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Assessment of the Effect of Acute Malaria on Some Renal Function Parameters amongst Port Harcourt Residents, Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author OUA designed the study and wrote the first draft of the manuscript. Author BST performed the experimental, statistical analyses and managed the literature searches. Author MTP wrote the protocol. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To assess some kidney function parameters in Port Harcourt residents with varying malaria parasite densities.
Study Design: Observational study.
Place and Duration of Study: Rivers State University Teaching Hospital and Department of Medical Laboratory Science, Rivers State University, Port Harcourt, between September and December 2023.

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Methodology: The study population comprised of one hundred (100) individuals within the ages of 21-60 years randomly sampled within Port Harcourt metropolis. A total of seventy apparently (70) healthy subjects, which comprised of 32 males and 38 females who served as control and a total of thirty (30) malaria infected subjects, which comprised of 16 males and 14 females were sampled and served as test subjects. Data was obtained from subjects using a questionnaire to obtain consent and socio-demographic information. Blood samples were collected via venipuncture and analyzed for malaria using thick and thin blood films and also estimated for serum urea, creatinine and electrolytes (Sodium, Potassium, Chloride and Bicarbonate). Statistical analysis was done using GraphPad prism Version 10 for Windows and results were presented as mean ± STD and $p<0.05$ was considered statistically significant.

Results: There were more males with malaria in this study (n=17) than females (n=14) but was not statistically significant. Age group 21-30 years had more malaria cases (17 cases) compared to age groups 31-40 years (4 cases), 41-50 years (3 cases), 51-60 years (6 cases), but this was not statistically significant. Urea and creatinine levels were higher in malaria-infected (test) subjects, than the control group, but there was no significant difference statistically. Na+ and K+ levels were significantly decreased in test subjects than in the control subjects and were considered statistically significant. Cl- levels showed a decrease in test subjects when compared to the control and HCO3- levels showed an increase in test subjects when compared to the control but were also not statistically significant. Pearson's correlation analysis was also carried out on malaria-infected subjects and there were strong correlations between urea and creatinine (>0.5) but was not statistically significant. Na+ and K+ also revealed a weak correlation but were statistically significant.

Conclusion: The study showed that varying malaria parasite densities lead to an increase and decrease in some kidney function parameters and severe malaria can lead to hyponatremia and hypokalemia leading to renal impairment.

Keywords: Renal function; Port Harcourt residents; malaria parasite densities.

1. INTRODUCTION

Malaria is a parasitic infection caused by Plasmodium parasites, which are spread to people through the bites of an infected female Anopheles mosquito [1]. It is a life-threatening disease that causes a range of symptoms and complications. Early symptoms include fever, headache, and chills, usually appearing 10–15 days after the infective mosquito bite, malaria symptoms can also progress severely to kidney failure, seizures, mental confusion, coma and death within a period of 24 hours, so an early diagnosis is very crucial [1]. The disease is widespread in tropical and subtropical regions in a broad band around the equator, including much of Sub-saharan Africa, Asia and America [2]. Five species of plasmodium are known to infect and transmit malaria to humans which are *Plasmodium vivax, Plasmodium falciparum, Plasmodium malariae, Plasmodium knowlesi*, and *Plasmodium ovale.* Most deaths are caused by *P. falciparum* and *P. vivax*, while *P. ovale* and *P. malariae* cause a generally milder form of malaria that is rarely fatal [2]. Not all anopheles mosquitoes have malaria, but if they bite a person with malaria, they can become infectious. Once they bite another person, this continues the cycle of spreading malaria from mosquito to people [3].

An estimated 241 million cases of malaria were recorded globally with over 627,000 deaths and children under five years mostly vulnerable and accounting for 80% of the mortalities [4]. And this is exactly what makes the need for a potent and reliable vaccine non-negotiable. And over the years two malaria vaccines have been openly acknowledged by the World Health Organization (WHO) which are the RTS, S/AS01 developed by GlaxoSmithKline (GSK) and the R21/Matrix-M developed by the university of Oxford (Oxford, UK) other malaria vaccine candidates are in development or trial phases, including transmission blocking vaccines that target the sexual stage of parasite development in the mosquito, and mRNA vaccines against malaria. Despite the global and national strategies to eradicate malaria infection, malaria has continued to be a global threat, particularly to Nigeria and Africa at large. Few studies have reported that severe malaria affects the kidneys leading to acute kidney injury. Hence, there is need to investigate the varying effects that different levels of parasite densities have on some kidney parameters, using Port Harcourt as the study population where no definitive study on

