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Research Article

Clinicobiochemical basis of iron profile in children with protein energy malnutrition

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Abstract

Background: Protein Energy Malnutrition is a widely recognized major health problem in the developing countries of the world. PEM is an important cause of childhood morbidity and mortality, leading to permanent impairment of physical and possibly mental growth of those who survive. As PEM progresses, multiple organ dysfunctions develops, with increasing severity there is increasing failure in the homeostatic mechanism of the body and damages to the immune defenses, which may result in infections and death.

Objectives: The objectives of this study was to estimate and compare the concentration of serum iron, ferritin and TIBC in PEM patients and healthy controls then correlate the values in the PEM children.

Materials and Methods: 30 cases of PEM and 30 healthy controls in the age group of 1-4 years were taken for the study. Serum ferritin, iron and TIBC were measured using Direct Chemiluminometric Assay - two site sandwich immunoassay method.

Results: The mean serum iron, ferritin and TIBC were 64.60 ± 20.30 µg/dl, 46.60 ± 22.40 ng/dl and 150.50 ± 35.80 µg/dl respectively which was significantly low ($p<0.001$) in children with PEM than in the control group.

Conclusion: There was significant decrease in the serum iron, ferritin and TIBC in PEM patients when compared to the controls. Serum iron profile can be used as a prognostic marker in PEM patients. Future work in this area will provide a clearer picture regarding significant decrease in the serum iron, ferritin and its regulation by dietary and humoral factors.

Keywords: Iron, ferritin, malnourished, total iron binding capacity

1. Introduction

Protein Energy Malnutrition (PEM) is a widespread nutritional disease in the developing countries[1]. PEM is defined as a spectrum of diseases arising as a result of an absolute or relative deficiency of calories and or protein in the diet[2,3]. In children, protein energy malnutrition is defined by measurements that fall below two standard deviations under the normal weight for age (underweight), height for age (stunting) and weight for height (wasting)[4]. Protein energy malnutrition usually manifests early, in children between six months and two years of age and is associated with early weaning, delayed introduction of complementary foods, a low-protein diet and severe or frequent infections[5,6]. The child may be marasmic or kwashiorkor. PEM is globally the most important risk factor for illness and death, with hundreds of millions of young children affected[7-9].

UNICEF reports that India has unfortunate distinction of having 75 million malnourished children below 5 years of age. Malnutrition is consequently the most important risk factor for the burden of disease in developing countries. It

increases one's susceptibility to and severity of infections, and is the major component of illness and death from diseases[10,11].

Iron is an essential part of haemoglobin, myoglobin and various enzymes. Its deficiency leads, mainly to anemia [12]. Iron is an important integral component or essential cofactor for several metabolic processes which is deranged in PEM [13]. Ferritin is the major iron storage compound and is a very efficient iron trap, as well as a readily available source of iron for metabolic requirements[14].

Nutritional deficiency adversely affects immune function and reduces the effectiveness of the host defence; thus inviting more infection and causing iron loss[15]. Socio-economic factors also have an important role in iron deficiency especially in developing countries[16]. Nutritional anemia is one of the major causes of growth retardation, decreased physical activities and defect in cognitive function in children[17].

There are conditions due to varying degrees of protein and calorie deficiency in which there is failure to maintain adequate weight gain and growth rate in the early stages, but as the condition progresses, there is loss of weight associated with loss of subcutaneous fat and muscle mass. With increasing severity there is increasing failure in the homeostatic mechanism of the body, as wll as micronutrient deficiencies like vit A, iron, zinc, magnesium and which in turn damage the immune defense resulting in infections and death[18]. With this view, the aims and objectives of this study were to estimate and compare the levels of serum iron, TIBC and ferritin in healthy and PEM patients and to correlate the results in the cases.

2. Materials and Methods

This prospective study was carried out on 30 children with age range of 12-48 months (1-4 years). An equal number of age and sex matched healthy subjects formed the control group. The study was carried out on children attending pediatric OPD of a medical college hospital.

Diagnosis of PEM: PEM was diagnosed by anthropometric measurements and physical examination.

