

Sources and Effect of Mercury on Human Health

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ABSTRACT

One of the common environmental pollutants that naturally exists on Earth as a result of volcanic eruptions and soil erosion is mercury. Additionally, a variety of human activities, such as the burning of coal in power plants, the smelting of zinc, the artisanal gold mining industry, etc., emit this environmental contaminant. Mercury can be found in various forms, including elemental, organic, and inorganic, and when consumed or administered, it can have a variety of negative health impacts. Mercury can be found in a variety of places, including soil, fish (such as swordfish and shellfish), and more. The mercury is bioaccumulated by the fish through its consumption of planktons and smaller fish. Because of various anthropogenic activities, there is mercury in the soil, which is then absorbed by the rice that is planted there. People who work in dental clinics, in companies that produce pesticides and insecticides, and in alkaline alkali factories are exposed to mercury. When consumed directly, the element is non-toxic; nevertheless, inhaling its vapor or agitated form makes it hazardous. It damages the brain system, liver, kidneys, and lungs. It is very harmful to children's central and peripheral nervous systems. Fetuses are exposed to mercury through placental blood, and nursing newborns also experience serious side effects since they receive mercury through their mothers' milk. This review provides an overview of mercury's physico-chemical

characteristics. In our environment, it draws attention to the various visible and unseen sources of mercury. It explains mercury's pharmacokinetic and pharmacodynamic effects. It also has hazardous impact on humans at all ages.

Keywords: *Mercury, Bioaccumulated, Environmental pollutants, Health Impacts, Pharmacokinetics.*

1. INTRODUCTION

Mercury, a toxic heavy metal, has caused substantial public health catastrophes in Iraq [Afriza, et.al 2013, Bjørklund, et.al 2017] and Minamata Bay, Japan [N.R., et.al 2013]. The therapeutic implications of reduced mercury exposure continue to be a topic of active discussion. Methyl, ethyl, phenyl, and similar groups represent inorganic mercury, which includes metallic mercury, mercury vapor (Hg_0), and mercurous ($\text{Hg}_{2^{++}}$) or mercuric (Hg^{++}) salts. Inorganic mercury includes substances in which mercury is chemically linked to carbon-containing structures. The chemical structure affects the pharmacokinetics, clinical significance, and biological behavior of different mercury forms. The many types of mercury undergo interconversion within a living organism. Inhaled elemental mercury vapor is effectively absorbed through the lungs and mucous membranes and is promptly oxidized into different forms; nonetheless, this process is insufficiently swift to avert significant accumulation of elemental mercury in the brain. Methyl mercury is readily absorbed through the gastrointestinal system and accumulates in diverse tissues; nevertheless, its capacity to traverse the blood-brain barrier is inferior to that of elemental mercury. It progressively demethylates to elemental mercury upon entering the brain [UNEP, Global Mercury Assessment, 2013]. Mercury salts are generally distinguished by low absorption, insolubility, and significant stability. The specific type of mercury, dosage, and exposure rate substantially affect human toxicity. Inhalation of mercury vapor predominantly impacts the brain as the principal organ impacted. Methyl mercury is disseminated throughout the body, while mercuric and mercurous chemicals markedly impair the neurological

system and gastrointestinal function (UNEP, Global Mercury Assessment, 2013). Acute exposure to vital mercury vapor can lead to severe pneumonitis, perhaps resulting in death in extreme instances (UNEP, Global Mercury Assessment, 2013). The concentration of toxins differs among various lozenges. Chronic low-level exposure to elemental or other forms of mercury leads to less pronounced symptoms and clinical manifestations, as elaborated below. There is contention on the methodologies for clinical assessment of mercury exposure, as well as substantial debate concerning the clinical implications of exposure to different types of mercury. This research intends to examine the existing data on these motifs and assess the clinical experience with DMPS for the extraction of mercury from the human body.

