Thymus Mast Cell Numbers Following Perinatal and Adult Exposures to Low Intensity 0.5 Hz Magnetic Fields*

by

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ABSTRACT. — In a factorial design, 40 male 200-day-old rats that had been exposed from 2.5 days before to 2.5 days after birth to either 0.5 Hz rotating magnetic fields (RMFs) between $10^{-3}$T to $10^{-6}$T or to sham fields and maintained after weaning in one of two typical caging conditions were exposed as adults to either one of three 0.5 Hz RMF intensities ($10^{-6}$T, $10^{-7}$T or $10^{-8}$T) or to sham fields or to colony room control conditions. The numbers of mast cells (MCs/mm²) were determined for thymus tissues stained with thionin and toluidine blue. Thymuses from adult rats that had been perinatally exposed to the RMF displayed a marginally significant 20% to 35% elevation in MC numbers relative to sham-field controls. However, the adult exposures did not significantly affect the MC numbers. The two postweaning caging conditions, a non-magnetic field comparator variable, induced a significant 35% difference in MC numbers. The absence of significant perinatal by adult RMF exposure interactions indicated that early magnetic field exposure did not alter adult thymus responsivity to weaker but more natural intensity levels.

INTRODUCTION

The thymus seems to be the principal source of mast cells (MCs) in the rat body (Csaba, 1972). These cells contain histamine, heparin, serotonin, proteinpolysaccharides and basic protein and have been implicated strongly in allergic reactions, localized occurrences of edemas and erythema (Mikolajczyk, 1963) and the induction of “restless” motor activity. Intense thymic masticytopoiesis can be induced in the rat by stimuli like pregnancy, X-rays, tumorous conditions, colchicine administration and cortisone injections (Csaba, 1972). Simple administration of 2 mA of galvanic current for 4.5 min can induce significant elevations of thymic mast cells within 24 h (Csaba, Horvath and Horvath, 1961). These data suggest that mast cell numbers in rat thymus may be a sensitive measure of weak environmental stimuli such as low intensity, extremely low frequency electromagnetic fields.

Experiments by Persinger, Carrey and Lafrenière (1978) have demonstrated that significant reductions in thymus weights occur in adult rats following perinatal exposure to 0.5 Hz rotating magnetic fields (RMF). Although we have not found significant thymus weight changes in rats exposed as adults to these fields, other experimenters

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have reported ELF associated alterations in thymic-related immunological reactions (see Persinger, 1974). The present study was designed to answer three specific questions: (1) Do 5-day exposures of adult rats to variation intensities ($10^{-6}T$ to $<10^{-9}T$) similar to natural sources alter thymic MC numbers? (2) Do perinatal 0.5 Hz RMF exposure produce long term alterations in thymic MC numbers and (3) Do perinatal exposures to RMFs at intensities known to alter thymus weights alter this organ’s MC population during adulthood to lower, more natural exposure intensities?

The existence of any statistically significant effect associated with low level magnetic field exposures must be evaluated carefully with regards to its absolute magnitude and practical relevance. The former problem can be alleviated somewhat by incorporating other, non-magnetic variables known to influence rat physiology/behavior, into the experimental design. Consequently, in a factorial design, we selected 5 adult conditions (4 field intensities and 1 colony control), 2 perinatal magnetic field conditions and 2 postweaning caging conditions to determine the responsiveness of thymic MC numbers.

METHOD

SUBJECTS. — Forty (40), 180 to 210 day old naive male albino Wistar rats selected from 18 litters that had been exposed perinatally for 5 days to either: $10^{-3}T$, $10^{-4}T$, or $5 \times 10^{-6}T$ variation 0.5 Hz rotating magnetic fields (RMF) or to one of three sham-field conditions, were used as subjects. Their parents had been obtained from Bio-Breeding Laboratories of Canada, Limited.

PROCEDURE. — In 6 separate exposure periods, a total of 18 pregnant 90- to 120-day-old females were exposed to one of three separate 0.5 Hz RMF variation intensity areas: $10^{-3}T$, $10^{-4}T$, or $5 \times 10^{-6}T$ or to one of three sham fields which involved the same areas used in the RMF sequences only the magnets had been removed (see Persinger, Lafreriè and Ossenkopp, 1974 for diagram of apparatus). All females were exposed in single 28 x 18 x 12 cm plastic cages to the experimental room, for either the RMF or sham-field conditions, on day 19 of gestation, (about 2.5 days before birth). Within 24 h of birth, the litters were reduced to 8 pups. The following experimental room parameters existed: (1) continuous and indirect lighting from overhead fluorescent lamps, 45 $\pm$ 5 lx at floor of cages; (2) masking sound from continuous operating motor, 70 db; and (3) (thermostat controlled ambient temperature) $24.5 \pm 0.2°C$, measured beside cages. At the end of the (perinatal) exposure period, the litters and mothers were removed to the colony room (LD 12:12, ambient temperature $22 \pm 1°C$, background noise $70 \pm 2$ db) and placed in 46 x 20 x 14 cm cages containing 6 mm corncob bedding. After weaning, the rats were separated according to sex and placed in groups of three in either standard wire cages (40.5 x 24 x 18 cm) or in plastic cages (46 x 20 x 14 cm); the corncob bedding in the latter was changed twice per week. The positions of the cages containing the perinatal RMF-exposed and sham field rats were counterbalanced in the rack or shelf space to attenuate possible position artifacts.

During 8, separate experimental runs between 9 May to 27 June 1976, the 200 $\pm$ 5-day-old subjects were taken to the experimental room and exposed continuously for 5 days to 0.5 Hz RMFs of either $10^{-6}T$ or $10^{-7}T$, or to $10^{-8}T$ or sham field (less than $10^{-9}T$) variations; the latter condition was associated with essentially no variation to the nearest $1\mu$ on a McPhar magnetometer. The first pair of intensities was produced by a pair of weak iron horseshoe magnets (IM) while the second pair of intensities was produced by aluminum "magnets" (AM) which when attached to the output shafts allowed for the small inductions ($10^{-8}T$ or less than $10^{-9}T$) in the exposure areas. Both sets of magnets were balanced to the nearest g to avoid possible weight artifacts. The pairs of magnets were used in the following experimental order: IM, AM, IM, AM, AM, IM, AM, IM; rats that had been housed in the plastic cages were used in series 1, 2, 7, and 8 while those housed in the wire cages were used in series 3 to 6. In a given exposure...