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Detection of Subclinical Neuropathies in Some Egyptian Workers Exposed To Lead (Cross-Sectional Study)

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Abstract Chronic lead toxicity is more common and serious for multiple organs. The objective of the present study was designed to detect subclinical neuropathies in Egyptian workers exposed to lead. A cross sectional study was carried out on sixty male Egyptian individuals; fifty workers were chronically occupationally exposed to lead and ten apparently healthy male volunteers not exposed to lead in their occupation served as a control group. All cases were subjected to clinical examination for lead toxicity. Neurological and nerve conduction study were done for both motor and sensory nerves. Estimation of blood and urine lead levels for all participants was done. A laboratory assessment was carried out for evaluation of hemoglobin level, reticulocytic count and basophilic stippling. The result of this study demonstrated elevation of both blood and urine lead levels of all workers. Increased in distal motor latency with slow conduction velocity and decreased amplitude of nerve conduction were observed in the studied nerves of all workers exposed to lead. Also, slow conduction velocity and decreased amplitude were the earliest and most sensitive finding of sensory conduction study of all workers exposed to lead. There were a significant correlation between blood and urine lead level, duration of exposure to lead and different parameters of nerve conduction. The present study concluded that nerve conduction either sensory or motor can give a clear image about chronic lead poisoning even with absence of any clinical findings (sub-clinical neuropathy). This study recommend periodic examination of workers exposed to lead for early detection and after recognition of these affected workers we must advise them improve their hygiene, use personal protective equipments or try to change their work and to notify industrial safety about them.

Keywords lead, nerve conduction, neuropathy

Introduction

Lead is a part of our world today. It is found in the dust, soil, water, air, food and paint of some homes or buildings built before 1978. These type of exposures affect the entire population, and occur primarily by ingestion or inhalation (Ragan & Turner, 2009).

Although lead is extremely useful in improving the performance of paint, gasoline, and plumbing, it is also dangerous (Bellinger, 2005). In industrial societies, sources of lead exposure include: the smelting and refining of lead, the production and disposal of storage batteries, combustion of leaded fuels, production of iron and steel, manufacture of leaded paints, burning of lead-painted surfaces, application of pesticides containing lead arsenate, and incineration of leaded plastics (Ye & Wong 2006). Lead toxicity is classified into acute and chronic. Chronic lead toxicity affects all body systems including the nervous system (Phipps et al., 2012).

Nerve conduction study is an essential element in the evaluation of peripheral neuropathies by clarifying the distribution and extent of involvement, type and time course of nerve damage. When these data are combined with clinical information, a full characterization of the neuropathy is possible (Bromberg, 2013).

Nerve conduction study is minimally invasive test that is widely available and standardized and is primarily requested in order to investigate sensory or motor dysfunction in the limbs (Vollans & Hasan, 2011). The compound muscle action potential is a biphasic potential with an initial negative or upward deflection from the baseline. For each stimulation site, the latency and amplitude are measured as shown in **Figure (1).** Motor

conduction study is monitored by the amplitude of compound muscle action potential, distal motor latency and the measured motor conduction velocities. (Soliman & Kothari 2002). This work was designed to detect subclinical neuropathies in Egyptian workers exposed to lead.

Subjects and methods

This cross sectional study was carried out on sixty male Egyptian individuals; fifty workers out of them were chronically occupationally exposed to lead, collected from automechanic workshops (welders, battery recyclers & chargers, and car painters).

The study was performed following approval of the Medical Research Ethical Committee of Faculty of Medicine, Tanta University. Workers and control group signed a written informed consent before starting the study and after complete description of the study. Privacy of the patient and confidentiality of the data and results of investigation will be maintained by using coding number. After recognition of these affected workers we must advise them improve their hygiene, use personal protective equipments or try to change their work.

The selected subjects were divided into four groups according to kind of their works:

►**Group I:** Ten male volunteers served as control group working in hospital (workers and male nurses) were included. They were apparently healthy persons of comparable age, socioeconomic life style and smoking habits compared to other groups and with no history of occupational lead exposure.

►**Group II:** Included sixteen welders.

►**Group III:** Included sixteen battery recyclers and chargers.

►**Group IV:** Included eighteen car painters.

All workers were chosen as moderate smokers with smoking index= 101-300 (smoking index=number of cigarettes per day X total duration by years). By history, all diabetics, cancer patients, alcohol consumers and addicts were excluded from this study.

Each one of the groups II, III and IV was subdivided into 3sub- groups according to the duration of exposure to lead (less than 10 years, 10-20 years and more than 20 years).

Subjects were interviewed for socio-demographic data & occupational history and subjected to clinical examination for lead toxicity, neurological examination, and electrophysiological study using the Neuropack II- NEM- 7102/K.O Nihon Kohden apparatus. Room temperature was adjusted at 25 °C (Edward et al., 2008).

Half ml blood without any preservative was used after digestion and 100ml urine was obtained without digestion for estimation of lead levels for all participants by using an inductively coupled plasma optical emission spectrometry according to Granadillo et al., (1994). Laboratory assessments was carried out on (2.5ml blood) added to EDTA tubes for evaluation of hemoglobin level by ERMA PCE210, reticulocytic count by method of Davis & Bigelow., (1989) and basophilic stippling according to Munoz & Guo, (2011).

Electrophysiological study

This study was done in the right side only of upper and lower extremities.

1- Motor conduction study for median, radial and common peroneal nerves was illustrated in Fig. 2 , 3 & 4 (respectively).

2- Sensory conduction study using antidromic technique for median, radial and sural nerves was illustrated in Fig.5, 6 & 7 (respectively).

Statistical study

Statistical presentation and analysis of the results of this study were conducted, using the mean, standard student t- test, Chi-square, Tukey`s test, Linear Correlation Coefficient, and Analysis of variance [ANOVA] tests by SPSS Version18.

Results

All workers and control participants were matched with comparable sociodemographic data with no significant differences between all studied groups as regard to age, marital state, residence and educational level. Also, no significant differences in occupational history of the studied groups of workers as regard to duration of exposure (Table 1). All workers in all studied groups did not use any protective equipment at all.

General manifestation and clinical examination (Table 2):

In the present study 75 % of welders, 93.75 % of battery recyclers & chargers and 22.22 % of car painters workers suffered from headache. While, abdominal pain (43.75 % of welders, 87.5 % of battery recyclers & chargers and 50 % of car painters) and constipation (37.5%, 62.5 % and 33.33 % in group II, III and IV respectively) were represented the only gastrointestinal manifestations. Moreover, dental caries was observed in 18.75 % and 5.56 % of battery recyclers & chargers and car painters respectively. There were significant differences between all studied groups as regard to headache and abdominal pain.

