Arh. hig. rada toksikol., **30** *(1979) suppl. pp. 267–273.*

SOME BIOCHEMICAL AND HAEMATOLOGICAL CHANGES IN OCCUPATIONAL EXPOSURE TO MERCURY VAPOUR

HASSAN M. ABDEL-KADER[1], M. MOSELHI[1], S. M. EL-SEWEDY[2], M. MAHFOUS[3], Y. M. EL-SADIK[1] and A. EL-DAKHAKHNY[1]

Department of Occupational Health, High Institute of Public Health, Alexandria University[1], Department of Applied Medical Chemistry, Medical Research Institute, Alexandria University[2] and Department of Biochemistry, Medical Research Institute, Alexandria University[3], Egypt

ABSTRACT

In 54 subjects occupationally exposed to mercury vapour (0.016 – 0.300 mg/m³) the following biological parameters were determined: haemoglobin, haematocrite, red and white blood cell counts, total serum proteins, serum albumin, α, β and γ-globulins, total and free cholesterol, serum and urinary ribonuclease, serum and urinary α-esterases, serum cholinesterase and serum transaminases.

Haemoglobin and white blood cell count were higher in mercury workers than in controls. Mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration were the only blood parameters significantly higher in symptomatic than in asymptomatic mercury workers or controls.

Serum albumin and esterified cholesterol were found to be decreased while serum γ-globulin and free cholesterol were increased in mercury workers, but there was no correlation between these parameters and blood mercury level or duration of exposure.

Mercury workers had a significant increase in the activities of ribonucleases, α-esterases and serum cholinesterase, but symptomatic and asymptomatic workers could not be differentiated on the basis of these enzymatic changes.

As out of ten workers with weighted daily exposure to mercury vapour 0.016 – 0.050 mg/m³ four showed signs and/or symptoms of mercurialism, the application of the threshold limit value of 0.05 mg/m³ for Egyptian population, with malnutrition and parasitic disease still prevalent, is questioned.

Although there is a rich literature on the toxicity of mercury compounds[14,20], not many data are available concerning the metabolic disturbances associated with exposure to mercury vapour. Moreover, there have been few studies correlating changes of enzymatic activities with exposure level to mercury vapour and with the frequency of signs and symptoms of mercurialism[8,11,16].

Requests for reprints should be sent to: Dr Hassan M. Abdel-Kader, High Institute of Public Health, Occupational Health Department, 165, Rue, El-Horryia, Alexandria, Egypt.

The evaluation of health risks from exposure to mercury vapour in man is often based on an empirical relationship between air mercury levels and frequency of signs and symptoms in the exposed population[7,12,20].

The present study was undertaken to investigate the relationship between changes in the blood picture, serum proteins, serum cholesterol, activities of serum and urinary ribonuclease, nonspecific α-esterases, serum cholinesterase, SGOT and SGPT and mercury levels in the blood of mercury workers with and without signs and symptoms of mercurialism. To our knowledge, no report on the changes of activities of ribonuclease or α-esterases in mercury exposure has been published.

POPULATION AND METHODS

The study comprised 54 workers exposed to mercury vapour at levels ranging from 0.016 to 0.30 mg/m^3, in a factory producing fluorescent lamps in Alexandria, as well as 17 control subjects. All subjects were clinically examined to detect signs and symptoms of mercurialism: irritability, loss of memory, insomnia, tremor and gingivitis. Urine samples (about 300 ml) were collected at the time of survey in flasks containing 15 ml toluene as preservative. Venous blood (10 ml) was withdrawn with vacutainers and transferred into dry tubes for later biochemical tests. Another 5 ml of blood was collected from each individual in a heparinized vacutainer for the haematological examination. The haematological examination comprised haemoglobin value (Hb), haematocrit value (Ht), red and white blood cell counts (R. B. C. and W. B. C.), mean corpuscular volume (M. C. V.), mean corpuscular haemoglobin (M. C. H.) and mean corpuscular haemoglobin concentration (M. C. H. C.) were computed[3].

Serum and urinary ribonuclease (RNase) activities were measured as described by Sigulem and co-workers[17]. Serum and urinary non-specific α-esterases were measured as described by El-Sewedy and co-workers[6]. Serum cholinesterase, total serum protein and protein fractions, as well as total serum cholesterol and esterified cholesterol were measured by standard methods[19]. Serum GOT and GPT were determined by means of standard Sigma kits.

Mercury vapour was sampled by means of MSA personal samplers and determined by the iodine-iodide method[1]. Blood mercury concentration was measured by the flameless vapour atomic absorption[15].

