in R using the estimates. The significance level was set at p value <0.05.

### Ethical considerations

Each patient agreed to take part in this study and gave signed consent after a brief session to explain aims and

methods. The study was approved by the Institutional Ethics Committee of both hospitals (REC-04062014 and R292, respectively) and conforms to the ethical principles outlined in the Declaration of Helsinki.

## RESULTS

### Clinical profiles, comorbidities, and laboratory profiles

Basic clinical data and major comorbidities with type 2 diabetes (hypertension, dyslipidemia, and obesity) and laboratory profiles are shown in [table 1](#). The mean age of the patients was 60 years ( $\pm 11.3$ ), where 83.40% of the patients had a history of hypertension (mean systolic blood pressure=131 mm Hg) and 93.43% had a history of dyslipidemia. In addition, 90.49% were either overweight or obese (mean body mass index (BMI)=31.9 kg/m<sup>2</sup>, mean waist circumference >107 cm in men and >104 cm in women). Smoking and/or history of smoking was lower than expected at 28.43% based on current statistics in the Middle East.

The majority of patients presented with high fasting blood glucose (BGL) and HbA1c levels (mean HbA1c=7.75). Lipid profiles of most patients were within the desirable range, although high-density lipoprotein (HDL) levels were poor in 52.39% of the patients ([table 1](#)). Microalbuminuria was found in 32.85% of the patients, and 30% had a high albumin/creatinine ratio. Serum 25(OH)D values were suboptimal in 65.86% of the patients, where 32.93% of those patients presented with a clinical deficiency. Poor glomerular filtration rate (eGFR) was found in 53.58% of the patients.

These data indicate that hypertension, obesity, and dyslipidemia are common comorbidities in patients with type 2 diabetes in UAE. In addition, most of the type 2 diabetes patients in this cohort had poor glycemic control and frequent renal involvement but good control of the lipid profiles.

### Complications of type 2 diabetes

Overall, one or more clinically diagnosed complications were present in 83.47% of the patients with type 2 diabetes included in this study ([table 2](#)). The single most prevalent diabetic complication was retinopathy (13.26%), followed by CAD (10.20%). Neuropathy and nephropathy were the most common combined complication (8.57%). Clinically diagnosed nephropathy was reported in only 5.92% ([table 2](#)) despite the high prevalence of suboptimal renal profiles ([table 1](#)).

The distribution of complications according to the age group of patients is shown in [table 3](#). Expectedly, complications were found to increase with age. In addition, two important observations were noteworthy; first, retinopathy was the constant complication found in all age groups; second, with increasing age the pattern of complications changed from being a single complication to a combination of complications ([table 3](#)).

The overall trend of these results indicate a high percentage of complications in patients with type 2 diabetes in UAE.

### Risk factors for complications

First, a simple logistic regression test was performed to assess the association of any complication as an outcome (response variable) and all clinical and laboratory variables of the patients (predictor variables). Clinical and laboratory variables were reported in at least 10% of patients to avoid the bias. Through this approach, several different clinical and laboratory variables were significantly associated with different complications (data not shown). Therefore, we performed stepwise multiple logistic regression analyses to determine the best model for each complication analysis (see Materials and Methods).

Duration of type 2 diabetes ( $p=0.003$ , OR=1.66), followed by the levels of eGFR and total cholesterol, were found to be significant predictor risk factors for the development of a type 2 diabetes complications, as shown in [table 4](#). Waist circumference, used as a obesity indicator, showed a tendency to influence the development of complications as well.

Similarly, duration of type 2 diabetes and the eGFR levels combined with smoking history were the best predictors for the development of CAD. Patients who smoked had almost twice (OR=1.98) the risk of developing CAD compared with non-smokers, whereas duration of type 2 diabetes increased this risk only by 1.25.

Multiple factors contributed to the development of diabetic retinopathy (DR). This included age ( $p=0.00025$ ), blood lipids (total cholesterol, triglycerides, and LDL-cholesterol;  $p<0.01$ ), and waist circumference ( $p=0.00018$ ). Although an association between DR and HbA1c and eGFR levels ( $p=0.0598$  and  $0.085$ , respectively) was observed, this was not significant. No significant predictors were seen for diabetic nephropathy, but urea concentration was the only factor that exhibited a trend of association with the presence of neuropathy ( $p=0.023$ ).

