Assessment of chronic neuropsychological effects of mercury vapour poisoning in chloral-alkali plant workers

Nurka Pranjić, Osman Sinanović, Jasenko Karamehić, Rušid Jakubović,
Clinical Hospital Tuzla, Department of Occupational Medicine, Department of Neuropsychiatry, Department of Pharmacology, University School of Medicine Tuzla, Bosnia and Herzegovina

Abstract:

A prospective case study was conducted in the Department of Occupational Medicine, Tuzla. The purpose of this study was to indicate negative effects from occupational exposure to mercury on behavioural and mental health, memory and psychomotor function that was tested in 46 chloral-alkali plant workers (mean age was 38. 8+/- 5. 7 years; mean age of occupational history 16. 5+/- 6. 0 years). Data on toxicological monitoring on atomic absorption spectrometer, and data on mental health were collected, psychiatric and other subjective symptoms, and behavioural, psychomotor and memory function tested. The data were compared to control group, 32 healthy non exposed workers. The study was designed to assess blood and urine mercury levels and length of occupational exposure and investigate its relationships to effects on the mental health. The mean air mercury levels were 0. 23 mg/m^3, the mean blood mercury concentrations was 3. 6 μg/ dl and the mean urine mercury concentrations were 151.7 +/- 180.4 μg/l. In 25 (53%) workers exposed to mercury vapour was identified Depression-Hypochondrias Syndrome (p trend < 0. 001) with higher scores for scales: Hysteria (p trend <0. 001), Schizoid and Psychoastenia (MMPI). All psychological parameters were in highly significantly correlations with mercury levels and length of occupational exposure. Pathological parameters were possible general identified if the concentration of blood mercury levels are >2. 9 μg/ dl, or urine mercury levels > 87 μg/l workers exposed to mercury vapour knew that toxic effects in body resulted in loosing some of intellectual abilities, and that people who handle chemicals had an increased health risk (ESW questionnaire). The occupational mercury exposed workers had introvert behaviour (EPQ). Aggressiveness was found in 71.7% workers. The cognitive disturbances: short-term memory loss, difficult to concentrate on tasks which require attention and thinking, were significantly differed compared to those of controls (p trend < 0. 001). In 24 (52%) exposed to mercury workers we have determined ego strength loss and regressive defensive mechanisms (LB). Handwriting disturbances-micrography we have identified in 27 (58.7%) workers.

Keywords: poisoning to mercury vapour, chloral-alkali plant workers, neuropsychological consequences

Introduction:

Chronic exposure to elemental mercury vapour is known to cause major effects on the central nervous system. Behavioural effects of occupational mercury exposure have been described for many years in numerous clinical reports of exposure to metallic mercury, inorganic mercury compounds, and organic mercury. Recently, quantitative psychomotor testing of workers with chronic low-level exposure to inorganic mercury has expanded our knowledge of the behavioural effects of mercury exposure. Mercury vapour poisoning is an uncommon but serious occupational disease causing a prominent neurotoxic syndrome (1-4).

This study described chronic mercury poisoning in a group of 46 men actually exposed to mercury vapour while performing routine maintenance work on the mercury cell of chloral-kali plant. Excessive exposure to mercury results in neurotoxic effects. There are still concerns that current occupational exposure levels may cause sub-clinical effects on the nervous system (3-6). Recent data have shown that mercury toxicity causes long-term, probable irreversible neurological consequence (7). Central nervous system are known to accumulate mercury after vapour exposure and Buchet and colleagues have reported that in a rat model brain concentrations of mercury were not influenced by chelation therapy (8). Additionally, Hargreaves and colleagues report a patient with mercury intoxication who had clinical improvement after chelation therapy, but 16 years letter at autopsy was found to have expansive elemental mercury deposits the brain (9).
After long-term mercury vapour exposure, however behavioural effects are less well recognized.

Methods:

A group of 46 men were exposed to elemental mercury for more than ten years while performing planned work on mercury cell lines at a chlorine manufacturing plant located in north-eastern Bosnia. The plant uses a mercury cathode as a catalyst. The data were compared to control group 32 non-exposed to chemical workers. The groups were identical in other common parameters including age, gender (all men), occupational history,

alcohol consumption and smoking, place of living (urban-rural), and level of education (p< 0. 05). Workers had serial measure of blood mercury and urine mercury. The parameters of this monitoring were determined by atomic absorption spectrometer. Data on toxicological monitoring, data of mental health were collected, psychiatric and other subjective symptoms (by questionnaire self report scale), psychomotor and memory function tested. For all workers (experimental and control groups) a battery of standard psychological tests was conducted. Testing on behavioural function was performed between 5-6 months of age and included numerous measure instruments: Environmental worry scale (EWS), Minnesota Modified Personal Inventory (MMPI), Purdue test of intelligence measuring intellectual function (tested on standard 25 minutes, and adapted for measure short-term memory function- tested 10 minutes), visual-motor gestalt test Benders (tests of cognitive and visual-motor ability- LB), Eysenck Personality Inventory (EPQ) and Finger-tapping test.