RESULTS

Table 1 shows the mean values of blood parameters in the mercury workers and controls. While there was no mercury above the limit of analytical sensitivity in the blood of controls, its mean concentration in mercury workers free from symptoms and/or signs of mercury poisoning (asymptomatic) was somewhat higher than in those showing symptoms and/or signs (symptomatic); the difference, however, was not significant. Hb and W. B. C. were significantly higher ($P < 0.05$) in both symptomatic and asymptomatic groups of mercury workers than in controls. M. C. H. and M. C. H. C. were found to be

TABLE 1
Blood parameters in mercury workers and control subjects (mean ± S.D.).

Parameter	Controls n = 17	Mercury workers		
		All n = 54	Asymptomatic n = 16	Symptomatic n = 38
Blood mercury (μg/100 ml)	Undetectable	9.65 ± 12.1	10.44 ± 9.97	9.19 ± 12.98
Hb (g/100 ml)	13.85 ± 1.04	15.23 ± 1.76[a]	15.50 ± 1.43[a]	15.15 ± 1.90[a]
Ht (%)	43.47 ± 3.41	45.10 ± 5.2	47.80 ± 3.16[a]	44.24 ± 4.54[b]
R.B.C. (million/mm³)	4.76 ± 0.74	4.87 ± 0.7	5.21 ± 0.54	4.69 ± 0.71[b]
W.B.C. (count/mm³)	4437 ± 692	5418 ± 1228[a]	5636 ± 1050[a]	5326 ± 1298[a]
M.C.V. (femtoliters)	93.44 ± 11.8	94.20 ± 13.45	92.20 ± 9.1	95.02 ± 14.9
M.C.H. (picograms)	29.63 ± 3.87	31.76 ± 4.91	29.86 ± 3.45	32.52 ± 5.24[a,b]
M.C.H.C. (%)	31.99 ± 1.33	33.91 ± 3.95[a]	32.10 ± 2.02	34.68 ± 4.12[a,b]
Age (years)	34.47 ± 6.33	29.61 ± 8.55[a]	24.06 ± 4.26	31.95 ± 8.72
Duration of exposure (years)	—	3.55 ± 2.21	2.03 ± 2.03	4.18 ± 1.96

a: Mercury workers significantly different from controls ($P < 0.05$)
b: Asymptomatic significantly different from symptomatic mercury workers ($P < 0.05$)

significantly elevated in symptomatic ($P < 0.05$) but not in asymptomatic mercury workers ($P > 0.05$).

In mercury workers, a statistically significant ($P < 0.05$) negative correlation was found between individual blood mercury levels and all the blood parameters presented in Table 2 except for M.C.V.; the correlation coefficients between mercury and Ht, R.B.C. and M.C.H., respectively, were low. It is interesting that mean levels of the blood parameters were found to be high in the mercury group with up to one year of exposure and then gradually decreased with increasing duration of exposure approaching control values.

TABLE 2
Correlation coefficient between blood mercury and other haematological parameters.

Test	Hb	Ht	R.B.C	W.B.C.	M.C.V.	M.C.H.	M.C.H.C.
r	−0.69	−0.38	−0.32	−0.62	+0.10	−0.29	−0.63
P	<0.01	<0.01	<0.05	<0.01	N.S.	<0.05	<0.01

Table 3 shows the mean levels of serum proteins and serum cholesterol. Mean serum albumin, and the albumin globulins ratio were significantly lower while γ-globulin was significantly higher in the exposed workers than in

controls. Esterified cholesterol was significantly lower while free cholesterol was significantly higher in mercury workers than in the controls. No significant differences in those parameters were observed, however, between symptomatic and asymptomatic mercury workers (Table 3). Moreover, none of these

TABLE 3
Serum proteins and blood cholesterol in mercury workers and controls (mean ± S.D.).

Biochemical parameters	Controls n = 17	Mercury workers		
		All n = 54	Asymptomatic n = 16	Symptomatic n = 38
Total proteins (g/100 ml)	10.03 ± 0.78	9.86 ± 1.54	10.10 ± 0.64	9.76 ± 2.40
Serum albumin*	54.34 ± 10.02	35.69 ± 17.56[a]	40.34 ± 18.32[a]	33.28 ± 16.64[a]
α-globulin*	15.68 ± 7.05	16.63 ± 5.07	14.63 ± 3.80	17.66 ± 5.42
β-globulin*	16.62 ± 5.40	16.29 ± 5.95	17.12 ± 6.36	15.86 ± 5.67
γ-globulin*	14.31 ± 9.36	31.42 ± 18.15[a]	28.05 ± 21.48[a]	33.16 ± 15.66[a]
Albumin/globulin	1.25 ± 0.62	0.66 ± 0.50[a]	0.82 ± 0.56[a]	0.58 ± 0.43[a]
Total cholesterol (mg/100 ml)	216.68 ± 55.25	198.94 ± 45.12	193.16 ± 40.20	201.74 ± 47.83
Free cholesterol (mg/100 ml)	46.07 ± 15.67	68.72 ± 18.44[a]	66.62 ± 19.56[a]	69.77 ± 17.88[a]
Esterified cholesterol (mg/100 ml)	170.61 ± 44.03	131.16 ± 33.07[a]	126.54 ± 27.92[a]	133.47 ± 36.06[a]
Esterification (%)	78.73 ± 4.82	65.50 ± 5.73[a]	65.68 ± 6.04[a]	65.40 ± 5.67[a]

a: Mercury workers significanthy different from controls
*: Expressed as % of total protein.

