

SHORT REPORT

Cadmium-induced renal tubular dysfunction in a group of welders

X. Ding¹, Q. Zhang², H. Wei¹ and Z. Zhang¹

¹Department of Toxicology, School of Radiation Medicine and Public Health, Soochow University, Suzhou 215123, People's Republic of China, ²Department of Pharmacy, The Fifth Affiliated Hospital of Xinjiang Medical University, Urumqi 830011, People's Republic of China.

Correspondence to: Z. Zhang, Department of Toxicology, School of Radiation Medicine and Public Health, Soochow University, Suzhou Industrial Park, Renai Road 199, Suzhou 215123, The People's Republic of China. Tel: 86-512-6588-0069; fax: 86-512-6588-0069; e-mail: zhangzengli@suda.edu.cn

Background	Occupational exposure to welding fumes has been associated with several diseases including metal fume fever, lung cancer, welder's pneumoconiosis and manganism. However, there are few reports on cadmium-induced renal tubular dysfunction in welders.
Aims	To evaluate the body burden of cadmium and cadmium-induced proteinuria in a group of Chinese welders.
Methods	Cadmium concentrations in the breathing zone and in urine were measured by atomic absorption spectrometry. β_2 -Microglobulin (β_2 -MG) in urine as a marker of renal tubular function was measured using an ELISA kit. All urinary parameters were adjusted by urinary creatinine (Cr).
Results	A total of 103 welders participated. The concentration of airborne cadmium in the welders' breathing zones ranged from 5 to 86 $\mu\text{g}/\text{m}^3$, and 17% of samples exceeded the threshold limit value. Six welders' urinary cadmium levels exceeded the Chinese recommended reference value. Urinary β_2 -MG levels increased significantly with increasing urinary cadmium levels and in two welders, the values were close to the level for chronic cadmium poisoning in China.
Conclusions	Environmental and urinary cadmium levels were raised in this group of welders and were associated with raised markers of renal tubular dysfunction. The exact source of the cadmium warrants further assessment.
Key words	Cadmium; proteinuria; renal tubular dysfunction; welding.

Introduction

Welding is a major industrial process used for joining metals. Occupational exposure to welding fumes is a serious occupational health problem all over the world. It is estimated that >1 million workers worldwide perform some type of welding [1]. The degree of risk to a welder's health from fumes depends on the composition, concentration and length of exposure. Occupational exposure to welding fumes has been associated with several diseases include metal fume fever, lung cancer, welder's pneumoconiosis and manganism [2]. However, there are few reports on renal dysfunction induced by cadmium (Cd) exposure in welders [3,4]. In this study, the body burden of Cd and proteinuria in welders was investigated. To our knowledge, this is the first report on damaged renal tubular function in Chinese welders.

Methods

The welders were recruited from a railway company. All the welders in the company agreed to participate in the

investigation. Pregnant welders and welders who had high blood pressure, diabetes, liver or renal diseases or other confounding medical complaints that could influence the biomarkers studied were excluded. The study protocol was approved by the Ethical Committee of the Soochow University.

All the welders performed shielded manual metal arc welding using various electrodes primarily on mild steel in the welding of crankcases. Welders worked 5–6 h/day in the premises, which were ventilated by a mix of natural ventilation from open windows and several exhaust fans. Local exhaust ventilation was absent near the welding areas. The only protective devices used during welding were shielding glass and goggles.

Breathing zone air samples were collected over two consecutive workdays. Urine samples were collected from all participants. Cadmium concentrations in urine (CdU) and air samples were analyzed by atomic absorption spectrometry (GF-AAS) (WS/T 32-1996). For β_2 -microglobulin (β_2 -MG) measurements, an ELISA kit (SUNBIO Biotechnology Co. Ltd) was used. Urine

creatinine was measured by an automatic biochemical analyzer. The urinary parameters were adjusted by creatinine in urine and expressed as microgram per gram Cr.

Results

One hundred and three welders participated (19 males and 84 females; aged from 25 to 52 years) with a duration of exposure ranging from 2 to 21 years (average age and SD 12.80 ± 7.27 years). The environmental level of Cd in the workplace was $5\text{--}86 \mu\text{g}/\text{m}^3$. Seventeen per cent of samples exceeded the threshold limit value ($0.01 \text{ mg}/\text{m}^3$).