Statistics: Statistical testing included Students t test and Fishers exact test. The analysis of variance was carried out comparing neurobehavioral tests. A probability factor of the p trend below < 0. 05 and < 0. 001 was considered as significant.

Results and Discussion:

Table 1 has shown that the means and standard deviation air mercury concentration in all months of year in chloral-alkali plant crossed over maximal permissible limit (MPL) 0. 05 mg/m^3. The highest levels of the air concentrations were found in summer-months (in the August was 0.4 mg/m^3, eight times higher than MPL) (3).
Average air mercury level was 0. 23 mg/m^3, average blood mercury concentration was 3. 55 μgr/dl, and average urine mercury concentration was 151.7+/- 180.4 μg/l (monthly retrospective urine samples over the past year were also available). Blood and urine mercury levels the control subjects have been at the lower level of detection in urine 2. 3+/-6. 2 μg/l. The results currently found an important number of workers (in 43 of 46) with a urine mercury level greater than 50 μg/l, which is considered a threshold for health risk by several authors (1, 3, 7).

The most frequent the central nervous system symptoms in experimental groups (table 1) and were significantly in relationship to control subjects were dizziness, have of injustice, to get angry, fatigue, suspicious, tremor and sleep changes (p trend <. 001). But all other evaluated symptoms were significantly in relationship to control subjects except have forgetfulness (p<. 05). This is an agreement with the results obtained by other authors (2-4).

The mean urine mercury concentrations dropped from 80 μg/l to 700 μg/l (figure 2) in exposed workers (the mean urine mercury concentrations was 151. 7 +/- 180. 4 μg/l), while mean urine mercury concentrations in control subjects was 2. 37 +/- 6. 24 μg/l). The average blood mercury monitor was 3. 55+/-2. 26 m g/dl (in control subjects 5. 655x 10^{-1} +/- 0. 15).

Dizziness, fatigue, easy to get angry, suspicious, sleep changes, tremor of hands, to have injustice, were most prominent behavioural symptoms in exposed to mercury workers and were in highly significantly correlations in relationships to symptoms of control subjects (p trend < 0. 001). But all other tested behavioural symptoms: dispirited, to spend oneself, headache, panic, were in significantly correlations in relationships to symptoms of control subjects except to have forgetfulness (p trend< 0.05; table 2). This is an agreement with the results obtained by other authors but not in all parameters (10, 14).
Our findings included neurobehavioural symptom abnormalities in 25 of 46 workers from MMPI test (table III). The workers in experimental group (EG) had increased values of scores from Depression (D), Hypochondria (Hs), Hysteria (Hy), Psychoastenia (Pt), and Schizophrenia (Sc) scales in comparison to the control group. The EG results point to significantly increased values of neurotic symptoms as well as characteristic MMPI profiles which are in direct connection to the level of mercury exposure (figure 1). It means that is true the hypothesis the greater the mercury exposure, the greater the neurological impairment. The blood mercury dose was generally associated with toxicity (7, 11, 13).
EG distinguished the profile of symptoms Hy-D-Hs-Pt-Sc, which involve the expressive inclination to hypochondriac fixation for some symptoms and schizophrenia interpretation, has a tendency of psychotic development. Psychoastenia symptoms happen as a type of association between emotional disturbances and somatic functioning.
Workers exposed to mercury knew that toxic effects resulted in loosing some of intellectual abilities (ESW questionnaire).

Neuropsychological testing (Purdue, standard) showed normal levels of intellectual functioning in both groups. But, there was significant correlation between results of testing modified Purdue. It means that mercury exposed workers had difficulty in concentrating on various tasks. Although they showed no particular deficits in memory, psychomotor performance, learning ability, their most striking deficit was one of impaired concentrations which resulted in erratic performance on various tests. This disorder was manifest primarily in emotional symptoms which had secondary effects on performance on standardized tasks of psychological performance (16).

