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Association between metabolic syndrome and chronic kidney disease in a Chinese urban population

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ABSTRACT

Background: Few studies have examined the relationships between the prevalence of chronic kidney disease (CKD) and the metabolic risk factors in a developing country such as China, where genetic and environmental backgrounds differ from those in Western countries.

Methods: The subjects of this cross-sectional study were the individuals from 18 to 92 y. The metabolic syndrome (MetS) was defined based on the criteria of Adult Treatment Panel Third Report (ATP III), but using body mass index (BMI) instead of waist circumference. CKD was defined as decreased estimated glomerular filtration rate (eGFR $<$ 60 mL/min/1.73 m^2) or presence of proteinuria (urine protein $\geq 1+$) assessed using dipstick method.

Results: A total of 26,601 subjects (average age of 48.7 y) were analyzed. Among them, the prevalence of the MetS and CKD was 36.4% and 3.0%, respectively. After adjustment for age, gender, cigarette smoking and alcohol drinking, the prevalence of CKD was significantly greater in subjects with than without MetS (OR 1.99, 95% CI 1.57–2.53, $p < 0.001$). Multivariate-adjusted odd ratios for CKD in subjects with 3, 4 or 5 MetS components were 1.82 (95% CI 1.31–2.52, $p < 0.001$), 2.92 (95% CI 2.09–4.09, $p < 0.001$), and 3.07 (95% CI 1.67–5.67, $p < 0.001$), respectively. After further adjustments were made for the other components of MetS, only high fasting glucose (OR 1.52, 95% CI 1.12–2.05) were significant risk factors for reduced renal function (eGFR $<$ 60 mL/min/1.73 m^2). High blood pressure (OR 1.81, 95% CI 1,42–2.29), high triglycerides (OR 1.34, 95% CI 1.11–1.67) and high fasting glucose (OR 2.07, 95% CI 1.62–2.66) were significant risk factors for proteinuria.

Conclusions: MetS was highly prevalent in the middle-aged and elderly Chinese population in the city of Jinan. There was a graded relationship between the number of MetS components and risk of CKD. High fasting blood glucose levels were the main risk factor of reduced renal function. High blood pressure, high fasting blood glucose levels and high triglycerides were main risk factors for proteinuria.

1. Introduction

Metabolic syndrome (MetS), characterized by central obesity, dyslipidemia (high triglycerides and low HDL cholesterol), high blood pressure and impaired fasting glucose, is a common disorder in developed countries [1]. The age-adjusted prevalence of MetS stands at approximately 34% in U.S. [2,3]. With dramatic economic development and increasingly sedentary lifestyle, the MetS has also become increasingly common in China. Data from national cross-sectional surveys reported that 64 million people were estimated to have MetS and the prevalence of MetS was 15.1% in Chinese population [4]. MetS includes the constellation of various metabolic abnormalities that have been associated with cardiovascular disease, stroke and type 2 diabetes mellitus in the general population. Although the definition was proposed by various agencies such as the National Cholesterol Education Program's Adult Treatment Panel III (NCEP-ATP III) and the International Diabetes Federation deffer (IDF) [5,6], they agreed on the essential components of MetS.

Chronic kidney disease (CKD) has also increased to be a global public health problem, especially among the poor require more social attention in developing nation [7,8]. Recent studies estimated that approximately 119.5 million people have CKD and the prevalence of CKD is 10.8% in China [9]. A rise in the incidence of CKD and end-stage renal disease in recent years paralleled increasing prevalence of MetS [10]. There are racial differences in CKD. Previous observational studies of US and Japan demonstrated that individuals with MetS were

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at increased risk of CKD [11,12]. Ninomiya et al. reported that MetS was a significant risk factor for CKD in 1440 community-dwelling individuals aged 40 y or older in Japan [13]. However, to our knowledge, there are sparse datas on the association between MetS and CKD in a developing country such as China, where genetic and environmental backgrounds differ from those in Western countries [14].

2. Methods

2.1. Study population

A total of 26,601 adults who visited the Health Checkup Clinic consecutively in Shandong Qianfoshan Hospital affiliated to Shandong University were enrolled in this cross-sectional study from April 2012 and ended in December 2013. Those participants come from all over Jinan of China to receive a regular paid health examination. Patients with manifest concomitant atherosclerotic vascular disease of myocardial infarction, stroke, heart failure and peripheral arterial disease were not included. The study was approved by ethics committee of Qianfoshan Hospital. Written informed consent for each participant was obtained.

