

Prevalence and Factors Associated with Elevated Urinary Albumin-to-Creatinine Ratio in Elderly Hypertensive Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study in a Shanghai Community

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ABSTRACT

Background: Hypertension and type 2 diabetes mellitus (T2DM) share complex, interrelated pathophysiological mechanisms that contribute to impaired cardiac and renal function, along with complications such as retinopathy. The urinary albumin-to-creatinine ratio (UACR) is a critical biomarker for early detection of renal dysfunction and serves as a diagnostic indicator for both hypertensive and diabetic nephropathy. This study aimed to assess the prevalence of elevated UACR and identify its determinants among elderly individuals with hypertension and T2DM residing in a Shanghai community.

Methods: A cross-sectional study was conducted from January to December 2023 at Chuansha Huaxia Community Health Service Center. The study included participants aged 60 and above with confirmed diagnoses of both hypertension and T2DM. Clinical and laboratory data were collected, and participants were categorized into elevated or normal UACR groups.

Results: Among 831 individuals, 428 had elevated UACR, while 403 had normal levels. Univariate logistic regression identified age, gender, body mass index (BMI), fasting blood glucose (FBG), triglycerides, and estimated glomerular filtration rate (eGFR) as significant factors ($P < 0.05$). Multivariate analysis revealed age, gender, and FBG as independent predictors. UACR was positively correlated with age, BMI, glycosuria, and proteinuria. A sharp increase in UACR was observed when FBG, uric acid, blood urea nitrogen, and creatinine surpassed critical thresholds, or when eGFR fell below a key value. Conversely, optimal levels of uric acid and triglycerides were linked to the lowest UACR.

Conclusions: These findings underscore the importance of monitoring metabolic and renal parameters to prevent kidney complications in this high-risk population.

Keywords: Urinary albumin-to-creatinine ratio; hypertension; type 2 diabetes mellitus; elderly; renal complications

1. INTRODUCTION

Hypertension and type 2 diabetes mellitus (T2DM) are prevalent chronic conditions worldwide. It is estimated that the prevalence of hypertension in Chinese adults is 23.2%, affecting up to 245 million individuals [1], while the prevalence of hypertension among Chinese T2DM patients is 54% [2]. A cohort study in Northeast China involving 15,557 individuals over 40 without diabetes, with a median follow-up of 5.5 years, revealed a prediabetes prevalence of 44.3% and a hypertension prevalence of 60.4%, with suboptimal awareness, treatment, and control rates (45.3%, 35.1%, and 4.8%, respectively) [3]. Among hypertensive patients, the prevalence of T2DM is also strikingly high [4].

Hypertension and T2DM have complex and interrelated pathophysiological mechanisms, both contributing to declines in cardiac and renal function as well as retinopathy [5]. In the elderly population, the decline in renal function is even more pronounced when both hypertension and T2DM are present. The urinary albumin/creatinine ratio (UACR) is an important indicator of early renal impairment and a key diagnostic criterion for hypertensive nephropathy and diabetic nephropathy [6]. In this study, we collected clinical data from elderly patients over 60 years of age with concurrent hypertension and T2DM in a Shanghai community, analyzing the proportion of elevated UACR and its influencing factors, to provide clinical references for the renal protection of elderly community patients with comorbid hypertension and T2DM.

2. MATERIALS AND METHODS

2.1 Study Subjects

We selected patients aged 60 and above with comorbid hypertension and type 2 diabetes mellitus who visited the Chuansha Huaxia Community Health Service Center of Shanghai from January to December 2023. Inclusion criteria were: (1) age $\geq$ 60 years, (2) diagnosed with hypertension, (3) diagnosed with type 2 diabetes. Exclusion criteria included: (1) age < 60 years, (2) secondary hypertension, (3) diabetes types other than type 2, (4) missing clinical data. The study was approved by the Ethics Committee of Chuansha Huaxia Community Health Service Center of Shanghai, and all participants provided informed consent.

2.2 Study Methods

We collected general clinical information from the patients, including gender, age, height, weight, and the presence of fatty liver, among others. After a 12-hour fast, blood and urine samples were collected the following morning for testing. The tests included assessments of liver and kidney function, blood lipids, fasting blood glucose (FBG), and urinary albumin-to-creatinine ratio (UACR). Liver function tests included alanine aminotransferase (ALT) and aspartate aminotransferase (AST). Kidney function tests included creatinine (Cr), urea nitrogen (UN), uric acid (UA), and estimated glomerular filtration rate (eGFR). Blood lipid profiles included triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C). Body mass index (BMI) was calculated using the formula: $BMI = \text{weight (kg)} / \text{height}^2 (\text{m}^2)$. The estimated glomerular filtration rate (eGFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula [7].

