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Mercury Toxicity and Health Effect

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Abstract
Mercury is a toxic heavy metal which is widely dispersed (in several chemical forms) in nature. It evaporates at room temperature and its inhalation and contact may cause poisoning. The toxicity of mercury depends on its chemical form and route of exposure. Due to the nonspecific symptoms, diagnosis is difficult in special circumstances with no initial history of mercury exposure. Most human exposure results from fish consumption, dental amalgam, cosmetics, agrochemicals and many other industries. Diagnosis of mercury toxicity can be challenging but can be obtained with reasonable reliability. Their sources, symptoms, complications have been described.

Keywords: Mercury, toxicity, fish, human, environment, nervous system and renal system.

Introduction
Mercury is a metal that's liquid at room temperature. It looks like silvery-white beads or balls (globules). Liquid mercury is sometimes called metallic or elemental mercury. Liquid mercury evaporates easily into the air, even at room temperature, to form mercury vapour.
Mercury in any form is poisonous, its toxicity most commonly affecting the neurological, gastrointestinal and renal organ systems. Poisoning can result from mercury vapour inhalation, mercury ingestion, mercury injection, and absorption of mercury through the skin.
Mercury has 3 forms: (1) elemental mercury, (2) inorganic salts, and (3) organic compounds. Perhaps the most deadly form of mercury is methylmercury. Only 2-10% of the ingested mercury is absorbed from the gut, and ingested elemental mercury is not absorbed at all; however, 90% of any methylmercury ingested is absorbed into the bloodstream from the gastrointestinal track.
Inorganic mercury toxicity occurs in several forms: metallic (Hg), mercurous form (Hg^{1+}), or mercuric form (Hg^{2+}). Inorganic mercury is highly toxic and corrosive.
Organic mercury can be further found in 3 forms: aryl and short- and long-chain alkyl compounds. Organic mercurials are absorbed more completely from the GI track than inorganic salts are; this is because of intrinsic properties, such as lipid solubility and mild corrosiveness (although organic mercury is much less corrosive than inorganic mercury).
Organic mercury compounds, specifically methylmercury, are concentrated in the food chain. Fish from contaminated water are the most common source. Industrial mercury pollution is often in the inorganic form, but aquatic organisms and vegetation in waterways such as rivers, lakes convert it to deadly methylmercury. Fish eat contaminated vegetation, and the mercury becomes biomagnified in the fish. Fish protein binds more than 90% of the consumed methylmercury so tightly that even the most vigorous cooking methods (eg, deep-frying, boiling, baking, pan-frying) cannot remove it.
In 1961, researchers in Japan correlated elevated urinary mercury levels with the features of the previously mysterious Minamata disease. Before Minamata disease was discovered, it plagued the residents around Minamata Bay in Japan with tremors, sensory loss, ataxia, and visual loss [1].
Minamata disease is an example of organic toxicity. In Minamata Bay, a factory discharged inorganic mercury into the water. The mercury was methylated by bacteria and subsequently ingested by fish. Local villagers ate the fish and began to exhibit signs of neurologic damage, such as visual loss, hearing loss, and ataxia. Babies exposed to the methylmercury in utero were the most severely affected. Furthermore, because mercury was also discovered in the breast milk of the mothers, the babies' exposure continued after birth [2].

2. Sources of mercury poisoning

Causes of elemental mercury toxicity include the following:

- Thermometers
- Barometers
- Batteries
- Bronzing
- Calibration instruments
- Dental amalgams
- Electroplating
- Fingerprinting products
- Fluorescent and mercury lamps
- Infrared detectors
- Jewelry industry
- Manometers
- Neon lamps
- Paints
- Photography
- Silver and gold production
- Semiconductor cells

The causes of organic mercury toxicity also include the following:

- Antiseptics
- Bactericides
- Farming industry
- Fungicides
- Germicidal agents
- Insecticidal products
- Laundry products
- Diaper products
- Paper manufacturing
- Pathology products
- Seed preservation
- Wood preservatives

The causes of inorganic mercury toxicity include the following:

- Acetaldehyde production
- Chemical laboratory work
- Cosmetics
- Disinfectants
- Explosives
- Ink manufacturing
- Mirror silvering
- Perfume industry
- Photography
- Tattoo inks
- Vinyl chloride production
- Wood preservation

Mercury may also be contained in some cosmetics, such as skin-lightening products [3]. One study measured international skin-lightening products for their mercury content, focusing on products available to consumers either online or in stores. The products were screened for mercury content using a portable x-ray fluorescence spectrometer [4, 5].

