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J. Fac. Med. Baghdad - 1987 Vol. 29 No. 2

LEAD ABSORPTION IN BATTERY WORKERS

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امتصاص الرصاص لدى العاملين في صناعة البطاريات

الخلاصـة:

من خلال دراسة ١٠٨ عامل في معمل البطاريات تم احتساب نسبة امتصاص الرصاص في الدم، فعالية انزيم (ALAD) في الدم ونسبة هيموغلوبين الدم آخذين بنظر الاعتبار العوامل التي تؤثر في زيادة الامتصاص، كما تم قياس تركيز الرصاص في هواء المعمل.

لقد تبين ان نسبة امتصاص الرصاص في ٦٠ر١٪ من العمال كانت ضمن النسب المقبولة (٤٠ - ٨٠ ميكروغرام / ١٠٠ ملم) في حين ارتفعت النسبة ما بين (٨٠ - ١٢٠ ميكروغرام / ١٠٠ ملم) في ١٣٪ من العمال وفقط ٠ر٩٪ من العمال كانت النسبة عندهم اعلى من (١٢٠ ميكروغرام / ١٠٠ ملم).

لقد تبين ان ٨١ر٤٪ من العمال كانت نسبة فعالية الانزيم (ALAD) اقل من ١٠٠ ميكروغرام / ملم كريات حمراء، كما تبين وجود انخفاض معنوي في نسبة هيموغلوبين الدم. اما درجة تركيز الرصاص في هواء المعمل فكانت اعلى من الحد المقبول بشكل عام. لقد استنتج من الدراسة وجود زيادة في نسبة امتصاص الرصاص لدى العاملين في صناعة البطاريات مقارنة بمجموعة السيطرة.

SUMMARY.

To study the incidence of Lead absorption in lead exposed workers, 108 battery workers (B.W.) were included in this study. Blood lead concentration (pbB), Delta-aminolevulinic acid dehydratase (ALAD) Haemoglobin concentration (Hb) and lead in air (PbA) were investigated. The study also took into consideration the role played by the different factors in increasing lead absorption. The results showed that 25.9% of the workers had PbB within the normal range (up to 40 ug/100ml), 60.2% had PbB within the acceptable range (40-80 ug/100ml), 13.0% had PbB indicating excessive absorption (80-120 ug/100ml), and 0.9% had pbB with dangerous level (above 120 ug/100ml). 81.4% of the workers had ALAD less than 100 μ/ml RBC (half the mean normal range) with a significant decrease in Hb concentration as compared with normal control. The Lead air in the work place was above the threshold limit value (TLV). We conclude that there is increased lead absorption among workers in battery manufacturers.

INTRODUCTION:

Lead intoxication was the most common poisoning in industry (1), and is still, one of the most prevalent occupational hazards (2).

The necessity of preventive measures has long been realized, and much has been written in regard to methods to reducing the lead hazard by improving conditions of work and proper medical supervision. The human exposure in lead-using industries has been reduced (3); the incidence and severity of poisoning have decreased substantially during recent years, but much still remains to be done to eliminate lead poisoning as an occupational disease (4).

In Iraq, lead is mainly used in the manufacture of storage batteries and in the printing press. many studies on lead have been made (5,6,7,8). The recent study by Jamil (9) on printing workers showed that lead absorption does exsist in such a group of exposed workers. Therefore the present study was carried out to throw some light on the incidence of Lead absorption among Battery workers, and it's relation to the degree of pollution as indicated by lead in air (Pb A) in the work place. The study also took into consideration the role played by the different factors in increasing lead absorptin.

Thus, blood lead concentration (Pb B) delta-amino laevulinic acid dehydratase activity (ALAD) and Haemoglobin concentration (Hb) were investigated.

MATERIALS AND METHODS:

Battery Workers (BW):

The 108 BW were employed in two storage battery factories in AL-Waziriah related to the State Enterprise of Battery Manufacture.