2.3 Diagnostic Criteria and Grouping

Hypertension was diagnosed according to the Chinese Guidelines for the Prevention and Treatment of Hypertension (2018 Revised Edition) (4), and T2DM was diagnosed based on the Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes (2020 Edition) [8]. A UACR of less than 30 mg/g was considered normal, with patients assigned to the normal UACR group, while a UACR of 30 mg/g or higher was considered elevated, with patients assigned to the elevated UACR group [9].

2.4 Statistical analyses

Statistical analyses were performed using SPSS 20.0 and R software. Quantitative data conforming to a normal distribution were described using mean $\pm$ standard deviation ($\bar{x} \pm s$) and compared between groups using t-tests. Data not conforming to a normal distribution were expressed as median (interquartile range) [M (QL ~ QU)] and compared using Mann-Whitney U tests. Categorical data were expressed as frequencies and compared using chi-square tests. Univariate Logistic regression analysis was conducted for age, gender, BMI, fatty liver, FBG, blood lipids, liver and kidney function with respect to elevated UACR, and significant factors were further analyzed using multivariate Logistic regression. Restricted Cubic Spline (RCS) analysis was performed for age, BMI, FBG, blood lipids, and liver and kidney function in relation to UACR. A p-value of less than 0.05 was considered statistically significant.

3. RESULTS

3.1 Basic Information

A total of 831 patients were included in the study and divided into two groups based on UACR status: the elevated UACR group and the normal UACR group (Table 1). The elevated UACR group consisted of 428 cases (51.50%), with 185 males

(43.22%) and 243 females (56.78%), and an average age of 69.73 ± 5.81 years. The normal UACR group consisted of 403 cases (48.50%), with 213 males (52.85%) and 190 females (47.15%), and an average age of 71.74 ± 6.12 years. There were statistically significant differences in gender and age between the two groups ($P < 0.01$).

There were statistically significant differences in height, BMI, UACR, FBG, and eGFR between the two groups ($P < 0.05$). However, there were no statistically significant differences in triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), alanine aminotransferase (ALT), aspartate aminotransferase (AST), creatinine (Cr), urea nitrogen (UN), and uric acid (UA) ($P > 0.05$).

Table 1 Characteristics of participants in normal of elevated UACR groups

Variables	Total	Normal UACR group	Elevated UACR group	t/Z/ χ^2	P Value
n (%)	831 (100)	403 (48.50)	428 (51.50)		
Sex, n(%)				7.71	0.005*
Male	398 (47.89)	213 (52.85)	185 (43.22)		
Female	433 (52.11)	190 (47.15)	243 (56.78)		
Age, years	70.77 ± 6.05	69.73 ± 5.81	71.74 ± 6.12	-4.85	<0.001*
Height, cm	160.23 ± 8.28	161.71 ± 8.04	158.84 ± 8.27	5.04	<0.001*
Weight, kg	64.88 ± 10.41	65.34 ± 10.26	64.45 ± 10.55	1.23	0.219
BMI, kg/m ²	25.25 ± 3.54	24.97 ± 3.43	25.51 ± 3.62	-2.21	0.027*
UACR, mg/g	30.80 (18.51~64.38)	18.21 (13.25~22.91)	63.36 (40.14~152.36)	-24.94	<0.001*
FBG, mmol/L	8.59 ± 2.51	8.03 ± 2.15	9.11 ± 2.71	-6.37	<0.001*
TG, mmol/L	1.58 (1.16~2.31)	1.57 (1.16~2.22)	1.58 (1.16~2.49)	-1.67	0.096
TC, mmol/L	4.82 ± 1.08	4.82 ± 1.04	4.81 ± 1.12	0.10	0.922
HDL-C, mmol/L	1.20 ± 0.29	1.22 ± 0.30	1.19 ± 0.28	1.47	0.143
LDL-C, mmol/L	2.55 ± 0.84	2.61 ± 0.82	2.51 ± 0.85	1.76	0.078
ALT, U/L	21.00 (16.00~28.00)	21.00 (16.00~28.00)	20.00 (16.00~28.25)	-0.53	0.593
AST, U/L	21.00 (18.00~25.00)	21.00 (18.00~24.00)	21.00 (18.00~26.00)	-0.82	0.414
Cr, μ mol/L	74.00 (64.00~89.00)	73.00 (64.00~88.00)	75.00 (63.00~89.25)	-0.30	0.761
UN, mmol/L	6.37 ± 1.91	6.26 ± 1.82	6.48 ± 1.99	-1.72	0.086
UA, μ mol/L	327.10 (277.15~393.10)	331.70 (282.75~391.85)	324.05 (270.25~396.83)	-0.97	0.330
eGFR, ml/min/1.73m ²	80.90 ± 17.36	83.20 ± 15.68	78.74 ± 18.56	3.76	<0.001*

