Xournals

Academic Journal of Chemical Sciences

ISSN UA | Volume 01 | Issue 01 | June-2018

Impact of Mercury on Human Health

Umakant Yadav[1]

Available online at: www.xournals.com

Received 4rth February 2018 | Revised 2nd May 2018 | Accepted 26th May 2018

Abstract:

Mercury exist naturally and it is an environmental contaminant that exposed humans, this exposure is more common than expected. In the amount of atmospheric mercury, release of processed mercury can lead to a progressive increase that enters the atmospheric-soil-water distribution cycles. Mercury poisoning is the result of exposure to mercury or mercury compounds that give result in various toxic effects which is depend on its chemical form and route of exposure. It is widely used in human activities and exposure of this metal from both artificial and natural sources is significantly increasing. High exposure to mercury induce changes in central nervous system, cardiovascular system, renal system, immune system, which give possible result in irritability, fatigue, behavioral changes, tremors, headaches, dysarthria, incoordination, hallucinations, hypertension in human and animals that has wide-ranging consequences, including alterations in endothelial function. This review paper, indicate the mercury exposure, effects of mercury on human health including endothelial and cardiovascular function, central nervous system.

Keywords: *Mercury, Endothelial and Cardiovascular Function, Central Nervous System*

Authors:

1. *Centre for Chemical and Pharmaceutical Science, Bathinda, Punjab, INDIA*

Introduction

Mercury is a heavy metal of known toxicity that is noted for public health disaster. It exists in several forms that is inorganic mercury (Hg0) and mercurous (Hg2++) or mercuric (Hg++) salts; and organic mercury, which includes compounds in which mercury is bonded to a structure containing carbon atoms (methyl, ethyl, phenyl, or similar groups). The various forms of mercury contain chemical structure in biological behavior, pharmacokinetics and clinical significance. The human health is affected by the exposure to mercury, while changes resulting from human exposure to mercury called the attention of scientific society.

Mercury is the third ranked by US Government Agency for Toxic Substances and Disease Registry of the most toxic elements and substances on the planet to arsenic and lead that continues to be dumped into water-soil, spoiled into atmosphere and consumed into food and water. By increasing 1.5% of mercury per year, human activities have triple the amount of mercury in atmosphere.

Below this figure represent the multiple routes through which humans are exposed to mercury.

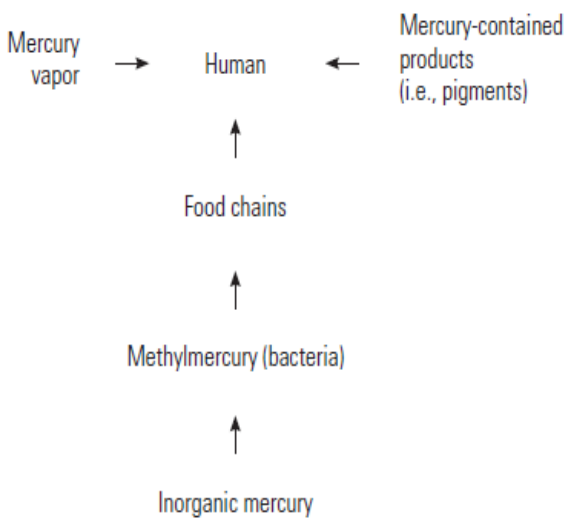

Figure 1: Route of Mercury Exposure in Humans

Environmental mercury can exist in its elemental form that is inorganic and organic mercury. Mercury exist as liquid form in its elemental form, which is spite of its low vapor (2 μm Hg), can be converted to a vapor at room temperature due to its low latent heat of evaporation and its relative absence from ambient air. From mercury vaporization or burning of mercury, toxic vapors are formed that containing materials can enter the respiratory system and pass readily into circulation.

Mercury Characteristics

At normal temperature and pressure, mercury is characterized as a highly malleable liquid. Mercury is mainly classified into three groups: elemental mercury, inorganic mercury and organic mercury. Mercury exists in several forms: inorganic mercury in which there have metallic mercury and mercury vapor and mercurous mercury (Hg+) or mercuric mercury (Hg++) salts; organic mercury also called organometallic that result from a covalent bond between mercury and a carbon atom of an organic functional group such as a methyl, ethyl, or phenyl group.

