INTERACTION BETWEEN ANEMIA AND BLOOD LEVELS OF IRON IN HOSPITALIZED CHILDREN

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ABSTRACT: The aim of this study was to investigate the relationship between anemia and serum iron levels. This research was performed on 363 children (mean age 5.43± 0.3) hospitalized in Louis Turcanu Children's Hospital of Timisoara. We observed iron deficiency anemia (IDA) in 43 children, iron deficiency without anemia (ID) in 32 children and only anemia (ferritin level normal) (OA) in 32 children, and 158 children were regarded as controls (C). The levels of iron and ferritin in serum were significantly lower in children with IDA than those of controls ($p< 0.001$). The most affected groups with IDA were children between 1 and 3 years old and those from rural areas, possible due to bottle-feeding with cow's milk and rapidly growth. The serum iron level in IDA group was found significantly lower than in the other groups as expected. There is positive correlation between iron levels and hemoglobin (Hb) levels ($r=0.44$, $p<0.001$).
KEYWORDS: Children; Iron Deficiency Anemia; Iron; Ferritin.

1. INTRODUCTION

Iron deficiency anemia is the most frequent and widespread nutritional deficiency in the world [A+01] because it is common in developing and developed countries alike. In fact, iron deficiency is the only micronutrient deficiency that is also prevalent in virtually all developed countries.
To this end, one of the U.S. national health objectives for 2010 is to reduce iron deficiency in vulnerable populations such as toddlers and women of childbearing age by 3% to 4 % [B+00].
Socioeconomic factors are associated with iron deficiency anemia in children. For example, infants and children of low-income and minority backgrounds have higher documented rates of iron deficiency anemia. [B+07] Infants are at risk for iron deficiency from insufficient dietary iron, variable absorption and rapid growth. IDA occurs with a peak prevalence of 4% to 8% in children between 1 and 3 years of age. The prevalence of iron deficiency increases with the duration of bottle-feeding of cow's milk in village especially.
Our objective in this study was to identify the age groups of children with iron deficiency and iron deficiency anemia and also to investigate the relationship between anemia and iron.

2. METHODS

2.1. Subjects

The study design was approved by the University of Medicine and Pharmacy,"Victor Babes", Timisoara. Signed informed consent was obtained for the screening phase of the project. Children and their caregivers (their mothers) were recruited during routine 1-month visits to Louis Turcanu Children's Hospital of Timisoara, which serves an extended region in west part of Romania.
Screening was based on a 15-minute questionnaire and a routine venous blood sample with extra blood (<5 mL total) for additional iron assays for children qualified by history. A total of 363 children (212 boys and 151 girls) with age between 1 month and 18 years were screened between October 2011 and March 2012.
Participation in the study was further restricted to healthy, full-term singleton infants, born to mother age>17 years, with birth weight >5th percentile and without perinatal complications, emergency Cesarean -section, maternal diabetes during pregnancy, heavy maternal alcohol use and another incapacitating condition.

2.2. Iron Status Assessment

Initial venous blood tests included a complete blood count. Hemoglobin (Hb) and the red blood cell index Mean Corpuscular Volume (MCV) of whole blood samples were measured with an automatic cell counter (Coulter SKTS, Beckman Coulter, USA). Remaining blood was separated for determination of serum iron and ferritin. Serum ferritin levels were determined by chemiluminiscence method by an immunanalyser (Immulite One, Bio DPC, CA, USA).
We used cutoffs from NHANES II [LGJ95], NHANES III, and Centers for Disease Control and Prevention publications, to determine which children qualified for the study hematologically.
For these children enrolled in study, the following variables were collected: age, gender, MCV, Hb, serum ferritin and serum iron levels.
IDA was defined as serum ferritin level of<12 µg/L, MCV of < 73 fL and hemoglobin level of<110 g/L. Infants with MCV <73 fl and Hb<110 g/L along with those who were clearly NA (Hb≥115 g/L) with normal MCV received questionnaire papers. For final iron status classification, ID was defined as 2 or more abnormal iron measurements, with serum iron<6 umol/L and ferritin <12 µg/L as additional abnormalities. IS was defined as Hb≥115 g/L and one or more abnormal iron measurements.
At least some of these additional iron measurements were available for 228 children (64%), of whom 205 met criteria for final classification (43 IDA, 32 ID, and 130 IS). The number of healthy children was 158 in our study. In this situation, we divided our subjects into four groups as iron deficiency anemia (IDA), iron deficiency without anemia (ID), only anemia (ferritin normal, low Hb) (OA) and healthy children (Control) (C). Missing data were due to insufficient blood or technical problems.

