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Original Research

Levels of iron and magnesium in serum of *plasmodium falciparum* malarial infected children in Abraka, Delta State, Nigeria

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Abstract

ABSTRACT

P. falciparum invasion and destruction of red blood cells modify mineral contents in serum o infected individuals and this may contribute to the disease mortality especially among children In this study therefore, the amount of iron, Fe and magnesium, Mg, in serum of*P. falciparum* infected children were estimated to provide baseline information in Abraka, a university community in Delta state, Nigeria. Twenty five *P. falciparum* infected children and twenty five uninfected children in apparent good health were screened and selected after obtaining informed consent from their parents. Serum Mg and Fe levels were estimated using established procedures and standard methods. Results shows that *P. falciparum* malarial infection significantly (p<0.05) reduced Mg (1.18±0.42 mEq/L) and Fe (0.46±0.15 mg/L) concentrations in a trend that depends on the malarial severity, when compared with values (Mg= 2.10+0.5(mEq/L; Fe= 1.31±0.37 mg/L) obtained from the uninfected children. Thus, *P. falciparum* malarial infection reduces Mg and Fe concentrations and this alter Fe and Mg –dependent metabolic and cellular activities to the detriment of the infected patient. Therefore, the experimental and clinical outcome of including Mg and Fe supplements to the anti malaria chemotherapeutic regimen should be validated in further studies.

INTRODUCTION

Malaria is caused by an infection with protozoa of the genus *Plasmodium*. It is an important public health problem in especially developing countries. *P. falciparum*, a pathogenic agent of malaria remains a major cause of morbidity and mortality of children under five years in endemic countries [1]. In Nigeria, malaria is the first reason for medical consultation and unfortunately, childhood mortality [2].

Some authors have associated malaria acquisition and severity (or *P. falciparum* virulence) to the concentrations of macrominerals (Mg,Na, K, Ca and P) and microminerals (Fe, Zn, Se, Cu and Co) in children [3-5].

Iron, Fe, is an essential micronutrient necessary for the transportation of respiratory gases via haemoglobin in the red blood cells. Iron also intervenes in the constitution of enzymatic systems that catalyze peroxides and cytochromes involved in cellular respiratory mechanisms and mitochondrial respiratory channels [6]. On the other hand, magnesium, Mg, is mainly found in intracellular fluid and in bones about 60% complexes with calcium. Magnesium functions in the activation of many enzymes requiring ATP – alkaline phosphatase, hexokinase, fructokinase, phosphofructokinase, adenyl cyclase etc. Magnesium also plays an active role in the metabolism of sodium, potassium and calcium. It acts on the heart, blood vessels, nerves, muscles and gut.

Malarial parasites invade and destroy red blood cells, and patients infected with the malarial parasites, also experience recurrent gastrointestinal symptoms such as nausea, vomiting and diarrhea. These consequences of

the malarial parasites could respectively alter the concentrations of Fe and Mg in serum.

Albeit, data on the significant variations of some micronutrients in the course of malarial infection in developing countries including Nigeria, where malnutrition and infection problem co exist need to be properly documented and kept under surveillance. In this regard therefore, the concentrations of Fe and Mg in serum of *P. falciparum* malarial infected children in Abraka, Delta state, Nigeria, were estimated to provide a baseline information and experimental guide.

MATERIALS AND METHODS

Study area and duration: The study was conducted in Abraka, Delta State, Nigeria, from July to November, 2011. In the Nigerian environment, malaria is hyper-endemic with transmission peaking during the rainy season; April to October**.**

Subjects: Fifty (50) children (25 infected with *P. falciparum* and 25 uninfected) between the ages of 2-14 years were selected from General Hospital, Abraka and Delta State University Health Centre, also in Abraka. Informed consent was obtained from the children's parents and approval was given by our faculty's Research and Bioethics Committee.

Estimation of serum Fe and Mg concentrations: The reagents used for the determination of serum Iron (Fe) and Magnesium (Mg) were packaged in commercial kits supplied by TECO DIAGNOSTICS, Anaheim, U.S.A. The levels of Fe and Mg in serum of the children participants were estimated spectrophotometrically by the appropriate commercial kit using manufacturer's manual instruction according to the methods of [7] for iron determination and [8] and [9] for magnesium determination.

Presence or absence of *P. falciparum* was confirmed by the Giemsa stain of the thick and thin blood smears and severity of malarial infection was classified into low (+), moderate (++) and high (+++) parasitemia based on the parasite density. Malarial infection is low when the parasite density was below 1,000 cells dL^{-1} blood, moderate- between 1,000- 10,000 cells dL^{-1} of blood and high- over 10,000 cells dL^{-1} of blood, [10].