Out of a total number of 300 workers employed in factory No. 1 and 200 workers employed in factory No. 2. 66 and 42 workers respectively were included in the study. All subjects in the two factories were questioned before obtaining the blood samples. The questionnaire included social and occupational history, personal habits, previous history of lead poisoning and subjective complaints like tiredness, loss of appetitendigestion, abdominal colics, constipation and wereexaminedfor Burton line. They were day workers subject to regulations regarding wet working methods, protective clothing, and a ban on eating, drinking and smoking in the work place. They were unber direct medical supervision. The male workers were 86 (57 in factort No. 1 and 29 in factory No. 2), and the females were 22 (9 in factory No. 1 and 13 in factory No. 2). Their mean age was 30 years (Table I). The weekly working time was similar for all workers i.e. 48 hours. The mean length of service was 3.8 years taking into consideration that workers in factory No. 2, with a length of service of more than 5 years were before that workers in factory No. 1, and the length of service was calculated from their work duration in both factories. Four workers only had previous occupational lead exposure in a secondary lead smelter related to the same enterprise. None of the BW, had an additional work related to lead exposure.

For comparison with exposed workers 100 workers matched for age (Table I) and sex (80 males & 20 female) from the State Enterprise for Dairy Products were investigated. Control wokers (CW):

Specimen Collection:

ten ml of blood specimens were obtained by venipuncture. The samples were transferred directly to disposable heparinized tubes for blood lead, ALAD and Hb determinations. For air sampling(3) general purpose personal samplers (Casella London Limited), were used with a 3.7 cm. disc holder. the filters used were

Table I. Number of workers in the different plants according to age.

AGE (Years)	BATTERY WORKERS			DAIRY WORKERS
	Factory No. 1	Factory No. 2	Total	Control
< 20	4	15	19	15
20-29	25	7	32	17
30-39	28	14	42	17
40-49	5	5	10	28
50 +	4	1	5	23
Total	66	42	108	100
Mean Age	31.10	28.10	30.16	37.45
Range	16-56	16-53	16-56	15-70

Whatman glass fiber (GF/A).

Blood lead measurement was done by Atomic flame absorption Spectrophotometry using (Pye Unicam, Atomic Absorption Spectrophotometer (series No. 2900).

Extration of lead from the whole blood was done by organic solvents (MIBK and APDC) using three different concentrations of lead standard solutions (25,50 & 100 ug/100ml), for calibration. All specimens were analysed in duplicates (10).

ALAD activities in whole blood was determined by the recommended colorimeteric method of Burch, H.B., and Siegel (11), while Hb & P.C.V. were determined by Coulter Counter, Model S-Plus, Fully Automatic Machine (Coulter Electronics, NS Hialean Florida, U.S.A).

Statistical Method:

The analysis of variance and the F-test were used to test the effect of different variables on the mean values of the different parameters. Student's t-test was also used to test the statistical difference between two means, and the correlation coefficient (r) was used to examine the possibility of any correlation betwen the different parameters.

RESULTS:

The frequency distribution and the mean ± SD of different parameters for both BW and CW are shown in Fig 1,2,3 and Table II.

Table II. Mean ± SD of PbB concentration, ALA-D activity and Hb concentration for battery workers and control subjects.

Group	No.	PbB (ug/dl)	ALA-D (u/ml RBC)	Hb (gm/dl)
Battery workrs	108	56.34 ± 23.75	77.04 ± 30.32	14.51 ± 1.14
Range		19-145	11-165	10.5-16.7
Control subjects	100	16.93 ± 9.20	198.09 ± 29.51	15.03 ± 1.31
Range		5-38	119 - 245	11.9-17.0
P		0.001	< 0.001	< 0.01

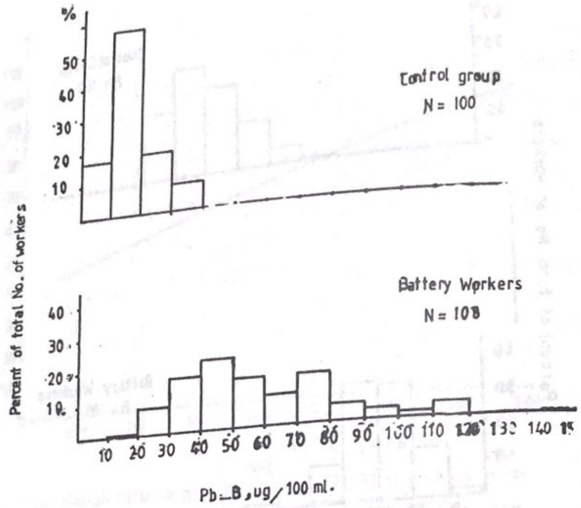

Fig. 1 - Frequency distribution of blood lead level (PbB) for the studied groups.

