Mercury Poisoning

1. The Disease Definition

Mercury is naturally occurring and is the only metal that is liquid at room temperature. It is found in organic and inorganic forms. The inorganic form can be further divided into elemental mercury and mercuric salts. Organic mercury can be found in long and short alkyl and aryl compounds. High mercury exposure results in permanent nervous system and kidney damage.

A. Clinical Description

Mercury in any form is toxic. There is a difference, however, in how it is absorbed, the clinical signs and symptoms, and the response to treatment modalities. Mercury poisoning can result from vapor inhalation, ingestion, injection, or absorption through the skin.

Elemental mercury can be in liquid form, which easily vaporizes at room temperature and is well absorbed (80 percent) through inhalation. Its lipid-soluble property allows for easy passage through the alveoli into the bloodstream and red blood cells. Once it is inhaled, elemental mercury mostly converts to an inorganic divalent or mercuric form by catalase in the erythrocytes. Small amounts of non-oxidized elemental mercury continue to persist and account for central nervous system toxicity. Elemental mercury as a vapor can penetrate the central nervous system, where it is ionized and trapped, attributing to its significant toxic effects. Elemental mercury is not well absorbed by the gastrointestinal tract and, therefore, when ingested, is only mildly toxic.

Short-term exposure (hours) to high levels of metallic mercury vapor in the air can damage the lining of the mouth and irritate the lungs and airways, causing tightness of the chest, a burning sensation in the lungs, and coughing. Other effects include nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation. Damage to the lining of the mouth and lungs can also occur from exposure to lower levels of mercury vapor over longer periods (for example, in some occupations where workers were exposed to mercury for many years).

Inorganic mercury, found mostly in mercuric salt, is highly toxic and corrosive. It enters the body orally or dermally and is absorbed at a rate of 10 percent of whatever is ingested. It accumulates mostly in the kidney, causing significant renal damage. Although poor lipid solubility limits penetration of the central nervous system, slow elimination and chronic exposure allow significant accumulation of mercuric ions in the central nervous system and subsequent toxicity. Long-term dermal exposure to inorganic mercury may also lead to toxicity.

Organic mercury can be found in three forms, aryl and short and long chain alkyl compounds. Organic mercurials are absorbed more completely from the gastrointestinal tract than are inorganic salts. Once absorbed, the aryl and long chain alkyl compounds are converted to their inorganic forms and possess similar toxic properties to inorganic mercury. The short chain alkyl mercurials are readily absorbed in the gastrointestinal tract and remain stable in their initial forms. Alkyl organic mercury has high lipid solubility and is distributed uniformly throughout the body, accumulating in the brain, kidney, liver, hair, and skin. Organic mercurials also cross the blood brain barrier and placenta and penetrate erythrocytes, attributing to neurological symptoms, teratogenic effects, and high blood-to-plasma ratio.

All forms of mercury are toxic to the fetus, but methylmercury most readily passes through the placenta. Even with an asymptomatic patient, maternal exposure can lead to spontaneous abortion or retardation.

Symptoms vary, depending on the nature of the exposure, the intensity of the exposure, and the chemical form. Acute toxicity usually results from the inhalation of elemental mercury or ingestion of inorganic mercury. Exposure to organic mercury leads to chronic toxicity and, occasionally, acute toxicity.

Acute exposure caused by inhaled elemental mercury can lead to pulmonary symptoms. Initial signs and symptoms, such as fever, chills, shortness of breath, metallic taste, and pleuritic chest pain, may be confused with metal-fume fever, which is caused by cadmium exposure. Other possible symptoms include stomatitis, lethargy, confusion, and vomiting.

Inorganic mercury or mercuric salt exposure mainly occurs through the oral and gastrointestinal tract. Its corrosive properties account for most of the acute signs and symptoms of inorganic mercury or mercuric salt toxicity. The acute presentation can include ashen-gray mucous membranes secondary to precipitation of mercuric salts, hematochezia, vomiting, severe abdominal pain, and hypovolemic shock. Systemic effects usually begin several hours after ingestion and may last several days. These effects include metallic taste, stomatitis, gingival irritation, foul breath, loosening of teeth, and renal tubular necrosis leading to oliguria or anuria.

Chronic exposure results in renal failure, dementia, and acrodynia. Acrodynia, known as pink disease and considered to be a mercury allergy, presents with erythema of the palms and soles, edema of the hands and feet, desquamating rash, hair loss, pruritus, diaphoresis, tachycardia, hypertension, photophobia, irritability, anorexia, insomnia, poor muscle tone, and constipation or diarrhea. Acrodynia does not present in everyone who is exposed to inorganic mercury, but it is an indicator of widespread disease.