Table 1: I A P classification of malnutrition (This is based on weight for age values.)[19]

Grade of malnutrition	Weight for age of the standard (median) (%)
Normal	> 80
Grade I	71-80 (mild malnutrition)
Grade II	61-70 (moderate malnutrition)
Grade III	51-60 (severe malnutrition)
Grade IV	< 50 (very severe malnutrition)

Exclusion criteria: Children with chronic infectious diseases like nephrotic syndrome, chronic glomerulonephritis and acute renal failure in which there is an excessive loss of proteins and patients with lead poisoning, thalassemia and with congenital anomalies were excluded from the study.

A semi–structured questionnaire (proforma) was used to obtain information from the subjects using interview method. Relevant information on the child's socio-demographic characteristics, nutritional indices and laboratory findings were documented. Study participants were grouped into upper, middle and lower socioeconomic classes based on the Oyedeji socio –economic classification scheme[20].

2.1. Sample collection, separation and preservation

The study protocol was approved by the institutional ethical committee before the commencement of the study. Aseptically 3ml of venous blood was collected with due informed and written consent from the parents of patients and controls. As soon as the blood was collected from the patients, it was carried to the laboratory in an ice-container. The blood was allowed to clot and serum was separated by centrifugation at 5000 rpm for 5 minutes. It was used to estimate various parameters.

Analytical procedure: Serum ferritin, iron and TIBC were estimated using Direct Chemiluminometric Assay - two site sandwich immunoassay method by using Bayers automated Chemiluminescence System (ACS: 180) (Automated Hormone Analyzer). The quality control was done for all the tests performed.

2.2.Statistical analysis

SPSS for windows Version-16 (2007) was employed for statistical analysis. The Independent-Sample's't' test procedure was used to compare the mean for two study groups. The One-Way ANOVA was used for one-way analysis of variance for a quantitative dependent variable by a single factor (independent) variable. The correlation between the parameters was worked out using Pearson's correlation. A 'p' value < 0.05 was considered to be statistically significant.

3. Results

This prospective study included 60 children, among them 30 were severely malnourished and 30 were well nourished (normal children). The characteristics of severely malnourished children are shown in Table 2. Among the PEM group, 65% were males and 35% were females, with a male to female ratio of 1.9**:**1. The mean±SD values of age, weight and height of the children with PEM and controls are as shown in table 2. The weight of children with PEM was decreased when compared to controls but was not statistically significant.

Table 2: Anthropometric data of study groups showing Mean±SD values

Sl.No	Variables	CASES (n=30)	CONTROLS (n=30)	p value
1	Age (years)	2.86 ± 1.02	2.72 ± 0.96	<0.05
2	Weight(kgs)	9.60 ± 1.64	13.70 ± 2.47	<0.05
3	Height(cms)	101.30 ± 2.95	102.86 ± 3.03	<0.05

42% of the children with PEM were in socio-economic class (SEC) IV, 28.8% in SEC III, 20% in SEC V and only 2.2% in SEC I. The subjects were of a lower socioeconomic class compared to the controls (p=0.00001) (Table 3).

Of the 30 mothers interviewed, 32.2% had primary education, 27.8% had no form of education, while 23.3% and 16.7% had secondary and tertiary education respectively. The educational status of mothers of children with PEM were lower compared to that of controls (p=0.0002) (Table 3).

Table 3: The socio-demographic characteristics of the subject and controls.

Sl.No	Variables	CASES (n=30)	Controls (n=30)
1	**Gender**		
	Male	17	17
	Female	13 1	13
2	**Social Economic Class**		
	I	2.20%	4.4%
	II	6.80%	30.00%
	III	28.80%	38.90%
	IV	42.20%	17.80%
	V	20.00%	8.90%
3	**Maternal Educational Status**		
	None	27.80%	10.00%
	Primary	32.20%	22.20%
	Secondary	23.30%	25.60%
	Post secondary	16.70%	42.20%

Table 4 presents the values of mean ± SD of iron in µg/dl, TIBC in µg/dl and ferritin in ng/ml of cases and controls. The mean serum iron, ferritin and TIBC were 64.60 ± 20.30 µg/dl, 46.60 ± 22.40 ng/dl and 150.50 ± 35.80 µg/dl respectively which was significantly low (p<0.001) in severely malnourished children than in normal children. Table 4 shows the value of 't' statistic to test the hypothesis that there significant difference between the mean iron, TIBC and ferritin values of cases and controls. Table 4 represents 'p' values for cases and controls. As represented in the table 4, there was a statistically significant decrease in the mean iron, TIBC and ferritin levels in PEM patients when compared to control

