EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 3
Issue: 7
207-212
Year: 2016

"ENVIRONMENTAL AND OCCUPATIONAL HAZARDS OF MERCURY FROM DENTISTRY AND PRACTICAL GUIDELINES TO MINIMIZE THEM"

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Article Received on 08/05/2016 **Article Revised on 28/05/2016** **Article Accepted on 19/06/2016**

ABSTRACT
Exposure to mercury is a potential hazard for anyone in the dental profession who handles mercury or mercury containing compounds. Due to mercury exposure from amalgam in the workplace, dental workers including the dentists, the dental hygienists and the dental assistants are at a particular risk of mercury hazards. Mercury exposure can seriously affect the health of both the patients and the dental professionals. Early exposure to low doses of mercury during pregnancy and through breastfeeding increases the risk of decrease in the intelligent quotient (IQ) amongst children. According to the WHO in 2005, mercury may have no threshold below which some adverse effects do not occur. Mercury vapours also alter the local environment posing grievous effects for the general population. This article throws light upon multiple health hazards of mercury associated with the dental treatment modalities and a few measures to prevent them. This will help to greatly reduce the human and environmental morbidity related to the mercury exposure.

KEYWORDS: Mercury toxicity, Acrodynia, Dentistry related hazards, Dental amalgam.

INTRODUCTION
"Mad as a hatter" is a colloquial phrase used in conversation to refer to a crazy person. In 18th and 19th century, mercury was used in the production of felt, which was used in the manufacturing of hats. People who worked in these hat factories were exposed daily to trace amounts of the metal, which accumulated within their bodies over time, causing some workers to develop dementia caused by mercury poisoning. Thus the phrase "Mad as a Hatter" became popular as a way to refer to someone who was perceived as insane.[1] *Mercury (Hg):* The atomic number of mercury is 80, atomic mass is 200.59. It is grouped as a transition metal and the melting point is -356.58°C. It is the only metal to exist as a "silvery" liquid at room temperature.[2]

***Forms of mercury*:** Metallic Hg - Stable/ Unreactive, Ionic Hg – Reactive, Salts - HgCl - Mercuric Chloride, Compounds – Amalgam, Methyl Hg - Reacted Toxic Form/ Poison and Vapour form.[3]

Uses of mercury and common mercury-added products: The mercury compound cinnabar (HgS) was used in pre-historic cave paintings for red colours, and metallic mercury was known in ancient Greece where it was used as a cosmetic to lighten the skin. In medicine, apart from the previously mentioned use of mercury as a cure for syphilis, mercury compounds have also been used as diuretics and mercury amalgam is still used for filling teeth in many countries.[4] Metallic mercury is used in thermometers, barometers and instruments for measuring blood pressure. A major use of mercury is in the chloralkali industry, in the electrochemical process of manufacturing chlorine, where mercury is used as an electrode. The largest occupational group exposed to mercury is dental care staff. During the 1970s, air concentrations in some dental surgeries reached 20g/m^3, but since then levels have generally fallen to about one-tenth of those concentrations. Inorganic mercury is converted to organic compounds, such as methylmercury, which is very stable and accumulates in the food chain. Until the 1970s, methyl mercury was

commonly used for control of fungi on seed grain. The general population is primarily exposed to mercury via food, fish being a major source of methyl mercury exposure[5] and dental amalgam. Several experimental studies have shown that mercury vapour is released from amalgam fillings, and that the release rate may increase by chewing.[6] Mercury in urine is primarily related to (relatively recent) exposure to inorganic compounds, whereas blood mercury may be used to identify exposure to methyl mercury. A number of studies have correlated the number of dental amalgam fillings or amalgam surfaces with the mercury content in tissues from human autopsy, as well as in samples of blood, urine and Plasma.[7] Mercury in hair may be used to estimate long-term exposure, but potential contamination may make interpretation difficult. Mercury is a naturally occurring metal; 50% of the mercury released to the environment comes from human activity. Of that 50%, 53% is emitted from combustion of fuels for energy production. 34% is from the combustion of waste. 13% is from all other sources, including manufacturers and consumers. Dentistry contributes for about 1%.[8] Cities and states in various part of the U.S. are implementing mercury source reduction programs and adopting new regulations on mercury sources. Traditionally, cities and states focused their pollution prevention efforts on industrial and manufacturing sources, but more stringent regulations on city waste treatment facilities have required additional efforts to look at non-industrial sources, such as hospitals, laboratories and dental clinics.