Inorganic Mercury Compound

Elemental Mercury or Metallic Mercury Compounds: Elemental mercury is poorly absorbed and presents little health risk in its liquid form but in vapor form, metallic mercury is readily absorbed through lungs and can produce body damage. Elemental mercury is highly diffusible and is able to pass through blood-brain as well as cell membranes and placental barriers to reach target organs because of its soluble characteristics. Mercury undergoes catalase and peroxidase-mediated oxidation in red blood cells and tissues in bloodstream and it is transformed into inorganic mercuric mercury and mercurous mercury that process limits is absorption. Inorganic mercury has low lipophilicity and a limited ability to cross cell membrane. Elementary mercury is used in sphygmomanometers and thermometers because of its uniform volumetric expansion, high surface tension and lack of vitreous adherence to surfaces. Metallic mercury are allow to be used to low electrical resistance and high thermal conductivity in electrical and electronic materials. Metallic mercury is used in electrochemical operations in chlorine and soda industries because of its high oxidation power.

Mercurous Mercury and Mercuric Mercury Compounds: Mercurous mercury is little absorbed in body that is in the form of mercurous chloride. The form of metallic mercury is changed into elementary mercury and mercuric mercury in the human body. Mercuric mercury is the combination of mercury with chlorine, sulfur or oxygen. Mercuric mercury can be found in different form such as mercuric chloride (HgCl2), that is highly toxic and corrosive; mercury sulfide (HgS), that is frequently used as a pigment in paints due to its red color; mercury fulminate (Hg(CNO)2), that is used as an explosive detonator. This compounds are used as a preservative for development of photographic film and it is ingested accidentally or as a suicidal purpose. Mercuric mercury is bind to the sulfhydryl groups or

erythrocytes, glutathione or metallothionein in blood stream and is transported suspended in plasma. Mercuric mercury accumulates in placenta, fetal tissues and amniotic fluid but it does not cross the blood brain barrier efficiently.

Organic Mercury

It is also called organometallic that give the result from a covalent bond between mercury and carbon atom of an organic functional group such as methyl, ethyl, or phenyl group. Methyl mercury reacts with sulfhydryl groups throughout the body, therefore potentially interfering with the function of any cellular or subcellular structure. Mercury is believed to interfere with DNA transcription and protein synthesis that included the protein synthesis in the developing brain with destruction of endoplasmic reticulum and disappearance of ribosomes. It is associated with reduction in Natural Killer cell activity as well as an imbalance in Th2:Th1 ratios favoring autoimmunity.

Effect on Central Nervous System

In the mercury compound, methyl mercury is primarily responsible for the neurological alterations present in humans and animals. Its mechanisms are related to toxic increase in reactive oxygen species (ROS). Injuries are caused by methyl mercury in central nervous system that are related to its ability to increase reactive oxygen species. Mercury's effect in nervous system is interference with the production of energy which can impair cellular detoxification processes causing the cell to either die or live in state of chronic malnutrition. Mercury is linked with increased tissue oxidative damage, and children with autism had significantly higher urinary levels of lipid peroxidation when compared to controls. Mercury can damage the blood brain barrier and it facilitates penetration of brain by other toxic metals and substance in central nervous system. The effect of mercury on central nervous system causes symptoms including depression, paranoia, extreme irritability, hallucinations, an inability to concentrate, memory loss, tremors of the hands, head, lips, tongue, jaw and eyelids, weight loss, perpetually low body temperature, drowsiness, headaches, insomnia, and fatigue. Mercury also causes various effects on other sensory systems including blindness, retinopathy, optic neuropathy, hearing loss, a reduced sense of smell, and abnormal touch sensation.

Effect on Cardiovascular System

Effect of mercury mainly associated with the central nervous system but inorganic mercury also produces profound cardiotoxicity. Prenatal exposure to methyl mercury may affect development of cardiovascular homoeostasis, in children with lower birth weight, systolic and diastolic blood pressure, increase 13.9mm Hg when cord blood mercury concentration increase from 1 to 10µg/l cord blood. Mercury exposure correlate with increased risk of hypertension, myocardial infarction coronary dysfunction and atherosclerosis. Oxidized low-density lipoprotein (LDL) have the levels of mercury levels. It is frequently found in atherosclerotic lesions that are linked with development of atherosclerotic disease and acute coronary insufficiency. Through the inactivation of "paraoxonase", toxic mercury effect on cardiovascular system, an enzyme that slows the LDL oxidation process and that has an important antiatherosclerotic action. Toxic effect of mercury produce on cardiovascular system that is not fully elucidated but this mechanism believed to involve an increase in oxidative stress. Exposure to mercury increases the production of free radicals, potentially because of the role of mercury in the Fenton reaction [111–113] and a reduction in the activity of antioxidant enzymes, such as glutathione peroxidase.

