https://doi.org/10.46389/rjd-2021-1026
www.rjdnmd.org

Rom J Diabetes Nutr Metab Dis
2021; volume 28, issue 2, pages 160-169

Original Research

Retinopathy and chronic kidney disease in type 2 diabetes mellitus

Butaina Haj, Simona Georgiana Popa*

Department of Diabetes, Nutrition and Metabolic Diseases, University of Medicine and Pharmacy Craiova, Romania

*Correspondence to: Simona Georgiana Popa, Assoc. Professor, MD, PhD, Department of Diabetes, Nutrition and Metabolic Diseases, University of Medicine and Pharmacy Craiova, 2-4 Petru Rares Street, Craiova, Romania, E-mail id: geossim@yahoo.com, Phone: +40727713051

Received: 16 May 2021 / Accepted: 10 June 2021

Abstract

Aims: To evaluate the prevalence of diabetic retinopathy (DR) and chronic kidney disease (CKD) and also the association between DR and CKD and their association with cardiometabolic and sociodemographic factors, in patients with type 2 diabetes. **Materials and Methods:** We studied medical records of 443 consecutive hospitalized adult patients with type 2 diabetes. Diabetic chronic complications, insulin secretion, diabetes therapy, control and duration, cardiometabolic and sociodemographic data were assessed. **Results:** The current study indicates that the overall prevalence of DR was 63.4%. Of these, 31.6% had non-proliferative DR and 31.8% had proliferative DR. The overall prevalence of CKD was 51.7%, of which 26.2% had only eGFR < 60 mL/min/1.73m^2), 39.5% had only albuminuria, and 11.8% (0.14–0.74%) had both. In 28.9% of patients, DR and CKD were associated, and only 12.7% of patients had neither DR nor CKD. The simultaneous presence of DR and CKD was significantly associated with diabetic peripheral neuropathy, peripheral artery disease and also with long lasting diabetes. About 2.4% of patients with DR associated with CKD were newly diagnosed with diabetes. Patients with DR associated with CKD presented significantly higher BMI and waist compared with patients with CKD alone and with patients without DR or CKD and higher uric acid levels compared with patients with DR alone and with patients without DR or CKD. **Conclusions:** The results of this study indicate a high prevalence of DR and CKD both isolated and associated in hospitalized type 2 diabetic patients, providing data on their prognosis and association with several cardiometabolic risk factors.

Keywords: cardiometabolic factors, chronic kidney disease, diabetic retinopathy, type 2 diabetes

Background and Aims

Diabetes represent one of the most important and frequent metabolic disease worldwide and is expected to increase in prevalence in conjunction with rising rates of obesity, population growth and ageing [1–3]. Moreover, the Global Burden of Disease Study 2010 indicated that between 1990 and 2010, diabetes was the non-communicable disease with the fastest increasing contribution to the burden of lost disability-adjusted life-years [4]. The prevention and control of diabetic chronic complications is important because the morbidity and mortality related with diabetes impose a global burden on socioeconomic development [5].

Diabetic nephropathy is a well-described diabetic complication and the leading cause of end stage renal disease and diabetic retinopathy (DR) is a highly specific visual complication of diabetes and the leading cause of blindness [6–8].

Despite attempts to link the two most important microvascular complications of diabetes, retinopathy and nephropathy, the

relationship has not so far been clearly described. Diabetes duration and glycemic, blood pressure, and lipid control have been shown to be consistently correlated with microvascular complications of diabetes, but to date, the relationship of one diabetic microvascular complication to another has not been fully clarified. In addition to sharing risk factors, such as hyperglycemia and hypertension, DR and chronic kidney disease (CKD) are reflected in the clinical manifestations of similar microvascular lesions in the glomerular and retinal vessels [8, 9]. Several studies have documented the association between DR and albuminuria in people with type 2 diabetes mellitus (T2DM) [10, 11], but on the other hand, DR has been shown to be a risk factor for microalbuminuria and macroalbuminuria [12].

However, the currently literature data suggest that the presence of a pre-existing retinopathy or nephropathy may contribute to the development of another [13, 14].

The main objective of this research was to evaluate the prevalence of DR and CKD and also the association between DR and CKD in patients with T2DM. The current study was designed also with the aim of evaluating the possible association of DR and CKD with cardiometabolic and sociodemographic factors in patients with T2DM.

Materials and Methods

The present study is a cross-sectional study conducted by analyzing the medical records of unselected patients with T2DM hospitalized in the Emergency Clinical Hospital Craiova, Department of Diabetes, Nutrition and Metabolic Diseases, during 1-year period.