Mercury has many desirable properties, and has been in use for many different types of industries. Some examples where mercury has been commonly used are in Thermometers, Bullets, Mercury Vapor Lamps, Fluorescent Lamps, Batteries (still used in "button" batteries manufactured outside U.S.), Thermostats (mercury switches), Blood pressure cuffs (sphygmomanometers), Manometers (for scientific instrumentation/testing), Laboratory Reagents (commonly used in several fixatives for blood testing, other diagnostic procedures) and Household Bleach (sodium hypochlorite) which is commonly manufactured using a "mercury cell' process, and trace amounts of mercury can be left within the final product. This manufacturing process is being phased out in U.S. ADA has not reviewed and does not endorse the results of these cities' studies. Estimated contributions from various sources to the Metropolitan Boston sewer system were studied. It is similar to results reported by other cities studying this question.[9] Some important facts to note are.

- The permitted industries' percentage of mercury contributed to a municipal sewer system is generally low, as they do not contribute large amounts of flow, when compared with households and other sources. Often, the largest contributors can result from infiltration (water that enters into sewer system through holes/cracks in the piping) and inflow (from rain storms collecting pollutants from streets, parking lots, etc.).

- The dental contribution, as noted previously, will vary from city to city, and estimates are difficult to generate due to the fact that one must make a series of assumptions from sampling small segments of offices to generate the total estimate. However, dentistry has been identified by many municipalities as an important component to their mercury reduction efforts.

Aquatic mercury cycle: Methylmercury is produced by methylation of inorganic mercury present in both freshwater and saltwater sediments, and accumulates in aquatic food chains in which the top-level predators usually contain the highest concentrations.[10] Organomercury compounds other than methylmercury decompose rapidly in the environment, and behave much like inorganic Hg compounds.[11] In organisms near the top of the food chain, such as carnivorous fishes, almost all Hg accumulated is in the methylated form, primarily as a result of the consumption of prey containing methylmercury; methylation also occurs at the organism level by way of mucous, intestinal bacteria, and enzymatic processes, but these pathways are not as important as diet.[12,13] "Minamata disease" resulted from the discharge of methylmercury from chemical factories into Minamata Bay. Once diluted and diffused in the water, it was concentrated to a high level in fish and filter-feeding shellfish by several routes, including bioconcentration and food chain biomagnification. When these fish and shellfish were consumed by humans, methylmercury gradually accumulated to exceed a threshold value, causing intoxication. Spontaneously poisoned cats, dogs, rats, waterfowl, and pigs behaved erratically and died; flying crows and grebes suddenly fell into the sea and drowned; and large numbers of dead fish were seen floating on the sea surface.[14] In laboratory studies, cats and rats fed shellfish from the Bay developed the same signs as those seen in animals affected spontaneously. Abnormal Hg content i.e., more than 30 mg/kg fresh weight--was measured in fish, shellfish, and mud from the Bay, and in organs of necropsied humans and cats that had succumbed to the disease. Mercury contamination of fish and sediments was still evident in 1981, although discharges from the acetaldehyde plant ceased in 1971.[14]

Dental amalgam: The constituents are Silver (Ag) - 40-70%, Tin (Sn) - 17-30%, Copper (Cu) - 2-40%, Zinc (Zn) - 0-2%, Indium (In) - 0-5%, Palladium (Pd) - 0-1% and Mercury (Hg) - 42-51%. [15] Causes of patient exposure to mercury are new and replaced amalgam restorations and leaching of amalgam due to mastication and wear of teeth. Mercury Vapour is released during refinishing or repairing. Hence, replacement of amalgam restorations is usually not indicated. Causes of provider or dentist exposure to mercury are mercury vapours during amalgam storage and disposal and mercury spill.

