

Acceptable radiation leakage of microwave ovens on pregnant and newborn rat brains

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Summary

The present article was intended to investigate the possible effects of the acceptable radiation leakage of microwave ovens on pregnant and new-born rat brains. Twenty-seven pregnant Wistar-albino rats were separated into three groups (n=9), a control group (sham-exposed) and two experimental groups. The experimental gravid rats were confined in Plexiglas cages and placed next to the closed door of a microwave oven (power-output: 550 W). The NIR 15 (NIR: non-ionising radiation) group of gravid rats were exposed to the leakage of microwave ovens daily for 15 minutes whereas the NIR 30 group was exposed daily for 30 minutes during their pregnancies. The most striking changes were observed in the NIR 30 group of rats. Congestive vessels, edema and degenerative neurones were noticed in all experimental dams. Chronic inflammatory cell infiltrate, and focal necrosis of neurones were seen only in the NIR 30 group of dams. Progressive edema and conspicuous congestive vessels were seen in the offspring of both experimental groups. Chronic inflammatory cell infiltrate, haemorrhage, necrotic neural tissues, and degenerative neurones with a reactive glial proliferation were observed only in the offspring of the NIR 30 group.

Key words: Non-ionising radiation; Microwave oven; Teratology.

Introduction

Microwave ovens are popular in food service facilities in general and are gaining popularity in self-service and food vending establishments. Such units are used in restaurants, cafeterias etc.

The energy generated to produce heat in these units falls within the microwave region of the electromagnetic spectrum, which includes frequencies ranging from 10 to 100,000 megacycles/second. The biological effects of exposure to microwave radiation result primarily from the heating of body tissues. The body tissues affected depend in general on the frequency of radiation, the intensity of the beam, length of exposure, and thermal conductance of the tissue. Frequencies less than 150 megacycles/second are not appreciably absorbed by the body. Between 150 and 1000 megacycles/second the energy is absorbed by the deeper body tissues, producing heat which is not perceived by the sensory mechanisms. From 1000 to 3000 megacycles/second absorption in the deeper body tissues tends to diminish, depending on skin thickness, thickness of fatty layer, the total mass of the body, and frequency of the energy. The range between 1000 and 10,000 megacycles/second tends to produce eye cataracts, with 3,000 megacycles/second the most critical frequency. Above 10,000 megacycles/second the skin surface absorbs an appreciable portion of the energy causing a sensation of warmth and provides a warning to the individual exposed [1].

There is continued concern over the risks associated with the use of microwave ovens and pressure to carry out frequent radiant surveys. The emission limit set by

the British standards (BS 5175, 1976) is for a power density of 50 W/sqm at a distance of 50 mm [2].

The present study was concerned with microwave ovens utilised in food-service establishments. The oven used in this study utilised a frequency of 2450 megacycles/second with the purpose of investigating the teratogenic effects of radiation leakage of microwave ovens on pregnant and new born rat brains.

Materials and Methods

Twenty-seven female Wistar-albino rats (170-190 gr.) were caged and fed standard pellet food during the study. The rats were obtained from the Department of Medical Science Application and Research Centre of Dicle University. The female rats were confined in a special cage over 48 hours for copulation with adult males. After confirming pregnancy with the vaginal smear method, the primipar rats were separated into three groups (n=9), a control group (sham-exposed) and two experimental groups, NIR 15 and NIR 30.

The experimental gravid rats were confined in Plexiglas cages (40x15x17 cm) which were placed next to the closed door of a microwave oven (power output: 550W, imperial V-8505T). The NIR15 group of gravid rats were indirectly exposed to the microwave oven leakage daily for 15 minutes whereas the NIR 30 group was indirectly exposed daily for 30 minutes during their pregnancies. The exposure started on the first day of gestation and was completed when gravid rats gave birth. Gravid rats were exposed at the same time every day. After each session, leakage from the microwave oven was measured by using a Detector Card (Microwave oven radiation leakage indicator, Enzone, USA). Specific absorption rate (SAR) was measured by using a non-interfering temperature probe technique [3].