3. Mercury Exposure

3.1 Inorganic mercury exposure

Exposure to inorganic mercury or mercuric salt occurs mainly through the oral and GI track. Its corrosive properties account for most of the acute signs and symptoms of inorganic mercury or mercuric salt toxicity [6, 7].

3.2 Organic mercury exposure

Organic mercury poisoning usually results from ingestion of contaminated food. The long-chain and aryl forms of organic mercury have similar toxic characteristics as inorganic mercury. The symptoms usually are delayed (days to weeks) after exposure.

3.3 Dietary consumption of mercury

The primary source of environmental exposure to mercury in the general population is through the consumption of contaminated fish [8]. Fish consumption has clear health benefits, and the risk posed by mercury exposure is currently speculative.

3.4 Inhalation exposure

Other forms of mercury exposure, such as elemental mercury vapor inhalation, occur when people vacuum or sweep mercury spills in an enclosed space. The proper authorities must handle any spill with the appropriate mercury decontamination kits and procedures.

Significant oral ingestion of elemental mercury may lead to significant environmental contamination as the mercury is passed, essentially unabsorbed, through the gastrointestinal track and expelled in the feces.

Minamata disease typically occurs in areas in which the population depends on seafood as a dietary staple and in areas in which industrial wastes contaminate the drinking water. Educate patients about alternative food sources and about eliminating their intake of contaminated fish.

Outbreaks of methylmercury poisoning also have occurred after the introduction of fungicide-treated grain into the food supply. Neither humans nor livestock should eat seed grain treated with mercurial fungicides.

4. Symptoms of mercury poisoning

Although mercury is poisonous (toxic), it usually only causes problems if inhale large amounts of it.

Very little mercury is absorbed by body if swallow a small amount of liquid mercury or get it on the skin for a short time. This is considered almost non-toxic and you'll probably have no symptoms.

However, if breathe in mercury vapour or globules, it can be absorbed into the bloodstream and cause symptoms such as: a cough, breathlessness, chest pains, a tight chest or a burning feeling in your chest, feeling irritable and nervous, shaking (tremor), coughing up blood, breathing difficulties.[5]

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. Other possible symptoms include stomatitis, lethargy, confusion, and vomiting. In addition, elemental mercury can also be injected, causing a life-threatening pulmonary embolism.

Symptoms related to toxicity are typically neurologic, such as the following:

- Visual disturbance - visual field constriction
- Ataxia
- Paresthesias (early signs)
- Hearing loss
- Mental deterioration
- Muscle tremor
- Movement disorders
- Paralysis and death - With severe exposure

Organic mercury targets enzymes, and the depletion of these enzymes must occur before the onset of symptoms.
It also targets specific sites in the brain, including the cerebral cortex (especially the visual cortex), motor and sensory centers (precentral and postcentral cortex), the auditory center (temporal cortex), and the cerebellum [4].
If methyl mercury intoxication is suspected, inquire about the patient's diet, including the following:

- Amount of fish consumed
- Frequency of consumption
- Types of fish consumed
- Source of fish consumed
- Source of water supply

Also inquire about classic symptoms, including the following:

- Perioral and facial paresthesias
- Headache
- Constriction of the visual fields
- Difficulty in hearing
- Memory loss
- Problems with walking

Methyl mercury exerts its most devastating effect on the CNS by causing the following:

- Psychiatric disturbances
- Visual loss
- Hearing loss
- Neuropathy

Severe poisoning eventually causes the patient to lie in a mute, semi rigid posture that is broken only by episodes of crying or primitive reflexive movements.
Babies exposed in utero are the most severely affected. They are affected by low birth weight, seizure disorders, profound developmental delay, incomplete visual loss (including tunnel vision) or total blindness, and hearing loss [6, 7].
Neurologic damage in the form of diffuse and widespread neuronal atrophy is most severe in patients exposed in utero [6].
Children so affected may have long-term stigmata, including visual loss, hearing loss, developmental delay, and seizure disorders.
Organic methylmercury toxicity and inorganic mercury toxicity show different pathologic effects [7]. Organic methylmercury toxicity causes prominent neuronal loss and gliosis in the calcarine and parietal cortices and cerebellar folia, as seen in cases of classic Minamata disease [9].
Elemental mercury (Hg) is found in liquid form, which easily vaporizes at room temperature and is well absorbed (80%) through inhalation. Its lipid-soluble property allows for easy passage through the alveoli into the bloodstream and red blood cells (RBCs). Once inhaled, elemental mercury is mostly converted to an inorganic divalent or mercuric form by catalase in the erythrocytes. This inorganic form has similar properties to inorganic mercury (eg, poor lipid solubility, limited permeability to the blood-brain barrier, and excretion in feces). Small amounts of nonoxidized elemental mercury continue to persist and account for central nervous system toxicity.
Elemental mercury as a vapor has the ability to penetrate the central nervous system (CNS), where it is ionized and trapped, attributing to its significant toxic effects.
Elemental mercury is not well absorbed by the GI track; therefore, when it is ingested (eg, thermometers), it is only mildly toxic.
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 (methylmercury) are readily absorbed in the GI track (90-95%) 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, producing neurologic symptoms, teratogenic effects, and high blood to plasma ratio, respectively.