## DISCUSSION

Our data reveal a high frequency of complications associated with patients with type 2 diabetes in the UAE. Age and renal function were the most useful predictors for the development of type 2 diabetes complications, while eGFR was found to be a potential single predictor for the development of diabetes complications, especially when considering type 2 diabetes duration.

In 2004, the WHO reported that an annual treatment cost of diabetes with microvascular complications to be approximately US\$3531, US\$7720 for diabetes patients with macrovascular disease and US\$11 337, which was nearly 23 times higher than the per capita expenditure for healthcare in the UAE. Since then, prevalence of diabetes has more than doubled.<sup>17</sup>

**Table 1** Demographic, clinical, and laboratory data of patients

Type of variables	Variable	Mean±SD	N (% of the category)	N (% of total)
Demographic variables	Gender			
	Male		216 (44.08)	490 (100)
	Female		274 (55.92)	
	Age (years)	60.6±11.3		
	≤35		12 (2.45)	490 (100)
	>35–50		70 (14.29)	
	>50–65		248 (50.61)	
	>65		160 (32.65)	
Clinical variables	History of hypertension			407 (83.40)
	History of dyslipidemia			455 (93.43)
	Smoking history			
	Current smoker		39 (7.98)	489 (99.80)
	Previous smoker		100 (20.45)	
	Never smoked		350 (71.57)	
	Diabetes duration (years)			
	≤5		151 (31.20)	
	>5–10		95 (19.63)	
	>10–15		85 (17.56)	
	>15–20		74 (15.29)	
	>20		79 (16.32)	
	BMI (kg/m <sup>2</sup> )	31.9±3.9		484 (98.78)
	Underweight: <18.5		1 (0.21)	
	Normal: ≥18.5–24.9		45 (9.30)	
	Overweight: ≥25.0–29.9		155 (32.02)	
	Obese: ≥30.0		283 (58.47)	
	Systolic blood pressure (mm Hg)	131±2		490 (100)
	≤120		128 (26.12)	
	>120–139		240 (48.98)	
≥140–159		94 (19.18)		
≥160		28 (5.71)		
Diastolic blood pressure (mm Hg)	76±2		490 (100)	
≤80		318 (64.90)		
>80–89		117 (23.88)		
≥90–99		48 (9.80)		
≥100		7 (1.43)		
Waist circumference (cm)			461 (94.08)	
Men: >90	107.7±14.5	199 (41.72)		
Women: target ≥80	104.7±12.4	262 (54.93)		
Laboratory variables	HbA1c (% , mmol/mol)	7.75%±1.61%		450 (91.8)
	Optimal: <7 (53 mmol/mol)		148 (32.89)	
	Fair: 7–8		137 (30.44)	
	High: >8 (64 mmol/mol)		165 (36.67)	
	Fasting plasma glucose (mmol/L)	8.58±3.48		125 (25.5)
	Optimal: <6.7		41 (32.80)	
	Fair: 6.7–7.8		21 (16.80)	
High: >7.8		63 (50.40)		

