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The association between blood pressure and blood cadmium in a Chinese population living in cadmium polluted area

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ARTICLE INFO

Article history:
Received 25 February 2013
Received in revised form
10 June 2013
Accepted 15 June 2013
Available online 24 June 2013

Keywords:
Cadmium
Blood pressure
Blood lipid

ABSTRACT

Cadmium exposure may be associated with high risk of hypertension. But inconsistent results have been reported. In this study, the association of blood pressure (BP) with blood cadmium (BCd) and the possible influencing factors were investigated. A total of 181 persons (71 men and 110 women) living near a cadmium smelter participated in this study. The participants completed a questionnaire and BP, BCd and related biochemical indicators were measured. The geometric mean of BCd was 3.84 μg/L and 3.32 μg/L for women and men. The systolic blood pressure (SBP) and diastolic blood pressure both increased with the increasing of BCd. The BP in women was positively correlated with BCd ($p < 0.05$). The BCd level of participants with hypertension was obvious higher (+28%) than those with normal BP. The prevalence of hypertension was increased with the increasing of BCd, in particular to women ($\chi^2 = 3.896$, $p = 0.048$). Cadmium level in blood was associated with elevation in blood pressure, especially for women.

1. Introduction

Cadmium (Cd) is a hazardous heavy metal that is widely distributed in the environment. It could accumulate in food, such as rice and vegetables. Food is one of major environmental source of Cd exposure for non-smoking population (Jarup, 2003). Long-term low level of oral Cd exposure may cause chronic damage to human body. The kidney, liver, bone, and cardiovascular systems are the most important organs for Cd toxicity (World Health Organization, 1992). An important toxicological feature of Cd is its long biological half-time (10–30 years) in humans (Nordberg, 1996).

It has been shown that Cd exposure may be associated with stroke, heart failure and myocardial infarction (Everett and Frithsen, 2008; Peters et al., 2010; Tellez-Plaza et al., 2012). Studies *in vivo* have indicated that long-term high level of Cd exposure could induce elevation of blood pressure (Perry Jr. et al., 1977). Epidemiological studies also suggest that Cd exposure is correlated with the elevation of blood pressure (Tellez-plaza et al., 2008; Eum et al., 2008; Caciari et al., 2012). However, studies also demonstrate that there are no (Beevers et al., 1976; Swaddiwudhipong et al., 2010; Mordukhovich et al., 2012) or even a negative association (Staessen et al., 1984) between blood pressure and Cd exposure. In addition, Lee et al. (2011) reported that the association of Cd and

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http://dx.doi.org/10.1016/j.etap.2013.06.006

hypertension was only found in male and no association was found in female.

Blood pressure is related with blood lipids level. It has been indicated that Cd may disturb lipids metabolism *in vivo* (Larregle et al., 2008). But we do know whether the hypertension caused by Cd is related with blood lipids level. This study tries to observe the association between blood Cd and blood pressure in a Chinese population living in a Cd polluted area. In addition, we also observe the effects of Cd exposure on blood lipids level.

2. Materials and method

2.1. Area and study population

Total 181 persons aged 40 years and older, living in a Cd-contaminated area, were recruited in this study. A smelter was located in this area and industrial wastewater was regularly discharged into the river near the factory. The concentrations of metals (Cd, Lead, and Copper) in the wastewater exceeded the levels of Chinese hygiene standards. The residents living in the polluted areas used the polluted river for irrigation from 1961 to 1995. The Cd concentration in rice was about 3.7 mg/kg and the main staple food in these areas was the rice that they produced from these fields. From 1996 onward, however, the residents stopped producing rice in these fields and began eating commercially available rice from other (non-polluted) areas (Cd in rice: 0.03 mg/kg). More detailed information has been provided previously (Wang et al., 2003). The participants in the study gave their informed consent and completed a questionnaire including information on medical and drug history, cigarette smoking, alcohol consumption and medical history of hypertension. Height and weight data were obtained to calculate body mass index (kg/m^2). Samples of venous blood were collected from each participant for determination of Cd concentration and biochemical indicators. During this study, Declaration of Helsinki was followed. This study was carried out with the permission of the Ethics Committees of Fudan University.

2.2. Exposure assessment

Collection of samples followed a strict protocol. Cd was measured as already described (Jin et al., 1998). Briefly, blood samples were collected in heparin tubes and stored frozen (−20 °C) until analyzed. Cd content in blood (BCd) was measured by graphite-furnace atomic absorption spectrometry (GF-AAS, ShimadzuAA-670, Kyoto, Japan). Between and within bottle homogeneity testing was below 6% and 7%. For quality control, reference material (lyophilized whole human blood) with two certified concentration (9.6 ± 1.7 μg/kg and 3.3 ± 0.9 μg/kg) were analyzed. The obtained Cd concentrations were 11.1 ± 0.2 μg/kg and 4.8 ± 0.3 μg/kg. The detection limit of Cd in blood using this method was 0.05 μg/L. BCd was used as measures of the exposure. BCd reflects Cd body burden (Diarmid et al., 1997), particularly in long term low level of exposure and after cessation of exposure.

2.3. Blood pressure measurement

The blood pressure was measured twice on right wrist using electronic sphygmomanometer (Omron, Dalian, China) in a sitting position. Because wrist blood pressure measured by the electronic sphygmomanometer was higher than arm blood pressure measured by mercury sphygmomanometer. In this study, hypertension was regarded as diastolic pressure >95 mm Hg and or/systolic pressure >160 mm Hg or receipt of current antihypertensive treatment.

2.4. Lipids level measurements

Fasting blood triglyceride (TG), total cholesterol (TC) and high density lipoprotein (HDL) level were measured by automatic biochemical analyzer (Hitach7150, Japan).

2.5. Statistical analysis

Database management and analysis were performed using SPSS11.5 (SPSS Inc, Chicago, IL, USA) and EPI INFO (Version 3.5.1, Centers for Disease Control and Prevention, Atlanta, GA, USA). Arithmetic means were compared by using one way-ANOVA and Pearson correlation was applied to analyze the correlation of BP with BCd (log-transformed), height, weight and other biochemical indicators. The data were expressed as mean ± SD. The criterion significance level was set at $p < 0.05$.

3. Results

3.1. 3.1. Characteristics of study population

The general characteristics of study population, the BCd concentration and lipids level were shown in Table 1. 61% of the participants were female. There were significant differences between men and women in height, weight and tobacco smoking ($p < 0.05$). The concentration of BCd in women was slightly higher than that in men. The systolic blood pressure (SBP) and diastolic blood pressure (DBP) in men were higher than those in women, but no significant differences were found. No obvious differences were found in blood lipids level between men and women.

3.2. BCd and blood pressure

The blood pressure, TG and TC were increased with the increasing of BCd in women (Table 2). Compared with the subjects with the lowest level of BCd, the SBP and DBP in the subjects with the highest level of BCd were increased by 8% and 4%, respectively, after adjusted for age and BMI. But no significant differences were found. Meanwhile, TG and TC increased by 30% and 17% in the people with the highest level of BCd compared with those with the lowest level of BCd. For men, the blood pressure, TG and TC level were higher in middle BCd group compared with other BCd group, but there was no significant difference.

Consequently, men and women were divided into three groups according to the level of blood pressure (Table 3). The BCd, TG and TC of those persons with high blood pressure