TABLE 4
Activities of serum and urinary RNase, α-esterases, serum cholinesterase, and serum transaminases (mean ± S.D.).

Biochemical parameters	Controls n = 17	Mercury workers		
		All n = 54	Asymptomatic n = 16	Symptomatic n = 38
Serum RNase (μg/100 ml)	48.83 ± 9.81	53.98 ± 15.72	56.49 ± 11.08[a]	52.95 ± 15.47
Urinary RNase (mg/liter)	21.47 ± 1.77	26.01 ± 2.20[a]	25.29 ± 1.28[a]	26.31 ± 1.54[a]
Serum esterases (units/ml)	6.32 ± 0.91	8.05 ± 1.84[a]	7.88 ± 0.60[a]	8.39 ± 0.92[a]
Urinary esterases (units/liter)	32.86 ± 5.15	43.58 ± 8.96[a]	41.52 ± 5.40[a]	43.99 ± 8.94[a]
Serum cholinesterase	99.76 ± 27.34	125.24 ± 24.98[a]	126.75 ± 15.36[a]	124.48 ± 26.69[a]
SGOT*	15.24 ± 2.97	15.17 ± 8.58	15.88 ± 6.04	14.81 ± 9.67
SGPT*	11.29 ± 2.56	9.69 ± 6.39	9.06 ± 3.64	10.10 ± 0.86

a: Mercury workers significantly different from controls
*n: 48 in all and 32 in symptomatic.

biochemical parameters showed any significant correlation with either blood mercury level or duration of exposure.

Table 4 shows the activities of the enzymes in serum and urine. No significant difference in the activity of SGOT or SGPT was found between workers exposed to mercury vapour and controls or between symptomatic and asymptomatic mercury workers. Significant increases were observed in the mean activity of serum and urinary α-esterases, serum cholinesterase and urinary ribonuclease in all the mercury workers as compared with control subjects. In asymptomatic workers the activity of these enzymes as well as serum RNase were significantly increased as compared with controls, but no significant differences were observed when compared with symptomatic workers. Moreover, a significant negative correlation between the activity of these enzymes and blood mercury concentration was found except for the urinary RNase, which was positive, and for serum RNase which was not significant.

TABLE 5

Correlation coefficient between blood mercury and enzymatic activity in mercury workers.

Test	Serum RNase	Urinary RNase	Serum α-esterases	Urinary α-esterases	Serum cholinesterase	SGOT	SGPT
r	+0.14	+0.63	−0.52	−0.57	−0.31	−0.67	−0.54
P	N.S.	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01

DISCUSSION

Haemoglobin values were significantly higher in exposed workers. This observation differs from that reported by El-Sadik and El-Dakhakhny[4]. Moderate leukocytosis was observed in mercury workers without any significant difference in the differential cell count between the mercury workers and controls. This is not in agreement with previous reports in which lymphocytosis and eosinophilia were reported in mercury workers[10]. Mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration were the only blood parameters significantly higher in symptomatic than in asymptomatic mercury workers or controls. These changes seem to be most pronounced during the first year of exposure to mercury vapour but tend to approach the control values with further exposure.

In mercury workers a positive correlation was obtained between mercury level in air and mercury in blood ($r = +0.75$). However, no useful association was found between mercury in blood and clinical manifestations. It is evident that the level of mercury in blood may be used for the monitoring of exposure but not as a criterion for the degree of health impairment.

The increased level of γ-globulin and decreased serum albumin and esterified cholesterol in mercury workers may indicate a liver impairment. It is

well known that serum albumin decreases and γ-globulin increases in acute and chronic hepatitis[19]. The esterified cholesterol may be depressed in liver parenchyma damage[19]. As no difference was found in these biochemical parameters between the symptomatic and asymptomatic mercury workers on one hand, and there was no correlation between them and either blood mercury level or duration of mercury exposure on the other, they could not be used as biological indicators of mercury exposure.

The study revealed that workers exposed to mercury vapour may have significantly increased activities of ribonucleases, α-esterases and serum cholinesterase but that symptomatic and asymptomatic workers could not be differentiated on the basis of these enzymatic changes. On the other hand, a significant negative correlation was found between the blood mercury level and the activities of serum and urinary α-esterase and serum cholinesterase, while the correlation between blood mercury and urinary ribonuclease was found to be positive. It is difficult to interpret these contradictory findings; further studies are required.