2.3. Data Analysis

Statistical analysis was performed with Stata version 9.2 (Statacorp, Texas, USA). Means, standard deviations and proportions are presented. Student's t-test and Anova were used to compare mean values between groups as appropriate. Pearson's correlation coefficient was calculated to assess the relationship between iron levels and Hb levels. A P-value <0.05 was considered statiscally significant.

3. RESULTS

In our study, children's Hemoglobin levels ranged from 3.2 to 15.3 g/dL with a mean level of 10.01 ±2.65 g/dL (median 10.65 g/dl, mode 11 g/dL). MCV levels ranged from 44 fL to 101.4 fL with a mean level of 70.79±13.55 fL (median 74 fL, mode 79 fL). Iron serum levels, measured at 228 children, ranged from 0.6 to 32.5 umol/L with a mean level of 8.44±6.19 umol/L (median 5.9 umol/L, mode 4 umol/L).
There was no statistically significant difference between boys and girls, either in the Hb levels (boys 9.91±2.66 g/dL vs girls 10.15±2.64 g/dL; t test, p=0.153) or in background characteristics were found. There are no statistically significant difference also between boys and girls with IDA either in the Hb levels (boys 7.25±2.17 vs girls 6.44±1.68; t test, p>0.05), in MCV values (boys 53.7± 9.91 vs girls 56.7±9.15; t test, p=0.42) or in Ferritin levels (boys 5.24± 2.63 vs girls 6 ± 2.72; t test, p=0.37), but in the iron values there are difference significant statistically between boys (3.91±2.45) and girls (5.51±4.21), p=0.03. (Figure 1)

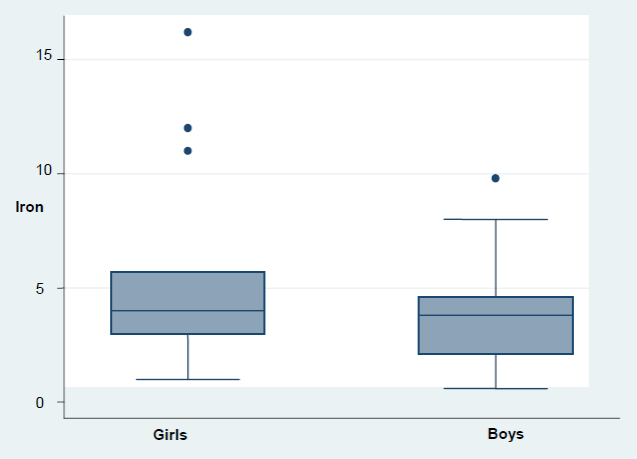

Fig. 1. Distribution of iron at boys and girls for IDA group

We compared Hb, MCV, Iron and Ferritin values of children among all groups (ANOVA) and these values differed significantly among groups, p<0.001 (Table 1). When the parameters of IDA, ID and OA were compared to controls, we observed a decline in the Hb, MCV, iron and ferritin levels of IDA group compared to controls (p=0.0008).

Table 1. Comparison of haematological parameters among groups (Mean±Standard Deviation)

	IDA (n=43)	ID (n=32)	OA (n=32)	CONTROL (n=158)
HB	6.93 ± 2.01	7.35 ± 2.20	8.58 ± 1.94	12.35 ± 1.02
MCV	54.94 ± 9.56	55.12 ± 8.77	69.78 ± 13.79	78.75 ± 7.91
IRON	3.72 ± 1.80	4.62 ± 3.38	10.26 ± 6.44	10.92 ± 6.36
FERRITIN	5.51 ± 2.74	5.54 ± 2.66	73.29 ± 97.61	39.10 ± 84.42

We found statistically significant differences only in Hb and ferritin levels between control and OA group. No significant difference was seen in the levels of

MCV and iron serum between control and OA group. The levels of Hb, MCV, iron and ferritin in ID were found to be low compared to control p<0.001, p<0.001, p<0.001, p<0.01 (Figure 2).