In this study, no motor manifestations were detected in all subjects after meticulous clinical examination of muscle status (normal, wasted or hypertrophied), observation of fasciculation or involuntary movements, muscle tone examination (normal, hypotonic or hypertonic) and lastly muscle power assessment. There was statistically significant difference between all studied groups as regards the presence of abnormal superficial sensation including pain, touch and temperature **(X^2 = 12.445 and P = 0.002**).

Laboratory investigation

As demonstrated in **Table (3),** the highest mean of blood lead level was observed in group III (71.001 ± 5.991µg/dl), followed by group IV and II (55.138 ± 6.172 and 46.111 ± 6.641 µg/dl respectively). Also, the highest mean urine lead level was 25.850 ± 3.592 µg/dl in group III. Significant differences were detected between all studied groups by ANOVA test **(F for blood lead level 121.190 and P= 0.000, while for urine lead level 146.86 and P= 0.000).**

By Tukey`s test, there were significant difference between each two groups for both blood and

urine lead level **(P= 0.000)** except between group III & IV in urine lead level.

► **Hemoglobin level, basophilic stippling & reticulocytosis:**

There was only one subject in group III suffered a decrease in hemoglobin level (Hb=10.6 gm/dl). No red blood corpuscle abnormalities neither basophilic stippling nor reticulocytosis were detected.

Electrophysiological changes of the studied groups:

Motor electrophysiological changes of the studied groups:

Median nerve compound muscle action potential was illustrated in **Table (4)**. By ANOVA test, there was significant increase in distal motor latency between workers and control group **(F= 17.282 and P = 0.000).** Regarding to amplitude and motor conduction velocity of median nerve, there were significant decrease in all workers compared to control group **(F1= 96.077 & F2=16.843 and P = 0.000)** respectively**.**

In radial compound muscle action potential, the mean of distal motor latency was 3.210± 0.197 ms in group I, 3.479 ± 0.588 (ms) in group II, 6.028 ± 1.598 ms in group III, and 3.837 ± 0.256 ms in group IV. While, amplitude and conduction velocity were significantly decreased in all groups of workers **(Table 5).**

Table (6) showed the muscle action potential of the common peroneal nerve, the highest mean with significance of distal motor latency was for group II and group III (6.920±0.978 and 6.843±0.518 (ms) respectively). The mean values of the amplitude were diminished in all workers. Additionally, the worst mean of conduction velocity was observed in group III 39.488 ± 3.964 (M/S) and the best one was groupI 51.640 ± 0.341(M/S)**.**

By ANOVA test, there were significant differences between all studied groups as regard to motor compound action potential of median, radial and common peroneal nerve (Table 4, 5 & 6). While by Tukey`s test, there were significant differences between each two group except between group III versus group IV of distal motor latency and motor conduction velocity and between group I versus II in amplitude and motor conduction velocity of median nerve (Table 4).

In radial nerve and by Tukey`s test, there were significant differences between group I versus III, II & III and III & IV as regard distal motor latency, while there were significant differences between group I & II, I & III and I & IV of amplitude and motor conduction velocity (Table 5).

Table 6 demonstrated significant difference between each two groups as regard to all motor compound action potential of common peroneal nerve except between II versus III and III versus IV of distal motor latency and amplitude respectively.

Sensory electrophysiological changes of the studied groups:

As regard amplitude of median sensory nerve action potential, there was a significant difference between all groups **(P= 0.000).** According to Tukey's test there were significant differences between each two groups except group III versus IV. The best conduction velocity for median sensory action potential was 42.320 ± 0.496 (M/S) for control group, decreasing gradually through car painters and welders groups till been worst in battery recyclers and chargers reaching group 31.036 ± 2.978 (M/S) **(Table 7).** According to Tukey's test there were significant differences between each two groups except group II & IV as regard sensory conduction velocity.

In this study, radial sensory nerve action potential, the best mean value of the amplitude was observed in group I (13.640 ± 0.608 µv) decreasing gradually till reaching the worst value (1.548 ± 0.526 µv) in group III. The mean values of the conduction velocity of the radial nerve decreased evidently in group III followed by group IV **(Table 8).**

In this study, the lowest amplitude of sural nerve was 3.033 ± 0.710 (µv) for battery recyclers & chargers group and the highest one was 28.450 ± 0.525 (µv) for control group **(Table 9).**

Correlations of all parameters of the present study with blood lead level:

There was a significant positive correlation between blood lead level and duration of exposure in all workers exposed to lead **(r= 0.493)** with linear relationship as shown in **Graph 1.**

In all workers exposed to lead, there was a positive correlation between blood lead level and distal motor latency of median, radial and common peroneal nerves. There were also, a negative correlation between blood lead level and both amplitude & motor conduction velocity of the same previous nerves **(Table 10, 11 & 12).** Furthermore, in all workers exposed to lead sensory conduction velocities and amplitude of the median, radial and sural sensory nerve action potential were in a negative linear correlation with blood lead level **(Table 13, 14 & 15).** While, the simple regression analysis between dependable factor (blood lead level) and independable one (duration of exposure and urine lead level) are done as illustrated in **Table (16 & 17).** This equation is used to predict dependable factor from independable one, in the current study the prediction of blood lead level is possible from duration of exposure by 22.7 % and from urine lead level by 54.619 % **(P-value= 0.000**).

There was a significant positive correlation between blood lead level and urine lead level in all workers **(r= 0.869)** with linear relationship **(Graph 2).**

Table (1) Duration of exposure to lead in all studied workers

		Group								Chi-Square	
		Group II		Group III		Group IV		Total			
		N(16)	%	N(16)	%	N(18)	%	N(50)	%	X^2	P-value
Duration	<10 years	4	25.00	4	25.00	4	22.22	12	24	2.567	0.633
	10-20 years	8	50.00	6	37.50	5	27.78	19	38		
	>20 years	4	25.00	6	37.50	9	50.00	19	38		

N: number, G I: control, G II: welders, G III: battery recyclers & chargers, G IV: car painters .

