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Chronic Lead Poisoning Prevention In Children With Calcium Supplementation

Aznan Leloa[1]*, Sri Sofyani[2]

[1]Pharmacology and Therapeutic Department, Faculty of Medicine, University of Sumatera Utara, Jl. dr. Mansyur No. 5, Medan 20155, Indonesia
[2]Department of Child Health, Faculty of Medicine, University of Sumatera Utara - Haji Adam Malik Hospital Jl. Bunga Lau no.7 Medan, Sumatera Utara 202136, Indonesia

Abstract : Lead poisoning is one of the environmental problems around the world affecting human health, especially in children. Chronic lead exposure can cause behavioural disorders, reduce the level of IQ, and cause impaired growth.

The aim of this study is to determine the effects of calcium supplementation in decreasing blood lead levels of children who are at high risk for chronic lead poisoning. Fiftysix school children aged 9-12 years who live in areas with highest traffic density in Medan (around Terminal Amplas) had chosen included in this quasi-experimental study which thenrandomly divided into two groups. One as control group (n=26) and another group (n=30) received calcium with a dose of 400 mg twice daily orally for three months. Samples for blood lead levels were collected before and after 3 months. Potential trends in whole blood lead, and haemoglobin were assessed using paired t-tests; comparison between two treatments was assessed by unpaired t-tests. Statistical significance was defined as $P < 0.05$.

After calcium suplementation there was a significant reduction (2.855 ± 0.4976 μg/dL; 93.6%; $P<0.001$) of blood lead level, while there was no significant difference in blood lead levels in control group after 3 months period. There was a trend of elevated levels of hemoglobin in calcium suplementation group.

The present study suggests that calcium suplementation with a dose of 400 mg twice daily orally for three months to children who are at high risk for chronic lead poisoning can reduce blood lead levels significantly.

Keywords : children, blood lead levels, chronic lead poisoning, calcium supplementation.

1. Introduction

Lead was one of the most dangerous environmental toxic substances. Its neurotoxic potential is highly significant but its secure blood level concentration remains unknown. Lead affects the cholinergic, dopaminergic and glutaminergic systems, thus intervening in the normal function of neurotransmission. Some studies claim that cognitive decline and low IQ can occur in concentrations <10 μg/dL[1].However, evidence indicating that some health effects can occur below this threshold is accumulating. Recent analyses suggest that health effects may become apparent at concentrations of <5 μg/dl and, indeed, that no evidence exists for a threshold, even at 1 μg/dl[1,2].

Sources of lead poisoning can include emissions from vehicles using leaded petrol and from base metal mining, smelting or lead manufacturing or recycling industries, dust, soil, paint, toys, jewelry, drinking water,

candies, ceramics, folk medicine and cosmetics. More over, lead from fuel can contaminate soil, and increase the blood level of children in urban areas [1,3], as a result of contact with the soil. Lead poisoning is one of the environmental problems for people living in urban area. Lead poisoning has been recognized as a serious environmental health problem throughout the world, particularly, for poor children in developing country [1,4].

In Indonesianchildren living in urban area with higher traffic density are at increased risk for blood lead levels above the actual acceptable limit[5]. Heinze et al faound that the mean blood lead concentration was significantly higher ($p<0.05$) in the central district (8.3 $\pm$ 2.8 microg/100ml; high traffic density area) than in the southern district (6.9 +- 3.5 microg/100 ml. In addition 26.7% of the children had lead levels greater than 10 microg/100 ml[5]. A study conducted in the city of Medan, found that there is an apparent link between the increase of the intensity of a motor vehicle with the air lead levels at the time of observation from 13.00 - 14.00. Air lead levels is highest in Terminal Amplas, i.e. 32.67 ug/m3, then in Pinang Baris and at Jalan Brigjend Katamso is 23 ug /m3[6].This air lead levels was far above the city of Medan threshold value of 2 ug/m3.

Children attending schools in urban areas with high traffic density are a high risk group for lead poisoning.We have done a cross-sectional study as a preliminary study; on sample of this elementary private school children Al-WasliyahTimbang Deli, Medan last year, obtained their mean blood lead levels was 2.580 μg/dl (lowest blood lead levels of 1.477 μg/dl and the highest 3.989 μg/dl, the median 2.735 μg/dl). The result was very surprising; it was found that the number of children with the levels of blood lead above the mean value was 54 percent. Of this group there were 33.3 % have delinquent problem, 11.1 % have aggressive behavior, 40.7 % have social problems, 29.6 percent have somatic problems, 22 percent suffered from impaired withdrawn; 7.4 percent had depression, and 7.4 percent had attention problems (there was a child who had some behavioral problems at once). Based on these results (result have not publish yet) it is necessary to find the good management to prevent the occurrence of behavioral disorders in children with blood lead levels were relatively high in the area of pollutants in the city of Medan.

Chronic lead poisoning and iron deficiency are concentrated in urban children from lower socioeconomic strata, and both impair neurocognitive development[7]. Hegazyet al have found a relation between anemia and blood levels of lead, copper, zinc and iron among children [8].From several previous studies it is known that calcium is one ingredient that can lower blood lead level [9,10,11].