This depends on the type and frequency of amalgam use. Causes of public and environment exposure are various amalgam sources and amalgam related procedures like carvings or suction, grindings, amalgam drains, regulated solid waste, particulate matter and waste water.

Anti-mercury claims, Health hazards of mercury

Inorganic mercury - Acute mercury exposure may give rise to lung damage. Chronic poisoning is characterized by neurological and psychological symptoms, such as tremors, changes in personality, restlessness, anxiety, sleep disturbance and depression. The symptoms are reversible after cessation of exposure. Because of the blood–brain barrier there is no central nervous involvement related to inorganic mercury exposure. Metallic mercury may cause kidney damage, which is reversible after exposure has stopped. It has also been possible to detect proteinuria at relatively low levels of occupational exposure. Metallic mercury is an allergen, which may cause contact eczema, and mercury from amalgam fillings may give rise to oral lichen planus. It has been feared that mercury in amalgam may cause a variety of symptoms. This so-called 'amalgam disease' is, however, controversial, and although some authors claim proof of symptom relief after removal of dental amalgam fillings, there is no scientific evidence of this.[16,17]

Organic mercury- Methyl mercury poisoning has a latency of 1 month or longer after acute exposure, and the main symptoms relate to nervous system damage.[18] The earliest symptoms are paresthesia and numbness in the hands and feet. Later, coordination difficulties and concentric constriction of the visual field may develop as well as auditory symptoms. High doses may lead to death, usually 2–4 weeks after onset of symptoms. The Minamata catastrophe in Japan in the 1950s was caused by methyl mercury poisoning from fish contaminated by mercury discharges to the surrounding sea. In the early 1970s, more than 10,000 persons in Iraq were poisoned by eating bread baked from mercury-polluted grain, and several thousand people died as a consequence of the poisoning. However, the general population does not face significant health risks from methyl mercury exposure with the exception of certain groups with high fish consumption. A high dietary intake of mercury from consumption of fish has been hypothesized to increase the risk of coronary heart disease.[19] In a recent case-control study, the joint association of mercury levels in toenail clippings and docosahexaenoic acid levels in adipose tissue with the risk of a first myocardial infarction in men was evaluated. Mercury levels in the patients were 15% higher than those in controls (95% CI, 5–25%), and the adjusted odds ratio for myocardial infarction associated with the highest compared with the lowest quintile of mercury was 2.16 (95% CI, 1.09–4.29; P for trend = 0.006). Another recent case-control study investigated the association between mercury levels in toenails and the risk of coronary heart disease among male health professionals with no previous history of cardiovascular disease. Mercury levels were significantly correlated with fish consumption, and the mean mercury level was higher in dentists than in non-dentists. When other risk factors for coronary heart disease had been controlled for, mercury levels were not significantly associated with the risk of coronary heart disease. These intriguing contradictory findings need to be followed up by more studies of other similarly exposed populations.

In short, to summarize, following are the important adverse effects- Neurotoxicity, Renal Dysfunction, Birth Defects, Arthritis, Multiple Sclerosis, Chronic Fatigue Syndrome, Candida Infection, Antibiotic Effects, Hodgkin's Disease, Mononucleosis, Depression, Ulcers, Epilepsy etc.[20]

Intraoral adverse effects are Oral lichenoid lesions, Discoloration of teeth, Discoloration of the gingival and peridental tissues, Amalgam tattoo, Electrogalvanic reactions etc.

