Original Papers

Elemental Mercury in Urine from Workers Exposed to Mercury Vapor

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Summary. Elemental mercury (Hg°) in urine samples from workers in thermometer manufacturing factories was determined. In a factory in which the mercury level in the ambient air averaged more than 0.1 mg Hg m⁻³, the Hg° concentration in the workers' urine ranged between 0.05 and 1.7 μg Hg l⁻¹ and constituted less than 1% of the inorganic mercury (In-Hg) in urine. Higher amounts of Hg° could be detected in urine on the day of the filling operation when thermometer blanks were filled with metallic mercury and on the following day when compared with other days. During this operation, the workers were exposed to mercury vapor levels with as much as 0.47–0.67 mg Hg m⁻³. Our findings suggest that Hg° appears in urine quite rapidly after the worker's exposure to unusually high mercury levels.

Key words: Elemental mercury – Inorganic mercury – Mercury in urine – Mercury in blood – Mercury in air – High level exposure to mercury vapor

Introduction

In factories handling metallic mercury, the determination of mercury in urine or blood, as well as air concentration analysis, have played an important role in evaluating the extent of mercury exposure as well as the degree of risk. Urinary mercury determination is widely used for exposure evaluation based on the fact that there is a correlation between occupational exposure and urinary mercury concentrations (Smith et al. 1970). Moreover, urine specimens can be easily collected. In addition to mercury in the work environment, the worker is exposed to mercury vapor from additional sources, such as that emanating from contaminated clothing and that related to particular work operations. In these cases also, urinary mercury is known to correlate well with individual mercury exposure as determined by the personal monitoring technique (Bell et al. 1973a; Yoshida et al. 1980).

In 1974, Henderson et al. found that elemental mercury (Hg°) can be detected in samples obtained from welders of mercury cells by a new technique that measures...
the chemical species of mercury in urine. Stopford et al. (1978) reported that Hg\(^{0}\) was detectable in urine samples from only 12% of workers exposed to mercury vapor, but could not be detected at all in those from control subjects. Furthermore, Henderson et al. (1974) indicated that the combination of determinations for Hg\(^{0}\) and for total mercury in urine may provide a better indicator than only that of total mercury for detecting an acute, unusual exposure to mercury vapor.

The purpose of this investigation is to study the relationship between Hg\(^{0}\) concentrations in urine and the extent of exposure to workers in thermometer factories and to find out whether Hg\(^{0}\) in urine is useful as an indicator for evaluating potentially dangerous levels of exposure to mercury vapor.

**Subjects and Methods**

In seven factories (I, T, TO, S, SA, TE and SI factories) manufacturing mercury thermometers, 32 male workers, aged from 21 to 60 years, and employed for 3-40 years, were studied.

The mercury in the ambient air was collected by placing bubblers containing a scrubbing solution of acidic permanganate in the work area, and the solution was measured for mercury by flameless atomic absorption. Individual mercury exposure was determined by a personal monitoring technique described by Bell et al. (1973b). Mercury vapor samplers were made by passing air through a glass tube containing gold wire, which was attached to the worker's collar in his breathing zone. The samples were collected continuously throughout the day work shift. After collection, the mercury was removed from the gold amalgam by thermal decomposition, absorbed in an acid-permanganate scrubber and subsequently determined by flameless atomic absorption.

Inorganic mercury concentration in the urine or blood was determined by the method of Magos (1971). Urine samples were collected during the day work shift in mercury-free polyethylene bottles, transported in a portable ice box and stored at 4°C. Analyses of Hg\(^{0}\) were performed immediately after collection. Blood samples were taken by vein puncture at the end of the work day and collected in heparinized glass tubes. Determination of Hg\(^{0}\) in urine was performed using the method of Henderson et al. (1974) with a sensitivity of 0.05 μg Hg l\(^{-1}\). To 20 ml of urine transferred into the sample flask, one drop of 0.1% TAS (Toshiba Silicon Ltd. in Tokyo) solution was added to prevent foaming, and the airstream was passed through the solution. The expelled Hg\(^{0}\) was collected with a gold wire absorber attached to the outlet of the sample flask. The Hg\(^{0}\) absorbed on the gold wire was determined in the manner described above.

**Results**

Characteristically, the factories manufacturing mercury thermometers were small and the ventilation was poor, except for the TE factory. In the I, T, and TO factories, the filling of thermometer blanks with metallic mercury and the finishing of the mercury filled blanks were performed in the same work area, and both were carried out twice or three times a week. However, the work place for the filling process in the other four factories was separate from that of the finishing process.

Figure 1 shows airborne mercury levels in seven factories manufacturing mercury thermometers. There was an average mercury level of more than 0.1 mg Hg m\(^{-3}\), in the I, T, and TO factories. The airborne mercury level near the filling operation area was particularly high in comparison with those of other places.

Table 1 shows elemental and inorganic mercury concentrations in urine and inorganic mercury concentration in the blood samples of 32 workers. The urinary