In our study, we analyzed medical records from the last available hospitalization during which clinical evaluation and all procedures were performed in order to assess diabetes control, diabetic chronic complications, cardiometabolic factors and other comorbidities.

The survey was conducted according to the International Conference on Harmonization—Good Clinical Practice Guidelines standards and World Medical Association Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Participants (Seoul, 2008) and being a retrospective analysis of medical data routinely recorded in our hospital database in compliance with European Union General Data Protection Regulation, no further approval of an ethics committee is required. All patients admitted to the hospital signed informed consent for the use of their medical data for research purposes.

Clinical and biological data

Information regarding sociodemographic (age, gender), anamnestic data (maximum reported weight, DM duration, type and doses of DM antidiabetic therapy, diabetic chronic micro- and macrovascular complications, personal medical history of hypertension, dyslipidemia and obesity, anti-hypertensive, or lipid lowering therapy), clinical and biological data were collected from the electronic medical record.

Clinical evaluation included assessment of anthropometric parameters: height, weight, and waist circumference, body mass index (BMI), systolic (SBP) and diastolic blood pressure (DBP). Subjects with a BMI ≥ 25 kg/m^2 were considered as having overweight/obesity. Abdominal obesity was defined as a waist circumference ≥80 cm in women or ≥94 cm in men. Hypertension was defined as SBP ≥140 mmHg and/or DBP ≥90 mmHg and/or antihypertensive therapy, or a personal history of hypertension.

The following biochemical data were analyzed from the electronic medical records: glycated hemoglobin (HbA_{1c}), fasting plasma glucose (FPG), C-peptide, total cholesterol (TC), triglycerides, HDL cholesterol (HDL-C), creatinine, GOT, GPT, GGT, uric acid, albuminuria. LDL cholesterol (LDL-C) were calculated using the Friedewald formula if total triglycerides levels were <400 mg/dL.

Diagnosis of hypo-HDL cholesterolaemia was considered when HDL-C level < 40 mg/dL in men or <50 mg/dL in women or drug treatment for low HDL-C and hypertriglyceridemia when triglycerides level ≥150 mg/dL or drug treatment for hypertriglyceridemia.

Hypercholesterolemia was defined as TC≥200 mg/dL and/or statin therapy and hyper-LDL cholesterolaemia was defined as LDL-C≥100 mg/dL and/or statin therapy.

Poor controlled diabetes was considered when HbA_{1c} > 7%.

Hyperuricemia was considered when uric acid levels were ≥6 mg/dL in women or ≥7 mg/dL in men. Normal reference interval for C-peptide was considered 0.8–3.8 nmol/L.

Diabetic chronic complications

Diagnosis of macrovascular complications (ischemic heart disease, stroke, peripheral arterial disease) was based either on clinical data (peripheral arterial pulse, lower limb non-traumatic amputation, motor deficits, personal history of angioplasty or arterial by pass) or para-clinical data (EKG, CT, MRI, Doppler ultrasounds, angiography) from medical records.

Diagnosis of DR was based on eye fundus examination results registered in the electronic medical records. The findings from eye fundus examination were used to classify eyes as having one of two phases of DR: non-proliferative DR and proliferative DR. Diabetic macular edema was an additional complication that was recorded separately from the retinopathy stages. Laser therapy was also recorded.

Diagnosis of diabetic peripheral neuropathy was based on Toronto score which was evaluated using signs, symptoms and neuropathy tests results recorded in the medical charts. Toronto score higher than 6 was considered positive.

CKD was defined based on estimated glomerular filtration rate (eGFR) and albumin excretion rate, according to Kidney Disease Improving Global Outcomes 2012 guidelines. CKD was defined as eGFR < 60 mL/min/1.73 m^2 (CKD-EPI equation) and/or albuminuria.

Statistical analysis

Continuous variables were expressed as mean and standard deviation. The categorical variables were expressed as a percentage. The differences in sociodemographic and clinical-biological parameters according to the presence of DR and CKD were tested using parametric tests (t-test, ANOVA) or non-parametric Mann-Whitney test for the continuous variables and Chi-square for the categorical variables. A $p < 0.05$ (two-tailed) was considered statistically significant. The statistical analysis was performed using the SPSS v19.0 software.

Results

The current analysis includes 443 subjects (230 female/213 male, 61.6 ± 10.9 years, 3.8% in the 20–39 age group, 38.4% in the age group 40–59 years, 54.6% in the age group of 60–79 years and 3.8% in the >80 years age group) admitted in the Clinic of Diabetes, Nutrition and Metabolic Disease from Emergency Clinical Hospital Craiova.

Prevalence of diabetic retinopathy

The overall prevalence of DR was 63.4%. Of these, 31.6% had non-proliferative DR and 31.8% had proliferative DR (Figure 1). There were no significant age and gender differences in the prevalence of DR (Table 1).