Acrodynia: Mercury poisoning (also known as hydrargyria or mercurialism) is a disease caused by exposure to mercury or its compounds.[21] Common symptoms of mercury poisoning include peripheral neuropathy (presenting as paresthesia or itching, burning or pain), skin discoloration (pink cheeks, fingertips and toes), swelling, and desquamation (shedding of skin). Mercury is thought to inactivate S-adenosyl-methionine, which is necessary for catecholamine catabolism by catechol-o-methyl transferase. Due to the body's inability to degrade catecholamines (e.g. Epinephrine) a person suffering from mercury poisoning may experience profuse sweating, tachycardia (persistently faster-than-normal heart beat), increased salivation, and hypertension (high blood pressure). Affected children may show red cheeks, nose and lips, loss of hair, teeth, and nails, transient rashes, hypotonia (muscle weakness), and increased sensitivity to light. Other symptoms may include kidney dysfunction (e.g. Fanconi syndrome) or neuropsychiatric symptoms such as emotional lability, memory impairment, or insomnia. Thus, the clinical presentation may resemble pheochromocytoma or Kawasaki disease.

Best Management Practices for Dental Amalgam and Other Metal Waste
Washington State Dental Association & The Department of Ecology (WSDA-DE BMPs)
The American Dental Association

While we recognize that dental amalgam is a safe material for filling cavities, its waste should be handled properly, recovered and recycled just as we do with other waste products.[22]

Theoretically, amalgam wastes discharged to publicly owned treatment works (POTWs) may be converted to other forms of mercury that are bioavailable. Dentists should do their part for the environment. The ADA's recent report found that there are few, if any rigorous

studies on the conversion of mercury to more bioavailable forms when released to the environment. Existing studies have indicated that the mercury release rates from amalgam released to the environment is very low (.006% or less), the period of studies have been short, and definitive conclusions cannot be drawn. EPA has not typically made a distinction, when regulating sewerage treatment plants, on the different chemical forms of mercury. Permitted requirements generally refer "total" mercury concentrations (particulate, dissolved, methylated and other forms all lumped together).

Types of Amalgam Wastes

- Non-contact amalgam (scrap) is excess mix leftover at the end of a dental procedure. Many recyclers will buy this clean scrap.
- Contact amalgam is amalgam that has been in contact with the patient. Examples are extracted teeth with amalgam restorations, carving scrap collected at chair side, and amalgam captured by chair side traps, filters or screens.

Practical guidelines to minimize mercury toxicity

WSDA-DOE/ADA BMPs- Collect all amalgam waste (both scrap and contact amalgam) in separate containers. No dangerous waste or amalgam is to be placed in the infectious waste "red bag". This would include extracted teeth with amalgam. As ADA recommends, use precapsulated alloys and recycle the used capsules. Properly manage and dispose off all other dangerous waste streams generated by the dental office (e.g., x-ray wastes, or lead foils/ aprons). Properly dispose off all scrap amalgam waste from traps, filters and separators with a licensed treatment, storage, disposal or recycling facility. The ADA recommends disposable chair side traps which can be recycled. Consider keeping different types (e.g. contact and non-contact) of amalgam wastes in separate containers. Keep amalgam out of sinks and never rinse amalgam waste down the drain. Clean or replace chair-side traps on a regular schedule and properly dispose off amalgam waste. Clean vacuum pump filters regularly, according to the manufacturer's recommendations. Maintain all disposal records on site for three years. Sludge and filters are considered a dangerous waste and must be recycled or disposed as such. The dentists should dispose off these wastes as a biomedical (red bag) waste.

Amalgam Waste Safe Handling Precautions

Amalgam waste may be mixed with body fluids, such as saliva, or other potentially infectious material. Personnel protective equipment such as utility gloves, masks, and protective eyewear when handling it should be used.

Disinfection/ Sterilization- Avoid vacuum line disinfectants that contain bleach. They may solubilize mercury from amalgam particles and increase the release of mercury into wastewater. Alternative disinfectants are E-Vac, MAXI-EVAC, Super Dent, Evacuation Cleaner ProE-Vac, Turbo Vac Line Flush, EZ-Zyme, Purevac etc.

Proper Use/maintenance of Existing Traps is an Important Amalgam Capture Mechanism

- Most chairside traps traps have 0.7 mm holes (#25 mesh).
- Pump Traps are a 40-mesh size, with a screen pore size of 0.425 mm.
- Together, they are estimated to capture over 65%-78% of all amalgam wastes.
- This capture efficiency can be increased by use of smaller mesh size traps.

