HEALTH CONSULTATION

Mercury in Perspiration Circumstance

Oakland County, Michigan

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Prepared by

Michigan Department of Community Health

Summary

A woman with symptoms of extremity numbness and leg pain saw a television show that highlighted the health effects of arsenic poisoning and asked her doctor to test her for arsenic. He ordered a urine test for metals and found high levels of mercury instead. Subsequent testing of her environment did not locate the source of her exposure, but did find that she was exuding mercury vapor thorough her perspiration.

Background and Statement of Issues

In late October 2003, a private physician in Oakland County, Michigan called a medical toxicology consultant from the Regional Poison Control Center (PCC) in Detroit, Michigan regarding a 59-year-old woman patient who had a high mercury urine test result. The woman had gone to her private physician and requested a metals test after experiencing what she thought were symptoms associated with arsenic toxicity. The toxicologist recommended a repeat urine test and a blood test with a caution to the woman not to have a fish meal within 10 days prior to the tests. The toxicologist further recommended that the woman's home be tested for a source of mercury and referred her to the Toxicology and Response Section of the Michigan Department of Community Health (MDCH).

The woman, whom we will refer to as Mrs. Bay, called MDCH on October 27, 2003 and requested that her home be tested. The urine test that had started the investigation, measured 151.1 micrograms of mercury per liter (ug/L) of urine in a 24-hour urine collection. It was based on a sample that was not adjusted for creatinine by the laboratory. Mrs. Bay had approached her doctor in September 2003 after she saw a television show regarding arsenic poisoning that had mentioned symptoms similar to what she had been experiencing. She had had numbness in her right hand that subsequently spread to her arm and then subsided. A short while later, she experienced the same symptoms in her left hand and arm and her legs had cramp-like pains radiating from a line of affected area the length of her leg. She also experienced, on one occasion, a numbness of her lips and tongue that made speaking difficult. The doctor ordered a 24-hour urine test for arsenic and mercury. The results showed urine arsenic was 19.4 ug and mercury was 515.6 ug.

On October 29, 2003, an MDCH staff member and a representative from the Oakland County Health Department visited the home and brought with them a Lumex® RA 915+ Mercury Vapor Analyzer that has a detection limit of 1 nanogram of mercury per cubic meter of air (ng/m30). They arrived at the home, and after acclimating the machine to the temperature of the house and running the necessary internal test of the device, proceeded to sample the home. The details of the finding are contained in Table 1. Below.

Table 1.
Selected Initial Characterization Samples in ng/m3

Location	Reading in ng/m3
Kitchen table surface	329
Family room, breathing zone (bz)	313
Living room (bz)	356
Dining room (bz)	365
Office (bz)	277
Bath off front entrance hall (bz)	306
Basement (bz)	245
Second Floor, top of stairs (bz)	370
Upstairs bath #1 (bz)	296
Upstairs bath #2 (bz)	513

During the investigation, every room in the house was checked; all storage areas, two vehicles, and a motor home in the driveway. The highest levels were found in the master bedroom. There were no significant levels found in the basement, or among the craft and art materials Mrs. Bay had stored there. MDCH took breathing zone measurements approximately 4 feet from floor level. These averaged approximately 300 ng/m3 on the first floor and in the mid 400 ng/m3 range in the master bedroom on the second floor. As they checked the master bedroom, the first significantly elevated mercury level was near a nightstand on Mrs. Bay's side of the bed where mercury vapors were detected at between 500 and 1,200 ng/m3. Mercury vapors near Mr. Bay's nightstand on the other side of the bed were detected at 308 ng/m3. Lumex readings near a foam rubber cosmetic applicator, resting on a dresser-top that held many closed bottles of makeup and conditioners, registered between 600 and 800 ng/m3. As they continued around the room, levels in a large clothes closet measured 1,300 ng/m3 upon opening the sliding door. Shoes at the bottom of it were scanned closely but were found to have mercury levels similar to those of the breathing zone measurements of the room. The air above a wicker clothes hamper measured 4,000 ng/m3 so it was removed from the closet and all the contents were sorted into individual plastic bags and sealed. The bags were put aside to develop headspace vapors while the investigation continued for the rest of the house and its contents.

