Effects of occupational exposure to lead on left ventricular echocardio graphic variables

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Abstract

BACKGROUND: Lead contamination can affect many body organs including the heart. This study assessed a number of echocardiographic indices to clarify the effects of lead on cardiac function among battery factory workers who are in constant exposure to lead.

METHODS: In a cross-sectional study, 142 male battery factory workers who had been exposed to lead for at least 1 year were evaluated. The subjects aged 25-55 years old and were excluded if they had hypertension, diabetes, or cardiovascular diseases. Demographic characteristics, professional profile, lead exposure, history of respiratory diseases, drugs intake, and lifestyle information of the participants were collected. Height, weight and blood pressure measurements were then performed. Blood tests were also ordered to determine blood lead levels. The subjects finally underwent M-mode and Doppler echocardiography. Linear regression analysis was used to establish the effects of lead on the target indices. All statistical analyses were conducted in $SPSS_{18}$.

RESULTS: The mean age and mean duration of lead exposure of the subjects were 41.78 ± 13.58 and 23.54 ± 14.44 years, respectively. The mean blood lead level was 7.59 ± 2.75 µg/dl. Left ventricular hypertrophy was detected in 12% of the participants. Blood lead levels were not significantly related with echocardiographic indices in the crude model or after adjustments for age alone or for age and other risk factors.

CONCLUSION: Blood lead levels of our participants were below standard values. In addition, no significant relation was found between left ventricular function indices and blood lead levels. The absence of such relations could have been caused by the exclusion of individuals with hypertension or cardiovascular diseases. Structural modifications in battery factories following legislations in Iran might have been responsible for low blood lead levels among the subjects.

Keywords: Occupational Exposure, Lead, Left Ventricular Echocardiography

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Introduction

Lead contamination involves a wide variety of body organs.[1] Long exposure to lead may result in memory impairment, increased reaction time, and inability to perceive information. It may also cause physical complications such as hypertension, renal complications, cognitive and psychiatric disorders, hemoglobin disorders and anemia, peripheral vascular disease,[2] and cancers including lung and stomach cancers and glioma.[3]

Among the numerous lead-containing products, leaded gasoline and batteries are the most important.[4] The extent of complications depends on exposure dose and duration, age, occupation, general health, and lifestyle.[5] However, even small occupational exposure doses would cause impaired cardiac function.[6] In addition, even little increases in blood lead level are associated with peripheral vascular disease[7] and hypertension.[8] Various blood levels of lead have been suggested as the risk factor for cardiovascular diseases and mortality in different societies. While cohort studies on individuals at

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occupational exposure to lead have reported a level above 40 μg/dl to be a risk factor for the mentioned problems, community-level studies found lead blood levels of higher than 10 μg/dl to be correlated with atherosclerosis, cardiovascular diseases, and increased mortality.[9-11]

Despite the absence of a well-established mechanism through which lead affects the heart, two main mechanisms have been suggested. Some researchers have identified lead to increase blood pressure and hence negatively affect the heart and coronary arteries. Others however, have considered increased atherosclerosis caused by lead to be responsible.[12] Lead has also been indicated as an independent risk factor for the incidence of cardiovascular diseases.[13]

Left ventricular function is among the most important indices in determining the prognosis of heart diseases. Various methods are available to qualitatively and quantitatively assess left ventricular function. Echocardiography is a non-invasive method which not only evaluates left ventricular function, but also determines the reason for the impaired ventricular function.[14] The present research tried to assess echocardiographic indices among battery factory workers to clarify the effects of lead on cardiac function.

Materials and Methods

In a cross-sectional study during 2011, 142 male battery factory workers in Isfahan (Iran) were selected using convenience sampling. The subjects aged 25-55 years old and had been chronically exposed to lead for at least one year. Individuals with a history of diabetes, hypertension, heart or kidney diseases, and cancers, as well as those using drugs affecting blood pressure were excluded.

After explaining the objectives of the study, informed consents were obtained. A questionnaire covering demographics (age, gender, education level, and marital status), job-related information, history of lead exposure (job, working experience, previous jobs, and how they were exposed), respiratory disease history, medicine intake, and lifestyle (smoking, leisure time physical activity, and diet) was then completed for all subjects.

The next step was to measure height (using a Seca measuring band) and weight (using a Seca scale) and to calculate body mass index (BMI) as weight divided by height squared. In addition, 3 measurements of sitting blood pressure with 5-minute intervals were performed after 20 minutes of rest. The 3 values were averaged and recorded as each person's blood pressure.