Statistics: Analysis of Variance (ANOVA) and Student's t test was used employed to compare the means of the parameters and the differences between means were considered significant at $p<0.05$.

RESULTS

The results obtained from the investigation into the levels of serum magnesium, Mg, and iron, Fe, of *P. falciparum* infected children are given in Tables 1 and 2.

Table 1 shows the changes in mean serum Mg and Fe levels induced by *P. falciparum* in children.

Table 1. Changes in mean serum magnesium and iron levels induced by *P. falciparum* malaria infection in children.

Parameters	Malarial infected children (n=25)	non-malarial infected children (n=25)
Magnesium (mEq/L)	1.18 ±0.42[a]	2.10±0.56[b]
Iron (mg/L)	0.46±0.15[a]	1.31±0.37[b]

Values are expressed as Mean ± SD for ('n') subjects.
Values bearing another superscript in a row differ significantly (P<0.05)
Reference range; Mg =1.30-2.50mEq/L, Fe=0.60-1.50mg/L

Results in table 1 indicated that the mean serum levels Mg and Fe in malarial infected children were significantly reduced ($p<0.05$) when compared to non-malarial infected children.

Table 2 shows the effect of malarial severity on serum Mg and Fe concentrations among infected children.

Table 2. Changes in serum magnesium and iron levels induced by *P. falciparum* malarial severity among infected children.

Patients	Mg(mEq/L)	Fe (mg/L)
Severity of malarial infection		
+ (n-9)	1.26±036[a]	0.56±0.14[a]
++ (n=10)	1.16±0.37[a]	0.43±0.17[a]
+++ (n-6)	1.09±0.43[a]	0.38±0.08[a]
Without malarial infection (n=25)	2.10±0.56[b]	1.31±0.37[b]

Tabulated data are written as Mean ±SD for 'n' number of children
Values bearing another superscript in a column differ significantly (p<0.05)
Reference ranges; Mg = 1.30-2.50 mEq/L; Fe = 0.60-1.50 mg/L
low (+) moderate (++) and high (+++) parasitemia based on the parasite density. Malarial infection is low when the parasite density was below 1,000 cells dL^{-1} blood, moderate- between 1,000- 10,000 cells dL^{-1} of blood and high- over 10,000 cells dL^{-1} of blood.

P. falciparum malarial infection reduced in both Mg and Fe levels in serum of infected children in a manner largely influenced by the severity of infection. Serum Fe and Mg levels of the malarial infected children further reduced as severity of infection increases. All

values, irrespective of the magnitude of infection differ significantly ($p<0.05$) from the comparable value obtained from the uninfected children.

DISCUSSION

P. falciparum malarial infection significantly reduced serum Mg and Fe levels among infected children in Abraka, Delta state, Nigeria (Table 1). These micronutrients further reduced as the degree of malarial infection increases (Table 2). Our observations agreed with the reports of [11] who also discovered that *P. falciparum* malarial infection reduced the levels of trace elements in serum of infected children from Cote d'Ivoire.

The malarial causative agent- *P. falciparum*, is capable of sticking to blood vessels (a process known as cytoadherence). This sticking leads to obstruction of microcirculation which results in dysfunction of multiple organs and breakdown in the body's immune system. These resultant effects of *P. falciparum* cytoadherence could modify micronutrient levels including Mg and Fe in serum of infected patients.

In addition, *P. falciparum* binds, invades and destroys red blood cells. In these processes, serum concentration of iron is depleted and intracellular levels of magnesium are also reduced. Therefore, the activities of *P. falciparum* reduces the amounts of red blood cells [3] and its replenishment is interrupted by the depleted levels of iron which is needed to produce red blood cells [4]. The associated reduction in magnesium levels will also hamper magnesium- dependent functions in the body. Actions like activation of the ATP – dependent enzymes would be inhibited resulting in altered regulation of intrahepatic biliary epithelium secretion and impairment of extracellular signals to intracellular effectors [12]. Muscle fatique, diminished red blood supply to tissue and organs of the body, have also been identified as consequences of reduced Mg level [12].

P. falciparum malarial infection may be associated with the enumerated possible derangements induced by Mg and Fe reduced amounts and these could complicate the infection and contribute to the disease mortality among children. Therefore, the role of supplementation at mitigating the resultant effects of *P. falciparum* – induced depletion of Mg and Fe levels should be investigated, and outcome possibly entrenched into anti malarial regimen.

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