its effect has been done. This research will tend to give more scientific backing on the effect that varying malaria parasite densities will have on some kidney function parameters. Malaria can be diagnosed through a rapid diagnostic blood test or through examination of a blood sample under a microscope. Treatment of acute malarial infection is based on the species of parasite, symptoms, and parasite resistance [5].

Severe malaria is known to affect various organs of the body causing acute respiratory distress syndrome (ARDS), multiple convulsions, prostration, shock, abnormal bleeding, jaundice, and acute kidney injury (AKI) [6]. Malaria is a global health concern and is a major cause of increased mortality and morbidity rates worldwide. Malaria parasites in humans tend to be associated with abnormalities of one or more peripheral organs, including the kidneys causing acute kidney injury (AKI). According to the latest world malaria report, there were 247 million cases of malaria in 2020. The estimated number of malaria deaths stood at 619,000 in 2021 compared to 625,000 in 2020 [7]. *P. falciparum* causes the most severe form of malaria and is responsible for most cases of AKI [8]. In some regions of the globe, including Nigeria, malaria is responsible for a significant part of patients admitted with AKI (more than 10% of cases) [9].

Kidney complications in Malaria mainly occur due to hemodynamic dysfunction and immune response. Liver complications leading to hepatomegaly, jaundice and hepatic dysfunction can also contribute to the occurrence of acute kidney injury [10]. It is also possible to find chronic kidney disease associated with malaria, mainly in patients suffering from repeated episodes of infection. Plasmodium antigens have already been detected in the glomeruli, suggesting a direct effect of the parasite in the kidney, which can trigger an inflammatory process leading to different types of glomerulonephritis. Clinical manifestations of kidney involvement in Malaria include proteinuria, microalbuminuria, urinary casts, reported in 20 to 50% of cases [11].

Malaria was the first parasitic infection to be clearly associated with glomerular diseases in tropical areas. Recent research has shown that severe malaria can cause disease in the glomeruli, tubules and in the interstitial regions. However, the relationship between malarial infection leading to acute kidney injury has not been fully understood, though there are several proposed mechanisms of its occurrence, which hemodynamic perturbations is one of them. This research seeks to clearly establish that at different malaria parasite densities present in the blood, electrolytes, urea, and creatinine levels in blood serum will be equally varied to indicate different levels of blood clearing and infection severity in the kidneys.

2. MATERIALS AND METHODS

2.1 Experimental Design

This is a cross-sectional study which is aimed at assessing some renal function parameters in Port Harcourt residents diagnosed with varying malaria parasite densities.

2.2 Study Area

The study was carried out in Port Harcourt, Port Harcourt is the capital of Rivers State, Nigeria. Port Harcourt is located at latitude 475°N and longitude 700°E and lies along Bonny River in the Niger Delta with a population of 1,148,665. The different areas of Port Harcourt the study was carried out in include Rivers State University, Agip, Borokiri, Diobu, Ada George, and Choba.

2.3 Study Population

The study population comprised of one hundred (100) individuals randomly sampled. A total of 30 malaria parasitized subjects and 70 malaria non-parasitized subjects, with varying age, location, and gender in different areas of Port Harcourt. The sample collection method used was standard venipuncture technique. Only subjects who did not have kidney disease or other disease conditions that could affect the measured parameters, were included via a questionnaire.

2.4 Eligibility Criteria

2.4.1 Inclusion criteria

Individuals who have not been on malaria medication prior to sample collection were enrolled in the study. Individuals who do not have kidney complications were included in the study. Individuals willing to provide consent were included in the study.

2.4.2 Exclusion criteria

Subjects who have malaria but have been on one or more antimalarial medications. Individuals

with acute and chronic kidney complications were also excluded from the study. Individuals who did not consent to enroll in this study were also excluded Individuals with organ dysfunction were excluded from the study.