Table (2): Chi square analysis for general manifestations and clinical examination of chronic lead poisoning in all studied workers and controls

		Group										Chi-Square	
		Group I		Group II		Group III		Group IV		Total of workers exposed to lead			
		N (10)	%	N (16)	%	N (16)	%	N (18)	%	N (50)	%	X^2	P-value
General manifestations 3days ago		0											
	Headache		0.00	12	75.00	15	93.75	4	22.22	31	62	20.082	<0.001*
	Abdominal pain	0	0.00	7	43.75	14	87.50	9	50.00	30	60	7.552	0.022*
	Constipation	0	0.00	6	37.50	10	62.50	6	33.33	22	44	3.328	0.189
	Dental caries	0	0.00	0	0.00	3	18.75	1	5.56	4	8	4.05	0.132
Clinical examination	Pain	0	0.00	5	31.25	11	68.75	16	88.89	32	64	12.445	0.002*
	Touch	0	0.00	5	31.25	11	68.75	16	88.89	32	64	12.445	0.002*
	Temperature	0	0.00	5	31.25	11	68.75	16	88.89	32	64	12.445	0.002*

*N: number, G I: control, G II: welders, G III: battery recyclers & chargers,G IV: car painters, *: significant*

Table (3): ANOA one way statistical analysis followed by tukey`s for blood and urine lead level in all studied workers

	Blood lead level (µg/dl)	Urine lead level(µg/dl)	ANOVA		
	Mean ± SD	Mean ± SD	F	F1	P & P1-value
Group I N(10)	28.460 ±0.825	8.014±0.600	121.190	146.86	0.000*
Group II N(16)	46.111± 6.641	20.608±1.459			
Group III N(16)	71.001± 5.991	25.850 ±3.592			
Group IV N(18)	55.138± 6.172	24.734 ±1.964			

Tukey`s test						
Blood	I& II	I& III	I& IV	II& III	II& IV	III & IV
	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Urine	I& II	I& III	I& IV	II& III	II& IV	III & IV
	0.000*	0.000*	0.000*	0.000*	0.000*	0.495

*N: number , G I: control, G II: welders, G III: battery recyclers & chargers, G IV: car painters, *: significant*
F ANOVA for blood lead level, F1 ANOVA for urine lead level , P Significance for blood lead level, P1 Significance for urine lead level

Table (4): ANOA one way statistical analysis followed by tukey`s for compound muscle action potential of the median nerve in all studied workers and control group

	Distal motor latency of the median nerve in (ms)	Amplitude of the median nerve (mv)	Motor conduction velocity of the median nerve (M/S)	ANOVA			
	Mean ± SD	Mean± SD	Mean± SD	F	F1	F2	P, P1 & P2-value
Group I N(10)	4.012±0.112	3.465±0.287	48.182±0.443	17.282	96.077	16.843	0.000*
Group II N(16)	4.814±0.411	3.216±0.755	47.213±2.051				
Group III N(16)	5.516±0.723	2.514±0.286	42.608±3.928				
Group IV N(18)	5.628±0.845	0.976±0.227	42.901±2.309				

Tukey`s test						
Distal motor latency	**I& II**	**I& III**	**I& IV**	**II& III**	**II& IV**	**III & IV**
	0.014*	0.000*	0.000*	0.015*	0.002*	0.956
Amplitude	0.523	0.000*	0.000*	0.000*	0.000*	0.000*
Motor conduction velocity	0.797	0.000*	0.000*	0.000*	0.000*	0.988

*N: number, G I: control, G II: welders, G III: battery recyclers & chargers,G IV: car painters, *: significant*
F ANOVA for Distal motor latency P-value for Distal motor latency ms: millisecond
F1 ANOVA for Amplitude P1-value for Amplitude mv: millivolt
F2 ANOVA for Motor conduction velocity P2-value for Motor conduction velocity M/S: Meter/Second

Table (5): ANOA one way statistical analysis followed by tukey`s for compound muscle action potential of the radial nerve in all studied workers and control group

	Distal motor latency of the radial nerve in ms	Amplitude of the radial nerve	Motor conduction velocity of the radial nerve	ANOVA				
	Mean ± SD	Mean± SD	Mean± SD	F	F1	F2	P & P1-value	P2-value
Group I N(10)	3.210±0.197	1.890±0.137	48.760±0.241	30.693	11.673	5.048	0.000*	0.004*
Group II N(16)	3.479±0.588	1.318±0.551	46.256±3.197					
Group III N(16)	6.028±1.598	1.121±0.281	45.954±1.968					
Group IV N(18)	3.837±0.256	1.122±0.287	45.463±1.955					

Tukey`s test						
Distal motor latency	**I& II**	**I& III**	**I& IV**	**II& III**	**II& IV**	**III & IV**
	0.879	0.000*	0.297	0.000*	0.653	0.000*
Amplitude	0.001*	0.000*	0.000*	0.417	0.399	1.000
Motor conduction velocity	0.035*	0.014*	0.002*	0.980	0.728	0.918

*N: number, G I: control, G II: welders, G III: battery recyclers & chargers,G IV: car painters, *: significant*
F ANOVA for Distal motor latency P-value for Distal motor latency ms: millisecond
F1 ANOVA for Amplitude P1-value for Amplitude mv: millivolt
F2 ANOVA for Motor conduction velocity P2-value for Motor conduction velocity M/S: Meter/Second

Table (6): ANOA one way statistical analysis followed by tukey`s for compound muscle action potential of the common peroneal nerve in all studied workers and control group

	Distal motor latency of the common peroneal nerve(ms)	Amplitude of the common peroneal nerve(mv)	Motor conduction velocity of the common peroneal nerve(M/S)	ANOVA			
	Mean ± SD	Mean±SD	Mean±SD	F	F1	F2	P, P1 & P2-value
Group I N(10)	4.709±0.366	5.780±0.457	51.640±0.341	22.490	42.511	61.585	0.000*
Group II N(16)	6.920±0.978	3.699±1.371	47.870±1.645				
Group III N(16)	6.843±0.854	2.011±0.822	39.488±3.964				
Group IV N(18)	6.031±0.518	1.958±0.856	43.056±1.935				

Tukey`s test						
Distal motor latency	I& II	I& III	I& IV	II& III	II& IV	III & IV
	0.000*	0.000*	0.000*	0.991	0.005*	0.013*
Amplitude	0.000*	0.000*	0.000*	0.000*	0.000*	0.999
Motor conduction velocity	0.002*	0.000*	0.000*	0.000*	0.000*	0.001*

*N: number, G I: control, G II: welders, G III: battery recyclers & chargers,G IV: car painters, *: significant*
F ANOVA for Distal motor latency P-value for Distal motor latency ms: millisecond
F1 ANOVA for Amplitude P1-value for Amplitude mv: millivolt
F2 ANOVA for Motor conduction velocity P2-value for Motor conduction velocity M/S: Meter/Second

Table (7): ANOA one way statistical analysis followed by tukey`s for sensory action potential of the median sensory nerve in all studied workers and control group

	Amplitude of median sensory nerve action potential (µv)	Sensory conduction velocity of median sensory (M/S)	ANOVA		
	Mean ± SD	Mean± SD	F	F1	& P1 – value
Group I N(10)	19.850 ± 0.583	42.320 ± 0.496	24.386	29.868	0.000*
Group II N(16)	15.653 ± 3.977	34.689 ± 3.565			
Group III N(16)	12.290 ± 2.387	31.036 ± 2.978			
Group IV N(18)	11.841 ± 1.586	35.400 ± 3.139			

Tukey`s test						
Amplitude	I& II	I& III	I& IV	II& III	II& IV	III & IV
	0.002*	0.000*	0.000*	0.003*	0.000*	0.957
Sensory conduction velocity	0.000*	0.000*	0.000*	0.005*	0.898	0.000*