In the first year of exposure to mercury the cognitive abilities decreased in poisoned workers, and than after 10 years of exposure to mercury. After 25 years there are ever low scores of cognitive abilities. But this figure showed that chronic exposure to mercury may results in short-term memory disturbances in workers even when they had lower mercury doses. Memory dysfunction was in relationship to duration time of exposure.

Further evaluation in this group of mercury exposed workers of the neuropsychological effects is underway, but long-term effects are evident (Depression-Hypochondria Symptom, short —term memory dysfunction, tremor).

Aggressiveness was found in 71.7%. The cognitive disturbances: short-term memory loss, difficult to concentration tasks which require attention and thinking were significantly deteriorated compared to those of controls (p trend < 0. 001). In 24 (52%) we have determined ego strength loss and regressive defensive mechanisms (LB). Handwriting disturbances-micrography we have identified in 27 (58.7%) exposed workers. We have identified fine tremor of the hands in 80 % workers.

All psychological parameters were in strong correlation with mercury levels and time-duration of exposure. The negative psychological effects we have detected of > 2. 9 μgr/dl blood mercury levels and of > 87 μg/l urine mercury levels. This phenomenon has been described by others authors (7).

Conclusion

Exposure to mercury vapour toxicity causes long-term, probably irreversible psychological consequences. In conclusion the results obtained showed a strong correlation between behavioural changes and blood and mercury concentrations and duration time of exposure.

Table 1: Blood, mercury and air concentration of mercury in experimental and control subjects

Mercury concentration	Experimental group M +/-SD	Control group M +/-SD
BLOOD μg/dl	3. 55 +/- 2. 36	5. 655x 10^{-1} +/- 0. 15
URINE μg/l	151. 69 +/- 180. 41	2. 37 +/- 6. 24
AIR mg/m^3	0. 23+/- 0. 19	-

Table 2 Summary of central nervous symptoms reported by all evaluated workers

	Groups:		Experimental		Control	
SYMPTOMS:	p		N	%	N	%
DISPIRITED	*		13	28.3	6	18. 8
DIZZINESS	**		29	63.0	2	6. 3
HAVE OF INJUSTICE	**		41	89.1	10	31.3
TO GET ANGRY	**		39	84.8	7	21.8
FATIGUE	**		39	84.8	6	18.8
SUSPICIOUS	**		15	32.6	3	9.4
TO SPEND ONESELF			33	71.7	7	21.8
HAVE FORGETFULNESS	**		27	58.7	13	40.6
HEADACHE	*		25	54.3	12	37.5
PANIC	*		27	58.7	10	31.3
TREMOR	**		27	58.7	6	18.8
SLEEP CHANGES	**		32	69.6	8	25.0
* p < .005 ** p < .001						

Figure 1: Correlation found between blood mercury concentration and the T mean scores for scale Depression (D) from Minesota Multiphasic Personality Inventory (MMPI) in workers exposed to mercury vapour. This figure showed that abnormal high T scores (>70) for scale Depression occurred when blood mercury concentration exceeded 3.6 µg/dl, but two workers had high scores when blood mercury concentration was < 1. 8 µg/dl.

