The Relationship between Blood Lead Level and Neuro-psychological and Hematological Findings in Lead-Exposed Workers of Battery Industry

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ABSTRACT

Background: Hematological effects and digestive and neuro-psychological signs and symptoms are some manifestations of lead toxicity. However, there are conflicting reports of their prevalence among lead exposed workers and their relationship with blood lead levels (BLL). This case- control study assessed the relationship between BLL and hematological indexes and digestive (abdominal colic, iron taste), neural (tinnitus, anosmia, paresthesia, weakness, dizziness, headache), and psychological (fatigue, sleep disturbance, forgetfulness) findings in battery-manufacturing workers.

Methods: Cases and controls were a sub-sample of lead exposed and non-exposed workers in battery-manufacturing industry. BLL concentrations, hematological indexes, and clinical manifestations were evaluated in the two groups. Statistical analyses were performed using SPSS software.

Results: There were no significant differences in age and years of work between the two groups. BLL (mean ±SD) was significantly higher in the lead exposed group than in the controls (36.54 ± 4.34µg⁄dl and 8.82 ± 3.96 µg⁄dl, respectively) (P<0.001). There was a significant relationship between BLL and headache, fatigue, paresthesia, weakness, forgetfulness, sleep disturbance, iron taste, anemia, and eosinophil level. However, there was not a significant relationship between anosmia and BLL.

Conclusion: BLLs correlated with some clinical and para-clinical findings. Therefore, preventive measures towards exposure to lead at work places, and routine hematological investigations should be included in bio-monitoring the health status of lead workers.

Keywords: Blood Lead Level, Digestive System, Hematology, Lead Battery, Neuropsychology.

INTRODUCTON

Lead is a significant occupational and environmental hazard. Adult lead (Pb) poisoning commonly occurs due to exposure to lead used in the workplace. Battery industry is one of the settings related to lead intoxication (1). This form of toxicity has been recognized for thousands of years, and is still around (2). Lead has multiple biologic effects (3). Hematological effects and digestive and neuropsychological signs and symptoms are some manifestations of lead toxicity (4-6). However, there are conflicting reports of their prevalence among lead exposed workers and their correlation with BLL (7-9). Neuropsychological and digestive signs and symptoms are the earliest manifestations of

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lead intoxication (4), but the correlation between those manifestations and BLLs in Iranian race is uncertain. Because of the difference in toxico-kinetic characteristic and also with respect to the high exposure to lead in lead battery industry, the possible hematological, neuropsychological and digestive signs and symptoms in Iranian workers were evaluated in this study.

The specific research study questions were:

1) What are the mean BLL, Hgb (hemoglobin), MCV (mean corpuscular volume), WBC (white blood cell), and eosinophil in two groups?

2) Is there a relationship between BLL, and clinical and para-clinical manifestations?

MATERIALS AND METHODS

This study was conducted by Health Department of Isfahan University of Medical Sciences (IUMS). The protocol was reviewed and approved by the Institutional Ethics Committee of the Faculty of IUMS. It was a prospective case-control study which was conducted in a battery-factory. The study population was divided into occupationally exposed to lead compounds group (case, n=70) and the reference group (control, n=76). The reference group consisted of administrative workers in the official division of the factory. All subjects who did not have gastrointestinal neuropsychological and hematological disorders in inclusion time were included in our study. BLL, hematological indexes, and digestive and neuro-psychological findings were evaluated in both groups. Blood samples were collected at the workplace between 8-10 am from the cubital vein following through skin cleaning using two or three swabs contaminating isopropanol. Blood (10ml) was collected using evacuated blood-collecting tubes.

A suitable number of tubes from the same batch were previously tested to ensure they were free from metal contamination. Lead blood analysis was carried out by using graphite furnace atomic absorption (Varian system) after preparing 5ml of each blood sample (an aliquot of whole blood with a mixture of nitric acid, ammonium phosphate, and triton X-100 were diluted and analyzed for lead by GFAA (graphite furnace atomic absorption). Data were shown in µg⁄dl and the detection limit for lead concentration was 1.0 µg⁄dl. Hgb, MCV, WBC, and eosinophil of residual 5ml of blood were measured using a Sysmex K-1000 hematological analyzer.