All gravid rats were examined weekly after each exposure by a radiologist using ultrasonography (US). A real time US (Toshiba SSA-270A) and 7.5 MHz linear transducer was used to detect cardiac activation and to count the number of fetuses.

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The rectal temperatures of gravid rats were also measured before and after each exposure two times a week. The same procedure was applied to the sham group except for exposure.

The gravid rats gave birth during the 21st and 22nd days of gestation. Immediately after, all offspring were weighed and their lengths were measured. Then dams and their respective offspring were anaesthetised and dissected for their brains. The brains were taken out totally and fixed in a solution of 10% formaldehyde. The tissues were then embedded in paraffin wax, sectioned and stained with hematoxylin-eosin (H&E). Histological assessments were performed using a lighted microscope.

Results

Interestingly, the gravid rats in the Plexiglas cages gathered near the microwave oven (attached to the door) in the first 10 minutes of each exposure of the NIR 15 and NIR 30 groups. The mean rectal temperature of experimental groups was 1°C higher after exposure than the sham group. The average SAR was 2.3 W/kg.

During the first week of gestation, the foetuses could not be detected with ultrasonographical examination because of their size. There were no resorbed or dead foetuses after the first week. The average number of pups/litter was the same in the controls and exposed dams. The mean weight and length of the exposed litters were almost identical to the control group of offspring.

No abnormality was observed in the control group of dams (Fig. 1a). In the NIR 15 group, inflammatory cell infiltrate, congestive vessels, and edema were observed in the meninges (Fig. 1b). However, the edema was more progressive in the NIR 30 group (Fig. 1c).

Furthermore, focal astroglial proliferation and degenerative neurones were seen in this group. The degenerative neuronal changes included the loss of nucleus and cell contour, and decreased dendrite spines (Fig. 1c). Focal necrosis and chronic inflammatory cell infiltrate were only observed in the NIR 30 group of dams. Although similar results were observed in the NIR 15 and NIR 30 group the abnormalities were clearer in the NIR 30 group. Immature neural tissues were seen in the control group of offspring (Fig. 1d). In the NIR 15 group pronounced edema and striking congestive vessels were noticed in the meninges (Figs. 2a, 2b). The most striking edema and lymphocytic inflammatory cell infiltrate were noted in the offspring of the NIR 30 group (Fig. 2c). In addition to these findings, haemorrhage, conspicuous congestive vessels and degenerative neurones with glial cell necrosis were observed only in offspring of the NIR 30 group (Fig. 2d).

It should be remembered that each figure given here is representative of each group. The percentage of histological changes was approximately 65% in both experimental groups.

Discussion

The increasing use of microwave radiation for industrial, scientific, medical and domestic purposes has

resulted in growing concern about the biological effects of microwaves on man [4, 5]. The central nervous system (CNS) is known to be highly sensitive to non-ionising radiation [6]. RF fields sinusoidally modulated at extremely low frequencies were found to cause CNS changes in vitro and particularly in the live animals at 16 Hz [7-9]. The physiological significance of these effects has not been established. The same type of field has also been shown to change EEG patterns in the brain [10, 11]. Neurones in the CNS of experimental animals can be affected by acute high-level and chronic low-level exposures at specific absorption rates (SARs) greater than 2 W/kg. In our study, SAR was 2.3 W/kg.

Some reports describe the thermal nature of MW energy absorption, others implicate non-thermal or “specific” MW effects at the molecular and cellular levels [12]. In our study, the mean rectal temperature of experimental gravid rats increased approximately 1°C after each exposure. An important consideration has been made about the CNS response to microwave-induced heating such as “hot-spots” in the brain. It was suggested that the resonant absorption of microwaves in the skull of many mammals may result in the focusing of energy and the production of “hot-spots” in the brain. It has been cited that MW effects may relate to higher absorption in such regions as the hypothalamus than in other tissues [13]. It is known that the higher exposure levels (250 and 500 W/m², 1.76 and 2.45 GHz) could result in thermal effects, however, it is unlikely that 100 W/m² would result in significant thermalization of the whole brain, but the possibility of “hot-spots” should never be ruled out [12].

