Int J Clin Exp Med 2018;11(8):8585-8592
www.ijcem.com /ISSN:1940-5901/IJCEM0077071

Original Article

Research on the prevalence of chronic kidney disease and risk factors in northern populations of China

Quanle Han[1], Daixi Zhang[1], Ruiying Mao[1], Shuping Zuo[1], Shouling Wu[2], Yujing Hao[1], Xiaokun Liu[1]

[1]Department of Cardiology, Tangshan Gongren Hospital, Tangshan, Hebei Province, China; [2]Department of Cardiology, KaiLuan General Hospital, North China University of Science and Technology, Tangshan, Hebei Province, China

Received March 30, 2018; Accepted May 11, 2018; Epub August 15, 2018; Published August 30, 2018

Abstract: Objective: To study the prevalence of chronic kidney disease (CKD) and related risk factors in northern populations of China. Methods: The population receiving physical examination from June 2006 to October 2007 by the Kailuan Group, Tangshan City, Hebei Province (Kailuan population), was selected for the cross-sectional study. There were a total of 101,510 people aged 18-98 years old, including 81,110 males and 20,400 females. Serum creatinine was determined using an enzyme method, and the estimated glomerular filtration rate was calculated using the CKD-epidemiology collaboration formula (USA). Additionally, the prevalence trend and risk factors of CKD were analyzed using the statistical method. Results: In this study, a total of 100,164 people were included, including 79,985 males and 20,179 females. Among these people, there were 13,494 CKD patients with an average age of (58.8±13.5) years, including 3,206 females (23.8%) and 10,288 males (76.2%). The remaining 86,670 people had no CKD with an average age of (50.8±12.1) years, including 16,973 females (19.6%) and 69,697 males (80.4%). Age, body mass index (BMI), systolic blood pressure (SBP), fasting blood glucose (FBG), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol, high-sensitivity C-reactive protein, and proportion of subjects taking hypotensive drugs and physical exercise in non-CKD group were lower than those in CKD group, and differences were statistically significant (all P<0.001). The proportion of male patients in the non-CKD group was higher than that in the CKD group, while the proportion of female patients in the non-CKD group was lower than that in the CKD group, and differences were statistically significant (both P<0.001). In terms of prevalence rate of CKD in different age and gender groups, it was 13.5% in the general population, 12.9% in males and 15.9% in females (all P<0.05). The prevalence rate of CKD gradually increased with age (P<0.001): it was 6.7%, 10.6% and 25.6% in the young, middle-aged, and elderly groups, respectively, and it was 6.3%, 9.5% and 24.4% in males in the three groups, and 7.6%, 14.5% and 34.1% in females in the three groups. There was no statistically significant difference between different gender in each group (P>0.05). Multivariate logistic regression analyses of influencing factors of CKD showed that age (odds ratio (OR) (95% CI) = 1.055 (1.053-1.057)), gender (OR (95% CI) = 0.561 (0.535-0.588)), SBP (OR (95% CI) = 1.012 (1.009-1.011)), BMI (OR (95% CI) = 1.021 (1.015-1.027)), LDL-C (OR (95% CI) = 1.345 (1.319-1.372)) and TG (OR (95% CI) = 1.323 (1.263-1.385)) were risk factors of CKD, while physical exercise (OR (95% CI) = 0.827 (0.785-0.872)) was a protective factor of CKD, and differences were statistically significant (P<0.001). After different gender stratification, multivariate logistic regression analyses of influencing factors of CKD showed that FBG (OR (95% CI) = 1.022 (1.000-1.045)) was a risk factor for male patients with CKD (P<0.05), but it had no effect on females (OR (95% CI) = 0.988 (0.976-1.000)) (P>0.05). Physical exercise (OR (95% CI) = 0.797 (0.750-0.846)) was a protective factor for female patients with CKD (P<0.05), but it had no effect on males (OR (95% CI) = 0.952 (0.852-1.065)) (P>0.05). Conclusion: CKD is prevalent in the population of Tangshan City, Hebei Province. Age, gender, BMI, SBP, LDL-C and TG are risk factors for the occurrence and development of CKD.

