SIDE-EFFECTS: MERCURY CONTRIBUTION TO BODY BURDEN FROM DENTAL AMALGAM

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Adv Dent Res 6:110-113, September, 1992

Abstract—The purpose of this paper is to examine and report on studies that relate mercury levels in human tissues to the presence of dental amalgams, giving special attention to autopsy studies. Until recently, there have been few published studies examining the relationship between dental amalgams and tissue mercury levels. Improved and highly sensitive tissue analysis techniques have made it possible to measure elements in the concentration range of parts *per* billion.

The fact that mercury can be absorbed and reach toxic levels in human tissues makes any and all exposure to that element of scientific interest. Dental amalgams have long been believed to be of little significance as contributors to the overall body burden of mercury, because the elemental form of mercury is rapidly consumed in the setting reaction of the restoration. Studies showing measurable elemental mercury vapor release from dental amalgams have raised renewed concern about amalgam safety.

Mercury vapor absorption occurs through the lungs, with about 80% of the inhaled vapor being absorbed by the lungs and rapidly entering the bloodstream. Following distribution by blood circulation, mercury can enter and remain in certain tissues for longer periods of time, since the half-life of excretion is prolonged. Two of the primary target organs of concern are the central nervous system and kidneys.

This manuscript is published as part of the proceedings of the NIH Technology Assessment Conference on Effects and Side-effects of Dental Restorative Materials, August 26-28, 1991, National Institutes of Health, Bethesda, Maryland, and did not undergo the customary journal peer-review process.

AUTOPSY STUDIES

There have been three recent autopsy studies relating the presence of dental amalgams in humans to mercury levels in tissue. In one study, specimens of white and gray matter from the brain were collected from 83 cadavers in Los Angeles County (Eggleston and Nylander, 1987). Tissue samples were analyzed by neutron activation analysis. Subjects were chosen as a non-randomized convenience sample, and each subject's death was sudden and unexpected. The subjects ranged from 13 to 59 years old, with the average age less than 30 years.

The investigators gave each cadaver a dental examination, after which they were segregated into one of three categories as controls, intermediates, or subjects. Controls were those who had 0 to 1 occlusal surfaces of amalgam and at least 14 posterior teeth. Intermediates had from 1.5 to 4 occlusal surfaces of amalgam. Subjects were those who had at least 5 surfaces of dental amalgam and a minimum of 10 posterior teeth.

Analysis of the tissue samples indicated that, for both white and gray matter, intermediates had tissue mercury levels significantly higher than those of controls ($p < 0.025$), and subjects also had higher mercury levels than controls ($p < 0.011$). Table 1 shows the mean tissue levels for gray matter. There was a progressive increase in tissue levels of mercury between groups with increasing occlusal amalgam surfaces. Likewise, for white matter (Table 2), there were increasing tissue mercury levels with increasing occlusal amalgams.

In conclusion, the authors stated that there was a positive correlation between the number of occlusal amalgam surfaces and mercury levels in the brain. In essence, their statistical analysis showed a significant difference between controls and subjects at probability levels of less than 0.011 and a difference between intermediates and controls at probability levels of less than 0.025.

A similarly designed study examined mercury levels in the CNS and kidneys (Nylander *et al.*, 1987). The 34 autopsy samples were collected in Stockholm, Sweden. In this study, the cases were selected randomly, over a period of about one year. By use of the same analytic technology, data were collected from the occipital lobe, cerebellum, semilunar ganglion, and kidney.

The data were subjected to linear regression analysis. The results showed a statistically significant correlation between number of amalgam surfaces and total mercury levels in the occipital cortex, with a p-value of < 0.001 and a correlation coefficient of 0.54. The regression equation $y = 7.2 + 0.24x$ had a 95% confidence interval for the regression coefficient of 0.11-0.37. Nine of the samples were taken from suspected alcohol abusers, and in those cases, mercury levels were somewhat lower than expected from the regression equation.

TABLE 1
ANALYSIS OF Hg IN GRAY MATTER*
(expressed as mean ng/g)

Controls	Intermediates	Subjects
(16)	(16)	(51)
6.70	10.57	15.21

* Mean age = 28.7 years.

TABLE 2
ANALYSIS OF Hg IN WHITE MATTER*
(expressed as mean ng/g)

Controls	Intermediates	Subjects
(13)	(12)	(35)
3.80	6.58	11.22

* Mean age = 29.8 years.

