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Mercury: The Lurking Danger

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ABSTRACT

Industrial revolution has changed the face of the world forever, but it has also brought environmental pollution as a byproduct, which has increasingly become a burden on mankind. Mercury pollution is one such major area of concern. Mercury toxicity first came to public attention by way of the Minamata and Iraqi tragedies. Over a period of time, information about the toxicity of low dose chronic mercury exposure began trickling in. This assumes great importance in view of the easy access of the toxicant to man through food, water, air, cosmetic products, and even vaccines. Besides this, it is a well known occupational hazard for dental staff, chloralkali factory workers, gold miners, etc. Mercury is now suspected to be a causative agent of numerous disorders involving neurological, psychological, nephrological, immunological, cardiac, and reproductive systems. It is therefore imperative that stringent measures be taken to prevent these disorders that could result from mercury exposure.

Keywords: Mercury, Methyl mercury, Chronic toxic exposure, Fish consumption

Drug Index Terms

Mercury - Drug Toxicity

Medical Index Terms

Mercurialism - Etiology; Industry; Pollution; Long Term Exposure; Environmental Exposure; Occupational Hazard; Dentist; Industrial Worker; Neurologic Disease - Etiology; Mental Disease -

Etiology; Kidney Disease - Etiology; Immunopathology - Etiology; Heart Disease - Etiology; Genital System Disease - Etiology; Human; Article

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Introduction

Irresponsible spilling of industrial waste into the sea was the main cause of the Minamata tragedy, which brought mercury starkly under the spotlight. This incident created panic about the toxicant among the lay public, and also of course among scientists. A number of studies were carried out subsequently, but over a period of time, the interest gradually faded. This is unfortunate because mercury is still a significant threat; it is omnipresent in the environment. The multiple pathways of mercury through air, water, food, vaccines, cosmetic products, etc., pose a serious concern, because it persists in the environment, and accumulates in the food chain[1-5]. This has serious implications with human beings at the top of the food chain getting the brunt of the toxicity owing to biomagnification. Recent research has clearly demonstrated significant adverse health effects even from low doses of mercury.

The toxicity of mercury

There are numerous studies documenting the disorders that result from exposure to mercury, ranging from neurological disorders to psychological, cardiac, immunological, hematological, nephrological and even reproductive damage. The unborn fetus, infants, and women are the most susceptible to mercury toxicity.

1. Effects of mercury on the nervous system

Inorganic mercuric salts such as mercuric chloride mainly affect the renal and gastrointestinal systems. Neurological symptoms include fine tremor, usually of hands and fingers, ataxia, and mental changes. Organic mercurial compounds are more likely to cause neurological disorders resulting in ataxia, dysarthria, paresthesia, and disturbed vision[6]. On studying the long term effects of methyl mercury exposure it was found that brain weights of subjects exposed to mercury were reduced by 80-200 g as compared to controls, implying that methyl mercury promotes single cell necrosis, resulting in thinning out of the brain cortex[7]. Recent studies have indicated that mercury plays an important contributory role in the development of various neurodegenerative diseases. Mercury blocks cellular sulfhydryl groups, causing the impairment of sulphur oxidation at cellular levels[8]. This is said to be characteristic of many chronic neurodegenerative disorders including Parkinson's disease, Alzheimer's disease, amyotrophic lateral sclerosis, lupus erythematosis, rheumatoid arthritis, and autism[9]. Mercury also blocks the immune function of manganese and zinc whose deficiencies cause serious significant neurological deficits[10].

Despite the multiple benefits of regular fish consumption, it remains a major source of mercury exposure to man. In a recent study conducted on fish eaters in the USA, it was found that fish

consumers performed poorly on tests requiring cognitive flexibility, word naming, mandatory recall, and more complex motor tests[11]. In another survey of a population on the Coast of Shiranui Sea, Japan, many fish consumers demonstrated low hair Hg levels (<10 ppm), and yet were found to be suffering from various neurological symptoms, particularly sensory disturbances of glove and stocking type[12]. In a study of adult population of Amazonian ecosystem with hair Hg below 50 micrograms/g, near visual contrast sensitivity and manual dexterity decreased significantly in dose dependent manner, and there was a tendency for increased muscular fatigue and decreased muscular strength among women[13]. Investigators studying the long-term effects of low dose exposure of mercury noticed hypoesthesia, ataxia, dysarthria, impairment of hearing, and visual changes in a study group ten years after methyl mercury exposure had ceased[14]. Mercury exposed workers of a chloralkali plant showed lower levels of performance for finger dexterity, tapping, and aiming, corresponding to increasing exposure[15]. Clear deficits in short-term auditory memory have been reported with repeated occupational exposure to mercury[16].

As far as the effects of mercury exposure in pregnancy is concerned, it has been observed that if the concentration of methyl mercury is very high in mothers they do not conceive; and even if they do, the fetus is usually aborted or stillborn. At even lower doses, conception and live birth occurred, but the child often suffered from serious neurological symptoms. Studies indicate that the difference in sensitivity between fetus and adult human is between 2 and 5, with fetus being more susceptible to methyl mercury toxicity[17]. Elemental mercury also crosses the placenta and causes human fetal toxicity. Methyl mercury has been demonstrated in mother's milk in cases of long term exposure. Neuropathological examination of brains of children prenatally exposed to organic mercury reveals dysplasia of cerebral and cerebellar cortices, neuronal ectopia, and several other developmental disturbances[18].