Keywords: Glomerular filtration rate, chronic kidney disease, risk factors, epidemiology

Introduction

As chronic kidney disease (CKD) has a high prevalence rate of 11%, it has been a global public health problem, and it is also an important risk factor of end-stage renal disease (ESRD), cardiovascular disease and premature death [1-4]. The disease is also the second major fastest-growing chronic disease leading to the death in the world after acquired immu-

Table 1. CKD-EPI formula

Gender	Scr (μmol/L)	GFR (CKD-EPI) ($mL \cdot min^{-1}$ ($1.73\ m^2$)$^{-1}$)
Female	≤ 62 years age	$144*(Scr/62)^{-0.329}*(0.993)^{age}$
	>62 years age	$144*(Scr/62)^{-1.209}*(0.993)^{age}$
Male	≤ 80 years age	$141*(Scr/80)^{-0.411}*(0.993)^{age}$
	>80 years age	$141*(Scr/80)^{-1.209}*(0.993)^{age}$

Note: CKD-EPI, chronic kidney disease-epidemiology; GFR, glomerular filtration rate.

nodeficiency syndrome, bringing huge financial burden to the family and society [5, 6]. At the same time, studies have confirmed that early detection of CKD and effective control of risk factors leading to CKD can help delay the progression of disease, improve health and extend life span [7]. In previous studies, risk factors were also found continuously. In addition to gender, age, and race, metabolic diseases, such as hypertension, obesity, diabetes mellitus and lipid metabolism disorder, were also confirmed in the progression of CKD [8-10].

In this study, the Kailuan cohort (ChiCTR-TNC-11001489) study was used to investigate and analyze the prevalence and risk factors of CKD in Tangshan City, Hebei Province, so as to provide more detailed data support for the primary prevention and secondary prevention of CKD.

Materials and methods

Research object

This study was approved by the Ethics Committee of Tangshan Gongren Hospital. The population receiving physical examination from June 2006 to October 2007 in Kailuan Group, Tangshan City, Hebei Province, was selected. There were a total of 101,510 people, aged 18-98 years old, including 81,110 males and 20,400 females. The records of population receiving physical examination were obtained from 11 hospitals (Kailuan General Hospital, Kailuan Linxi Hospital, Kailuan Zhaogezhuang Hospital, Kailuan Tangjiazhuang Hospital, Kailuan Fan'gezhuang Hospital, Kailuan Lujiatuo Hospital, Kailuan Jinggezhuang Hospital, Kailuan Linnancang Hospital, Kailuan Qianjiaying Hospital, Kailuan Majiagou Hospital, and Kailuan Branch).

Inclusion criteria: Subjects aged ≥18 years; subjects without cognitive impairment and were able to complete the questionnaire independently; subjects who agreed to participate in the study and signed the informed consent.

Exclusion criteria: Subjects who refused to participate in this study; subjects with glomerular filtration rate data missed.

Data materials

General material collection: Epidemiological questionnaire and anthropometry: Epidemiological questionnaire design, data completion and anthropometric methods are shown in the literature already published by our research group [11, 12]. Age, gender, body mass index (BMI), systolic blood pressure (SBP), fasting blood glucose (FBG), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), high-sensitivity C-reactive protein (hs-CRP), and proportion of subjects taking hypotensive drugs and physical exercise were analyzed and compared.

According to the age of subjects, they were divided into the young (<40 years old), the middle-aged (40-60 years old) and the elderly group (≥60 years old).

Collection of related laboratory data: After fasting antecubital venous blood (5 ml) was drawn from all participants in the morning and placed into an ethylene diamine tetraacetic acid tube and centrifuged at 3,000 rpm for 10 minutes at room temperature within 30 minutes. The upper-layer serum was taken, and serological indexes were determined using the Beckman full-automatic biochemical analyzer within 4 hours.

Estimated glomerular filtration rate (eGFR): eGFR was calculated using the CKD-epidemiology collaboration (CKD-EPI) formula developed by CKD-EPI (USA) [12]. See **Table 1**.

Determination of CKD events: According to the *Clinical Practice Guidelines for Chronic Kidney Disease and Dialysis* prepared by the Kidney Disease Outcome Quality Initiative of National Kidney Foundation Working Group, GFR <60 mL/min is used as a criterion of CKD [1].

