Int Arch Occup Environ Health (1987) 59:551–557

Women in dental surgeries: reproductive hazards in occupational exposure to metallic mercury

Radzisław Sikorski[1], Teodor Juszkiewicz[2], Tomasz Paszkowski[1], and Teresa Szprengier-Juszkiewicz[2]

[1] Clinic of Gynaecology, Institute of Obstetrics and Gynaecology, Academy of Medicine, Lublin, Poland
[2] Department of Pharmacology and Toxicology, Institute of Veterinary Research, Puławy, Poland

Summary. Eighty-one women (45 dentists and 36 dental assistants) occupationally exposed to metallic mercury underwent a toxicoclinical examination. Total mercury lebels (TMLs) were determined in scalp and pubic hair by cold vapour AAS. Furthermore a detailed questionnaire study was made concerning adverse reproductive events. TMLs in the hair of the exposed women examined exceeded significantly those determined in the hair of 34 controls not exposed to mercury. All exposed women had continued working during pregnancy. There was a significant, positive association between TMLs in the hair of exposed women and the occurrence of reproductive failures in their history. The relation between TMLs in the scalp hair and the prevalence of menstrual cycle disorders was statistically significant. These findings indicate that dental work could be another occupational hazard with respect to reproductive processes.

Key words: Metallic mercury – Reproduction – Spontaneous abortion – Congenital malformation – Menstrual disorders

Introduction

Increasing occupational exposure of women to toxic chemicals seems to constitute one of the causal agents leading to the drastically increasing prevalence of adverse reproductive events in modern society [11]. Among the environmental contaminants with possible reproductive toxicity, mercury and its compounds are currently receiving a great deal of attention. As reviewed by Koos and Longo [16], all available empirical and experimental evidence indicates that mercury possesses a considerable gametotoxic, mutagenic and embryofeto-

Offprint requests to: R. Sikorski, Klinika Ginekologii, Jaczewskiego 8, 20-090 Lublin, Poland

pathologic potential in many of its chemical forms, including metallic mercury vapour. Mercury-induced oestrus cycle impairments seem to be due to the disregulating effect of mercury on the hypothalamic-pituitary-gonadal axis [18]. Inhaled mercury vapour readily crosses through to the placenta [7]. Concentration of mercury in the cord blood was close to that in the blood of mothers who had been exposed to mercury during pregnancy [6]. Compared to the general population, an increased prevalence of menstrual disorders was observed in women working in dental surgeries with air mercury contents not exceeding 0.08 mg/m^3 [27].

About 3% of the mercury produced yearly in the world is used in dentistry as an amalgam substrate [4]. Mercury can contaminate dental surgeries when filling material is being prepared, using open mortar or a poorly maintained automatic amalgamator. Elevated mercury levels were determined in blood and urine obtained from dental personnel [5, 14, 15]. Considering the large number of female dental team workers exposed to mercury, the urgent need to evaluate the adverse effects of such exposure on reproduction has recently been emphasized [8].

The main purpose of the present study was to elaborate on the possible ways metallic mercury exposure may affect the reproductive processes of women working in dental surgeries. Simultaneously an attempt was made to elucidate the toxicoclinical value of scalp and pubic hair analyses as indicators of long-term mercury exposure.

Subjects and methods

The subjects for the study were randomly recruited from a population of women occupationally exposed to metallic mercury in dental service surgeries in the Lublin region of south-eastern Poland. Eighty-one women (45 dentists and 36 dental assistants) underwent both toxicologic and questionnaire examination. The detailed, anonymous questionnaire concerned demographic data, reproductive history and working conditions. Samples of head and pubic hair were taken from those women as well as from 34 women not exposed professionally to mercury who served as a control group. Hair was chosen for the present study because it constitutes a material easy to sample, store and analyze. It has been shown that human hair can be used as an indicator for long-term exposure to mercury [1]. It therefore gives, unlike blood and urine, not only information about actual levels, but also about past exposure. Some authors have suggested that pubic hair is more useful than scalp hair in assessing human exposure to environmental mercury [3, 12, 13, 20]. Compared to scalp hair, pubic hair is less exposed to external contamination with dust, smoke, cosmetics, etc. Therefore pubic hair analysis seems to reflect mercury intake by an examined individual more accurately than scalp hair examination.