Maternal hair and cord blood concentrations are considered good biomarkers for mercury exposure to fetus. Peak maternal hair mercury concentration of 165-320 ppm has been correlated for neurological deficits in infants including varying degrees of psychomotor retardation[19]. Greatest fetal risk appeared to be during the 2nd trimester. Subtle effects on brain function in the domains of language, memory, and motor activity with reference to prenatal methyl mercury exposure have been reported, even when maternal hair Hg was only 6 micrograms/g, corresponding value for blood being approximately 24 micrograms/l[20]. Following consumption of pilotwhale meat, the cord blood and hair mercury concentration showed a positive co relationship with deficits in language along with attention, memory, and to a lesser extent disturbances in visuospatial and motor function[21]. Prenatal exposure to methyl mercury may cause constriction of visual fields and deafness[22]. Ganjam district in Orissa, India has been declared as a hot spot of pollution by the Laboratory of Environmental Toxicology, Berhampur University. An extensive study in Ganjam area has found that nutritional deficiency gets compounded when the population is exposed to mercury through air, food, water and landmass. Out of a total of 85.4% malnourished children, 78.4% lived close to an industrial area which was environmentally contaminated with mercury[23].

2. Effects of mercury on the reproductive system

Mercury adversely affects the reproductive potential of both males and females. As already mentioned, high concentration of Hg interferes with conception in the female. At lower levels, the fetus is often aborted or is stillborn. This is supported by a study on female dental assistants with high occupational exposure to Hg, who were found to be less fertile than unexposed controls[24].

Mercury has been implicated in some accounts of sub-fertility in Hong Kong males[25]. Organic as well as inorganic mercury decreases the percentage of motile spermatozoa. After 30 minutes incubation with 20 micromole methyl mercuric chloride, less than 5% of human spermatozoa were found motile[26].

3. Effects of mercury on the immune system

Both organic and inorganic mercury suppress immune response. Mercury intoxication has been associated with decreased antibody formation, lymphocyte function, and increased infectivity[27]. Inorganic mercury may cause immunologically mediated diseases, e.g., glomerulonephritus, acrodynia (Pink disease), and contact allergy. Infants exposed to phenyl mercury from treated diapers, and young children ingesting mercuric chloride in teething powders have been found to develop acrodynia and Kawasaki disease[28]. Significantly decreased levels of serum IgG and IgA were observed in workers occupationally exposed to metallic mercury vapors chronically[29]. Mercury inhibits deiodination of T4 to T3 in chloralkali workers exposed to mercury vapors for an average of 10 years[30]. The intensity of Listeria monocytogenes infection of the internal organs, as well as their survival rates were found to increase upon chronic exposure to mercury[31]. A single dose of 20 g mercuric chloride was found to aggravate infection with herpes simplex virus type 2 (HSV-2) in mice[32]. Metallothionein (MT) is known to exert cytoprotective effect against heavy metal toxins. It has been found that metallothionein immunization together with mercuric chloride treatment in BALB/c mice dramatically decreased bone mineral density and humoral bone formation indices, alkaline phosphatase activity, and osteocalcin[33].

4. Effects of mercury on the cardiovascular system

Prenatal exposure to methyl mercury may affect development of cardiovascular homoeostasis in children with lower birth weight. Systolic and diastolic blood pressure increase by 13.9 mm Hg when cord blood mercury concentration increases from 1-10 micrograms/l cord blood[34]. Neonates born to mothers with high consumption of fish/gram have been found to have higher RBC Hg levels than others.

5. Effects of mercury on liver and kidney

It has been found that kidneys accumulate highest levels of mercury as compared to the brain or liver[35]. It has been reported that mercury accumulates in liver when injected as methyl mercury chloride, and the hepatotoxicity is proportional to increased lipid peroxidation[36]. Workers have earlier concluded that severity of hepatotoxicity and nephrotoxicity is consistent with elevation of mercury concentrations Significant proteinuria is often encountered in workers chronically exposed to mercury[37]. The brain to liver mercury ratio increases with aging in mice[38].

Mercury was shown to increase the levels of SGPT, bilirubin, and blood urea nitrogen in dimethyl mercury treated rats[39]. Dimethyl mercury also increased the triglyceride levels in rat liver[40]. Renal dysfunction increases plasma creatinine level upon methyl mercury intoxication involving 5 ppm mercury for two years[41]. Decrease in the level of protein (brain and liver), acid and alkaline phosphatase, and glutathione S transferase upon 0.5 micromol/ml mercury intoxication was found, while high oxidative stress was found to be significantly increased in brain and liver[42].

6. Genetic effects of mercury exposure

Mercury genotoxicity has been observed in animals as well as in plants. Statistically significant relationship between blood cell mercury levels and frequencies of cells with chromatid type aberrations, unstable chromosome type aberrations, and aneuploidy in lymphocytes from persons with prior exposure to methyl mercury through fish ingestion has been reported[43]. Hg induced DNA single strand breaks using single cell gel electrophoresis assay has been demonstrated[44]. The percentage of damaged nucleus and average length of DNA migration increased as metal concentration and time increased. Mercury is also known to induce c mitosis in plants[45].

Conclusion

In view of the profound toxicological effects of mercury even at low exposure levels, and factors such as biomagnification, and easy access of the toxicant to man, it is imperative that preventive measures should be taken at individual, governmental, and industrial levels. The scientific community has an important role to play in creating an atmosphere of attentive care towards the common man, who should question the mercury content of products he is using, be it canned fish, cosmetic cream, or a vaccine. The government should make stringent rules regarding mercury contamination of environment, and fix acceptable mercury content of consumer products. A few countries have launched massive awareness campaigns. In some cases, this has met with great success, for instance in the Netherlands, exposure to thimerosol (merthiolate) through pharmaceuticals has been substantially reduced[46]. But elsewhere in most parts of the world, the government plays into the hands of powerful industrialist lobbies, and does little about factories contaminating flora, fauna, air, and water, and the manufacture of mercury-contaminated products. The condition is worse in developing countries where there is little awareness regarding mercury contamination of the food chain.

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