*N: number, G I: control, G II: welders, G III: battery recyclers & chargers,G IV: car painters, *: significant*
F ANOVA for Distal motor latency P-value for Distal motor latency ms: millisecond
F1 ANOVA for Amplitude P1-value for Amplitude mv: millivolt
F2 ANOVA for Motor conduction velocity P2-value for Motor conduction velocity M/S: Meter/Second

Table (8): ANOA one way statistical analysis followed by tukey`s for sensory action potential of radial sensory nerve in all studied workers and control group

	Amplitude of radial sensory nerve action potential (µv)	Sensory conduction velocity of radial sensory (M/S)	ANOVA		
	Mean ± SD	Mean ± SD	F	F1	P & P1-value
Group I N(10)	13.640 ± 0.608	46.780 ± 0.892	115.151	96.021	0.000*
Group II N(16)	6.318 ± 2.621	40.379 ± 4.068			
Group III N(16)	1.548 ± 0.526	27.455 ± 1.834			
Group IV N(18)	6.480 ± 1.248	35.989 ± 3.300			

Tukey`s test						
Amplitude	**I& II**	**I& III**	**I& IV**	**II& III**	**II& IV**	**III & IV**
	0.000*	0.000*	0.000*	0.000*	0.992	0.000*
Sensory conduction velocity	0.000*	0.000*	0.000*	0.000*	0.001*	0.000*

*N: number, G I: control, G II: welders, G III: battery recyclers & chargers,G IV: car painters, *: significant*
F ANOVA for Distal motor latency P-value for Distal motor latency ms: millisecond
F1 ANOVA for Amplitude P1-value for Amplitude mv: millivolt
F2 ANOVA for Motor conduction velocity P2-value for Motor conduction velocity M/S: Meter/Second

Table (9): ANOA one way statistical analysis followed by tukey`s for sensory action potential of sural sensory nerve in all studied workers and control group

	Amplitude of sural nerve action potential (µv)	Sensory conduction velocity of sural nerve(M/S)	ANOVA		
	Mean ± SD	Mean ± SD	F	F1	P & P1-value
Group I N(10)	28.450 ± 0.525	44.370 ± 0.834	670.539	108.292	0.000*
Group II N(16)	7.829 ± 1.065	40.732 ± 1.130			
Group III N(16)	3.033 ± 0.710	35.237 ± 0.939			
Group IV N(18)	5.453 ± 2.467	36.457 ± 2.068			

Tukey`s test						
Amplitude	**I& II**	**I& III**	**I& IV**	**II& III**	**II& IV**	**III & IV**
	0.000*	0.000*	0.000*	0.000*	0.001*	0.000*
Sensory conduction velocity	0.000*	0.000*	0.000*	0.000*	0.001*	0.089

*N: number, G I: control, G II: welders, G III: battery recyclers & chargers,G IV: car painters, *: significant*
F ANOVA for Distal motor latency P-value for Distal motor latency ms: millisecond
F1 ANOVA for Amplitude P1-value for Amplitude mv: millivolt
F2 ANOVA for Motor conduction velocity P2-value for Motor conduction velocity M/S: Meter/Second

Table (10): Spearman correlation between blood lead level and different motor parameters of the median nerve in workers exposed to lead

Motor parameters of median nerve in workers exposed to lead		Blood lead level	
		(r)	P-value
Distal motor latency	Group II	0.834	<0.001*
	Group III	0.877	<0.001*
	Group IV	0.661	0.003*
	Total	0.758	<0.001*
Amplitude	Group II	-0.615	0.011*
	Group III	-0.887	<0.001*
	Group IV	-0.864	<0.001*
	Total	-0.471	<0.001*
Motor conduction velocity	Group II	-0.330	0.212
	Group III	-0.919	<0.001*
	Group IV	-0.732	0.001*
	Total	-0.741	<0.001*

*G II: welders ,G III: battery recyclers & chargers, G IV: car painters, *: significant*

Table (11): Spearman correlation between blood lead level and different motor parameters of the radial nerve in workers exposed to lead

Motor parameters of radial nerve in workers exposed to lead		Blood lead level	
		(r)	P-value
Distal motor latency	Group II	0.632	0.009*
	Group III	0.903	<0.001*
	Group IV	0.691	0.002*
	Total	0.795	<0.001*
Amplitude	Group II	-0.883	<0.001*
	Group III	-0.966	<0.001*
	Group IV	-0.808	<0.001*
	Total	-0.747	<0.001*
Motor conduction velocity	Group II	-0.721	0.002*
	Group III	-0.819	<0.001*
	Group IV	-0.714	0.001*
	Total	-0.566	<0.001*

*G II: welders ,G III: battery recyclers & chargers, G IV: car painters, *: significant*

Table (12): Spearman correlation between blood lead level and different motor parameters of the common peroneal nerve in workers exposed to lead

Motor parameters of common peroneal nerve in workers exposed to lead		Blood lead level	
		(r)	P-value
Distal motor latency	Group II	0.902	<0.001*
	Group III	0.924	<0.001*
	Group IV	0.628	0.005*
	Total	0.679	<0.001*
Amplitude	Group II	-0.758	0.001*
	Group III	-0.921	<0.001*
	Group IV	-0.949	<0.001*
	Total	-0.867	<0.001*
Conduction velocity	Group II	-0.861	<0.001*
	Group III	-0.989	<0.001*
	Group IV	-0.758	<0.001*
	Total	-0.945	<0.001*

*G II: welders ,G III: battery recyclers & chargers, G IV: car painters, *: significant*

Table (13): Spearman correlation between blood lead level and different sensory parameters of the median nerve in workers exposed to lead

Sensory parameters of median nerve in workers exposed to lead		Blood lead level	
		(r)	P-value
Amplitude	Group II	-0.710	0.002*
	Group III	-0.971	<0.001*
	Group IV	-0.885	<0.001*
	Total	-0.803	<0.001*
Conduction velocity	Group II	-0.905	<0.001*
	Group III	-0.992	<0.001*
	Group IV	-0.774	<0.001*
	Total	-0.883	<0.001*

*G II: welders ,G III: battery recyclers & chargers, G IV: car painters, *: significant*

Table (14): Spearman correlation between blood lead level and different sensory parameters of the radial nerve in workers exposed to lead

Sensory parameters of radial nerve in workers exposed to lead		Blood lead level	
		(r)	P-value
Amplitude	Group II	-0.928	<0.001*
	Group III	-0.935	<0.001*
	Group IV	-0.923	<0.001*
	Total	-0.944	<0.001*
Conduction velocity	Group II	-0.807	<0.001*
	Group III	-0.915	<0.001*
	Group IV	-0.947	<0.001*
	Total	-0.974	<0.001*

*G II: welders ,G III: battery recyclers & chargers, G IV: car painters, *: significant*