UACR, urinary albumin/creatinine ratio; BMI, Body Mass Index; FBG, Fasting blood glucose; TG, triglyceride; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; ALT, Alanine aminotransferase; AST, Aspartate transaminase; Cr, Serum Creatinine; UN, Serum Urea Nitrogen; UA, Serum Uric Acid;

eGFR, estimated glomerular filtration rate

* $P < 0.05$

3.2 Analysis of Factors Influencing Elevated UACR

Table 2 summarizes the results of analysis of factors influencing elevated UACR in the participants. Univariate logistic regression analysis was conducted for age, gender, BMI, fatty liver, FBG, triglycerides (TG), total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), alanine aminotransferase (ALT), aspartate aminotransferase (AST), creatinine (Cr), urea nitrogen (UN), uric acid (UA), and estimated glomerular filtration rate (eGFR) to determine their association with elevated UACR. The results indicated that age, gender, BMI, FBG, TG, and eGFR were significantly related to the elevation of UACR ($P < 0.001$ for age, FBG, and eGFR; $P = 0.006$ for gender; $P = 0.029$ for BMI; $P = 0.009$ for TG), while other factors showed no significant correlation ($P > 0.05$).

Subsequent multivariate logistic regression analysis, including age, gender, BMI, FBG, TG, and eGFR, revealed that age, gender, and FBG are independent factors influencing the elevation of UACR ($P < 0.001$ for age and FBG; $P = 0.010$ for gender).

Table 2 Results of logistic regression analysis

Variables	Univariate logistic regression analysis			Multivariate logistic regression analysis		
	OR ¹	95%CI ²	P Value	OR ¹	95%CI ²	P Value
Age	1.06	1.03~1.08	<0.001*	1.05	1.03~1.08	<0.001*
Sex						
Female	—	—		—	—	
Male	0.68	0.52~0.89	0.006*	0.68	0.51~0.91	0.010*
BMI	1.05	1.00~1.09	0.029*	1.04	1.00~1.08	0.076
Fatty liver						
No	—	—				
Yes	1.22	0.91~1.64	0.182			
FBG	1.21	1.14~1.29	<0.001*	1.21	1.13~1.29	<0.001*
TG	1.15	1.04~1.28	0.009*	1.07	0.96, 1.19	0.221
TC	0.99	0.88~1.13	0.922			
HDL-C	0.70	0.44~1.13	0.144			
LDL-C	0.86	0.73~1.02	0.079			
ALT	1.00	0.99~1.01	0.937			
AST	1.01	0.99~1.02	0.290			
Cr	1.01	1.00~1.01	0.065			
UN	1.07	0.99~1.15	0.087			
UA	1.00	1.00~1.00	0.670			
eGFR	0.98	0.98~0.99	<0.001*	0.99	0.98~1.00	0.100

¹ OR = Odds Ratio, ² CI = Confidence Interval

BMI, Body Mass Index; FBG, Fasting blood glucose; TG, triglyceride; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; ALT, Alanine aminotransferase; AST, Aspartate transaminase; Cr, Serum Creatinine; UN, Serum Urea Nitrogen; UA, Serum Uric Acid; eGFR, estimated glomerular filtration rate

* $P < 0.05$

3.3 Correlation of UACR with Age, BMI, Glycosuria, and Proteinuria

According to Table 3, the urinary albumin-to-creatinine ratio (UACR) showed a significant linear correlation with age, glycosuria, and proteinuria ($P < 0.001$), and also with body mass index (BMI) ($P = 0.029$). This indicates that for this group of patients, as age, BMI, glycosuria, and proteinuria gradually increase, UACR is likely to rise accordingly.