Laser therapy was performed in 44% of patients with proliferative DR and in 1.4% of patients with non-proliferative DR.

24.1% of the patients with proliferative DR had maculopathy and only 6.4% of the patients with non-proliferative DR had maculopathy.

Vitreous hemoragy was found in 5.7% of the patients with proliferative DR.

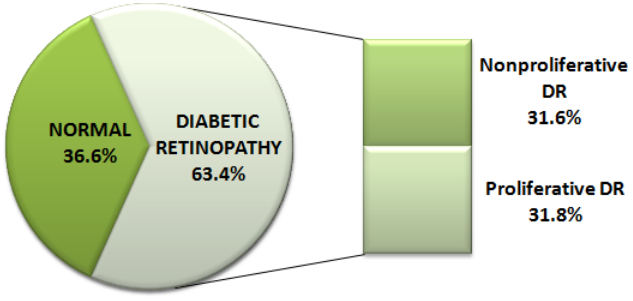

Figure 1: Prevalence of diabetic retinopathy. DR, diabetic retinopathy.

https://doi.org/10.46389/rjd-2021-1026

Table 1: Prevalence of diabetic retinopathy by gender and age groups.

	Age (years)				
	20–39	40–59	60–79	>80	Overall
Total population					
DR present	64.3	64.7	64.5	35.3	63.4
Non-proliferative DR	42.9	30.6	32.2	23.5	31.6
Proliferative DR	21.4	34.1	32.2	11.8	31.8
Men					
DR present	60.0	65.1	60.6	50.0	62.0
Non-proliferative DR	30.0	24.4	28.4	25.0	26.8
Proliferative DR	30.0	40.7	32.1	25.0	35.2
Women					
DR present	75.0	64.3	67.7	22.2	64.8
Non-proliferative DR	75.0	36.9	35.3	22.2	36.1
Proliferative DR	0.0	27.4	32.3	0.0	28.7

Prevalence of chronic kidney disease

The overall prevalence of CKD was 51.7%, of which 11.8% had eGFR < 60 mL/min/1.73m^2 associated with albuminuria (Figure 2). Analysis of the eGFR categories distribution indicated that 26.2% of the participants had stage 3–5 CKD (Figure 2). Albuminuria was detected in 39.5% of the analyzed subjects (Figure 2, Table 2).

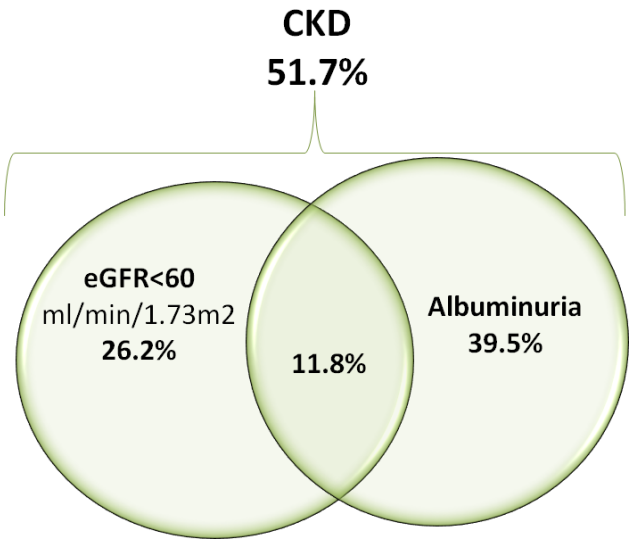

Figure 2: Prevalence of chronic kidney, albuminuria and eGFR < 60 mL/min/1.73m^2. CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

The prevalence of CKD increased significantly with age (p = 0.03), the highest prevalence being in the 80+ age group (Table 2). Regarding the gender distribution of CKD prevalence there were no significant differences (Table 2).

The distribution of eGFR categories by gender, age groups and overall are presented in Table 2. Stage 3–5 CKD predominated in patients over 60 years of age, overall but also in both genders, except CKD stage G5, which predominated in males in the 40–59 age group (Table 2). Albuminuria was predominant in patients over 80 years of age for both sexes (Table 2).

Prevalence of diabetic retinopathy associated with chronic kidney disease

Isolated DR was detected in 35.6% of patients, while CKD alone was diagnosed in 22.9% of patients (Figure 3). Only 12.7% of patients had neither DR nor CKD.

Diabetic retinopathy and CKD were significantly associated in analyzed T2DM patients (p < 0.001). In 28.9% of patients, DR and CKD were associated (Figure 3).

