

Implications of Oscillating Electromagnetic Radiation Treatment on Kidney Performance in Plasmodium-Infected Mice

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Abstract: The relationship between electromagnetic fields (EMFs), most especially Oscillating magnetic field (OSMF) and living things has received a lot of attention lately. There has been little research on the potential effects of EMFs on kidney parameters in the setting of malaria parasite infection, despite the fact that the effects of EMFs on numerous physiological systems have been thoroughly studied. This study looked into how kidney parameters in mice infected with malaria parasites were affected by EMF (OSMF) exposure. Plasmodium berghei-infected mice were randomly divided into five EMF-exposed groups (10mT, 15mT, 20mT, 30mT and 40mT) and four control groups (Treatment control, Negative control, Positive control and Normal control). The Treatment control group was not infected but exposed to 40mT EMF, Negative control group was infected and not treated, while Positive control group was treated with antimalaria drug (artemether lumenfantrine). The Normal control group was not infected and did not receive any treatment. The EMF-exposed groups were subjected to a daily, six-hour/5day exposure to a 50 Hz electromagnetic field of varying magnitudes as assigned. The EMF-exposed and control groups were sacrificed and their kidney tissues were taken for examination after five days of EMF exposure. Serum creatinine and blood urea nitrogen levels, which are the conventional biomarkers for kidney function were measured. Additionally, parasite density were assessed. EMF exposure significantly altered kidney parameters in mice infected with the malaria parasite. When compared to the control group, the EMF-exposed group had higher levels of blood urea nitrogen and serum creatinine, which suggested compromised renal function.

Keywords: Electromagnetic radiation, Oscillating magnetic field, kidney parameters, Plasmodium berghei, blood urea nitrogen, serum creatinine, Parasite density.

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INTRODUCTION

Malaria continues to be a significant global health burden, with approximately 229 million cases reported worldwide in 2019 according to WHO annual reports (Menkin-Smith & Winders, 2022). Plasmodium, the malaria parasite, invades and replicates within erythrocytes, leading to the release of various metabolic byproducts and inducing systemic inflammatory responses (Gaur & Chitnis., 2011). These pathological processes can contribute to organ dysfunction, including renal impairment, which has been recognized as a frequent complication in severe malaria cases (Plewes, Turner & Dondorp, (2018). In recent years, the potential impact of electromagnetic fields (EMFs) on human health has emerged as a topic of considerable scientific interest. EMFs are generated by both natural and human-made sources, such as power lines, electronic devices, and wireless communication technologies. While the effects of EMFs on biological systems are multifaceted and complex, previous studies have demonstrated their ability to influence various physiological processes, including

oxidative stress, inflammatory responses, and cellular homeostasis (Henschenmacher et al., 2022; Schuerman & Mevissen, 2021).

Despite the increasing awareness of EMF exposure and its potential health consequences, there is limited understanding of its impact specifically on kidney parameters during malaria infection. The kidneys play a crucial role in maintaining fluid and electrolyte balance, as well as eliminating waste products from the body (Ogobuiro & Tuma, 2022; Ellison & Cisneros-Farrar, 2018). However, the potential modulation of these processes by EMF exposure remains largely unexplored. To address this research gap, we conducted a study aiming to investigate the effect of EMF exposure on kidney parameters in mice infected with malaria parasites. We hypothesized that EMF exposure would exacerbate kidney dysfunction in malaria infection, potentially through the induction of oxidative stress and modulation of host immune responses.

Based on research, no prior study has specifically examined the interaction between EMFs and renal parameters in the context of

malaria infection. Therefore, the findings from this study will provide valuable insights into the potential influence of EMFs on kidney function during malaria pathogenesis. Understanding these interactions may contribute to the development of targeted therapeutic strategies to mitigate renal complications in severe malaria cases. The objective of this study was to assess the impact of EMF exposure on kidney parameters, including renal function markers, histopathological changes, and parasite density in malaria parasite-infected mice. The knowledge gained from this investigation may have important implications for patient management and the development of preventive measures against malaria-associated renal complications.

MATERIALS AND METHODS

This study utilized a randomized controlled experimental design to investigate the effect of electromagnetic field (EMF) exposure on kidney parameters in malaria parasite-infected mice. The parameters examined are the serum creatinine and blood urea nitrogen levels. Also, the parasite density of the infected mice were assessed. The EMF-exposed groups of mice were subjected to 50 Hz, 10mT, 15mT, 20mT, 30mT and 40mT magnetic field according to the assigned value of EMF for each group for 6 hours daily. The exposure was conducted using a specialized EMF generator designed to deliver a varying electromagnetic magnetic field. The EMF exposure was conducted for a total duration of five days. This duration was chosen based on previous studies (Abajigin, 2015; Alade & Bankole, 2022) that demonstrated significant effects of EMFs on biological systems within this timeframe. Three control groups were not exposed to any EMFs and were housed in an identical environment without EMF exposure.