Table 3 Correlation between UACR and Age, Urine glucose and Urine protein [n (%)]

Variables	Total (n=831)	UACR, mg/g			χ^2 trend	P Value
		<30 (n=403)	30~300 (n=381)	>300 (n=47)		
Age, years					18.77	<0.001*
<67	232 (27.92)	138 (34.24)	85 (22.31)	9 (19.15)		
67~<73	298 (35.86)	145 (35.98)	136 (35.70)	17 (36.17)		
≥73	301 (36.22)	120 (29.78)	160 (41.99)	21 (44.68)		
BMI, kg/m ²					4.74	0.029*
<23.6	264 (32.04)	139 (34.84)	112 (29.63)	13 (27.66)		
23.6~<26.2	281 (34.10)	139 (34.84)	127 (33.60)	15 (31.91)		
≥26.2	279 (33.86)	121 (30.33)	139 (36.77)	19 (40.43)		
Urine glucose					18.97	<0.001*
0	560 (67.88)	294 (73.50)	242 (64.02)	24 (51.06)		
1+	71 (8.61)	31 (7.75)	34 (8.99)	6 (12.77)		
2+	52 (6.30)	26 (6.50)	23 (6.08)	3 (6.38)		
3+	52 (6.30)	23 (5.75)	26 (6.88)	3 (6.38)		
4+	90 (10.91)	26 (6.50)	53 (14.02)	11 (23.40)		
Urine protein					19.52	<0.001*
0	650 (78.79)	386 (96.50)	258 (68.25)	6 (12.77)		
1+	143 (17.33)	12 (3.00)	108 (28.57)	23 (48.94)		
2+	12 (1.45)	1 (0.25)	5 (1.32)	6 (12.77)		
3+	15 (1.82)	1 (0.25)	5 (1.32)	9 (19.15)		
4+	5 (0.61)	0 (0.00)	2 (0.53)	3 (6.38)		

UACR, urinary albumin/creatinine ratio; BMI, Body Mass Index

* $P < 0.05$

3.4 Correlation of UACR with Various Factors

Restricted Cubic Spline (RCS) analysis was performed to assess the correlation of the UACR with age, BMI, FBG, TG, TC, HDL-C, LDL-C, ALT, AST, Cr, UN, UA, and eGFR (Fig. 1). The results indicated that UACR is significantly correlated with FBG, TG, Cr, UN, UA, and eGFR ($P < 0.05$), while no significant correlations were found with the other factors ($P > 0.05$).

Although UACR might exhibit a linear relationship with TG and UA (P -nonlinear > 0.05), the graphical representation showed that the lowest UACR values corresponded to critical values of 1.30 mmol/L for TG and 314.09 μ mol/L for UA. The steepest slope of UACR was observed when FBG, Cr, UN, and eGFR reached critical values of 7.26 mmol/L, 82.52 μ mol/L, 6.82 mmol/L, and 77.09%, respectively. These findings suggest that UACR may rapidly increase when FBG, UA,

UN, and Cr exceed 7.26 mmol/L, 362.81 μ mol/L, 82.52 μ mol/L, and 6.82 mmol/L, respectively, or when eGFR is below 77.09%. Conversely, the lowest UACR values were observed when UA and TG were at 314.09 μ mol/L and 1.30 mmol/L, respectively.