Statistical processing

Data were input by specially-assigned personnel trained uniformly by the hospital personnel

Table 2. Basic materials of study population

Item	Non-CKD (n = 86,670)	CKD (n = 13,494)	χ^2/t	P
Age (year)	50.8±12.1	58.8±13.5	-70.3	<0.001
Male (n, %)	69,697 (80.4)	10,288 (76.2)	126.5	<0.001
Female (n, %)	16,973 (19.6)	3,206 (23.8)	127.2	<0.001
BMI (kg/m^2)	24.9±3.4	25.5±3.4	-18.3	<0.001
SBP (mmHg)	129.8±20.5	139.2±22.3	-48.9	<0.001
FBG (mmol/L)	5.4±1.6	5.6±2.1	-13.9	<0.001
LgTG (mmol/L)	0.1±0.3	0.2±0.3	-32.9	<0.001
LDL-C (mmol/L)	2.3±0.9	2.5±0.8	-29.1	<0.001
HDL-C (mmol/L)	1.5±0.4	1.6±0.4	-18.1	<0.001
Lg (hs-CRP)	-0.1±0.67	-0.04±0.63	-9.8	<0.001
Taking hypotensive drugs (n, %)	8,957 (10.3)	2,291 (17.0)	516.9	<0.001
Physical exercise (n, %)	12,810 (14.8)	2,375 (17.6)	72.2	<0.001

Note: CKD, chronic kidney disease; BMI, body mass index; SBP, systolic blood pressure; FBG, fasting blood glucose; LgTG, triglyceride after logarithmic conversion; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; Lg (hs-CRP), high-sensitivity C-reactive protein after logarithmic conversion.

Table 3. Prevalence rate of CKD in different age and gender groups

Group	Prevalence rate of CKD (CKD case/group case; n, %)				Z	P
	Total population (n = 100,164)	Young group (n = 16,333)	Middle-aged group (n = 60,388)	Elderly group (n = 23,443)		
Male CKD/n (n, %)	10,288/79,985 (12.9)	772/12,178 (6.3)	4,506/47,263 (9.5)	5,010/20,544 (24.4)	126.53	<0.001
Female CKD/n (n, %)	3,206/20,179 (15.9)	317/4,155 (7.6)	1,899/13,125 (14.5)	990/2,899 (34.1)	127.16	<0.001
Total	13,494/100,164 (13.5)	1,089/16,333 (6.7)	6,405/60,388 (10.6)	6,000/23,443 (25.6)	123.15	<0.001

Note: CKD, chronic kidney disease.

in the Research Center, and verified by researchers in the Cardiovascular Laboratory of Kailuan Hospital. SPSS 13.0 was used for statistical analysis. Measurement data conforming to the normal distribution are presented as ($\overline{X}$ ± sd), measurement data not conforming to the normal distribution were presented as the median (quartile), and the independent-samples t test and rank sum test were used for the intergroup comparison as appropriate. Analysis of variance was used for the comparison among groups. Enumeration data is presented as percentage, and Chi-square test was used for the comparison of rate. Influencing factors of CKD were analyzed using the logistic regression analysis. P<0.05 (two-sided test) suggests that the difference is statistically significant.

Results

Basic materials of study population

In this study, a total of 100,164 people were included, including 79,985 males and 20,179 females. Among these, there were 13,494 CKD patients, with an average age of (58.8±13.5) years, including 3,206 females (23.8%) and 10,288 males (76.2%). The remaining 86,670 people had no CKD with an average age of (50.8±12.1) years, including 16,973 females (19.6%) and 69,697 males (80.4%). Age, BMI, SBP, FBG, TG, LDL-C, HDL-C, hs-CRP, and proportion of subjects taking hypotensive drugs and physical exercise in non-CKD group were lower than those in CKD group, and differences were statistically significant (all P<0.001). The proportion of male patients in the non-CKD group was higher than that in the CKD group, while the proportion of female patients in the non-CKD group was lower than that in the CKD group, and differences were statistically significant (both P<0.001). See **Table 2**.