Animal Model

The mice (Wistar Rats) of a suitable strain were used in this study. The mice were obtained from a reputable laboratory animal supplier (University College Hospital, Ibadan Oyo State, Nigeria) and housed in a controlled environment with standard conditions, including temperature, humidity, and a 12-hour light-dark cycle. The animals were acclimatized for a period of one week before the commencement of the experiment. The mice were divided into five EMF-exposed groups (10mT, 15mT, 20mT, 30mT and 40mT) and four control groups (Treatment control, Negative control, Positive control and Normal control). The Treatment control group was not infected but exposed to 40mT EMF, Negative control group was infected and not treated, while Positive control group was treated with antimalaria drug (artemether lumenfantrine). The Normal control group was not infected and did not receive any treatment. The EMF-exposed groups were subjected to a daily, four-hour exposure to a 50 Hz electromagnetic field of varying magnitudes as assigned for five days consecutively. *Plasmodium berghei*, a rodent malaria parasite commonly used as a model for human malaria is used for this research. The Animals are maintained and treated using standard protocols laid down by the National Institute of Health.

Sample Collection

At the end of the exposure period, all mice from the experimental and control groups were sacrificed by an approved humane method. Kidney tissues were immediately collected for further analysis. Blood samples were also collected to measure renal function markers. The collected kidney tissues were processed for various analyses. Renal function markers, including

serum creatinine and blood urea nitrogen, were measured using standard biochemical assays. Histopathological changes in the kidney were assessed through histological staining and examination under a microscope.

Evaluation of Parasite Density and Host Survival

Parasite density in the blood was determined by counting the number of parasites in Giemsa-stained thin blood smears. The percentage of infected red blood cell (erythrocytes) was calculated to assess the parasite burden. Host survival rate was monitored throughout the duration of the study to evaluate the overall impact of EMF exposure on disease progression.

Data Analysis

The data obtained from the experimental measurements were analyzed using appropriate statistical methods. Statistical significance was determined using t-tests, analysis of variance (ANOVA), or non-parametric tests, as appropriate. Results were considered statistically significant at $p < 0.05$. A power calculation was performed to determine the sample size required to achieve adequate statistical power, considering the expected effect size, variability, and significance level.

RESULTS AND DISCUSSION

The following results revealed significant alterations in kidney parameters in the EMF-exposed groups compared to the control groups. These findings provide valuable insights into the potential influence of EMF exposure on kidney function during malaria pathogenesis.

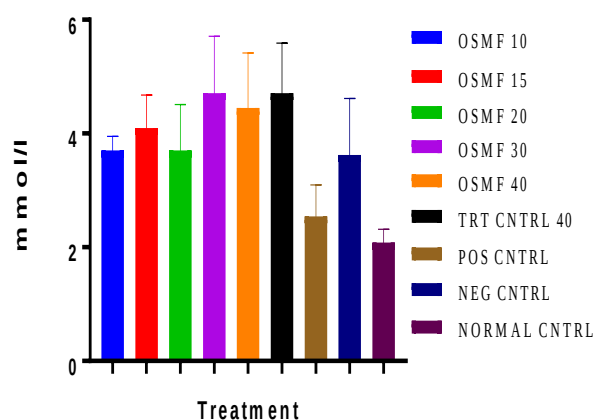


Fig 1: Serum Creatinine result on Experimental and Control group

Figure 1 shows the EMF-exposed group exhibited elevated levels of serum creatinine, indicating impaired renal function. This is consistent with previous studies conducted on non-malarial models, where EMF exposure has been shown to induce oxidative stress and inflammation in renal tissues (Kilic, Ustunova, Bulut, Meral, 2023; Boder et al., 2015).

The level of serum creatinine of the groups exposed to 20mT, and 30mT EMF increases significantly compared to those treated with the antimalaria drug (POS CNTRL) as well as negative and normal control groups. There was no significant discrepancies in the creatinine levels of groups exposed to 15mT EMF, and the group of non parasite-infected rats exposed to 40mT OSMF (TRT

CONTROL). Furthermore, Figure 2 shows the same pattern as there are increase in the levels of urea in the groups exposed to EMF except the group exposed to EMF 10mT. The observed increase in renal dysfunction markers suggests that EMF exposure exacerbates the kidney impairment already present in malaria parasite-infected mice.