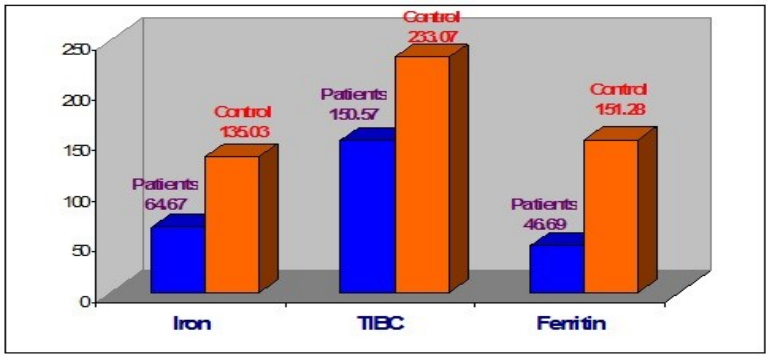
group (p<0.0001). This is also shown graphically as bar diagram in figure 1 which shows that there is a significant decrease in the serum levels of iron, TIBC and ferritin in PEM patients when compared to the control group. There was no correlation between the values of serum iron, ferritin and TIBC.

Table 4: Mean ± SD and p values of iron, TIBC and ferritin

Variables	Cases (n = 30)	Controls (n = 30)	t value	p value
Iron	64.60 ± 20.30	135.0 ± 31.80	-10.0	<0.0001 (HS)
TIBC	150.50 ± 35.80	233.0 ± 42.60	-7.9	<0.0001 (HS)
Ferritin	46.60 ± 22.40	151.20 ± 69.90	-7.6	<0.0001 (HS)

SD = Standard Deviation; P value = level of significance
HS = Highly Significant; t value = test of significance

Fig 1: Bar diagram showing the mean values of serum iron, TIBC and ferritin in the study groups



4. Discussion

Protein-energy malnutrition (PEM) is one of the important causes of under 5 morbidity and mortality in our country[21]. The National Child Nutritional Survey conducted in 2000 demonstrated that among the children of 6 to 71 months of age, almost 49% were found stunted and nearly 12% wasted and 52% were underweight[22-23].

Malnutrition increases one's susceptibility to and severity of infections, and is the major component of illness and death from diseases. The risk of death is directly correlated with the degree of malnutrition [24].

Iron is an important integral component or essential cofactor for several metabolic processes which is deranged in PEM. Ferritin is the major iron storage compound. Malnutrition associated with iron deficiency is more common in kwashiorkor but not in marasmic children [25]. In this study toddlers, male children and children of low socioeconomic condition were the most vulnerable groups for malnutrition. This finding was also consistent with the other study [26].

In the present study, the mean serum concentration of iron, TIBC and ferritin levels were decreased in PEM patients when compared to control group. Velasquez et al., found that there was significant decrease in serum iron and ferritin levels in PEM patients[27]. Our finding do not agree with the study done by Rahman MA et.al., who have shown normal levels of iron and TIBC in severely malnourished children[22].

The possible mechanism of decrease in serum iron, TIBC and ferritin levels are due to poor diet, elevated needs and chronic loss from parasitic infections. Diarrhea and other infections can cause malnutrition through decreased nutrient absorption, decreased intake of food, increased metabolic requirements, and direct nutrient loss. Parasite infections can also lead to malnutrition [28]. Another mechanism for decreased iron and ferritin is majority of dietary non-haem iron enters the gastrointestinal tract in the ferric form. However, Fe^{3+} is thought to be essentially non-bioavailable and therefore, it must first be converted to ferrous iron prior to absorption. The most potent enhancer is ascorbic acid (vitamin C), which acts by reducing ferric iron to the more soluble and absorbable ferrous form. There are numerous dietary components capable of

reducing Fe^{3+} to Fe^{2+}, including ascorbic acid, and amino acids such as cysteine and histidine .Hence deficiency of ascorbic acid and amino acids leads to significant decrease in serum iron and ferritin [29].

In conclusion, severely wasted malnourished children, the mean serum concentration of iron, TIBC and ferritin levels were decreased in PEM patients when compared to control group. Serum iron profile can be used as a prognostic marker in PEM patients. Future work in this area will provide a clearer picture when iron profile is correlated with dietary and humoral factors.

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