Because of prevention should be the single most important way of dealing with lead poisoning [1], we have done a study to define the effect of calcium administered 2 x 400 mg/day for 3 months at primary school age children on their blood lead levels.

2. Material and Methods

2.1 Subjects

Fifty six school children participated in this quasi-experimental design of randomized clinical trial.was conducted in school children The study subjects(aged 9 – 12 years old)were at high risk of lead pollution in the city of Medan, whom is domiciled and doing activities (school) in overcrowded vehicles. The exclusion criteria werechildren with kidney failure, abnormalities of brain dysfunction, malnutrition,history of allergies or resigned after being given an explanation.All subjects were followed the study protocol, including not to change daily menu and eating habits. Subjects were divided into two groups by using simple random sampling; one group as control (n = 26) and another group (n = 30) were treated by giving calcium supplements at a dose of 2 x 400 mg daily for 3 months. The study was conducted in Private Elementary Schools Al-WasliyahTimbang Deli, Jalan Pertahanan, District Medan Amplas, Medan, Provinceof Sumatera Utara. Assent was obtained from the participated subjects with consent from their parents/guardians. The study was conducted after obtaining approval from the Health Research Ethical Committee of Medical School, University of Sumatera Utara.

2.2 Laboratory examination

Venous blood was collected from each child using vacutaineras much as ± 6cc,before and after3 month of treatment. The content of lead in blood (mg/dL) was measured in duplicate samples by atomic absorption spectrophotometry (AAS) using a Perkin-Elmer spectrophotometer. A coefficient of variation <5% was reached before analysis of actual samples.

2.3. Data Analyis

The results are expressed as means ± SDs for normally distributed continuous variables, as medians and ranges for non-normally distributed continuous variables. Obtained data were then analyzed for the difference of means using paired and unpaired T-test while the assosiation between blood lead level and haemoglobin was analyzed by Pearson correlation test. A P value <0.05 was considered significant level.

3. Result

A total of 62 children were enrolled who are 9 to 12 years of age, have blood lead levels between 0,4 and 12 μg/dL. There was none the control group with blood lead level above of 10μg/dL; while in the calcium group there was only one subject with blood lead level above of. The subjects were randomly divided in two group, ie. 32 children in calcium supplementation group and 30 children as control without calcium supplementation. Of this, 56 completed 3 months of follow up (30 and 26 children, respectively). Subjects who did not complete the study did not return as per schedule requirements. Compliance with supplement administration was 82 ± 18% for calcium group. There were no statistically significant differences between the group at enrolment on blood lead levels, age, sex, family income, nutrition status, and hand/object-to-mouth behaviour (table 1).

Table 1 Base Line Characteristics Variables at Enrolment (mean ±SD)

Variable	Control Group	Calcium Group
Blood lead levels (μg/dL)	2.538 ± 0.07807	3.053 ± 0.4886
Age (y)	10.7 ± 1.3	10.5 ± 1.7
Body weight (kg)	29.19 ± 8.99	29.34 ± 7.67
Gender ratio (boy/girl)	12/14	20/10
Family income (Rp)	2.035.000 ± 263.000	2.035.000 ± 115.000
Home exposure point	169.4	170
Hand/object to mouth (touches/min)	0.4 ± 0.6	0.4 ± 0.5

Table 2 Biochemical Mean Values During the Course of the Study

Variables	Control	Calcium	Significancy
Blood lead levels (μg/dL) Enrolment	2.538 ± 0.07807	3.053 ± 0.4886	0.1435
Blood lead levels (μg/dL) 3 Months	2.462 ± 0.1269	0.1983±0.09428	= 0.0001
Significancy	0.6096	<0.0001	
Haemoglobin (g/dL) Enrolment	13.03 ± 0.1766	12.76 ± 0.586	0.2563
Haemoglobin (g/dL) 3 Months	13.07 ± 0.1606	13.18 ± 0.1781	0.7254
Significancy	0.8726	0.0847	

Table 2 shows that the percentage reduction of blood lead level in the calcium group was 93.6%, while in the control group was 3.3%. This different is highly significant (P = 0,000). Haemoglobin level almost no change (0.31%) in the control group after 3 months observation, while in the calcium group there is a small (3.29%) increase of haemoglobin levels after 3 months calcium adminstration. However, haemoglobinelevation levels were not significant.

There is an inverse correlation between blood lead levels and haemoglobine levels in the calcium group, but it is very weak (r = - 0.056).During the study period, there were no serious adverse events. No abdominal pain complaints occurred in both groups.

4. Discussion

Although the quantities of lead to which individuals are exposed vary widely, susceptibility of an individual to the effects of a specific level of exposure is another highly important factor in development of lead toxicity. Susceptibility to lead toxicity is known to be influenced by a number of physiological and environmental factors: age; season of the year (body temperature, dehydration, ultraviolet light); calcium, phosphorus and vitamin D; dietary protein; ascorbic acid; nicotinic acid; alcohol; other heavy metals [12]. Susceptibility to lead toxicity can be modified by several dietary factors. Low dietary intakes of calcium or iron (20% of recommended levels) substantially increase the toxicity of the same level of lead exposure to rats[12].

