The Amalgam Controversy: An Overview

Anuraag Gurtu[†], Sumit Mohan[††], AnuragSinghal[†††], Tarun Ahuja[††††]

† Reader, Department of Conservative Dentistry & Endodontics, Institute Of Dental Sciences, Bareilly, (U.P)
†† Senior Lecturer, Department of Conservative Dentistry & Endodontics, Institute Of Dental Sciences, Bareilly, (U.P)
††† Professor & Head, Department of Conservative Dentistry & Endodontics, Institute Of Dental Sciences, Bareilly, (U.P)
†††† Professor & Head, Department of Conservative Dentistry & Endodontics, Maharanapratap College of Dentistry and Research Centre, Gwalior, (M.P)

Date of Receiving :06/Jul/2012
Date of Acceptance :29/Jul/2012

ABSTRACT: *Amalgam technically means an alloy of mercury with any other metal. This material has been extensively used as a restorative material since its inception. Ever since its introduction in early nineteenth century, dental amalgam has been a subject of many controversies because of its mercury content. Earlier people knew that though mercury was poisonous, the mercury exposure was too small to hurt anyone. With the passage of time, a great body of evidence has accumulated showing that mercury is released from amalgam in significant quantities and it spreads around the body, including from mother to foetus, and that the exposure causes physiological harm. This article overviews this controversy.*

KEYWORDS: Amalgam, Alloy, Mercury, Allergy

THE HISTORY OF AMALGAM

The history of amalgam started with its use by the alchemists of China and Europe who were fascinated with mercury, the only metal that is liquid at room temperature, and which would evaporate with mild heat. They knew that liquid mercury could dissolve powders of other metals, such as tin, copper or silver. European methods for using a paste of silver shavings dissolved in mercury as dental restorations were introduced to America by the Crowcour brothers in around 1830. Problems with excessive expansion in early amalgam were solved in time by adding the tin, zinc, and copper. The formula and technique for using amalgam has remained virtually unchanged for the past one hundred years.[1]

The **"First Amalgam War"** started almost immediately. The toxic effects of mercury, including dementia and loss of motor control, were common in those times and many dentists objected to the obvious disadvantage of using such a dangerous material in people's mouths. In 1845, the American Society of Dental Surgeons asked its members to sign a pledge never to use it. The economics were compelling. At a time when the only other feasible restorative material was gold, amalgam looked to be the restorative material for the masses. Then, as today, patients did not show signs of acute poisoning as they left the dentist's office, so this did not appear to be a problem. As the use of amalgam grew, the American Society of Dental Surgeons fell apart, and in 1859, the proamalgam faction formed the American Dental Association, the same organization that leads the dental profession in the USA to this day, and remains steadfast in its defense of amalgam.[1,2]

The **"Second Amalgam War"** was provoked in the 1920's by Professor Alfred E. Stock, a leading chemist at the *Kaiser Wilhelm Institute in Germany*. Adverse effects on his own health from mercury in the lab led him to question the supposed safety of mercury from dental amalgam. His research concluding that there were adverse health effects was published in leading scholarly journals of the day. It touched off a debate that raged through the 1930's without a clear resolution, only to fade away in the storm of World War II.[2]

The argument in the late 1970's"**Third Amalgam War"** reopened as modern methods of detecting the presence of trace amounts of mercury were introduced, including mass spectrophotometry and the Jerome mercury vapor detector. The chain of toxic events in relation to mercury in amalgam was:

1) Amalgam releases significant amounts of mercury.
2) The mercury distributes to tissues around the body, and is the biggest source of mercury body burden.
3) The mercury from amalgam crosses the placenta and into breast milk, resulting in significant pre- and post-partum exposures for infants.
4) Adverse physiological changes occur from that exposure on the immune, renal, reproductive and central nervous systems, as well as the oral and intestinal flora.[3,4]