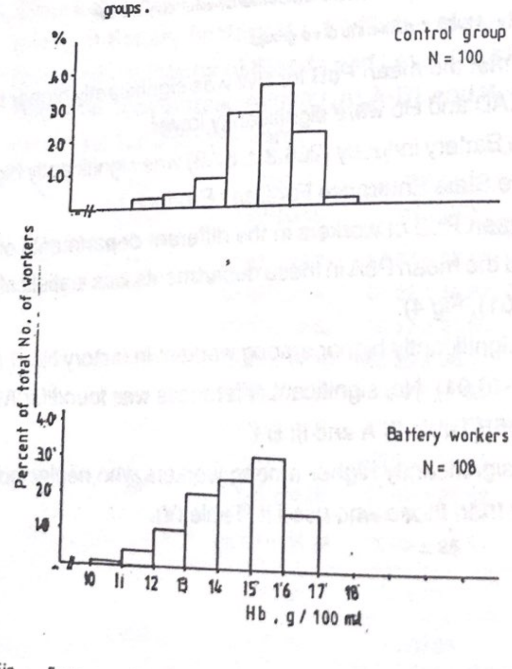

Fig . Frequency distribution of haemoglobin concentration (Hb) for the studied groups.

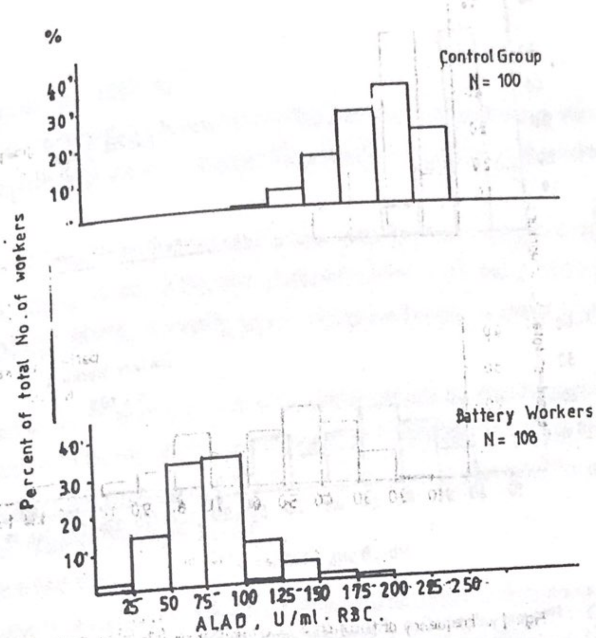

Fig.3. Frequency distribution of δ-aminolevulinic acid dehydratase activity (ALAD) for the studied groups.

The results indicate that the mean PbB for BW was significantly higher than that of the CW while ALAD and Hb were significantly lower.

The mean PbA in the Battery industry (266.3 ± 87.8) was significantly higher than that for control (The State Enterprise For Dairy Products).

The correlation between PbB of workers in the different departments of the two battery factories and the mean PbA in these departments was statisticaly significant ($r=0.58$, $P<0.01$); Fig 4).

The mean PbB was significantly higher among workers in factory No. 1 than those in factory No. 2 ($P<0.01$). No. significant differences was found for ALAD and Hb ($P>0.05$, $P>0.05$)(Table III A and III B).

The mean PbA was significantly higher among workers who neglected the use of mask during work than those who used it (Table IV).

