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Metabolic syndrome and chronic kidney disease in general Chinese adults: Results from the 2007–08 China National Diabetes and Metabolic Disorders Study ☆

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ABSTRACT

Background: China is undergoing a rapid transition to an urbanized and Western diet pattern, which worsens the public health burden of metabolic syndrome (MS) and chronic kidney disease (CKD). We aimed to estimate the prevalence of CKD among adults with MS and to evaluate the association between MS and CKD in China.
Methods: The data were obtained from the China National Diabetes and Metabolic Disorders Study conducted from June 2007 to May 2008. A total of 15,987 individuals aged 20 y or older were included as study participants.
Results: Age-standardized prevalence of CKD, which was defined as a glomerular filtration rate <60 ml/min/1.73 m^2, in participants with and without MS was 4.64% and 3.30%, respectively. The multivariate-adjusted odds ratio of CKD associated with MS was 1.495 (95% CI: 1.190–1.879). Elevated blood pressure, elevated fasting glucose, elevated triglycerides, and reduced high-density lipoprotein cholesterol had statistically significant increased odds ratios of 1.218, 1.256, 1.325 and 1.797 for CKD, respectively, while elevated waist circumference was not significantly associated with an increased odds ratio of CKD.
Conclusions: Our study suggests an increasing prevalence of CKD among Chinese adults with MS and a strong association between CKD and MS.

1. Introduction

China's large population has a high prevalence of chronic kidney disease (CKD) [1,2], which contributes greatly to the increase of cardiovascular disease, end-stage renal disease and kidney transplantation [3]. Metabolic syndrome (MS), which is characterized as a cluster of metabolic abnormalities including obesity, hyperglycemia, hypertension and dyslipidemia [4], shares many risk factors with CKD [5,6]. During the past decade, the association of MS with CKD has been emerging [5]. According to Yi-Jing Sheen's review, the association between MS and CKD in different populations varies with odds ratio (OR) ranging from 0.93 to 2.60 [6]. Of dozens of studies on MS and CKD, an insufficient number involves epidemiologic studies focusing on the Chinese population. To the best our knowledge, there have been less than ten studies to date [7–13], and most of these were regional or involved a single province [7–12]. The most recent nationwide study was reported by Chen, who analyzed the data from the International Collaborative Study of Cardiovascular Disease in Asia (InterASIA) study conducted during 2000 to 2001 [13]. In the past decade, China is undergoing a rapid transition to an urbanized and Western diet pattern, including high-protein food intake [14], which worsens the public health burden of MS and CKD. Therefore, our knowledge needs to be updated.

Given this background, we utilized the data from the 2007–08 China National Diabetes and Metabolic Disorders Study; we aimed to estimate the prevalence of CKD among adults with MS and to evaluate the association between MS and CKD in Chinese adults.

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2. Material and methods

2.1. Study population

The 2007–08 China National Diabetes and Metabolic Disorders Study was a nationwide population-based cross-sectional survey, conducted from June 2007 to May 2008. The details of the study have been described elsewhere [15]. In brief, a multi-stage stratified sampling method was used to select a nationally representative sample of Chinese adults aged >20 y. A total of 17 study group field centers participated in the study, and 54,240 individuals from the general population were selected and invited. Of those individuals, 87.3% (47,325 individuals: 18,976 men and 28,349 women) participated, and 85.2% (46,239 individuals: 18,419 men and 27,820 women) completed the study. Considering kidney function was not the primary expected outcome, serum creatinine (SCr) was not measured at all of the centers. Therefore, we only included 15,987 individuals (6421 men and 9566 women) with complete data on SCr, fasting plasma glucose, systolic blood pressure, diastolic blood pressure, serum triglyceride level, serum high-density lipoprotein cholesterol (HDL-c), and waist circumference. The map of inclusive/exclusive centers is shown in Fig. S1. This study was approved by the institutional review boards from all of the 17 participating centers. Written informed consent was obtained from each participant prior to data collection. The 17 institutional review boards' approvals covered every participant in the study.

2.2. Data collection

A standard questionnaire was designed and administered by trained physicians or nurses to collect information on demographic characteristics, lifestyle risk factors, and personal medical history. Educational level was categorized as college level or above, secondary school, and elementary school or below. Yearly family income was categorized as <10,000 China Yuan (CNY), 10,000–30,000 CNY and >30,000 CNY. Cigarette smoking was defined as a lifetime history of smoking at least 100 cigarettes. Alcohol drinking was defined as consuming alcohol at least once per week for ≥1 y. Physical activity was defined as participating in moderate or vigorous activity for 30 min/day for at least 3 days a week. Body weight and height were measured without shoes and in light clothing. Waist circumference was measured at the middle point between the costal margin and iliac crest. Blood pressure was measured using a standardized mercury sphygmomanometer in the sitting position after at least 5 min of rest; 2 consecutive readings of blood pressure were taken on the same arm and the mean of the 2 measures was used for analysis [15].