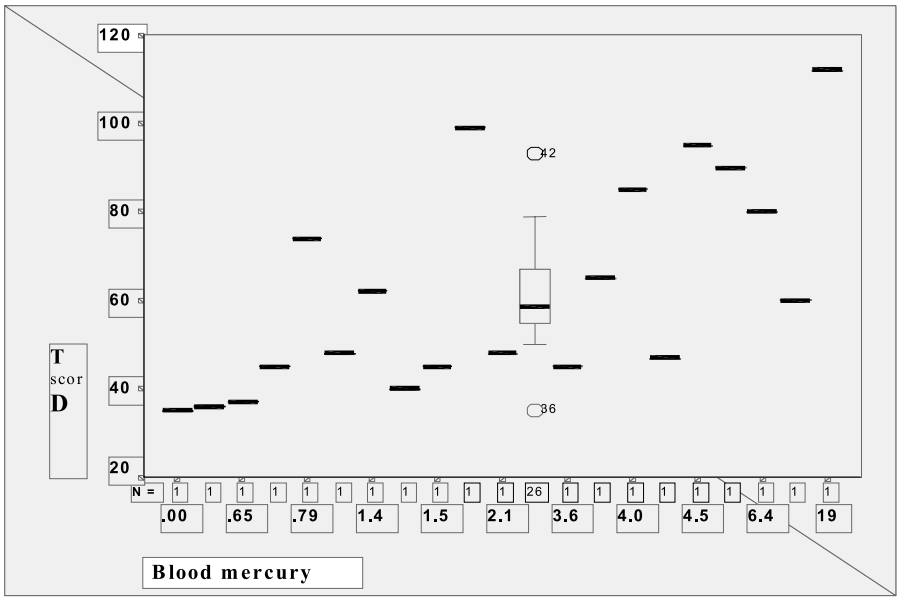


Table 3. The mean scores of scale MMPI for groups

	MEAN VALUES AND GROUPS		
PERSONAL INVENTORY	**Experimental**	**Control Groups**	**p**
Hypochondria (Hs)	69. 6+/- 18. 1	51. 2+/- 10. 5	**
Depression (D)	63. 4+/- 17. 5	48. 0+/- 13. 2	**
Hysteria (Hy)	64. 4+/- 15. 6	51. 2+/- 10. 0	**
Psychopathy (Pd)	47. 8+/- 9. 4	45. 4+/- 8. 0	
Paranoia (Pa)	52. 6+/- 14. 8	46. 4 +/- 12. 0	
Psychoastenia (Pt)	57. 0+/- 9. 5	50. 7+/- 9. 0	*
Schizophrenia (Sc)	54. 1+/- 9. 7	48. 3+/- 8. 3	*
Hypomania (Ma)	52. 7+/- 11. 9	50. 1+/- 9. 7	

In 25 of 46 workers exposed to mercury vapour was identified Depression-Hypochondrias Symptom (p< 0.001**) with higher scores for symptom scales: Hysteria (p<0. 001), Schizoid and Psychoastenia (MMPI). This results is in accordance with the results obtained by other authors (3, 6,7).

Figure 2: Correlation found between blood mercury concentration and the T-scores of symptom scale introversion/ extroversion (I/E) — Eysenck questionnaires (EPQ) in workers exposed to mercury vapour. This figure showed that when blood mercury concentration exceeded 3.6 μg/dl workers had introvert behaviour. This phenomenon has been described by others authors (4, 9, 13).

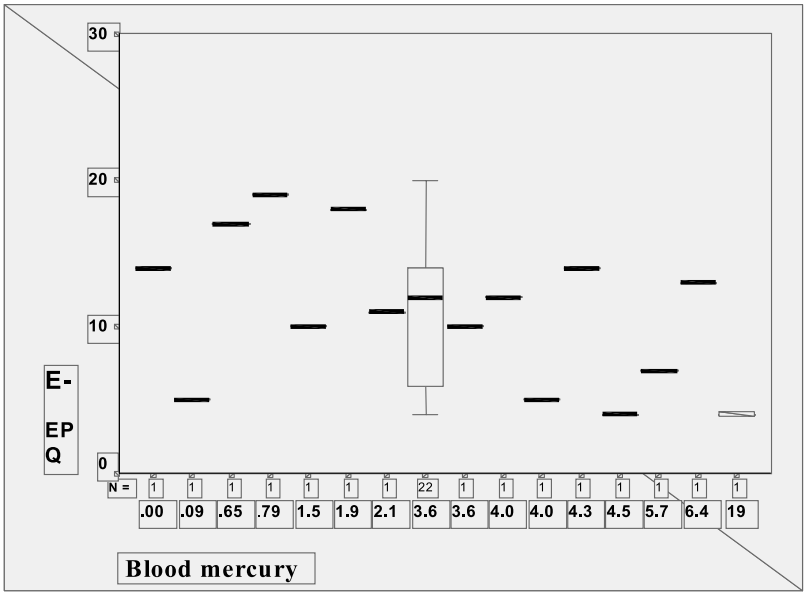
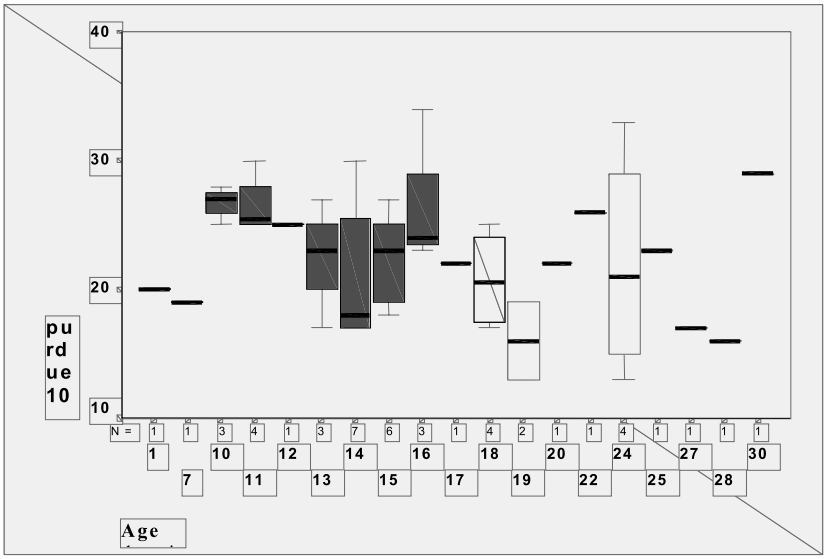


