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Malaria parasitaemia: effect on serum sodium and potassium levels

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Abstract

Serum sodium (Na^+) and potassium (K^+) levels were analyzed in 150 confirmed malaria patients from five different hospitals in Enugu metropolis, southeast Nigeria. The patients were divided into four different age brackets; 1-10, 11-20, 21-40 and >40 years respectively. Sixty apparently healthy, age-matched individuals were used as control subjects. The mean ± SD of the Na^+ and K^+ levels in malaria patients of all age ranges were significantly decreased (P<0.05) when compared with the controls. Comparison of the different age brackets showed a statistically significant difference (P<0.05) between the mean ± SD in the (11-20years) age bracket compared with the other age brackets. There was however no significant difference (P>0.05) between the values obtained in the age brackets; 1-10, 21-40, and > 40 years respectively. The study shows that there is significant lowering of the Na^+ and K^+ levels in malaria infection. Subjects between 11-20 years were the most vulnerable in this regard from the result of the study and constitute the major risk group. Electrolytes (Na^+ and K^+) should be monitored in malaria patients to enhance patient management.

Keywords: Effect; parasitaemia; malaria; sodium; potassium; serum.

Introduction

Malaria is a life-threatening parasitic disease transmitted through the bite of a female anopheles mosquito (WHO, 2003a). It is a disease that can be treated in just 48 hours, yet it can cause fatal complications if the diagnosis and treatment are delayed (Kakkilaya, 2002). Malaria in man is caused by four distinct species of malaria parasite; *Plasmodium vivax, Plasmodium falciparum, Plasmodium ovale and Plasmodium malariae.* Most adults living in malaria endemic areas have partial immunity and are at risk of chronic or repeated infections (WHO, 2003a). Many are asymptomatic carriers of the disease (Kakkilaya, 2002). Approximately 50% of the Nigerian population experience at least one episode of malaria yearly (Madaki and Zoakah, 2002). Typically, malaria produces fever, headache, vomiting and other flu-like symptoms. If drugs are not available for treatment or the parasites are resistant to them, the infection can progress rapidly to become life-threatening (White, 1996; Stanley, 1997). Malaria parasites are developing unacceptable levels of resistance to one drug after another and many insecticides are no longer useful against mosquitoes transmitting the disease (WHO, 2003b). Sodium (Na^+) is the major cation of extra cellular fluid and as such plays a central role in the maintenance of the normal distribution of water and osmotic pressure in various fluid compartments (Tietz *et al.,* 2001). Potassium (K^+) on the other hand is the major intracellular cation, having an average cellular concentration in tissue cells of 150mmol/L (Kaplan *et al.,* 1995). In addition to water balance, these electrolytes play an important role in maintenance of pH, regulation of heart and muscle function, electron transfer reactions as well as serving as cofactors for enzymes (Mayne, 1994). Disorders of water balance include hyponatreamia, hypernatraemia, hypokalaemia and hyperkalaemia, which also occur in conditions of electrolyte disturbance, such as severe malaria infection (Kakkilaya, 1997). In human erythrocytes infected with the mature form of the malaria parasite, plasmodium falciparum, the cytosolic concentration of Na^+ is increased and that of potassium is decreased (Dworak *et al.,* 1975). Kakkilaya (2002) observed that malaria is often associated with abnormalities of fluid, electrolytes (Na^+ and K^+) and acid-base balance. These can occur in any body but are more common in severe *falciparum* malaria, extremes of age and in patients with high degree of fever and vomiting. Nutritional status, hemoglobin type and erythrocyte glucose-6-phosphate dehydrogenase activity all influence response to malaria infection (Heindricks *et al.,* 1971). Since Na^+ and K^+ have been shown to be highly indispensable in water homeostasis, which is fundamental to the survival of all organisms, it is necessary to estimate the levels of these electrolytes in all cases of *falciparum* malaria (Bradley *et al.,* 1996) and in severe malaria infection for better management of such patients.

Materials and Methods

Subjects: The study subjects were made up of one hundred and fifty (150) confirmed malaria patients recruited from the outpatient Department, University of Nigeria Teaching Hospital in Enugu Metropolis. The subjects were divided into four different age ranges; 1-10 years, 11-20 years, 21-40 years and > 40 years respectively. Sixty apparently healthy age-matched individuals were used as controls. Informed consent was obtained from all the subjects and adequate approval was given by the institute's ethical committee before the study commenced.

Inclusion Criteria: All the test subjects were confirmed malaria patients.

Exclusion Criteria: Subjects with abnormal sodium and potassium levels (electrolyte imbalance) were excluded from the control group of the study.

Sample Collection and Preparation: Two specimen bottles were used for each subject. Anticoagulant bottles containing K_2 EDTA for malaria parasite test and chemically plain bottles for electrolyte assay. Blood samples (5ml) were collected by clean venepuncture from the ante-cubital fossa into already labeled bottles, without undue pressure to either the arm or the plunger of the syringe. The samples were mixed by gentle inversion. The samples in the K_2 EDTA anticoagulant bottles were tested immediately for malaria parasite, after staining their thick blood films with Giemsa stain, while those samples in the plain tubes were allowed to clot, and the clotted samples centrifuged at 3000 rpm for 5 min to obtain the sera. The serum supernatants were separated into sterile bottles and analyzed immediately. When immediate analysis was not possible, the samples were stored in the refrigerator and analysis carried out within 4 days.

Analytical Methods:
The malaria parasite density was determined by examining a thick blood film stained by Giemsa method (Cheesbrough, 1998).