RELEASE OF MERCURY FROM AMALGAM

Amalgam is an alloy of many metals, with mercury being one of the most predominant. Experts from books on

dental materials tells that *gamma and mu phase* only serves to obscure the fact that the mercury is not all reacted. This was refused by Masi et al[5]who assessed the amalgam surface using a photomicrograph. In their research where the probe touched the surface, droplets of free liquid mercury are squeezed out into view. This process does not require heating the sample, as some have objected, it was repeated down to the temperature of liquid nitrogen.[6]

Old amalgam restorations contain significantly less mercury than new ones.[7,8] It was quantified in the human mouth by Svare et al, Gay et al, Vimy and Lorscheider, and others.[9-13]By using a Jerome Mercury Vapor Detector and other methods, these groups were able to measure the mercury content of the air in the mouths of people with or without amalgams, before and after chewing. The baseline mouth air of people with amalgams contains more mercury than that of people without amalgams. After ten minutes of chewing gum, the mercury concentration in mouth air does not change in subjects without amalgams, while for those with amalgam fillings it increases 8 to 10 folds, and remains elevated for at least 90 minutes.

Vimy and Lorscheider derived an average absorbed mercury dose of 10 μg per day from amalgam fillings from their measurements of mouth air.[12]Other groups have reported varying estimates. On the low end, Mackert[14] and Berglund et al[15], by applying assumptions and inferences concerning how much mouth air is actually inhaled, arrived at average daily doses for subjects with twelve or more amalgam surfaces, of 1.83 and 1.7 μg, respectively (not zero). The question of inhaling mouth air should be moot, though, because elemental mercury vapor is lipophilic, and is absorbed easily through cell membranes and mucosal barriers. On the high end, Patterson et al[15]reported absorbed doses of as much as 27 μg per day. Skare and Engqvist[16]by metabolic methods, arrived at a figure of 12 μg per day for a group of subjects with an average of 47 amalgam surfaces.

SPREAD OF MERCURY THROUGHOUT THE BODY

Frykholm[17] in his study of mercury in amalgam involved giving eight volunteers four new fillings each, labeled with radioactive Hg.[203] He was able to detect excretion of the radioactive mercury in urine for seven days, and in faeces for thirteen days. From this he concluded that the release of mercury from the fillings, while not zero, was self limiting, and should therefore be no problem for the exposed people.

Murray Vimy and Fritz Lorscheider undertook to use radioactive mercury to examine the question of tissue retention of mercury from amalgams fillings. They placed twelve occlusal fillings tagged with radioactive ^{203}Hg in the mouth of a sheep. The fillings were over-carved, not left high in the occlusion and the operators were careful to rinse all amalgam particles from the animal's mouth after placement. After twenty nine days, the sheep was killed, and the coronal portions of the teeth containing the radioactive fillings were removed. The sheep was placed in a full body gamma ray scanner showing translocation of radioactive mercury from the amalgam fillings into several organs. The teeth had been extracted prior to scanning, and the high concentration of radioactivity in the mouth region demonstrates movement of mercury into the jawbone from the fillings.[18]

Hahn et al[19]repeated the same experiment using a monkey, which would eat much the same food and chew in much the same way as humans. The results were virtually identical to those found with the sheep.The monkey experiment was confirmed by Danscher et. al.[20]

Tere is a multitude of scientific literature that shows thhat amalgam derived mercury spreads around the body, and that amalgam typically provides the greatest portion of the mercury to be found in the human body. Several autopsy studies showed a correlation between the mercury concentration in various tissues and organs of the human cadavers and the number of fillings or surfaces of amalgam present.[21-23]Blood levels of mercury correspond to amalgam exposure.[24]Subjects with amalgam excrete higher amounts of mercury in the faeces. Mercury in urine, blood, and faeces declines after amalgam removal.[25]

