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Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission

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Highlights

- Carcinogenic effects of exposure to RFR generated by base stations of mobile phone on rats.
- Increased incidence of tumors of the brain and heart in RFR-exposed rats.
- Call for the re-evaluation of IARC conclusions on the carcinogenic potential of RFR in humans.

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Abstract

Background

In 2011, IARC classified radiofrequency radiation (RFR) as possible human carcinogen (Group 2B). According to IARC, animals studies, as well as epidemiological ones, showed limited evidence of carcinogenicity. In 2016, the NTP published the first results of its long-term bioassays on near field RFR, reporting increased incidence of malignant glial tumors of the brain and heart Schwannoma in rats exposed to GSM – and CDMA – modulated cell phone RFR. The tumors observed in the NTP study are of the type similar to the ones observed in some epidemiological studies of cell phone users.

Objectives

The Ramazzini Institute (RI) performed a life-span carcinogenic study on Sprague-Dawley rats to evaluate the carcinogenic effects of RFR in the situation of far field, reproducing the environmental exposure to RFR generated by 1.8 GHz GSM antenna of the radio base stations of mobile phone. This is the largest long-term study ever

performed in rats on the health effects of RFR, including 2448 animals. In this article, we reported the final results regarding [brain](#) and heart tumors.

Methods

Male and female Sprague-Dawley rats were exposed from prenatal life until natural death to a 1.8 GHz GSM far field of 0, 5, 25, 50 V/m with a whole-body exposure for 19 h/day.

Results

A statistically significant increase in the incidence of heart Schwannomas was observed in treated male rats at the highest dose (50 V/m). Furthermore, an increase in the incidence of heart Schwann [cells hyperplasia](#) was observed in treated male and female rats at the highest dose (50 V/m), although this was not statistically significant. An increase in the incidence of malignant [glial tumors](#) was observed in treated female rats at the highest dose (50 V/m), although not statistically significant.

Conclusions

The RI findings on far field exposure to RFR are consistent with and reinforce the results of the NTP study on near field exposure, as both reported an increase in the incidence of tumors of the brain and heart in RFR-exposed Sprague-Dawley rats. These tumors are of the same histotype of those observed in some [epidemiological studies](#) on cell phone users. These experimental studies provide sufficient evidence to call for the re-evaluation of IARC conclusions regarding the carcinogenic potential of RFR in humans.

Keywords

RF; Sprague-Dawley rats; Life-span bioassay; Mobile phone; Carcinogenicity

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Introduction

Early warnings on the potential carcinogenic risks of mobile phone radiofrequency radiation (RFR) raised in the early 2000 when, for the first time, it was published that people using mobile phones had a significant increased risk to develop vestibular Schwannoma and brain tumors (Hardell et al., 2003, Hardell et al., 2002). In 2011, the International Agency for Research on Cancer (IARC) classified RFR as possible human carcinogen (Group 2B) based on limited evidence both in humans and experimental animals (Baan et al., 2011, IARC, 2013). Two epidemiological case-control studies resulted more informative for the IARC evaluation, showing that the risk to develop brain tumors and vestibular Schwannoma was increased in people with the highest cumulative use of mobile phones, in people who had used mobile phones on the same side of the head as that on which their tumor developed, and in people whose tumor was in the temporal lobe of the brain (the area of the brain that is most exposed to RFR when a wireless phone is used at the ear) (Hardell et al., 2011; Interphone study group, 2010). Another small case series study contributed to the IARC evaluation of evidence for an association of vestibular Schwannoma with

mobile phone (Sato et al., 2011). The IARC Working group also noted that well conducted mechanistic studies showed that RFR induced aneuploidy, spindle disturbances, altered microtubule structures or DNA damage in several in vivo and in vitro models (IARC, 2013). Nevertheless, the IARC Working Group evaluated the overall evidence from mechanistic studies as inconclusive (IARC, 2013).

Experimental studies defining the potential carcinogenic effects of exposure to RFR have been largely inadequate because of the exposure conditions applied, because of the limited number of animals used in each experimental group and because of the short duration of the experiments. Since the late 90's, the need for well-conducted studies on laboratory animals has been identified by several public health institutions, including the World Health Organization and the US Food and Drug Administration (FDA, 1999, Repacholi, 1997). Indeed the conduct of cancer bioassays with RFR presents challenges that are not ordinarily met in studies with chemical or other physical agents. For example, the radiation frequency is an important determinant of the specific absorption rate (SAR). The whole-body SAR provides little information about spatial or organ-specific energy deposition, as it strongly depends on field polarization and animal posture. Furthermore, long-term exposure to RF radiation at a fixed frequency and power density will result in substantial changes in SAR over time as an animal gains body weight. Even if the power is adjusted for body weight changes, the spatial distribution can vary (IARC, 2013). Although SAR is a key parameter for thermal RFR effects, several other parameters of RFR exposure such as exposure duration, frequency, polarization, modulation, and environmental magnetic fields are of importance for biological RFR effects (IARC, 2013, Belyaev, 2010). In addition physiological parameters, which may vary in development and between individuals, are of importance (IARC, 2013, Belyaev, 2010). Variability of physiological parameters need to be addressed in long-term bioassays using a large group of animals adequately randomized.

