REAL-TIME MEASUREMENT OF BRAIN MICROCIRCULATION DURING RF-EMF EXPOSURE USING AN “8”-SHAPED LOOP ANTENNA.

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ABSTRACT

Aim of present study was to investigate whether radio frequency electromagnetic field (RF-EMF) exposure induces reversible effects on brain microcirculation observable only during exposure. Using our developed ‘‘8’’-shaped loop

*This study was financially supported by The Committee to Promote Resarch on the Possible Biological Effects of Electromagnetic Fields, Ministry of Internal Affairs and Communications, Japan.

antenna, we exposed rat equipped with a cranial window to RF-EMF at 2W/kg of averaged SAR of target area just under the window. Three microcirculatory parameters, BBB permeability, vessel diameter and plasma velocity showed no significant differences between sham and RF-EMF exposed rats even during exposure period. These results reveal no reversible effects of RF-EMF exposure, at least not on these three parameters in rat brain microcirculation, under these conditions.

INTRODUCTION

Few studies have directly observed brain microcirculation during exposure to radio frequency electromagnetic fields (RF-EMF). Our previous study showed no effects of RF-EMF exposure on blood-brain barrier (BBB), plasma velocity or vessel diameter, as microcirculatory parameters in rat brain using a cranial window method[1]. However, the changes in these parameters were measured just after RF-EMF exposure, but not during exposure. To simultaneously perform measurements of rat brain microcirculation and RF-EMF exposure to a local cerebral region just under the cranial window, we developed a new type of antenna, ‘‘8’’-shaped loop antenna[2]. Aim of the present study was to investigate whether RF-EMF exposure induces reversible effects on brain microcirculation observable only during RF-EMF radiation.

MATERIAL AND METHODS

INTRAVITAL MICROSCOPY

Twenty male Sprague-Dawley rats (456±7 g) were used. The rats were divided into two groups: RF group was exposed to RF-EMF and Sham group was not exposed to any RF-EMF. All rats were subjected to cranial window implantation and intravital-microscopic observation under pentobarbital anesthesia with a cocktail of ketamine and xylazine. The pial microcirculation within cranial windows was observed using a fluorescent microscope equipped with an ICCD camera. In order to measure the microcirculatory parameters, several types of fluorescent dyes were administered via the tail vein.

RF-EMF EXPOSURE

Rat heads were locally exposed to 1,439MHz electromagnetic near-field TDMA (time division multiple access) signal for PDC (Personal Digital Cellular, Japanese cellular telephone standard) systems by an ‘‘8’’-shaped loop antenna placed 4 mm over the cranial window. RF-EMF exposure was maintained at a brain averaged SAR (2.0W/kg).

EXPERIMENTAL PROTOCOL

During 80 min experimental period including 50 min RF-EMF exposure, three microcirculatory parameters in pial venules, BBB-function, plasma velocity and vessel diameter were measured every 10 min, and the results were compared between RF and Sham group. At the end of experiments, we fixed the rat brains with 4% paraphormaldehyde

and examined albumin leakage using immunohistochemistry. The statistical analysis was performed by Student's *t*-test or ANOVA.

RESULTS

AVERAGED SAR OF TARGET AREA

Fig. 1 shows SAR distribution of rat phantom model at 1 W of input power into the 8-shaped loop antenna. The SAR distribution was localized at a parietal region of brain. When a averaged SAR of target area just under the cranial window was 2.0 W/kg, the whole brain and whole body averaged SARs were 0.37 and 0.02 W/kg, respectively.

MICROSCOPIC OBSERVATION DURING RF EXPOSURE

Using an intravital fluorescence microscopy and an 8-shaped loop antenna enable us to directly observed rat pial microcirculation and exposed RF-EMF to rat, simultaneously (Fig. 2). Plasma image flowing in microvessels of the pia mater was visualized by FITC-Dx injected into vein.

BBB PERMEABILITY

Blood-brain barrier (BBB) permeability was evaluated by extravasation of FITC-dextran of 70,000 molecules injected into a rat venule. Although fluorescence intensity of pia mater area decreased through an experimental period, there were no significant differences of the fluorescence intensity between sham and RF-EMF exposed grouped.

VESSEL DIAMETER

Vessel diameters of sixteen different venules in each rat were measured every 10 min and were indicated as a percent diameter of initial value. No significant differences of the percent diameter were recognized between two groups.

PLASMA VELOCITY

Velocities of plasma flowing in pial venules were measured by a dual-slit method and indicated as a percent velocity of initial value. No significant differences of the percent velocity were showed until the end of experiment.

HISTOLOGY

To confirm whether serum albumin was accumulated in parietal region of rat brain, we observed an albumin leakage in rat brain section using an immunohistochemistry. No positive stain was recognized in two groups.

DISCUSSION AND CONCLUSION

Our developed new type of loop antenna, an ‘‘8’’-shamped loop antenna succeeded to concentrate SAR distribution into the target area just under the cranial window. This was convenience to evaluate dynamic changes in microcirculatory

parameters in the target area during RF-EMF exposure. In present experiment, we focused on three microcirculatory parameters, BBB permeability, vessel diameter and plasma velocity. However, no significant differences of these parameters were recognized between sham and exposed group even in during exposure period. Therefore, these results suggest no effects of RF-EMF exposure, at least not on three parameters in rat brain microcirculation, under these conditions.

REFERENCES

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Fig. 1 SAR distribution

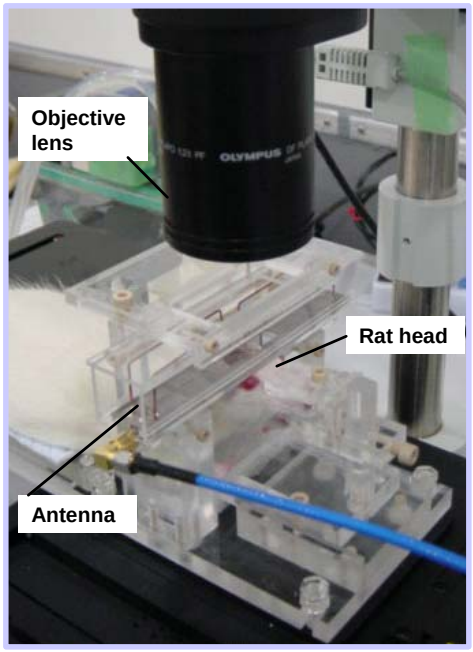

Fig. 2 RF-exposure and observation system