Hair samples were washed prior to analysis in a mercury-free detergent, repeatedly rinsed with redistilled water and then dried at room temperature. Total mercury was determined by cold vapour atomic absorption spectrometry after digestion of samples with sulphuric, nitric and perchloric acids. The analytical procedure has been presented elsewhere in detail [26]. The age of women in the exposed group ranged from 21 to 56 years and in the control group from 20 to 46 years.

Since a skewing to the right of the determined TMLs was observed in the exposed group, estimates given are ranges and geometric means. Statistical analysis was done on the hair mercury determinations and questionnaire data by means of nonparametric methods such as the Spearman rank correlation coefficient (r_s), Mann-Whitney U-test and Wilcoxon matched-pairs signed-ranks test [23].

Table 1. Total mercury levels determined in the hair of the women examined (in mg/kg)

Material	Group	N	Range	Geometric mean	Significance of difference[a]
Scalp hair	D	45	0.042–27.344	0.505	$U = 799$
	DA	36	0.043–59.546	0.542	$P = 0.912$
	D + DA	81	0.042–59.546	0.527	$U = 758$
	C	34	0.017– 0.308	0.100	$P = 0.00014$
Pubic hair	D	45	ND – 2.120	0.330	$U = 615.5$
	DA	36	ND –18.166	0.510	$P = 0.0568$
	D + DA	81	ND –18.166	0.381	$U = 741$
	C	34	ND – 0.524	0.060	$P = 0.0001$

[a] Mann-Whitney U test

D: dentists; DA: dental assistants; D + DA: all exposed women examined; C: nonexposed control women; ND: not detected

Results

Table 1 shows the results of mercury determinations in the hair of examined women. TMLs determined in the hair of examined dental team workers exceeded significantly those measured in non-exposed controls (for scalp and pubic hair, $P = 0.00014$ and 0.0001, respectively; Mann-Whitney U-test). The dispersion of TMLs in the hair of exposed women was found to be much greater than in the control group. Geometric means of TMLs in scalp and pubic hair of the dental assistants examined were higher than those determined in the hair of dentists, although these differences were not statistically significant (for scalp and pubic hair $P = 0.912$ and 0.0658, respectively; Mann-Whitney U-test). A statistically significant correlation was established between TMLs in scalp hair and the concentrations of this metal in pubic hair in both exposed ($r_s = 0.550$, $P = 0.000001$) and control ($r_s = 0.501$, $P = 0.00001$) groups. Scalp hair TMLs measured in the examined women exceeded on average their pubic hair values by 35.3% and the difference was significant ($P = 0.040$; Wilcoxon matched-pairs signed-ranks test).

The number of years of work in the dental profession ranged in the women examined from 0.5 to 27 years and appeared to have a statistically significant effect on the determined scalp ($r_s = 0.500$, $P = 0.00001$) and pubic ($r_s = 0.311$, $P = 0.0036$) hair TMLs. The number of amalgam fillings prepared or placed per week by the women examined ranged from 4 to 96. The number of amalgam fillings used per week was established to affect significantly mercury deposits in scalp ($r_s = 0.378$, $P = 0.00032$) and pubic ($r_s = 0.239$, $P = 0.0292$) hair.

Fifty-seven out of the 81 female dental team workers had at least one pregnancy before the day of examination. All these women had occupational contact with filling materials containing mercury during pregnancy, including its first trimester. Of 117 pregnancies (57 women) with a known outcome and which had taken place in the mercury-exposed group, 28 pregnancies (23.9%) in 19

Table 2. Adverse pregnancy outcomes in the history of exposed women

Pregnancy outcome		Number of cases	%[a]
Spontaneous abortion		19	16.2
Stillbirth		3	2.6
Congenital malformation		6	5.1
– spina bifida	5		
– interatrial defect	1		
Total		28	23.9

[a]Percentage of the total number of pregnancies in the exposed group (117)

Table 3. Hair TMLs in relation to reproductive failures in the history of the exposed women (geometric means)

TMLs in the hair (mg/kg)	RF(+)[a]	RF(−)[b]	Significance of difference[c]
Scalp	1.516	0.461	U = 184 P = 0.0038
Pubic	0.887	0.167	U = 140 P = 0.00032

[a] Reproductive failures in the history
[b] No reproductive failures in the history
[c] Mann-Whitney U-test

women terminated with reproductive failure, such as spontaneous abortion, stillbirth or congenital malformation (Table 2). This contrasts with seven adverse pregnancy outcomes (11.1%) in five women, out of 63 pregnancies (30 women) in the history of non-exposed control women. Reproductive failures in the history of exposed women were significantly associated with TMLs determined in their scalp ($P = 0.0038$; Mann-Whitney U-test) and pubic ($P = 0.00032$; Mann-Whitney U-test) hair (Table 3) while no such relationship was found in the non-exposed women (for scalp and pubic hair TMLs: $P = 0.8808$ and 0.9282, respectively; Mann-Whitney U-test).