Continued

Table 1 Continued

Type of variables	Variable	Mean±SD	N (% of the category)	N (% of total)
	Random blood glucose (mmol/L)	9.10±4.00		367 (74.9)
	Optimal: <7.8		169 (46.05)	
	Fair: 7.8–11.1		116 (31.61)	
	High: >11.1		82 (22.34)	
	Total cholesterol (mmol/L)	3.90±1.06		438 (89.4)
	Optimal: <5.2		385 (87.90)	
	Fair: 5.2–6.2		35 (7.99)	
	High: >6.2		18 (4.11)	
	Triglyceride (mmol/L)	1.52±0.78		437 (89.2)
	Optimal: <1.7		312 (71.40)	
	Fair: 1.7–2.2		52 (11.90)	
	High: >2.2		73 (16.70)	
	HDL-cholesterol (mmol/L)	1.20±0.48		439 (89.6)
	Men: optimal>1		104 (23.69)	90 (20.50)
	Poor ≤1			
	Women: optimal >1.3		105 (23.92)	140 (31.89)
	Poor ≤1.3			
	LDL-cholesterol (mmol/L)	2.01±0.90		439 (89.6)
	Optimal: <2.6		344 (78.36)	
	Borderline high: 2.6–3.3		60 (13.67)	
	High: 3.4–4.1		23 (5.24)	
	Very high: >4.1		12 (2.73)	
	Microalbuminuria (mg)	66.92±154.34		140 (28.6)
	Optimal: <30		94 (67.14)	
	Microalbuminuria: 30–300		36 (25.71)	
	Macroalbuminuria: >300		10 (7.14)	
	Albumin/creatinine (mg/mmol)	41.79±151.10		204 (41.6)
	Optimal: <3		103 (50.49)	
	Borderline high: 3–30		71 (34.80)	
	High: >30		30 (14.71)	
	Creatinine (µmol/L)	92.63±84.43		466 (95.1)
	Men: target 70–120		166 (35.62)	41 (8.80)
	Non-target>120			
	Women: target 50–90		203 (43.56)	
	Non-target >90		56 (12.02)	
	Urea (mmol/L)	6.54±5.36		440 (89.8)
	Target: 2.5–7.1		334 (75.91)	
	Non-target: >7.1		106 (24.09)	
	eGFR (mL/min/1.73m <sup>2</sup> )	81.09±28.26		446 (95.1)
	Optimal: ≥90		207 (46.41)	
	Kidney damage: 15–89		231 (51.79)	
	Kidney failure: <15		8 (1.79)	
	Serum 25(OH)D (nmol/L)	64.23±27.39		334 (68.2)
	Optimal: >75		114 (34.13)	
	Insufficiency: 50–75		110 (32.93)	
	Deficiency: <50		110 (32.93)	

BMI, body mass index; eGFR, estimated glomerular filtration rate; HDL, high-density lipoprotein; LDL, low-density lipoprotein; N, number.

**Table 2** Types and frequencies of vascular complications of type 2 diabetes patients

Type of the complication	N (%)
No complications	81 (16.53)
Single diabetic complication	
Neuropathy	21 (4.29)
Nephropathy	29 (5.92)
Retinopathy	65 (13.26)
Coronary artery disease	50 (10.20)
Combined diabetic complication	
Neuropathy, coronary artery disease	15 (3.06)
Neuropathy, nephropathy	17 (3.47)
Neuropathy, retinopathy	42 (8.57)
Nephropathy, coronary artery disease	21 (4.28)
Retinopathy, coronary artery disease	25 (5.10)
Nephropathy, retinopathy	24 (4.90)
Neuropathy, nephropathy, coronary artery disease	14 (2.86)
Neuropathy, retinopathy, coronary artery disease	16 (3.27)
Nephropathy, retinopathy, coronary artery disease	24 (4.90)
Neuropathy, nephropathy, retinopathy	24 (4.90)
Neuropathy, nephropathy, retinopathy, coronary artery disease	22 (4.49)
Total	490 (100)

N, number.

Diabetic complications were present in over 80% of the investigated cohort, where nearly 50% of the patients had two or more complications with retinopathy being the most common single complication, followed by CAD.

Reported hypertension, dyslipidemia, and measured obesity were the most common risk factors present in the cohort. These rates, estimated at over 80%, are much higher than those reported in the general UAE population<sup>10</sup> and in other regional populations, as well

**Table 3** Distribution of complications according to age groups of patients

Age	N	Complications: N (%)	Most common complication: (%)
≤35	12	5 (41.7)	Retinopathy (16.7) Neuropathy (16.7)
35–50	70	49 (70)	Retinopathy (18.6)
50–65	248	208 (83.9)	Retinopathy (16.1)
>65	160	151 (94.4)	Combination of R, Nph, and CAD (10.6)
Total	490		

CAD, coronary artery disease; N, number; Nph: nephropathy; R, retinopathy.