Prevalence rate of CKD in different age and gender groups

In terms of prevalence rate of CKD in different age and gender groups, it was 13.5% in the general population, 12.9% in males and 15.9% in females (all P<0.05). The prevalence rate of CKD gradually increased with age (P<0.001): it

Table 4. Multivariate logistic regression analyses of influencing factors of CKD

Independent variable	β	SE	Wald	P	OR (95% CI)
Age	0.054	0.001	3,214.250	<0.001	1.055 (1.053-1.057)
Gender	-0.579	0.024	572.319	<0.001	0.561 (0.535-0.588)
SBP	0.010	<0.001	371.473	<0.001	1.012 (1.009-1.011)
BMI	0.021	0.003	47.522	<0.001	1.021 (1.015-1.027)
FBG	-0.005	0.005	0.771	0.380	0.995 (0.985-1.006)
LDL-C	0.297	0.010	855.413	<0.001	1.345 (1.319-1.372)
TG	0.280	0.023	142.440	<0.001	1.323 (1.263-1.385)
Physical exercise	-0.190	0.027	512.386	<0.001	0.827 (0.785-0.872)
Taking hypotensive drugs	-0.027	0.029	0.844	0.358	0.974 (0.920-1.031)

Note: CKD, chronic kidney disease; SE, standard error; BMI, body mass index; SBP, systolic blood pressure; FBG, fasting blood glucose; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; OR, odds ratio.

Table 5. Multivariate logistic regression analyses of influencing factors of CKD after different gender stratification

Group	Independent variable	β	SE	Wald	P	OR (95% CI)
Male	Age	0.043	0.002	359.962	<0.001	1.044 (1.039-1.049)
	SBP	0.008	0.001	51.815	<0.001	1.008 (1.006-1.014)
	BMI	0.006	0.006	1.099	0.294	1.006 (0.995-1.018)
	FBG	0.022	0.011	3.920	0.048	1.022 (1.000-1.045)
	LDL	0.504	0.022	518.239	<0.001	1.656 (1.586-1.730)
	TG	0.136	0.051	7.224	<0.001	1.146 (1.038-1.265)
	Physical exercise	-0.049	0.057	0.734	0.391	0.952 (0.852-1.065)
	Taking hypotensive drugs	0.076	0.060	1.606	0.205	1.079 (0.959-1.215)
Female	Age	0.057	0.001	2,861.020	<0.001	1.058 (1.056-1.061)
	SBP	0.010	0.001	332.842	<0.001	1.015 (1.009-1.011)
	BMI	0.028	0.004	63.571	<0.001	1.029 (1.022-1.036)
	FBG	-0.012	0.006	3.641	0.056	0.988 (0.976-1.000)
	LDL	0.240	0.011	436.527	<0.001	1.272 (1.243-1.301)
	TG	1.13	0.044	661.251	<0.001	3.117 (2.858-3.399)
	Physical exercise	-0.227	0.031	55.441	<0.001	0.797 (0.750-0.846)
	Taking hypotensive drugs	-0.043	0.033	1.674	0.196	0.958 (0.898-1.022)

Note: CKD, chronic kidney disease; SE, standard error; BMI, body mass index; SBP, systolic blood pressure; FBG, fasting blood glucose; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; OR, odds ratio.

was 6.7%, 10.6% and 25.6% in young, middle-aged, and elderly groups, respectively; and it was 6.3%, 9.5% and 24.4% in males in the three groups, and 7.6%, 14.5% and 34.1% in females in the three groups (**Table 3**).

Multivariate logistic regression analyses of influencing factors of CKD

Multivariate logistic regression analyses of influencing factors of CKD showed that age (odds ratio (OR) (95% CI) = 1.055 (1.053-1.057)), gender (OR (95% CI) = 0.561 (0.535-0.588)), SBP (OR (95% CI) = 1.012 (1.009-1.011)), BMI (OR (95% CI) = 1.021 (1.015-1.027)), LDL-C (OR (95% CI) = 1.345 (1.319-1.372)) and TG (OR (95% CI) = 1.323 (1.263-1.385)) were risk factors of CKD, and differences were statistically significant (all P<0.001). Physical exercise (OR (95% CI) = 0.827 (0.785-0.872)) was a protective factor of CKD (**Table 4**).