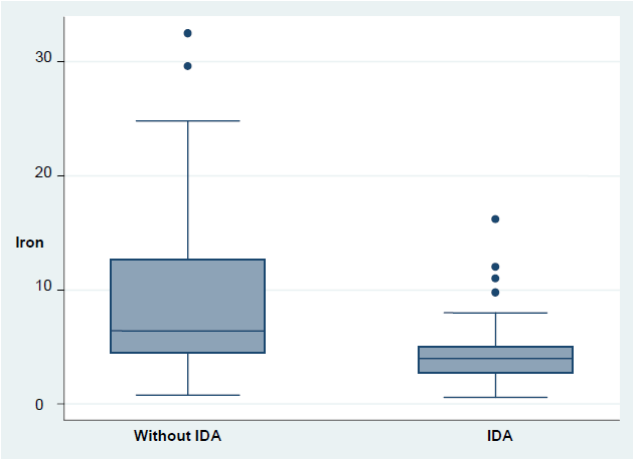

Fig. 2. Iron level at IDA group and non-IDA group

When we compared hematological parameters at different groups of age for children with IDA, we observed than the most affected group is from 1 to 3 year aged (Table 2).

There are significant differences between MCV in each group of age (p<0.05).

We compared Hb and iron level in children from rural and urban areas and we observed declined values in children from rural areas (rural Hb =6.50±1.73 vs urban Hb =7.58±2.28 and rural Iron =4.22±3.91 vs urban Iron =5.01±2.83) (Figure 3) but the difference is not statistically significant (p>0.05).

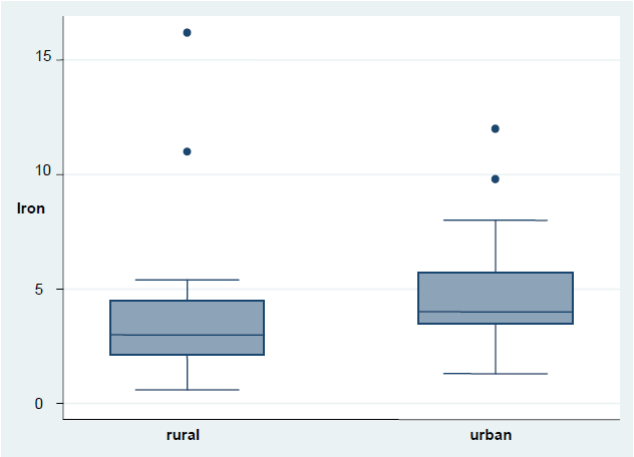

Fig. 3. Iron level at rural vs urban children for IDA group

Table 2. The comparison of hematological parameters among groups of age (mean±standard error)

	<1 year	1-3 years	4-6 years	7-9 years	10-12 years	13-15 years	16-18 years
HB P=0.07	7.42±2.36 N=11	6.43± 1.7 N=18	8.33±1.42 N=3	4.4 N=1	4±0.56 N=2	8.15±1.9 N=2	7.83±1.56 N=6
MCV P=0.03	53.2±10.69 N= 7	50.65±6.84 N=12	61±11.35 N=3	45.6 N=1	72 N=1	51 N=1	63.32±4.97 N=5
IRON P=0.76	4.07±3.16 N=8	4.73±3.98 N=15	4.96±2.68 N=3	4.5 N=1	- N=0	3.05±1.34 N=2	5.6±3.76 N=5
FERRITIN P=0.29	6±2.92 N=10	4.72±2.35 N=18	4.83±2.75 N=3	3 N=1	7.5 N=2	8.5±2.12 N=2	6.41±3.1 N=6

4. DISCUSSION AND CONCLUSIONS

In this research, the serum iron level in IDA group was found significantly lower than in other groups as it would be expected. We found a positive correlation between iron levels and Hb levels (r=0.44, p<0.001).

The most affected groups were children between 1 and 3 years old and those from rural areas, possible due to bottle-feeding of cow's milk.

Iron deficiency is a worldwide health problem, especially for infants, rapidly growing adolescents, pregnant women and aged women. Iron deficiency is associated with lower cognitive test scores in infants, impaired scholastic performance, shortened attention span, reduced muscle function and physical activity, and impaired mental acuity in older children and adults [Lee99].

Iron plays an essential role in many biological processes and it is important to maintain iron concentration within its narrow normal range [And99, Gla07, S+11].

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