Table (15): Spearman correlation between blood lead level and different sensory parameters of sural nerve in workers exposed to lead

Sensory parameters of sural nerve in workers exposed to lead		Blood lead level	
		(r)	P-value
Amplitude	Group II	-0.946	<0.001*
	Group III	-0.912	<0.001*
	Group IV	-0.941	<0.001*
	Total	-0.849	<0.001*
Conduction velocity	Group II	-0.922	<0.001*
	Group III	-0.951	<0.001*
	Group IV	-0.846	<0.001*
	Total	-0.937	<0.001*

*G II: welders ,G III: battery recyclers & chargers, G IV: car painters, *: significant*

Table (16): Simple regression analysis between blood lead level (Dependable variable) and duration of exposure (Independable variable)

Linear regression	Unstandardized Coefficients		Standardized Coefficients	T	P-value	R^2%
	B	Std. Error	Beta			
(Constant)	47.495	2.910		16.320	0.000	22.7%
Duration of exposure	0.623	0.159	0.493	3.923	0.000	
Dependent Variable: blood lead level =47.498+0.6233*Duration						

Table (17): Simple regression analysis between blood lead level (Dependable variable) and urine lead level (Independable variable)

	Unstandardized Coefficients		Standardized Coefficients	T	P-value	R^2%
	B	Std. Error	Beta			
(Constant)	-6.361	8.301		-0.766	0.447	54.619%
Urine lead level	2.679	0.346	0.745	7.744	0.000	
Dependent Variable: blood lead level = -6.361 + 2.679* ULL						

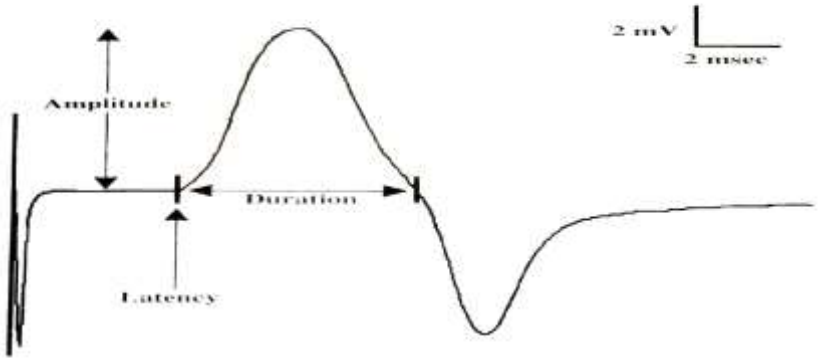


Fig (1): Compound muscle action potential (Preston & Shapiro 2007).

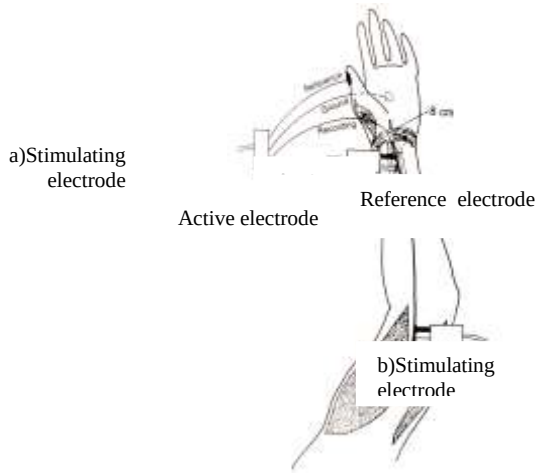


Fig. (2): Standard technique of motor conduction study for median nerve (Weber 1988).

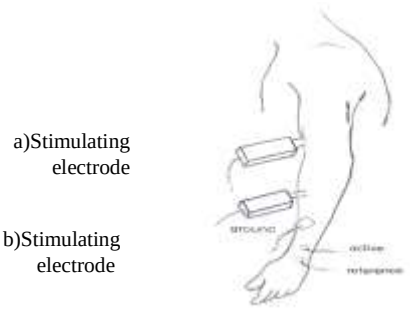


Fig. (3): Standard technique of motor conduction study for radial nerve (Papanas et al., 2010).

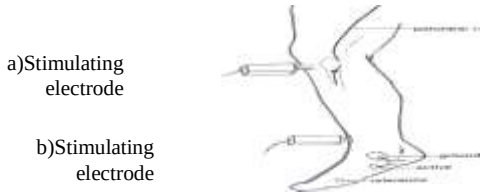


Fig. (4): Standard technique of motor conduction study for common peroneal nerve (Weber 1988).

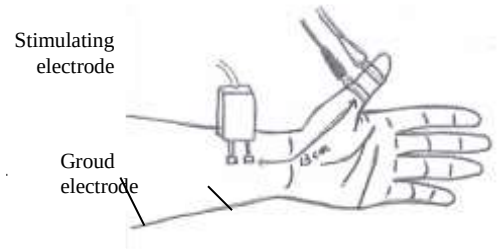


Fig. (5): Standard technique of sensory conduction study for median nerve (Miles, 2009).

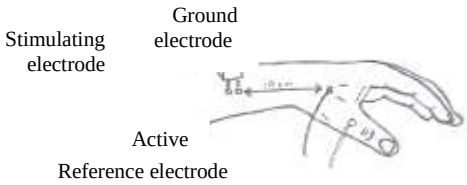


Fig.(6):Standard technique of sensory conduction study for radial nerve (Papanas et al., 2010).

