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RESEARCH ARTICLE

Effect of lead on cardiorespiratory system in lead smelters: A case–control study

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ABSTRACT

Background: Lead is a chemical agent with little or negligible use in the human body. However, deleterious effect can occur if it builds up in the body resulting in multiorgan damage. Long-term exposure to lead occurs through occupational and environmental sources such as mining smelting. Once the level of lead increases in the body, it starts accumulating in the brain, lungs, liver, kidney, teeth, bones, etc. This exposure is preventable if appropriate health measures are taken in industries. Hence, increased awareness should be instilled among the industrialist and workers both so that appropriate measures can be taken to reduce the health hazards in the society. **Aims and Objectives:** The present study aims to identify the cardiorespiratory changes in lead smelters. The cardiorespiratory tests were performed on subjects for the determination of blood pressure (BP) , electrocardiographic changes, and pulmonary function tests (PFTs). **Materials and Methods:** The cross-sectional case–control study including 100 subjects were divided into two groups: Group A is of 50 controls and Group B was of lead smelters. The cardiorespiratory tests performed on subjects comprised of recording of electrocardiogram (ECG), measurement of Systolic BP (SBP) and Diastolic BP (DBP), and determination of PFT in controls and lead smelters. Data was analyzed using appropriate statistical tests. **Results:** Highly significant ($P < 0.001$) changes were found in SBP, DBP, heart rate, forced expiratory volume in 1st second (FEV_1), FEV_1/forced vital capacity, and peak expiratory flow rate in lead smelters as compared to the control subjects. **Conclusion:** Lead has a deleterious effect on human health. Long-term exposure will lead to cardiovascular abnormalities, so the knowledge and awareness of the problem is essential to limit the risk of lead exposure. The current occupational safety standards for blood lead must be lowered and criterion for screening elevated lead exposure needs to be established in industries.

KEY WORDS: Lead Toxicity; Pulmonary Function Tests; Blood Pressure; Electrocardiography; Smelting

INTRODUCTION

Lead is one of the most common elements present on the earth and due to its physical and chemical properties and its abundant availability at a low cost, it is widely used in plumbing, batteries, alloys, white paints, construction, etc.[1-3] Smelting is a process of applying heat to an ore to extract a base metal. Lead smelters are huge plants for the production of lead and people working here are called smelters. The safety level of lead exposure has not yet been identified; however, the US Centers for Disease Control and Prevention and the WHO state that the blood level of the lead of 10 µg/ dl or above is a cause of concern.

The routes by which lead smelting can lead to lead exposure are inhalation or ingestion of lead dust particles and gases.

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Smelters are exposed to direct long-term inhalation of the dust and gases.

It is reported in the previous studies that prolonged lead exposure may result in the development of hypertension, myocardial ischemia, stroke, coronary heart disease,[4] chronic obstructive pulmonary diseases (COPD), and asthma. However, the results on respiratory systems are not clearly explained yet.

In developing countries, occupational lead exposure is commonly unregulated and monitoring of exposure is most neglected. Although several countries adopt measures to reduce the emission of lead, environmental contamination by this metal still remains a public health problem. This exposure is preventable if appropriate safety measures are undertaken. To prevent the deleterious effect of lead exposure on the smelters, it is mandatory to create awareness among the industrialist so that they can take appropriate measures to decrease the health hazards.

Most of the study suggested a relation between cardiovascular outcomes and lead exposure, but the effect on respiratory system is still controversial, and more studies are needed to clarify these effects. The present study aims to find out the effect of lead on cardiorespiratory system in the smelters.

Aims and Objectives

This study aims to identify the cardiorespiratory changes in lead smelters of Southern Rajasthan using appropriate statistical analysis.

The cardiorespiratory tests performed on subjects comprised as follows:

1. Recording of electrocardiogram (ECG) in controls and lead smelters by Cardiofax machine
2. Measurement of systolic blood pressure (SBP) and diastolic BP (DBP) in controls and lead smelters by sphygmomanometer
3. Determination of pulmonary function tests (PFT) in controls and lead smelters by Spiro Excel 2000.

MATERIALS AND METHODS

Study Design

This was a cross-sectional case–control study.

Study Site

The study site was tertiary care hospital in Southern Rajasthan.

Ethical Clearance

Ref. GU/HREC/EC/2017/1245.

This study was done to complete Short-Term Studentship Project of Indian Council of Medical Research in 2017–2018. One hundred subjects were recruited for the study, there were 50 adults aged 18–50 years who worked in lead smelters in Southern Rajasthan were selected on the basis of the duration of work/exposure, medical history, family medical history, and socioeconomic status. A general physical examination was done on all the subjects also, 50 control subjects were included in the study comprising of ward boys, laboratory attendants, and relatives of the patients.