PLACENTAL TRANSFER OF MERCURY

Babies with their still-developing nervous systems are known to be more sensitive to the effects of mercury exposure than adults.This was made tragically clear in the case of the Minamata Bay methyl mercury poisoning, in Japan in the 1960's, where children were born with profound developmental disturbances, while the adults suffered much less. There is a substantial experimental literature on the neuroteratological effects of mercury, where both humans and animals exposed to low doses of mercury *in utero* and soon after birth show measurable deficits in intelligence, coordination, and other measures of neurological development. [26-33]

ALLERGY TO AMALGAM

Allergic reactions to mercury though rare but are reported. Djerassi and Berova[34]patch tested 180 subjects with amalgam fillings, and found that 16.1% of those without allergic disease, and 22.5% of those with allergic disease, tested positive for mercury allergy. Of sixty subjects without amalgam fillings, none tested positive for mercury allergy. In a study of 29 patients with oral lichen planus, 62% were positive for mercury allergy. [35]

Mercury exposure is known to induce autoimmune reactions in susceptible animals,[36-38] and one investigation shows the same for amalgam. Hultman et al[39] implanted gelatin coated particles of either finished amalgam or unmixed silver alloy in the peritoneal cavity of mice known

to be genetically susceptible to mercury induced autoimmune reactions. Over the course of the experiment, both groups displayed their characteristic reactions of hyperimmuno-globulinemia, serum autoantibodies targeting nucleolar proteins and systemic immune complex deposits.

RENAL IMPLICATIONS

Amalgam restorations releasing mercury have got severe urinary tract and renal implications. Molin et al[40]reported that urinary albumin increased in humans one year after removal of amalgams. Mercury is known to concentrate in the proximal tubules, which are the primary site of sodium reuptake, so it makes sense that urinary sodium excretion increased if the mercury is inhibiting the function of those cells. Although these effects could be described as "subclinical," in that overt disease was not induced, it demonstrates how much stress is placed upon the kidneys by the presence of amalgam, and suggests how patients with kidney malfunction may be endangered by amalgam fillings.

RISKS TO DENTIST

One of the statements in support of amalgam has been that dentists' health status is not different from that of the general population, despite the fact that we are exposed in our work to mercury. Due to the mercury hygiene rules promulgated by the profession, operators don't touch mixed amalgam with the hands while placing it into patients' teeth. They store excess amalgam in tightly closed containers under various liquids to prevent vapors from escaping in the operatory, dispose it properly etc. Inspite of that, there is evidence that mercury exposed dentists and staff do suffer various effects.

In a study by Echeverria et al[41], dentists with high baseline urinary mercury levels showed neuropsychological and motor control deficits. In another studies, dentists and staff with high mercury levels had altered porphyrin (hemoglobin) metabolism, as well as neurobehavioral changes, including impairment of attention, motor and perceptual skills and increased irritability.[42-43]

In a survey of 7,000 female dental assistants, a subgroup of 418 women who placed over 30 amalgams per week and had poor mercury hygiene habits, had a fertility rate of 63% that of control women not exposed to mercury. [44] Many other studies point to a negative effect of mercury vapor exposure on reproductive outcomes. Depression and mood alteration is a known feature of chronic mercury toxicity.[45-47]