2. SOURCES OF MERCURY EXPOSURE

The World Health Organization notes that substantial exposure to mercury generally occurs in occupational environments, through the intake of contaminated fish, or via the release of mercury from dental amalgams (Bjørklund et al. 2018, Zulaikhah et.al 2015). The Earth's crust contains about 0.5 parts per million of mercury, mainly found in its elemental state or as sulfides. Stormy activity and gemstone outgassing result in atmospheric exposures. Coal combustion and mining activities, especially those associated with gold and mercury extraction, represent major contributors to atmospheric mercury levels. Atmospheric mercury, when deposited in aquatic environments, is transformed by bacteria into organic forms such as methyl or ethyl mercury. These organic compounds are then taken up by smaller organisms and subsequently ingested by larger fish. Mercury concentrations can accumulate in the tissues of apex predator fish, including marlin, swordfish, and tuna. Human exposure to mercury mainly occurs via the ingestion of organic mercury compounds, such as methyl, dimethyl, or ethyl mercury, primarily sourced from seafood, or through the inhalation of elemental mercury vapor from dental amalgams or occupational environments. The World Health Organization (Bjørklund. et al. 2018, Zulaikhah et.al 2015) and Berglund et al. (Genchi et.al 2017) report that human

exposure to metallic mercury arises from the outgassing of mercury vapor from blend paddings, potentially attaining levels of 2 to 28 micrograms per hand face per day, with an absorption rate of approximately 80%. Mercury is recognized as an infrequent source of mercury vapor (Kretsinger et.al 2013). A documented case of idiopathic thrombocytopenic purpura has been attributed to the vacuuming of exposed mercury, resulting in significant acute exposure to mercury vapor. The primary natural sources of methyl and dimethyl mercury (organic mercury) are freshwater and saltwater fish.

3. PHARMACOKINETICS OF MERCURY EXPOSURE

3.1. Inorganic Mercury

3.1.1 Elemental mercury, also referred to as metallic mercury (Hg_0). In comparison to the 7–10% absorption of ingested metallic mercury and the 1% absorption via skin contact, approximately 80% of metallic mercury vapor released from emulsions is absorbed through inhalation. Mercury vapor demonstrates a significant affinity for sulfhydryl groups upon entering the body, resulting in the formation of bonds with sulfur-containing amino acids within the organism. Mercury vapor is conveyed to the brain either in a dissolved state within serum or attached to red cell membranes (Damin. et.al 2009). Metallic mercury readily crosses the placenta and infiltrates the fetal brain after passing through the blood-brain barrier (Houston. et.al 2007, Counter et.al 2004). Upon entering the bloodstream, metallic mercury swiftly oxidizes to form mercuric mercury [UNEP, Global Mercury Assessment, 2013]. Nonetheless, the rate of oxidation is inadequate to avert considerable absorption by the central nervous system while the substance remains in its metallic state. Organ dysfunction may be associated with metallic mercury, which is present in multiple tissues such as the thyroid, bone, myocardium, muscles, adrenal glands, liver, feathers, skin, sweat glands, pancreas, enterocytes, lungs, salivary glands, testes, and prostate. Mercury preferentially interacts with sulfhydryl groups, affecting T cell activity and the binding sites on T cell surfaces. Mercury is present in bone milk and accumulates in the tissues of both the fetus and placenta. Mercuric mercury is the primary form of metallic mercury excreted. The excretory

half-lives of metallic and mercuric mercury differ considerably depending on the organ of deposition and redox state, spanning from a few days to several months, with specific pools like the central nervous system demonstrating half-lives that can exceed several years. No correlation is observed between the concentrations of metallic mercury in the brain and those in hair [UNEP, Global Mercury Assessment, 2013]. The accurate assessment of body burden presents challenges due to these complications.

3.1.2 Mercury in its ionic form (Hg^{2++}). Hg_2Cl_2 (calomel), a mercury salt, demonstrates low solubility in water and exhibits minimal absorption in the gastrointestinal tract, although it is believed that some may oxidize into more bioavailable forms. In addition to serving as an intermediary between metallic and mercuric mercury, the persistence of mercurous mercury in the body seems unlikely [UNEP, Global Mercury Assessment, 2013]. The correlation between calomel and acrodynia, or pink illness, suggests the occurrence of absorption.

