Evaluation of Biological Effects of Intermediate Frequency Magnetic Field − Reproductive and Developmental Toxicity in Rats and Genotoxicity in Mammalian Cell Line −

Background

Biological studies to evaluate the effects of the intermediate frequency magnetic field exposures are needed because of lack of such studies for the assessment on potential health risks. Our previous studies revealed that intermediate frequency magnetic field exposure did not affect the chick embryogenesis and micronucleus formation in mammalian cells.

Objectives

This study aims to determine whether or not a 20 kHz, magnetic field exposure has embryotoxic, fetotoxic and/or teratogenic potential. Another aim is to determine chromosomal aberration or point mutation *1 potentials of 2 kHz, 20 kHz or 60 kHz magnetic fields by mouse lymphoma assay.

Principal Results

1. Embryotoxic, fetotoxic and/or teratogenic effects in rats

A 20 kHz, 0.2 mT (rms) sinusoidal magnetic field (32-fold greater than ICNIRP guidelines *2 for the general public) was either exposed or sham-exposed to a group of 25 pregnant Crl:CD (SD) rats from gestation day 7 to day 17 for 22hr/d. Experiments were conducted in a blind fashion. Identical experiments were repeated twice to confirm the reproducibility of outcome. No reproducible changes related to magnetic field exposure were found in the body weight gain, clinical signs, hematology, blood biochemistry and gross pathology of dams. Number of implants, number of postimplantation loss, number and body weight of live fetuses, sex ratio and incidence of low body weight fetuses also did not significantly differ between sham-exposed (control) and magnetic field exposed groups. No significant changes were found in the incidence of external, skeletal and visceral malformations in the exposed fetuses.

Under the present experimental conditions, a 20 kHz sinusoidal, 0.2 mT (rms) magnetic field exposure during organogenesis was neither embryo/fetotoxic nor teratogenic and did not interfere with the fetal development in the rat.

2. Evaluation of genotoxic effects by mouse lymphoma assay

A mouse lymphoma cell line, L5178Y $tk^{+/-}$ -3.7.2c, was chosen to estimate the effects of the magnetic field exposure on direct genotoxixity and DNA damage repair caused by methylmethane sulfonate (MMS). The cells were exposed to magnetic fields of 0.91mTrms (146 times greater than ICNIRP guideline *2) at 2kHz, 1.1mTrms (176 times) at 20kHz and 0.11mTrms (18 times) at 60kHz, for 24h at 37℃ in 5% carbon dioxide. In statistical analysis, neither significant nor reproducible difference was found between the mutation frequencies for all magnetic field exposure conditions (Table 2). To examine the effects on DNA damage, the cells were exposed to each magnetic field with MMS which potentiates mutation. In statistical analysis, neither significant nor reproducible difference was found between the mutation frequencies for all magnetic field exposure conditions (Table 2).

These results indicated that the intermediate frequency magnetic fields used in this study did not induce point mutation and chromosomal aberration, and did not affect DNA damaged by MMS or DNA damage repair system in mammalian cells.

Future Developments

Magnetic field will be exposed from premating to preimplantation period to examine the toxicity in reproduction and male fertility in the rats. Estimation of the effect of the intermediate frequency magnetic fields by transformation tests, chromosomal aberration test of global gene expression tests will be performed.

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Reference

I. Nishimura, et.al., 2008, “Reproductive and developmental toxicity of intermediate frequency magnetic field exposure, - Effects of 20 kHz, 0.2 mT, sinusoidal magnetic field exposure on the rat organogenesis”, CRIEPI Report V07003 (in Japanese)
S. Nakasono, et.al., 2008, “Evaluation of genotoxicity of intermediate frequency magnetic fields by mouse lymphoma assay”, CRIEPI Report V07005 (in Japanese)

*1 : A type of mutation that causes the replacement of a single base nucleotide with another nucleotide of the genetic material, DNA.
*2 : Magnetic field exposure limits for the public (6.25 μT, from 0.8 to 150 kHz) were set by The International Commission on Non-ionizing Radiation Protection (ICNIRP). The value includes 50 times reduction factor based on nerve stimulation phenomena.

