**TABLE 472e-1 HEAVY METALS (*CONTINUED*)**

| Main Sources | Metabolism | Toxicity | Diagnosis | Treatment |
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| **Mercury** | | | | |
| Metallic, mercurous, and mercuric mercury ($Hg$, $Hg^{+}$, $Hg^{2+}$) exposures occur in some chemical, metal-processing, electrical-equipment, automotive industries; they are also in thermometers, dental amalgams, batteries.<br>Mercury is dispersed by waste incineration. Environmental bacteria convert inorganic to organic mercury, which then bioconcentrates up the aquatic food chain to contaminate tuna, swordfish, and other pelagic fish. | Elemental mercury (Hg) is not well absorbed; however, it will volatilize into highly absorbable vapor. Inorganic mercury is absorbed through the gut and skin. Organic mercury is well absorbed through inhalation and ingestion. Elemental and organic mercury cross the blood-brain barrier and placenta. Mercury is excreted in urine and feces and has a half-life in blood of ~60 days; however, deposits will remain in the kidney and brain for years. Exposure to mercury stimulates the kidney to produce metallothionein, which provides some detoxification benefit. Mercury binds sulfhydryl groups and interferes with a wide variety of critical enzymatic processes. | Acute inhalation of Hg vapor causes pneumonitis and noncardiogenic pulmonary edema leading to death, CNS symptoms, and polyneuropathy.<br>Chronic high exposure causes CNS toxicity (mercurial *erethism*; see Diagnosis); lower exposures impair renal function, motor speed, memory, coordination.<br>Acute ingestion of inorganic mercury causes gastroenteritis, the nephritic syndrome, or acute renal failure, hypertension, tachycardia, and cardiovascular collapse, with death at a dose of 10–42 mg/kg.<br>Ingestion of organic mercury causes gastroenteritis, arrhythmias, and lesions in the basal ganglia, gray matter, and cerebellum at doses >1.7 mg/kg.<br>High exposure during pregnancy causes derangement of fetal neuronal migration resulting in severe mental retardation.<br>Mild exposures during pregnancy (from fish consumption) are associated with declines in neurobehavioral performance in offspring.<br>Dimethylmercury, a compound only found in research labs, is "supertoxic"—a few drops of exposure via skin absorption or inhaled vapor can cause severe cerebellar degeneration and death. | Chronic exposure to metallic mercury vapor produces a characteristic intention tremor and mercurial *erethism*: excitability, memory loss, insomnia, timidity, and delirium ("mad as a hatter"). On neurobehavioral tests: decreased motor speed, visual scanning, verbal and visual memory, visuomotor coordination.<br>Children exposed to mercury in any form may develop *acrodynia* ("pink disease"): flushing, itching, swelling, tachycardia, hypertension, excessive salivation or perspiration, irritability, weakness, morbilliform rashes, desquamation of palms and soles.<br>Toxicity from elemental or inorganic mercury exposure begins when blood levels >180 nmol/L (3.6 µg/dL) and urine levels >0.7 µmol/L (15 µg/dL). Exposures that ended years ago may result in a >20-µg increase in 24-h urine after a 2-g dose of succimer.<br>Organic mercury exposure is best measured by levels in blood (if recent) or hair (if chronic); CNS toxicity in children may derive from fetal exposures associated with maternal hair Hg >30 nmol/g (6 µg/g). | Treat acute ingestion of mercuric salts with induced emesis or gastric lavage and polythiol resins (to bind mercury in the GI tract). Chelate with dimercaprol (up to 24 mg/kg per day IM in divided doses), DMSA (succimer), or penicillamine, with 5-day courses separated by several days of rest. If renal failure occurs, treat with peritoneal dialysis, hemodialysis, or extracorporeal regional complexing hemodialysis and succimer.<br>Chronic inorganic mercury poisoning is best treated with *N*-acetyl penicillamine. |