3.1.3 Mercuric chloride (HgCl_2), previously employed as a preservative and in photographic processes, can be ingested accidentally or intentionally. Initially, around 2% of the substance is absorbed; however, prolonged exposure may increase absorption due to its corrosive effects on the intestine. Mercuric mercury has limited ability to cross the blood-brain barrier; nonetheless, it can accumulate in the placenta, fetal tissues, and brain through specific transport mechanisms. In the bloodstream, it interacts with proteins such as glutathione and metallothionein. It generally accumulates in the liver, kidneys, and other organs. Excretion occurs via multiple pathways, including urine, feces, sweat, tears, breast milk, and saliva. The half-life of most oral doses of mercuric mercury is 42 days; however, some may remain in the body for prolonged durations.

3.2. Organic Mercury Compounds

Humans predominantly encounter organic mercury compounds, especially methyl mercury, via fish consumption. Methyl mercury demonstrates stability and is readily absorbed

via the skin, lungs, and intestines. It is present throughout the body, with significant concentrations observed in the brain, liver, kidneys, placenta, and fetus. It interacts with sulfhydryl groups, particularly in cysteine. Over a span of 70 days, the body methodically converts methyl mercury into inorganic mercury, with around 90% excreted via feces. Hair mercury reflects recent blood concentrations, with a minor quantity excreted in breast milk. Although ethyl mercury has a shorter excretory half-life, it demonstrates similar behavior. Dimethyl mercury is easily absorbed through the skin and presents considerable health hazards; even slight exposure can lead to lethal consequences.

4. THE EFFECTS OF MERCURY ON HEALTH

Exposure to mercury can result in considerable negative health outcomes, especially related to chemical compounds like methyl mercury. Methyl mercury can enter the body through ingestion, dermal exposure, or inhalation, and it accumulates in fish. Upon absorption, it interacts with protein sulfhydryl groups, thereby disrupting cellular processes and leading to adverse effects. The condition predominantly affects the nervous system, particularly in fetuses and young children, who are more vulnerable and may exhibit symptoms such as developmental delays, cognitive impairments, and motor deficits. Extended exposure may result in symptoms including memory impairment, tremors, and sensory disturbances. Mercury accumulates in the brain, liver, kidneys, and placenta. Inorganic mercury, derived from methyl mercury, may negatively impact kidney function over time. Prenatal exposure raises concerns due to its potential to induce brain impairment and developmental deficiencies in the fetus. Occupational exposure may result in mercury poisoning, particularly in sectors that employ mercury or its compounds. Acute exposure, even with limited contact, especially to dimethyl mercury, can result in fatal outcomes. Repeated exposure to mercury through contaminated food, water, or air may result in long-term health effects, including impairment of the immune and cardiovascular systems. Regular assessment of mercury concentrations in vulnerable populations is crucial for effective prevention.

5. CONCLUSION

Mercury accumulation in essential organs, including the brain, liver, kidneys, and placenta, is associated with significant health risks. The brain is susceptible to considerable cognitive impairments, motor challenges, and enduring neurological harm. The accumulation of mercury in the kidneys and liver poses significant risks to these organs; inorganic mercury, derived from methyl mercury, is especially responsible for long-term kidney damage. Mercury exposure during pregnancy poses significant risks, as it can lead to enduring neurological and developmental issues that impact fetal growth and brain function. Mercury poisoning poses a significant risk to workers in sectors such as mining, manufacturing, and healthcare that handle mercury or its derivatives. Acute exposure can be fatal even at low doses, particularly for highly toxic substances such as dimethyl mercury. Prolonged or recurrent exposure for workers may lead to chronic health issues, including irreversible damage to internal organs and the nervous system. Chronic exposure to mercury from contaminated food, water, or air can adversely affect brain development, cardiovascular health, and vulnerable systems in patients. Comprehensive monitoring of mercury exposure in high-risk populations is essential for effective management, alongside the implementation of strict regulations and measures to mitigate exposure. Mitigating the adverse impacts of mercury on public health necessitates safeguarding at-risk groups, including pregnant women and healthcare workers.

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