2.5 Sample Collection

Standard venipuncture technique was used to collect 5ml of blood from each participant into Ethylene diamine tetra-acetic acid (EDTA) and Lithium Heparin bottles for hematological and chemical analysis. Each blood sample was properly mixed with the anticoagulant to avoid clotting and ensure homogeneity before the analysis. Samples for chemical analysis were spun using a centrifuge at 3000RPM for 5 minutes. The plasma was collected into plain bottles for analysis of electrolytes, urea and creatinine. Samples were promptly analyzed for malaria parasite, creatinine, urea and electrolytes levels.

2.6 Laboratory Analysis

The serum biochemistry determinations were done using commercial test kits; Spectrum test kits and UV spectrophotometer were used. The instrument was calibrated before use, commercial quality control samples and other quality control measures such as non-use of lysed samples were also observed in the analysis.

2.6.1 Estimation of serum urea concentration

Method: Urease- Colorimetric method [12].

Principle: Urea is hydrolyzed in the presence of water and urease to produce ammonia and carbon dioxide.

$$\text{Urea} + H_2O \xrightarrow{\text{urease}} 2NH_3 + CO_2$$

The free ammonia in an alkaline pH and in the presence of an indicator forms a coloured complex proportional to the urea concentration in the sample.

2.6.2 Estimation of serum creatinine concentration

Method: Buffered kinetic Jaffè reaction without deproteinization [13].

Principle: Creatinine reacts with picric acid under alkaline conditions to form a yellow red coloured complex. The absorbance of the colour produced, measured at a wavelength of 492nm, is directly proportional to the creatinine concentration in the sample.

Creatinine + Picrate Alkaline pH yellow-red complex

2.6.3 Estimation of electrolytes

Method: Ion Selective Electrode (ISE AC 9000)

Principle: Ion Selective Electrode is an electrochemical sensor. It can transfer the change of ionic activity in solution into the change of electrode potential. There is a linear relationship between the logarithm of ionic activity in solution and electrode potential. In a kind of electrolytic solution, the most salts exist in the form of ions. The electro-switching reaction occurs between selective electrode and the relative ion. The potential of ion selective electrode changes as the ionic concentration in sample changes but the potential of reference electrode is always constant thus forming a potential difference between the ion selective electrode and reference electrode. The potential difference was measured, and the corresponding ion concentration can be calculated using the Nernst equation. This analyzer measures potassium (K), sodium (Na), chloride (Cl), calcium (Ca), pH, bicarbonate (HCO_3), and ionic gap.

2.6.4 Identification of malaria parasite

2.6.4.1 Thick blood film preparation

A thick blood film was prepared by placing a drop of blood on a clean grease-free glass slide and stained with Giemsa statin. The stained film was examined microscopically using a light microscope with oil immersion objective (100x).

2.6.4.2 Thin blood film preparation

Thick and thin blood films were prepared by placing a drop of blood on a clean grease-free glass slide and stained with Giemsa statin. The stained films were examined microscopically using a light microscope with oil immersion objective (100x). Using oil immersion objective, the number of parasites in the area covered were equally counted. The procedure was repeated three (3) times, and the average count was taken.

Parasite Density was calculated using the formula.

Results
+ -mild infection
++ - severe infection

2.8 Statistical Analysis

All statistical analysis was performed using GraphPad prism version 10 for Windows. The results were expressed as mean± standard deviation, the difference in parameters across the groups were investigated using a one-way analysis of variance (ANOVA) followed by Tukey's multiple comparison. P<0.05 were considered significant while the difference in the two groups was analyzed using T-test (p<0.05) and Pearson correlation analysis.

