Heavy Metal Detoxification

Symptoms of Exposure and Toxicity

There are 35 metals that concern us because of occupational or residential exposure; 23 of these are the heavy elements or “heavy metals”: antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc (Glanze 1996). Small amounts of these elements are common in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chronic toxicity (poisoning). Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer’s disease, Parkinson’s disease, muscular dystrophy, and multiple sclerosis. Allergies are not uncommon, and repeated long-term contact with some metals (or their compounds) may cause cancer (CIS 1999).

For some heavy metals, toxic levels can be just above the background concentrations naturally found in nature. Therefore, it is important to learn about heavy metals and take protective measures against excessive exposure. In most parts of the United States, heavy metal toxicity is an uncommon medical condition; however, it is a clinically significant condition when it does occur. If unrecognized or inappropriately treated, toxicity can result in significant illness and reduced quality of life (Ferner 2001). For persons who suspect that they or someone in their household might have heavy metal toxicity, testing is essential. Appropriate conventional and natural medical procedures may need to be pursued (Dupler 2001).

The association of symptoms indicative of acute toxicity is not difficult to recognize because they are usually severe, rapid in onset, and associated with a known exposure or ingestion (Ferner 2001). Symptoms include: cramping, nausea, and vomiting; pain; sweating; headache; difficulty breathing; impaired cognitive, motor, and language skills; mania; and convulsions. Symptoms of chronic exposure (impaired cognitive, motor, and language skills; learning difficulties; nervousness and emotional instability; and insomnia, nausea, lethargy, and feeling ill) are also easily recognized; however, they are much more difficult to associate with their cause. Symptoms resulting from chronic exposure are very similar to symptoms of other health conditions and often develop slowly over months or even years. Sometimes symptoms of chronic exposure subside; thinking the symptoms are related to something else, people postpone seeking treatment.

Definition of a Heavy Metal

“Heavy metals” are chemical elements with a specific gravity at least 5 times that of water. The specific gravity of water is 1 at 4Â°C (39Â°F). Specific gravity is a measure of density of a given amount of a solid substance when it is compared to an equal amount of water. Some well-known toxic metals with a specific gravity 5 or more times that of water are arsenic (5.7), cadmium (8.65), iron (7.9), lead (11.34), and mercury (13.546) (Lide 1992).

Beneficial Heavy Metals

In small quantities, certain heavy metals are nutritionally essential for a healthy life. Some of these are trace elements (eg, iron, copper, manganese, and zinc). These elements, or some form of them, are commonly found naturally in foodstuffs, fruits and vegetables, and in commercially available multivitamin products (CIS 1999). Diagnostic medical applications include direct injection of gallium during radiological procedures, dosing with chromium in parenteral nutrition mixtures, and the use of lead as a radiation shield around x-ray equipment (Roberts 1999). Heavy metals are also common in industrial applications such as the manufacture of pesticides, batteries, alloys, electroplated metal parts, textile dyes, steel, and so forth (CIS 1999). Many of these products are in our homes and add to quality of life when properly used.

Toxic Heavy Metals

Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Heavy metals may enter the human body via food, water, air, or absorption through the skin in agriculture, manufacturing, pharmaceutical, industrial, or residential settings. Industrial exposure is common in adults. Ingestion is the most common route in children (Roberts 1999). Children may develop toxic levels from normal hand-to-mouth activity (ie, coming in contact with contaminated soil or eating objects that are not food such as dirt or paint chips) (Dupler 2001). Less common routes of exposure include a radiological procedure, inappropriate dosing or monitoring during intravenous (parenteral) nutrition, a broken thermometer (Smith 1997), or a suicide or homicide attempt (Lupton 1985).

As a rule, acute poisoning is more likely to result from inhalation or contact with dust, fumes or vapors, or materials in the workplace. However, lesser levels of contamination may occur in residential settings, particularly in older homes with lead paint or old plumbing (CIS 1999). The Agency for Toxic Substances and Disease Registry (ATSDR) in Atlanta, Georgia (a part of the U.S. Department of Health and Human Services) was established by congressional mandate to perform specific functions concerning adverse human health effects and diminished quality of life associated with exposure to hazardous substances. The ATSDR is responsible for

assessment of waste sites and providing health information concerning hazardous substances, response to emergency release situations, and education and training concerning hazardous substances (ATSDR Mission Statement 2001). In cooperation with the U.S. Environmental Protection Agency, the ATSDR has compiled a Priority List for 2001 called the “Top 20 Hazardous Substances.” The heavy metals arsenic (1), lead (2), mercury (3), and cadmium (7) appear on this list.

