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Biochemical and histopathological effects of mobile phone radiation on the liver of Swiss albino mice

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SUMMARY

The electromagnetic radiation from the mobile phone is a subject of recent study because of the enormous increase in mobile phone use throughout the world. The objective of this experiment was therefore to investigate the biochemical and histopathological effects of mobile phone radiation on male Swiss albino mice's liver. Male mice were categorized into three groups in this research: control group (A), exposed group for 40 minutes (B) and exposed group for 60 minutes (C). Experimental groups were exposed to radiation per day for 60 days from 4G connected mobile phones. The control group received no radiation. At the end of the radiation exposure, biochemical (alanine transaminase (ALT) and aspartate transaminase (AST)) and histological tests were performed. The results indicated that there was significant ($P<0.05$) increase in mean values of ALT and AST in both radiation-exposed groups of mice if compared to the control group. Histopathologically marked infiltration of mononuclear cellular aggregates were present surrounding the bile duct and hepatic artery in the liver of 60-minute-exposure group, whereas in 40-minute-exposure group congestion was observed in the portal vein and the central vein of the liver. The findings revealed and evidenced that mobile phone radiation has harmful effects on enzyme activity and liver tissue.

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INTRODUCTION

Mobile phones are one of the most important innovations, and an increasing number of smartphone users raise interest in the impact on living organisms of the electromagnetic fields (EMF) (Bortkiewicz, 2001). The extension of mobile phone use throughout the world has made susceptibility to electromagnetic field radiation (EMR) omnipresent in modern society (Feychting et al., 2005). In Bangladesh, the total population is of 160 million, and total number of mobile users is 157,544,000 (BTRC, 2014). Mobile phones are becoming popular about 91 percent among younger generations worldwide (Rainie, 2013). Mobile phones have completely changed the way of life and are an important part of daily life. With the increased use of mobile phones, their potential effects on human health have become more important (Kumar et al., 2013; Balci et al., 2007).

Human exposure to the electromagnetic radiation of mobile phones damages cell walls, particularly red blood cell walls, and induces imbalance among blood enzymes (Alghamdi, 2012; Hasan et al., 2014). EMR may be absorbed by various organs of the body, in particular the liver and kidneys, depending on the places where mobile phones are carried (Topali et al., 2015). Reddy (2017) studied that the levels of Aspartate aminotransferase and Alanine aminotransferase were enhanced significantly due to alterations of these enzymes, which

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evidenced that EMR induces detrimental alterations in hepatic tissues. Creatinine and blood urea nitrogen increased significantly, which indicates that kidneys absorb the mobile radiation and alters the levels of urea and creatinine. Hanafi et al. (2012) reported that liver tissue in-group of infant animals exposed for one month to EMR represented many hepatocytes with vacuolated cytoplasm and altered nuclear structure, as well as lymphomonocytes infiltrations around the portal vein. To our knowledge, there is no research work that has been done on the effects of mobile phone radiations using mice model in Bangladesh. It is tough to continue experimental exploration on human beings, and hence the Swiss albino mice were chosen as the experimental research model for this empirical study. Considering the above facts, the present study was structured to observe the biochemical and histopathological impacts of mobile phone radiation on the liver in Swiss albino mice, as this may mimic to human.

MATERIALS AND METHODS

The study was carried out during the period from July to December 2019 in the Department of Anatomy and Histology at Bangladesh Agricultural University (BAU), Mym-ensingh. The following methods were implemented for experimenting.

Animals, management and experimental plan

For this study, male Swiss albino mice were purchased from the Department of Pharmacy, Jahangirnagar University, Dhaka. The mice were six weeks of age and weighed about 25-30 g at the time of collection. The mice were housed in a group and kept in a galvanized iron sheet roof in cages (2×1 sq. ft.) All the mice seemed to have good health and had no visible deformities. Experimental protocols were approved by the Animal Welfare and Ethical Committee on Laboratory Animal Use, Faculty of Veterinary Science, Bangladesh Agricultural University. After 1-week acclimatization, the mice were randomly divided into three equivalent groups: each group contained seven mice (n=7) and the groups were A, B and C. Among the three groups, Group (A) was considered as control, fed on mice pellet and fresh drinking water, whereas Group (B) was exposed to 40 minutes of radiation per day, and Group (C) was exposed to 60 minutes of radiation per day.

Mobile phone radiation exposure

A conversational commercially available cellular mobile phone with Global System for Mobile Communication (2100 Mhz) digital technology was used for radiation exposure. Before exposure to radiation, an electromagnetic radiation detector was used to measure the frequency of electromagnetic radiation (EMR) emitted from mobile phones in an interactive call the 1900-2200 MHz frequency. The EMR was produced by two 4G mobile phones (Huawei GR5 2017). One cell phone was placed in the middle of the cage. A call was made from another mobile phone and it was assured that the cell phone on the inside of the cage was powered on. The mobile phone was kept in the loudspeaker mode, during the whole time of EMR exposure. Experimental groups were exposed the phone calls daily for two months (from 10.00 AM to 11.00 AM). The control group of mice was maintained under similar conditions without radiation exposure.