After at least 10 h of overnight fasting, an oral glucose tolerance test was performed on all subjects for the measurement of serum glucose and insulin. Participants with no history of diabetes were administered a standard 75-g glucose solution, while participants with a self-reported history of diabetes were given a steamed bun that contained approximately 80 g of complex carbohydrates for safety reasons. Fasting blood samples were also taken to measure serum triglyceride and HDL-c level. All laboratory measurements met a standardization and certification program [15].

2.3. Definition of metabolic syndrome and chronic kidney disease

2.3.1. Metabolic syndrome

Metabolic syndrome was defined using the National Cholesterol Education Program Adult Treatment Panel III (NECP-ATP-III) criteria as ≥3 of the following 5 metabolic components: 1) elevated waist circumference: ≥90 cm (males) or ≥80 cm (females); 2) elevated triglycerides: ≥1.69 mmol/l or the use of lipid medications; 3) elevated blood pressure: systolic blood pressure ≥130 mm Hg, or diastolic blood pressure ≥85 mm Hg, or the use of antihypertensive medications; 4) elevated fasting glucose: ≥5.6 mmol/l or the use of diabetes medications; 5) reduced HDL-c: <1.04 mmol/l (male) or <1.29 mmol/l (female) [4].

2.3.2. Definition of chronic kidney disease

Glomerular filtration rate (GFR) was calculated using the abbreviated equation developed by the modification of diet in renal disease (MDRD) study with modification for the Chinese population [16]. Considering most of our centers measured SCr on a Hitachi analyzer using the Jaffe's kinetic method, we adopted the following equation: $175 \times (\mathrm{SCr} \times 0.01131)\ (\mathrm{mmol/l})^{-1.234} \times \mathrm{Age}\ (\mathrm{y})^{-0.179} \times (0.79$ if female), which has been validated in the Chinese population and is also used by previous studies [9]. Chronic kidney disease (CKD) was defined as a GFR <60 ml/min/1.73 m^2 according to the US National Kidney Foundation guidelines [17].

2.3.3. Other definitions

Standard World Health Organization criteria were used for the diagnosis of diabetes: fasting glucose ≥7.0 mmol/l or 2 hour postprandial glucose ≥11.1 mmol/l, or self-reported use of diabetes medications [18]. Hypertension was defined according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: systolic blood pressure of ≥140 mm Hg, diastolic blood pressure of ≥90 mm Hg, or self-reported use of antihypertensive medications [19].

2.4. Statistical analysis

Data were analyzed using SPSS 18.0 or Stata 11.0 software for Windows. Data were expressed as the mean ± SD, median with interquartile range, or percentage as suitable. Comparisons between groups were analyzed by *t*-test or Mann–Whitney *U*-test for measurement data, and χ^2 test for enumeration data.

Age-standardized prevalence of CKD was compared in populations with and without MS according to gender. Age-standardized point prevalence estimates and standard error (SE) stratified by sex were calculated using Stata (ver. 11.0) *svy* commands (direct standardization) to account for the multi-stage stratified random sampling design. The calculation was weighted based on Chinese population data from 2006 [20]. The crude prevalence of CKD was determined for participants with and without the five individual components of MS, which was also calculated by the number of the MS components.

Logistic regression analysis was utilized to examine the association between MS and its components and CKD. Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated using a forward stepwise method. The covariables in the multivariate analysis were age (continuous variable), gender, ethnics, educational level, yearly family income, cigarette smoking, alcohol drinking, and physical activities. Because hypertension and diabetes are the most important established risk factors for CKD [21], a further adjustment for hypertension and diabetes was performed in the next step. In particular, we calculated the adjusted OR after excluding the individuals with diabetes since diabetes population do much contribution to CKD.

We conducted a sensitivity analysis between study participants and the excluded participants to evaluate the relevance because large amount of individuals dropped out of our analysis. All statistical tests were 2 sided. $P < 0.05$ was considered statistically significant.

3. Results

The clinical characteristics of the study participants are shown in Table 1. Of a total of 15,987 participants, 4749 had MS. On average, participants with MS were older, more likely to be Han, had a relatively low level of education and a high level of yearly family income compared with their participants without MS. The mean level of serum creatinine was significantly higher among the participants with MS compared with those without MS.