Patients with stage G3a and G3b CKD had predominantly normal eye fundus examination, suggesting that not only diabetes contributed to

Table 2: Prevalence of chronic kidney disease by gender and age groups.

	Age (years)				Overall
	20–39	40–59	60–79	>80	
Total population					
CKD present	35.7	45.2	56.0	70.6	51.7
G1 (eGFR ≥90 mL/min/1.73 m²)	92.9	56.9	15.0	5.9	33.4
G2 (eGFR: 60–89 mL/min/1.73 m²)	7.1	30.5	46.8	76.5	40.4
G3a (eGFR: 45–59 mL/min/1.73 m²)	0.0	5.4	18.9	17.6	13.0
G3b (eGFR: 30–44 mL/min/1.73 m²)	0.0	4.8	13.3	0.0	9.0
G4 (eGFR: 15–29 mL/min/1.73 m²)	0.0	0.6	4.3	0.0	2.6
G5 (eGFR <15 mL/min/1.73 m²)	0.0	1.8	1.7	0.0	1.6
Albuminuria	35.7	41.0	37.0	64.7	39.5
Men					
CKD present	50.0	49.4	59.8	75.0	55.7
G1 (eGFR ≥90 mL/min/1.73 m²)	90.0	65.9	17.8	0.0	40.0
G2 (eGFR: 60–89 mL/min/1.73m²)	10.0	17.6	40.2	75.0	31.0
G3a (eGFR: 45–59 mL/min/1.73 m²)	0.0	8.2	19.6	25.0	14.3
G3b (eGFR: 30–44 mL/min/1.73 m²)	0.0	4.7	17.8	0.0	11.0
G4 (eGFR: 15–29 mL/min/1.73 m²)	0.0	1.2	2.8	0.0	1.9
G5 (eGFR <15 mL/min/1.73 m²)	0.0	2.4	1.9	0.0	1.9
Albuminuria	50.0	42.4	41.9	62.5	43.3
Women					
CKD present	0.0	41.0	52.8	66.7	48.0
G1 (eGFR≥90 mL/min/1.73 m²)	100.0	47.6	12.7	11.1	27.1
G2 (eGFR: 60–89 mL/min/1.73 m²)	0.0	43.9	52.4	77.8	49.3
G3a (eGFR: 45–59 mL/min/1.73 m²)	0.0	2.4	18.3	11.1	11.8
G3b (eGFR: 30–44 mL/min/1.73 m²)	0.0	4.9	9.5	0.0	7.2
G4 (eGFR: 15–29 mL/min/1.73 m²)	0.0	0.0	5.6	0.0	3.2
G5 (eGFR <15 mL/min/1.73m²)	0.0	1.2	1.6	0.0	1.4
Albuminuria	0.0	39.5	33.1	66.7	36.1

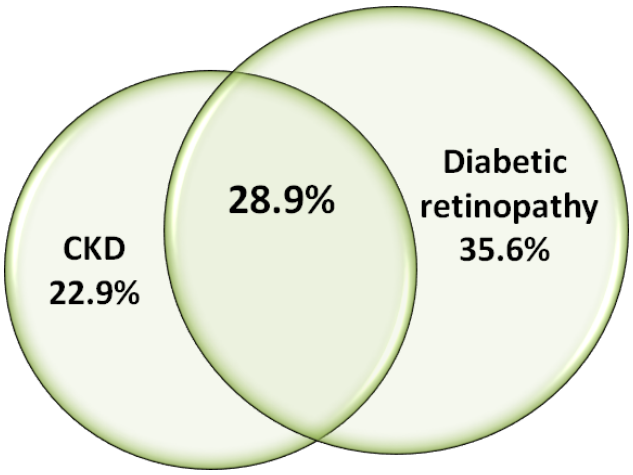

Figure 3: Association of chronic kidney disease with DR. CKD, chronic kidney disease.

CKD pathogeny, but also other potential causes such as hypertension, chronic pyelonephritis, hyperuricemia, etc. (Table 3).

In advanced stages of CKD (G4-G5), proliferative DR was predominantly detected, indicating diabetes as a leading cause of CKD progression (Table 3).

Analysis of factors associated with diabetic retinopathy and/or chronic kidney disease in patients with type 2 diabetes

The simultaneous presence of DR and CKD was significantly associated with

https://doi.org/10.46389/rjd-2021-1026

Table 3: Association of eGFR categories with diabetic retinopathy stages.

		Diabetic retinopathy (%)		
		Normal	Non-proliferative DR	Proliferative DR
eGFR categories (%)	G1	11.4	11.8	10.2
	G2	12.8	13.9	13.7
	G3a	6.3	3.0	3.7
	G3b	4.2	1.9	3.0
	G4	0.5	0.9	1.2
	G5	0.5	0.5	0.7

obesity, abdominal obesity, diabetic peripheral neuropathy, peripheral artery disease and also with hyperuricemia (Table 4).