Note: The ATSDR provides comprehensive protocols called Medical Management Guidelines for Acute Chemical Exposures in Volume III of the Managing Hazardous Material Incidents Series. These protocols have a Chemical Abstracts Service (CAS) number and give a description of toxic substances; routes of exposure; health effects; prehospital, triage, and emergency medical department care; antidotes and treatment; disposition and follow-up; and reporting instructions. The series may be viewed or downloaded from the ATSDR web site at no cost.

Commonly Encountered Toxic Heavy Metals

As noted earlier, there are 35 metals of concern, with 23 of them called heavy metals. Toxicity can result from any of these metals. This protocol will address the metals most likely encountered in our daily environment. Four metals included in the ATSDR’s “Top 20 Hazardous Substances” list will be covered in this protocol. Iron and aluminum, which do not appear on the ATSDR’s list, will also be discussed.

Arsenic

Arsenic, number 1 on the ATSDR’s “Top 20 List,â€ is the most common cause of acute heavy metal poisoning in adults. Arsenic is released into the environment by the smelting process of copper, zinc, and lead, as well as the manufacturing of chemicals and glasses. Arsine gas is a common byproduct produced by the manufacturing of pesticides that contain arsenic. Arsenic may be also be found in water supplies worldwide, leading to exposure of shellfish, cod, and haddock. Other sources are paints, rat poisoning, fungicides, and wood preservatives. Target organs are the blood, kidneys, and central nervous, digestive, and skin systems (Roberts 1999; ATSDR ToxFAQs for Arsenic).

Lead

Lead is number 2 on the ATSDR’s “Top 20 List.” Lead accounts for most cases of pediatric heavy metal poisoning (Roberts 1999). It is a very soft metal and was used in pipes, drains, and soldering materials for many years. Millions of homes built before 1940 still contain lead (eg, in painted surfaces), leading to chronic exposure from weathering, flaking, chalking, and dust. Every year, industry produces about 2.5 million tons of lead throughout the world. Most of this lead is used for batteries. The remainder is used for cable coverings, plumbing, ammunition, and fuel additives. Other uses include paint pigments and in PVC plastics, x-ray shielding, crystal glass production, and pesticides. Lead targets the bones, brain, blood, kidneys, and thyroid gland (CIS 1999; ATSDR ToxFAQs for Lead).

Mercury

Number 3 on ATSDR’s “Top 20 List” is mercury. Mercury is generated naturally in the environment from degassing of the earth’s crust, from volcanic emissions. It exists in three forms: elemental mercury, organic and inorganic mercury. Mining operations, chloralkali plants, and paper industries are significant producers of mercury (Goyer 1996). Atmospheric mercury is dispersed across the globe by wind and returns to the earth in rainfall, accumulating in aquatic food chains and lake fish (Clarkson 1990). Mercury compounds were added to paint as a fungicide until 1990. These compounds are now banned; however, old paint supplies and surfaces painted with these old supplies still exist. Mercury continues to be used in thermometers, thermostats, and dental amalgam. (Many researchers suspect dental amalgam to be a possible source of mercury toxicity [Omura 1996; O’Brien 2001].) Medicines, such as mercurochrome and merthiolate, are still available. Algaecides and childhood vaccines are also potential sources. Inhalation is the most frequent cause of exposure to mercury. The organic form is readily absorbed in the gastrointestinal tract (90-100%); lesser, but still significant amounts of inorganic mercury are absorbed in the gastrointestinal tract (7-15%). Mercury targets the brain and kidneys (Roberts 1999; ATSDR ToxFAQs for Mercury).

Cadmium

Cadmium, number 7 on ATSDR’s “Top 20 list,” is a byproduct of the mining and smelting of lead and zinc. It is used in nickel-cadmium batteries, PVC plastics, and paint pigments. It can be found in soils because insecticides, fungicides, sludge, and commercial fertilizers that use cadmium are used in agriculture. Cadmium may be found in reservoirs containing shellfish. Cigarettes also contain cadmium. Lesser-known sources of exposure are dental alloys, electroplating, motor oil, and exhaust. Inhalation accounts for 15-50% of absorption through the respiratory system; 2-7% of ingested cadmium is absorbed in the gastrointestinal system. Cadmium targets the liver, placenta, kidneys, lungs, brain, and bones (Roberts 1999; ATSDR ToxFAQs for Cadmium).

