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Health Hazards Due to Mercury : Dental Consideration

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ABSTRACT

Mercury is a heavy metal element that cannot be created or destroyed. The Sources of mercury can be Natural, Human activities and Remobilization of historic sources. It exists in three different forms namely elemental, inorganic and organic having different toxicity profiles with different implications for children's health and development. Dental amalgam is known to contributes well to it . Mercury from amalgams is found in plasma but is rapidly cleared and stored in body tissues in short and long term exposures through inhalation, ingestion , dermal contact and causes toxicity/ poisoning like acrodynia , Hunter-Russell syndrome, and Minamata disease . National, regional and global actions, both immediate and long-term, are urgently needed to reduce or elimi¬nate releases of mercury and its compounds to the environment. WHO proposes Reduction of use and exposure , Use of alternative materials, Improved recycling/recovery , Technological improvements and Good policies should be encourage to fight against the health hazard . Aim of this review is to shortly revise about the mercury ,its classification, toxicity, menifestations and management and precautions including dental considerations.

KEYWORDS Mercury ; Minamata disease ; Dental Amalgam ; Toxicity ; Pink disease

Introduction

Mercury is an unique base metal which is molten at room temperature named after the planet, Mercury. Scientifically, it is designated as Hg with its element number being Eighty (80). It is volatile in nature and vaporizes easily . The vapours from elemental mercury are easily (80- 100%) absorbed from lung and nasal tissues. Once absorbed, it may enter the bloodstream and penetrate cells , blood-brain barrier, placental barrier and fetal tissues.

Mercury exists in various forms: **Elemental** (or metallic) [Figure 1], **Inorganic** (exposure through occupation , e.g. mercuric chloride). **Organic** (e.g., methylmercury, exposure through diet). [1] These forms of mercury differ in their degree of toxicity and in their deleterious effects on the nervous, and on lungs, kidneys, skin and eyes.

Atomic weight – 200.59
Density – 13.53 g/cm^3
Melting point - -38.83 C°
Boiling point - 356.73 C°

Figure. 1 Elemental/Metallic mercury

Uses of mercury :

A plethora of consumer products contain mercury, from paints, switches, fluorescent bulbs, and electronic devices, to pesticides, fungicides (used in seeds and bulbs) and cosmetics (mascara, eyeliner and skin-lightening creams). In medicine, mercury is an ingredient in dental amalgam, acts as a preservative in pharmaceuticals and is used in blood pressure machines Because mercury responds to change in temperature and pressure, it has long been used in thermometers, barometers and navigational instruments. In industry, it is used in the smelting process, in nuclear reactors, as an antifouling agent in paper, and in the production of chlorine, lye and plastic and is used to recover gold from stream sediments.

Sources of mercury:

Natural: volcanic explosions , weathering of rocks, . **Human activities**: combustion of coal, gold and mercury mining, cement manufacturing , pesticides, , caustic soda, chlorine, mir-

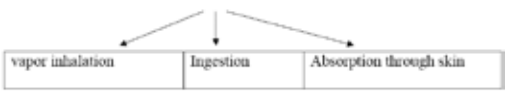
rors and medical devices , industrial leaks, dentistry, waste incineration. **Remobilization of historic sources**: mercury in landfill waste, soil, sediment, water

Most mercury in the environment comes from activities of human and heavy industries. About , 70% of the mercury released in atmosphere in the last 100 years is attributed to man made.