There were two bathrooms on the second floor. One has two sinks and the other has one. Mrs. Bay used one sink in each room and mercury vapor levels in the drain areas of each of them showed vapor levels (1900 ng/m3) much higher than that of the sink only Mr. Bay used (276 ng/m3). The interior of her vehicle in the driveway, with outdoor temperatures of approximately 65^0 F that day, measured a maximum of 391 ng/m3. His vehicle was the same temperature, but measured only 25 ng/m3.

While they were sampling the dining room on the first floor for the second time, and finding a background breathing zone reading of approximately 220 ng/m3, Mrs. Bay said she was feeling an uncomfortable sweating around her neck and asked that they check her with the Lumex®. When the hose of the Lumex® came within an inch of her neck near the top of her sweater the machine registered 1,200 ng/m3.

When staff returned upstairs to check the plastic bags of clothing they numbered them, recorded the contents, and documented the Lumex® readings taken on each. The results are shown on Table 2.

Table 2. **Bagged Items from the Master Bedroom Hamper**

Items	**Reading in ng/m3**
Bag 1. Towel	3,500
Bag 2. Blue and white blouse	2,100
Bag 3. Bed sheet	600
Bag 4. Mrs. Bay's underwear	19,000 to 32,000
Bag 5. Mr. Bay's underwear	1,048
Bag 6. Mrs. Bay's underwear	2,700 to 18,000
Bag 7. Mr. Bay's underwear and washcloth	3,200

In summary MDCH and Oakland County Staff performed a comprehensive investigation of the home, its contents and the couple's vehicles, but were unable to find any area or object that could be the source of exposure for Mrs. Bay. They sampled the jewelry items she brought back from a recent visit to Europe and found them to be mercury free.

Mrs. Bay had a follow-up blood and urine test on 11/6/03 and the results were 131 ug for a 24-hour urine test and 25.8 microgram per liter (ug/L) for blood. Based on the National Health and Nutritional Examination Survey of over 1700 women between the ages of 16 and 49 years of age, 95% of the unexposed participants were shown to have less than 5 ug/l in urine and less than 7.1 ug/l in blood. The geometric mean for the population of this survey was 0.72 ug/L for urine and 1.02 for blood.

MDCH and PCC discussed the phenomenon of Mrs. Bay's measurable mercury vapor release via perspiration and proposed a way to see if that was actually occurring in a controlled environment demonstration. MDCH and the toxicologist asked Mrs. Bay to come to the hospital on 11/19/03. She was asked to shower and wash her hair at home and put on newly purchased clothing that could not have been impacted in any way by mercury contamination in her home or elsewhere. The toxicologist and a representative from MDCH met her at the hospital. The MDCH representative had with him the agency's other mercury-sensing instrument, a Lumex Light® vapor analyzer that has a detection limit of 0.1 micrograms per cubic meter of air (ug/m3). The unit conversion from nanograms to micrograms is one thousand nanograms are equivalent to one microgram.

The MDCH staff first tested the breathing zone of the library room at the hospital, the room where the Lumex was started, brought to room temperature and given an internal test to ensure that it was performing accurately. He then tested the office where Mrs. Bay was to be tested. Both rooms showed 0.0 ug/m3 in the breathing zone and near the floor. Mrs. Bay was tested at several body locations with the device: her neck, her hair, her shoes inside and out, and her breath. All of the initial tests on Mrs. Bay's person registered 0.0 ug/m3. The toxicologist then

asked Mrs. Bay to walk vigorously up and down the hospital corridors and staircases until she was starting to perspire. She did this for approximately 10 minutes and then staff tested her once again. She changed from the clothes she was wearing during the exercise into a hospital garment and placed her clothes in a plastic bag for testing the headspace that developed. Mrs. Bay was asked to breathe into the tube of the Lumex® and her breath and any contribution by her dental mercury amalgam was measured. The test was repeated after Mrs. Bay brushed her teeth with a brush and paste provided by the toxicologist.

The results of the pre-exercise and post-exercise tests are found in Table 3.