Iron

Discussion of iron toxicity in this protocol is limited to ingested or environmental exposure. Iron overload disease (hemochromatosis), an inherited disorder, is discussed in a separate protocol. Iron does not appear on the ATSDR’s “Top 20 List,” but it is a heavy metal of concern, particularly because ingesting dietary iron supplements may acutely poison young children (eg, as few as five to nine 30mg iron tablets for a 30 pound child).

Ingestion accounts for most of the toxic effects of iron because iron is absorbed rapidly in the gastrointestinal tract. The corrosive nature of iron seems to further increase the absorption. Most overdoses appear to be the result of children mistaking red-coated ferrous sulfate tablets or adult multivitamin preparations for candy. Fatalities from overdoses have decreased significantly with the introduction of child-proof packaging. In recent years, blister packaging and the requirement that containers with 250mg or more of iron have child-proof bottle caps have helped reduce accidental ingestion and overdose of iron tablets by children. Other sources of iron include drinking water, iron pipes, and cookware. Iron targets the liver, cardiovascular system, and kidneys (Roberts 1999).

Aluminum

Although aluminum is not a heavy metal (specific gravity of 2.55-2.80), it makes up about 8% of the surface of the earth and is the third most abundant element (ATSDR ToxFAQs for Aluminum). It is readily available for human ingestion through the following sources: food additives, antacids, buffered aspirin, drinking water, automobile exhaust, tobacco smoke, and use of nasal sprays, astringents, antiperspirants, aluminum foil, aluminum cookware, cans, ceramics, and fireworks (ATSDR ToxFAQs for

Aluminum).

About 20 years ago, researchers began to find what they considered to be significant amounts of aluminum in the brain tissue of Alzheimer's patients. Although aluminum was also found in the brain tissue of people without Alzheimer's disease, recommendations to avoid sources of aluminum received widespread public attention. As a result, many organizations and individuals began to dispose of all their aluminum cookware and storage containers, and become wary of other possible sources of aluminum (eg, soda cans, personal care products, and drinking water) (Anon 1993).

However, although there were studies that demonstrate a positive relationship between aluminum in drinking water and Alzheimer's disease, the World Health Organization (WHO) had reservations about a causal relationship because the studies did not account for total aluminum intake from all possible sources (WHO 1998). Although there is no conclusive evidence for or against aluminum as a primary cause for Alzheimer's disease, most researchers agree it is an important factor in dementia and deserves continuing research. Reducing exposure to aluminum is a personal decision. Workers in the automobile manufacturing industry also have concerns about long-term exposure to aluminum (contained in metal working fluids) and the development of degenerative muscular conditions as well as cancer (Brown 1998; Bardin 2000). The ATSDR has compiled a ToxFAQs to answer the most frequently asked health questions about aluminum. Aluminum targets the central nervous system, kidney, and digestive system.

Symptoms of Exposure and Toxicity

Exposure to toxic heavy metals is generally classified as acute, 14 days or less; intermediate, 15-354 days; and chronic, more than 365 days (ATSDR). Additionally, acute toxicity is usually from sudden or unexpected exposure to a high level of the heavy metal (eg, careless handling, inadequate safety precautions, or accidental spill or release of toxic material often in a laboratory, industrial, or transportation setting). Chronic toxicity results from repeated or continuous exposure, leading to an accumulation of the toxic substance in the body. Chronic exposure may result from contaminated food, air, water, or dust; living near a hazardous waste site; spending time in areas with deteriorating lead paint; maternal transfer in the womb; or from participating in hobbies that use lead paint or solder. Chronic exposure may occur in either the home or workplace. Symptoms of chronic toxicity, often similar to many common conditions, may not be easily recognized. Routes of exposure include inhalation, skin or eye contact, and ingestion (ATSDR MMGs and ToxFAQs; Anon 1993; WHO 1998; CIS 1999; Roberts 1999; Dupler 2001; Ferner 2001).

Arsenic

Exposure to arsenic occurs mostly in the workplace, near hazardous waste sites, or in areas with high natural levels. Symptoms of acute arsenic poisoning are sore throat from breathing, red skin at contact point, or severe abdominal pain, vomiting, and diarrhea, often within 1 hour after ingestion. Other symptoms are anorexia, fever, mucosal irritation, and arrhythmia. Cardiovascular changes are often subtle in the early stages, but can progress to cardiovascular collapse.

Chronic or lower levels of exposure can lead to progressive peripheral and central nervous changes, such as sensory changes, numbness and tingling, and muscle tenderness. A typical symptom is a burning sensation ("needles and pins") in hands and feet. Neuropathy (inflammation and wasting of the nerves) is usually gradual and occurs over several years. There may also be excessive darkening of the skin (hyperpigmentation) in areas not exposed to sunlight, excessive formation of skin on the palms and soles (hyperkeratosis), or white bands of arsenic deposits across the bed of the fingernails (usually 4-6 weeks after exposure). Birth defects, liver injury, and malignancy are possible. Arsenic has also been used in homicides and suicides.