DISCUSSION:

The findings of the present study are in agreement with general consensus of

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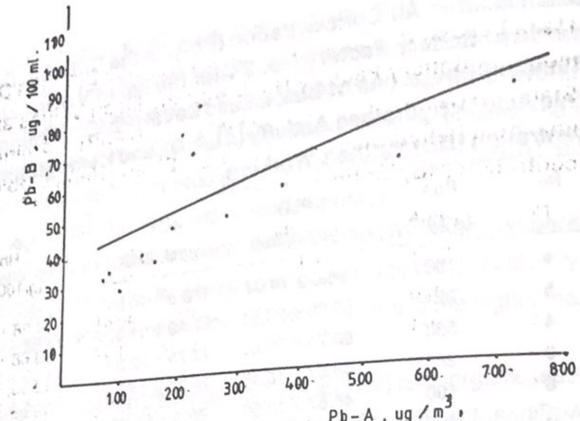

Fig . Correlation between mean blood (lead) level (Pb-B), of workers in the different departments of the two battery factories and the mean lead-in-air concentration (Pb-A) in these departments.

Table IIIA. Mean Lead-in-Air Concentration (PbA) in the Different Departments in Battery Factory No. 1 with the Mean Values and the Standard Deviations of Blood Lead Level (PbB) , Amino levulinic Acid Dehydratase Activity (ALA-D), and Hemoglobin Concentration for their Workers.

Department	No.	PbA ($\mu g/m^3$)	PbB (μg/100ml)	ALA-D μ/ml. RBC)	Hb (g/100ml)
Grid casting	6	232	82.67 ± 22.21	77.67 ± 27.27	14.3 ± 1.27
Pasting	9	410	94.56 ± 24.41	64.22 ± 16.37	14.38 ± 1.27
Plate cutting	6	720	70.67 ± 12.82	59.17 ± 21.60	15.45 ± 0.64
Asembly	15	370	55.27 ± 16.10	85.20 ± 26.14	15.87 ± 1.19
Charging	10	205	74.40 ± 22.57	74.5 ± 28.59	15.04 ± 1.20
Rubber	8	140	39.00 ± 9.29	71.75 ± 15.45	15.39 ± 1.14
Maintenance	6	—	47.5 ± 8.46	65.67 ± 38.85	14.8 ± 0.97
Office Workers	6	80	34.00 ± 8.39	97.67 ± 26.82	13.85 ± 1.44
Total	66	308.14 ± 216.25	62.80 ± 25.28	75.39 ± 26.11	14.79 ± 1.10
F			11.75	1.71	1.54
P.		< 0.001	> 0.05	> 0.05	

F' = 2.18
0.05; 7958

Table IIIB. Mean Lead-in-Air Concentration (PbA) in the Different Departments in Battery Factory No. 2 with the Mean Values and the Standard Deviations of Blood Lead Level (PbB) , Amino levulinic Acid Dehydratase Activity (ALA-D), and Hemoglobin Concentration (HB) for their Workers.

Department	No.	PbA (μg/m^3)	PbB (μg/100ml)	ALA-D μ/ml. RBC)	Hb (g/100ml)
Grid casting	4	160	35.0 ± 10.03	106.5 ± 40.81	14.28 ± 1.26
Pasting	5	221	68.20 ± 27.64	67.60 ± 11.97	13.68 ± 1.58
Plate cutting	4	550	60.75 ± 23.41	77.75 ± 22.37	13.33 ± 1.62
Asembly	9	280	48.67 ± 18.45	78.78 ± 25.63	13.56 ± 1.44
Charging	6	190	46.67 ± 13.85	88.0 ± 61.36	14.78 ± 0.80
Plastic	4	100	27.75 ± 5.25	68.25 ± 10.24	12.38 ± 0.75
Maintenance	6	—	43.00 ± 11.87	56.83 ± 22.18	15.63 ± 0.19
Office Workers	4	70	32.25 ± 9.84	104.5 ± 50.22	14.43 ± 0.73
Total	42	224.43 ± 160.09	46.19 ± 19.73	79.62 ± 35.01	14.06 ± 1.46
F			2.99	1.19	3.23
P			< 0.05	> 0.05	< 0.01

F' ,34 = 2.030 0.05; 7,34

opinion that workers exposed to lead dust or fume have increased absorption of Lead (12). Gibson (12) stated that the upper acceptable limit of PbB is 60 ug/100 ml while Landrigen and Bakers (13) stated that it should not exceed 40 ug/100ml. Campara (14) found that the threshold for impaired performance in exposed workers lies below PbB of 60 ug/100ml which is the current threshold limit value (TLV) but taking into account the categories of lead absorption (15).