In a histopathological study, cytoplasmic vacuolisation of neurones, irregular swelling of axons and a decrease in dendritic spines of cortical neurones have been described (1.76 and 2.45 GHz, 100 and 200 W/m²). Neuronal changes were observed in acute responses whereas axonal swelling and dendritic spinal changes were only observed in chronic exposures [12]. We also observed similar histological findings especially in the second group of rats which were exposed to a microwave oven 30 minutes daily (Fig. 1c).

The potential effects of RF exposure on human growth and development remain controversial and assessment of various reports demands considerable circumspection [14]. It is known that developing organs are more vulnerable than mature organs to MW radiation because of a lower capacity to dissipate the non-ionising radiation. Although it is not well documented that MW radiation is teratogenic, RF radiation was found to be teratogenic at exposure conditions that approached lethal levels for the pregnant animals [15]. Abnormalities like haemorrhages, exencephaly, stunting and fetal death were observed in mouse foetuses when exposed in an environmentally-controlled wave guide at days 7-13 of gestation in the range of 1.23 kW/m² (2.45 GHz) incident power [16]. In our study, foetuses could not be seen during the first week of gestation because of their size and there were no resorbed foetuses with ultrasonographical examination

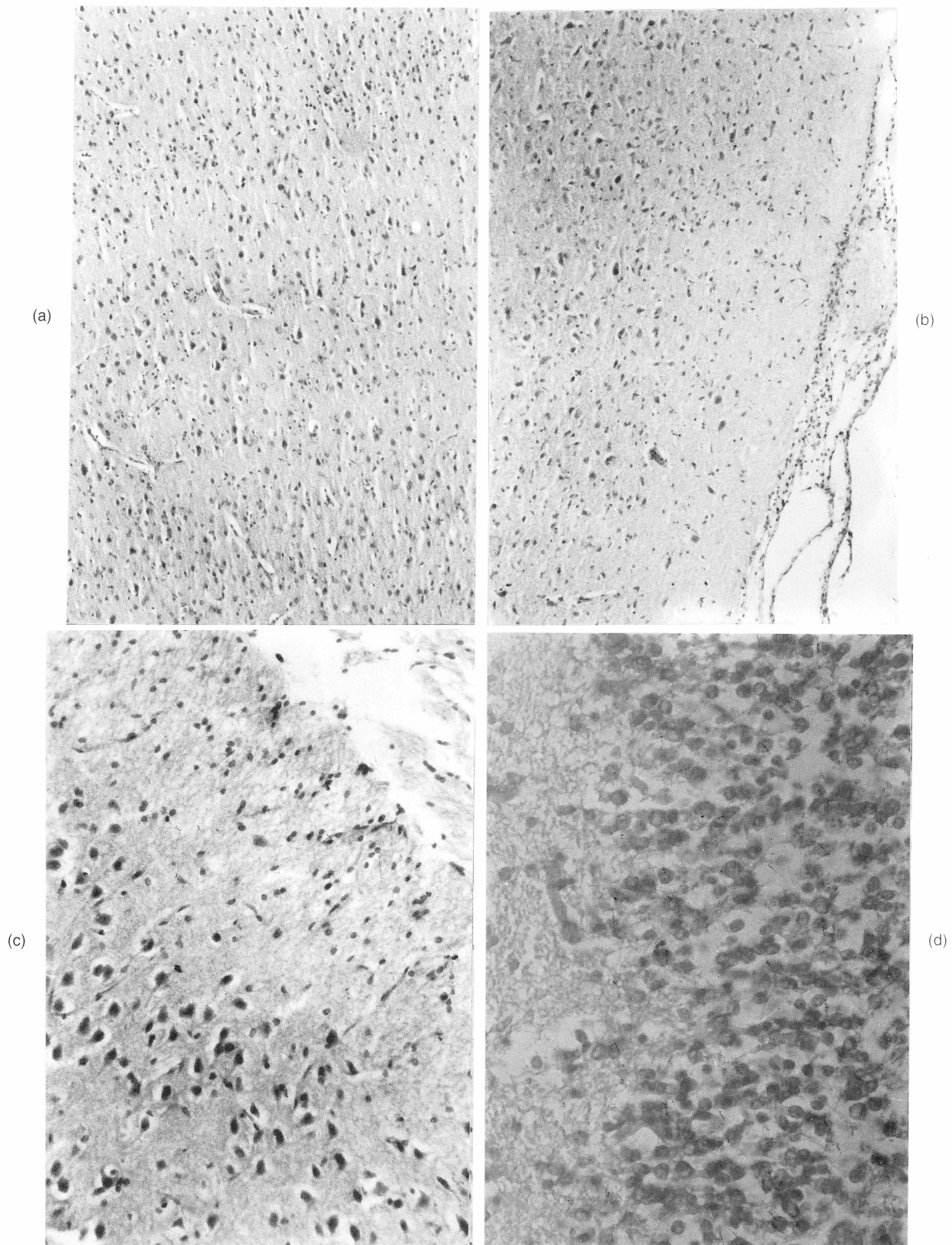


Figure 1. — (a) Normal neural tissues in the control group of dams (H&E, original magnification x41), (b) Inflammatory cell infiltrate and striking edema in the meninges of the NIR 15 group of dams (H&E, original magnification x41), (c) Sparse inflammatory cell infiltrate, striking edema and decreased dendritic spines of the neurones in the NIR 30 group of dams (H&E, original magnification x82), (d) Immature appearances of neural tissues in the control group of offspring (H&E, original magnification x165).