The onset of symptoms usually is delayed (days to weeks) after exposure. Organic mercury targets enzymes, and the depletion of these enzymes must occur before the onset of symptoms. Toxicity symptoms are typically neurological, such as visual disturbance (e.g., scotomata, visual field constriction), ataxia, paresthesias (early signs), hearing loss, dysarthria, mental deterioration, muscle tremor, movement disorders, and, with severe exposure, paralysis and death. Organic mercury targets specific sites in the brain, including the cerebral cortex (especially visual cortex), motor and sensory centers (precentral and postcentral cortex), auditory center (temporal cortex), and cerebellum.

B. Sources of Exposure

Sources of exposure to elemental mercury include barometers, batteries, bronzing, calibration instruments, chlor-alki production, dental amalgams, electroplating, fingerprinting products, fluorescent and mercury lamps, infrared detectors, the jewelry industry, manometers, neon lamps, paints, paper pulp production, photography, silver and gold production, semiconductor cells, and thermometers.

Sources of exposure to inorganic mercury toxicity include antisyphilitic agents, acetaldehyde production, chemical laboratory work, cosmetics, disinfectants, explosives, embalming, fur hat processing, ink manufacturing, mercury vapor lamps, mirror silvering, the perfume industry, photography, spermicidal jellies, tattooing inks, taxidermy production, vinyl chloride production, and wood preservation.

Sources of exposure to organic mercury include antiseptics, bactericidals, embalming agents, the farming industry, fungicides, germicidal agents, insecticidal products, laundry products, diaper products, paper manufacturing, pathology products, histology products, seed preservation, wood preservatives, and contaminated food (mainly seafood).

People who utilize complementary and alternative medicine (CAM) may have an increased risk of exposure to a variety of toxic substances including mercury, especially when using products that are manufactured outside of the USA.

Occupational exposure to mercury hazards are addressed in specific OSHA (Occupational Safety and Health Administration) standards for the general industry, shipyard employment, and the construction industry. More information is available at www.osha.gov/SLTC/mercury/, including exposure limit information from OSHA, the National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Industrial Hygienists (ACGIH).

C. Population at Risk

The 2016 annual report of the American Association of Poison Control Centers' National Poison Data System documented 1,126 exposures to mercury or compounds containing mercury. Of these, 98 were in children younger than 6 years and 629 were in persons older than 19. Overall, 25 people were reported to have moderate effects, five had major effects, and 2 people died as a result of mercury exposure. A cluster of mercury poisonings was seen in Iowa in 2011 from the use of Ayurvedic products obtained from India.

D. Diagnosis, Treatment, and Prognosis

Mercury in urine is used to test for exposure to metallic mercury vapor and to inorganic forms of mercury. Measurement of mercury in whole blood or scalp hair is used to monitor exposure to methylmercury. Urine is not useful for determining whether exposure has occurred to methylmercury. Levels in blood, urine, and hair may be used together to predict possible health effects that may be caused by the different forms of mercury. Whole blood mercury levels are usually less than 2 micrograms per deciliter (µg/dL) in unexposed people, except for those with a high dietary intake of fish

Methylmercury concentrates in erythrocytes; therefore, mercury levels in blood remain high in acute toxicity. The blood level correlation with chronic methylmercury toxicity is more variable. Methylmercury exhibits a blood-to-plasma ratio of 20:1, a characteristic of inorganic mercury. This higher ratio may be useful in determining if the patient was exposed to organic or inorganic mercurials. Aryl mercury compounds accumulate in red blood cells, but are metabolized to inorganic mercury more rapidly, thus, demonstrating lower blood-to-plasma ratios than those observed with methyl mercury exposures. Following high exposure to inorganic mercury salts, the blood-to-plasma ratio ranges from a high of 2:1, to 1:1. Paraesthesias are expected if blood mercury levels are higher than 20 µg/dL.

Inorganic mercury redistributes to other body tissue; thus, its levels in the blood are accurate only after acute ingestion. In general, blood levels of mercury are helpful for recent exposures and for determining if the toxicity is secondary to organic or inorganic mercury, but not for a guide to therapy. Urine mercury levels are typically less than 10 to 20 µg/L. Excretion of mercury in urine is a good indicator of inorganic and elemental mercury exposure but is unreliable for organic mercury (methylmercury) because elimination occurs mostly in the feces. No absolute correlation exists between the urine mercury levels and the onset of symptoms; however, levels higher than 300 µg /L are associated with overt symptoms. Mercury levels in the urine also can be used to gauge the efficacy of chelation therapy. For workers chronically exposed to mercury compounds, urinary excretion with mercury levels higher than 50 µg /L is associated with an increased frequency of tremor.

Do not induce emesis if the compound ingested is of the caustic inorganic form. Gastric lavage is recommended for organic ingestion, especially if the compound is observed on the abdominal x-ray series. Gastric lavage with protein-containing solutions (e.g., milk, egg whites, salt-poor albumin) or 5 percent sodium formaldehyde sulfoxylate solution may bind gastric mercury and limit its absorption. Activated charcoal is indicated for gastrointestinal decontamination because it binds inorganic and organic mercury compounds to some extent. Whole bowel irrigation may be used until rectal effluent is clear and void of any radiopaque material. However, effectiveness in decreasing the gastrointestinal transit time of elemental mercury is doubtful because of the high density of elemental mercury and the low density of the whole bowel irrigant solutions. Likewise, whole bowel irrigation has no adsorptive effect on any type of mercury within the gastrointestinal tract.