Most of the patients with DR associated with CKD had long lasting diabetes with duration higher than 10 years (Table 4). About 2.4% of patients with DR associated with CKD were newly diagnosed with DM (Table 4).

Patients with DR associated with CKD presented significantly higher BMI and waist compared with patients with CKD alone and with patients without DR or CKD (Table 5).

The DM duration was significantly higher in patients with DR associated with CKD compared with patients with DR alone or CKD alone and also with patients without DR or CKD (Table 5).

Patients with DR associated with CKD presented significantly lower eGFR and higher uric acid levels compared with patients with DR alone and with patients without DR or CKD (Table 5).

Discussion

The current study indicates that the overall prevalence of DR was 63.4%, with similar distribution of non-proliferative and proliferative DR and the overall prevalence of CKD was 51.7%, of which 26.2% had stage 3–5 CKD and 11.8% had eGFR < 60 mL/min/1.73m^2 associated with albuminuria. DR and CKD were associated in 28.9% of patients.

These findigs are similar to other studies, although some reported that non-proliferative DR is more common. Thus, a study performed in Korea indicated that the overall prevalence of DR was 67.76%, from these 39.3% had non-proliferative DR and 28.4% had proliferative DR [15]. Liu Y. et al. reports that the prevalence of DR was 34.08% among diabetic patients from Mainland China, non-proliferative DR being more frequent [16]. Several studies indicated that the increased duration of DM is a risk factor for developing DR [17, 18].

Another finding of the current study was the high prevalence of CKD among hospitalized T2DM patients, results which are consistent with those reported by Thomas et al. in a study performed in Australia (23.1% of T2DM patients from primary care had eGFR < 60 mL/min/1.73 m^2 and 34.6% had albuminuria) and by New J. P., et al. in a study performed in the United Kingdom (eGFR < 60 mL/min/1.73 m^2 was detected in 31% of diabetic patients and albuminuria in 37% of these patients) [19, 20]. However, the prevalence of stage 3–5 CKD in T2DM was lower than that reported by Vinagre et al. (20% for renal impairment and 16.7% for albuminuria) and by Rodriguez-Poncelas A. et al. in a sample of 1145 T2DM patients treated in primary care consults in Spain (18% had a eGFR < 60 mL/min/1.73 m^2 and 15.4% had albuminuria) [21, 22].

Current study indicated that in 28.9% of patients, DR and CKD were associated, and only 12.7% of patients had neither DR, nor CKD. These findings are different from those reported by Penno G. et al. in the large cohort of the RIACE Italian multicenter study, which indicate that the majority of subjects (51.87%) had neither DR nor CKD, and an association between DR and CKD

Table 4: Factors associated with diabetic retinopathy and/or chronic kidney disease.

Variables (%)		Without DR or CKD	DR alone	CKD associate with DR	CKD alone	p value
Number of participants		55	154	125	99	
Body mass index (kg/m^2)	Normal weight	28.8	21.2	10.6	21.4	0.02
	25–30	28.8	21.9	28.5	32.7	
	≥30	42.3	57.0	61.0	45.9	
Abdominal obesity		71.4	89.0	94.1	84.4	0.001
Diabetes duration	Diabetes new case	29.1	11.0	2.4	20.2	<0.001
	<1 year	10.9	2.6	1.6	4.0	
	1–5 years	18.2	8.4	4.8	13.1	
	5–10 years	16.4	24.7	18.4	14.1	
	10–20 years	25.5	44.8	49.6	41.4	
	≥20 years	0.0	8.4	23.2	7.1	
Antidiabetic therapy	Non-insulin therapy	63.6	78.6	69.6	64.6	Ns
	Insulin therapy	50.9	57.8	64.8	40.4	0.01
HbA_{1c}≥7%		87.3	92.9	89.5	81.6	Ns
Insulin secretion	Normal C-peptide	63.6	72.0	58.3	73.9	Ns
	Low C-peptide	12.7	14.0	11.1	4.3	
	High C-peptide	23.6	14.0	30.6	21.7	
Diabetic macrovascular complications	Overall	43.6	77.3	84.0	76.8	<0.001
	Peripheral artery disease	43.6	71.4	79.2	55.6	<0.001
	Ischemic heart disease	38.2	59.1	66.4	68.7	0.001
	Stroke	5.5	8.4	12.0	13.1	Ns
Diabetic peripheral neuropathy		69.1	84.8	91.5	85.9	0.002
Hypertension		80.0	83.1	91.2	89.9	Ns
Hypercholesterolemia		38.9	30.1	32.0	32.7	Ns
Hyper-LDL cholesterolemia		79.6	73.9	76.8	74.1	Ns
Hypertriglyceridemia		50.0	45.8	58.4	54.1	Ns
Hypo-HDL cholesterolemia		32.7	54.8	55.4	65.9	0.003
Hyperuricemia		9.6	15.7	31.2	25.3	0.002

was found only in 11.50% [14]. The high prevalence of DR and CKD identified in our study could be justified by the fact that hospitalized patients were more likely to have long lasting diabetes and multiple associated comorbidities.