Of the 45 exposed women who were examined and who were younger than 40, fourteen (31.1%) complained of menstrual disorders, which they described as irregular, painful or haemorrhagic menstrual bleeding. The prevalence of menstrual disorders in exposed women was significantly associated with the number of years worked in the dental profession ($P = 0.0052$; Mann-Whitney U-test). The relation between hair TMLs in the exposed women and the prevalence of menstrual disorders was established to be statistically significant in the case of scalp hair ($P = 0.0444$; Mann-Whitney U-test; Table 4). When analyzed for pubic hair TMLs, the relationship described above was no longer significant

Table 4. Hair TMLs in relation to menstrual disorders in the exposed women (geometric means)

TMLs in the hair (mg/kg)	MD(+)[a]	MD(−)[b]	Significance of difference[c]
Scalp	0.570	0.305	U = 135 P = 0.044
Pubic	0.330	0.365	U = 181 P = 0.378

[a] Menstrual disorders
[b] No menstrual disorders
[c] Mann-Whitney U-test

Table 5. Cases of excessively high mercury concentrations determined in the hair of examined women confronted with reproductive failures in their case history

Item	Profession	Total mercury levels in hair		Reproductive failures
		Scalp (mg/kg)	Pubic (mg/kg)	
1	DA	59.546	18.166	2× ab; 1× malf
2	D	27.344	0.520	1× ab
3	DA	3.101	3.793	2× ab
4	DA	4.965	0.666	Not known
5	D	3.832	0.346	3× ab; 1× malf
6	DA	0.608	3.043	Not known
7	DA	2.397	0.579	Not known
8	DA	2.295	1.112	1× ab; 1× malf
9	D	1.292	2.120	1× malf

D: dentist; DA: dental assistant; ab: spontaneous abortion; malf: congenital malformation

($P = 0.378$; Mann-Whitney U-test). Of the 21 non-exposed control women up to 40 years old, four (19.0%) had menstrual disorders. The occurrence of menstrual disorders in the control group was not associated significantly with TMLs in their scalp and pubic hair ($P = 0.926$ and 0.8808, respectively; Mann-Whitney U-test).

Discussion

Elevated mercury concentrations in the hair of dental personnel have been detected by various authors [9, 10, 17, 19, 21, 24, 25]. Most studies concerned scalp hair, and pubic hair was used only in a few cases [9, 17]. Mercury levels reported by the above-mentioned authors exceeded values obtained by us. This difference may be due to the dissimilarities in analytical procedures as well as to the different background mercury exposure level in Poland in comparison with countries in which the other studies were carried out [2, 13].

Sinclair et al. and Lenihan et al. observed in the dentists studied that hair mercury levels correlated significantly with the number of years in practice [17, 24]. No such relationship was found however by Gutenmann et al. [9]. Brady et al. found that the number of amalgam fillings inserted per week had little effect on blood mercury levels in dentists [5]. Our results suggest that hair mercury concentration can be considered as the measure of certain occupational factors like dental practice characteristics.

Extensive use of mercury-containing materials in dentistry is well known as a hazard to the general health. The effect on reproduction, however, is almost unexplored. The surprisingly high prevalence of reproductive failures and menstrual disorders observed in the dental team workers examined as compared to a control group needs to be confirmed in a larger study. It is difficult, however, to consider our results merely due to chance or any form of bias. To illustrate this, Table 5 presents the reproductive history of the exposed women with the highest TMLs in hair.

For the moment we consider dental surgery personnel as another professional group exposed to reproduction-toxic chemicals in their work environment. This forms an additional argument for the reduction of mercury contamination in dental laboratories. Apart from certain preventive measures recommended in occupational contact with mercury [22], dental personnel should be well informed about the toxic potential of this metal. In our study, almost 60% of exposed women knew very little about the reproductive toxicity of mercury.