3. RESULTS AND DISCUSSION

Table 1. Demographic characteristics of study participants

Characteristics	Infected (test)	Non-infected (control)
No of Participants (N=100)	30	70
Gender		
Male	16	32
Female	14	38
Age Group		
21-30	17	44
31-40	4	10
41-50	3	10
51-60	6	6

Table 2. Comparison of some kidney function parameters in malaria patients and healthy control

Parameters	Control	Test	P-value	Remarks
Urea (mmol/l)	5.46±2.042	5.58±2.104	0.78	NS
Creatinine (mg/dl)	1.18±0.3310	1.24±0.3311	0.3832	NS
Na(mmol/l)	140.3±4.460	136.6±4.556	0.0003	S
K(mmol/l)	3.82±0.3689	3.52±0.3143	0.0003	S
Cl(mmol/l)	107.9±4.744	106.5±5.614	0.2034	NS
HCO3 (mmol/l)	25.91±3.23	26.50±2.71	0.3875	NS

Key:
NS – non-significant
S – Significant
Na- Sodium, K- Potassium, Cl- Chloride, HCO3- Bicarbonate

Table 3. Comparison of some kidney function parameters in patients with varying malaria parasite densities

Parameters	Control	One plus (+)	Two plus (++)	F-value	P-value	Remark
Urea(mmol/l)	5.46±2.042	5.42±2.659	6.39±2.382	0.4981	0.6092	NS
Creatinine (mg/dl)	1.18±0.3310	1.23±0.3292	1.30±0.3737	0.4718	0.6253	NS
Na (mmol/L)	140.3±4.460a	137.3±4.191ab	1.33±5.413a	8.78	0.0003	S
K (mmol/L)	3.82±0.3689a	3.55±0.3140ab	3.40±0.3162a	7.558	0.0003	S
Cl (mmol/L)	107.9±4.744	106.4±5.932	107.4±4.037	0.901	0.409	NS
HCO3 (mmol/L)	25.91±3.23	26.16±2.71	28.20±2.16	1.294	0.278	NS

Key:
NS – Non-significant
S – Significant

Table 4. Effect of gender on some kidney function parameters

Parameters	Female	Male	P-value	Remark
Urea(mmol/l)	5.786±2.070	5.189±2.006	0.14 64	NS
Creatinine (mg/dl)	1.219±0.3254	1.179±0.3385	0.5454	NS
Na (mmol/L)	139.2±4.877	139.3±4.715	0.9475	NS
K (mmol/L)	3.736±0.4098	3.729±0.3416	0.9329	NS
Cl (mmol/L)	108.0±4.609	107.0±5.450	0.2877	NS
HCO3 (mmol/L)	26.19±3.40	25.98±2.73	0.7321	NS

Key:
NS- Non-significant
S- Significant

Table 5. Effect of age ranges on some kidney function parameters

Parameters	21-30years	31-40years	41-50years	51-60years	F-value	P-value	Rmrk
Urea (mg/dL)	5.74±1.999	5.35±2.143	4.58±1.894	5.40±2.317	1.188	0.317	NS
Cr (mmol/L)	1.24±0.3361	1.12±0.2469	1.23±0.3742	1.04±0.3109	1.586	0.1979	NS
Na (mmol/L)	138.7±4.889	140.7±4.428	139.3±4.385	139.8±5.114	0.7299	0.5366	NS
K (mmol/L)	3.69±0.3941	3.89±0.3521	3.83±0.3015	3.617±0.3407	1.808	0.1509	NS
Cl (mmol/L)	108.4±4.950	105.4±5.585	107.5±3.755	105.6±5.336	2.038	0.4593	NS
HCO3(mmol/L)	26.21±3.115	25.71±3.667	25.38±2.599	26.67±2.902	0.4593	0.7114	NS

Key:
NS- Non-significant
S- Significant

Table 6. Comparison of some kidney function parameters in malaria patients and healthy control subjects based on age range (21-30 years)

Parameters	Control	Test	P-value	Remark
Urea(mmol/l)	5.67±1.995	5.92±2 .060	0.6692	NS
Creatinine (mg/dl)	1.21±0.3326	1.31±0.3454	0.3227	NS
Na (mmol/L)	139.8±4.598	136.0±4.641	0.005	S
K (mmol/L)	3.77±0.4044	3.48±0. 2777	0.0081	S
Cl (mmol/L)	108.6±4 .481	107.7±6.104	0.518	NS
HCO3 (mmol/L)	25.86±3.27	27.12± 2.52	0.1604	NS

Key:
NS- Non-significant
S- Significant

Table 7. Comparison of some kidney function parameters in malaria patients and healthy control subjects based on age range (31-40 years)