Clinical Assessment

Clinical evaluation of all workers (case and control groups) and collection of blood samples were done simultaneously. Neurological (tinnitus, anosmia, headache, dizziness, paresthesia, and weakness), psychological (sleep disturbance, forgetfulness, and fatigue), and digestive (abdominal colic and iron taste) manifestations were evaluated in both groups. For examination of muscle force, the patients were asked to flex or extend a muscle group against resistance provided by clinician (10). Muscle force was recorded as 0 (absent sign) and 1(present sign). Anosmia was examined by initially ensuring that each nasal passage is open by compressing one side of the nose and asking the patient to sniff through the other. The patient should then close both eyes. One nostril was closed and test smelling in the other with substances such as cloves, coffee, soap or vanilla (familiar and nonirritating odors). The participants were asked about things that they smelled. Then, the other nasal passage was tested. A person should normally perceive odor on each side, and can later identify it (11). Recording other signs and symptoms was done in the same way for anosmia. Forgetfulness was investigated by asking questions with answers that could be checked against other sources so that one could know whether or not the patient was confabulating (making up facts to compensate for a defective memory). These might include the day's weather, appointment time, medications, or laboratory tests taken during the day (asking what the patient had for breakfast could be a waste of time unless you could check the accuracy of the answer) (11). To investigate other symptoms, the participants were questioned for their histories. Data on age, number of years at work in workers were obtained.

An informed consent was obtained from each person after the nature of the procedure(s) had been fully explained, and the research

assistant immediately started assessments according to the study protocol.

Statistical Analysis

Data were presented as mean □□SD. For the assessment of the relationship between BLL and other findings, Pearson correlation coefficient was utilized. To assess relationship between BLL concentrations and other findings and group differences in normally-distributed continuous variables (e.g. age), independent t-test was run. Chi^2 and Fisher test were applied to the evaluation group differences in abundantly- distributed clinical findings. The statistical test was two-tailed, and $P < 0.05$ was considered significant. Data were analyzed using SPSS software version 10.0.

RESULTS

There were no significant differences in age and years at work between the two study groups (Table 1). Blood lead and eosinophil levels were significantly higher in the lead exposed group. However, Hgb and MCV were significantly lower in the case group (Table 2). Blood lead concentrations were between 5 and 21 µg /dl in the non-exposed group and between 12 and 49 µg /dl in the lead-exposed group. Pearson correlation coefficient showed a negative relationship between BLL and MCV (r= -0.28; P= 0.001). However, there was a positive relationship between BLL and eosinophil (r= -0.18, P = 0.02). Frequencies of distributions for headache, paresthesia, weakness, fatigue, forgetfulness, sleep disturbance, iron taste, and anosmia were significantly higher in the case group in comparison with the control group (Table 3). There was also a significant difference in proportion of headache, paresthesia, weakness, fatigue, forgetfulness, sleep disturbance, and iron taste between case and control groups (Table 4).

Table 1. Age and years of work in the two groups

	Control group	Lead-exposed group	P-value
	mean ± SD	mean ± SD	
Age (year)	35.50±3.70	34.71±0.52	0.24
Years of work	11.22±0.20	10.76±0.28	0.17
Number	76	70	

Table 2. Blood lead level (BLL), Hgb, MCV, WBC, and eosinophil in the two groups
MCV, Mean corpuscular volume, WBC

	Control group	Lead-exposed group	
	mean ± SD	mean ± SD	P-value
BLL (µg/dl)	8.82±3.96	36.54±4.34	<0.001
Hgb (g/dl)	15.714±0.956	15.109±1.179	0.001
MCV(fl)	91.45±8.29	87.64±9.02	0.009
WBC	7735.53±1975.63	7158.57±1978.76	0.08
Eosinophil	1.53±0.84	2.00±1.24	0.007

