RELATION BETWEEN HYPOCHROMIC MICROCYTIC IRON DEFICIENCY ANEMIA AND LEAD POISONING AMONG PRIMARY SCHOOL AGE CHILDREN IN EL-MINIA CITY.

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ABSTRACT:

Background: Iron deficiency anemia is a growing health problem among primary school aged children. Environmental pollution is a major health problem in developing as well as developed countries. The anemia among primary school aged children is often associated with a decrease in iron and an increase in heavy metals as lead. Our study was done to estimate the relation between blood lead level > 10 µg/dl, and iron deficiency anemia among primary school aged children in El-minia city.

Patients and methods: This cross sectional study was conducted on 120 primary school aged children. Venous blood samples were taken from them to estimate red blood cell count (RBC), hemoglobin (Hb), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) as well as iron , ferritin and lead levels. The studied children was divided into anemic and non-anemic (control) groups. The anemic group was classified into mild, moderate and severe anemia. The subjects of the study were also categorized into 2 groups low blood lead level group and high blood lead level group.

Results: Nearly about 63% of children had blood lead levels ≥ 10 µg/dl. There was a significant association of Lead level ≥ 10 µg/dl with anemia, decreased iron absorption and hematological parameters affection. High blood lead levels were associated with low serum iron and ferritin.

Conclusion: The prevalence of lead poisoning is significantly high among primary school aged children. Iron deficiency is one of the common health problems among primary school aged children. There is relationship between iron deficiency anemic children and their high blood lead levels. Our recommendations were:

- Planning programs and policies to minimize sources of lead exposure.
- Health education to the public and health care providers about childhood lead toxicity.

Screening for blood lead level and iron to manage the diseased cases

KEY WORDS:

Iron · Anemia · Lead · Poisoning · Children

INTRODUCTION:

Iron Deficiency which causes hypochromic microcytic anemia, also increases the absorption of lead. Therefore, in patients with hypochromic microcytic anemia, the blood levels of lead increase causing more decrease in hemoglobin. Also, repeated exposure to high levels of lead causes hypochromic microcytic anemia[1]. There are many dietary factors influence iron absorption, e.g. ascorbate and citrate increase iron uptake. Lead has competitive inhibition effect on absorption of Iron. Also, it interferes with several enzymes involved in heme biosynthesis[2]. Blood lead level equal to or greater than 10 µg/dl is a significant public health problem In school aged children[3]. In 1991, the Centre for Diseases Control and prevention (CDC) expert panel defined all children with blood lead level of 10µg/dl or more as having lead poisoning[4]. Both iron deficiency and lead poisoning can permanently impair cognition and intelligence and their combined effects may be particularly severe. School aged children exposure to lead occurs through diet, air, drinking water and ingestion of paint chips, moreover iron and calcium deficiency in these children increases the absorption of lead[5].

Environmental lead exposure occurs from automobile exhaust of leaded gasoline. At home, exposure among children may occur either due to ingestion of old leaded chips or pigments and glazes used in pottery[6]. Inorganic lead compounds are found in many commercial products and industrial materials such as paints, plastics storage batteries, insecticides and ceramics. Lead is dispersed throughout the environment primary as the result of anthropogenic activities. The general population is exposed to lead in ambient air, in many food, in drinking water and in dust .Lead is transferred continually between air, water and soil by natural chemical and physical resources such as weather, the environmental sources of metallic lead and its salts are paint, auto exhaust, food and water[7]. The largest sources of lead is paint manufactured before 1978 and the dust created when it decays. This paint was used for many purposes including painting the interior and exterior of houses, playground equipment ,farm machinery and toys. Other items also contain lead jewels and hair dyes have high lead contents, improperly glazed pottery, certain cosmetics, lead crystal, certain hobbies such as stained glass and target shooting can expose children to lead[8].

For children the most important pathway are ingestion of chips from lead painted surfaces, (children can ingest loose paints as results of pica), food from soldered plumbing. Inhalation of lead from automobile emissions which may be inhaled directly or deposited in the soil. Children playing near roads and freeways may not only breathe the exhaust fumes, but may come in contact with contaminated dirt automobile emissions which may be an important source of lead in urban residents.

