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Original research

The prevalence of hypertension in relation with the normal albuminuria range in type 2 diabetes mellitus within the South Korean population: The Korean National Health and Nutrition Examination Survey, 2011–2012

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ABSTRACT

Aims: The coexistence of hypertension (HTN) and diabetes mellitus (DM) increases the risk of cardiovascular disease. In some studies, normal albuminuria has also been associated with cardiovascular disease and HTN. Therefore, we examined the relationships between albuminuria and the prevalence of HTN and its control rate in type 2 DM patients.
Results: We analyzed data from the 2011–2012 Korea National Health and Nutrition Examination Survey, and 1188 subjects with type 2 DM were included in the study. We divided albuminuria into 3 albuminuria tertiles (T): T1: <4.82 mg/g; T2: 4.82–17.56 mg/g; and T3: ≥17.56 mg/g. The systolic and diastolic blood pressure were positively correlated with the albumin to creatinine ratio (ACR) after adjusting for all covariates ($P < 0.001$). Type 2 DM subjects with hypertension had more ACR T3 (odds ratio = 2.018, 95% confidence interval = 1.445–2.818) than subjects without HTN. Subjects with controlled HTN had less ACR T3 than subjects without controlled HTN (odds ratio = 0.566, 95% confidence interval = 0.384–0.836). When, we redivided albuminuria by <10, 10–30 (high normal albuminuria), 30–300 mg/g (microalbuminuria), and 300 mg/g ≤ (macroalbuminuria), the odds ratio for high normal albuminuria and microalbuminuria was 1.52 and 2.24, respectively in the presence of HTN, however, high normal albuminuria was not associated with HTN control.
Conclusions: In conclusion, albuminuria within the high normal range was associated with the prevalence of HTN in South Korean patients with type 2 DM.

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1. Introduction

Cardiovascular diseases (CVDs) have become the leading cause of death in many countries. Unhealthy behaviors, obesity, dyslipidemia, hypertension (HTN), and type 2 diabetes mellitus (DM) are well-known CVD risk factors [1–4]. The coexistence of HTN and DM increases the risk of CVD [1,5], therefore, it is important to control blood pressure in patients with type 2 DM as it is to control their blood-glucose levels [6–8]

Microalbuminuria is one of the microvascular complications associated with type 2 DM, and it has been proposed as an outstanding biomarker for predicting CVDs and nephropathy in type 2 DM [9–11]. Many studies have found associations between microalbuminuria and HTN, even though the exact mechanism underlying these associations has not been clarified [12–18]. Findings from recent studies have shown that the conventional microalbuminuria range (30–300 mg/g) and the normal albuminuria range were associated with CVDs [9,19] and HTN [20–22] in patients with type 2 DM and in the general population [10,19,22–24].

Previous Korean studies have also analyzed the relationship between albuminuria and HTN; however, most of the studies were either confined to the established microalbuminuria range or they involved subjects who did not have type 2 DM [7,23,24]. Moreover, recent studies undertaken in Asia have also found relationships between albuminuria within the normal range and cardiometabolic risk factors [25], metabolic syndrome [26], HTN [27], arterial stiffness, and carotid atherosclerosis [28]. Therefore, we analyzed the relationships between the prevalence of HTN and its control rate and albuminuria in type 2 DM patients using the entire Korean population.

2. Material & methods

2.1. Survey overview

We analyzed the data from the 2011 to 2012 Korean National Health and Nutrition Examination Survey (KNHANES). The Division of Chronic Disease Surveillance at the Korean Center for Disease Control and Prevention began the KNHANES in 1998 as a nationwide survey. The KNHANES involves trained investigators who evaluate national health and nutrition levels using physical examinations, health interviews, and nutritional evaluations. To ensure the survey is representative of the non-institutionalized civilians within the South Korean population, it uses a rolling sampling design that can extrapolate data from cross-sectional, multistage, stratified, and clustered samples to all geographic regions, genders, and ages within the 2005 census registry [29].

2.2. Subjects

We limited the study to include participants who were aged ≥19 years (n = 12,859). We excluded subjects with type 2 DM who had liver cirrhosis, chronic hepatitis B or C infections, pulmonary and extra-pulmonary tuberculosis, and cancers. Those who did not answer the questions about their medical histories and had not fasted for >8 h before the blood samples were taken were excluded from the study. After excluding the subjects who met the exclusion criteria, 1188 subjects were included in this study. All of the participants provided written informed consent, and the study protocol was approved by the Korean Center for Disease Control and Prevention's institutional review board.

2.3. Lifestyle variables

A self-report questionnaire was used to assess the participants' smoking statuses, physical activity levels, and alcohol consumption levels. Current smokers were defined as those who smoked at the time of the study and had smoked ≥100 cigarettes during their lives. Heavy drinkers were defined as those individuals who drank ≥30 g/day. The International Physical Activity Questionnaire was used to determine physical activity levels [30]. Regular exercise was defined as subjects who exercised >5 times a week at a moderate intensity for >30 min per session or subjects who exercised intensely >3 times a week for >20 min per session. We analyzed nutrient intake using nutrition label per day by 24-h recall from KNHANES V, four nutrient variables (energy, carbohydrate, protein and fat) were computed, and the energy percentages of carbohydrates, protein, and fat were calculated. Nutrition education history was categorized as either yes or no.

2.4. Anthropometric and laboratory measurements

Skilled staff carried out the physical examinations using standard procedures. Weights and heights were measured up to the nearest 0.1 kg and 0.1 cm, respectively, with the subjects wearing only light clothing and not wearing shoes. The waist circumference (WC) was determined at the narrowest point between the lower rib margin and the iliac crest while the subject exhaled. The body mass index (BMI) was calculated as the weight (kg) divided by the square of the height (m). The systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured 3 times at 5-min intervals using a standard mercury sphygmomanometer (Baumanometer®, WA Baum Co. Inc., Copiague, NY, USA), and the mean values of the second and third measurements were recorded as the final blood pressure (BP) measurements.

After fasting for at least 8 h, blood samples and random mid-stream urine samples were obtained for analysis. The samples were appropriately transported to and stored at the Central Testing Institute, and they were used within 24 h to obtain the fasting blood glucose (FBG) levels, white blood cell (WBC) counts using a Hitachi 7600 Automatic Analyzer (Hitachi Ltd., Tokyo, Japan). The glycated hemoglobin (HbA1c) levels were also evaluated using high-performance liquid chromatography (Tosoh HLC-723G7®; Hitachi Ltd., Tokyo, Japan).

The urine and serum creatinine levels and the urine albumin levels were determined using kinetic colorimetric and turbidimetric assays using a Hitachi 7600 Automatic Analyzer (Hitachi Ltd., Tokyo, Japan). We calculated the estimated glomerular filtration rate (eGFR) using the Chronic Kidney Disease Epidemiology Collaboration equation: eGFR (mL/min

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