Multivariate logistic regression analyses of influencing factors of CKD after different gender stratification

After different gender stratification, multivariate logistic regression analyses of influencing factors of CKD showed that age, SBP, BMI, FBG,

LDL-C, and TG were risk factors for CKD in males, while age, SBP, BMI, LDL-C, and TG were risk factors for CKD in females. Physical exercise was a protective factor (**Table 5**).

Discussion

CKD has a higher prevalence rate in China, showing rapid growth. Current studies have found that there is a large fluctuation in the data about total prevalence rate of CKD. Chen et al. studied the sample survey data in Chinese population in 2000-2001, and found that the overall incidence rate of CKD in population was 2.53% [13]. The team of Wang of Peking University First Hospital found that the total prevalence rate of CKD in 2006-2010 was about 10.8%, indicating that the number of CKD patients in China is increased year by year [14]. In this study, cross-sectional analysis showed that the overall incidence rate of CKD in Tangshan City, Hebei Province was 13.5% in 2006-2007, which was similar to that obtained by the team of Wang. Previous studies found that CKD greatly increased the onset risk of coronary artery disease, stroke and congestive heart failure [15-17]. Recent studies have found that diabetes mellitus has become a major cause of CKD. Moreover, primary prevention and secondary prevention for relevant known risk factors inducing and exacerbating CKD, such as hypertension, diabetes mellitus and obesity, are far from perfect [8-10, 18]. Furthermore, further studies on unknown CKD risk factors are needed.

Age is an issue that each individual must face. The longitudinal study showed that GFR in subjects without CKD is also decreased with natural aging [19]. Some population-based studies found that the incidence rates of proteinuria and CKD are also increased with age, which is consistent with the results in this study [20]. According to logistic regression analysis, age was a risk factor for CKD, and the risk of CKD was increased by 5.5% for every 1 year old (95% CI = 1.053-1.057, P<0.001). Based on different age (young group, middle-aged group and elderly group), the prevalence rates of CKD were 6.8%, 9.5% and 24.4% in males, 7.6%, 14.5% and 34.1% in females, respectively. The prevalence rates of CKD in males and females were increased with age (P<0.001).

Current research data on whether gender is a risk factor for CKD remains controversial. In this study, logistic regression analysis results revealed that gender was a protective factor for CKD (OR (95% CI) = 0.561 (0.535-0.588)) (P<0.05). After different gender stratification, multivariate logistic regression analyses of influencing factors of CKD showed that FBG (OR (95% CI) = 1.022 (1.000-1.045)) was a risk factor for male patients with CKD (P<0.05), but it had no effect on females (OR (95% CI) = 0.988 (0.976-1.000)) (P>0.05). At present, many studies have reported that males show worse outcome of kidney disease, and onset risks of proteinuria and CKD in general population are higher [20-23]. However, Jafar et al. evaluated the therapeutic effect of angiotensin inhibitor on CKD via 11 randomized clinical studies, and made a conclusion that the risks of serum creatinine and ESRD are not increased in males, and the incidence rate of outcome event was higher in females than that in males after the baseline blood pressure and urinary protein excretion rate are adjusted, which is consistent with that made in this study [24]. The specific reasons need further study.

Obesity and being overweight are harmful factors for CKD, and BMI is a risk factor for CKD (OR (95% CI) = 1.021 (1.015-1.027), P<0.001). Due to major changes in people's dietary structure, the proportion of obese people constantly rises [25, 26]. Studies have found that the proportion of CKD in obese people with BMI greater than 30 is 3 times that in non-obese people [27, 28]. Foster et al. studied the predictive indexes of new-onset CKD in general population, and also showed that the risk of CKD is increased by 23% by BMI (OR (95% CI) = 1.230 (1.080-1.410)) [19]. Lu et al. studied and found that the mechanism of obesity in causing CKD or accelerating decline in GFR may exert effects through multiple pathways, including obesity complications (such as diabetes mellitus and hypertension), and direct metabolic effect, leading to excessive fat [29]. Abdominal obesity, increased waist circumference, and increased fat around the renal sinus are positively correlated with the occurrence of CKD.