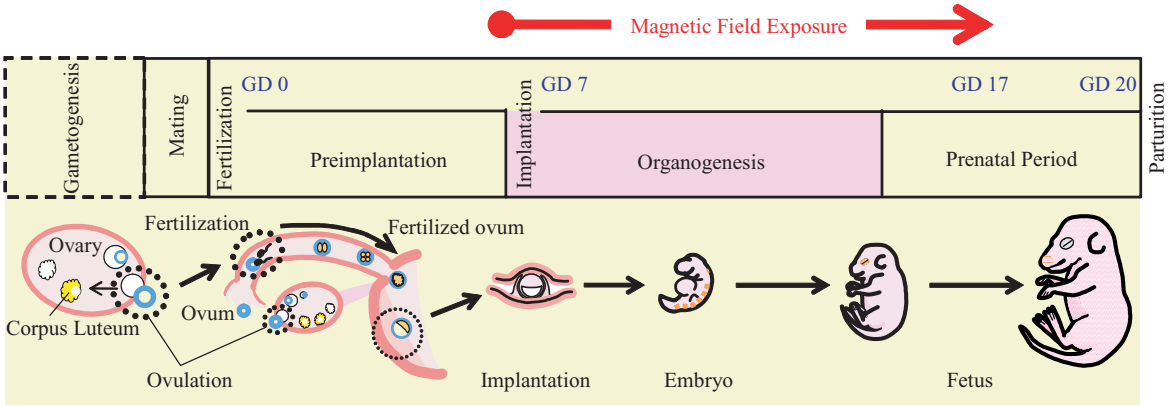

Fig.1 Time Course of Fetal Development in the Rat

Table 1 Effects of 20 kHz, 0.20 mT(rms) Magnetic Field Exposure during Rat Organogenesis

Endpoint	Experiment 1		Experiment 2	
	Control	Exposed	Control	Exposed
Number (no.) of examined dams: ED	25	25	25	25
Total no. of examined fetuses	368	349	349	345
No. of fetuses per dam	14.7±1.2 [a]	14.0±1.6	14.0±1.5	13.8±1.8
No. of dams with dead embryos and fetuses／ED	7／25	8／25	9／25	7／25
% of dead embryos and fetuses per dam	2.3±4.0 [a]	2.8±4.5	2.7±3.9	1.9±3.1
No. of dams with low body weight fetuses [b]／ED	1／25	1／25	1／25	0／25
No. of dams with externally malformed fetuses／ED	0／25	2／25	1／25	0／25
No. of dams with viscerally malformed fetuses／ED	1／25	4／25	3／25	1／25
No. of dams with skeletally malformed fetuses／ED	0／25	1／25	0／25	0／25

a) mean ±SD; b) no more than 2.5 g

No reproductive and developmental endpoints showed statistically significant changes due to 20 kHz magnetic field exposures

Table 2 Effect of 2 kHz, 20 kHz or 60 kHz Magnetic Field on Genotoxicity in Mouse Lymphoma Assay

Mutagen	Endpoints (Mutation Frequency)	Exposure Conditions			
		Sham [a]	2kHz, 0.91mT	20kHz, 1.1mT	60kHz, 0.11mT
	Number of Tests	6 times [b]	5 times	5 times	5 times
-	Point Mutation	0	1(↑)[c]	0	0
	Chromosomal Aberration	1(↑)	0	0	0
	Total Mutation [d] 0		0	0	1(↓)
+	Point Mutation	2(↓↓)	0	0	0
	Chromosomal Aberration	0	0	0	0
	Total Mutation [d] 0		0	0	0

a) Non-energized exposure condition to confirm the equivalence between control and exposure systems.
b) Six flasks were used for each test (three for control and another three for exposure).
c) The number shows a number of significant changes. The arrow shows a direction of the change.
d) Sum of point mutation and chromosomal aberration

These results indicated that the intermediate frequency magnetic fields used in this study did not induce point mutation and chromosomal aberration, and did not affect DNA damaged by MMS or DNA damage repair system in mammalian cells.