Classification of the degree of parasitaemia:
The malaria parasite density was graded as follows;
1 parasite/ field: low density (+)
2-9 parasites / field: medium density (++)
>20 parasites / field: high density (+++) (Cheesbrough, 1998)

Serum Sodium and Potassium analysis:
The sodium and potassium in the samples were analyzed using flame emission spectrophotometric method (Tietz *et al.,* 1996).

Procedure: 1 in 100 dilution of serum was made with deionized water in universal container, mixed and aspirated into the flame analyzer at a wavelength of 589nm for Na^+ and 765nm for K^+, having calibrated the machine with a standard solution containing 140mmol/L Na and 4.0 mmol/L of deionized water.

Statistical Analysis: Data from the study was analyzed separately using paired t-test at 95% confidence interval and analysis was done using the Statistical Package for Social Sciences (SPSS). Results are presented as mean ± standard deviation (± SD) and P values <0.05 are considered significant.

Results

Table 1 shows the mean (± SD) of the Na^+ and K^+ in all the malaria patients and the overall control subjects. It showed a statistically significant decrease (P<0.05) in both Na^+ and K^+

levels in the test subjects when compared with the controls.

TABLE 1
Variations in mean ± SD of serum sodium (Na^+) and potassium (K^+) levels in all the malaria patients and control subjects.

Subjects	N	Na^+ (mmol/L)	K^+ (mmol/L)
Test Subjects	150	133.65 ± 3.37	3.39 ±0.17
Control Subjects	60	137.78 ±3.47	4.03 ± 0.56
P-value		P<0.05*	P<0.05*

***** = Statistically Significant.

In table 2, the mean (± SD) of Na^+ and K^+ in malaria patients of different age brackets were compared statistically with the age-matched controls and there was significant differences (P<0.05) in all the age brackets, between the test subjects and their age-matched controls.

TABLE 2
Comparison of Mean ± SD of serum sodium (Na^+) and potassium (K^+) levels of malaria patients and control subjects in the different age brackets.

Age Bracket	Subjects	N	Na^+ (mmol/L)	K^+ (mmol/L)
1-10 years	Test subjects	35	134.26 ± 2.49	3.41 ± 0.52
	Control subjects	15	136.90 ± 2.66	4.02 ± 0.61
	P-value		P<0.05*	P<0.05*
11-20 years	Test subjects	40	130.95 ± 1.47	3.19 ± 0.17
	Control subjects	15	138.47 ± 3.18	4.04 ± 0.26
	P-value		P< 0.05*	P<0.05*
21-40 years	Test subjects	40	134.68 ± 2.87	3.49 ± 0.33
	Control subjects	15	137.47 ± 3.72	4.01 ± 0.49
	P-value		P<0.05*	P<0.05*
> 40 years	Test subjects	35	134.94 ± 3.66	3.46 ± 0.36

	Control subjects	15	138.27 ± 4.37	4.06 ± 0.67
	P-value		P<0.05*	P<0.05*

* = Statistically Significant.

The mean values in the different age brackets were compared with one another and only the 11-20 years bracket was significantly decreased (P<0.05) when compared to the other three (3) age brackets (Table 3).

TABLE 3
Test of difference between the (mean ± SD) of serum sodium (Na^+) and potassium (K^+) levels in malaria patients of different age brackets.

Age Range	N	Na^+ (mmol/L)	K^+ (mmol/L)
1-10 years	35	134.26 ± 2.49	3.41 ± 0.52
11-20 years	40	130.95 ± 1.47	3.19 ± 0.71
P- value		P<0.05*	P<0.05*
11-20 years	40	130.95 ± 1.47	3.19 ± 0.17
21-40 years	40	134.68 ± 2.87	3.49 ± 0.33
P-value		P<0.05*	P<0.05*
11-20 years	40	130.95 ± 1.47	3.19 ± 0.17
> 40 years	35	134.94 ± 3.66	3.46 ± 0.36
P-value		P<0.05*	P<0.05*
1-10 years	35	134.26 ± 2.49	3.14 ± 0.52
21-40 years	40	134.68 ± 2.87	3.49 ± 0.33
P-value		P>0.05	P>0.05
1-10 years	35	134.26 ± 2.49	3.14 ± 0.52
> 40 years	35	134.94 ± 3.66	3.46 ± 0.36

P-value		P>0.05	P>0.05
21-40 years	40	134.68 ± 2.87	3.49 ± 0.33
>40 years	35	134.94 ± 2.66	3.46 ± 0.36
P-value		P>0.05	P>0.05

*** =** Statistically Significant.

Discussion

The results of the study show that malaria infection leads to a reduction in the levels of both serum sodium and potassium. A significant difference ($P<0.05$) was observed between the malaria patients and the overall control subjects as well as the test subjects of all the age brackets in comparison with their age-matched controls. Dworak et al (1975) stated that there is a progressive decrease in Na and K in 12 hrs of the parasite's occupancy whereas Kakkilaya (2002) reported a mild hyponatraemia in malaria patients. Both findings are in line with the reductions observed in the present study. The reason for the decrease in K^+ level might also be linked with the statements of Heindricks et al (1971) who reported that host cells loose up to 75-80% of their normal potassium content during the course of malaria attack. The present study however revealed the vulnerability of the 11-20 years age bracket being the age group with a significant decrease in Na^+ and K^+ levels in malaria infection. The reason for this is not fully known. The study further shows the importance of electrolyte management in malaria patients to prevent electrolyte (Na^+ and K^+) depletion.

Conclusion

The study draws attention to the need to manage electrolyte derangements in the overall management of malaria infections. The age-related effect that made the 11-20 years age bracket to appear most vulnerable should be further investigated and always taken into consideration in management and treatment of malaria in patients of this age bracket. In general, serum electrolytes should be estimated in malaria patients of all ages to prevent complications, which might result from electrolyte depletion, as these may have grave consequences.

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