4.1 Nervous system effects

Methyl mercury exerts its most devastating effect on the CNS by causing psychiatric disturbances, ataxia, visual loss, hearing loss, and neuropathy [9].
Excretion of inorganic mercury, as with organic mercury, is mostly through feces. Renal excretion of mercury is considered insufficient and contributes to its chronic exposure and accumulation within the brain, causing CNS effects [9, 10].
Excretion of alkyl mercury occurs mostly in the form of feces (90%), secondary to significant enterohepatic circulation. The biological half-life of methylmercury is approximately 65 days [9, 11-14].

4.2 Renal effects

Necrosis of the proximal tubules is a common direct renal toxic effect. Unexplained renal abnormalities with neuropsychiatric disturbances should prompt the physician to consider mercury toxicity [15, 16].
Mercury-containing disk batteries are a concern because of their ability to cause corrosion and ulceration of the GI mucosa [17, 18]. With battery ingestion, one would expect signs of inorganic mercury exposure, such as hyper salivation and vomiting, rather than signs of organic mercury poisoning.
One major risk factor for mercury toxicity is industrial contamination. Workers employed in the manufacturing of mirrors, thermometers, fluorescent lights, and radiography machines, as well as in gold mining, are at risk for inorganic mercury poisoning. Organic mercury poisoning can occur among exposed workers in the paper and pulp industries [19, 20].
Even the mercury vapors from dental amalgam have been of concern as a possible, although controversial, source of exposure among dental workers and the general population [16].
Two randomized studies of a total of 1041 children aged 6-10 years whose dental caries were treated with either amalgam or resin composite fillings showed no group differences on extensive batteries of neuropsychological tests after 5-7 years of follow up [15].
Recovery from mercury poisoning is variable. Acute intoxication with methylmercury resulted in coma and death in the Minamata [21, 22]. Delayed toxicity can also occur, as in a fatal case in which symptoms developed only several months following absorption of dimethylmercury through the skin. Mercury vapors also can result in acute neurologic and generalized symptoms.
In a case of a family exposed to methylmercury through the ingestion of contaminated pork, the more severe clinical manifestations were found in the younger children [23].
Outcome in mercury toxicity depends on the form of the mercury compound and the severity of exposure. Mild exposure to inorganic (ie, elemental, mercuric salt) and organic compounds can result in a complete recovery. Fatality

is usually the result of severe exposure to mercuric salt. Most organic mercury exposures leave a neurologic sequela. Minimal dermal exposure to dimethylmercury has resulted in progressive neurologic deterioration and death, with initial symptoms delayed for several months [24].

All forms of mercury are toxic to a fetus, but methylmercury most readily passes through the placenta. Even with an asymptomatic patient, maternal exposure can lead to spontaneous abortion or retardation [25, 26].

Once the neurologic sequelae of Minamata disease are evident, the damage is irreversible, and severe intoxications have been fatal. However, the damage may be minimized if detected early enough. Effects of long-term exposure are only now being fully recognized. Most survivors of Minamata disease have chronic neuropathologic conditions such as the following:

- Ataxia
- Visual loss
- Psychiatric disturbances
- Sensory loss
- Chronic paresthesias

Compared with other, babies exposed to Minamata disease in utero have a more dismal prognosis. Their sequelae include the following:

- Severe developmental delay
- Low birth weight
- Persistent cognitive impairment

5. Consultation, Prevention and Care

Activated charcoal is indicated for GI decontamination because it binds inorganic and organic mercury compounds to some extent.

Seafood rich in organic mercury should of course be avoided. Predators such as sharks and tuna typically have increased mercury concentrations compared with herbivorous fishes.

Because of the high morbidity and mortality rates associated with methyl mercury poisoning, especially in utero, pregnant women and nursing mothers should avoid consuming larger fish, because their mercury concentrations tend to be higher than those in smaller fish.

Workplace hygiene and careful monitoring and disposal of industrial waste are equally important in the prevention of mercury poisoning.

Minamata disease can be prevented by reducing or eliminating one's consumption of fish caught from bodies of water that are contaminated with high concentrations of mercury.

Consult to the regional poison control center or a medical toxicologist.

Mercury toxicity can be avoided by the use of vegetarian fishes.

Replaces products contain mercury from their other alternatives.

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