Exclusion Criteria

The subjects having any family history or history of cardiorespiratory diseases (recent respiratory infection, asthma, COPD, myocardial infarction, congestive heart diseases, any systemic disease, and diabetics) were excluded from the study.

The subjects were clearly informed about the nature of the study. A written informed consent was taken from the subject. The case study form having questionnaire was filled by the subjects of both the groups about information regarding the sociodemographic characteristics, personal habits such as alcohol consumption, smoking habits, nutritional status, and details about the duration of work in the smelters, and a short medical history. The following tests were conducted in all the patients:

PFT

PFTs[5] were conducted on the subjects by fully computerized, portable Spiro Excel 2000 in an upright position. The following parameters were recorded as follows:

1. Slow vital capacity (SVC)
2. Forced VC (FVC)
3. Maximum voluntary ventilation (MVV).

First, the anthropometrical data comprising of age, sex, height, weight, occupation, and smoking history were entered in the software. Before the PFTs, the operator demonstrated the PFT measurement technique, and the subjects were encouraged throughout the test.

Procedure

To perform the test, the following steps were strictly followed:

1. Nose was clipped and the mouthpiece of spirometer was inserted between the teeth and the lips
2. The subjects were asked to breathe in the room air, through the mouthpiece with the nose clipped
3. SVC was recorded by following the instructions, appearing on the screen. By recording the SVC, various volumes such as tidal volume, inspiratory reserve volume, expiratory reserve volume, and VC were recorded along with the inspiratory capacity and expiratory capacity
4. FVC was recorded by asking the subject to forcefully expire after a deep inspiration. The flow-volume loop was

formed which would predict the pulmonary functions of the volunteer. Forced expiratory volume in 1st second (FEV_1), FEV_1/FVC, peak expiratory flow rate, and FVC could be determined through this measurement. The shape of the inspiratory and expiratory loop determines the total lung capacity and residual volume and type of derangement of pulmonary functions (normal/obstructive/restrictive)

5. MVV was recorded by asking the subject to hyperventilate (rapid and forceful breathing) to his maximum capacity.

The tests were repeated twice and the best results were considered. The data collected were compiled and analyzed using appropriate statistical tools.

BP

The SBP and DBP of the population under study were measured using sphygmomanometer by palpatory and auscultatory method.

ECG[6]

We used Cardiofax to carry out electrocardiography on the subjects.

Procedure

1. The patient was asked to lie in the supine position comfortably
2. The instrument was checked for satisfactory earthing
3. Cardiac jelly was rubbed, and then, the limb leads marked right arm, left arm, right leg, and left foot were applied firmly with the help of rubber straps
4. The speed of the chart paper was adjusted at 25 mm/s, and a record of calibrations was obtained such that 1 mV input would give a 10 mm vertical deflection of the stylus on the chart paper
5. The lead selector knob was adjusted, so as to record the activity in the leads 1, 2, 3, aVR, aVL, and aVF in that order
6. Chest electrodes were applied at the appropriate position on the chest after applying the cardiac jelly. The lead selector knob was adjusted to the chest position and activity in the chest leads V_1 to V_6 was recorded in that order
7. The appropriate strip of the chart paper was labeled according to the leads recorded.

Alternatively, in the ECG machine with the provision of automatic recording of all 12 leads, the lead selected was adjusted to autoposition after placing the electrode at the appropriate place on the body and the recordings were taken.

Statistical Analysis

After collecting the data, the data were analyzed using software package used for statistical analysis version 16.0 and Microsoft Office Excel 2007. The results were analyzed using mean, standard deviation, and the unpaired Student's *t*-test. $P < 0.05$ (two tailed) was used to find out the statistical significance.

RESULTS

Findings of the present study are depicted in Tables 1 and 2.

DISCUSSION

Lead exposure even in very small amount acts as a potent poison and poses a major environmental health problem in India. Once absorbed into the body, lead inhibits the functioning of certain enzymes often with severe pathological consequences. As the result of the present study, highly significant cardiorespiratory changes were seen in lead exposed smelters as compared to control group observed in the study conducted in Southern Rajasthan.

In the present study, highly significant changes were seen in SBP, DBP, and heart rate among the lead smelters as compared to the control group. No significant ECG changes were seen, but some subjects showed left axis deviation due to ventricular hypertrophy. Exposure to lead alters the metabolism of cholesterol resulting in dyslipidemia and atherosclerosis which to increase the risk of cardiovascular disease. Lead poisoning results in significant derangements in cardiovascular system including depression of myocardial contractile activity, electrical disturbances, and tissue metabolic damage.[7-9]

It also causes an increase in the vascular tone and peripheral resistance, stimulation of the renin–angiotensin system, reduction in the availability of nitric oxide, and increased oxidative stress and also hampers the cardiac autonomic control.