The current study indicates that 11.0% of patients with isolated DR were patients with newly diagnosed DM and 10.3% of patients with isolated CKD were newly diagnosed DM. Similar to our findings, Hao Z. et al, indicated a high prevalence of DR (20.3%) in patients with newly diagnosed T2DM [23]. The insidious onset of hyperglycemia symptoms that lead to late diagnosis of diabetes, after a long period of untreated hyperglycemia, but also other cardiometabolic risk factors (e.g. obesity, hyperuricemia) and lifestyle elements (e.g. smoking) are potential explanations for the increased prevalence of DR and CKD in newly diagnosed patients with diabetes [23, 24].

https://doi.org/10.46389/rjd-2021-1026

Table 5: Sociodemographic and biological parameters associated with diabetic retinopathy and/or chronic kidney disease.

Variables (Mean ± SD)	Without DR or CKD	DR alone	CKD associate with DR	CKD alone
Age	58.6 ± 12.2	60.3 ± 10.6	61.7 ± 9.9[¥]	65.3 ± 11.3[†,&]
BMI	28.8 ± 8.7	31.3 ± 8.2*	31.7 ± 5.4[#,¥]	30.0 ± 7.9
Maximum BMI	32.2 ± 8.7	34.8 ± 8.4*	35.2 ± 6.7[#]	33.5 ± 5.6
Waist	100.1 ± 16.6	106.3 ± 15.5*	109.2 ± 13.9[#,¥]	104.5 ± 16.3
DM duration	5.7 ± 5.9	11.1 ± 7.8*	14.2 ± 7.2[#,‡,¥]	9.2 ± 8.4[†,&]
Insulin dose/kg	0.4 ± 0.3	0.5 ± 0.3	0.5 ± 0.4	0.5 ± 0.3
eGFR	90.2 ± 15.9	88.6 ± 13.9	64.4 ± 25.3[#,‡]	64.5 ± 22.6[†,&]
SBP	137.1 ± 19.7	141.0 ± 19.7	142.6 ± 22.1	141.4 ± 19.4
DBP	83.3 ± 11.8	81.2 ± 12.6	79.6 ± 12.6	81.1 ± 11.2
Cholesterol	187.3 ± 58.1	179.0 ± 47.7	182.9 ± 48.4	189.5 ± 79.7
HDL cholesterol	38.7 ± 13.4	40.5 ± 12.8	37.6 ± 13.0[‡]	38.2 ± 13.4
LDL cholesterol	105.8 ± 48.3	104.0 ± 44.2	99.4 ± 40.5	101.9 ± 39.8
Triglycerides	197.4 ± 150.2	165.6 ± 96.0	208.0 ± 128.2[‡]	238.5 ± 427.1
Creatinine	0.8 ± 0.1	0.8 ± 0.1	1.3 ± 0.7[#,‡]	1.2 ± 0.9[†,&]
Uric acid	4.4 ± 1.5	4.8 ± 1.4	5.8 ± 2.0[#,‡]	5.6 ± 1.8[†,&]
HbA1c	10.1 ± 2.8	9.8 ± 2.0	9.6 ± 2.2	10.1 ± 2.7
C-peptide	2.9 ± 2.2	2.3 ± 1.4	3.3 ± 2.3	2.8 ± 1.5

*$p < 0.05$ DR alone vs. without DR or CKD; [†]$p < 0.05$ CKD alone vs. without DR or CKD; [#]$p < 0.05$ CKD associate with DR vs. without DR or CKD; [&]$p < 0.05$ RD alone vs. CKD alone; [‡]$p < 0.05$ RD alone vs. CKD associate with DR; [¥]CKD alone vs. CKD associate with DR.