***Abbreviations:*** ATPase, adenosine triphosphatase; BPb, blood lead; CDC, Centers for Disease Control and Prevention; CNS, central nervous system; DMSA, dimercaptosuccinic acid; ECG, electrocardiogram; GI, gastrointestinal; ICU, intensive care unit; IQ, intelligence quotient; LFT, liver function tests; OSHA, Occupational Safety and Health Administration; RBC, red blood cell.

residents in parts of Bangladesh and Western India. Contamination was formerly considered only a problem with deep wells; however, the geology of this region allows most residents only a few alternatives for potable drinking water. The combustion of leaded gasoline with resulting contamination of air and soil with *lead oxide* remains a problem in some countries of Central Asia, Southeast Asia, Africa, and the Middle East. Populations living in the Arctic have been shown to have particularly high exposures to *mercury* due to long-range transport patterns that concentrate mercury in the polar regions, as well as the traditional dependence of Arctic peoples on the consumption of fish and other wildlife that bioconcentrate methylmercury.

A few additional metals deserve brief mention but are not covered in Table 472e-1 because of the relative rarity of their being clinically encountered or the uncertainty regarding their potential toxicities. *Aluminum* contributes to the encephalopathy in patients with severe renal disease, who are undergoing dialysis (Chap. 424). High levels of aluminum are found in the neurofibrillary tangles in the cerebral cortex and hippocampus of patients with Alzheimer's disease, as well as in the drinking water and soil of areas with an unusually high incidence of Alzheimer's. The experimental and epidemiologic evidence for the aluminum–Alzheimer's disease link remains relatively weak, however, and it cannot be concluded that aluminum is a causal agent or a contributing factor in neurodegenerative disease. Hexavalent chromium is corrosive and sensitizing. Workers in the chromate and chrome pigment production industries have consistently had a greater risk of lung cancer. The introduction of *cobalt* chloride as a fortifier in beer led to outbreaks of fatal cardiomyopathy among heavy consumers. Occupational exposure (e.g., of miners, dry-battery manufacturers, and arc welders) to *manganese* can cause a parkinsonian syndrome within 1–2 years, including gait disorders; postural instability; a masked, expressionless face; tremor; and psychiatric symptoms. With the introduction of methylcyclopentadienyl manganese tricarbonyl (MMT) as a gasoline additive, there is concern for the toxic potential of environmental manganese exposure. For example, a recent study found a high prevalence of parkinsonian disorders in a community with risks proportionate to estimated manganese exposures emitted by local ferroalloy industries. Epidemiologic studies have also suggested that manganese may interfere with early childhood neurodevelopment in ways similar to that of lead. *Nickel* exposure induces an allergic response, and inhalation of nickel compounds with low aqueous solubility (e.g., nickel subsulfide and nickel oxide) in occupational settings is associated with an increased risk of lung cancer. Overexposure to selenium may cause local irritation of the respiratory system and eyes, gastrointestinal irritation, liver inflammation, loss of hair, depigmentation, and peripheral nerve damage. Workers exposed to certain organic forms of *tin* (particularly trimethyl and triethyl derivatives) have developed psychomotor disturbances, including tremor, convulsions, hallucinations, and psychotic behavior.

*Thallium*, which is a component of some insecticides, metal alloys, and fireworks, is absorbed through the skin as well as by ingestion and inhalation. Severe poisoning follows a single ingested dose of >1 g or >8 mg/kg. Nausea and vomiting, abdominal pain, and hematemesis precede confusion, psychosis, organic brain syndrome, and coma. Thallium is radiopaque. Induced emesis or gastric lavage is indicated within 4–6 h of acute ingestion; Prussian blue prevents absorption and is given orally at 250 mg/kg in divided doses. Unlike other types of metal poisoning, thallium poisoning may be less severe when activated charcoal is used to interrupt its enterohepatic circulation. Other measures include forced diuresis, treatment with potassium chloride (which promotes renal excretion of thallium), and peritoneal dialysis.