Mercury comes under the category of most severely toxic metallic compounds

SEVERELY TOXIC	MODERATELY TOXIC	SLIGHTLY TOXIC
MERCURY Cadmium Arsenic Vandex-tin	Thallium Arsenic Selenium Copper	Lead Arsenic Tin oxide

Routes of Toxicity of mercury :



Elemental Mercury
Mercuric Sulphide (HgS)
Inorganic Salts ($HgCl_2$ / Hg_2Cl_2)
Organomercurials (CH_3HgCl)

ELEMENTAL / METALLIIC MERCURY –

Also known as 'QUIICKSIILVER'

Routes of exposure : Inhalation : 70-80% absorption

Elimination: Through Urine and Feces

Toxicity : skin , Lungs, eyes, gingival,Central nervous system, kidneys, immune system

Sources : explosions of Volcanos, weathering of rocks , degassing, Combustion of coal , waste incineration , gold/ silver mining, fluorescent lights, batteries, , chloralkali plants , thermometers, sphyngomanometers, Dental amalgams,

INORGANIC MERCURY: Mercuric chloride

Routes of Exposure- Ingestion - 10% absorbed Skin - can be high and deadly

Elimination - Renal

Toxicity- High to moderate Primary- kidneys, gastrointestinal tract Secondary - central nervous system

Sources : Disinfectants, , cosmetics, Vapor lamps, , Latex paint, antimicrobials , Bactericidals , Embalming agents , Farming industry , Fungicides and Germicides , Insecticidal products , Laundry products , Paper manufacturing , embalming, Photography, Pathology and Histology products , Seed and Wood preservatives.

ORGANIC MERCURY: (METHYL MERCURY)

Routes of Exposure : Ingestion - 10% absorbed Gastrointestinal - Fast & complete absorptioSkin - can be high and deadly Parenteral - 100% absorbed Transplacental

Elimination : Renal and Feces - T1/2 45 to 70 days in adults

Toxicity: Primary: kidneys, gastrointestinal tract central nervous system
Secondary: cardiovascular

Sources : Antisyphilitic agents , production of Acetaldehydes , Cosmetics , Disinfectants , Explosives materials , , Fur hat factory , Wood preservation, Ink productions , Photography , , Mirror silvering ,Perfume industry , Mercury lamps , Tattooing inks , Vinyl chloride manufacturing

Factors affecting health:
Type of mercury :
Elemental (or metallic) , **Inorganic** (exposure through occupation , e.g. mercuric chloride). **Organic** (e.g., methylmercury, exposure through diet)

The main target organ for inhaled mercury vapor is mainly the brain . Mercuric chloride salts damage the gut lining and kidney , while methyl mercury is widely distributed throughout the body.

Dose: High dose shows acute poisonings and low dose shows chronic effects

Safe Tolerable Doses:

- US EPA- 0.1 µg of methylmercury/kg body weight/day
- FAO/WHO JECFA: 1.6 µg/kg body weight/week

Maximum allowable concentrations

elemental mercury	0.1 mg/m³ ()
organic mercury	0.05 mg/m³
methylmercury	1 ppm (1 mg/L)
inorganic mercury	2 ppb (0.002 mg/L)

Age : Mercury levels in cord blood, placenta, kidneys and liver of fetuses and and in the brain and kidneys of infants suggest that there exist potential dangers to pregnant women and children. Foetus are most prone and susceptible and, the CNS is the most affected system in childrens

Duration of exposure: Half lives of metallic mercury is multiphasic, effective half life of 42 days for 80% . Toxicity is related more to magnitude of mercury retention rather than rate of accumulation. Acute exposures have a latency period of one or more weeks of time.

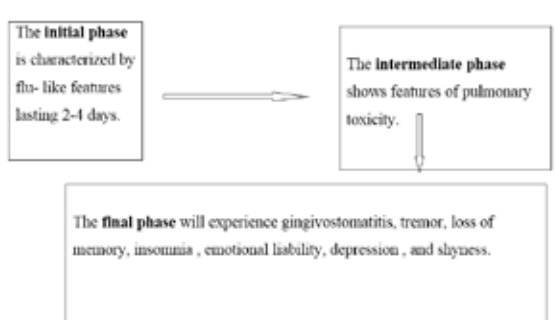
Route of exposure (inhalation, ingestion , dermal contact and)

Methylmercury is the major source of body toxicity in children worldwide. They directly exposed by consuming contaminated fishes, and also transplacentally from mothers having increased blood levels of methylmercury. It also passes into breast milk but at very low levels. Of the three routes, transplacental route of exposure is the most dangerous one.