2.2. Data collection

Blood was collected by means of venipuncture after an overnight fast of at least 10 h. Serum creatinine was measured by means of using the Roche enzymatic method on an automatic biochemistry analyzer (Roche P Modular with Roche creatininase Plus assay). Protein in urine was measured on a morning urine sample using an immediate semiquantitative urine protein dipstick test and graded as negative, trace, 1 +, 2 +, 3 + or 4 +. Participants with pyuria were excluded from the analysis of proteinuria due to concern of urinary tract infection. Women during menstruation were asked to receive a urine routine test 3 days after menstruation. Fasting blood glucose, hemoglobin, serum albumin, serum uric acid (UA), serum total cholesterol, low-density lipoprotein, cholesterol (LDL), high-density lipoprotein (HDL) cholesterol, and triglycerides were also measured by automatic biochemistry analyzer. Sociodemographic characteristics, such as health history (e.g., hypertension and diabetes) and lifestyle behaviour (e.g., smoking and habitual drinking) were obtained by means of questionnaire. Diabetes was defined as fasting blood glucose ≥ 7.0 mmol/L or by the use of hypoglycemic agents or by self-reported history of diabetes. Blood pressure was measured using a sphygmomanometer, and three measurements were taken at 5 min intervals. The mean of the three readings was calculated, unless the difference between the readings was > 10 mm Hg, in which case the mean of the two closest measurements was used. Hypertension was defined as systolic blood pressure of > 140 mm Hg or diastolic blood pressure of > 90 mm Hg, or both, or patients already being prescribed antihypertensive medicaments.

2.3. Definition of CKD and metabolic syndrome

CKD was defined as an estimated glomerular filtration rate (eGFR) of < 60 mL/min/1.73 m^2, or the presence of proteinuria assessed using dipstick method. Glomerular filtration rate was estimated [estimated glomerular filtration rate (eGFR)] using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula: GFR = 141 × min [serum creatinine (Scr)/κ,1]α × max (Scr/κ,1) − 1.209 × 0.993age × 1.018 (if female) × 1.159 (if black), where κ is 0.7 for females and 0.9 for males; α is − 0.329 for females and − 0.411 for males; min indicates the minimum of Scr/κ or 1 and max indicates the maximum of Scr/κ or 1 [15,16]. Proteinuria was defined as the presence of urine protein of at least grade 1 + [17,18].

MetS was defined according to the modified criteria of the National Cholesterol Education Program Adult Treatment Panel Third Report (ATP III) [1], and using BMI instead of waist circumference as a risk component. Adiposity was defined using Asian criteria as BMI ≥ 25.0 kg/m^2 in the present study. MetS status was considered positive if the study participant had three or more of the following: 1) obesity, defined by a BMI ≥ 25.0 kg/m^2; 2) elevated blood pressure (systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg or treatment of hypertension) 3) increased plasma triglycerides (≥ 150 mg/dL) or treated dyslipidemia; 4) low fasting HDL cholesterol (men < 40 mg/dL and women < 50 mg/dL); and 5) elevated fasting glucose (≥ 100 mg/dL) or use of anti-diabetic medication.

Baseline characteristics were described using means and standard deviations for continuous variables and counts and percentages for categorical variables. Comparisons of baseline characteristics by CKD status were assessed using *t*-tests and chi-square tests for continuous and categorical variables, respectively. MetS status, the presence of individual MetS components, and the number (0 to 5) of MetS components were determined. Multiple logistic regression models and 95% confidence intervals were used to estimate the odds of having CKD that are associated with MetS status, individual MetS components, and the number of MetS components when age, gender, BMI, current cigarette smoking are held constant. The association of number of components of MetS with prensence of CKD, proteinuria and eGFR with were derived using analysis of variance. SPSS system 19.0 (SPSS Inc.) was used to perform all statistical analyses; significance levels were determined at $p < 0.05$, two tailed.

3. Results

3.1. Characteristics of study participants at baseline

In the current analysis, the analytical sample included 26,601 participants from baseline (2012 − 2013). The mean age of participants was 48.7 y (± 14.3; range, 18–92). 71.7% (19,062) were male, 28.3%(7539) were female. Among study participants, 51.3% (13,638) had elevated blood pressure; 52.9% (14,068) were defined as having obesity; 8.1% (2161) had low fasting HDL cholesterol; 55.1% (14,661) had elevated fasting glucose; and 27.6% (7348) had elevated triglycerides. Overall, 36.4% (9693) participants had MetS, 3.0% had CKD (794) and 12.6% (3353) had diabetes mellitus, respectively. Informed consent was obtained from all individual participants included in the study.

3.2. Comparison of study participants by CKD status

Compared to those without CKD, participants with CKD were older (mean age 58.6 vs. 48.4 y) and the proportion of women in CKD group was lower compared with the proportion in non-CKD group (22.7% vs. 28.5%). The percent of participants who were drinking alcohol in the past 12 months was significantly lower among those with CKD than those without CKD (35.9% vs. 43.8%). Study participants with CKD had significantly higher mean BMI, systolic/diastolic blood pressure, fasting glucose, glycated hemoglobin (HbA1c), fasting total cholesterol, fasting triglyceride (TG), LDL and γ-glutamyl transpeptidase (GGT) than those without CKD. There was no difference in proportions of smokers, hemoglobin, alanine-aminotransferase (ALT), asparate-aminotransferase (AST) and fasting HDL cholesterol level between people with and without CKD (Table 1).

3.3. Associations between MetS, the number of MetS components and CKD

Without adjustment for covariates, participants with MetS had 2.43-fold higher odds of having CKD than those without MetS. Age- and gender-adjusted odds ratios indicate that participants with MetS had 1.99-fold higher odds of having CKD than those without MetS ($p < 0.001$) (Table 2). After adjustments were made for age, sex, current smoking and current drinking, MetS was also associated with CKD (OR 1.99, 95% CI 1.57–2.53, $p < 0.001$). The number of