Following the nomination to study cell phone radiofrequency radiation made by the U.S. Food and Drug Administration, the US National Toxicology Program (NTP) started a large systematic and integrated experimental project on RFR, including in vivo long-term bioassays in Harlan Sprague-Dawley (HSD) rats and B6C3F1/N mice exposed to RFR from prenatal life up to 2 years in the situation of near field, reproducing the exposure to RFR generated by the antenna of mobile phone (Wyde et al., 2016).

In 2005, the Ramazzini Institute (RI) started a life-span carcinogenic study on Sprague-Dawley rats to evaluate the carcinogenic effects of RFR in the situation of far field, reproducing the environmental exposure to RFR generated by an 1.8 GHz GSM antenna of the radio base stations of mobile phone (Soffritti et al., 2006, Soffritti et al., 1999). This is the largest long-term study ever performed in rats on the health effects of RFR, including 2448 animals. The plan of the experiment is reported on Table 1.

The elaboration of the NTP studies have been already completed and a report of partial findings has been recently published (Wyde et al., 2016). The communication of the first important findings of the study was urged by two factors: 1) the fact that also a small increase of the incidence of tumors induced by the exposure to RFR could have great impact for public health; and 2) because the tumors of the brain and heart observed at low incidence in male rats exposed to Global System for Mobile Communications (GSM) – and Code Division Multiple Access (CDMA) – modulated cell phone RFR in the NTP study are of the type similar to the ones observed in some

epidemiological studies of cell phone users. Interim cohorts were also examined for evidence of RFR-induced genotoxicity: DNA damage was significantly increased in the frontal cortex of male mice (both CDMA and GSM), peripheral leukocyte of female mice (CDMA only) and hippocampus of male rats (CDMA only) (Smith-Roe et al., 2017). Previous studies have also shown that RFR might disrupt the blood-brain barrier. (Nittby et al., 2008).

The elaboration of the RI study data is still ongoing. However, partial findings are now available and, for the same reasons reported by the NTP, we felt motivated to publish urgently the final results on brain and heart tumors.

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Section snippets

1.8GHz base station exposure system and facilities

In order to expose the animals to a mobile phone radiofrequency field representative of a 1.8 GHz base station, a specific radiation system, totally representative of the real environmental situation present in geographic areas close to GSM base station radiation emissions (Fig. 1). The exposure system was designed and constructed by TESEO S.P.A. Company, Turin, Italy. The field generation, in order to be representative of a real GSM field emission, has been modulated in GMSK mode, in Call ...

Food and water consumption, body weight and survival

The experiment proceeded smoothly and no unexpected alteration in the clinical status of the animals was observed in the various groups. The biophase parameters for control and treated groups are presented in Fig. 3. No differences were observed in mean water consumption (A and B), food consumption (C and D), mean body weight (E and F) or survival index (G and H), either in male or in female rats. ...

Neoplastic lesions

In this article we are reporting the final results from the histopathological evaluation of all ...

Conclusions

In 2005, the RI started a life-span carcinogenic study on Sprague-Dawley rats to evaluate the carcinogenic effects of RFR in the situation of far field, reproducing the environmental exposure to RFR generated by 1.8 GHz GSM antenna of the radio base stations of mobile phone. This is the largest long-term study ever performed in rats on the health effects of RFR, including 2448 animals. In this article, we report the final results regarding brain and heart tumors. A statistically significant ...

Acknowledgements

This article is in memory of Prof. Cesare Maltoni, who started this project a long time ago and left us the task of accomplishing it: we hope we have come up to his expectations. It is with a great sense of gratitude and recognition that we thank Dr. Morando Soffritti for his invaluable contribution to planning and conducting the experiments when he was Director of our Cesare Maltoni Cancer Research Center. We are grateful to all staff at the Laboratory of the CMCRC/RI for their commitment to ...

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Ethics review and approval

The experiments were ...

References (30)

R. Baan

Carcinogenicity of radiofrequency electromagnetic fields

Lancet Oncol. (2011)

R.H. Alison

Morphology and classification of 96 primary cardiac neoplasms in fischer 344 rats

Vet. Pathol. (1987)

L.E. Anderson

Two-year chronic bioassay study of rats exposed to a 1.6 GHz radiofrequency signal

Radiat. Res. (2004)

I.Y. Belyaev

Dependence of non-thermal biological effects of microwaves on physical and biological variables: implications for reproducibility and safety standards

Eur. J. Oncol. - Libr. (2010)

B.R. Berridge

Non-proliferative and proliferative lesions of the cardiovascular system of the rat and mouse

J. Toxicol. Pathol. (2016)

M. Carlberg *et al.*

Evaluation of mobile phone and cordless phone use and glioma risk using the bradford hill viewpoints from 1965 on association or causation

Biomed. Res. Int. (2017)

S.A. Elmore

Proceedings of the 2016 national toxicology program satellite symposium

Toxicol. Pathol. (2017)

FDA, 1999. Letter of Nomination of Agents to the National Toxicology Program.

Available at:...

M. Giovannini

Schwann cell hyperplasia and tumors in transgenic mice expressing a naturally occurring mutant NF2 protein

Genes Dev. (1999)

L. Hardell

Case-control study on the use of cellular and cordless phones and the risk for malignant brain tumours

Int. J. Radiat. Biol. (2002)



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