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Low-level mercury exposure and peripheral nerve function

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ABSTRACT

Background: Mercury is known to be neurotoxic at high levels. There have been few studies of potential peripheral neurotoxicity among persons with exposure to elemental mercury at or near background levels.
Objectives: The present study sought to examine the association between urinary mercury concentration and peripheral nerve function as assessed by sensory nerve conduction studies in a large group of dental professionals.
Methods: From 1997 through 2006 urine mercury measurements and sensory nerve conduction of the median and ulnar nerves in the dominant hand were performed, and questionnaires were completed, on the same day in a convenience sample of dental professionals who attended annual conventions of the American Dental Association. Linear regression models, including repeated measures models, were used to assess the association of urine mercury with measured nerve function.
Results: 3594 observations from 2656 subjects were available for analyses. Urine mercury levels in our study population were higher than, but substantially overlap with, the general population. The only stable significant positive association involved median (not ulnar) sensory peak latency, and only for the model that was based on initial observations and exclusion of subjects with imputed BMI. The present study found no significant association between median or ulnar amplitudes and urine mercury concentration.
Conclusions: At levels of urine mercury that overlap with the general population we found no consistent effect of urine mercury concentration on objectively measured sensory nerve function.

1. Introduction

Mercury is a metal occurring in several forms and is ubiquitous in the environment. The nervous system is sensitive in varying degrees to all forms of mercury. Exposure to high levels of metallic, inorganic or organic mercury can damage the brain, peripheral nerves, kidneys and the developing fetus (ATSDR, 1999). Inorganic or elemental mercury primarily affects the nervous and renal systems, with peripheral neuropathy being one of the major neurological effects (Letz et al., 2000; Chu et al., 1998; Clarkson et al., 2003).

Associations between mercury exposure and peripheral nerve impairment usually have been studied in occupationally exposed populations experiencing high mercury exposure (Letz et al., 2000; Levine et al., 1982; Urban et al., 1999). Urine mercury levels among subjects in these studies, which assess exposure to elemental mercury, have been in the range of 500 μg/L or greater. There are few large studies that have focused on peripheral nerve impairment among persons with low-level or 'background' elemental mercury exposure (i.e., with mean urine mercury concentrations at or near background population levels) (Kingman et al., 2005; DeRouen et al., 2006). Most studies involving 'low-level' elemental mercury exposure suffer from one or more weaknesses in design: poorly defined exposures and/or outcomes, lack of appropriate biomarkers of exposure, small numbers of subjects, and/or no controls (Brownawell et al., 2005).

Dental professionals' occupational exposure to mercury vapor from dental amalgam (~50% mercury by weight) has been a concern for many years (ATSDR, 1999; Brownawell et al., 2005). In the late 1970s and early 1980s, the (arithmetic) mean urine mercury level among dentists was 14.2 μg/L, and the urine mercury level appeared to be strongly related to the number of

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amalgam restorations placed per week (Naleway et al., 1985). Following educational campaigns for the proper use and disposal of amalgam, the mean urine mercury levels among dentists in the late 1980s and early 1990s fell to less than 5 μg/L (Naleway et al., 1991; Martin et al., 1995).

Urine mercury levels have been documented among the general population in the United States by the National Health and Nutrition Examination Survey (NHANES). In the 1999–2000 NHANES survey, the (arithmetic) mean urine mercury concentration based on spot urine specimens among women aged 16–49 years old (n = 1748) was 1.55 μg/L (CDC, 1999). Although mean urine mercury levels among dental professionals (both for males and females) remain somewhat above the NHANES population levels, the overlap of the distributions is considerable (Fig. 1).

The goal of the present study was to examine the association between urinary mercury concentration and peripheral nerve function as assessed by sensory nerve conduction studies in a large group of dental professionals.

2. Methods

2.1. Study and subject selection

Data for this study were collected from subjects who volunteered to attend one or more health screenings conducted during the annual American Dental Association (ADA) conferences during the years 1997–2006. Subjects included dentists, dental assistants and dental hygienists who had urine mercury concentrations assessed and sensory nerve conduction measurements performed on their dominant hands during the same screening. The present study was approved by the Institutional Review Boards at the ADA and at the University of Michigan.