Parameters	Control	Test	P-value	Remark
Urea(mmol/l)	5.22±2.172	5.69±2.352	0.7276	NS
Creatinine (mg/dl)	1.06±0.2614	1.28±0.1143	0.1373	NS
Na (mmol/L)	142.0±4.163	137.5±3. 697	0.085	NS
K (mmol/L)	3.97±0.3130	3.70±0.4163	0.205	NS
Cl (mmol/L)	106.3±5.755	103.3±5 .188	0.3769	NS
HCO3 (mmol/L)	26.20±3.67	24.50±3.87	0.4555	NS

Key:
NS- Non significant
S- Significant

Table 8. Comparison of some kidney function parameters in malaria patients and healthy control subjects based on age range (41-50 years)

Parameters	Control	Test	P-value	Remark
Urea(mmol/l)	5.032±1.947	3.110±0.4423	0.1275	NS
Creatinine (mg/dl)	1.230±0.4305	1.233±0.08083	0.9899	NS
Na (mmol/L)	139.7±4.692	138.0±3.606	0.5787	NS
K (mmol/L)	3.850±0.3171	3.800±0.3000	0.8133	NS
Cl (mmol/L)	108.0±3.859	106.0± 3.606	0.4425	NS
HCO3 (mmol/L)	25.50±2.953	25.00±1.000	0.7841	NS

Key:
NS- Non significant
S- Significant

Table 9. Comparison of some kidney function parameters in malaria patients and healthy control subjects based on age range (51-60years)

Parameters	Control	Test	P-value	Remark
Urea(mmol/l)	4.997±2.619	5.805±2.136	0.5709	NS
Creatinine (mg/dl)	1.045±0.1947	1.035±0.4179	0.9587	NS
Na (mmol/L)	142.3±2.875	137.3±5.854	0.0898	NS
K (mmol/L)	3.833±0.2251	3.400 ±0.3033	0.0185	S
Cl (mmol/L)	105.5±5.891	105.7±5.284	0.9559	NS
HCO3 (mmol/L)	26.50±3.39	26.83±2.63	0.8531	NS

Key:
NS- Non-significant
S- Significant

Table 10. Correlation of Age vs Parameters (Urea, Creatinine and Electrolytes) in malaria-infected subjects

	Urea	Cr	K^+	Na^+	Cl^-	$HCO3^-$
r^2	-0.193	-0.301	0.063	0.193	-0.097	-0.205
P-value	0.305	0.105	0.738	0.306	0.609	0.276
Remark	NS	NS	NS	NS	NS	NS

3.1 Discussion

Malaria is a common parasitic disease of tropical and subtropical regions of the world. Approximately 500 million individuals become the victim of malaria each year [14]. Among these, infections resulting from *P. falciparum*, if left untreated, might cause kidney and brain complications and even death [14]. This study was carried out to assess some kidney function parameters in Port Harcourt residents with varying malaria parasite densities. A total of one hundred (100) subjects were enrolled in the study, 70 healthy individuals as control and thirty (30) malaria confirmed patients, as test subjects.

This study revealed that malaria parasite infection occurred more among males (16) than females (14), as seen in Table 1, this is like the findings of a study by Obi et al. [15], who reported a higher rate of malaria infection among males (32.2%) than females (25.6%). Report from study by Etusim et al. [16], revealed similar findings. However, a study conducted by Sakzabre et al. [17] reported contrary findings with women having higher rate of malaria infection as compared to their male counterparts (69.07% and 30.93%) respectively. While a study by Adedapo et al. [18] reported that both males and females are at equal risks of infection with malaria parasite except for pregnant women who were found to be at a higher risk. This disparity with other findings could be due to differences in population group, sample size, geographical location, and species of the parasite. The gender variations with regards to outcome of this study could be due the working environment difference of the males compared to the females. Most males are more exposed to tedious work environments than the females.

Prevalence of malaria infection was found to be higher among age group 21-30 years (17) compared to age groups 31-40years (4), 41-50 years (3), 51-60 years (6) as seen in Table 1. The high malaria infection rate in this age group (21-30 years) could be due to the stress condition and hyperactivity of this age group as they are more active in outdoor activities. A study in Enugu Nigeria, also reported similar findings within the age group (21-30 years) having higher prevalence of malaria and lower in age range (0-11 years).