Current study indicated that the simultaneous presence of DR and CKD were significantly associated with obesity and with abdominal obesity, which is consistent with other research results. Grey et al. reported that the increased risk of retinopathy correlates with higher BMI in a sample of 14,657 diabetic patients followed up for an average of 6.68 years [23, 25]. Data regarding the association of DR with obesity are conflicting, with studies reporting a lack of correlation and even an negative correlation between BMI and DR [26, 27]. Chan J. C. Y. et al. indicated that in patients with T2DM, a higher BMI appeared to have a protective effect on DR [27]. Man R. E. et al. shows that isolated abdominal obesity is a more clinically relevant risk factor for DR than BMI in T2DM patients [28]. Association of DR with obesity and abdominal obesity indicated the potential role of insulin resistance in the occurrence and progression of retinopathy.

Association of DR with CKD may be the key to understanding the pathogenic mechanisms common to microvascular complications of diabetes.

Future studies are needed to focus on establishing pathogenic mechanisms common to all microvascular complications as well as those specific to each microvascular complication so that physicians can effectively identify people at increased risk for developing and progression of chronic microvascular diabetic complications.

Lifestyle optimization, weight loss, obtaining and maintaining glycemic control, treating dyslipidemia and hyperuricemia should be important components of prevention programs and microvascular complications management.

The results obtained are of major importance for the medical system and can be of great help in the implementation of the microvascular

complications prevention programs, together with the reduction of the costs for treatment of these diseases.

Conclusions

The results of this study indicate a high prevalence of DR and CKD both isolated and associated in hospitalized T2DM patients, providing data on their prognosis and association with several cardiometabolic risk factors.

This finding suggests that it is essential to actively identify and combat the modifiable risk factors associated with microvascular diabetic complications in order to prevent or reduce their progression.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. International Diabetes Federation. (2019). IDF Diabetes Atlas ninth edition. 2019 update. Available from https://www.diabetesatlas.org/upload/resources/material/20200302_133351_IDFATLAS9e-final-web.pdf, accessed 16 February 2021.
2. Centers for Disease Control and Prevention. (2020). National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States, 2020. Available from: https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf, accessed 10 February 2021.
3. World Health Organization. (2014). Global status report on noncommunicable diseases 2014. Available from http://apps.who.int/iris/bitstream/10665/148114/1/9789241564854_eng.pdf, accessed 16 February 2021.
4. Murray, C. J., Vos, T., Lozano, R., et al. (2012). Disability-adjusted life years (DALYs) for 291 disease and injuries in 21 regions, 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 380: 2197–223.
5. Lin, X., Xu, Y., Pan, X., et al. (2020). Global, regional, and national burden and trend of diabetes in 195 countries and territories: an analysis from 1990 to 2025. *Sci Rep*. 10(1): 14790. doi:10.1038/s41598-020-71908-9.
6. Eckardt, K. U., Coresh, J., Devuyst, O., et al. (2013). Evolving importance of kidney disease: from subspecialty to global health burden. *Lancet* 382: 158–169. doi: 10.1016/S0140-6736(13)60439-0.
7. Moţa, E., Popa, S. G., Moţa, M., et al. (2015). Prevalence of chronic kidney disease and its association with cardiometabolic risk factors in the adult Romanian population: the PREDATORR study. *Int Urol Nephrol*. 47(11): 1831–1838. doi:10.1007/s11255-015-1109.
8. Rodríguez-Poncelas, A., Mundet-Tudurí, X., Miravet-Jiménez, S., et al. (2016). Chronic kidney disease and diabetic retinopathy in patients with type 2 diabetes. *PLoS One*. 11(2): e0149448. doi:10.1371/journal.pone.0149448.
9. Jeng, C. J., Hsieh, Y. T., Yang, C. M., Yang, C. H., Lin, C. L., Wang, I. J. (2016). Diabetic retinopathy in patients with diabetic nephropathy: Development and progression. *PLoS One*. 11(8): e0161897. doi:10.1371/journal.pone.0161897.
10. Narang, U. R., Jagadhami, V., Singla, M., et al. (2019). A study of prevalence of microalbuminuria and diabetic retinopathy in rural patients presenting to a tertiary care Hhospital in North India. *Int J Contemp Med Res*. 6(8): H18–H22. http://dx.doi.org/10.21276/ijcmr.2019.6.8.30.
11. Manaviat, M. R., Afkhami, M., Shoja, M. R. (2004). Retinopathy and microalbuminuria in type II diabetic patients. *BMC Ophthalmol*. 4: 9. doi:10.1186/1471-2415-4-9.
12. Moriya, T., Tanaka, S., Kawasaki, R., et al. (2013). Diabetic retinopathy and microalbuminuria can predict macroalbuminuria and renal function decline in Japanese type 2 diabetic patients: Japan Diabetes Complications Study. *Diabetes Care* 36(9): 2803–2809. doi:10.2337/dc12-2327.
13. Girach, A., Vignati, L. (2006). Diabetic microvascular complications--can the presence of one predict the development of another? *J Diabet Comp*. 20(4): 228–237. doi:10.1016/j.jdiacomp.2006.03.001.
14. Penno, G., Solini, A., Zoppini, G., et al. (2012). Rate and determinants of association between advanced retinopathy and chronic kidney disease in patients with type 2 diabetes: the Renal Insufficiency And Cardiovascular Events (RIACE) Italian multicenter study. *Diabetes Care* 35(11): 2317–2323. doi:10.2337/dc12-0628.
15. Yun, J. S., Lim, T. S., Cha, S. A., et al. (2016). Clinical course and risk factors of diabetic retinopathy in patients with type 2 diabetes mellitus in Korea. *Diabetes Metab J*. 40(6): 482–493. doi:10.4093/dmj.2016.40.6.482.
16. Liu, Y., Song, Y., Tao, L., et al. (2017). Prevalence of diabetic retinopathy among 13473 patients with diabetes mellitus in China: a cross-sectional epidemiological survey in six provinces. *Br Med J Open*. 7(1): e013199. doi:10.1136/bmjopen-2016-013199.
17. Voigt, M., Schmidt, S., Lehmann, T., et al. (2018). Prevalence and progression rate of diabetic retinopathy in type 2 diabetes patients in correlation with the duration of diabetes. *Exp Clin Endocrinol Diabet*. 126(9): 570–576. doi:10.1055/s-0043-120570.
18. Zou, W., Ni, L., Lu, Q., et al. (2016). Diabetes onset at 31–45 years of age is associated with an increased risk of diabetic retinopathy in type 2 diabetes. *Sci Rep*. 6: 38113. doi:10.1038/srep38113.
19. Thomas, M. C., Weekes, A. J., Broadley, O. J., Cooper, M. E., Mathew, T. H. (2006). The burden of chronic kidney disease in Australian patients with type 2 diabetes (the NEFRON study). *Med J Aust*. 185(3): 140–144. doi:10.5694/j.1326-5377.2006.tb00499.x.
20. New, J. P., Middleton, R. J., Klebe, B., et al. (2007). Assessing the prevalence, monitoring and management of chronic kidney disease in patients with diabetes compared with those without diabetes in general practice. *Diabet Med*. 24(4): 364–369. doi:10.1111/j.1464-5491.2007.02075.x.
21. Rodriguez-Poncelas, A., Garre-Olmo, J., Franch-Nadal, J., et al. (2013). Prevalence of chronic kidney disease in patients with