The kidney cortex was analyzed from seven subjects who had from 11 to 33 surfaces containing amalgam and also from five amalgam-free individuals. The individuals with amalgams had a mean concentration of 433 ng of Hg *per* g of wet tissue. The amalgam-free individuals had a mean kidney tissue level of 49 ng/gm. This difference was again statistically significant at a probability level of < 0.02.

In addition, six of the specimens from the occipital cortex were analyzed for inorganic and total mercury. The results showed that 77% of the mercury detected was inorganic.

Another Swedish study compared eight deceased dental staff (seven dentists, one assistant) and 27 deceased control subjects (non-dental staff) for mercury levels in the CNS, kidney, and various organs and glands (Nylander *et al.*, 1989). The groups were similar in terms of mean amalgam surfaces, as seen in Table 3. Four of the dental staff subjects had amalgams, and the dental status of the other four was unknown. Twenty of the control subjects had amalgams. There were five males among the eight dental staff members, and 23 males among the 27 controls. The dental staff subjects had mean tissue mercury concentrations that were from five to ten times greater than the controls in the occipital cortex, pituitary gland, and kidney, as shown in Table 4.

The subjects with the highest levels of mercury in their occipital cortices (cases 1 and 2 in Table 5) were the oldest subjects, who had not been practicing for several years and 15 years, respectively, prior to death. It is highly probable that they lacked the environmental awareness of potential mercury hazards that their later colleagues had. Those same two dentists also had the highest pituitary gland levels (Table 6). It is interesting to note that the dental staff person with the largest number of amalgams (case no. 7) had the lowest level of pituitary mercury concentration.

Table 7 shows the kidney levels of mercury for the four dental staff measured. The mean level of concentration for control subjects was 273 µg/kg. Although limited in size, this study indicates that mercury vapor exposure in dental practice can lead to increased tissue levels in the kidneys, some endocrine glands (including the pituitary), and the CNS.

TABLE 3
COMPARISON GROUPS

	Total No.	Gender (M/F)	Amalgam Surfaces	Subjects With Amalgams
Dental Staff	8	5/3	20	(N = 4)
Control Subjects	27	23/4	17.2	(N = 20)

In order to keep these tissue mercury levels in perspective, it is useful to compare them with data collected in other studies. A study conducted in Seattle looked at total mercury burden in 14 autopsied organs from 113 persons, covering a very broad range of ages (Mottet and Body, 1974). The autopsies were performed on a non-randomized sample of convenience. Table 8 shows a summary of some of the data. Note especially the level of kidney mercury (757 µg/kg). This is approximately triple the kidney level of the controls measured in the Swedish study and approximately one-half of the kidney level of the dental staff subjects (Table 4).

The Seattle study concluded that urban populations have a greater mercury tissue burden than do rural populations. In addition, they stated that the data did not reveal a statistically significant increase in tissue levels of mercury with age. The researchers concluded that past environmental exposure levels did not exceed the capacity of the body to eliminate mercury.

MERCURY LEVELS IN INDIVIDUALS WITH PARKINSON'S AND ALZHEIMER'S DISEASES

In an epidemiologic case-control study of mercury body burden and idiopathic Parkinson's disease, subjects living in Singapore were measured for mercury levels in blood, urine, and scalp hair (Ngim and Devathasan, 1989). Although this study did not deal with *post mortem* tissue levels, it seems quite appropriate to mention it along with the autopsy studies. There were 54 cases with idiopathic Parkinson's disease and 95 matched controls. Subjects with Parkinson's disease had significantly higher mean levels of mercury in all three media than did the controls. Table 9 shows the number of Parkinson's cases and controls which fell into three categories of blood mercury levels.

These blood levels may be somewhat elevated due to the fact that the population of Singapore is multi-ethnic, made up primarily of Chinese, Malays, and Indians. Each group is known to use considerable amounts of ethnic medicines which are over-the-counter preparations and often contain mercury. In summary, the authors concluded that the body burden of

TABLE 4
MERCURY IN TISSUES (expressed as µg/kg*)

	Occipital Cortex Hg	Pituitary Gland Hg	Renal Cortex Hg
Dental Staff	61	1599	1533
Control Subjects	11	108	273

* Based on data from Nylander *et al.* (1989).

TABLE 5
INDIVIDUAL DENTAL STAFF OCCIPITAL CORTEX LEVELS OF MERCURY*

Case No.	Sex	Age	Amalgam Surfaces	Occitipal Cortex Hg µg/kg
1	M	80	10	300
2	M	82	NA	84
3	M	60	NA	16
4	F	57	NA	4
5	M	50	NA	39
6	F	30	20	13
7	M	61	40	14
8	F	67	10	18
Mean		61	20	61

* Based on data from Nylander *et al.* (1989).