In the present study, 28 BW (25.9%) had PbB within the normal range (up to 40 ug/100ml), 65 workers (60.2%) had PbB within the accptable range (40-80 ug/100ml), 14 workers (13.0%) had PbB indicating excessive absorption (80-120 ug/100ml) and only one worker (0.9%) had PbB within the dangerous level (above 120 ug/100ml). Such distribution may be due to the different exposure levels between different departments, as indicated by the difference in the mean PbA concentration between different departments in the two battery factories (Table III A & III B) and/or individual variability in the sensitivity to toxic agents.

None of the CW had ALAD less than 100 u/ml RBC while 88 out of 108 BW (81.5%) had such ALAD activity; these values are in accordance with the degree of increased lead absorption, indicated by their mean PbB level and indicate that determination of ALAD activity might be used for estimating the level of exposure provided that further studies are to be done to categorize the different limits of ALAD at different degrees of lead exposure.

The significantly lower Hb concentration in the BW when compared with CW is due to the high level of Lead exposure found in the battery industry as indicated by the higher level of mean PbA above the TLV and the higher mean PbB level for BW.

The current industries threshold limit value (TLV) for inorganic lead on the basis of a life time of 8 hour work day is 150 ug/m^3. The higher mean PbA in battery industry above the TLV indicates the degree of hazard to which BW are exposed (16,17,18,19).

However, Lee (20) reported that PbB threshold for developing anemia in lead-exposed workers is not certain while Barker (21) suggested a permissible biological limit of PbB level between 40-60 ug/100ml. In this study the threshold for developing anemia and, hence, the permissible biological limit cannot be found probably because of the wide range and variations in Hb concentration for workers with different PbB levels. Even those BW who have PbB above 80 ug/100ml (n=15) and supposed to have excessive lead obsorption (15), had a mean Hb concentration of 14.3 ± 1.52 gm/100ml l00ml which is not significantly different ($P>0.05$) from the rest of workers who had Hb con. of 14.54 ± 1.37 gm/100ml.

These findings support the view of Zielhuis (22) that Hb estimation can be used for preventive purpose and indicates that a fall in Hb concentration in serial estimations for lead exposed workers is an indication of lead toxicity after exclusion of other causes of developing anemia.

The generally higher level of PbA in factory No. 1 than in factory No. 2 which is a new factory with modern engineering precausions together vith the significantly higher mean PbB ($P<0.001$) among workers in the former than those in the later indicates, that factory No. I should be subjected to more strict engineering preventive and control measures.

The significant correlation between PbA and PbB in BW (fig 4) was in consistence with the findings of Sakur (23), and the workers who neglected the use of the mask during work were found to have a significantly higher PbB than those who used it (Table IV).

The findings of this study lead us to conclude that there is increased lead absorption among workers in battery manufacturing factories and that the hazard is variable among different departments depending on the amount of dust produced at th work place.

Table IV. Mean values and standard deviations of blood lead level (PbB), -amino levulinic acid dehydratase activity (ALA-D), and haemoglobin concentration (HB) for battery workers according to the habbit of using the mask or not.

Habbit of Using the Mask	N	PbB (μg/100m)	ALA-D (μ/ml.RBC)	HB (g/100ml)
Mask Users	45	48.96 ± 19.92	81.80 ± 28.78	14.77 ± 1.07
Non Mask Users	63	61.62 ± 26.55	73.63 ± 31.03	14.14 ± 1.60
Total	108	56.39 ± 23.75	77.04 ± 30.32	14.51 ± 1.14
F		7.30	1.93	6.01
P		< 0.01	> 0.05	< 0.05

F* = 3.94

0.05; 1,106

REFERENCES:

1. Aub, J.C., Fairhall L.T., Minot, A.S., and Reznikoff, P. Lead Poisoning. Medicine (Baltimore) 1925, 4: 1-250.

2. Hassan, M.D. Health hazards resulting from possible exposure to lead compounds in Iraqi industriés. M.Sc. Pharmacy Thesis, University of Baghdad 1977.

3. Malcolm, D. Prevention of long term sequelae following the absorption of lead. Arch. Environ. H1th., 1971; 23: 292-298.