Results of logistic regression analysis showed that both LDL-C (OR (95% CI) = 1.345 (1.319-1.372)) and TG (OR (95% CI) = 1.323 (1.263-1.385)) were risk factors for CKD (both P< 0.001), which were inconsistent with research results of Rahman et al.; in the prospective cohort study of Rahman et al., 3,939 CKD

patients aged 21-74 years were followed up for 4.1 years on average, and the decline in baseline ESRD and GFR by 50% was taken as the endpoint of event, but no single index of blood lipid and lipoprotein was independently associated with the outcome event [30]. Therefore, total cholesterol, TG, VLDL-C, LDL-C, HDL-C, apolipoprotein A-1, apolipoprotein B, and LP (a) have no independent correlations with CKD. However, McMahon et al. studied and found that the high TG level increased the risk of CKD (OR (95% CI) = 1.710 (1.140-2.590)), but the low serum HDL-C level did not increase the risk of CKD (OR (95% CI) = 0.890 (0.810-0.970)) [31].

Results of logistic regression analysis in this study showed that physical exercise was a protective factor for CKD (OR (95% CI) = 0.827 (0.785-0.872)). Inflammatory factors play important roles in the occurrence and development of CKD [32-34]. Howden et al. performed the clinic trials about 10 relevant data reviews, most of which had small sample size and were non-randomized and non-clinical controls [35]. Meta-analyses showed that physical exercise, as a protective factor for CKD, might have the following mechanism: exercise training can increase exercise capacity, increase muscle strength and function, reduce blood pressure, and improve inflammatory and oxidative stress biomarkers. However, statistical differences in renal function, cardiovascular disease and improvement of life quality remain unclear.

It was found in this study that CKD was preventable and controllable. In particular, the early detection plays a crucial role in delaying the progression of kidney disease, promoting people's health and extending people's lifespan. It is suggested that people should control blood pressure, blood glucose, blood lipids, and weight, and increase exercise, so as to delay the occurrence and development of CKD.

There were some limitations in this study. First, data came from the physical examination for workers in Kailuan Group, most of workers voluntarily received physical examination, and there was no lack of loss of some data. In particular, some biases in questionnaire content, amount of exercise, etc., may be caused due to the lack of unified standards. Second, Kailuan Group is engaged in heavy industry, so the gender ratio of workers is different from that of natural population, possibly producing a certain influence on results. Third, smoking, drinking, dietary status, history of coronary heart disease, genetic factors, related diseases, drugs and other factors should be included for natural population, so as to make the results more comprehensive and better serve the clinic.

In conclusion, the occurrence and development of CKD can be delayed through controlling blood pressure, blood glucose, blood lipids, and weight, and increasing exercise. In this study, a cross-sectional research method was used to analyze the Kailuan population, and this study covered the whole population with large sample size, so it was representative for the northern region of China. This study can provide data support for the Sanitary Administration Department to develop primary prevention and secondary prevention measures of CKD.

Acknowledgements

This work was supported by Key Technology Research Program of Hebei Provincial Department of Health (20171382).

Disclosure of conflict of interest

None.

Address correspondence to: Quanle Han, Department of Cardiology, Tangshan Gongren Hospital, No.27 Wenhua Road, Lubei District, Tangshan 063000, Hebei Province, China. Tel: +86-0315-2305008; E-mail: hanquanle85hy@126.com

References

[1] Gan L and Zuo L. Current ESRD burden and its future trend in Beijing, China. Clin Nephrol 2015; 83: 17-20.

[2] Coresh J, Astor BC, Greene T, Eknoyan G and Levey AS. Prevalence of chronic kidney disease and decreased kidney function in the adult US population: third national health and nutrition examination survey. Am J Kidney Dis 2003; 41: 1-12.

[3] Binder H, Kurz T, Teschner S, Kreutz C, Geyer M, Donauer J, Kraemer-Guth A, Timmer J, Schumacher M and Walz G. Dealing with prognostic signature instability: a strategy illustrated for cardiovascular events in patients with end-stage renal disease. BMC Med Genomics 2016; 9: 43.