Cheng et al found that higher calcium intake was associated with lower bone lead levels, but this relation became insignificant when adjustment was made for vitamin D. They also observed inverse associations of blood lead levels with total dietary intake of vitamin C and iron. Therefore, they then suggest that low dietary intake of vitamin D may increase lead accumulation in bones, while lower dietary intake of vitamin C and iron may increase lead levels in the blood[2]. Hoewever during the present study there was no modification in their daily diets, except in the calcium group the subjects ingested 400 mg calcium twice daily for three months.

Physiologically calcium level is determined by the levels of vitamin D in the blood. It has been suggested that vitamin D supplementation may increase blood lead in children and adults with previous lead exposure. In fact, high-dose vitamin D3 supplementation and the concomitant increased serum 25D did not result in increased whole-blood leadconcentration[14]. Previously Rosen et al found that reduction in 1, 25-dihydroxyvitamin D in children will be assosiated with increased lead absorption [15]. Mechanisms explaining the effect of calcium on lead toxicity may be related to absorption of lead from the gastrointestinal tract or renal tubule or to function of the parathyroid [12].There is an abundance of evidence, which demonstrates that dietary calcium decreases gastrointestinal lead absorption and thereby reduce lead toxicity. Considerable experimental data support the premise of potential role for calcium supplementation in the amelioration of lead poisoning. Ca-binding proteins have a high affinity for lead[16]. Blood lead level in exposed animals are higher in those fed calcium deficient diets[17]. Studies using stable isotopes of lead fed simultaneously with calcium to adults showed a decreased in lead absorption[18]. Increasing dietary calcium is associated with decreases in gastrointestinal lead absorption and blood lead level in some studies[13,19,20] but not in others[15,21]. In a longitudinal study Lanphear et al found a marginal correlation between blood lead level and calcium intake in a cohort of 12- to 24-month old children who received 900 mg calcium per day[21].

Aninterventional study aimed at preventing lead accumulation in infants in which formula-fed non led poisoned infants were supplemented with Ca-glycerophosphate (188 mg/L vs. 465 mg/L) did not find a benefit over 9 months of treatment, blood lead level increased 2.4 μg/dL in the unsupplemented and 2 μg/dL in the supplemented group[11]. Of interest, there was no effect of supplementation on urinary calcium excretion or iron status. [11]

The published data supporting a potential role of calcium supplementation in the treatment of mildly to moderately lead poisoned children are limited. A single uncontrolled study examined the potential effects of Ca-supplementation on a Ca-deficient and lead poisoned population in China. The source of lead exposure in this group was from leaded gasoline usage and industrial pollution. Shen et al provided a total daily intake of 800 mg calcium (the current recommended dietary allowance for this age group) to a group of 35 children who were aged 49 to 70 months and whose pre-treatment calcium intake was 300 mg/day. A 10 μg/dL fall in blood lead level was observed over a 2 months period, although lead exposure was presumably ongoing and changed[22]. In the present study, after 3 months of follow-up, we found the percentage reduction of blood lead level in calcium group was 93.6% (2.85± 0.498μg/dL), while in control group was 3%. This different is highly significant ($P<0.0001$) (table 2). Something noteworthy, in the present study using a total of 800 mg/day calcium supplementation was not associated with toxicity.

The present study demonstrated that a great percentage reduction of blood lead level in the calcium group (93.6%) compared to that in the control group (3.3%). This different is highly significant (P = 0,000). Haemoglobin level almost no change (+ 0.31%) in the control group after 3 months observation, while in the calcium group there is a small (3.29%) not-significant increase of haemoglobin levels after 3 months calcium administration (table 2). As significant reduction of blood lead level with slightly increase of haemoglobin

level produce an non-significant inverse correlation (r = - 0.056) between blood lead levels and haemoglobine levels in the calcium group.

There is increasing interest in the interaction of nutritional deficiencies with toxic metals. Iron deficiency and elevated blood lead concentrations reportedly occur together, and zinc also plays an important role in lead metabolism. However, after controlling for initial blood lead levels, groups administered zinc and/or iron did not have lower blood lead levels concentrations than the placebo group ($P < 0.05$). Neither iron nor zinc can be recommended as the sole treatment for lead-exposed school children [23]. However, Zimmermann et al found that providing iron in a fortified food to lead-exposed children may reduce chronic lead intoxication [7]. Recent study conducted by Keramati et al found no correlation between blood lead concentration and iron deficiency in the Iranian children. However, this is due to all Iranian children had lead intoxication [24]. From the present study we also find that is no correlation between blood lead levels with blood haemoglobin levels.

In conclusion, three months calcium supplementation of 800 mg/day is effective for reducing blood lead levels in children. Chronic lead poisoning in children may be prevented with calcium supplementation.

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