4. DISCUSSION

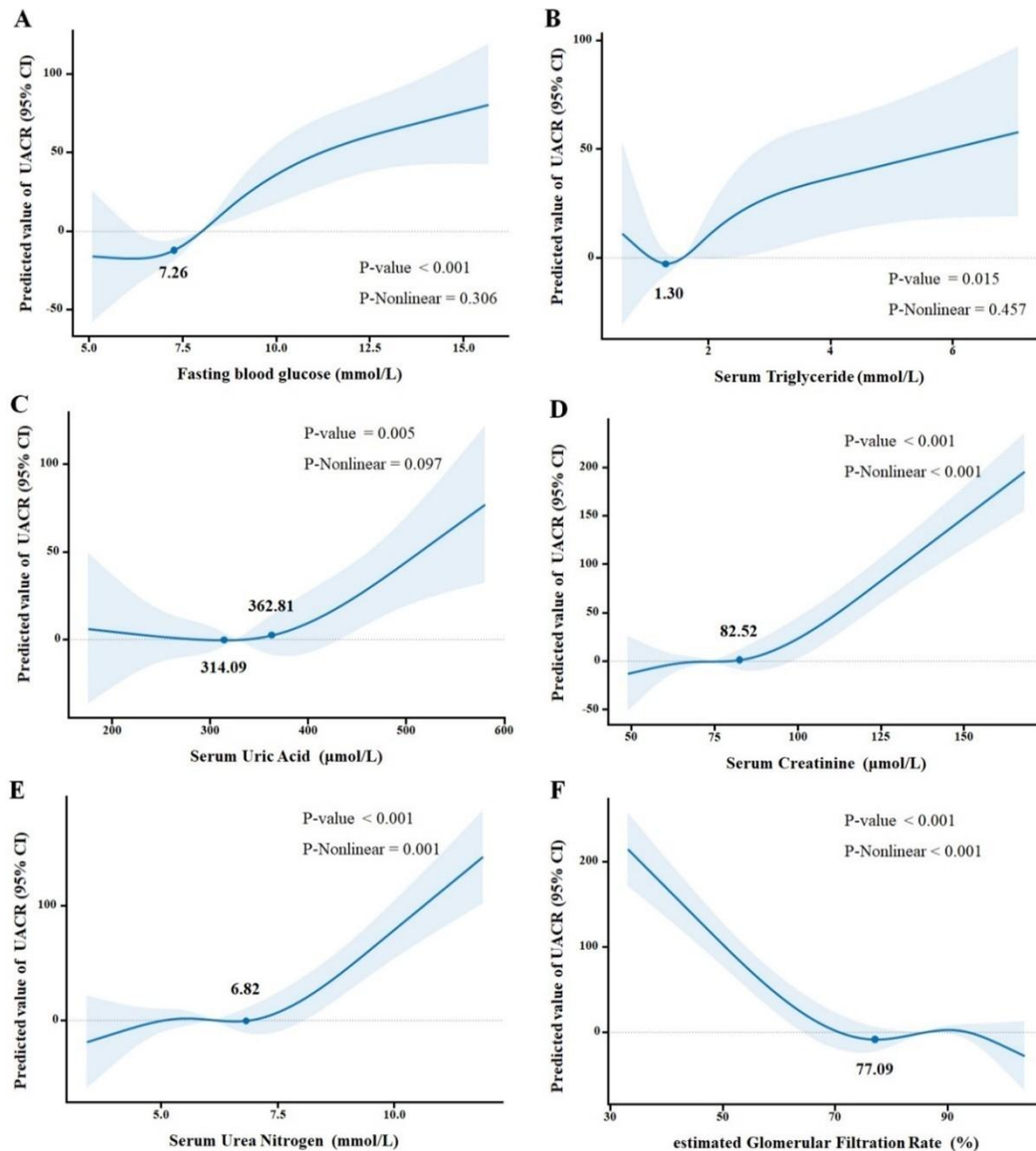


Fig. 1 Correlation between urinary albumin/creatinine ratio and various factors. (A) Fasting blood glucose, (B) Serum Triglyceride, (C) Serum Uric Acid, (D) Serum Creatinine, (E) Serum Urea Nitrogen, (F) estimated Glomerular Filtration Rate

Hypertension and type 2 diabetes mellitus (T2DM) share many common pathogenic mechanisms, such as insulin resistance, over-activation of the renin-angiotensin-aldosterone system, inflammation, and dysregulation of glucose and lipid metabolism, all of which can cause vascular damage and a decline in renal function^[10]. The urinary albumin-to-creatinine ratio (UACR) is an important indicator for diagnosing diabetic nephropathy and hypertensive nephropathy^[4, 8], and is easily measurable, making it suitable for early screening of kidney damage in large populations. UACR is also strongly correlated with hypertension combined with T2DM^[11] and is closely related to cardiovascular events and mortality resulting from these diseases^[12].

In this study, we found that the proportion of patients aged 60 and above with comorbid hypertension and T2DM with UACR ≥ 30 mg/g was 51.50%, which is higher than those with UACR < 30 mg/g, indicating a higher risk of renal function impairment in this segment of the community's population. A cross-sectional study in China involving 33,303 adults over

40 years old reported a median UACR value of 9.43, with the proportion of elevated UACR ranging from 9.6% to 16.9%^[13]. Another cross-sectional study in Taiwan involving 2,350 adults over 40 years old found an overall proportion of elevated UACR to be 12.98%, with the proportion of elevated UACR among diabetic patients being 32.36%^[14]. The proportion of patients with elevated UACR in our study is higher than in these two studies, possibly because our subjects were elderly people over 60 years old with concurrent hypertension and T2DM, leading to a higher proportion of elevated UACR.