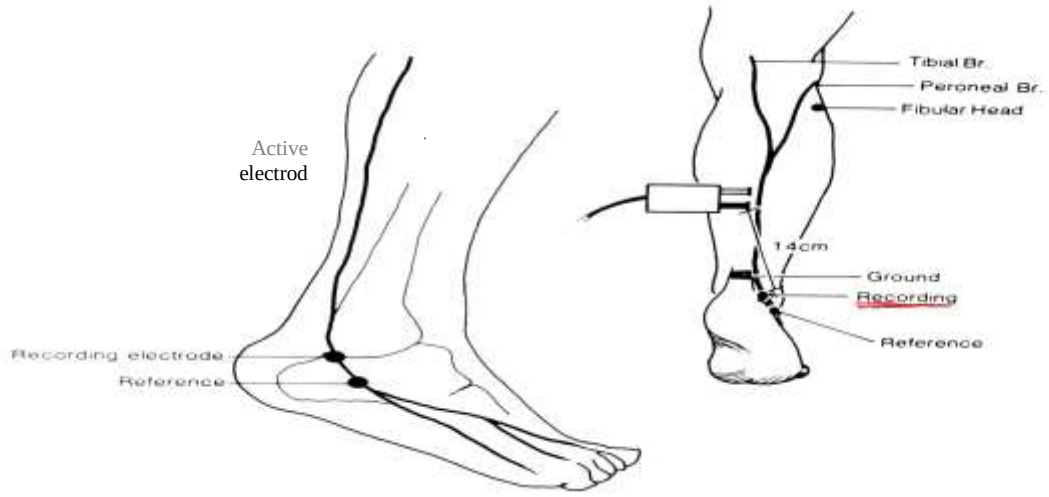
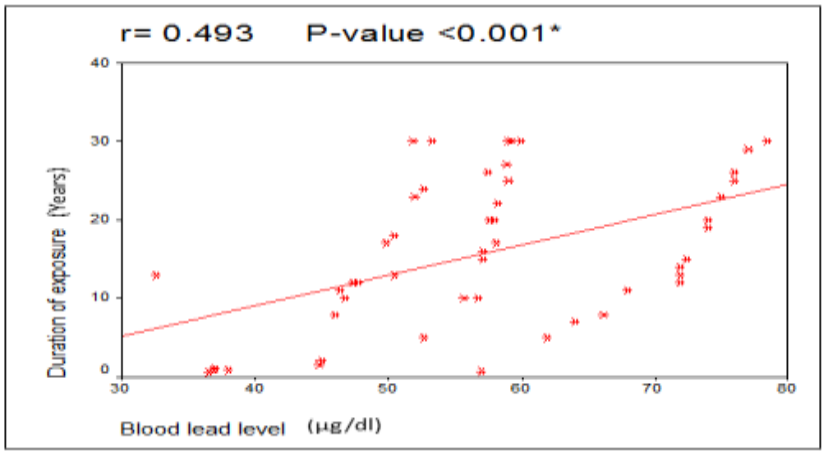
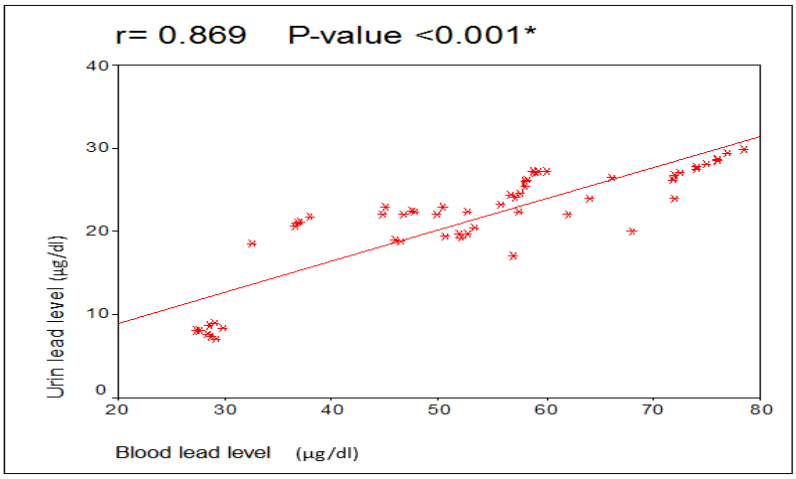


Fig.(7):Standard technique of sensory conduction study for sural nerve (Weber 1988).



Graph (1): Correlation between blood lead level and Duration of exposure in workers exposed to lead



Graph (2): Correlation between blood lead level and urine lead level in workers exposed to lead. *: significant

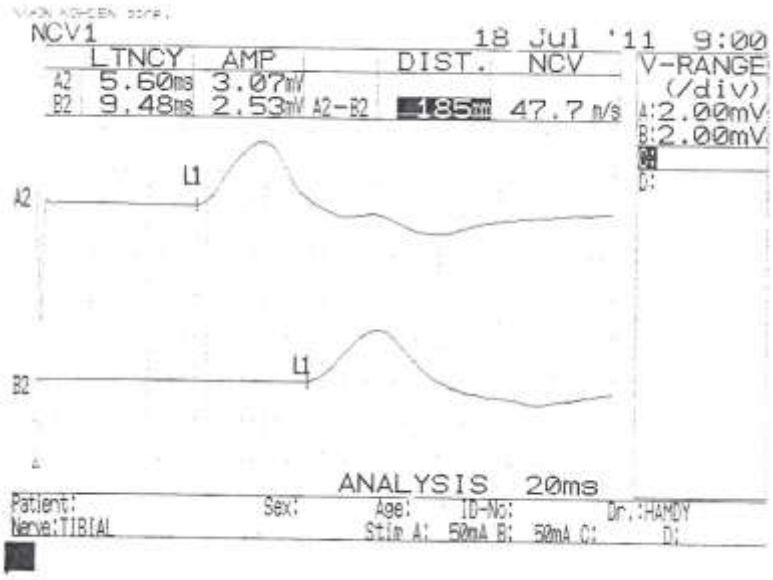


Fig (8): Motor conduction study of the median nerve of a case study from welders (group II) showing delayed distal motor latency, low amplitude and slightly reduced motor conduction velocity in the compound muscle action potential in the median nerve.

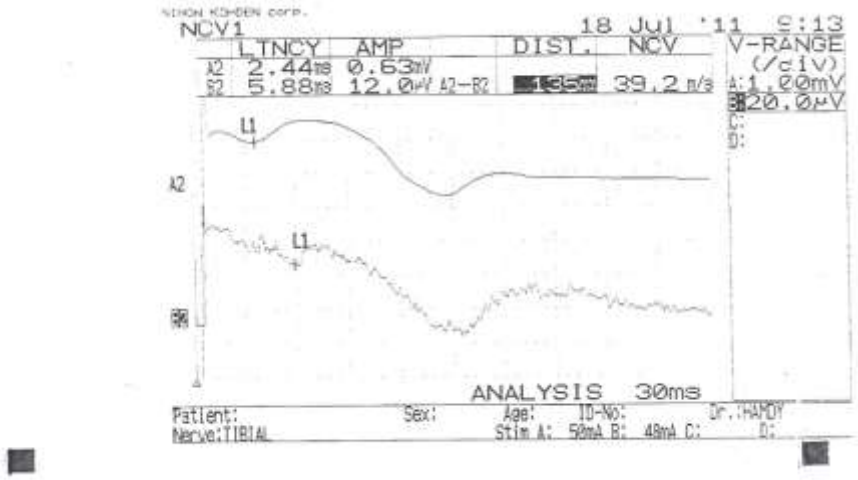


Fig (9): Motor conduction study of the radial nerve of a case study from welders (group II) showing low amplitude and reduced motor conduction velocity of the radial nerve.