Table 3. Controlled Atmosphere Testing

Location	**Readings in ug**
Library bz	0.0
Office	0.0
Breath, pre-brushing	0.0
Breath, post-brushing	0.3
Shoes inside and out	0.0
Mrs. B hair and neck pre-exercise	0.0
Post-exercise hair tests	0.1; 0.6; 0.3
Post-exercise forehead	0.0
Post-exercise axilla	0.2; 0.1; 0.1; 0.0
Post-exercise forehead	0.0
Post-exercise bagged clothes (worn 4 hours)	0.6; 2.1; 4.0
Post-exercise neck	0.2
Post-exercise groin area and torso	0.0

Mrs. Bay's husband submitted blood and urine samples that day. He said he had not experienced any symptoms similar to his wife. The results of his test came back 3 ug/L of mercury for urine and 5.2 ug/L of mercury for blood. On November the toxicologist doctors at the Poison Control Center started Mrs. Bay on a course of oral chelation, DMSA (Succimer), at the dosage of 500 milligrams (mg.) 3 times a day for 5 days and 500 mg. 2 times a day for 14 days. She had weekly CBC, liver and renal function tests done during the 19-day chelation. The 3-week post-chelation 24-hour urine test showed 12 ug/L.

On December 2, MDCH staff accompanied by environmental health representatives from the Macomb County health agency visited the homes of two close relatives of Mrs. Bay, a religious retreat facility, and a school, trying to find the location where she might have been exposed to mercury. They were unable to detect any mercury vapor with the Lumex at any of these places except at a floor location in the basement of one of the residences where levels of 400 to 500 ng/m3 were found. The homeowner said that this was an area where they had recently broken some fluorescent bulbs and cleaned up the shards and the powder.

Later the same day they visited Mrs. Bay who was then more than half way through her course of chelation. The MDCH asked to sample Mrs. Bay's person with the Lumex and she agreed. The results are listed in Table 4.

December 2, 2003 Sampling of Mrs. Bay

Location	Reading in ug/m3
Metal necklace she wore	3 to 4
Neck at sweater-line	100
Palms of her hands	15

MDCH staff later investigated the home of a close friend of the family for mercury and the results were negative. A woman who was Mrs. Bay's roommate on a tour of Europe in September, and spent time in most of the same places, was asked to have a blood and urine test as an indicator of whether the exposure might have occurred on the trip. Her test results for mercury also came back negative.

Discussion

In the course of the investigation MDCH staff met several times with Mrs. Bay to ask her about her travels and activities before the onset of symptoms. She had been on a trip to Eastern Europe in late summer and soon after returning started feeling ill one evening while babysitting a young child. She felt unusual, disorienting symptoms that caused her to call a neighbor for assistance. In the days following, she developed a rash on her torso that her doctor thought might be an allergic reaction. She received a shot to counter the reaction and the rash went away in about a week. Soon afterwards she started experiencing the numbness mentioned earlier. Prompted by the television show information that made her suspect arsenic poisoning, she visited her doctor to request testing for metals.

MDCH asked her about her most recent trip to Mexico, which she indicated took place in January 2003. She said she did not bring back any mercury bearing souvenirs or cosmetics. When asked specifically about Crema de Belleza Manning, a skin lotion implicated in mercury poisonings in Mexico and border states in the mid 1990s, she said she had 3 bottles at home. She said she had used it to lighten small skin discolorations, but had discontinued its use 5 to 7 years previously because someone had told her it contained lead. MDCH staff asked her to bring the bottles to the next meeting and she brought 3 unopened and shrink collar sealed 160 milliliter bottles. MDCH opened one bottle and measured the headspace above the lotion with the Lumex®. It registered a spike of 44,000 ng/m3. When asked several times on subsequent occasions if she had used it more recently than 5 years ago, Mrs. Bay said she hadn't. She added that when she had used it she applied it so sparingly to her hands and face that one bottle would last her a year or more.

The main routes of exposure for elemental mercury are ingestion, dermal absorption and inhalation of mercury vapors. Of the three, inhalation is the most hazardous route particularly to children and women of childbearing age.