Although the developed world no longer uses lead as a petrol additive, automotive exhaust derived lead resides as historical ceiling or attic dust within habitations and trapped in surface layers of soil surrounding them. High levels of lead in soil and house dust have been associated with increased blood lead levels in children. Also lead can be deposited on and retained by crops, particularly leafy vegetables[9].Lead glazed used in making battery and ceramic ware, soldered plumbing. Water from leaded pipes, water from water coolers is another potential source of lead exposure. Several folk remedies and cosmetics (Kohl) used in many countries have been shown to contain large amount of lead[10] Some of the most important additional lead exposures occur due to residence in an urban environment or near stationary emission sources (e.g. smelters). Also renovation of homes using lead-based paint, contact with interior lead paint dust and occupational exposure. Cases at high risk of exposure are school-age children, pregnant women and their fetuses[11]. Anemia in children leads to increased morbidity and mortality[12]. Adverse health effects of anemia in children include impaired psychomotor development and renal tubular function, poor cognitive performance and mental retardation[13,14]. Therefore, this study was done to determine the association of blood lead level more than 10 μg/dl, with the increased risk to anemia compared to levels less than10 μg/dl .

SUBJECTS AND METHODS:

This work was conducted on a total of 120 apparently healthy children at primary school age (6-12 years old) from the pediatric clinic in El-Minia University hospital a verbal consent was taken from the mother or the father after informing them about the nature and the aim of the study.

Inclusion criteria -school aged children their aged between (6 -12 years). - Apparently healthy children.

Exclusion criteria

- children below 6years and children above 12 years.
- children with chronic infections, thalassemia, chronic hemolytic anemia hemoglo binopathies or other cases except iron deficiency anemia.

The control group was selected from those attending the out patients clinic for evaluating physical fitness for different sports. Data related to age, gender, residence, degree of father and mother's education and their occupation, also, socioeconomic status data was collected from the mothers.

According to the WHO definition of anemia based on hemoglobin level less than 11 g/dl, the studied population was divided into anemic and control groups[15]. The anemic group was further classified into categories of mild (Hb level 10-10.9g/dl), moderate (Hb level 8-9.9g/dl) and severe (Hb level < 8g/dl) anemia. Also the studied population was classified into two groups, <10 μg/dl serum lead level and ≥10 μg/dl serum lead level. Using sterile disposable 5ml syringe a venous blood sample was taken from each child and divided into three tubes. The first tube (containing EDTA) used for blood picture and hematological parameters estimation using Celttac autoanalyzer, these parameters included the red blood cell count (RBC), hemoglobin (Hb), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC). The second tube (containing heparin) for estimation of lead, by the flame atomic absorption spectrophotometer. (Perkin Elmer AAS 460 Ueberlingen-Germany). The blood lead level (BLL) was determined by HGA graphite furnace atomic absorption spectrophotometer. The third tube, Hitachi 911 autoanalyzer was used for serum iron estimation using Merck reagent kits. serum ferritin estimated by Elecsys 1010 - Japan.

STATISTICAL ANALYSIS:

Analysis of data was done by SPSS (Statistical Package for Social Sciences) version 13 for windows. Comparing the individual characteristics was done by Chi-square test and we used t-test to compare the hematological parameters between anemic and control groups. Results were expressed as the mean ± standard deviation (SD). Significant values of P at <0.05 and <0.001 were considered.

RESULTS:

The number of cases was 120 children with ages ranging from 6 to12 years with a mean value of 8.39 ± 2.09 years. Our cases were classified into two groups according to blood lead levels (BPb), group (1) approximately 63.3% (n = 76) of children had a blood lead ≥10 μg/dl (high blood lead level group {HBLL}), and group (2) 36.7% (n = 44) had a blood lead level <10 μg/dl (low blood lead level group {LBLL}). The blood lead level in the study group ranging between 7 to 20 μg/dl. The socioeconomic characteristics of the high and low blood lead level groups were studied (Table 1). higher BLL was among children >9 years old. Also, blood lead level was higher in males than females in urban more than rural areas, and those of low social standard and children of illiterate mothers and fathers. A significantly greater proportion of children with lead levels ≥10 μg/dl (63.2%) had anemia compared to those with lead levels <10 μg/dl (27.3%) P value=0.001 (Table2). There was a significant difference in distribution of different categories of anemia among the high (≥10 μg/dl) and low (<10 μg/dl) blood lead level groups. The mild form of anemia among (HBLL) group was 28.9%, while among (LBLL) group was 4.5%. The severe form of anemia among (HBLL) group was 21.1%, while among (LBLL) was 4.5% (Table 3).

As regards hematological parameters mean values and serum ferritin in anemic and control groups they were compared in (Table 4). The hematological parameters were significantly lower among the anemic than the control group. No significant difference was detected between the groups As regard the RBC count. A significant decrease in the level of Fe among the anemic than the control group (p < 0.001). Regarding the BLL between anemic and control groups, a significantly high BLL was found among anemic in comparison to control group (p < 0.001. Table 5 reveals the correlation between the blood lead levels and hematological parameters. There was a significant negative correlation between lead and Hb, MCV, MCH, Fe, and ferritin (r = -0.459, r-0.271, r = -0.379, r = -0.468 and r = -0.549, respectively) (p < 0.001). In Table 6 the blood iron and ferritin levels were significantly lower in the high BLL group than those of the low BLL group (49.08 ± 19.09 and 51.54 ± 24.49 in high BLL group), (61.02 ± 21.31 and 78.61 ± 24.68 low BLL group respectively).