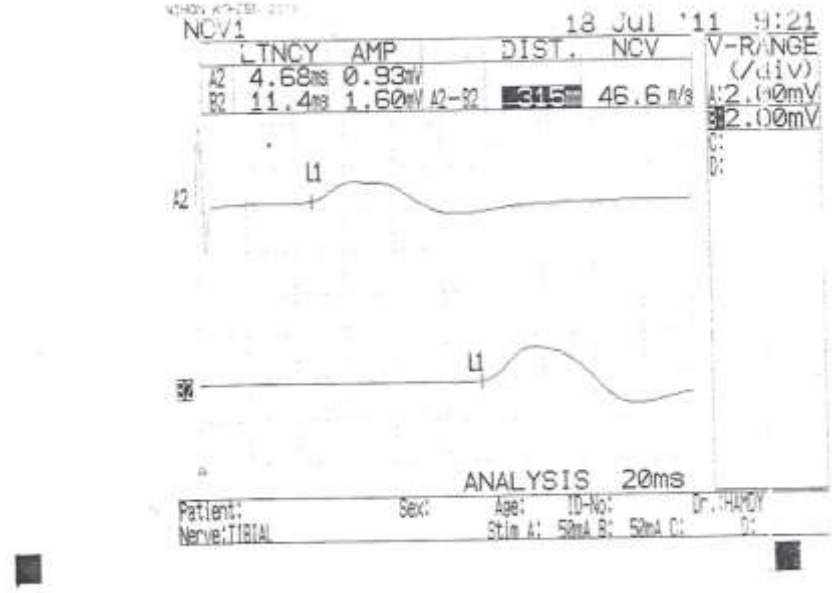


Fig (10): Motor conduction study of the common peroneal nerve of a case study from welders (group II) showing low amplitude and reduced motor conduction velocity of the common peroneal nerve.

DISCUSSION

Lead is a cumulative metallic poison that causes both acute and chronic intoxication. Chronic poisoning is more common and serious (Al-Rudainy 2010). Long-term lead exposure can result in lead neuropathy (Sadeghniiat-Haghighi et al., 2013). The classic form of lead neuropathy is a motor one, but sensory involvement may occur also (Thomson & Parry, 2006).

According to Gharaibeh et al., (2014), automechanic (welders, battery recyclers and chargers, and car painters) are at high risk for lead exposure so why the choice of these occupations was done in the current study. In Egypt, there are many small automechanic workshops, where workers exposed to lead by inhalation. So, this study was designed to detect subclinical neuropathies in Egyptian workers exposed to lead.

In the current study, all workers did not use any protective equipment. This finding might be attributed to negligence using of protective equipments is out of mind in difficult socioeconomic level population, so the high blood and urine lead level are expected outcome. Lormphongs et al., (2003) and Centers for Disease Control and Prevention, Morbidity and Mortality (2013) found that, blood lead level in occupational workers who used cotton masks were lower than workers who never used any protective masks.

In the current study, the mean blood lead level was higher (71.001 ± 5.991 µg/dl) in battery chargers and recyclers than other groups. Blood lead level has been accepted as the most reliable biomarker for lead toxicity (Al-Rudainy, 2010). Ahmed et al., (1987)

reported that the acceptable blood lead level in Egypt is 30µg/dl. While the acceptable blood lead level in Tahran and in America are 9.33µg/d and 10 µg/dl respectively (Herman et al., 2007 and Sadeghniiat-Haghighi et al., 2013).

In the current study, the mean blood lead level in control group was 28.460 ± 0.825. This high level could be attributed to many causes such as air pollution which is a serious problem in the major cities in Egypt (Ahmed et al., 1987). Eating fish from River Nile showing increased lead level from contamination by drainage of industrial discharges in it, as reported by El-Kattan et al., (2008). Also, water is a source of lead poisoning from lead water pipe (Woolf et al., 2007, El-Kattan et al., 2008 and Ismail, 2011).

In this study, there was a significant positive correlation between blood lead level and the duration of exposure in all workers exposed to lead with linear relationship. Similar result was noticed in Oman by Al-Rudainy, (2010). This result could be explained by lead is a cumulative poison, when inhaled daily; it mounts up in the tissues by time (Gulson & Salome, 2012). In addition, the most highly significant correlation with duration of exposure was group III (battery recyclers and chargers). A study done in India by Patil et al., (2006) who found that workers in battery manufactures and recyclers had the worse blood lead level and clinical manifestations. Moreovere, Gharaibeh et al., (2014) denoting that, working or living near battery factories usually associated with high blood lead concentrations.

In this study, the highest mean of urine lead level was 25.850 µg/dL in group III (battery recyclers and chargers) with significant differences between all studied groups by Tukey`s test. Furthermore, there was significant positive correlation between blood lead level and urine lead level in all workers. This was in accordance with, Moreira& Neves (2008) and Latif et al., (2013). So, urine can be used to replace blood for the assessment of occupational exposure to lead to avoid the invasive blood sampling. This result could be due to that, most of the lead absorbed into the body is excreted by the kidney (approximately 65%) (Abdel-Maaboud et al., 2005).

In the present study, the general manifestations from chronic lead poisoning represented by headache 62%, abdominal pain (60 %) and constipation (44 %). The majority of them were in group III. Dental caries was found in 8% of workers exposed to lead. Baker et al., (1979) reported that, no toxic effects could be detected below 40 µg/dl. Also, California Department of Public Health Occupational Lead Poisoning Preventive Program (2009) claimed that, the non specific symptoms "constipation and headache" appeared at the range of 40-79 µg/dl. In contrast, Gharaibeh et al., (2014) found that abdominal colic, constipation and headache starting to appear at 10 µg/dl.

In the current study, there was only one subject in group III suffered decrease in hemoglobin level (Hb=10.6 g/dl). This result coincided with Lidsky & Schneider (2003) and Herman et al., (2007) who found that, lead can produce anemia both by interfering with heme synthesis and by decreasing iron absorption from gut. Kwong et al., (2004) found a relationship between iron and lead. Iron deficiency anemia may increase the risk of lead poisoning.

The present study revealed no clinical abnormalities in red blood corpuscle such as basophilic stippling or reticulocytosis. Moreover, Fonte et al., (2007) and Gunturu et al., (2011) studied cases with occupational lead poisoning, high blood lead level, hemoglobin level decreases**,** basophilic stippling and reticulocytosis become positive. On other hand, Shobha et al., (2009) studied another cases with occupational lead poisoning with no one had basophilic stippling inspite that their blood lead level were elevated 4-12 times above normal.

Basophilic stippling represents aggregation of ribosomal RNA in the cytoplasm of the red blood cell especially in the peripheral blood smear (Valentine et al., 1976 and Phipps et al., 2012). It was considered since 1899 as a classic laboratory sign of lead poisoning, now it considered a non specific finding for lead poisoning as it found in 27 % of internal medicine patients "malignant, rheumatologic, hematologic, cardiovascular and other diseases". Also, basophilic stippling is present in a small percentage of normal people (Cheson et al., 1984).