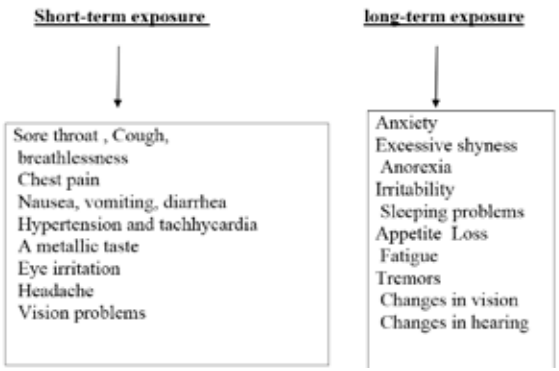
Mercury is a multipotent cytotoxin that intervenes in the primary processes of the cell and affects the basic functions of the cell.

Metallic mercury vapor can be inhaled and absorbed through the alveoli in the lungs. It is the main route of entry into the body tissues . Metallic mercury is very less likely entered from the skin and GIT and their absorption is poor via this route.

The acute toxicity by mercury vapor occur in **three phases**.



Complications due to exposure to high levels of mercury vapors



Mercury Toxicity and its complications [2,3,4,5,6]

SYSTEM INVOLVED	SYMPTOMS
Digestive System	Diarrhea/constipation Colitis Loss of appetite loss of weight Nausea/vomiting
Emotions	Aggressiveness Anger, Anxiety Depression Fear nervousness Hallucination Lethargy Confusion Manic depression Mood swings Shyness
Head	Dizziness Ringing in ears Fainting Headaches
Heart	Anemia Chest pain Heartbeat rapid or irregular
Lung	Chest congestion Respiration distress Asthma breathlesness
Muscles	Cramping Joint aches Muscle aches Muscle weakness Stiffness
Neurological/Mental	Fine tremor concentration loss Learning disorders Memory loss Numbness Slurred speech
Nose	Sinusitis Increase mucus formation Stiff nose
Oral/Throat	Bad breath Alveolar Bone loss Gingivitis/bleeding gums Leukoplakia (white patches) Burning sensation Metallic taste Sore throats Ulcers of oral cavity
Immune system	suppresses the primary humeral antibody response

Disorders related to Chronic Mercury Poisoning:

Acrodynia	Fibromyalgia
Alzheimer's diseases	Hormonal disorders
Anterior lateral sclerosis (ALS)	Immune system abnormalities
Asthma	Kidney disease
Arthritis	Learning disorders
Autism	Liver disorders
Chronic fatigue	Multiple sclerosis
Crohn's disease	Parkinson's disease
Depression	Senile dementia
Developmental defects	Thyroid disease
Diabetes	
Eczema	
Emphysema	

MINAMATA DISEASE: The disease is due to organic mercury toxicity In 1950s ,the most severe accident of industrial pollution , mercury poisoning occurred in small seaside town of minamata , japan. A local petrochemical and plastic company chisso corporation dumped about 27 tons of methyl mercury into the minamata bay for period of 35-37 years. The mercury was methylated by bacteria and was ingested by fish. The villagers nearby consumed the fishes and shows signs of neurologic diseases , such as loss of vision , hearing loss, numbness of extremities and ataxia. It lead to severe neurological damage and killed more than 900 peoples. Greater than 2 million peoples involved in health problems and get permanently disabled.

Babies exposed in utero were the most severly affected and exposure further continued after birth also, because mercury was also recovered in the breast milk of the mothers [7]

- Perioral and facial paresthesias
- Visual-field constriction
- Respiratory distress
- Nonspecific dermatitis
- Headache, fatigue, tremors and Extremity numbness
- Ataxia and dysarthria

ACRODYNIA (Pink disease)
It is Considered as idiosyncratic process . it ischronic toxicity due to elemental mercury exposure, occurs mainly in young children and is lead to following .