Table (1): Distribution of socioeconomic characteristics in relation to blood lead levels among primary school aged children in El- Minia city .

Characters of studied group		**Blood lead level**				**Test of significance**
		Low <10 μg/dl		**High ≥10 μg/dl**		
		No	(%)	No	(%)	
Age	children (≥9years old)	18	(40.9)	40	(52.6)	
	children (<9years old)	26	(59.1)	36	(47.4)	P = 0.39
sex	Male	18	(40.9)	46	(60.5)	
	Female	26	(59.1)	30	(39.5)	P = 0.1
Residency	Urban	24	(54.5)	40	(52.6)	
	Rural	20	(45.5)	36	(47.4)	P = 1.0
Mother education	Educated	6	(13.6)	8	(10.5)	
	Illiterate	38	(86.4)	68	(89.5)	P = 0.89
Father education:	Educated	6	(13.6)	8	(10.5)	
	Illiterate	38	(86.4)	68	(89.5)	P = 0.79

Table 2 Prevalence of anemia in relation to blood lead levels among primary school aged children in El-Minia city.

	Blood lead level				Test of significance
	Low <10 µg/dl (n = 44)		High ≥10 µg/dl (n = 76)		
	No	(%)	No	(%)	
No anemia	32	(72.7)	28	(36.8)	p = 0.00
Anemia	12	(27.3)	48	(63.2)	P =0.00

Table (3): Distribution of hemoglobin level in relation to blood lead levels among primary school aged children in El- Minia city.

Hemoglobin level	blood lead <10 µg/dl (n = 44)		blood lead ≥10 µg/dl (n = 76)	
	No	(%)	No	(%)
No anemia (Hb level ≥11 g/dl)	32	(72.7)	28	(36.8)
Mild anemia (Hb level 10-10.9 g/dl)	2	(4.5)	22	(28.9)*
Moderate anemia (Hb level 8-9.9 g/dl)	8	(18.3)	10	(13.2)
Severe anemia: (Hb level < 8 g/dl)	2	(4.5)	16	(21.1)*

* p = < 0.05

Table (4): Comparison between mean values of different hematological parameters and serum level of ferritin in anemic and control groups among primary school aged children in El- Minia city.

	Anemic group (n = 60) Mean ± SD	Non-anemic (n = 60)	Test of significance
RBC ($\times 10^6$ mm^3)	4.01 ± 0.49	4.19 ± 0.26	t = -1.7 p = 0.08
Hb (g/dl)	9.01 ± 0.86	12.17 ± 0.44	t = -17.2 p = 0.00
Hct	28.63 ± 2.25	36.60 ± 2.00	t = -14.5 p = 0.00
MCV(μ^3)	70.05 ± 14.78	81.51 ± 6.68	t = -3.8 p = 0.00
MCH	21.77 ± 3.19	27.11 ± 1.21	t = -8.5 p = 0.00
MCHC	31.41 ± 1.96	33.57 ± 1.89	t = -4.2 p = 0.00
Ferritin (ng/ml)	40.19 ± 23.44	82.26 ± 9.74	t = -9.0 p = 0.00

Table (5): Correlation of different hematological parameters, serum iron and ferritin levels in relation to blood lead level among primary school aged children in El-Minia city.

Hematological parameters	Blood lead level r-value	p-value
RBC ($\times10^6$ mm^3)	0.115	(0.35)
Hb (g/dl)	-0.459	(0.00)
MCV(μ^3)	-0.271	(0.03)
MCH	-0.379	(0.00)
Fe (µg/dl)	-0.468	(0.00)
Ferritin (ng/ml)	-0.549	(0.00)

r = correlation coefficient

Table (6): Mean values of serum iron (Fe) and ferritin in relation to blood lead levels among primary school aged children in El-Minia city .