REFERENCES

1. DeMaar FE. Historically, when and by whom was silver amalgam introduced? SciEdu Bull 1972;5(1):23-6.
2. Black GV. The physical properties of silver tin amalgams. Dent Cosmos 1896;36:965-92.
3. Stock A. Dicgefarhalichkeit des queeksilberdampfes und der amalgame[Danger from mercury and from amalgam fillings]. Med Klin 1926;22: 1209-12, 1250-2.
4. Dodes JE. The amalgam controversy- an evidence based analysis. J Am Dent Asso 2001;32:348-56.
5. Masi, JV. Corrosion of Restorative Materials: The Problem and the Promise. Symposium: Status Quo and Perspectives of Amalgam and Other Dental Materials 1994;April 29-May 1.
6. Masi, JV. Personal communication
7. Radics L, Schwander H, Gasser F. The crystalline components of silver amalgam studied using the electronic x-ray microprobe ZWR 79:1031-1036.
8. Gasser F. New studies on amalgam. Quintessenz 1976:47-53.
9. Gay et al. Chewing Releases Mercury from Fillings. Lancet 1979; 985, .
10. Patterson, JE et al. Mercury In Human Breath From Dental Amalgams. Bull Environ ContamToxicol 1985; 34:459-68.
11. Vimy MJ, Lorscheider FL. Dental amalgam mercury daily dose estimated from intro-oral vapor measurements: A predictor of mercury accumulation in human tissues. J Trace Elem Exper Med 1990;3:111-23.
12. Vimy MJ, Lorscheider FL. Serial measurements of intra-oral air mercury: estimation of daily dose from dental amalgam. J Dent Res1895; 64:1072-75.
13. Svare CW, Peterson LC, Reinhardt JW, Boyer DB, Frank CW, Gay DD, Cox RD. The effects of dental amalgams on mercury levels in expired air. J Dent Res1981; 60: 1668-71.
14. Mackert JR, Factors affecting estimation of dental amalgam mercury exposure from measurements of mercury vapor levels in intraoral and expired air. J Dent Res 1987; 66:1775-80.
15. Berglund, A. Estimation by a 24 hour study of the daily dose of intra-oral mercury vapor inhaled after release from dental amalgam. J Dent Res 1990; 69: 1646-51.
16. Skare I, Enkqvist A. Human exposure to mercury and silver released from dental amalgam restorations. Arch Environ Health1994; 49: 384-394.
17. Frykholm KO. On mercury from dental amalgam: its toxic and allergic effects and some comments on occupational hygiene. ActaOdontolScand 1957; 15 (supplement22): 7-108.
18. Hahn LJ, Kloiber R, Leininger RW, Vimy MJ, Lorscheider FL. Dental "silver " tooth fillings: a source of mercury exposure revealed by whole body scan and tissue analysis. FASEB J 1989; 3:2641-6.
19. Hahn LJ et al. Whole-Body Imaging of the Distribution of Mercury Released from Dental Fillings into Monkey Tissues. FASEB J 1990; 4:3256-609.

