SHORT COMMUNICATION

Correlation between Blood Lead Levels and Anaemia in Commercial Enamel Paint Industry Workers

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Abstract:

Background: Lead causes acute, sub-acute or chronic poisoning through occupational exposure along with decrease in some trace elements like iron, whose absorption, distribution, metabolism and elimination being affected. Iron deficiency is a serious problem especially in developing countries and lead toxicity can augment anaemia directly by decreasing absorption of Iron and also by inhibiting enzymes of heme synthesis. *Aim and Objectives:* To assess haematological indices and serum iron and ferritin levels in Enamel paint industry workers who are exposed to very high Lead levels due to their occupation, and determine iron deficiency anaemia. *Materials and Methods:* Blood lead concentration was measured by Atomic Absorption Spectrophotometric (AAS) method. Haematological tests were performed using cell counter to measure haemoglobin, red blood cell and white blood cell count, etc. Mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration were calculated. Serum ferritin and iron levels were assayed by chemilumenescence and spectrophotometric methods respectively. *Results*: All the parameters measured and calculated were found to be altered in paint workers as compared to healthy controls, with significant increase in blood lead level and decrease in the haematological as well as other analyte values. *Conclusion*: There seems to be a direct relationship between chronic lead exposure and the haematological disturbances, resulting in iron deficiency anaemia. Hence awareness about this association should be increased and protective measures should be implied accordingly.

Keywords: Hemoglobin, Lead, Anaemia, Iron, Ferritin

Introduction:

Lead is one of the most toxic elements which may cause acute, sub-acute or chronic poisoning through environmental and occupational exposure [1]. An increase in heavy metals such as lead is often associated with decrease in some trace elements like iron with their absorption, distribution, metabolism and elimination being affected [2]. It is noted in some studies that absorption of lead can decrease iron absorption from Gastro Intestinal (GI) tract [3]. Together, these interactions produce the cumulative effect of decreasing the Red Blood Cells (RBCs) producing anaemia. The levels of lead can be higher in the cities having heavy air pollution and for this reason trace element distribution in urban populace can be affected.

Iron plays an essential role in many biological processes and it is important to maintain its concentration within the normal narrow range of 60-170μg/dL for males [4]. The physiological function of iron is to participate in oxidation-reduction reactions that take place in the process of electron transfer in the respiratory chain. Iron deficiency is a serious problem that affects a great part of the world's population, especially in developing countries [5]. Lead, being one of the most common toxic metal contaminants in environment, augment the prevalence of anaemia,

by causing iron deficiency, and also indirectly by affecting major aspects of heme synthesis, like synthesis of the enzyme Delta-Amino Levulinic Acid (δ-ALAD) and insertion of iron into protoporphyrin [6]. Although the association between iron deficiency and lead has been investigated in a number of cases, results remain inconsistent.

Lead exposure is much more in some populations who have to come in close contact with the substance during the course of their daily occupation, like the workers associated with commercial enamel paint industry. Lead-based enamel paint is most likely to be found on window frames, doors, skirting boards, kitchen and bathroom boards, exterior walls, gutters, metal surfaces and fascias. It can also be found on interior walls, ceilings and areas [7].

The aim of the present study is to establish the relationship between lead, one of the most common toxic contaminant of our environment these workers are exposed to on a daily basis, and anaemia, one of the commonest diseases prevalent in our third world society.

Materials and Methods:

The study was in accordance with Declaration of Helsinki [10] and guidelines on good clinical practice. It was also approved by the Institutional Review Board and Medical Ethics Committee.

Informed consent was taken from each of the participant prior to the study. Pre-designed validated questionnaires and forms were then used to record the demographic data and past medical histories [8]. Clinical manifestations of lead poisoning in the factory workers were examined and noted.

Exclusion criteria- workers who were treated for any cardiac, hepatic and renal diseases as well as workers who took medicines that can alter haematological, biochemical and renal indices were excluded.