Effect on Renal System

Mercury level is more accumulate in kidney compare to brain and liver. Nuclear factor κB (NF-κB) is a thiol-dependent transcriptional factor that helps cell survival and protects cells from apoptotic incentives. Mercuric ion Hg is known one of the strongest thiol-binding agents that impairs NF-κB activation and DNA binding at low µM concentrations in kidney epithelial cells leading to apoptosis. In this, increase the plasma creatinine level upon methyl mercury intoxication for 5ppm mercury by renal dysfunction. By using mercury, causes to damage kidney and suggests a linkage between mercury exposure and acute tubular necrosis, glomerulonephritis, chronic renal disease, renal cancer and nephrotic syndrome. Mercury exposure can lead to various kidney injuries including: subacute-onset nephrotic syndrome, tubular dysfunction, secondary focal segmental glomerulosclerosis, syncreticatic nephrotic syndrome, nephritic syndrome, nephrotic-range proteinuria, glomerular disease, and membranous glomerulonephritis.

Effect on Immune System

By failure of immune system, chronic infectious diseases are not caused but are a conscious variation of the immune system to an otherwise lethal heavy metal environment". Immune system function is damaged by mercury that is most likely its deleterious effects on the polymorphonuclear leukocytes (PMNs). Mercury through destruction of adrenocorticosteroids production prevents normal stimulation of PMNs production and also affects PMN function by

inhibiting their ability to destroy foreign substances. Allergies, asthma, and autoimmune-like symptoms are developed by mercury, especially rheumatoid. In central nervous system, mercury can produce an immune response and induce alteration in immune cell production and function. Increased levels of mercury by ingestion of mercury with yeasts, bacteria and molds which are thought to function in a protective manner to absorb excess mercury body. Mercury effects on immune system of human body that includes allergic disease, amyotrophic lateral sclerosis, arthritis, autoimmune thyroiditis, autism/attention deficit hyperactivity disorder, eczema, epilepsy, psoriasis, multiple sclerosis, rheumatoid arthritis, schizophrenia, scleroderma, and systemic lupus erythematosus.

Effect on Reproduction

In case of concentration of methyl mercury is very high in mothers, they do not conceive but in case of low concentration of methyl mercury, they have low rate of pregnancy the foetus is aborted or is stillborn. At even lower doses conception and live birth occurred but child suffered from serious neurological symptoms. In case of male, mercury have adverse effects on spermatogenesis, epididymal sperm count, and testicular weight. But in case of female, toxic mercury inhibit the release of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) from the anterior pituitary that effect estrogen and progesterone levels leading to ovarial dysfunction, painful or irregular menstruation, premature menopause, and tipped uterus.

Review of Literature

Langworthl et al. (1997), concluded that exposure of mercury vapor in dentistry can reach at high levels. Reduce the exposure of mercury by improving technical equipment and better standards of hygiene. Completed the health screening program by participants in which including analysis of mercury in urine. The U-Hg levels were particularly related to hours of practice, number of amalgam restoration placed, method of amalgam preparation and application, type of amalgam capsules used and type of cooling and heating system. By mercury exposure, induce the adverse health effects in dentistry.

Hyman (2004), dictated that population cannot effectively excrete mercury and is at greater risk than general population and that this susceptibility is likely due to genetic differences, diet, exposure to other toxicants, antibiotics etc. According to this paper, mercury is a risk factor in many diseases but can be measured safely and body detoxified, mitigating some of its effects.

Bridges and Zalups (2010), concluded that mercuric ions are transported to various organ system and tissues. In various organs and tissues, involvement of amino acid, anion and drug transporters in uptake and secretion of mercuric ions. Intestinal absorption of Hg^{2+} and CH_3Hg^{+} occurs, the exact mechanisms involved in the uptake and secretion of mercuric ions by enterocytes have not been identified.