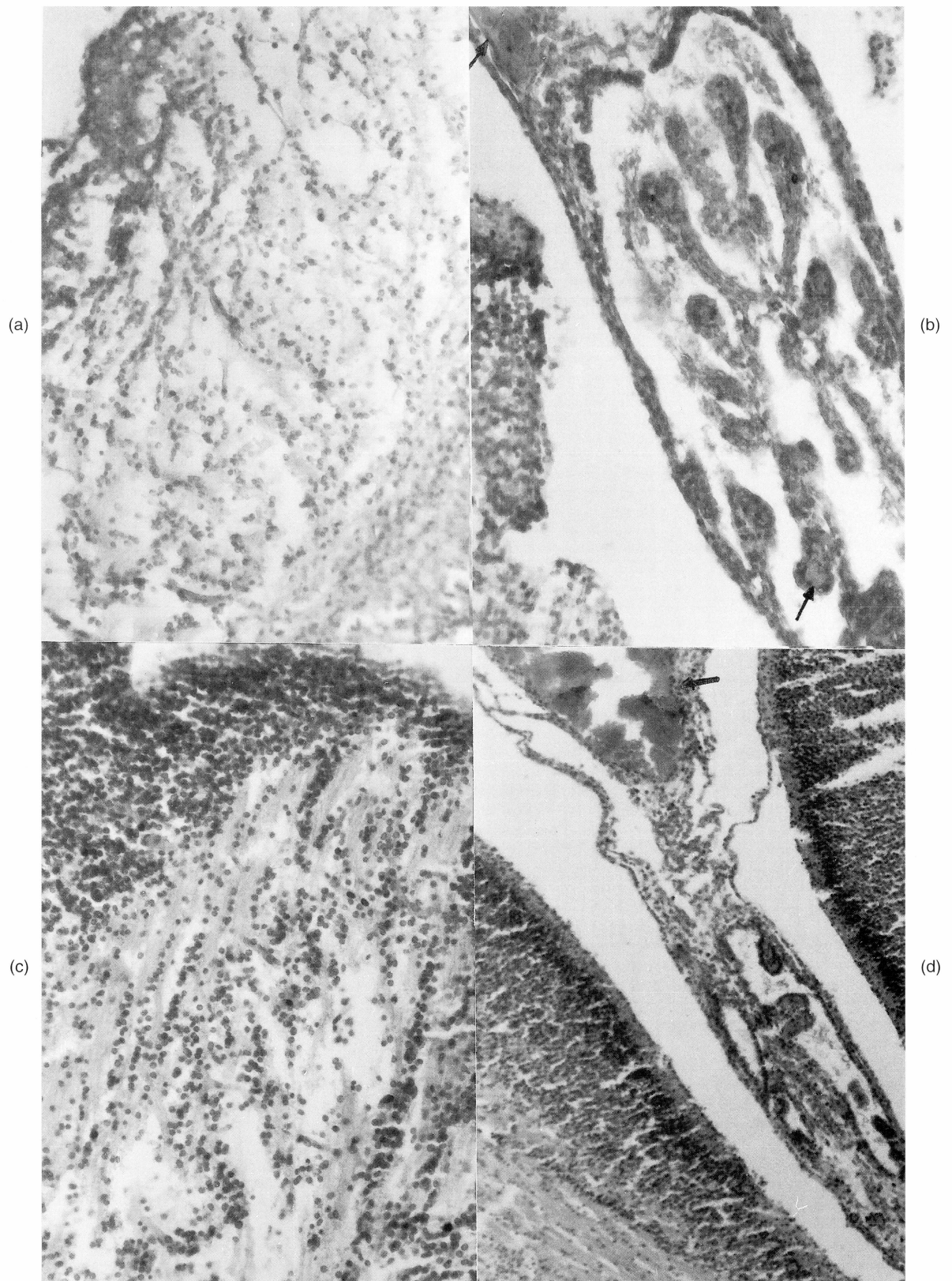


Figure 2. — (a) The striking edema in the NIR 15 group of offspring (H&E, original magnification x82), (b) Congestive vessels (arrows) in the NIR 15 group of offspring (H&E, original magnification x82), (c) The striking edema and inflammatory cell infiltrate in the NIR 30 group of offspring (H&E, original magnification x82), (d) Congestive vessels (arrow) in the NIR 30 group of litters (H&E, original magnification x41).

after the first week. No teratogenic effects were found when 10 pregnant rats were exposed 8 hours daily to MW irradiation (915 MHz, 100 W/m²) on days 1-14 of gestation [12]. In an experimental study increased incidence of cranioschisis was observed in mice fetuses exposed to 2.45 GHz at 34-280 W/m² for 100 minutes daily during pregnancy. The mean live fetal weight per litter was also found to decrease with exposure at the highest power density [17]. In our study, there were no striking differences in the weight and length means of the experimental offspring with controls.

RF heating has been used to relieve the pain of uterine contractions during labour and the babies in these studies were born healthy and without evidence of physical injury or mental retardation over the following year [18, 19]. However, gross structural defects would be unlikely to develop with exposure of a human foetus at this late stage since it is almost fully developed at parturition. RF diathermy has been used for treatment of various pelvic conditions during pregnancy and some congenital defects were observed in the offspring, whereas some women had no difficulties with conception, pregnancy or offspring [14]. Although there is no precise mechanism concerning the teratogenic effects of MW radiation, the rise in temperature of the foetus has been considered to cause damage in MW-induced developmental abnormalities [12].

In several studies, power densities of leakage were found to be 50 W/m² at 5 cm from the oven surface, less than 15 W/m² at a distance of 30 cm and 0.1 W/m² at a distance of 1m from the oven surface [12, 15]. Although personal exposure to a microwave oven is very small because of the rapid decrease in power density, the leakage should be reduced to levels well below the limits applicable to the general public. In our study, leakage of the microwave oven was found to be within normal safety limits. However, the teratogenic effect of the MW oven was observed especially in the NIR 30 group of offspring. We conclude that exposure to a microwave oven may cause teratogenic changes histologically in offspring brains. Although pregnant users are not exposed to microwave radiation under the same conditions as in our experiment they should pay attention – in terms of distance – to a microwave oven when it is working.

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