TABLE 6
INDIVIDUAL DENTAL STAFF PITUITARY LEVELS OF MERCURY*

Case No.	Sex	Age	Amalgam Surfaces	Pituitary Gland Hg µg/kg
1	M	80	10	4040
2	M	82	NA	3650
3	M	60	NA	2690
4	F	57	NA	350
5	M	50	NA	350
6	F	30	20	300
7	M	61	40	135
8	F	67	10	1280
Mean		61	20	1599

* Based on data from Nylander *et al.* (1989).

TABLE 7
INDIVIDUAL DENTAL STAFF KIDNEY LEVELS OF MERCURY*

Case No.	Sex	Age	Amalgam Surfaces	Renal Cortex Hg µg/kg
1	M	80	10	
2	M	82	NA	2110
3	M	60	NA	1545
4	F	57	NA	
5	M	50	NA	945
6	F	30	20	
7	M	61	40	
8	F	67	10	
Mean		61	20	153

* Based on data from Nylander *et al.* (1989).

TABLE 8

MEAN MERCURY LEVELS (expressed as μg/kg mercury*)

Tissue	Level	Tissue	Level
Kidney	757	Spleen	122
Liver	250	Pancreas	65
Heart	102	Cerebellum	132
Muscle	126	Cerebrum	81
Lung	251	Cord	87

* Based on data from Mottet and Body (1974).

TABLE 9

THE DISTRIBUTION OF INDIVIDUALS WITH PARKINSON'S DISEASE AND CONTROLS AT THREE LEVELS OF BLOOD MERCURY*

Parkinson's Cases	Controls	Hg ng/mL
6	46	0 - 5.8
20	28	5.9-14.2
28	21	14.3+

* Based on data from Ngim and Devathasan (1989).

mercury is strongly associated with Parkinson's disease.

Another recent study used case-control methodology to compare trace element levels in various CNS subcellular areas of autopsied cases with Alzheimer's disease and normal controls (Wenstrup *et al.*, 1990). The study measured the levels in 10 Alzheimer's disease patients and 12 controls who had no history of dementia, other neurological disorders, or systemic diseases affecting the brain. Table 10 shows a summary of the statistically significant relationships of mercury levels in various subcellular fractions taken from the temporal lobe of the cerebrum of each subject. The Alzheimer's subjects had significantly higher levels of mercury in their microsomes, higher ratios of mercury to selenium in both their cellular nuclei and microsomes, and an elevation of mercury relative to zinc in the microsomes. In their overall conclusions, the authors reported that they found elevated mercury and bromine, as well as diminished rubidium, selenium, and zinc in certain cellular areas of the Alzheimer's cases. They expressed concern not only about the elevated mercury, but also about the diminished selenium and zinc levels, because these elements help protect biological tissue against mercury toxicity. The authors recommended that future studies should determine whether elevated mercury levels in the brain with Alzheimer's disease is a primary event or represents deposition of mercury on a degenerating brain.

CONCLUSIONS

In summary, the studies reviewed in this paper indicate that mercury vapor exposure from environmental sources or dental amalgams appear to contribute to tissue burdens, especially in the CNS, kidneys, and certain glands. Further studies must be conducted for verification of that occurrence, as well as for exploration of whether the contribution is of significance to human health. Broad-scale studies should be conducted on the question of whether the presence of amalgam restorations can cause impairment of physical or mental health. Studies should be designed to determine the physical and mental health of dental care providers relative to their peers, since those providers as a group appear to bear significantly higher tissue levels of mercury than comparable control subjects. Finally, there should be further replication by other investigators of studies relating dental amalgam restorations to tissue levels of mercury.

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TABLE 10

SUMMARY OF MERCURY CONTENT IN SUBCELLULAR FRACTIONS FROM INDIVIDUALS WITH ALZHEIMER'S DISEASE AND CONTROLS*

	Controls	Alzheimer's	Significance
Hg (ng/g) Microsomes	40.0	59.8	$p < 0.05$
Hg/Se Nuclei	0.080	0.166	$p < 0.01$
Hg/Se Microsomes	0.134	0.331	$p < 0.01$
Hg/Zn Microsomes	1.49	3.11	$p < 0.01$

* Based on data from Wenstrup *et al.* (1990).