Urea and Creatinine serve as important biomarkers in the assay of renal function. This study in Table 2 revealed an increase in urea and creatinine levels in test subjects compared to control subjects, although this was not statistically significant. The increase in urea and creatinine levels in malaria-infected (Test) subjects could be due to dehydration because of fever from the malaria parasite infection and because of parasite sequestration into the renal microvasculature. A study by Onyeneke et al. [19] reported significant decrease in urea levels in mild and moderate parasitemia compared to the control subjects. On the other hand, serum creatinine levels decreased in mild parasitemia but increased significantly in moderate and severe parasitemia [19].

Electrolytes play a vital role in the acid-base balance and normal functioning of the body. This study also demonstrated significant decrease in sodium and potassium levels in test subjects compared to the control subjects ($p<0.05$). Hyponatremia and hypokalemia have been identified as common outcomes of malaria due to increased vasopressin (ADH) secretion which is a key factor in the reduced level of sodium in malaria as stated in a study by Ikekpeazu et al. [20] and Ndaka et al. [21] who also reported similar findings in malaria infected subjects. However, Maitland et al. [22] reported no change in the level of sodium (Na+) and potassium (K+) in malaria infected subjects as compared to healthy individuals, although this research was carried out in children. *P. falciparum* infected individuals were frequently observed with hypokalemia and hyponatremia compared to other species in infected individuals as suggested by Jasani et al. [23]. Chloride (Cl-) and bicarbonate (HCO3-) levels showed varied increase and decrease in mean ± STD for test and control subjects and there were no significant differences between them. This could be because of the effect of the different age ranges in the study.

The results obtained in Table 3 showed no statistical significance in serum urea and creatinine levels in subjects infected with one plus (+) malaria, two plus (++) malaria and in the control group when compared statistically using Tukey's multiple comparison test. There was a decrease ($P>0.05$) in the level of urea and creatinine in subjects affected with one plus (+) malaria when compared to the control and an increase in urea and creatinine levels in subjects infected with two plus (++) malaria when compared to the mild infection (+). Although this was not statistically significant, low levels of creatinine and urea in the group with one plus malaria suggests that the severity of malaria has an influence on the level of urea and creatinine in the infected subjects. The observed increase in urea and creatinine levels in the group with two plus (++) malaria could be because of sequestration of the parasite into the renal microvasculature bed which may lead to ischemia. However, a study by Onyeneke et al. [19] reported a significant decrease in urea levels in mild and moderate parasitemia compared to the control subjects. On the other hand, creatinine levels decreased in mild parasitemia but increased significantly in moderate and severe parasitemia. Na+ and K+ levels showed significant decrease in subjects with one plus (+) malaria and two plus (++) malaria when compared to the control group. Results from Tukey's multiple comparison test in Na+ and K+ showed significant difference ($p<0.05$) in the mean ± SD of subjects with one plus (+) malaria compared to the control but there was no statistical significance between one plus and two plus (++) infected subjects. This indicates that the level of kidney dysfunction maybe determined by the severity of malaria infection in the infected individuals. It has been reported that there was a significant increase in K+ levels in malaria infected individuals compared to their control. There was no statistical significance in Cl- levels in subjects with one plus (+) malaria when compared with the control and subjects with two plus (++) malaria. There was a decrease in mean of Cl- in malaria infected subjects compared to the control leading to hypochloremia, although this was not statistically significant. This would be because of loss of Cl- in sweat due to severity of malaria parasite infection. A study by Baloch et al. [24] also reported similar findings in malaria infected subjects. HCO3 levels showed no statistical significance when compared in control, one plus (+) and two plus (++) malaria infected subjects. Results showed an increase in HCO3 levels in one plus malaria and two plus malarias compared to the control, although there was no significant difference statistically, ($p=0.2788$) this could be due to electrolyte imbalance caused by the severity of the malaria infection. It has been reported that there was a significant decrease in HCO3- levels in groups with severe malaria infection when compared with the mild group. This shows that the level of kidney dysfunction may be determined by the severity of malaria infection in the infected subjects.

Effect of gender on some kidney function parameters as shown in Table 4 revealed no statistical significance. Although there was an increase in all kidney function parameters analyzed in female subjects compared to males, there was no significant difference between them. This could be because of sex hormones on the kidneys.