Lead

Acute lead exposure is also more likely to occur in the workplace, particularly in manufacturing processes that include the use of lead (eg, where batteries are manufactured or lead is recycled). Even printing ink, gasoline, and fertilizer contain lead. Symptoms include abdominal pain, convulsions, hypertension, kidney dysfunction, loss of appetite, fatigue, and sleeplessness. Other symptoms are hallucinations, headache, numbness, arthritis, and vertigo.

Chronic exposure to lead may result in birth defects, mental retardation, autism, psychosis, allergies, dyslexia, hyperactivity, weight loss, shaky hands, muscular weakness, and paralysis (beginning in the forearms). Children, who are particularly sensitive to lead (absorbing as much as 50% of the ingested dose), are prone to ingesting it because they chew on painted surfaces and eat products not intended for human consumption (eg, hobby paints, cosmetics, hair colorings with lead-based pigments, and playground dirt). In addition to symptoms found in acute lead exposure, symptoms of chronic lead exposure could include allergies, arthritis, autism, colic, hyperactivity, mood swings, nausea, numbness, lack of concentration, seizures, and weight loss.

Mercury

Acute mercury exposure may occur in the mining industry and in the manufacturing of fungicides, thermometers, and thermostats. Liquid mercury, because of its beautiful silver color and unique behavior when spilled, is particularly attractive to children. Children are more likely to undergo acute exposure in the home from ingesting mercury either from a broken thermometer or drinking medicine that contains mercury. Because mercury vapors concentrate at floor level, crawling children are subject to a significant hazard when the mercury is sprinkled throughout the house during religious ceremonies or an accidental spill (Zayas 1996). Mercury spills are difficult to clean up, and mercury may remain undetected in carpeting for some time. Symptoms of acute exposure are cough, sore throat, shortness of breath, abdominal pain, nausea, vomiting, diarrhea, headache, weakness, visual disturbances, tachycardia, hypertension, and a metallic taste in the mouth.

Chronic exposure to mercury may result in permanent damage to the central nervous system (Ewan 1996) and kidneys. Mercury can also cross the placenta from mother to fetus (levels in the fetus are often double those in the mother) and accumulate, resulting in mental retardation, brain damage, cerebral palsy, blindness, seizures, and inability to speak.

Dental amalgam is also suspected as being a possible source of mercury toxicity from chronic exposure. Some physicians suggest that amalgam fillings could be part of the explanation for the explosion of learning problems and autism in children since World War II, a time period corresponding with the introduction and widespread use of mercury amalgam (O'Brien 2001). Studies in both animals and humans have confirmed the presence of mercury from amalgam fillings in tissue specimens, blood, amniotic fluid, and urine (Vimy 1990; Willershausen-Zonnchen 1992; Gebel 1996; Omura 1996; Sallsten 1996; Isacsson 1997). However, according to Dr. Robert M. Anderton of the American Dental Association, "There is no sound scientific evidence supporting a link between amalgam fillings and systemic diseases or chronic illness" (Anderton 2001).

The American Dental Association (ADA) does acknowledge that amalgam contains mercury and reacts with others substances. However, the ADA concludes that amalgam continues to be a safe material (ADA 2009). Researchers reported finding “no significant association of Alzheimer’s disease with the number, surface area, or history of having dental amalgam restoration” and “no statistical significant differences in brain mercury levels between subjects with Alzheimer’s disease and control subjects” (Saxe 1999).

The metallic mercury used by dentists to manufacture dental amalgam is shipped as a hazardous material to dental offices. Although the ADA does not advise removing existing amalgam fillings from teeth, it does support ongoing research to develop new materials that will prove to be as safe as dental amalgam (Anderton 2001). Symptoms of chronic exposure in adults and children could include tremors, anxiety, forgetfulness, emotional instability, insomnia, fatigue, weakness, anorexia, cognitive and motor dysfunction, and kidney damage. People who consume fish more than twice weekly show very high serum levels of mercury.

Cadmium

Acute exposure to cadmium generally occurs in the workplace, particularly in the manufacturing of batteries and color pigments used in paint and plastics, as well as in electroplating and galvanizing processes. Symptoms of acute cadmium exposure are nausea, vomiting, abdominal pain, and difficulty breathing.