as worldwide.<sup>18–20</sup> The high percentage of hypertension, in particular, has a significant effect on the incidence of microvascular and macrovascular complications. Systolic blood pressure in these patients was above normal (>120 mm Hg) and above the recommended target level of 130/80 mm Hg set for patients with diabetes mellitus.<sup>14,21</sup> A recent report suggests that this target level (130/80 mm Hg) should be achieved in Asians, owing to the stronger association of hypertension, kidney disease, CVD and stroke,<sup>22</sup> which may also be relevant to the UAE. The higher systolic and diastolic blood pressure levels reported in the current study may be additional parameters, to the elevated BGL and HbA1c levels, toward explaining the high percentage of complications observed in this cohort, since hypertension has been shown to be associated with retinopathy, CAD, kidney disease as well as peripheral vascular disease. A previous study in the UAE on a mixed population reported a prevalence of 58% for retinopathy, 60% for CVD and 31% with diabetic nephropathy.<sup>17</sup>

The link between good glycemic control and the low incidence of microvascular and macrovascular complications in patients with type 2 diabetes is well established.<sup>23,24</sup>

A high prevalence of obesity, poor glycemic control, and cardiovascular events were reported in previous studies to be the major causes of comorbidities in patients with type 2 diabetes, especially in an older age group.<sup>25</sup>

In addition, the high rate of vitamin D deficiency is another factor associated with both obesity and type 2 diabetes.<sup>26,27</sup> Vitamin D deficiency is primarily related to cultural aspects in the UAE and requires better monitoring, especially in women. Greater effort is also needed to control obesity and glycemic levels in patients with type 2 diabetes.

However, it is noteworthy that the high percentage of statin use (93.43%) was reflected by lower lipid profiles, suggesting that dyslipidemia is well controlled in this cohort. The general pattern of dyslipidemia in patients with type 2 diabetes is high triglycerides, high LDL-cholesterol, and low HDL-cholesterol.<sup>12</sup> In the current cohort, more than 80% had optimal levels of total cholesterol, and more than 70% had desirable values of triglycerides and LDL-cholesterol. The only indicator for dyslipidemia was the relatively low levels of HDL-cholesterol in 46.39% of males and 57.14% of females, which may be due to genetic factors or certain medications. The low HDL levels constitute a higher risk of CVD.

There was also a clear discrepancy with renal involvement and type 2 diabetes in this cohort. Microalbuminuria, the early sign of the nephropathy, was only significantly abnormal in about 30% of the patients, while possible renal damage reflected by eGFR levels was reported in about 60% of patients. However, microalbuminuria may be underestimated as microalbuminuria data was only available for 28.57%, while eGFR levels were reported in 91.02% of patients.

eGFR, which is widely used as a marker of diabetic nephropathy, and disease duration were the most

**Table 4** Association between clinical and laboratory variables with complications of type 2 diabetes in the study subjects

Variables†	Estimate	SE	OR (95% CI)	p
Complication versus no complication				
Waist circumference	0.0277	0.0146	1.03 (1.00 to 1.06)	0.058
Cholesterol total	-0.4024	0.1716	0.67 (0.48 to 0.94)	0.019*
eGFR	-0.0354	0.0138	0.97 (0.94 to 0.99)	0.010*
Duration of type 2 diabetes	0.5047	0.1707	1.66 (1.19 to 2.31)	0.003*
Coronary artery disease (CAD) versus no CAD				
Creatinine	-0.0047	0.0027	1.00 (0.99 to 1.00)	0.085
eGFR	-0.0210	0.0081	0.98 (0.96 to 0.99)	0.010*
Smoking	0.6839	0.2702	1.98 (1.17 to 3.38)	0.011*
Duration of type 2 diabetes	0.2240	0.0855	1.25 (1.06 to 1.48)	0.009*
Retinopathy versus no retinopathy				
Age	-0.0586	0.0160	0.94 (0.91 to 0.97)	0.00025*
BMI	0.0620	0.0309	1.06 (1.00 to 1.13)	0.045
Waist circumference	-0.0574	0.0153	0.94 (0.91 to 0.97)	0.00018*
HbA1c	-0.1669	0.0886	0.85 (0.71 to 1.00)	0.0598
Cholesterol-total	1.2527	0.3973	3.50 (1.64 to 7.80)	0.0016*
Triglycerides	-0.5821	0.2113	0.56 (0.37 to 0.84)	0.0059*
LDL-cholesterol	-1.2845	0.4356	0.28 (0.12 to 0.64)	0.0032*
eGFR	0.0144	0.0084	1.01 (1.00 to 1.03)	0.085
Neuropathy versus no neuropathy				
Urea	0.1335	0.0589	1.14 (1.02 to 1.29)	0.023