	Low blood lead level <10 µg/dl (n = 22) Mean ± SD	High blood lead level ≥10 µg/dl (n = 38) Mean ± SD	Test of significance
Fe (µg/dl)	61.02 ± 21.31	49.08 ± 19.09	t = 2.24 p = 0.02
Ferritin (ng/ml)	78.61 ± 24.68	51.54 ± 24.49	t = 4.10 p = 0.00

DISCUSSION:

The World Health Organization (WHO) estimates that nearly half of school aged children in developing countries are suffering from iron deficiency[43]. Similar results were also given by Wasserman[44], early in the course of lead poisoning in children the anemia is hypochromic. Our results go with Wright and Hammad[45,46], who estimated that iron deficiency is a major health problem worldwide, and children are particularly vulnerable because of their rapid growth and the increased iron requirement. Similarly ,chronic lead poisoning mainly affects young children because they have more hand to mouth activity and absorb lead more efficiently than adults. In our study about (63.2%) of primary school age children who had blood lead level ≥10 µg/dl were anemic , which go along with a study done by Jain et al.,[6]. In which there was a significant association of moderate and severe anemia with 10-19.9 µg/dl blood lead levels. Our study reported a significant association of mild and severe anemia with 10-20 µg/dl blood lead levels, the difference in results may be due to the difference in the sample size between the two studies. Our study is similar to the estimation obtained for children in India[17,18]. On the basis of neurological toxicity the Center for Disease Control and Prevention defined the cut off value of l0 µg/dl as a limit for an elevated blood lead level[19].

In a study done by Schwartz et al.,[20] the blood lead levels of the children living near lead smelters in the US of Idaho, were near 25 µg/dl and were associated with anemia in a dose-related manner. In addition, Drossos et al.,[21] reported that children with BLL >30 µg/dl had a linear decline in hemoglobin level. On the other hand our results were far from results that were given by, Froom et al.,[22] who suggested that hemoglobin level did not correlate well with BLL and suggested that anemia is not related to lead at low BLL. However, other studies reported a variable association[23-27]. High blood Lead level causes anemia by impairing synthesis of hemoglobin and increasing the red blood cell destruction rate[28]. It is also possible that iron deficiency, increases lead absorption in the body, resulting in high BLL[29,30].

The findings of our study demonstrate an association between elevated BLL and severity of iron deficiency anemia. In this study high BLL among school children (>9years old) may be due to the more exposure period to sources of lead toxicity and more usage of crayon in school and high BLL in male children more than female children may be explained by more outdoors activities in males so more exposure to motor cars exhaust. We found that the level of iron in the anemic group was significantly lower than the control group similarly to Jain et al.,[6].

Findings, Iron has an essential role in many biological processes and its deficiency negatively affects the health of school children. Therefore, it is important to maintain iron concentration within normal[31]. In the present study, the anemic group blood lead level was significantly higher than the control group blood lead level. A possible cause is that Iron deficiency increases absorption of lead from the intestines. Similarly a study carried out in Canada, revealed high BLL in babies with Iron deficiency[25].

Other studies revealed significant associations between Iron deficiency and high blood lead level[30,34]. The results of this study showed that Hb, Hct, MCV, MCH and ferritin values of children in anemic group decreased in comparison to control group. Blood lead levels were higher in anemic group of children. This could be due to that iron deficiency increases lead absorption which inhibits heme synthesis, thus decreasing hematological parameters[28].

We found that high BLLs were associated with lower iron and ferritin levels than lower lead levels. Lead has competitive inhibition effect on iron metabolism as it is taken up by the iron absorption machinery instead of iron. Also, it interferes with heme biosynthesis[2]. Control of lead pollution is much slower and more sporadic In developing countries such as India,. Some studies estimated that more than half of children in India have blood lead levels > 10 µg/dl [18]. The present study revealed an association between blood lead level and low serum iron and ferritin levels. This is similar to several studies reporting higher proportions of children with elevated blood lead levels among those with low iron and ferritin levels [39-41].

These results suggest that inadequate iron increases the effect of lead contamination in the environment by increasing its absorption[39]. The results of the present study are inconsistent with that obtained by Hershko et al.,[42]. Who reported a lack of correlation between iron and blood lead.

CONCLUSION:

- Iron deficiency is the most important nutritional problem among children; lead poisoning is a common environmental health threat to children. Both iron deficiency and lead poisoning disproportionately affect children. lead levels ≥10 μg/dl in primary school aged children were associated with an increased risk of mild and severe anemia, decreasing iron absorption and negatively affecting the hematological parameters. High BLLs were associated with low blood level of iron and ferritin.
- Our results suggest a strong link between iron deficiency and high blood lead levels.

Recommendation:

- Develop programs and policies to minimize sources of exposure to lead.
- Educate the public and health care providers about childhood lead poisoning and sources of food containing iron
- Surveillance of potentially exposed population group, especially the vulnerable ones (children, pregnant women, workers).
- Screening of children for (Blood pb and iron levels) and referral of anemic children for medical care as necessary .
- Environmental standards legalizations that remove lead from petrol/gasoline, paint, plumbing pipes and also remove lead solder from food cans.
- Providing iron supplemented meal for school age children

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