Chronic exposure to cadmium can result in chronic obstructive lung disease, kidney disease, and fragile bones. Protect children by carefully storing products containing cadmium, especially nickel-cadmium batteries. Symptoms of chronic exposure could include alopecia, anemia, arthritis, learning disorders, migraines, growth impairment, emphysema, osteoporosis, loss of taste and smell, poor appetite, and cardiovascular disease.

Aluminum

Although aluminum is not a heavy metal, environmental exposure is frequent, leading to concerns about accumulative effects and a possible connection with Alzheimer’s disease (Anon 1993). Acute exposure is more likely in the workplace (eg, unintentional breathing of aluminum-laden dust from manufacturing or metal finishing processes).

Chronic exposure may occur in the workplace from accumulated exposure to low levels of airborne aluminum dust and handling aluminum parts during assembly processes over many years. In the home, we are in constant contact with aluminum in foods and water, cookware and soda cans, and other items with high levels of aluminum (eg, antacids, buffered aspirin, treated drinking water, nasal sprays, toothpaste, and antiperspirants) (Anon 1993; ATSDR ToxFAQs for Aluminum). Citric acid (eg, in orange juice) may increase aluminum levels by its leaching activity.

Aluminum-based coagulants are used in the purification of water. However, the beneficial effects of using aluminum to treat water have been balanced against potential health concerns. Water purification facilities follow a number of approaches to minimize the level in “finished” water (WHO 1998). Symptoms of aluminum toxicity include memory loss, learning difficulty, loss of coordination, disorientation, mental confusion, colic, heartburn, flatulence, and headache.

Laboratory Testing and Diagnosis for the Presence of Heavy Metals

Diagnosing heavy metal toxicity requires observation of presenting symptoms, obtaining a thorough history of potential exposure, and laboratory tests. Routine laboratory tests include blood tests, liver and renal function tests, urinalysis, fecal tests, x-rays, and hair and fingernail analysis. Many of these tests are not routinely performed in a doctor’s office. However, your physician can take blood samples and send them to the appropriate testing laboratory. Chest x-rays are recommended for persons with respiratory symptoms, and abdominal x-rays can detect ingested metals (refer to the ATSDR ToxFAQs for specific information).

Arsenic

Arsenic levels can be measured in blood, urine, hair, and fingernails. Because arsenic clears fairly rapidly from the blood, blood tests are not always useful (Dupler 2001). Therefore, urine tests are the most reliable for arsenic exposure within the past few days; hair and fingernail testing are used to measure exposure over the past several months (ATSDR ToxFAQs for Arsenic). Abdominal x-rays can reveal metallic fragments (Ferner 2001). Note: Hair treatments (including hair dyes) can contaminate hair samples. When testing for any heavy metal, the most accurate results are obtained from hair that has not been chemically treated for at least 2 months.

Lead

When there are presenting symptoms of lead toxicity, blood testing is done. Blood lead levels in children higher than 10 Âµg/dL are considered to be of concern (Ferner 2001; ATSDR ToxFAQs for Lead). Symptoms in adults may not appear until blood lead levels exceed 80 Âµg/dL (Dupler 2001). However, medical treatment is usually necessary in children with levels of 45 Âµg/dL. Significantly lower levels of 30 Âµg/dL in children can cause mental retardation or cognitive and behavioral problems (ATSDR ToxFAQs for Lead). A complete blood count (CBC) is also done to check for abnormalities on red blood cells (basophilic stippling). In children, long-bone x-rays may reveal bands called “lead lines” that indicate failure of the bone to rebuild. These bands are not actual lead concentrations, but bone abnormalities. Adults do not have lead lines. X-rays of the abdomen can reveal swallowed objects, such as paint chips, fishing sinkers, curtain weights, or bullets (Ferner 2001). A less common test is measurement of lead in teeth (ATSDR ToxFAQs for Lead). All children with brain-related symptoms should be considered for lead toxicity (Ferner 2001).

Mercury

A 24-hour urine specimen is collected for measurement of mercury levels. Chest x-rays can reveal a collection of mercury from exposure to elemental mercury or a pulmonary embolism containing mercury (Ferner 2001). Abdominal x-rays can reveal swallowed mercury as it moves through the gastrointestinal tract. Blood and urine samples are used to determine recent exposure, as well as exposure to elemental and inorganic forms of mercury. Scalp hair is used to test for exposure to methylmercury. Liver and kidney function tests are also important in severely exposed persons. Blood mercury levels should not exceed 50 Âµg/L (see the ATSDR Medical Management Guidelines).

Cadmium