Biochemical analysis

After ending of the experimental period, each mouse was euthanized by using chloroform before 2 ml of blood were taken in a 5 ml disposable syringe by cardiac puncture for measurement of biochemical analysis such as alanine transaminase (ALT) and aspartate transaminase (AST). Then the blood was put in the glass test tube and fixed in a slanting situation at room temperature for two hours; then glass test tubes were incubated overnight in the refrigerator at 4°C. Serum from the samples was detached and centrifuged at 3000 rpm. Serum samples were kept at -20°C for biochemical study. ALT and AST were measured by using a spectrophotometer.

Histopathology

After blood collection, the liver tissues were collected for the gross and histological study from the control group and radiation-exposed groups of mice. After gross observation, samples were preserved in 10% formaldehyde solution for proper fixation. Then the samples were processed for histopathological study. The paraformaldehyde-fixed tissue sample was processed and stained with H&E staining protocol as per the standard method. The histological study was carried out by using a light microscope Olympus BX 51 to best demonstrate the result.

Statistical analysis

All the collected data were stored in Microsoft Excel 2016 and imported to the software Graph Pad Prism 7 for analysis. All the research data were conferred as mean ± standard error, and variation among the groups of mice were compared applying one-way ANOVA followed by Tukey's multiple comparison test. The variation was expressed statistically significant when the p values were less than 0.05.

RESULTS

Biochemical study

The results of mobile phone radiation on various biochemical parameters such as alanine transaminase (ALT) and aspartate transaminase (AST) in different groups of mice were presented in Figs. 1-

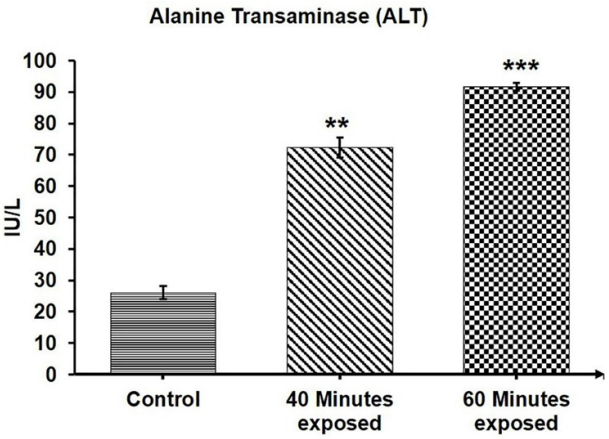

Fig 1. Effects of mobile phone radiations on Alanine Transaminase (ALT) in different groups of mice. Values were given as mean ± SE. ** = Significant at 5% ($p< 0.05$) level of probability. *** = Significant at 1% ($p< 0.001$) level of probability.

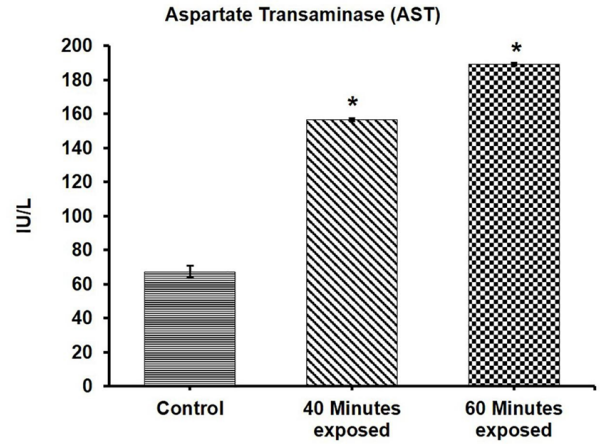

Fig 2. Effects of mobile phone radiations on Aspartate Transaminase (AST) in different groups of mice. Values were given as mean ± SE. * = Significant at 5% ($p< 0.05$) level of probability.

2, and the values of all data are summarized in Table 1. There was a significant increase in ALT ($p<0.001$) and AST ($p<0.05$) in 60-minute-exposure group (C) compared to the 40-minute-exposure group (B) and control group (A) of mice.

Histopathological study

In the control group (A) of mice, the liver was found normal histological architecture. In 40 minutes, (B) and 60 minutes (C) exposed groups of mice congestion was found in the portal vein (PV) and central vein (CV) of the liver. Enlargement of the central vein and portal vein (PV) was observed in these groups of mice compared to the control group of mice. In 60 minutes, the radiation-exposed group (C) of mice showed marked mononuclear cellular infiltration surrounding the bile duct and hepatic artery as well as dilatation of sinusoids (Fig. 3).