[4] Foley RN, Parfrey PS and Sarnak MJ. Clinical epidemiology of cardiovascular disease in chronic renal disease. Am J Kidney Dis 1998; 32: S112-119.
[5] Naghavi MC, Wang H, Lozano R, Davis A, Liang X, Zhou M, Vollset SE, Ozgoren AA, Abdalla S and Abd-Allah F. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the global burden of disease study 2013. Lancet 2015; 385: 117-171.
[6] Bello AK, Levin A, Manns BJ, Feehally J, Drueke T, Faruque L, Hemmelgarn BR, Kernahan C, Mann J, Klarenbach S, Remuzzi G and Tonelli M. Effective CKD care in European countries: challenges and opportunities for health policy. Am J Kidney Dis 2015; 65: 15-25.
[7] Levey AS, Andreoli SP, DuBose T, Provenzano R and Collins AJ. CKD: common, harmful, and treatable--world kidney day 2007. Am J Kidney Dis 2007; 49: 175-179.
[8] Xue C, Ye XD, Li W, Peng Q, Ding HY, Zhang YH, He DF, Bai X, Huang Y, Song YS, Pang L and Liao YH. Prevalence of chronic kidney disease in Jing adults in China: a village-based study. Clin Nephrol 2013; 79: 50-56.
[9] Kunimura A, Amano T, Uetani T, Harada K, Yoshida T, Suzuki A, Shimbo Y, Kitagawa K, Harada K, Kato B, Kato M, Takashima H, Ando H, Matsubara T, Ishii H and Murohara T. Prognostic impact of concurrence of metabolic syndrome and chronic kidney disease in patients undergoing coronary intervention: involvement of coronary plaque composition. J Cardiol 2013; 61: 189-195.
[10] Kim CS, Choi JS, Bae EH, Ma SK, Ahn YK, Jeong MH, Kim YJ, Cho MC, Kim CJ and Kim SW. Association of metabolic syndrome and renal insufficiency with clinical outcome in acute myocardial infarction. Metabolism 2013; 62: 669-676.
[11] Wang F, Wu S, Song Y, Tang X, Marshall R, Liang M, Wu Y, Qin X, Chen D and Hu Y. Waist circumference, body mass index and waist to hip ratio for prediction of the metabolic syndrome in Chinese. Nutr Metab Cardiovasc Dis 2009; 19: 542-547.
[12] Jia Z, Zhou Y, Liu X, Wang Y, Zhao X, Wang Y, Liang W and Wu S. Comparison of different anthropometric measures as predictors of diabetes incidence in a Chinese population. Diabetes Res Clin Pract 2011; 92: 265-271.
[13] Chen J, Wildman RP, Gu D, Kusek JW, Spruill M, Reynolds K, Liu D, Hamm LL, Whelton PK and He J. Prevalence of decreased kidney function in Chinese adults aged 35 to 74 years. Kidney Int 2005; 68: 2837-2845.
[14] Zhang L, Wang F, Wang L, Wang W, Liu B, Liu J, Chen M, He Q, Liao Y, Yu X, Chen N, Zhang JE, Hu Z, Liu F, Hong D, Ma L, Liu H, Zhou X, Chen J, Pan L, Chen W, Wang W, Li X and Wang H. Prevalence of chronic kidney disease in China: a cross-sectional survey. Lancet 2012; 379: 815-822.
[15] Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF 3rd, Feldman HI, Kusek JW, Eggers P, Van Lente F, Greene T and Coresh J. A new equation to estimate glomerular filtration rate. Ann Intern Med 2009; 150: 604-612.
[16] Shlipak MG, Heidenreich PA, Noguchi H, Chertow GM, Browner WS and McClellan MB. Association of renal insufficiency with treatment and outcomes after myocardial infarction in elderly patients. Ann Intern Med 2002; 137: 555-562.
[17] Garg AX, Clark WF, Haynes RB and House AA. Moderate renal insufficiency and the risk of cardiovascular mortality: results from the NHANES I. Kidney Int 2002; 61: 1486-1494.
[18] Zhang L, Long J, Jiang W, Shi Y, He X, Zhou Z, Li Y, Yeung RO, Wang J, Matsushita K, Coresh J, Zhao MH and Wang H. Trends in chronic kidney disease in China. N Engl J Med 2016; 375: 905-906.
[19] Foster MC, Hwang SJ, Larson MG, Lichtman JH, Parikh NI, Vasan RS, Levy D and Fox CS. Overweight, obesity, and the development of stage 3 CKD: the Framingham heart study. Am J Kidney Dis 2008; 52: 39-48.
[20] Fox CS, Larson MG, Leip EP, Culleton B, Wilson PW and Levy D. Predictors of new-onset kidney disease in a community-based population. JAMA 2004; 291: 844-850.
[21] Haroun MK, Jaar BG, Hoffman SC, Comstock GW, Klag MJ and Coresh J. Risk factors for chronic kidney disease: a prospective study of 23,534 men and women in Washington county, Maryland. J Am Soc Nephrol 2003; 14: 2934-2941.
[22] Gu X and Fang XH. Diagnosis, stages and epidemiologic studies of chronic kidney disease in elderly adults. Chin J Geriatr 2016; 35: 556-559.
[23] Chen Y, Shen FX, Chen SS, Zheng YK. Kidney function changes and the risk factors in hospitalized patients aged 80 years and over. Chin J Geriatr 2015; 34: 530-533.
[24] Jafar TH, Schmid CH, Stark PC, Toto R, Remuzzi G, Ruggenenti P, Marcantoni C, Becker G, Shahinfar S, De Jong PE, De Zeeuw D, Kamper AL, Strangaard S and Levey AS. The rate of progression of renal disease may not be slower in women compared with men: a patient-level meta-analysis. Nephrol Dial Transplant 2003; 18: 2047-2053.
[25] Camilleri B, Bridson JM, Sharma A and Halawa A. From chronic kidney disease to kidney transplantation: the impact of obesity and its treatment modalities. Transplant Rev (Orlando) 2016; 30: 203-211.