Venous blood samples were taken from all subjects in the early morning and kept in lead-free heparinized tubes at 4°C. Blood lead levels were then evaluated by a flameless atomic absorption spectrophotometer.[8]

After completing the questionnaires and performing the necessary examinations and tests, M-mode and Doppler echocardiography were performed on all subjects by a cardiologist and according to the guidelines of American Society of Echocardiography.[15] Left ventricular end-diastolic dimension (LVEDd), interventricular septum (IVS), posterior wall thickness (PWT), left atrium diameter (LAD), aortic diameter (AoD), left ventricular ejection fraction (LVEF), left ventricular mass (LVM), left ventricular mass index (LVMI), and early to late diastolic filling (E/A) were measured in the echocardiogram. All measurements were made by a Vivid-3 Cardiology Ultrasound Machine and an adult probe. In M-mode echocardiography, parasternal long axis view and parasternal short axis view at the level of papillary muscle were used to determine left ventricular dimensions. In the absence of any regional wall motion abnormalities, measurements were made at mid-ventricular level. PWT and IVS were also measured on the same section. The obtained data was used to calculate LVM and LVMI.[16] According to Penn's formula, an LVM level higher than 177 g was identified as left ventricular hypertrophy.[17]

Maximum and minimum ventricular sizes at mitral valve level were considered as end-systolic and end-diastolic dimensions, respectively.[15] LVEF was determined based on Simpson method. Doppler echocardiography was employed to determine E/A. Mitral blood flow velocity was measured in the apical view at end-expiration and maximum flow.[18]

The collected data was analyzed in $SPSS_{18}$ (SPSS Inc., Chicago, IL, USA). The relations between blood lead levels and cardiac function indices were assessed by correlations. Using a linear regression model, first the crude effects of lead on the mentioned indices were determined. The model was then adjusted for smoking, daily physical activity, systolic blood pressure, BMI, and age to reevaluate the effects.

Results

A total number of 142 male battery factory workers with a mean age of 41.78 ± 13.58 years (range: 21.00-72.00 years) were evaluated. Demographic characteristics of the subjects are summarized in table 1. More than 50% of the participants were illiterate or had completed elementary school. They had been working in battery making profession for 23.54 ± 14.44 years. Moreover, their daily working hours were 9.77 ± 2.26 (range: 5.00-16.00 hours) and 62% of the subjects worked more than 8 hours a day. Most workers (79.7%) were exposed to lead through both inhalation and skin. The mean blood lead level among the participants was 7.59 ± 2.75 μg/dl (range: 2.60-16.10 μg/dl).

Table 1. Demographic characteristics of the studied population

Variables	Value
Age (years)	41.78 ± 13.58
Educational level	
• Illiterate	3 (2.1%)
• Junior high school	69 (48.3%)
• High school	50 (35.0%)
• University degree	20 (14.0%)
Marital Status (married)	118 (82.5%)
Average monthly payment (Toman)	
• Less than 300,000	36 (25.2%)
• 300,000-500,000	105 (73.4%)
• 500,000-800,000	1 (0.7%)

Values are expressed as mean ± SD or number (%).

Table 2. History of diseases and lifestyle indicators among the studied population

Variables	Values
History of dyslipidemia	16 (11.2%)
History of respiratory diseases	18 (12.6%)
Regular physical activity*	57 (39.9%)
• days/ week	3.50 ± 2.57
• minute/day	16.48 ± 27.07
Smoking	
• Non-smoker	97 (67.8%)
• Ex-smoker	19 (13.3%)
• Smoker	26 (18.2%)
Body mass index (kg/m^2)	25.70 ± 3.72
Systolic blood pressure (mmHg)	111.52 ± 13.60
Diastolic blood pressure (mmHg)	70.06 ± 8.95

Values are expressed as mean ± SD or number (%).

Table 2 presents the history of diseases and lifestyle-related factors. Echocardiography findings among the studied population are shown in table 3. LVM ranged from 62.67 to 248.48 g and 12% of the subjects had left ventricular hypertrophy. The mean blood lead levels were not significantly different between individuals with LVM higher than 177 g and others (8.05 ± 2.84 vs. 7.55 ± 2.75 μg/dL; P = 0.501).

Table 4 reports the effects of lead on echocardiographic indices in the crude model and two models adjusted for age, and for age, disease history, physical activity, smoking, and BMI. As it is seen, blood lead levels had no significant effects on any of the echocardiographic indices in either the crude model, or the adjusted models.

Table 3. Echocardiographic indices of the studied population

Variable	Mean ± SD
Left ventricular end-diastolic dimension (mm)	47.6 ± 5.3
Interventricular septal (mm)	8.50 ± 3.20
Posterior wall thickness (mm)	8.30 ± 1.20
Left atrium diameter (mm)	35.60 ± 3.80
Aortic diameter (mm)	28.80 ± 5.30
Left ventricular ejection fraction (%)	62.49 ± 4.51
Left ventricular mass (g)	133.91 ± 34.18
Left ventricular mass index	76.29 ± 58.71
Early to late diastolic filling	1.83 ± 2.45

Discussion

The present study revealed mean blood lead levels of 142 male battery factory workers to be below the standard level. In addition, lead levels were not found to be associated with any of left ventricular function indices.

A number of other studies have also evaluated the effects of lead on left ventricular function indices. Tepper et al. assessed the relation between lead levels and measured blood pressure in 108 battery factory workers. They reported blood lead levels to be significantly associated with diastolic blood pressure, but non-significantly related with systolic blood pressure and LVM.[19] Similarly, we found lead to non-significantly and slightly affect left ventricular function indices.