 https://doi.org/10.46389/rjd-2021-1026

type 2 diabetes in Spain: PERCEDIME2 study. *BMC Nephrol*. 14: 46. doi:10.1186/1471-2369-14-46.

22. Vinagre, I., Mata-Cases, M., Hermosilla, E., et al. (2012). Control of glycemia and cardiovascular risk factors in patients with type 2 diabetes in primary care in Catalonia (Spain). *Diabetes Care* 35(4): 774–779. doi:10.2337/dc11-1679.
23. Hao, Z., Huang, X., Qin, Y., et al. (2020). Analysis of factors related to diabetic retinopathy in patients with newly diagnosed type 2 diabetes: a cross-sectional study. *Br Med J Open*. 10(2): e032095. doi:10.1136/bmjopen-2019-032095.
24. Yau, J. W., Rogers, S. L., Kawasaki, R., et al. (2012). Global prevalence and major risk factors of diabetic retinopathy. *Diabetes Care* 35(3): 556–564. doi:10.2337/dc11-1909.
25. Gray, N., Picone, G., Sloan, F., Yashkin, A. (2015). Relation between BMI and diabetes mellitus and its complications among US older adults. *South Med J*. 108(1): 29–36. doi:10.14423/SMJ.0000000000000214.
26. Rooney, D., Lye, W. K., Tan, G., et al. (2015). Body mass index and retinopathy in Asian populations with diabetes mellitus. *Acta Diabetol*. 52(1): 73–80. doi:10.1007/s00592-014-0602-2.
27. Chan, J. C. Y., Chee, M. L., Tan, N. Y. Q., Cheng, C. Y., Wong, T. Y., Sabanayagam, C. (2018). Differential effect of body mass index on the incidence of diabetes and diabetic retinopathy in two Asian populations. *Nutr Diabet*. 8(1): 16. doi:10.1038/s41387-018-0018-0.
28. Man, R. E., Sabanayagam, C., Chiang, P. P., et al. (2016). Differential association of generalized and abdominal obesity with diabetic retinopathy in Asian patients with type 2 diabetes. *J Am Med Assoc Ophthalmol*. 134(3): 251–257. doi:10.1001/jamaophthalmol.2015.5103.