Table 1: Comparison of cardiovascular variables in controls and lead smelters

Variable	Control (*n*=50)	Smelters (*n*=50)	Significance
SBP (mmHg)	121±0.6808	133±2.303	<0.0001*
DBP (mmHg)	78.7±0.4583	82.58±1.134	<0.0001*
Heart rate (bpm)	79.42±1.191	87.99±2.306	<0.0001*
PR interval (s)	0.1552±0.003899	0.1648±0.004063	0.7741 (NS)

*showing $P<0.005$ statistically significant. SBP: Systolic blood pressure, DBP: Diastolic blood pressure

Table 2: Comparison of respiratory variables in control subjects and lead smelters

Variable	Control (*n*=50)	Smelters (*n*=50)	Significance
FVC (l)	3.393±0.08503	1.735±0.1102	<0.0001*
FEV_1 (l)	2.86±0.07033	1.716±0.1075	<0.0001*
FEV_1/FVC	82.92±0.7554	83±1.894	<0.0001*
PEFR (l/min)	7.275±0.1867	5.019±0.4012	<0.0001*

*showing $P<0.005$ statistically significant. FEV_1: Forced expiratory volume in 1st second, FVC: Forced vital capacity, PEFR: Peak expiratory flow rate

Lead mainly affects the larger airways due to their small particle size resulting in a number of respiratory disorders over a passage of time. The findings of our study also clearly indicate the deranged PFT values. Reversible pathology associated with the inflammatory and immune process in the interalveolar septa, whereas the collagen fiber accumulation characterized by fibrotic processes could indicate irreversible degenerative alterations. Lungs exposed to lead, especially the intra-alveolar septa with mononuclear cell accumulation, were thickened, the alveolar surface became smaller and the alveoli were irregularly organized.[10]

Limitation of the Study

1. Blood lead levels of the subjects could not be estimated as it was beyond the scope of this study
2. Smaller sample size which could be taken care of, by choosing a larger sample from the population.

CONCLUSION

Long-term exposure to lead has a toxic effect on the heart and lungs. Knowledge and awareness of the problem are essential to limit the risk of lead exposure. The reduction of lead in the air can greatly reduce the exposure of lead through inhalation and ingestion through contaminated food, water, and beverages. This study gives a message to both the industrialist and smelters that they should regularly get their physical examinations done along with complete workup of the cardiovascular and respiratory system so that timely preventive and corrective measures can be adopted to reduce the health hazards to as minimum as possible.

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REFERENCES

1. Khazdair MR, Boskabady MH, Afshari R, Dadpour B, Behforouz A, Javidi M, *et al.* Respiratory symptoms and pulmonary function testes in lead exposed workers. Iran Red Crescent Med J 2012;14:737-42.
2. Jacobs DE, Wilson J, Dixon SL, Smith J, Evens A. The relationship of housing and population health: A 30-year retrospective analysis. Environ Health Perspect 2009;117:597-604.
3. Tong S, von Schirnding YE, Prapamontol T. Environmental lead exposure: A public health problem of global dimensions. Bull World Health Organ 2000;78:1068-77.
4. Lustberg M, Silbergeld E. Blood lead levels and mortality. Arch Intern Med 2002;162:2443-9.
5. Binawara BK, Gahlot S, Mathur KC, Kalwar A, Gupta R, Caudhary R. Pulmonary function tests in three wheeler diesel taxi drivers in Bikaner city. Pak J Physiol 2010;6:28-31.
6. Greenland P, Xie X, Liu K, Colangelo L, Liao Y, Daviglus ML, *et al.* Impact of minor electrocardiographic ST-segment and/or T-wave abnormalities on cardiovascular mortality during long-term follow-up. Am J Cardiol 2003;91:1068-74.
7. Fioresi M, Simões MR, Furieri LB, Broseghini-Filho GB, Vescovi MV, Stefanon I, *et al.* Chronic lead exposure increases blood pressure and myocardial contractility in rats. PLoS One 2014;9:e96900.
8. Vassallo DV, Lebarch EC, Moreira CM, Wiggers GA, Stefanon I. Lead reduces tension development and the myosin ATPase activity of the rat right ventricular myocardium. Braz J Med Biol Res 2008;41:789-95.
9. Silveira EA, Lizardo JH, Souza LP, Stefanon I, Vassallo DV. Acute lead-induced vasoconstriction in the vascular beds of isolated perfused rat tails is endothelium-dependent. Braz J Med Biol Res 2010;43:492-9.
10. Bilge O, Turhan O, Sena E. The effect of lead inhalation on rat lung morphology. Turk J Med Sci 1999;29:617-22.

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