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Assessment of Iron and Biochemical Parameters of Malaria Patients in Maiduguri, North-Eastern NigeriaGali, R.M.¹, Mamza, Y.P.¹, Medugu, J.T. *¹, Musa, A.H.¹, Tijjani, H.¹, Genesis, R.Y.², Gata, G.E.¹.*Department of Medical Laboratory Science College of Medical Sciences, University of Maiduguri¹, Department of Chemical Pathology University of Maiduguri Teaching Hospital Borno State Nigeria².**Author for Correspondence *: medugujessy@gmail.com /+234-813-468-7292***Abstract**

Malaria is a life-threatening disease and one of the major causes of human deaths worldwide, with countries in Africa being most affected. If left untreated, malaria can lead to anaemia and renal failure, demonstrating the need to monitor the level of electrolytes and iron among malaria infected patients. A total of one hundred and sixty (160) plasmodium parasitized subjects participated in the study, of which one hundred and thirty-nine (139) subjects tested positive for malaria parasites (+1) and twenty-one (21) were positive for malaria (+2). One hundred (100) healthy non-parasitized individuals were monitored as controls. The levels of sodium, potassium, bicarbonate, serum urea, creatinine and serum iron were determined among the subject participants, using standard techniques. It was observed that the mean serum iron, sodium, chloride, urea and creatinine levels were significantly higher in subjects which tested positive for malaria parasites (+1) when compared to the controls, while subjects with malaria positive (+2) had significantly lower serum iron when compared to the healthy controls. It was also observed that the malaria positive (+2) subjects had significantly higher levels of urea and creatinine when compared to healthy controls. The results of the biochemical parameters in the malaria-infected subjects observed in this study is a demonstration of the need for electrolytes estimations to be incorporated in the management of the malaria infected individuals to avoid acid-base imbalance and renal impairment.

Keywords: Electrolytes, serum iron, urea and creatinine

Introduction

Malaria is the most significant mosquito-borne disease globally, and one of the major causes of mortality among humans (Vajda and Webb, 2017). It thrives in the tropical areas of Asia, African and Central and South America (Alhassan *et al.*, 2017). Even though the number of malaria cases globally has scaled down from an estimated 262 million in 2000 to 214 million in 2015, about 300,000 people still die of malaria annually (World Health Organization, 2015). Human malaria is caused by four species of Plasmodium; *P. falciparum*, *P. vivax*, *P. ovale* and *P. malariae*, among which *P. falciparum* is responsible for the complication of the disease, and the causes of 90% malaria deaths (World Health Organization, 2013). These parasites are transmitted by the bite of vectors belonging to the *Anopheles funestus* group and the *Anopheles gambiae* complex (Coetzee and Fontenille, 2004). Transmission may also occur by blood transfusions or congenitally from mother to foetus (Alho *et al.*, 2017).

Typically, malaria symptoms include fevers, headaches, vomiting and flu-like symptoms. Complications such as anaemia, cerebral malaria, hypoglycaemia, metabolic acidosis, renal failure, and respiratory distress are seen in *P. falciparum* infected individuals (Kocha *et al.*, 2003; Louis *et al.*, 2002). These complications can be fatal if diagnosis and treatment are delayed. However, if properly and promptly managed these complications can be avoided.

Iron is an essential micronutrient necessary for oxygen transport via haemoglobin in the red

