Mercury, Adverse Effects

ICD-10 T56.1

Rose H. Goldman

Mercury (Hg) poisoning can occur from exposure to either inorganic mercury (elemental mercury or mercury salt compounds) or organic mercury compounds. Diagnosis is based upon the combination of symptoms, the signs on physical examination, and the history of exposure. Laboratory tests to determine the concentration of mercury in blood and urine can be helpful in supporting the diagnosis. The signs and symptoms vary by the type of mercury or mercurial compound, and by the dose and length of exposure.

Acute poisoning by elemental or inorganic mercurial compounds is rare, and often presents with respiratory tract or skin irritation, kidney damage, stomatitis (inflammation of the mouth and gums), and gastrointestinal complaints. Renal injury is of particular concern after exposure to mercuric chloride. Neurological symptoms can develop subsequently, and are similar to those seen from chronic overexposure. Chronic exposure is much more common and is associated with the classic triad of tremor, psychological disorder (extreme shyness and emotional labilty termed "erethism"), and stomatitis. An initial fine resting tremor may progress to an intention tremor. A sensory peripheral neuropathy may develop with distal paresthesias. Early cognitive changes can eventually progress to dementia as a later manifestation.

Organic mercury is felt to be more toxic than inorganic mercury. Exposure to organic compounds is usually chronic, and results in the insidious onset of progressive neurological symptoms. Early symptoms include numbness and tingling of the extremities and around the lips. Later symptoms include decreased motor coordination, with gait ataxia, tremor, and difficulties with fine motor movements. Other symptoms of severe exposure and poisoning include constriction of the visual fields, central hearing loss, spasticity with increased deep tendon reflexes, and cognitive changes. Children are more sensitive to the effects of mercury, and thus are affected at much lower doses, raising issues for pregnant workers. Most of the research done concerning developmental effects of mercury on children relates to methylmercury, rather than inorganic mercury compounds that are more common in the workplace. Nevertheless, this research offers some insight on possible acceptable levels of mercury exposure to women of child-bearing age in the workplace. In 2000, a National Research Council (NRC) committee recommended a benchmark dose level of 58 μg/L mercury in cord blood, based on adverse developmental effects from in utero methylmercury expo-

sure. In order to account for uncertainties and individual variability in response to toxic effects, the NRC recommended dividing by an uncertainty factor of 10 and calculated a reference dose of 5.8 μg/L mercury in cord blood. ATSDR defines the minimum risk level (MRL) as 13.6 μg/L based upon the results of another study. Urinary mercury is the preferred biomarker for low-level exposures to elemental and inorganic mercury. In terms of inorganic work place compounds, urinary mercury is the preferred biomarker for low-level exposures to elemental and inorganic mercury.

Clinical diagnosis is supported by elevation of the concentration of mercury in blood and/or urine. Inorganic mercury can be detected in both blood and urine. Organic mercury is predominately excreted through the gastrointestinal tract (feces), so it is best detected in blood. The finding of an elevated blood mercury, but not detectable urine mercury, is very suggestive of exposure to organic mercury, particularly methylmercury. There does not appear to be a precise correlation between the biological monitoring results and toxic manifestations. For persons nonoccupationally exposed, urinary mercury is generally less than 5 μg Hg/gram creatinine and usually less than 1 μg/g. Subclinical neurological effects for elemental mercury have been reported at urinary mercury levels between 20 and 100 μg/L. ACGIH recommends that the blood inorganic mercury of workers not exceed 15 μg/L and that urine values not exceed 35 μg/g creatinine. Organic mercury is rarely detected in urine unless exposures are enormous. Neurotoxicity thresholds for blood mercury in adults have been suggested to be between 50 and 200 μg/L. Some recent data have been suggestive of increased risks of cardiovascular disease with mercury levels that are much lower.

Occurrence

Reliable data concerning the actual incidence of mercury poisoning are unavailable. The number of cases of adverse effects of mercury and the proportion that is occupationally related are not known.

Causes

Mercury is a silvery white metal that naturally occurs in the earth's crust and in the ocean. It is found in numerous rocks and is recovered primarily from cinnabar ore (HgS). Elemental mercury has been used in scientific instruments such as thermometers and barometers. Mercury vapor has also been used to illuminate street lights, fluorescent lamps, and advertising signs. Mercury can also form alloys (or amalgams) with other metals, such as gold, silver, zinc, and cadmium. Amalgams can then be used to help extract gold, create dental fillings (of silver-mercury amalgam), and help extend the life of batteries (with nickel and cadmium) and to be a component in some cosmetics. Use of mercury in the tanning and taxidermy felt (hat) industries in the 19th century led to psychosis among exposed workers and the phrase "mad as a hatter."

Inorganic mercury exists in two oxidative states (mercurous and mercuric) and combines with other elements, such as chlorine (mercuric chloride), sulfur, and oxygen to form inorganic mercury compounds or salts. Inorganic mercury enters the air from mining of ore, burning of coal, and incineration of medical wastes. Some of these inorganic compounds have been used for medicinal purposes, such as mercuric chloride ($HgCl_2$) to disinfect wounds and mercurous choride (an antiseptic called calomel [Hg_2Cl_2]) to kill bacteria. Mercuric sulfide (HgS) has been used to make a red paint pigment, vermilion, and mercuric oxide (HgO) to make mercury batteries.