Venous blood samples (10ml) were collected from 33 male paint factory workers and 42 age matched male control subjects. Each sample was collected in heparinised tubes, in order to analyse blood lead concentration, RBC count and serum iron and ferritin. Lead free syringes and lead free polythene containers were used to minimize the risk of lead contamination throughout the study.

Blood lead concentration was determined by using Atomic Absorption Spectrophotometry (AAS) method (Perkin Elmer, 2310) [9]. Haematological tests were performed using cell counter Sysmex KX21 to measure Haemoglobin (Hb), Red Blood Cell (RBC) count and White Blood Cell (WBC) count. The values were then used for calculating Mean Corpuscular Volume (MCV) Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC). Serum was separated by centrifuge and ferritin and iron levels of all the subjects were determined using Chemilumenescence analyser (Beckman Coultier, Access II) and spectrophotometrically by an autoanalyser (Meril AutoQuant 100) respectively.

Statistical Analysis:

Results were evaluated with student't' test and Pearson correlation tests to determine statistically significant alterations of indices between groups. Statistical analysis was conducted with software package SPSS 10.0 (statistical package for social sciences). Results were expressed as Mean ± SD and $p<0.05$ was deemed as statistically significant.

Results:

The results of the investigated parameters are depicted in Table 1.

Table 1: Comparison between Blood Lead, Haematological Indices, Serum Ferritin and Iron Levels in Enamel Paint Factory Workers and Controls

Parameters	Factory Workers (N=33)	Control Subjects (N=42)	p value
Blood Lead (µd/dl)	42.3 ± 6.1	8.1 ± 1.2	<0.001
Hb (gm/dl)	9.72 ± 0.89	13.9 ± 1.8	<0.001
RBC (x106/µl)	4.14 ± 0.78	5.3 ± 1.5	<0.001
WBC (x103/µl)	4.91 ± 0.8	7.6 ± 2.4	<0.001
MCV (fl)	71.1 ± 2.11	95.32 ± 2.16	<0.001
MCH (pg)	27.61 ± 1.1	28.22 ± 1.31	0.035
MCHC (gm/dl)	26.72 ± 1.31	25.2 ± 0.91	<0.001
Ferritin (ng/dl)	16.51 ± 0.92	28.61 ± 1.71	<0.001
Iron (µg/dl)	12.8 ± 5.9	61.3 ± 2.6	<0.001

Values represent Mean ± SD Hb - Haemoglobin, RBC - Red Blood Cell, WBC - White Blood Cell, MCV - Mean Corpuscular Volume, MCH - Mean Corpuscular Haemoglobin and MCHC - Mean Corpuscular Haemoglobin Concentration.

It goes without mentioning that workers involved in enamel paint industry are subjected to a very toxic level of lead in their day to day work, hence the blood lead levels are remarkably high in them as compared to the non-exposed control group ($p<0.001$). The investigations also show a significant decrease in haemoglobin with increasing values of blood lead concentrate ($p<0.001$). The significant reduction of both RBC and WBC count indicate the marked changes in hematological parameters, with all the calculated indices of MCV, MCH, and MCHC significantly altered. Also significant declines in the serum ferritin and iron levels were observed in the paint workers as compared to the controls.

Discussion:

Lead as a highly toxic heavy metal is very harmful for our health in many ways. In the present study, blood lead levels were found to be highly variable among the enamel paint industry workers, which is hardly surprising given the high degree of variability in exposure, uptake and metabolism in every individual. Also the subjects for this study did not show or complain about any signs and symptoms associated with metabolic dysfunctions due to their raised blood lead levels.

All the haematological parameters under study were significantly affected by the lead. Other studies have already shown that Hb content which is 13-16 G/dL for males, markedly decrease with increased value of blood lead [11]. However, the significant decrease in RBC, WBC and calculated indices also suggest that toxic effects of lead involve the haematopoietic system in humans, indicating a high predisposition towards anaemia. In this study, almost all the hematopoietic parameters showed a highly significant change ($p<0.001$) in enamel paint industry workers as compared to the normal healthy control group. The calculated parameter MCH values show p value of 0.035, which also indicates a significant decrease in MCH values in paint industry workers. Decline in serum iron and ferritin (12-300ng/dL in males) also suggests the propensity towards severe anaemia; iron deficiency anaemia defined as haemoglobin concentration of 11gm/dl or less with low serum iron and ferritin level (<10µg/dl).