Stow et al. (2011), in arctic, exposure of mercury at current levels have adverse impacts on human health, mainly developing in fetus and children and required the further research to determine the subtle effects of mercury on human health that are persistent. In arctic population, needed to relationship between mercury and cardiovascular disease in further research.

Houston (2011), concluded that mercury induces the mitochondrial dysfunction with reduction in ATP, depletion of glutathione and increase lipid peroxidation. Oxidative stress and decrease oxidative defense are common. Mercury effects on vascular that contain some symptoms including oxidative stress and inflammation, reduction in oxidative defense, thrombosis, vascular smooth muscle dysfunction, endothelial dysfunction, dyslipidemia, and immune and mitochondrial dysfunction. The clinical consequence of mercury including hypertension, CHD, MI, cardiac arrhythmias, sudden death, reduced heart rate variability, increased carotid IMT and carotid artery obstruction, CVA, generalized atherosclerosis, and renal dysfunction, insufficiency, and proteinuria.

Nabi (2014), concluded that pathways of mercury by means of air, food, water, pharmaceuticals, cosmetics etc. that are impact on human health and aspects like biomagnification of mercury along the food chain ambiguous the problem. By several studies, effect of toxic mercury as industrial health danger for goldminers, chloralkali workers and dental personnel.

Rice (2014), concluded that earliest record of China, in which “Mad Hatter disease” was occurred by the effect of mercury toxicity due to which several people was lost. But in Japan “Minamata disease” was occurred that was spread by the mercury and so many people was lost.

Conclusion

Mercury plays an important role in various numerous organ system and tissues of human. Increasing the effects of mercury on human health over the years by evaluation of epidemiological consequences. Mercury effects contain the pathways due to which toxicity effects are occurred such as air, food, water, pharmaceuticals and cosmetics etc. The systemic

effects of mercury on cardiovascular, renal system, central nervous system, reproduction and immune system of human health due to which some symptoms are seen such as irritability, fatigue, behavioral changes, tremors, headaches, dysarthria, incoordination, hallucinations, hypertension. In case of low dose of mercury, toxicity effect is less and safety precaution is not taken generally.

References:

"What is the Impact of Mercury Contamination on Human Health in the Arctic?" Available at: https://www.amap.no/documents/download/173

Azevedo, Bruna Fernandes, *et al.* "Toxic Effects of Mercury on the Cardiovascular and Central Nervous Systems." *Journal of Biomedicine & Biotechnology*, July 2012, pp. 1–11.

Bernhoft, Robin A. "Mercury Toxicity and Treatment: A Review of the Literature." *Journal of Environmental and Public Health*, vol. 2012, 2012, pp. 1–10.

Bridges, Christy C., and Rudolfs K. Zalups. "Transport of Inorganic Mercury and Methylmercury in Target Tissues and Organs." *Journal of Toxicology and Environmental Health*, Part B, vol. 13, no. 5, June 2010, pp. 385–410.

Genchi, Giuseppe, *et al.* "Mercury Exposure and Heart Diseases." *International Journal of Environmental Research and Public Health*, vol. 14, no. 1, Dec. 2017, p. 74.

Houston, Mark C. "Role of Mercury Toxicity in Hypertension, Cardiovascular Disease, and Stroke." *The Journal of Clinical Hypertension*, vol. 13, no. 8, Nov. 2011, pp. 621–627.

Hyman, Mark. "The Impact of Mercury on Human Health and the Environment." *Alternative Therapies*, vol. 10, no. 6, 2004.

Langworth, S., *et al.* "Exposure to Mercury Vapor and Impact on Health in the Dental Profession in Sweden." *Journal of Dental Research*, vol. 76, no. 7, 1997, pp. 1397–1404.

Nabi, Shabnum. "Methylmercury Cycle and Its Implications on Human Health." *Bulletin of Environment, Pharmacology and Life Sciences*, 3 (6), 2014, pp. 272–285.

Rice, Kevin M., *et al.* "Environmental Mercury and Its Toxic Effects." *Journal of Preventive Medicine & Public Health*, 2014, pp. 74–83.

Zahir, Farhana, *et al.* "Low Dose Mercury Toxicity and Human Health." *Environmental Toxicology and Pharmacology*, vol. 20, no. 2, 2005, pp. 351–360.