20. Danscher G et al. Traces of Mercury in Organs from Primates with Amalgam Fillings Experim MolecPathol 1990; 52:291-9.
21. Eggleston DW, Nylander M. Correlation of Dental Amalgam with Mercury in Brain Tissue. J Prosth Dent 1987; 58(6):704-7.
22. Friberg L et al. Mercury in the Central Nervous System in Relation to Amalgam Fillings. Swed Med J 1986; 83(7):519-22.
23. Nylander M et al. Mercury concentrations in the human brain and kidneys in relation to exposure from dental amalgam fillings. Swed Dent J 1987; 11:179-87.
24. Snapp KR, Boyer DB, Peterson LC, Svare CW. The contribution of dental amalgam to mercury in blood. J Dent Res 1989; 68: 780-785.
25. Molin M, Bergman B, Marklund SL, Schutz A, Skerfving S. Mercury, selenium, and glutathione peroxidase before and after amalgam removal in man. ActaOdontolScand 1990; 48: 189-202.
26. Berlin M et al. Prenatal Exposure to Mercury Vapor: Effects on Brain Development. The Toxicologist 1992;12(1):7(A245).
27. Grandjean P et al. Cognitive Deficit in 7 Year Old Children With Prenatal Exposure to Methyl Mercury. Neurotoxicol Teratol 1997; 19(6):417-28.
28. Grandjean P et al. Cognitive Performance of Children Prenatally Exposed to "Safe" Levels of Methyl Mercury. Environ Research 1998;77(2):165-72.
29. Danielsson BR et al. Behavioral Effects of Prenatal Metallic Mercury Inhalation Exposure in Rats. NeurotoxicolTeratol 1993;15(6):391-6.
30. Aschner M et al. Metallothionein Induction in Fetal Rat Brain and Neonatal Primary Astrocyte Cultures by In Utero Exposure to Elemental Mercury Vapor. Brain Res 1997; 778(1):222-32.
31. Eccles CU, Annau Z. Prenatal Methyl Mercury Exposure: II. Alterations in Learning and Psychotropic Drug Sensitivity in Adult Offspring. NeurobehavToxicolTeratol 1982; 4(3):377-82.
32. Fredriksson A et al. Behavioral Effects of Neonatal Metallic Mercury Exposure in Rats. Toxicology 1992; 74(2-3):151-60.
33. http://altcorp.com/thimerosal. htm .
34. Djerassi E, Berova N. The possibilities of allergic reactions from silver amalgam restorations. Internat Dent J 1969; 19(4):481-8.
35. Finne,, K et al. Oral Lichen Planus and Contact Allergy to Mercury. Int J Oral Surg 1982; 11:236-9.
36. Druet P et al. Immune dysregulation and auto-immunity induced by toxic agents. Transplant Proc 1982;14(3):482-4.
37. Druet P, Bernard A, Hirsch F, Weening, JJ, Gengoux P, Mahieu P, Berkeland S. Immunologically Mediated Glomerulonephritis Induced by Heavy Metals. Arch. Toxicol 1982; 50:187-94.
38. Hirsch F, Kuhn J, Ventura M, Vial MC, Fournie G, Druet P. Autoimmunity Induced by HgCI2 in Brown-Norway Rats: I. Production of monoclonal antibodies. J Immunol 1986; 136(9):3272-6.
39. Hultman P, Johansson U, Turley SJ, Lindh U, Enestrom S, Pollard KM. Adverse Immunological Effects and Autoimmunity Induced by Dental Amalgam and alloy in Mice. FASEB J 1984;8(14):1183-90.
40. Molin M et. al. (1990) op. Cit.
41. Echeverria, D; Heyer, N; Martin, MD; Naleway, CA; Woods, JS; Bittner, AC. Behavioral Effects of Low-Level Exposure to Hg^0 Among Dentists. NeurotoxicolTeratol 1995; 17(2):161-8.
42. Gonzalez-Ramirez, D; Maiorino, RM; Zuniga-Charles, M; Xu, z; Hurlbut, KM; Junco-Munoz, P; Aposhian, MM; Dart, RC; Gama, JHD; Escheverria, D; Woods, JS; Aposhian, HV. . Sodium 2,3-Dimercaptopropane-1-Sulfonate Challenge Test for Mercury in Humans: II. Urinary Mercury, Porphyrins and Neurobehavioral Changes of Dental Workers in Monterrey, Mexico. J PhrarmacolExperimTher 1995; 272:264-74.
43. Echeverria, D; et al. Neurobehavioral Effects From Exposure to Amalgam Hg0: New Distinctions Between Recent Exposure and Hg Body Burden. FASEB J 1998; 12:971-80.
44. Rowland, AS; et al. The Effect of Occupational Exposure to Mercury Vapour on the Fertility of Female Dental Assistants. Occupat Environ Med 1994;51:28-34.
45. Gerhard, I; et al. Heavy Metals and Fertility. J Toxicol Environ Health 1998; 54(8):593-611.
46. Lee, IP. Effects of Environmental Metals on Male Reproduction. In: Reproduction and Developmental Toxicity of Metals; Ed: Clarkson, TW; et al.:253-78, Plenum Press, NY, 1983.
47. Uzzell, GP; Oler, J. Chronic low level mercury exposure and neuropsychological functioning. J Clin Exper Neuropsych 1986; 8: 581-593.

Corresponding Address:
Dr. Anuraag Gurtu
Email: dranuraaggurtu@gmail.com