blood cell and also intervenes in the constitution of enzymatic systems such as catalases, peroxydases and cytochromes that play an essential role in cellular respiratory mechanisms (Inocent *et al.*, 2008). Malaria is associated with both acute and chronic anaemia due increased destruction of parasitized red blood cells, immune-mediated red cell lysis, phagocytosis and splenic sequestration of the red blood cells (Autino *et al.*, 2012). The accelerated haemolysis of red cells due to malaria causes iron-deficiency anemia and it remains highly prevalent globally, particularly in areas of the world where malaria morbidity and mortality rates are high (Prentice *et al.*, 2007). The consequences of iron deficiency anaemia range from effects on energy metabolism and immune function to effects on cognitive and motor development (Walter, 1993). Some severe life-threatening complications such as acute renal failure and acute respiratory syndromes, acidosis, respiratory distress and jaundice are also associated with malaria (Idonije *et al.*, 2011). These complications are thought to be preceded by derangement in biochemical parameters which indicated renal involvement (urea and creatinine) and electrolyte imbalance (sodium, chloride, bicarbonate and potassium). A country-specific evidence shows that Nigeria has the largest population at risk of malaria in Africa (Alaba and Alaba, 2003). Malaria is responsible for 90% of reported cases of tropical disease in Nigeria (Alaba and Alaba, 2003), accounts for 50% out-patient consultation, responsible for 15% of hospital admission and also one of the top three causes of death in the country (World Health Organization, 2004). There is therefore, the need for research on the possible consequences on biochemical parameters with the hope of reducing the rate of morbidity and mortality within the Nigerian population.

Materials and Methods

The cross-sectional study was carried out among malaria patients attending the University of Maiduguri Teaching Hospital. The purpose and nature of the research was explained to each participant and written informed consent was obtained. Ethical approval was obtained from the ethical committee of the University of

Maiduguri Teaching Hospital. Two-hundred and sixty (260) participants were recruited for the study. One hundred and sixty (160) subjects were malaria infected while one-hundred (100) healthy non-parasitized subjects were included as a control. Patients with diabetes, hypertension, renal disorders, and pregnant women or on any medication were excluded. Subjects that decline to give consent were also excluded.

Collection of Blood Specimens

Five millimetres (5ml) of venous blood was collected from each volunteer using plain vacutainer bottle. The blood sample was allowed to clot, then dislodged and centrifuged at 1,500 revolutions per minute for 5 minutes at room temperature (20-24 °C) to obtain the serum. The serum was decanted into cryovial bottles and stored frozen until required for analysis. Biochemical analysis was done within 48 hours of serum collection.

Sample Analysis:

Giemsa- stained thick blood film was used to determine the presence malaria parasites as per the specifications described previously by Cheesebrough (2009). The levels of sodium and potassium, within the blood, were measured using the flame photometer method described by Jeffery *et al.* (1989). The levels of chloride, within the participants' blood, were determined using the titrimetric method described by Schales and Schales (1941), whereas back titration (Boone and Field, 1953) was used for bicarbonate level estimation. The levels of serum urea were estimated using the diacetyl monoxime method described by Wybenga *et al.* (1971). The creatinine levels were estimated using alkaline picrate method described by Jaffe (1886), and the serum iron levels were determined using the colorimetric method as described by Bauer and Fairbanks (1984).

Statistical Analysis

Statistical analysis was conducted using the PAW Statistic 18, a statistical analysis package from SPSS Inc, California, USA. The results were expressed as mean \pm standard deviation. The data was analysed using student's t-test. The level of significance was set at 95% confidence

interval, where a p-value less than or equal to 0.05 (≤ 0.05) was considered statistically significant.

Result

The subjects were divided into participants based on the level of parasitaemia; those positive for malaria parasites (+1), those positive for malaria (+2). A comparison of the mean values of serum iron, sodium, potassium, chloride, bicarbonate, urea and creatinine levels in malaria positive (+1) patients and controls (Table 1) showed that the mean values of serum sodium, chloride and iron in controls were significantly

higher ($p=0.04$, $p=0.03$) than malaria parasite positive (+1) participants. The mean values of urea and creatinine in control individuals were significantly lower ($p=0.00$) than the malaria parasite positive (+1) individuals. On the other hand, in malaria positive (+2) subjects the mean value of serum iron was significantly lower than the controls ($p=0.01$), whereas the values of urea and creatinine were significantly higher in malaria positive (+2) patients when compared to the control individuals ($p= 0.00$, $p= 0.01$) respectively (Table 2).