- Painful extremities
- De- epithelisation and Desquamation and Pinkish discoloration
- Hypertension
- Sweating
- Insomnia, irritability, apathy

Diagnositic tests for amalgam toxicity:

1. **Careful history taking:** Careful history taking to find potential sources of exposure. Eg. food, activities, environment etc.
2. **Clinical observation for signs and symptoms for mercury toxicity**
3. **Urine mercury:** Urine test is of diagnositic value for measuring elemental mercury. Preferably morning Urine samples are taken over a day period for analysis of traces of mercury. Urine mercury typically reflects inorganic exposure.
4. **Blood mercury:** A blood test can also be used to measure exposure to high levels of mercury within three days of being exposed. Total blood mercury reflects organic exposure.
5. **Hair mercury:** it is an good indicator of total body, long term exposure.

WHO Guideline for safety

Water: 1 µg/litre for total mercury [8]

Air: 1 µg/m3 (annual average) [9]

WHO estimated a tolerable concentration of 0.1-0.2- µg/m3 from inhalation mercury vapour exposure in long term basis and a tolerable intake of total mercury of 2 µg/kg bodyweight per day.[10]

Human daily dose of mercury from various sources is:
Dental amalgam = 3.0-17.0 µg/day (Hg vapor)

Fish and seafood = 2.3 µg/day (methylmercury)

Other food = 0.3 µg/day (inorganic Hg)

Air & water = Negligible traces

DENTAL PROSPECTUS AND CONSIDERATION:
Amalgam, an alloy of mercury (Hg), is an excellent and versatile dental filling material. It has been widely used in dentistry since 100 years due to its low cost, strength, durability , ease of application and bacteriostatic effects.

Dental Amalgam has been the most popular and effective filling material used in dentistry . In the united state ,food and drug administration (FDA) dental amalgam is regulated and popularized as a medical device. Although it sometimes is called "silver amalgam," amalgam actually consists of a combination of metals including silver, mercury, copper and tin .Small amounts of zinc, indium or palladium are also added. Modern amalgams precapsulated alloy consisting of 42% to 45% mercury by weight.[Figure 2]

One of the most controversial sources of mercury toxicity is dental amalgams, which contain inorganic mercury and its exposure is estimated between 5 to 15 micrograms per day from brushing, chewing, grinding, and corrosion.

Figure 2. Amalgam restoration in teeth.

Amalgam war
In 1843, in New York City , The American Society of Dental Surgeons was founded and declared use of amalgam as malpractice because of the risk of mercury toxicity in patients and dentists and asked all its members to sign a pledge to abstain from using it.[11] It was the beginning of the amalgam war.[12] Because of its stance against amalgam, membership in this society gets declined, and due to the reductions in number of members, the was Society banded in 1856 . In 1859, the American Dental Association was founded and it did not forbid use of amalgam.

Dental Amalgam Waste Products : During the dental amalgam filling process and removal of filling, a large number of waste products is formed .[13,14]

Elemental mercury vapour — Directly Released from amalgam alloy

Dental amalgam scrap - Amalgam particles remaining in the dappen dish following restoration placement that have not come into contact with the patient.

Amalgam waste — Amalgam particles generated during polishing and carving process and on removal of restoration , that have come into contact with patient mucosa and secretions

Amalgam sludge — Amalgam fine particles which goes in waste water of dental office, usually trapped in chair-side traps and vacuum filters.