In the analysis of factors influencing elevated UACR, we found that age, BMI, FBG, triglycerides (TG), and estimated glomerular filtration rate (eGFR) are associated with elevated UACR, and that age, female gender, and FBG are independent influencing factors. It is well known that as age increases, renal function gradually declines, and eGFR also gradually decreases^[15]. In this study, we also found a significant linear correlation between age and UACR; as age increases, UACR significantly rises, and the proportion of patients with elevated UACR also significantly increases. In terms of gender, the proportion of female patients with elevated UACR in this study was higher, which is consistent with the results of other studies^[15]. This suggests that in the elderly population with hypertension and T2DM, we may need to pay more attention to the renal function of females and older patients.

Moreover, we found that FBG was independently associated with elevated UACR, and subsequent Restricted Cubic Spline (RCS) analysis confirmed a clear correlation between the two, with UACR levels rising rapidly when FBG exceeded 7.26 mmol/L. Since all subjects included in this study had a confirmed diagnosis of T2DM, elevated FBG indicates poor glycemic control in these patients. Previous studies have shown a definite correlation between elevated FBG and UACR and renal function impairment, which is particularly evident in diabetic patients^[16]. For elderly patients with comorbid hypertension and T2DM in this community, stricter glycemic control may be required to reduce the occurrence of kidney damage, and maintaining FBG below 7.26 mmol/L might be even more beneficial.

Previous research has indicated that uric acid is an independent risk factor for metabolic syndrome and is strongly correlated with atherosclerosis in T2DM patients^[17]. A cross-sectional study in China involving 3,212 T2DM patients also confirmed that uric acid is an independent risk factor for diabetic nephropathy and is significantly correlated with proteinuria^[18]. In our study, Logistic analysis did not show that serum uric acid is a risk factor for elevated UACR, but RCS analysis showed a clear correlation between uric acid and UACR, with the lowest UACR levels observed at a uric acid level of 314.09 $\mu\text{mol/L}$, and rapid increases in UACR levels when uric acid exceeded 362.81 $\mu\text{mol/L}$. Our findings slightly differ from the aforementioned studies, and further exploration is needed to obtain stronger evidence.

Triglycerides (TG) have a strong correlation with UACR. A 2024 South Korean study involving 19,340 participants found that UACR is positively correlated with triglycerides, and the correlation between proteinuria and triglycerides, total cholesterol (TC), and high-density lipoprotein cholesterol (HDL-C) becomes more pronounced as proteinuria progresses from normal to severely elevated^[19]. The results of our univariate Logistic analysis showed a correlation between TG and elevated UACR, and RCS analysis also indicated an association between TG and UACR, with the lowest UACR levels observed at a TG level of 1.30 mmol/L. Although multivariate Logistic analysis did not find TG to be an independent influencing factor of UACR, it still indicates some correlation between the two. Although many studies have confirmed that the Triglyceride-glucose index has a good predictive and evaluative role in chronic kidney disease and diabetic nephropathy^[20-22], we did not use this indicator in this study because we wanted to find specific cut-off values for FBG and TG, making it easier to monitor and intervene in community patient management.

5. Conclusion

In summary, we found that among patients aged 60 and above with comorbid hypertension and T2DM in this community, the proportion of elevated UACR is high, and there are many patients with impaired kidney function. Actively controlling weight, blood glucose, triglycerides, and uric acid may help protect the kidneys and renal function of these patients. Due to the limitations of sample size and funding, this study could not conduct a larger-scale epidemiological survey. We hope that in subsequent studies, we can conduct some retrospective or prospective cohort studies to obtain stronger clinical evidence.

Author contributions

Shao-feng Wang: Data curation, Investigation, Writing – Original draft. **Hai-ying Zhang:** Data curation, Investigation, Writing – Original draft. **Hao-jun Dai:** Methodology, Formal analysis, Writing – Original draft. **Jie Gong:** Methodology, Formal analysis, Writing – Original draft. **Jin-jin Shi:** Validation, Writing – Review and editing. **Jing-wen Ling:** Validation, Writing – Review and editing. **Rosnani Hashim:** Conceptualization, Supervision, Writing – Review and editing. **Yi-hong Wei:** Conceptualization, Supervision, Writing – Review and editing.

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Ethics statements

The research was approved by the Ethical Committee of Chuansha Huaxia Community Health Service Center of Shanghai (Protocol No. and Date: PW2019A-14, 2019.10.10). Informed consent was obtained from all individual participants included

in the study (Consent Form No. and Date: 20191120100533053).

Conflicts of Interest

The authors declare no conflicts of interest.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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