Absorption of iron is competitively inhibited by

lead [2]. This results in a decrease in iron store in body, indicated by a decrease in ferritin level. The best documented effects of lead on blood are about its interference with the biosynthesis of heme, which is essential for the production of Hb. Also it has been postulated that two important aspects of haematopoiesis affected by lead are the formation of the enzyme δ-ALAD and insertion of iron into protoporphyrin [11]. These, along with the direct effect of lead on absorption of iron and its storage, directly gives rise to a tendency of iron deficiency anaemia in lead toxicity, as suggested by the various haematological indices.

From this study it can be proposed that the effect of lead on heme synthesis can lead to haematological damage. The overall effect is the disruption in the production of haemoglobin as well as other respiratory pigments like cytochromes, which require heme. Hence, lead exposure at toxic level can also cause improper utilization of oxygen for proper oxidative functions in body.

Conclusion:

The toxic effects of lead are multiple and seen on almost all major systems in our body, including gastrointestinal, hepatobilliary, cardiovascular and haematological systems. It directly inhibits the uptake and storage of iron by our body. It also affects the haematological indices by interfering with the production of δ-ALAD and porphyrin, thereby producing faulty heme. Both affect in production of iron deficiency anaemia in people suffering from chronic lead exposure. This study is an effort towards trying to find out the relationship between chronic lead exposure and the haematological disturbances created by it on individuals, and to spread awareness among the general population about the same.

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References

1. Mazumdar I, Goswami K. Chronic Exposure to Lead: A Cause of Oxidative Stress and Altered Liver Function in Plastic Industry Workers in Kolkata, India. *Indian J Clin Biochem* 2014; 29 (1); 89-92.
2. Hegazy A, Zaher M, Abd El-Hafez MA, Morsey AA, Saleh RA. Relation between Anaemia and Blood levels of Lead, Copper, Zinc and Iron among Children. *BMC Research Note*. 2010; 3: 133.
3. Schuman K. The toxicological estimation of heavy metal content (Cd, Hg, Pb) in food for infants and small children. *Z Ernahrungswiss* 1990; 29(1); 54-73.
4. Andrews NC. Disorders of Iron metabolism. *N Engl J Med* 1999; 341(26): 1986-95.
5. Lopez MA, Martos FC. Iron availability: An updated review. Int J Food Sci Nutr 2004; 55(8); 597-606.
6. Bannon DL, Abounader R, Lees PS, Bressler JP. Effect of DMT1 knockdown on Iron, Cadmium and Lead uptake in Caco-2 Cells. *Am J Physiol Cell Physiol* 2003; 284(1); C44-50.
7. www.environment.gov.au/protection/chemicals-management/lead/lead-in-house-paint.html
8. Mazumdar I, Goswami K, Md Ali S. Status of serum calcium, vitamin D and parathyroid hormone and hematological indices among lead exposed jewelry workers in Dhaka, Bangladesh. *Indian J Clin Biochem* 2016 DOI 10.1007/s12291-016-0582-9.
9. Zinterhofer LJ M, Jatlow P I, Fappiano A. Atomic absorption determination of lead in blood and urine in the presence of EDTA. *J Lab Clin Med* 1971; 78: 664-74.
10. Macklin R. The Declaration of Helsinki: Another revision. *Ind J Med Ethics* 2009; 6: 2-4.
11. Anetor JI, Akingbola TS, Adeniyi FA, Taylor GO. Decreased total and ionized Calcium levels and Hematological indices in occupational lead exposure as evidence of the Endocrine disruptive effect of Lead. *Int J Occup Env Med* 2005; 9(1): 15-21.

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