Use chelating agents if the patient is symptomatic, if systemic absorption is anticipated, or if increased blood or urine levels are present. Chelating agents contain thiol groups, which compete with endogenous sulfhydryl groups.

Hemodialysis is used in severe cases of toxicity when renal function has declined. The ability of regular hemodialysis to filter out mercury is limited because of mercury's mode of distribution among

erythrocytes and plasma. However, hemodialysis, with L-cysteine compound as a chelator, has been successful.

Neostigmine may help motor function in methylmercury toxicity. This toxicity often leads to acetylcholine deficiency. Polythiol is a non-absorbable resin that can help in facilitating the removal of methylmercury, which is then excreted in the bile after enterohepatic circulation.

The outcome depends on the form of the mercury compound and severity of exposure. Mild exposure can result in a complete recovery. Severe exposure to mercuric salt is usually fatal. Most organic mercury exposures leave a neurological sequela. Very minimal dermal exposure to dimethyl mercury has resulted in progressive neurologic deterioration and death, with initial symptoms delayed for several months.

E. Prevention of Exposure

Controlling occupational mercury exposure is best accomplished through substituting it with a non-toxic chemical, depending on the application. If this cannot be done, engineering, administrative, and personal protective equipment (PPE) including protective clothing and respirators should be used.

Information regarding how to safely handle, dispose of, or recycle fluorescent light bulbs that may contain mercury is available at www.epa.gov/solidwaste/hazard/wastetypes/universal/lamps/index.htm.

If a household thermometer is broken, the amount of mercury contained in an oral thermometer is small and does not present an immediate threat to human health. However, if it is not properly cleaned up and disposed of, it may present a health risk over time, particularly to infants, toddlers, and pregnant women. If a thermometer is broken on a counter top or uncarpeted floor, children should be removed from the area. Mercury is not absorbent, so it should not be wiped or blotted up with a cloth or paper towel. That will only spread the mercury and break it up into smaller beads, making it more difficult to find and remove. Instead, the beads of metallic mercury should be cleaned up by using one sheet of paper to carefully roll them onto a second sheet of paper, or by sucking very small beads of mercury into an eyedropper. After picking up the metallic mercury in this manner, it should be placed in a plastic bag or airtight container. The paper and eyedropper should also be bagged in a zip-lock plastic container. All plastic bags used in the cleanup should then be taken outside of the house or apartment and disposed of properly, according to instructions provided by the local health department or environmental officials. The room should be ventilated with outside air and closed off from the rest of the home. Fans that direct the air to the outside and away from the inside of the house should be used for a minimum of one hour to speed the ventilation. See also www.epa.gov/mercury/spills/index.htm#thermometer.

If larger amounts of metallic mercury are found (for example, a jar of liquid mercury), they should be contained in an airtight container, and the local health department should be called for instructions on how to safely dispose of it. If the mercury is in an open container or the container does not have a lid, a piece of plastic wrap should be placed around the top of the container to prevent vapors from escaping; then the handler's hands should be washed thoroughly. If a larger amount is spilled, people should leave the area and the local health department and fire department should be contacted. Metallic mercury should not simply be thrown away. Instead, professional help should be sought.

Consumers of complementary and alternative medicine supplements, especially those manufactured outside of the USA should discuss their risk of exposure to heavy metals and other toxins with their medical practitioners to determine the need for testing or intervention. An FDA fact sheet is available at www.fda.gov/downloads/ForConsumers/ConsumerUpdates/ucm050819.pdf.

The FDA advises that pregnant women and women of childbearing age who may become pregnant should not eat shark, swordfish, king mackerel, or tilefish. This advice is given because methylmercury (short chain alkyl organic mercury) levels are relatively high in these fish species. Women of childbearing

age are included in this advice because dietary practices immediately before pregnancy could have a direct bearing on fetal exposure during pregnancy, particularly during the earlier months.

2. Reporting Criteria

A. Disease Reporting

Mercury poisoning is reportable if:

- Blood mercury values are equal to or greater than the equivalent of 2.8 micrograms per deciliter.
- Urine mercury values are equal to or greater than the equivalent of 20 micrograms per liter.

Mercury poisonings must be reported within a week to the Iowa Department of Public Health by the physician or health practitioner attending any person having a reportable disease and by laboratories performing tests identifying reportable diseases. Reporting can be through the Iowa Disease Surveillance System (IDSS), or by phone, fax, or mail. The preferred reporting method is through IDSS. To report via phone, fax or mail, please use the contact information and Mercury Case Report Form available in the Epi Manual and online at https://wiki.idph.iowa.gov/Portals/3/userfiles/12/Mercury_Case_Report_Form.pdf