Normal levels of serum cholinesterase were previously reported in mercury exposure[11]. The increase in the activity of serum cholinesterase we found, may reflect the well-known toxic effect of mercury on the kidneys. It is well known that the kidney is the site of accumulation of mercury irrespective of the form of mercury compound involved[2,5]. High levels of serum cholinesterase were previously observed in nephrotic disease[9].

Out of ten workers with weighted daily mercury exposures between 0.016 and 0.05 mg/m³ four showed signs and/or symptoms of mercurialism. It is therefore concluded that the most frequently used threshold limit value, namely that of the American Conference of Governmental Industrial Hygienists (0.05 mg/m³)[18], may comprise an insufficient margin of safety for the Egyptian worker. Whether this may be attributed to the higher susceptibility of a population with a high prevalence of parasitic disease and with prevalent malnutrition[13] remains to be studied.

REFERENCES

1. *Analytical Committee, ACGIH.* Determination of Mercury in Air: American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1957.
2. *Clarkson, T. W., Magos, L., and Greenwood, M. R.* Transport of elemental mercury into fetal tissues. Biol. Neonate, **21** (1972) 239–244.
3. *Dacie, J. V., and Lewis, S. M.* Practical Hematology 4th ed., J. and A. Churcill Ltd., London, 1970, p. 61.
4. *El-Sadik, Y. M., and El-Dakhakhny, A.* Effects of exposure of workers to mercury at a sodium hydroxide producing plant. Am. Ind. Hyg. Assoc. J., **31** (1970) 705–710.
5. *El-Sadik, Y. M.* Mercury poisoning. Medicine Today, **5** (1971) 91–95.
6. *El-Sewedy, S. M., Araf, R., Abdel-Aal, G., and Mostafa, M. H.:* The activities of urinary α-esterases in Bilharziasis and its possible role in the diagnosis of Bilharzial Bladder Cancer in Egypt. Trans. R. Soc. Trop. Med. Hyg., **72** (1978) 525–528.

7. *Friberg, L., and Nordberg, G. F.* Inorganic mercury – a toxicological and epidemiological appraisal, In: Miller, M. W., and Clarkson, R. W. (eds.), Mercury, mercurials and mercaptans, Springfield, C. C. Thomas, 1973, p. 3.

8. *Goldwater, L. J., and Joselow, M. M.* Absorption and excretion of mercury in man: XIII. Effects of mercury exposure on urinary excretion of coproporphyrin and delta-aminolevulinic acid. Arch. Environ. Health, **15** (1967) 327–331.

9. *Harper, H. A. (ed.).* Enzymes, In: Review of Physiological Chemistry. 15th ed. Los Altos, California, Lange Medical Publications. 1975, Chapter 8, p. 165.

10. *International Labour Office.* Encyclopedia of Occupational Health and Safety: Mercury, Vol. II I. L. O., Geneva, 1972, pp. 862–863.

11. *Lauwerys, R. R., and Buchet, J. P.* Occupational exposure to mercury vapours and biological action. Arch. Environ. Health, **27** (1973) 65–68.

12. *NIOSH.* Criteria for a recommended standard. Occupational exposure to inorganic mercury. Washington, Public Health Service, U. S. Department of Health, Education and Walfare, 1973.

13. *Noweir, M. H.* Safe level criteria for air contaminants for developing countries, presented at the American Industrial Hygiene Association Conference, May 12–17, Miami Beach, Florida, U.S.A., 1974.

14. *Petering, H. G., and Tapper, L. B.* Pharmacology and Toxicology of Heavy Metals: Mercury, Pharmac. Ther. A., **1** (1976) 131–151.

15. *PYE UNICAM.* Manual of the Atomic Absorption Methods for the Unicam SP 90 Atomic Absorption Spectrophotometer, Sheet No. 1, PYE Unicam Ltd., Cambridge, England.

16. *Rentos, P. G., and Seligman, E. J.* Relationship between environmental exposure to mercury and clinical observation. Arch. Environ. Health, **16** (1968) 794–800.

17. *Sigulem, R. M., Brasel, J. A., Velasco, E. G., Rosso, P., and Winick, M.* Plasma and urine ribonuclease as a measure of nutritional status in children. Am. J. Clin. Nutr., **26** (1973) 793–797.

18. *Threshold Limits Committee.* Threshold limit values for chemical substances and physical agents in the workroom environment. American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1974.

19. *Varley, H. (ed.).* The plasma proteins, In: Practical Clinical Biochemistry, 4th ed., William Heinemann, Medical Books, London, and Inter. Science Book Inc., New York, 1967.

20. *World Health Organization.* Environmental Health Criteria 1: Mercury, WHO, Geneva, 1976.