Behaviour of biological indicators of cadmium in relation to occupational exposure

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Summary. Cadmium in blood (CdB), cadmium in urine (CdU) and beta2-microglobulins (β2MU) were determined in 83 male workers exposed to cadmium fumes. CdU was measured both on 24-h urine samples and on spot samples. The behaviour of the biological indicators of cadmium was assessed in relation to degree of current exposure, length of exposure and cumulative exposure (computed as concentration of cadmium at the workplace multiplied by duration of exposure). CdB values were significantly higher in the subgroups of subjects with higher current cadmium exposure and in the subgroups of subjects with greater cumulative exposure, but the test levels were not influenced by duration of exposure. CdU levels were significantly higher in the subgroups of subjects with greater cumulative exposure, but were less influenced by current exposure or duration of exposure. Considering the entire population, a rather close correlation \(r = 0.69\) was observed between CdB and CdU. When the population was divided according to level of current exposure, a close relationship was observed between the two indicators in all subgroups; nevertheless, for identical CdU values, the CdB values were higher in the subjects with heavier current exposure. Even if in all Cd workers the β2MU levels were in the range of reference values, the highest β2MU levels were found in the subjects with CdU > 10 µg/l. The data confirm that CdU is prevalently influenced by the body burden of metal, but they also suggest that the CdB levels are not influenced solely by the intensity of current exposure but also depend to a considerable degree on the body burden.

Key words: Occupational exposure – Blood cadmium – Urine cadmium – Beta2-microglobulins – Cumulative exposure

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Introduction

Knowledge on the toxicology of cadmium has greatly progressed in the last ten years so that reliable biological monitoring programmes can now be developed. Cadmium in blood (CdB) is generally considered to be an useful test to evaluate current exposure. Cadmium in urine (CdU), in low-level exposure, is considered to reflect the body burden, while in high absorption conditions, without kidney damage, it is an indicator of current exposure. Measurement of beta2-microglobulins in urine (β2MU) is the most frequently used test that reveals early kidney damage.

The different meaning assigned to the two indicators of dose is mainly due to the fact that, while CdB is well correlated with the environmental levels of cadmium, CdU is well correlated with both the quantity of metal deposited in the renal cortex and the length of exposure. CdU becomes an indicator of current exposure when the levels of the metal in the renal cortex approach the critical concentration [1, 8–10].

The aim of the present research was to ascertain whether the meaning normally assigned to the two indicators of dose can be so clearly differentiated as described above.

The influence of current exposure and length of exposure on the levels of the indicators was studied in 83 subjects occupationally exposed to cadmium.

The behaviour of these indicators in relation to the presumable total exposure over the entire working life was also investigated, in view of the fact that on the one hand the exposure levels had not been constant and on the other that the difference in length of service between the individual subjects is often not indicative of a real difference in total exposure.

Subjects and methods

All subjects were employed at the same factory in the production of cadmium alloys and were thus exposed to cadmium fumes.

Figure 1 shows the atmospheric concentrations of cadmium (CdA) measured with area samplers (according to NIOSH guidelines, 1977) over the years in different departments of the factory.

Although no measurements are available for the years prior to 1975, it is reasonable to assume that the industrial hygiene conditions were substantially the same, since no significant technical changes had been made before that time.

When the present study was carried out in 1982, the atmospheric concentrations were also measured using personal samplers, which gave mean CdA values of 67 μg/m³ in foundry A, 28 μg/m³ in foundry B, and 3 μg/m³ during cadmium alloy processing operations.

Eighty-three male workers between the ages of 23 and 58 were examined. The workers were divided into subgroups according to current exposure, length of service and cumulative exposure.

It was ascertained that none of the subjects included in the statistical analysis suffered from kidney disease; in addition, all the subjects had proteinuria values below 0.20 g/l and β2MU levels below 260 μg/l (200 μg/g creatinine).

CdU was measured in 24-h urine and in spot samples of urine obtained separately at 8:00 h. The CdU values in the spot samples were expressed in μg/l and μg/g creatinine and the CdU values in the 24-h samples were expressed in μg/l and μg/24 h.