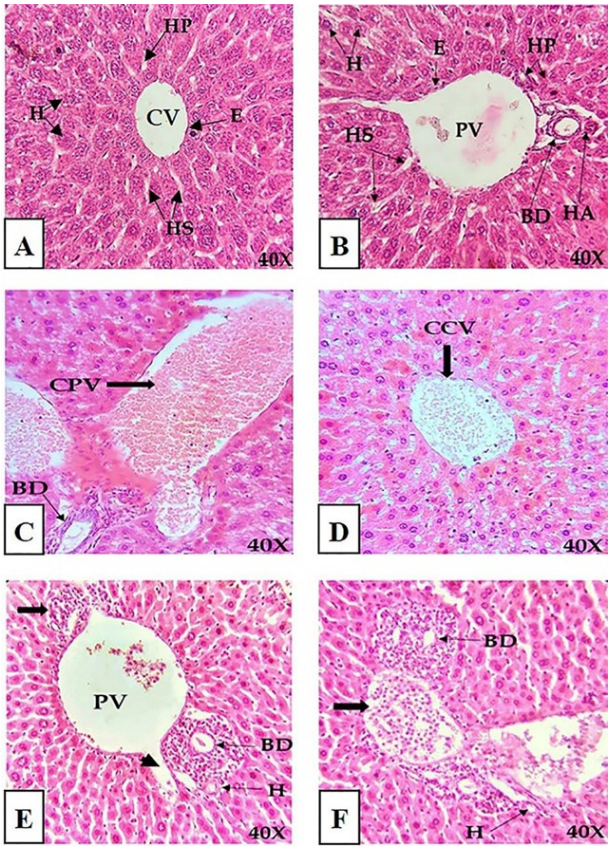

Fig 3. Histopathological observation of the liver of control (**A-B)** group, 40 minutes exposed group (**C-D**) and 60 minute-exposure-group (**E-F**) of mice in H&E stain (40X). In the liver of the control group of mice normal histological appearance was observed (A-B). Congestion (black arrow) was found in the portal vein (PV) and central vein (CV) of the liver of 40-minute- exposure group of mice (C-D). There was dilation of the portal vein (arrowhead marked) also mononuclear cellular infiltration (black arrow) surrounding the bile duct and hepatic artery was found in the liver of the 60-minute-exposure group of mice (E-F). CV= Central Vein, PV= Portal Vein, BD= Bile Duct, HA= Hepatic Artery, HS= Hepatic Sinusoids, H= Hepatocytes, E= Endothelial cell, HP= Hepatic Plates, CCV= Congested Central Vein, CPV= Congested Portal Vein.

Table 1. Effects of mobile phone radiation on biochemical parameters in different groups of mice. Mean ± SD of serum levels of ALT, AST

Groups	Group A (Control)	Group B (40 minutes exposed)	Group C (60 minutes exposed)
Mean ± SD of ALT (U/L)	26.06±2.01	72.26±3.24**	91.69±1.12***
Mean ± SD of AST (U/L)	67.08±3.50	156.50±0.83*	189.18±0.68*

significant at 5% P ***<0.001 **<0.01 *<0.05 compared to control

DISCUSSION

In the present investigation, alanine transaminase (ALT) and aspartate transaminase (AST) were significantly increased in 60-minutes-exposure group, followed by 40-minute-exposure group of mice. The significant increase in levels of transaminase indicates the EMR induced influence on hepatocytes, and led to apoptosis, necrosis and cell damages. Boris et al. (2010), Abdol et al. (2013), Sharma et al. (2017) and Lahijani et al. (2009) had also documented similar findings in their experiments. The elevation of serums AST and ALT in response to EMR were agreed by the Eid et al. (2015) study, which found that ALT and AST in serum and hepatic tissue, and oxidative stresses (MDA & H2O2) increases in liver followed exposure to mobile radiation in male rats.

Regarding the histopathological changes, the result of the present investigation showed that congestion was found in the portal vein and central vein of 40- and 60-minute-exposure groups of mice. Enlargement of the central vein and portal vein was observed in these groups of mice in comparison to the control group of mice. In the 60-minute group, the radiation-exposure mice showed marked mononuclear cellular infiltration surrounding the bile duct and hepatic artery. The histological investigation indicated that there is a direct relationship between the EMR irradiation period and the degree of the pathological alterations. The present finding in 60-minute-exposure group was partially similar to the study of Aberumand et al. (2016), who observed structural changes such as condensation nuclei in some cells, irregular cell arrangement, infiltration of inflammatory cells, swelling and fatty changes of hepatocytes, and granulation of cytoplasm in the exposed group of animals. The present findings were in agreement with the results of the previous research conducted by Meo et al. (2019), who reported that infiltration of inflammatory cells in the portal tract was found in the liver and pancreas in Wistar albino rats caused by mobile phone radiation exposure.

Conclusion

Based on the findings of this experiment, it could be assumed that the alanine transaminase (ALT) and aspartate transaminase (AST) values were increased in the mice groups exposed to 40 and 60 minutes compared to the control group. Increased levels of ALT and AST are the key biomarkers of liver damage, and we find their manifestation in the histopathology analysis. The present study may be considered as an experimental base for relevant human studies. The result of this research work will undoubtedly help future researchers to have a guideline in carrying out further detail study on mobile phone radiation.

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