Figure 3: Correlation found between the scores of scale " Purdue 10" and age of duration of exposure to mercury vapour in experimental group.



References:

1. Chang LW. Neurotoxic effects of mercury- a review. Environmental research 1977; **14**: 329-373.
2. Bunn WB, Mc Gill CM, Berber TE, Cromer JW, Goldwater Lj. Mercury exposure in Chlor-alkaly plants. American Industrial Hygienist Association Journal 1986; **47**: 249-254.
3. Anonymous. Occupational mercury poisoning. Morbidity and mortality Weekly report 1980; **29**: 393-395.
4. Smith RG. Dose response relationship associated with known mercury absorption at dose levels of inorganic mercury. In: Environmental Mercury contamination, eds: Harting R, Dinman B, Ann Arbor, Micigan: Arm Arbor Science Publishers, 1972. pp 207-222.
5. Triebig G, Buttner J. Neurotoxic occupational substances: Metal and their compounds. A literature review of the years 1970-1982. Zentblatt fur Bakteriologie Microbiologie and Hygiene 1983; **177** : 11-36.
6. Goyer Ra. Environmentally related diseases of the urinary tract. Medical clinics of North America 1990; **74** : 377-389.
7. Bluhm Renata, Bobbit GR, Larry WW, Alastair JJ, Wood J, Bonfiglio F,sarzen C, Andrew JH, Branch RA. Elemental Mercury Vapour Toxicity, Treatment and Prognosis After Acute Intensive Exposure in Chlor-alkaly Plant Workers. Neuropsychological Findings and Chelator 1992; **11** : 201-210.
8. Buchet JP, Lauwerys RR. Influence of 2,3 Dimercaptopropane -1-sulfonate and dimercaptosucinic acid on the mobilization of mercury from tissues of rats pre-treated with mercuric chloride, phenilmercury acetate or mercury vapours. Toxicology 1989; **54**: 323-333.
9. Hargreaves RJ, Evans JG, Janota I, Magos L, Cavanogh JB. Persistent mercury in nerve cells 16 years after metallic mercury poisoning. Neuropathology and Applied Neurobiology 1988; **14**: 443-452.
10. Andersen A, Ellingsen DG, Morland T, Kjuus H. A neurological and Neuropsychological Study of Chlor-alkali Workers Previosly Exposed to Mercury Vapour. Acta Neurologica Skandinavica 1993; **88 (6)**: 427-433.
11. Bluhm R, Bobbit GR, Larry WW. Elemental Mercury Vapour Toxicity, Treatment and Prognosis After Acute Intensive Exposure in Chlor-alkaly Plant Workers. Neuropsychological Findings and Chelator1992; **11**: 201-210.
12. Fiedler NC, Maccia C, Kipen H. Evaluation of Chemically Sensitive Patients. Journal Occupational Medicine1992; **34(5)**: 529-53.
13. Gothe CJ, Molin C, Nilsson CG. The Environmental somatization syndrome. Psychosomatics 1995; 36(1): 1-1.
14. Mullerminy H, Erber D, Moller H, Mullerminy B, Bongartz G. Is there a hazard to health by mercury exposure from amalgam due to MRI. Journal Magnetic Resonance Imaging , 1996; **6 (1)**: 258-260.
15. Stewart De, Raskin J. Psychiatric assessment of patients with " 20th century disease ("total allergy syndrome"). Canadian Medical Association Journal 1985; 33: 1001-1100.
16. Yeates KO, Mortensen ME. Acute and chronic neuropsychological consequences of mercury vapour poisoning in two early adolescents. Journal of Clinical Experimental Neuropsychology 1994; **16(2)**: 209-222.