Table 1 provides details of Cd exposure in this population. CdU ranged from 0.05 to $12.4 \mu\text{g}/\text{g Cr}$. According to the diagnostic criteria of occupational cadmium poisoning in China, seven welders whose CdU values exceeded $5 \mu\text{g}/\text{g Cr}$ were sampled across two subsequent days. Six welders whose CdU were constantly $>5 \mu\text{g}/\text{g Cr}$ in two successive days were classified as 'subjects under surveillance' of Cd exposure.

There was a significant difference in β_2 -MG excretion in different CdU intervals [analysis of variance (ANOVA) analysis, $P < 0.05$]. In the group with CdU $>3 \mu\text{g}/\text{g Cr}$, the levels of β_2 -MG were significantly higher than those in CdU $<3 \mu\text{g}/\text{g Cr}$ group (ANOVA, $P < 0.01$). Two welders' β_2 -MG concentrations were 920 and $935 \mu\text{g}/\text{g Cr}$, respectively, which were close to the diagnostic criteria of chronic cadmium poisoning in China ($1000 \mu\text{g}/\text{g Cr}$).

Discussion

This study found evidence of renal tubular dysfunction in welders with raised urinary cadmium levels. Increased urinary excretions of chromium, nickel, manganese, lead, barium, aluminum and fluoride have been reported in various populations of welders [5] but there is a limited amount of research on Cd exposure in welders. The data presented in this study clearly show that Cd was emitted in the fumes produced during welding as 17% of samples exceeded the threshold limit value [6] and was being

absorbed by the welders. The components of welding fumes emanate chiefly from the consumable electrode. The base metal, paint and surface coatings also contribute to the composition of the welding aerosol. The exact source of the Cd in this investigation is unknown and merits further study.

Both the American Conference of Governmental Industrial Hygienists and the China Health Criteria recommend a biological exposure index for Cd exposure (CdU concentration) of $5 \mu\text{g}/\text{g Cr}$ [5,7]. However, urinary cadmium concentrations $<5 \mu\text{g}/\text{g Cr}$ do not indicate freedom from kidney damage. Several studies reported that tubular proteinuria occurred $<5 \mu\text{g}/\text{g Cr}$ of urinary Cd [8–10]. Zhang *et al.* [10] reported a 15% prevalence of proteinuria in workers with a CdU level of $3\text{--}5 \mu\text{g}/\text{g Cr}$. Our study's findings concur with these studies. For the range of $3\text{--}5 \mu\text{g}/\text{g Cr}$ of CdU, the mean values of β_2 -MG in welders was $\sim 402 \mu\text{g}/\text{g Cr}$, which suggests that CdU levels of $3\text{--}5 \mu\text{g}/\text{g Cr}$ could also be associated with renal tubular dysfunction.

To inhibit exacerbation of tubular proteinuria, an upper reference limit of $300 \mu\text{g}/\text{g Cr}$ for the urinary concentration of β_2 -MG has been proposed. In this study, for six welders with CdU levels $>5 \mu\text{g}/\text{g Cr}$, the mean value of β_2 -MG was $671 \mu\text{g}/\text{g Cr}$. In two of them, β_2 -MG values were 920 and $935 \mu\text{g}/\text{g Cr}$, respectively, which approach the exposure value for chronic poisoning ($1000 \mu\text{g}/\text{g Cr}$) in China [8].

Our study demonstrates that welding fume exposure can lead to increased urinary cadmium levels and markers of renal tubular dysfunction. As the rate of China's economical growth has increased, many industrial hygiene problems have arisen. Our study findings suggest that Cd exposure should be assessed in some categories of welders.

Key points

- Welding fumes exposure can lead to increased urinary cadmium and β_2 -microglobulinaemia suggesting renal tubular dysfunction.
- The exact origin of the cadmium needs further study.
- Cadmium exposure should be assessed in some categories of welders.

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Conflicts of interest

None declared.

Table 1. The concentration of Cd and β_2 -MG in welders' urine

CdU ($\mu\text{g}/\text{g Cr}$)	<1	1–3	3–5	>5
CdU ($\mu\text{g}/\text{g Cr}$)	0.55 ± 0.06	1.24 ± 0.11	3.88 ± 0.26	7.02 ± 2.1
β_2 -MG ($\mu\text{g}/\text{g Cr}$)	183 ± 18	211 ± 35	$402 \pm 63^*$	671 ± 92
Welders (n)	14	12	70	7

* $P < 0.01$ compared to '1–3' group, ANOVA.

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