2.2. Nerve conduction measures

Electrodiagnostic studies of the median and ulnar sensory nerves were conducted in the dominant hand using established techniques (Kimura, 1983), which have been shown to have high inter-examiner and intra-examiner reliability (Salerno et al., 1999). Tests were performed using antidromic, supramaximal stimulation, a stimulation-to-recording distance of 14 cm, and ring-recording electrodes placed around digits two and five. Hand temperature was recorded and the hand was warmed if the mid-palmar temperature was below 32 °C. Analyses in this study considered only peak, not take-off latencies because this is the more reliable of the two latency measures (Salerno et al., 1999). Analyses focused on measurements for median amplitude (baseline to peak), median peak latency, ulnar amplitude and ulnar peak latency. Latency measurements had a precision of 0.1 ms, and amplitude measurements had a precision of 0.1 μV. Longer latencies and smaller amplitudes are indicative of deteriorating nerve function relative to shorter latencies and higher amplitudes. The nerve conduction studies were performed as part of screening for carpal tunnel syndrome (CTS), a mononeuropathy involving the median nerve. Although screening for peripheral polyneuropathy (i.e., neuropathy in more than one nerve) was not the original intent of the data collection, the evaluation of results of two distal sensory nerves in the upper extremity can be used as a means of evaluating the general health of the peripheral nervous system and provides an objective measure of nerve impairment.

Nerves that had an absent response during nerve conduction testing were assigned a value for latency equal to 3 standard deviations (SD) above the study sample mean and a value for the amplitude equal to the lowest recorded amplitude in the study sample (n = 12; 0.3%).

2.3. Mercury exposure assessment

Mercury assayed in spot urine samples based on a single void was used as a biomarker to characterize mercury exposure. Mercury in urine is almost completely composed of inorganic mercury; the organic mercury content of urine is negligible (Berglund et al., 2005). All samples were held at 4° C until analysis, which was conducted at the ADA laboratory in Chicago, IL using a cold vapor atomic absorption spectrophotometer with a method described elsewhere (Martin et al., 1995).

The limit of detection (LOD) for urinary mercury analyses was 0.2 μg/L. Urine mercury concentration levels below the LOD were assigned a value of (LOD)/(square root of 2) (n = 22, 0.5%). This

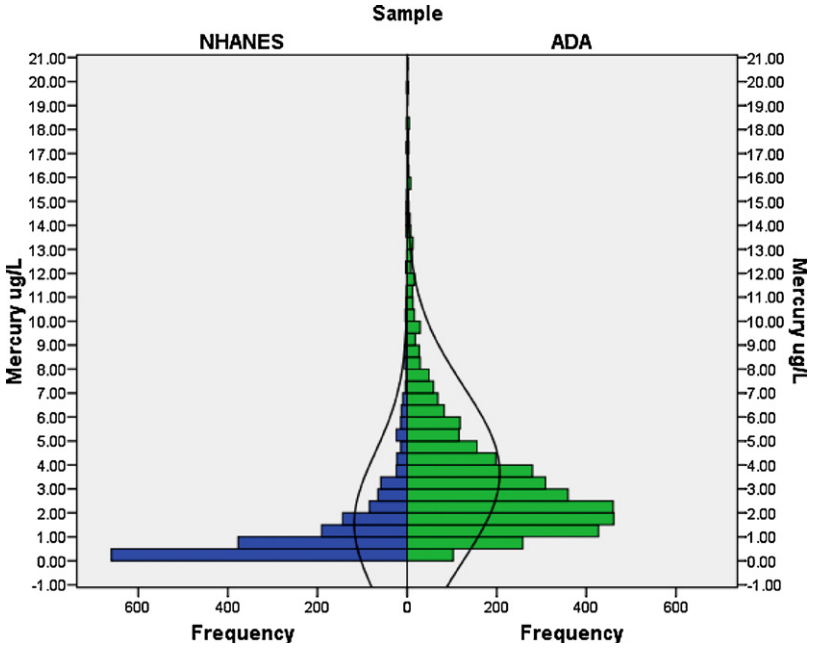

Fig. 1. Comparison of Urine Mercury Distributions from NHANES and the Current Study of Dentists and Dental Hygienists Who Attended ADA Conventions. Figure excludes 22 ADA sample mercury values of greater than 21 μg/L, up to 76.7 μg/L.