†Only significant and suggestive associations are shown.  
BMI, body mass index; eGFR, estimated glomerular filtration rate.

significant predictors for the development of type 2 diabetes complications. Suboptimal eGFR levels have been reported to increase the risk of cardiovascular events in patients with type 2 diabetes independently by 2.2–3.1 fold,<sup>28 29</sup> both in younger and older patients. van der Velde *et al*<sup>30</sup> reported that eGFR and age together could significantly predict cardiovascular events in type 2 diabetes in younger patients but not in the elderly. In addition, a meta-analysis including 31 reports suggested low eGFR (<60 mL/min/1.73 m<sup>2</sup>) was independently related to the overall mortality due to type 2 diabetes.<sup>31</sup> This study had a relatively low number of patients with eGFR levels below 60 mL/min/1.73 m<sup>2</sup>; therefore, a larger study is warranted in order to confirm eGFR as a predictor for type 2 diabetes-associated complications and toward adding it as a routine clinical test. A previous study of ours also reported that cardiac rhythm anomalies may already be present in type 2 diabetes even if eGFR falls between 60 and 90 mL/min and suggested additional factors that may lead to the increased mortality associated with type 2 diabetes complications.<sup>32 33</sup>

Further evidence of the increased risk of kidney disease in patients with diabetes is associated with serum vitamin 25(OH)D that was reported in 65.85% of patients, which is close to the number observed here with poor eGFR rate.<sup>34</sup> This confirms previous findings

in diverse cohorts of a correlation between kidney function and vitamin D levels. In addition, a previous study in the UAE reported significant microalbuminuria in 61% of patients with type 2 diabetes,<sup>35</sup> also confirming our findings.

Prevalence of one or more complications due to type 2 diabetes was over 80%, with the prevalence increasing with age to 94.4% in the over-65 year-old age group. Overall, the prevalence of microvascular complications is almost double compared with macrovascular complications (20.41% vs 10.20%). The most common single complication was DR, which was clinically detected in 13.26% of patients. Furthermore, retinopathy was found in all age groups. DR is the leading risk factor of blindness in the working-age adults, especially in patients with longer disease duration.<sup>36</sup> In this study, age, obesity, and lipids parameters were the main significant risk factors for the development of DR. Dyslipidemia is a well-known risk factor for the development of DR. For instance, elevated serum total cholesterol and LDL-cholesterol are known risk factors for the development of retinal hard exudate (reviewed in ref 36).<sup>36</sup> Furthermore, van Leiden *et al* reported that in addition to the levels of total cholesterol, the levels of triglycerides as well as BMI also contribute to the development of DR regardless of the glycemic levels.<sup>37</sup>

A previous report in the UAE indicated a retinopathy prevalence in patients with type 2 diabetes at 19%.<sup>38</sup> This possibly indicates improved care since 2008, when that study was reported, as there are more diabetes centers located throughout the UAE that are implementing comprehensive screening to identify diabetic complications and provide early treatment for retinopathy. Prevalence of retinopathy in our study was also well below other populations in the Gulf area (19.7% in Saudi Arabia and 23.5% in Qatar),<sup>39,40</sup> which may be due to differences in disease duration, level of care, and the sample sizes in the different studies.

Although we did not observe an association between the BMI and DR, we found DR to be associated with waist circumference. This is in line with a previous multiethnic study that reported a consistent association between the waist-to-hip ratio with DR but not with BMI,<sup>41</sup> confirming that obesity is a risk factor for development of DR.

## CONCLUSIONS

This study investigated the current status of type 2 diabetes and its main complications in the UAE. Comorbidities and diabetes-associated complications were found to be higher as compared with other countries, most likely due to the increased levels of hypertension, obesity and decreased kidney function. Although dyslipidemia was generally well controlled, glycemic control and obesity need more attention and care. The study also suggests low eGFR especially in combination with longer disease duration could be related to the vascular complications observed and may be a useful predictor for the development of diabetes complications. In summary, the current study has identified the main trends in type 2 diabetes progression, comorbidities, and associated complications among UAE patients. Considering the high prevalence of the disease and its devastating human, social and economic costs in the UAE and the Middle East region, this can contribute toward more effective screening and improved treatment protocols.

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