In the present study, there were no clinical motor manifestations detected in all subjects of the studied groups. While the superficial sensation including pain, touch and temperature in group II, III and IV were decreased significantly. However, Thomson & Parry (2006) found that, both motor and sensory manifestations for lead poisoning occurred at 80 µg/dL but motor manifestation may appear above 100 µg/dL. Also, Dsouza et al., (2009) observed that, wrist drop of lead poisoning occurred when blood lead above 106.5 µg/dL. Another study had been done by Shobha et al., (2009) who found that both motor and sensory manifestations may appear even below the level of 70 µg/dL. This result may be attributed to the effects of lead on both central and peripheral nervous systems. Central nervous system is more affected in children but peripheral nervous system is more in adult (Bellinger, 2004). Lead interferes with the ability of calcium to trigger exocytosis of neurotransmitters in neuronal cells suggesting that lead might generally target proteins involved in calcium-mediated signal transduction (Goldwin, 2001).

Sadeghniiat-Haghighi et al., (2013) found that, no significant differences in nerve conduction indices between the two sides (right and left extremities) among all participants. So this study was done in the right side only. In this study, there were significant differences between all four studied groups as regards distal motor latency, amplitude and motor conduction velocity of median, radial and common peroneal nerves. This result was parallel to that obtained by Gidlow (2004) and Thomson and Parry (2006), who found prolongation of distal motor latency values than normal in workers excessively exposed to lead.

These findings could be explained by Bleecker et al., (2005) who found that, lead directly

damages the peripheral nerves through axonal degeneration and demyelination.

The median nerve appears to be more susceptible to lead effects than the ulnar nerve and distal motor latency is considered sensitive and early indicator for motor conduction study abnormalities by axonal degeneration and segmental demylination" (Chia et al., 1996). So, the present study preferred the median nerve than the ulnar nerve.

Additionally, Bilińska et al., (2004) found lowered amplitude of motor nerves "radial and common peroneal nerves" than the control group even if there were no clinical manifestations which is called the subclinical neuropathy, which coincide with results of the current study.

In this study, the worst sensory conduction velocity for the median nerve was obvious in group III (battery recyclers and chargers). These results were in accordance with those of Chia et al., (1996) who found changes in sensory nerve parameters compared with controls with a significant difference in both groups. Bilińska et al., (2005) observed a significant reduction in the conduction velocity for the sural nerve in workers exposed to lead. This result could provide an explanation that sensory nerve action potential measures the integrity of the fastest conducting myleinated fibers Rubens et al., (2001).

The present study concluded that both blood and urine lead level and nerve conduction either sensory or motor can give a clear image about chronic lead poisoning even with absence of any clinical findings (sub-clinical neuropathy).

Recommendation

The OSHA guidelines should be followed for safety of workers health and environment.

- Workers hygiene should be improved through awareness about the nature and hazards of this work.
- The personal protective equipments should be available for workers, who must be educated about the importance of avoidances or minimization of exposure to lead.
- Pre- employment and periodic medical examination including blood and urine lead levels and nerve conduction assessments should be performed to welder, battery recycler and charger and car painter workers. This screening protects workers from developing sensory or motor nerve affection by allowing early recognition of these affected workers who must try to change their work.
- The head of workshop and industrial safety must be notified about any case detected.

Acknowledgment

Thanks to Prof. Dr.Tarek El-Nemr, Professor of Physics, Faculty of Science, Tanta University, for his help in blood and urine lead level assessment.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Limitations

This study limited by the small sample size to the extent that it is not possible to make any strong conclusions. Prospective and controlled studies involving larger numbers of chronic lead exposed workers involving other different types of occupational workshops in different regional area to evaluate the magnitude of the problem in Egypt are needed. Further work should include determination of blood lead level in relations to nutrition and level of trace elements such as zinc, iron, calcium and magnesium and the relationship between blood lead level and different antioxidants and if they have protective role for electrophysiological changes in workers chronically exposed to lead.

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الملخص العربى

الاكتشاف تحت الاكلينيكي لاعتلال الاعصاب الطرفية فى بعض العمال المصريين المتعرضين مهنيا للرصاص (دراسه عينة احصائية)

د/علياء عبد الحكم إبراهيم هديب وأ.د/ منى محمد حشمت وأ.د/ايمان مصطفى سليمان ود إيناس إبراهيم المداح[1] وأ.د/ ألهام محمد قاسم[2]

التسمم المزمن بالرصاص هو الأكثر شيوعا وخطورة مما يسببه من اعتلال في وظيفة العديد من أجهزة الجسم. وتهدف هذه الدراسة لتحديد كيفية اكتشاف اعتلال الاعصاب الطرفية تحت الإكلينيكية فى العمال المصريين المتعرضين مهنيا للرصاص. و قد أجريت دراسة عينه إحصائيه على ستين من الأفراد الذكور المصر.يين. خمسون منهم كانوا عمالا متعرضيين مهنيا للرصاص بشكل مزمن وقد تم جمعهم من ورش العمل (عمال اللحام، إعادة تدوير البطاريات وأجهزة الشحن ودهان السيارات).

في حين تم اخذ عشرة متطوعين من الذكور الأصحاء ظاهريا لم يتعرضوا للرصاص فى وظائفهم كمجموعة ضابطه. وقد خضعت جميع الحالات للفحص السريري لاعراض التسمم بالرصاص، والفحص العصبي ودراسة التوصيل العصبي للجهاز (الحسي والحركي). وقد تم تقدير مستويات الرصاص فى الدم والبول لجميع المشاركين. وأجري تقييم المختبر من أجل تقييم مستوى الهيموجلوبين، وعدد الخلايا الشبكية ومستقعد التنقير. وقد اظهرت نتائج هذه الدراسة ارتفاع كل من مستويات الرصاص فى الدم والبول في العاملين المتعرضين للرصاص. وكشفت هذه الدراسة وجود زيادة في طور الخفاء القاصي الحركى مع بطء وانخفاض واضح فى السعة للتوصيل العصبي وذلك لكل الفئات المعرضة للرصاص. أيضا، كانت السعة بطيئة والتى تعد من اوائل التغيرات والأكثر حساسية فى دراسة التوصيل الحسي الغير طبيعي لجميع العاملين المعرضين للرصاص. ولقد لوحظ ارتباط كبير بين كل من مستوى الرصاص فى الدم والبول ومدة التعرض للرصاص والمعاير المختلفة من التوصيل العصبي. وخلصت هذه الدراسة الى أن التوصيل العصبي الحسي أو الحركي يمكن أن يعطي صورة واضحة عن التسمم بالرصاص المزمن حتى مع عدم وجود أي نتائج سريرية (الاعتلال العصبي تحت الاكلينيكي). وتوصي هذه الدراسه ب الفحص الدوري للعمال المعرضين للرصاص للكشف المبكر و بعد التعرف علي هؤلاء العمال المتضررين علينا أن ننصحهم بتحسين النظافة الشخصية، واستخدام معدات الوقاية الشخصية أو محاولة تغيير عملهم وابلاغ الامن الصناعي بذلك.

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