ADA Environment Report estimates that U.S. dental facilities, using a combination of chair side and vacuum pump filter traps collect 77.8% of amalgam wastes discharged.

The Weight of Wastes Generated by removal of Dental Amalgam Restorations and the Concentration of Mercury in Dental Wastewater[23] - On the basis of studies of particle-size distribution in amalgam wastewater, O'Connor Associates Environmental Inc. estimated that a conventional chairside trap with a screen pore size of 0.70 mm would trap 30% by weight of amalgam wastes and that 50% of the amalgam wastes that bypassed this trap would be captured by the second trap (the pump trap) if it had a screen pore size of 0.425 mm (#40 mesh). From these estimates, O'Connor Associates Environmental Inc. concluded that conventional traps in the dental chair could capture 65% by weight of amalgam wastes.

***Trap Collection Efficiency*:** Smaller mesh size will typically require more frequent changes. However, it will reduce maintenance needs for downstream equipment (e.g. vacuum pump, amalgam separators).

Practical Guide to Integrating BMPs (Best Management Practices) Into the Practice

Non-contact (scrap) amalgam

- Place non-contact, scrap amalgam in wide-mouthed, airtight container that is marked "Non-contact Amalgam Waste for Recycling."
- Make sure the container lid is well sealed.

Amalgam capsules

- After mixing amalgam, place the empty capsules in a wide-mouthed, airtight container that is marked "Amalgam Capsule Waste for Recycling."
- Capsules that cannot be emptied should likewise be placed in a wide-mouthed, airtight container that is marked "Amalgam Capsule Waste for Recycling."
- Make sure the container lid is well sealed.
- When the container is full, send it to a recycler.

Disposable & reusable chair-side traps

- Open the chair-side unit to expose the trap.

- Remove the trap and place it directly into a wide-mouthed, airtight container that is marked "Contact Amalgam Waste for Recycling."
- Make sure the container lid is well sealed.
- When the container is full, send it to a recycler.
- Traps from dental units dedicated strictly to hygiene may be placed in with the regular garbage.
  Replace the trap into the chair-side unit. (Do not rinse the trap under running water as this could introduce dental amalgam into the waste stream).

Vacuum pump filters

- Change the filter according to the manufacturer's recommended schedule.
- Remove the filter. While holding the filter over a tray or other container that can catch any spills, decant as much of the liquid as possible without losing any visible amalgam.

Dental Amalgam Separators

The following information was provided by the ADA in July, 2003.

Amalgam Separator Technologies in the Market: The Principles of work are Sedimentation, Filtration, Chemical filtration (e.g. Chelation), Centrifugation and a Combination of above technologies.

Basic challenge for any separator is to effectively handle "slug" loads without clogging, and allow sufficient time/area to isolate flow from vacuum systems. Separators come in many different shapes and sizes.

Practical Issues for Selection of Amalgam Separators are its Cost, Effectiveness (Short & Long Term), Maintenance, Reliability, Solids Handling and Disposal, Integrity of Vacuum Systems, Space and Utility Requirements, Dental Office/building Constraints, Regulatory Considerations , Ease of Maintenance and Replacement and the Effect on Other Equipment. Hg urinary levels has dropped in providers from 1985 = 5.8µg Hg/L to 1995 = 4.9µg Hg/L due to precautions taken.

Amalgam restrictions

These are not considered in the United States. Sweden, Denmark, and Germany have proposed restrictions on amalgam use. The intent is to reduce the environmental release of Hg, it is not due to amalgam restoration danger. Environmental concerns may limit the usage, not the "mercury poisoning" of the patients. Amalgam alternatives are Composite Resin Restorations, Gold, Porcelain and Gallium Alloys. Under study are various pressure compounds and consolidated silver compounds.

CONCLUSION

Continue to use amalgam unless esthetics is a concern. Use conservative preparations. Use resin sealants for non-carious fissures. Monitor research on bonded amalgams. Practice safe mercury hygiene. Stay informed.

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