References

1. Airey D (1983) Mercury in human hair due to environment and diet: a review. Environ Health Persp 52:303–316
2. Airey D (1983) Total mercury concentrations in human hair from 13 countries in relation to fish consumption and location. Sci Total Environ 31:157–180
3. Benson W, Gabica J (1972) Total mercury in hair from 1000 Idaho residents – 1971. Pestic Monit J 6:8–83
4. Berlin M (1979) Mercury. In: Friberg L (ed) Handbook on the toxicology of metals. Elsevier North Holland Biomedical Press, Amsterdam New York Oxford, pp 503–530
5. Brady J, Gemmiti-Nunn D, Polan A, Mitchell D, Weil R (1980) The relationship of dental practice characteristics to blood mercury levels. NY State Dent J 46:420–424
6. Clarkson T (1977) Mercury poisoning. In: Brown S (ed) Clinical chemistry and chemical toxicology of metals. Elsevier North Holland Biomedical Press, Amsterdam New York, pp 189–200
7. Clarkson T, Magos L, Greenwood M (1972) The transport of elemental mercury into fetal tissues. Biol Neonate 21:239–244
8. Clarkson T, Nordberg G, Sager P, Berlin M, Friberg L, Mattison D, Miller R, Mottet N, Nelson N, Parizek J, Rodier P, Sandstead H (1983) An overview of the reproductive and developmental toxicity of metals. In: Clarkson T, Nordberg G, Sager P (eds) Reproductive and developmental toxicity of metals. Plenum Press, New York London, pp 1–25
9. Gutenmann W, Silvin J, Lisk D (1973) Elevated concentrations of mercury in dentists' hair. Bull Environ Contam Toxicol 9:318–320
10. Helsby C (1976) Determination of mercury in fingernails and body hair. Anal Clin Acta 82:427–430

11. Hemminki K, Niemi ML, Kyyronen P, Koskinen K, Vainio H (1983) Spontaneous abortion as risk indicator in metal exposure. In: Clarkson T, Nordberg G, Sager P (eds) Reproductive and developmental toxicity of metals. Plenum Press, New York London, pp 369–380
12. Hopps H (1977) The biologic bases for using hair and nail for analyses of trace elements. Sci Total Environ 7:71–89
13. Juszkiewicz T, Szprengier T, Radomański T (1981) Mercury content in human pubic and scalp hairs. Nat Sci 3:53–62
14. Kelman G (1978) Urinary mercury excretion in dental personnel. Br J Ind Med 35:262–265
15. Kessel R, Bencze K, Hamm M, Sonnabend E (1980) Untersuchungen über die Quecksilber-Konzentrationen in der Raumluft, im Blut und im Urin bei zahnärztlicher Tätigkeit in Klinik und freier Praxis. Dtsch Zahnärztl Z 35:457–461
16. Koos B, Longo L (1976) Mercury toxicity in pregnant women, fetus and newborn infant. Am J Obstet Gynecol 127:390–409
17. Lenihan J, Smith H, Harvey W (1973) Mercury hazards in dental practice. Br Dent J 135:363–369
18. Mattison D (1983) Reproductive and developmental toxicity of metals – female reproductive system. In: Clarkson T, Nordberg G, Sager P (eds) Reproductive and developmental toxicity of metals. Plenum Press, New York London, pp 42–91
19. Nixon G, Smith H (1965) Hazards of mercury poisoning in the dental surgery. J Oral Ther Pharmacol 1:512–514
20. Nord P, Kadaba M, Sorenson J (1973) Mercury in human hair. Arch Environ Health 27:40–44
21. Prichard J, McMullin J, Sikondari A (1982) The prevalence of high mercury levels in dentists' hair. Br Dent J 153:333–336
22. Recommendation in dental mercury hygiene – editorial (1984) J Am Dent Assoc 109:617
23. Siegel S (1956) Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Company, Inc., New York Toronto London
24. Sinclair P, Turner P, Johns R (1980) Mercury levels in dental students and faculty measured by neutron activation analysis. J Prosthet Dent 43:581–585
25. Stanković M, Milić S, Djurić D, Stanković B (1977) Cadmium lead and mercury content of human scalp hair in relation to exposure. In: Brown S (ed) Clinical chemistry and chemical toxicology of metals. Elsevier North Holland Biomedical Press, Amsterdam New York, pp 327–331
26. Szprengier T (1977) Zmodyfikowana metoda oznaczania rtęci w materiale biologicznym z zastosowaniem spektrofotometrii atomowo-absorpcyjnej. Med Weter 33:182–185
27. Vikstraitisz J (1967) Nositelstvo rtutu i sosoianie zdrovia ženshtchin rabotajushtchih v stomatologitcheskih kabinetah. Vopr Epidemiol Gig Lit SSR 4:234–239

Received May 23, 1986 / Accepted May 4, 1987