Table 1: Mean values of serum iron, sodium chloride, potassium, bicarbonate urea and creatinine in malaria positive (+1) patients and control subjects.

Parameters	Malaria Patients (+1) (N= 139)	Control Subjects (N= 100)	p-value
	Mean±SD	Mean±SD	
Iron ($\mu\text{mol/L}$)	10.47±4.87	15.87 ± 5.49	0.030
Na+ (mmol/L)	135.80 ±6.69	137.69±4.99	0.040
Cl- (mmol/L)	93.76±7.30	100.91±5.49	0.027
K+ (mmol/L)	3.78±0.61	3.87±0.58	0.739
HCO ₃ ⁻ (mmol/L)	22.35±1.84	22.13±1.95	0.992
Urea (mmol/L)	7.30±4.75	4.10±1.00	0.000
Creatinine ($\mu\text{mol/L}$)	130.00±53.46	74.00±18.53	0.000

Table 2: Mean values of serum iron, sodium chloride, potassium, bicarbonate urea and creatinine in malaria positive (+2) patients and control subjects.

Parameters	Malaria Patients (N= 21)	Control Subjects (N= 100)	p-value
	Mean±SD	Mean±SD	
Iron ($\mu\text{mol/L}$)	1.14±2.86	15.87 ± 5.49	0.004
Na+ (mmol/L)	136.80 ±5.96	137.69±4.99	0.436
Cl- (mmol/L)	98.76±7.30	100.91±5.49	0.272
K+ (mmol/L)	3.76±1.71	3.87±0.58	0.566
HCO ₃ ⁻ (mmol/L)	21.42±1.71	22.13±1.95	0.603
Urea (mmol/L)	7.90±4.85	4.10±1.09	0.000
Creatinine ($\mu\text{mol/L}$)	129.00±48.46	74.00±18.53	0.001

Discussion

Malaria is an infectious disease characterized by fatal complications when untreated/improperly treated. This study was carried out to assess the iron and biochemical parameters in patients infected with malaria in Maiduguri, North-Eastern Nigeria.

The results of this study indicated that the serum iron, sodium and chloride levels were lower in patients which tested positive for the malaria parasite (+1) when compared to healthy individuals (control). It was also noted that the serum iron levels were lower in malaria-infected patients (+2) when compared to patients who tested positive for the *Plasmodium falciparum* (+1). These results were similar to those obtained in studies previously conducted (Holy et al., 2015; Sangita, 2014; Sangita, 2014; Ikekpeazu et al., 2010 and Adeosun et al., 2006). It has previously been observed that a decrease in serum iron in malaria-infected individuals may be more pronounced in individual with other infections (Caulfield *et al.*, 2004). An electrolyte imbalance in the body may serve as an indicator of renal failure. This has previously been found among malaria-infected individuals by Kirk and Horner (1995). Malaria parasites induce the destruction of red blood cells, which contribute to the pathophysiology of the anaemia associated particularly with acute malaria (Wickramasinghe and Abdalla, 2000).

This study also showed that the levels of urea and creatinine were significantly higher in malaria infected individuals when compared to the healthy individuals. Our finding is consistent with previous reports (Shivakumar and Saisekhar, 2015; Akaninwor *et al.*, 2013; Godse, 2013). However, the findings of this study contradicted results previously obtained by Ogbadoyi and Gabi (2007), who reported that there were no significant changes in the levels of creatinine and urea, between the malaria infected subjects and healthy individuals.

The results from this study present lower levels of serum iron, sodium and chloride, and higher urea and creatinine levels in malaria-infected patients when compared with the healthy control subjects. These results indicate that malaria can

be associated with both renal impairment and anaemia, thus demonstrating the need to incorporate the measurement of biochemical parameters in the diagnosis and management of malaria control within the Nigerian population. Due to the fact that other unknown factors may also contribute to renal failure in malaria infections, more research is needed to ultimately avoid future malaria complications.

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