Mercury can also combine with organic compounds to form methylmercury, phenylmercury, and merthiolate. The most common population exposure to mercury is to methylmercury, through fish consumption. Methylmercury forms when inorganic mercury is released into the air or water through industrial pollution, accumulates in aquatic environments, and is acted upon by microbes. Methylmercury bioaccumulates through the food chain so that concentrations are highest in large predatory fish. Other forms of organic mercury include ethylmercury (thimersol), which has been used as a preservative in vaccines; phenylmercurics, used as fungicides; and toxic dimethylmercury for chemistry laboratory processes.

Most workplace occupational mercury poisonings in the United States are due to exposure to elemental mercury or inorganic mercury compounds. Inorganic mercury exposure has been described in many occupations, including miners; workers manufacturing or repairing mercury-containing instruments, fluorescent lamps, batteries, and pharmaceuticals; workers in chlor-alkali mercury cell operations for production of chlorine and caustic soda; platers of jewelry; and dentists, dental technicians, and other laboratory workers. In South American nations and some other developing countries, metallic mercury has been used to extract gold during the mining process. Frequently, there is little or no control of exposure, resulting in overexposures among workers, as well as contamination of land and waters and exposure to residents of mining areas. Organic mercury poisoning has occurred as a result of environmental contamination; and eating of contaminated fish (fisherman and community members in Minamata, Japan) and ingestion of seeds and grains treated with mercury fungicide (Iraq). Workers handling organic mercury fungicides may be at risk for exposure. Rare cases of fatal poisoning in laboratory workers exposed to the highly toxic dimethylmercury have been described.

Pathophysiology

Elemental mercury is absorbed after the inhalation of mercury vapor. There is negligible gastrointestinal absorption. Soluble mercurial salts can also be absorbed after inhalation, and to a limited extent after ingestion. Alkylmercurials such as methylmercury are highly absorbed from the gastrointestinal tract, and also from inhalation and skin contact. In the blood,

most mercury (especially alkylmercury) is found within red blood cells. Mercury compounds are distributed to many tissues, particularly the kidney and the brain. Mercury binds to sulfhydryl groups and may interfere with many cellular enzyme systems. The exact mechanism of action for neuronal damage is not known.

Both organic and elemental mercury compounds can cross the blood-brain barrier and the placenta, and are secreted in breast milk. Mercury compounds are eliminated in the feces, saliva, and sweat. Some inorganic mercury, but almost no methylmercury, is excreted in the urine.

Prevention

The first step in prevention is to reduce exposures. Substitution of less toxic substances will eliminate exposure. For example, substitutes can be found for mercury-containing instruments, such as mercury-containing sphygmomanometers and thermometers. These changes decrease not only mercury that enters the environment and community, but also exposures to workers who would otherwise be involved in manufacturing mercury-containing instruments.

When it is not possible to substitute, then use of engineering controls, often with enclosure or ventilation of processes that use mercury or mercurial compounds, is often the most effective means of reducing exposures. Use of appropriate protective clothing and gloves is important because mercury can be readily absorbed through the skin. Proper respiratory protection needs to be provided in situations in which other engineering methods are not possible or sufficient. Workers who handle mercury and those working nearby need respiratory protection.

Proper housekeeping and clean-up of any spilled mercury is essential in order to avoid ongoing exposures. So is providing locations to wash hands, and to eat and smoke in areas separate from where mercury is handled. Changing clothes and showering before leaving work decreases ongoing worker exposure, and the likelihood of contaminating the home environment.

Worker training should include specific information about the health effects of mercury and the need to use proper protective measures and work processes.

Preplacement examinations should be geared to identifying persons with any risk factors for increased sensitivity to mercury, such as renal disease or pregnancy. Periodic urinary mercury levels (spot samples corrected for creatinine) are useful for monitoring exposure to inorganic mercury, and, if levels are high, for triggering review of working conditions. Use of urine monitoring will avoid confusion with exposure from fish, since methylmercury is not excreted in urine (but can be detected in blood).

In order to protect the developing fetus, careful control of mercury exposure is particularly important for women workers of childbearing age, especially pregnant workers. Women who are pregnant, or in the process of con-

ceiving, should also limit environmental exposures to methylmercury by avoiding eating high-mercury-containing fish, such as swordfish, tile fish, shark, and king mackerel. EPA advises keeping daily intake to about one 7-ounce can of tuna per week.

Further Reading

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Mesothelioma

ICD-10 C45

James Leigh

Malignant mesothelioma is a cancer with unique features of etiology, diagnosis, management, and prevention. It most commonly occurs in the pleura, less commonly in the peritoneum, and much more rarely in the pericardium or tunica vaginalis. Nearly all cases are related to asbestos exposure. There has been a dramatic epidemic increase in incidence throughout the world during the past 40 years. Mesothelioma is a disease of long latency, generally 20 to 60 years from first exposure to the time of diagnosis.

Previously considered a rare disease, it is now as common in some countries as kidney cancer, liver cancer, cervical cancer, and uterine cancer. Unlike lung cancer, it is not related to tobacco smoking.

The clinical presentation of the pleural tumor is often a pleural effusion (in 95% of patients), chest pain, and dyspnea (in 40% to 70% of patients). The peritoneal tumor commonly presents with ascites or bowel obstruction. A detailed history of occupational and environmental asbestos exposure is vital to diagnosis. Chest radiography and tomography demonstrates pleural opacity. Tissue diagnosis can be made on pleural or peritoneal fluid cytology or pleural biopsy obtained via needle biopsy, thoracoscopy, or thoracotomy. Peritoneoscopy or laparotomy may be required to obtain tissue in peritoneal mesothelioma.

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Cover photographs by Earl Dotter illustrate airborne, ergonomic, safety, and physical hazards at work, all of which are preventable.

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