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THE EFFECTS OF OSCILLATING ELECTROMAGNETIC RADIATION ON KIDNEY FUNCTION IN PLASMODIUM-INFECTED MICE

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Abstract

The interaction of electromagnetic fields (EMFs), particularly the oscillating magnetic field (OSMF), and living things has recently received a lot of attention. Despite the fact that the effects of EMFs on numerous physiological systems have been thoroughly studied, there has been little research on the potential effects of EMFs on kidney parameters in the context of malaria parasite infection. This study looked at how EMF (OSMF) exposure affected kidney parameters in mice infected with malaria parasites. Mice infected with Plasmodium berghei 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 was exposed to 40mT EMF, while the Negative control group was infected and exposed to 40mT EMF, The negative control group was infected but not treated, whereas the positive control group received antimalarial treatment (arthemether lumenfantrine). The Normal control group was not infected and was not treated. The EMF-exposed groups were exposed to a 50 Hz electromagnetic field of varying magnitudes for six hours per day for five days. After five days of EMF exposure, the EMF-exposed and control groups were sacrificed, and their kidney tissues were collected for analysis. The conventional biomarkers for kidney function, serum creatinine and blood urea nitrogen, were measured. In addition, parasite density was determined. In mice infected with the malaria parasite, results show that EMF exposure significantly altered kidney parameters. The EMF-exposed group had higher levels of blood urea nitrogen than the control groups.

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

Introduction

According to WHO annual reports, malaria continues to be a significant global health burden, with approximately 229 million cases reported worldwide in 2019 (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, this study examines the interaction between electromagnetic fields (EMFs) and renal parameters in malaria infection, providing insights into their potential influence on kidney function. The findings may help develop targeted therapeutic strategies to mitigate renal complications in severe cases.

MATERIALS AND METHODS

This study utilized a controlled experimental EMF 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 (arthemether 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

All mice from the experimental and control groups were sacrificed using a humane technique at the conclusion of the exposure period. Tissues from the kidney were immediately collected for additional examination. Additionally, blood samples were taken to assess markers of renal function. The gathered kidney tissues were prepared for a number of tests. Using common biochemical assays, renal function markers such as serum creatinine and blood urea nitrogen were measured. Through histological staining and microscopy, histopathological changes in the kidney were evaluated.

Evaluation of Parasite Density and Host Survival

Giemsa-stained thin blood smears were examined for the number of parasites to determine the parasite density in the blood. To determine the parasite burden, the percentage of infected red blood cells (erythrocytes) was calculated. The study's host survival rate was tracked throughout in order to assess the overall effect of EMF exposure on the development of the disease.

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.

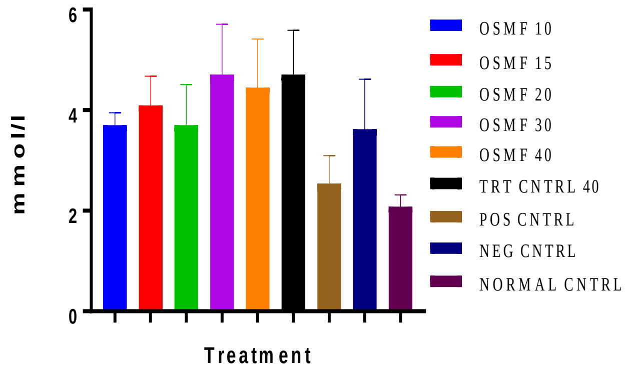

Fig 1: Serum Creatinine result on Experimental and Control group

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; Bodera et al., 2015).

The level of serum creatnine 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 creatnine 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.

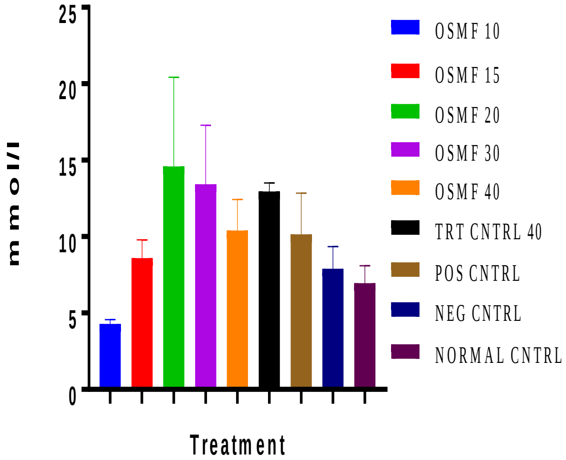

Fig 2: Effect on Kidney Urea on Experimental and Control groups

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

From Figure 3, hyperchloremia examination of kidney tissues from the EMF-exposed group revealed notable alterations compared to the control group. Increased chloride in the experimental groups exposed to EMF could point to kidney problems, such as renal tubular acidosis. These changes are consistent with previous reports on EMF-induced renal damage in other animal models (Hasan et al., 2021; Schuermann & Mevssen, 2021; Borzoueisileh, 2020).

Moreover, the severity of the histopathological alterations correlated with the duration and intensity of EMF exposure.

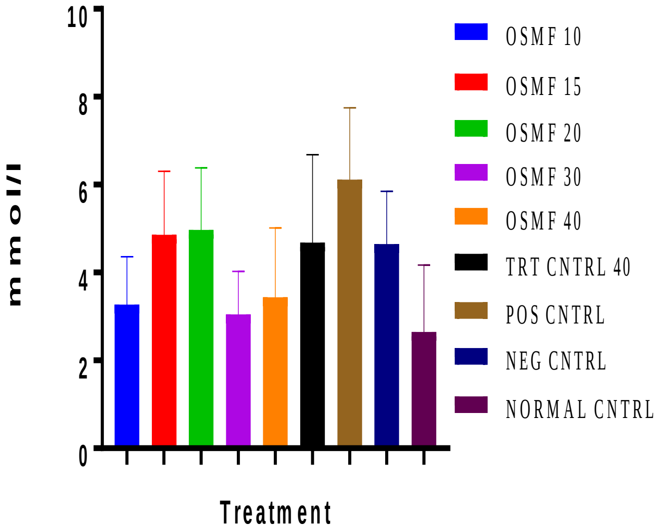

Fig 3: Effect on Kidney Chloride on Experimental and Control groups

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 CNRL(+)). 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

Finally, the purpose of this study was to look into the effect of electromagnetic field (EMF) exposure on kidney parameters in malaria parasite-infected mice. We investigated the effect of EMF exposure on renal function markers, histopathological changes, and parasite density using a randomized controlled experimental design. This study found that EMF exposure exacerbated renal dysfunction, as evidenced by elevated serum creatinine and blood urea nitrogen levels. Histopathological examination of the kidneys of EMF-exposed mice revealed interstitial inflammation, indicating renal injury. Furthermore, EMF exposure was linked to increased parasite density and a lower host survival rate.These findings highlight the need for additional research to elucidate the underlying mechanisms and investigate potential therapeutic interventions to mitigate the negative effects of EMF exposure on kidney function during malaria.

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