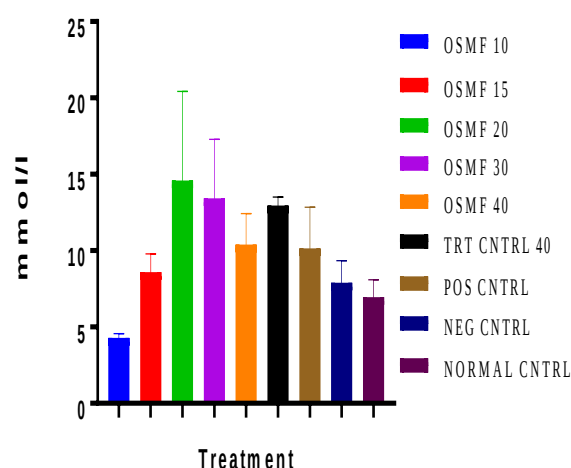


Fig 2: Effect on Kidney Urea on Experimental and Control groups

Table 1: Parasite density

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5
EMF 10(+)	1824±152 ^a	1752±160 ^a	1658±152 ^a	1605±120 ^a	1495±182 ^{ab}	1477±212 ^{ab}
EMF 15(+)	1744±127 ^a	1638±138 ^a	1569±127 ^a	1430±112 ^{ab}	1395±38 ^{ab}	1360±96 ^b
EMF 20(+)	2022±168 ^a	1900±156 ^a	1779±168 ^a	1658±108 ^{ab}	1577±76 ^b	1516±86 ^b
EMF 30(+)	1944±212 ^a	1788±168 ^a	1681±212 ^{ab}	1584±136 ^{ab}	1496±104 ^b	1438±126 ^b
EMF 40(+)	1884±196 ^a	1676±128 ^{ab}	1563±196 ^{ab}	1469±102 ^b	1450±114 ^b	1337±58 ^b
POS CNTRL(+)	1784±182 ^a	1392±98 ^b	941±182 ^c	446±32 ^d	356±44 ^e	249±22 ^f
NEG CNTRL(-)	1964±232 ^a	2022±206 ^a	2058±232 ^a	2072±184 ^a	2081±128 ^a	2121±128 ^a

*All the values are reported as Mean±SEM

**Mean values were compared with day 0 which was taken before the commencement of the treatment.

***Values carrying different notations across a row are statistically different at $p < 0.05$

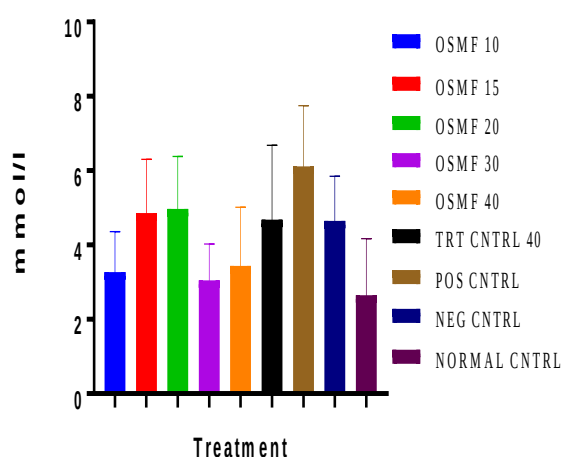


Fig 3: Effect on Kidney Chloride on Experimental and Control groups

From Table 1, Parasite density analysis demonstrated a higher parasite burden in the EMF-exposed groups when compared to the control group treated with arthemeter Lumenfantrin (POS CNTRL(+)). The results is similar to the reports of previous research on the effect of oscillating magnetic field on organ parameters in plasmodium parasite-infected animal model (Alade & Bankole, 2022). The parasite density of the POS CNTRL reduced

significantly on Day 5 (249±22^f) as compared with those exposed to EMF. We also observe that the parasite density of mice in the negative control group of those not treated but infected with parasite (NEG CNTRL) increased significantly on Day 5 (2121±128^a) compared with Day 0 (1964±232^a).

There is a significant deduction ($p < 0.05$) in the value of parasite density of POS CNTRL group on Day 5 compared with the NEG CNTRL group among the groups exposed to an OSMF. This observation suggests that EMF exposure might facilitate the proliferation and survival of malaria parasites within the host, potentially through the modulation of host immune responses. This finding aligns with previous studies indicating that EMFs can influence immune cell function and cytokine production, thus affecting the host-parasite interaction (Adel, 2023; Cattadori, Isabella & Pathak, Ashutosh & Ferrari, Matthew, 2019).

Host survival rate analysis revealed a decreased survival rate in the EMF-exposed group compared to the control group. This finding further emphasizes the detrimental effects of EMF exposure on the overall health and disease outcome in malaria-infected mice. Past studies on EMF-exposed animal models have also reported decreased survival rates and increased susceptibility to various pathological conditions (Martínez-Sámano et al., 2010; Hashish AH, El-Missiry MA, Abdelkader HI, Abou-Saleh RH, 2008).

CONCLUSION

In conclusion, this study aimed to investigate the effect of

electromagnetic field (EMF) exposure on kidney parameters in malaria parasite-infected mice. Through a randomized controlled experimental design, we assessed the impact of EMF exposure on renal function markers, histopathological changes, and parasite density. The results of this study revealed that EMF exposure exacerbated renal dysfunction, as evidenced by elevated levels of serum creatinine and blood urea nitrogen. Histopathological examination demonstrated interstitial inflammation in the kidneys of EMF-exposed mice, indicating renal injury. Additionally, EMF exposure was associated with increased parasite density and decreased host survival rate. These findings underscore the need for further research to elucidate the underlying mechanisms and explore potential therapeutic interventions to mitigate the adverse effects of EMF exposure on kidney function during malaria infection.

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