Table 3. Abundantly-distributed clinical findings in the two groups

	Control group		Lead-exposed group		P-value
	number	percent	number	percent	
Headache	16	21.1%	35	50%	<0.001
Dizziness	3	3.9%	8	11.4%	0.08
Paresthesia	0	0%	7	10.0%	0.005
Weakness	4	5.3%	20	28.6%	<0.001
Fatigue	13	17.1%	38	54.3%	<0.001
Tinnitus	0	0%	3	4.3%	0.10
Anosmia	0	0%	4	5.7%	0.05
Forgetfulness	3	3.9%	11	15.7%	0.01
Sleep disturbance	9	11.8%	18	25.7%	0.02
Abdominal colic	1	1.3%	4	5.7%	0.15
Iron taste	0	0%	36	51.4%	<0.001

Table 4. Correlation between clinical findings and BLL

	Blood lead level(μg/dl)		P-value
	Absent signs/symptoms	Present signs/symptoms	
Headache	18.57±13.78	28.75±13.58	<0.001
Dizziness	21.59±14.44	28.55±14.26	0.12
Paresthesia	21.20±14.22	40.14±5.52	0.001
Weakness	20.15±14.21	32.08±11.80	<0.001
Fatigue	18.06±13.7	29.6±12.9	<0.001
Tinnitus	21.9±14.5	34.7±2.3	0.06
Anosmia	21.7±14.5	35.5±0.58	0.13
Forgetfulness	21.17±14.45	30.93±12.14	0.01
Sleep disturbance	20.82±14.27	27.78±14.39	0.02
Abdominal colic	21.76±14.53	32±10.02	0.12
Iron taste	17.28±13.50	36.86±2.58	<0.001

DISCUSSION

Many studies have reported the toxic effects of lead exposure on human. Most of these studies have noted an association between signs and symptoms of the disease and BLLs, but some of them have not noted this association. Therefore, the present study was carried out in our setting (industrial and ethnic one).

The findings presented here indicate that in Iranian industrial workers, acute exposure to lead correlates with Hgb, MCV, and eosinophil levels and some clinical findings (headache, fatigue, paresthesia, weakness, forgetfulness, sleep disturbance, and iron taste). However, it does not correlate with WBC, dizziness, tinnitus, anosmia, and abdominal colic. All clinical and para-clinical findings which were higher in the lead exposed group correlated with BLL except for anosmia. Although anosmia was the only symptom which was significantly higher in the case group than in the control group, it did not correlate with BLL. The absence of that correlation despite existing significant differences between the two groups may have been related to other diseases. Our findings are consistent with some but not all previously published observations. Froom did not find any significant correlation between Hgb and BLL and there are several possible explanations for these discrepancies. First, the absence of correlation between acceptable levels of lead exposure and Hgb levels may have been related to the high proportion of smokers in his cohort study. Second, Hgb levels have been reported to correlate with bone lead levels even in the presence of low BLL levels (8). Significant statistical differences for hemoglobin (Hb), packed cell volume (PCV), reticulocyte, total white blood cell (WBC), monocyte, and systolic and diastolic blood pressure between exposed and non-exposed subjects have been observed in a study by Ukaejiofo (6).

Rubens investigated 46 lead poisoning patients (not a case-control study) and did not find any significant correlations between weakness and BLL (12). Sood encountered 11 patients with lead toxicity that all had presented diffuse abdominal pain (2). Some of the previously published observations which confirm our findings are included in studies by Anteror (Hgb, MCV) (9), Kirkby (abdominal colic) (7), Rubens (paresthesia) (12), and Winnik (iron taste) (13). The difference between our study and other studies could be due to the difference in BLL.

The influence of exposure to lead on the frequency of micronuclei (MN), nuclear buds, and nucleoplasmatic bridges was also investigated in peripheral blood lymphocytes in 15 male battery-manufacturing workers and 15 controls matched for age and smoking habits (4). Their findings indicated the genotoxicity of lead, pointing to a micronucleus assay as a relevant test for assessing genotoxic effects resulting from occupational exposure (4).

In conclusion, considering kinetic and industrial differences, BLL may correlate with some clinical and para-clinical findings. Therefore, preventive measures towards exposure to lead in workplaces and routine hematological investigations should be included in bio-monitoring the health status of lead workers

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