[26] Camara NO, Iseki K, Kramer H, Liu ZH and Sharma K. Kidney disease and obesity: epidemiology, mechanisms and treatment. Nat Rev Nephrol 2017; 13: 181-190.
[27] Kovesdy CP, Furth SL and Zoccali C. Obesity and kidney disease: hidden consequences of the epidemic. Pediatric Nephrology 2017; 32: 537-545.
[28] Karuparthi PR, Yerram P, Saab G, Mcfarlane SI and Whaley-Connell A. Obesity and chronic kidney disease: therapeutic implications. Therapy 2007; 4: 585-595.
[29] Lu JL, Kalantar-Zadeh K, Ma JZ, Quarles LD and Kovesdy CP. Association of body mass index with outcomes in patients with CKD. J Am Soc Nephrol 2014; 25: 2088-2096.
[30] Rahman M, Yang W, Akkina S, Alper A, Anderson AH, Appel LJ, He J, Raj DS, Schelling J, Strauss L, Teal V and Rader DJ. Relation of serum lipids and lipoproteins with progression of CKD: the CRIC study. Clin J Am Soc Nephrol 2014; 9: 1190-1198.
[31] McMahon GM, Preis SR, Hwang SJ and Fox CS. Mid-adulthood risk factor profiles for CKD. J Am Soc Nephrol 2014; 25: 2633-2641.
[32] Munoz Mendoza J, Isakova T, Cai X, Bayes LY, Faul C, Scialla JJ, Lash JP, Chen J, He J, Navaneethan S, Negrea L, Rosas SE, Kretzler M, Nessel L, Xie D, Anderson AH, Raj DS and Wolf M. Inflammation and elevated levels of fibroblast growth factor 23 are independent risk factors for death in chronic kidney disease. Kidney Int 2017; 91: 711-719.
[33] Grabner A and Faul C. The role of fibroblast growth factor 23 and Klotho in uremic cardiomyopathy. Curr Opin Nephrol Hypertens 2016; 25: 314-324.
[34] Singh S, Grabner A, Yanucil C, Schramm K, Czaya B, Krick S, Czaja MJ, Bartz R, Abraham R, Di Marco GS, Brand M, Wolf M and Faul C. Fibroblast growth factor 23 directly targets hepatocytes to promote inflammation in chronic kidney disease. Kidney Int 2016; 90: 985-996.
[35] Howden EJ, Coombes JS, Strand H, Douglas B, Campbell KL and Isbel NM. Exercise training in CKD: efficacy, adherence, and safety. Am J Kidney Dis 2015; 65: 583-591.