Inhalation of high levels of elemental mercury can cause permanent neurological damage and kidney impairment. The Agency for Toxic Substances and Disease Registry (ATSDR) recommends that breathing zone mercury levels not exceed 1,000 ng/m^3 for long term exposures as would be likely in a residence (1). This recommended level is based on both animal studies and human epidemiology studies that describe the health effects of inhalation of mercury-contaminated air. Workers who were exposed to mercury vapors in an occupational setting exhibited hand tremors, increases in memory disturbances, and slight subjective and objective evidence of autonomic nervous system dysfunction. The ATSDR minimal risk level (MRL) for mercury in air was derived from the lowest observed adverse effect level (LOAEL) from this study of 26,000 nanograms of mercury per cubic meter of air (ng/m^3). Because workers were only exposed during working hours, the LOAEL was adjusted to account for continuous exposure. The resulting value was divided by an uncertainty factor of 10 to protect sensitive human subgroups and by a factor of 3 because a LOAEL was used rather than a no observed adverse effect level (NOAEL). The resulting MRL is 0.2 micrograms per cubic meter (ug/m^3) or 200 ng/m^3. An MRL is defined as an estimate of the daily exposure level to a hazardous substance that is not expected to result in adverse, non-cancer health effects. The ATSDR recommended value for residential setting of less than 1000 ng/m^3 is an action level that if exceeded would prompt the need for further cleanup or other remedial action.

Addressing the Unique Vulnerabilities of Children

Children may be at greater risk than adults from certain kinds of exposure to hazardous substances at sites of environmental contamination. They engage in activities such as playing outdoors and hand-to-mouth behaviors that increase their exposure to hazardous substances. They are shorter than adults, which means they breathe dust, soil, and vapors close to the ground. Their lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. The developing body systems of children can sustain permanent damage if toxic exposures are high enough during critical growth stages.

Children who breathe metallic mercury vapors may develop a disorder known as acrodynia, or "pinks disease." The symptoms of this disorder include severe leg cramps, irritability; and abnormal redness of the skin, followed by peeling of the skin of the hands, nose, and soles of the feet. Itching, swelling, fever, fast heat rate, elevated blood pressure, excessive salivation or sweating, rashes, fretfulness, sleeplessness, and / or weakness may also be present. This disorder may also occur in teenagers and adults. Exposure to mercury vapors is more dangerous for children than for adults, because inhaled mercury vapors easily pass into the brain and nervous system of young children and may interfere with the development process. Exposure to high levels of mercury vapor can also cause lung, stomach, and intestinal damage. Death due to respiratory failure can result in cases of extreme exposures (3).

The woman who was experiencing the mercury vaporization from the surface of her skin did not have any children living in her home. She did, however, up until the time of her diagnosis, enjoy holding her grandchild who was less than one year old at the time. Considering the levels measured on her person, especially in the area where the child would rest its head on her shoulder, she was advised to refrain from holding the child until her course of treatment and

follow-up tests indicated the hazard no longer existed. The child was tested as a part of the investigation and the test results did not indicate any exposure.

Conclusions

MDCH made the following conclusions:

The mercury vapors that were being generated by Mrs. Bay through her perspiration were considered a health hazard in certain circumstances until her chelation was complete and testing indicating a lowering of her body burden and the levels of mercury vapor leaving her skin surface.

The source of the mercury and even the form in which the element might have been available were not determined. The risk posed to people other than Mrs. Bay by the unknown source is indeterminate.

Recommendations

The following recommendations were made by MDCH during the investigation:

1. Test all locations that were frequented by the woman for mercury vapor.
2. Arrange biological testing of her husband and her grandchild.
3. Participate in the testing of the woman's perspiration in a controlled environment at a local hospital.
4. Carefully discuss the woman's diet, use of diet supplements, medication, and cosmetics over a sufficient period of time prior to the first positive mercury test during which exposure may have occurred.
5. Contact people who accompanied the woman on travel out of the country and if possible arrange for their biological testing.

Public Health Action Plan

All recommendations listed above were implemented during the course of the investigation or shortly afterwards and no further actions are recommended at this time.

The MDCH tested every location that was proposed as a possible point of exposure for mercury vapor except for the village she visited in Eastern Europe.

MDCH consulted with professionals at the Poison Control Center in Detroit and arranged a controlled environment test at a hospital.

MDCH is be available to address any public health questions or concerns regarding this contamination circumstance. Please contact the Michigan Department of Community Health, Division of Environmental and Occupational Epidemiology at 1-800- 648-6942.

References

- ATSDR (Agency for Toxic Substances and Disease Registry). 2000. Suggested Action Levels for Indoor Mercury Vapors in Homes or Businesses with Indoor Gas Regulators.

- ATSDR (Agency for Toxic Substances and Disease Registry). 1999. Toxicological Profile for Mercury, Update.

- National Health and Nutritional Examination Survey (NHANES), 1999-2000 Data, Centers for Disease Control and Prevention

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