Table 5 also revealed effects of different age groups on some kidney function parameters. This study revealed a decrease in urea and creatinine levels in age groups (31-40 years), (41-50 years), and (51-60 years) when compared to age groups (21-30 years) which had higher values. Although, Tukey's multiple comparison test revealed that there was no significant

difference between them. This would be because of varying malaria parasite densities and lifestyle changes in the different age groups. The increase in sodium and potassium levels across age groups would be due to increasing age associated with increasing susceptibility to be effects of dietary sodium and potassium on blood pressure: the ability of the kidneys to excrete a salt load decreases with age. Cl- and HCO3 levels also revealed no statistical difference with age groups.

Comparison of some kidney function parameters in malaria patients and healthy control subjects based on age range (21-30 years) in Table 6, showed an increase in urea and creatinine levels in test subjects compared to their control, although this was not considered statistically significant. Na+ and K+ levels showed significant decrease in mean ± SD of test subjects compared to their control, this indicates hyponatremia and hypokalemia in malaria-infected subjects in age group (21-30 years), this would be due to sweating elicited by malaria infection due to fever and urinary loss and may account for the decrease in the levels of electrolytes [25]. Cl- and HCO3 levels showed no significant difference between test and control subjects within this age group. This could be due to parasite density and number of infected subjects in this age group.

Comparing the kidney function parameters in test and control subjects in age group (31-40 years) in Table 6, revealed slight increase in urea and creatinine levels in test subjects compared to their control. Na+ and K+ levels revealed a decrease in test subjects compared to the control group. This is because of renal impairment due to malaria infection, reduction in Na+ and K+ levels in the blood leads to an increase in Cl-and HCO3 concentration resulting to metabolic alkalosis and hyperchloremic acidosis. There was no statistical significance in all parameters, this could be due to the population size of infected subjects within this age group.

Comparison of some kidney function parameters in malaria patients in control and test subjects in age range (41-50 years) in Table 8, also showed no statistical significance in urea, creatinine Na+, K+, Cl-, and HCO3- levels analyzed. This could also be due to Population size, and severity of infection in subjects in this age group.

Results from Table 9 showed an increase in urea and creatinine levels in test subjects compared to their control, however, this was not statistically significant (p=0.5709 and p=0.958 respectively). This could be because of the effect of parasite density on the kidneys. Na+ level also revealed a decrease in test subjects compared to their control, but there was no significant difference between test subjects and control. K+ revealed a significant decrease in test subjects compared to their control, increased excretion of K+ from the kidney and excess vomiting in *P. falciparum* malaria infection maybe a cause of hypokalemia. Severe hypokalemia suggests severity of P. falciparum malaria infection. Yoek [11] reported similar findings of hypokalemia in children. Cl- and HCO3 also revealed no statistical significance in test and control subjects.

Results from Table 10 showed Pearson's correlation analysis carried out in malaria Infected subjects (N=30) showed no strong correlation for any kidney function parameter analysed. Urea and creatinine levels showed weak negative correlations indicating that as age increases, urea and creatinine decreases with (p=0.305 and p=0.105). K+ and Na+ levels showed weak positive correlation, however there were no significant difference statistically. Cl-and HCO3 also revealed weak negative correlations and there was no significant difference statistically(p>0.05).

4. CONCLUSION

In conclusion, malaria infection has impacted significant changes in some renal function parameters because of the varying parasite densities. The degree of impact on these parameters depends on the severity of the parasitemia and the use of these kidney parameters can be helpful for monitoring the extent of infection and providing appropriate solution to the affected patients during treatment and management. This incidence being higher in males and in age group 21-30 years causes hyponatremia and hypokalemia and is common in malaria and they are associated with severe malaria. Hyponatremia and hypokalemia are common in malaria, and they are associated with the severe forms of malaria than with non-severe malaria. Correction of the electrolyte imbalance in severe cases is of great significance in the management of the patients.

ETHICAL APPROVAL AND CONSENT

Written consent was obtained from each participant before the samples were collected

upon issuance of ethical clearance from the Department of Medical Laboratory Science, Rivers State University.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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