4. World Health Organization Envirommental Heath Criteria. 3 Lead WHO: Geneva. 1977.

5. Al-Gharbaw; A.J.A. Lead poisoning. A. study of lead exposure in some Iraqi industries in Baghdad. Dissertation of diploma in Medicine - University of Bagh-

dad 1974.
6. Al-Nasiri Industrial lead poisoning in Iraq. D.P.H. dissertation. University of Baghdad 1977.
7. Al-Bassam, K.S. Soil pollution in North of Iraq. Proceedings of the first scientific conference for Iraqi Society for Environment protection conference for Iraqi Society for Environment protection and improvement 27th. 29th. March 1984.
8. Al-Timimi D.J.; Al-Shamma G.A. and Al-Ani, A.S. Percentage incidence of lead intoxication in 35 clinically suspected patients. J. Fac. Med. Baghdad 1985; 27, 43-47.
9. Jamil, H.; Al-Timimi, D.J.; Al-Ajzan J.K.; and Al-Ghabban, S.I. (In press), Lead absorption in printing workers.
10. Whiteside P.J. Pye Unicam Attomic absorption Data Book, 2nd edition. Pye Unicam Ltd. England 1976.
11. Burch, H.B., and Siegel, A.L. An improved method for the determination of Erythrocyte 6-aminelevulinic acid dehydratase. Clin. Chem. 1971; 17: 1038-1041.
12. Gibson, S.L.M., Mackenzie, J.C., and Golberg, A. The Diagnosis of industrial lead poisening. Brit. J. Industr. Med. 1968; 25: 40-51.
13. Landrigan, P.J., and Baker, E.L.T. Epidemiological aspects of occupational lead poisoning. J.UDEH.1983; 5 (supp): 145-155. Abstract.
14. Campara, P., D. Andres. F., and Micciolo, R.C. Physiological performance of workers with blood lead concentration below the current (TLV). Int. Arch. Occup. Environ. Health 1984; 53: 233-246. Abstract.
15. Lane, R.E., Hunter, D., Malcolm, D., Williams, M.K., Hudson, T.G.F., Browne, R.C., Mecallum, R.I., P.S.I., Goldberg, A., Beritic, T., Vigliani, E.C., Kehoe, R.A., and King, E. Diagnosis of inorganic lead poisoming: A statement. Brit. Med. J 1968; 4: 501.
16. Kehoe, R.A. The metabolism of lead in man in health and disease. J. Poy. Inst. Public Health 1961; 24: 81, 181, 129, 177. Cited by: Bactjer 1973 in Sartwell, P.E. (Ed.): Maxcy-Rosenau Preventive Medicine and public Health. 10th Edition; appletion Century Crofts; New York.
17. Slander, S., and Cramer, K. Interrelationships between lead in blood, lead in urine, and aminolevulinic acid in urine during lead work. Brit. J. Industr. Med.

1970; 27: 28-39.
18. Dossing, M., and Pauler, P.E. Blood and air lead concentration during five years of an occupational during five years of an occupational hygiene programme and problems due to welding operation. Ann. occup. Hyg. 1983; 27: 367-372.
19. Kanboor, F.I., and Auraha, A.M.N. Air Pollution in Babylon Storage battery factory No. 2 proceedings of the symposium on Environmental protection from industrial pollution. 13th. - 16th. May. State Organization of Industrial Design and construction. 1985.
20. Lee, K. Occupational lead exposure of storage battery workers in Korea. Brit. J. Industr. Med. 1982; 39: 283-289.
21. Barker, E.L.J., Landrigan, P.J., Barbour, A.G., Cox, D.H., Folland, D.S., Ligo, R.N., and Throckmarton Occupational lead poisoning in the United States: Clinical and biochemical findings related to blood lead. Brit. J. Industr. Med. 1979; 36: 314-332.
22. Zielhuis, R.L. Interrelationship of biochemical responses to the absorption of inorganic lead, Arch. Environ. H1th, 1971; 23: 299-310.
23. Sakuria, H., Sugita, M., and Tsuchiya, K. Biological response and subjective symptoms in low level lead exposure. Arch. Environ. H1th. 1974; 29: 157-163.