Amalgam is not stable after it is filled into tooth,it constantly release mercury

vapours into your body and this mercury bioaccumulates. It is known from animal studies that mercury vapors are emitted continuously from dental amalgam and are cumulated body tissues .[15,16]

Humans with amalgam fillings have significantly elevated mercury levels in blood, and about 3 ± 5 times more mercury in urine , 2 to 12 times more mercury in their body tissues than individuals without dental amalgam.[17,18,19,20,21]

Mercury is constantly and continuously circulates in environment and humans are frequently exposed by air, water, and food. Exposure to mercury in human individuals with amalgam restoration occurs during the dental restoration and its removal .

Precautions for removals of amalgam restoration :
- Providing you with an seperate air source and instructing you not to breathe by mouth.
- Cold-water spray should be used to minimize mercury vapors.
- Rubber dam isolation should be used so patient should not swallow or inhale vapours of mercury.
- High-volume suction / evacuator should be used be used continuously near the tooth at all times to remove the mercury vapor.
- Patient should immediately Wash their mouth after the fillings have been removed and the dentist should also change gloves after the removal after it.
- Protective wear /clothes and face should be Immediately cleaned once the fillings are removed
- Using room air purifiers.
- Use mercury substitutes or indium amalgam . The indium helps retain the mercury and less vapour formation . There are also high-copper amalgams. They contain less mercury and more copper.

Mercury Waste Management
1. All personnel involved in the handling of mercury and dental amalgam

Should be trained regarding the potential hazards of mercury vapor and they should have good mercury hygiene practices. Personnels Professional clothes must be separated before leaving the working area.

2. Work should be done in well ventilated areas and exhaust, the air conditioning filters should be replaced periodically. Floor coverings should be non absorbent, seamless and easy to clean.

3.There should be Periodical checkup for the dental operatory atmosphere for mercury vapor using dosimeter badges and mercury vapor analyzer for rapid assessment after any mercury or clean up procedure. [22]

4. Some amount of mercury vapor is released during the intraoral placement and condensation procedures, so a rubber dam should be used to prevent contact with the patient and high-volume evacuation suctions should be used to prevent intraoral vapor from escaping.

5. amalgam scrape should be collected and stored under water, glycerin, or x-ray fixer in a airtight bottle.

6.Waste amalgam particles are generated during the placement and removal of amalgam restorations in the dental office and may goes into dental office waste water. **Source control**, which is the elimination of mercury from the waste water going into sewage treatment plants should be done for the reduction of mercury discharged into the surrounding environment.

7. Amalgam separators are evaluated using the ISO Standard 11143. , the efficiency of the amalgam separator is required to be at least 90-95% (mass fraction) removal of particles.[23].

8. Incineration of used amalgam capsules must be avoided to prevent volatilization of Hg to the atmosphere. Recovery of heavy metals through the recycling processes should be than disposal in landfills as it carry risk of leaching into the ground water. The recycled metals can be reused in the manufacturing of dental amalgam.The ADA strongly recommends and promotes the Re and recycling as a best management practice for dental offices.[24,25]

Steps required for elimination of mercury hazards

1. To Conduct national assessments of mercury usage and disposal and promote educational works for the health and environment.[26]

2. To Promote the use of mercury-free alternative resources , e.g. for thermometers,manometers devices and ensure that mercury-containing devices are taken back by the manufacturer or properly disposed off.

3. To Develop mercury clean-up and waste-handling, storage and safe-handling procedures; To promote management of health-related waste containing mercury.

4. Encourage countries to develop and implement policies on mercury; and promoting effective ways to control mercury emissions from cremation.

5. Steps to make widely available inexpensive mercury-free products, and facilitate their procurement.

6. Promote long-term monitoring and programmes to reduce occupational exposure

Conclusion :

Considerable amount of mercury waste is generated during various dental procedures which has to be minimized and proper disposal methods have to be used to control its hazardous effects. Increased mercury hygiene measurement and regular control of working atmosphere should be improved to prevent mercury exposure. Strategic actions should be taken to eliminate use of mercury and promote development of mercury alternatives.

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Conflict of Interest: None Declared

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