Zou et al. suggested E/A to be significantly lower in lead-exposed subjects compared to unexposed individuals.[20] Schwartz studied 9932 American adults whose information was collected by the Second National Health and Nutrition Examination Survey. Finally, blood lead level was reported to significantly, but not strongly, affect left ventricular hypertrophy (P = 0.0087; B = 0.028).[21] We however, could not establish a significant relation between blood lead levels and LVM. The difference between the two studies might have been resulted by the greater number of evaluated persons by Schwartz.

In another study, Kasperczyk et al. compared a group of lead-exposed individuals with a control group working in lead factories in Southern Poland.

Table 4. Effects of blood lead levels on echocardiographic indices

	Beta	P	95% confidence interval
Crude model:			
Left ventricular end-diastolic dimension	-0.029	0.733	(-0.039-0.027)
Interventricular septal	-0.045	0.600	(-0.025-0.015)
Posterior wall thickness	0.057	0.505	(-0.005-0.010)
Left atrium diameter	-0.010	0.905	(-0.025-0.022)
Aortic diameter	-0.013	0.879	(-0.031-0.036)
Left ventricular ejection fraction	0.013	0.877	(-0.257-0.301)
Left ventricular mass	0.003	0.975	(-2.067-2.132)
Left ventricular mass index	-0.119	0.167	(-6.218-1.0684)
Early to late diastolic filling	-0.019	0.825	(-0.170-136)
Second model:*			
Left ventricular end-diastolic dimension	-0.031	0.721	-0.039-0.027
Interventricular septal	-0.048	0.575	-0.026-0.014
Posterior wall thickness	0.050	0.552	-0.005-0.010
Left atrium diameter	-0.015	0.862	-0.026-0.022
Aortic diameter	0.012	0.890	-0.031-0.036
Left ventricular ejection fraction	0.016	0.857	-0.254-0.303
Left ventricular mass	-0.004	0.961	-2.123-2.021
Left ventricular mass index	-0.118	0.170	-6.232-1.114
Early to late diastolic filling	-0.015	0.857	-0.167-0.139
Third model:**			
Left ventricular end-diastolic dimension	-0.005	0.954	-0.035-0.033
Interventricular septal	-0.040	0.656	-0.026-0.016
Posterior wall thickness	0.081	0.334	-0.004-0.011
Left atrium diameter	0.020	0.815	-0.021-0.027
Aortic diameter	0.001	0.992	-0.035-0.35
Left ventricular ejection fraction	0.041	0.651	-0.222-0.354
Left ventricular mass	0.042	0.611	-1.437-2.435
left ventricular mass index	0.029	0.746	-1.074-1.495
Early to late diastolic filling	-0.018	0.840	-0.179-0.146

* Adjusted for age

** Adjusted for age, body mass index, smoking, physical activity, and systolic and diastolic blood pressure

IVS, LVDd, PW, LVEF, LAD, AoD, and right ventricular diastolic dimension were evaluated through echocardiography. While LVEF was 3% less in lead-exposed individuals compared to the control group, LVDd and LVM were respectively 6% and 11% higher. Blood lead level was found to have significant positive relations with LVDd and LVM.[22] Since blood pressure has an independent effect on left ventricular hypertrophy and function,[23-25] we excluded hypertensive or cardiovascular patients. However, Kasperczyk et al. did not eliminate the confounding factor of blood pressure.[22]

A review article suggested that despite the observed cardiovascular effects of lead, adequate evidence to confirm the relationship has not yet been provided.[26] Another review article evaluated studies on the effects of chronic lead exposure on cardiovascular function and diseases. It suggested that although animal, tissue, and cell cultivation models had found lead to be effective on blood pressure, endothelial injury and dysfunction, atherosclerosis, and cardiovascular diseases, evidence is still insufficient to validate such a mechanism at clinical and epidemiological levels.[27]

As mentioned, previous studies could not establish the definite effects of lead on left ventricular function and echocardiographic indices. However, some research has revealed lead to affect cardiovascular diseases and their associated mortality.[2,28] Stimulation of the oxidative stress system, inflammation, alteration of nitric oxide signaling pathways, endothelial injury, vascular smooth muscle cells proliferation, and inhibition of fibrinolysis have been suggested as the probable mechanisms through which lead impacts on cardiac function.[29]

Conclusion

The present study could not indicate a significant relation between blood lead levels and echocardiographic indices of left ventricular function.

Eliminating hypertensive and cardiovascular patients, as the high risk population, might have been responsible for the lack of relation. On the other hand, the low blood lead levels may suggest structural improvements in battery factories after introducing new legislations in Iran. Evaluating other factors such as bone lead level, which is a better indicator of chronic lead-exposure, may result in different findings. Moreover, longitudinal studies on the incidence and mortality of cardiovascular diseases among lead-exposed individuals can provide more useful information.

Conflict of Interests

Authors have no conflict of interests.

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