On the Mechanism of Rf-Emf-Exposure Associated DNA Damage and Long Term Risks

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Abstract

Exposure to radio frequent electromagnetic fields (RF-EMF) as emitted by mobile phones, can damage the cellular DNA. During the ATHEM in vitro research program we confirmed 1) genotoxic effects under some but not all conditions, 2) a latency period from start of exposure to first incidence, and 3) the role DNA repair. In human volunteers we found exposure associated genotoxic and cytotoxic effects in mucosal cells. The volunteers' report on little or heavy mobile phone use and the findings in the individuals' cell samples, point towards an accumulation of RF-EMF induced effects over time. Our data corroborate international reports on RF-exposure related DNA oxidation. We observed these exposure related DNA damages associated with activated specific DNA repair mechanisms. Repair failure results in permanent DNA damage, which increases the risk for cell transformation. We observed no acute adverse health effects, however, a potential long term risk can't be excluded. The available data are not sufficient to redefine existing exposure limits to protect also from long term effects, the data call for risk management strategies to promote the safe use of the technology.

Keywords: Mobile Phone, Radio frequent Electromagnetic Fields, RF-EMF, Genotoxicity, Biological Mechanism

1. Introduction

Mobile phones, smart phones, etc. exchange data via microwaves at low intensities. These signals are also referred to as radio frequency electromagnetic fields (RF-EMF). To avoid tissue heating in exposed users the signal intensity is limited by international guidelines. There are biological effects not covered by these guidelines, which were investigated in two research programs (ATHEM- 1 and ATHEM-2 project) sponsored by the Austria Workers compensation board (AUVA). The research focus was on possible mechanisms, how RF-EMF can damage the cells' DNA.

2. Methods

Cell culture: Over 10 different cell lines were grown under standard conditions, exposed or sham exposed to GSM or UMTS RF-EMF signals, at intensities up to the current exposure limit and below (GSM up to 2 W/kg; UMTS: 0,25 to 1 W/kg). Then the DNA in the cell nuclei was analyzed by generally accepted methods, like Comet assay for DNA strand breaks, and micronucleus testing for permanent DNA alterations, and proteomic analyses.

Human Volunteers were exposed for 2 hours per day for five consecutive days, through the cheek to expose the mouth epithelium to defined intensities. Exfoliated buccal mucosa cells were sampled and analyzed for genotoxic and cytotoxic effects [1].

All exposures and analyses were performed under double-blind conditions.

3. Results and Discussion

Human Volunteers: The RF-EMF exposure caused moderate genotoxic and cytotoxic effects. These changes were, moreover, more pronounced in persons who reported the highest levels of cellular phone use, a finding consistent with an accumulation of exposure-related cellular changes over time.[1]

In vitro: The in vitro experiments on genotoxicity confirmed the existence of various levels of sensitivity. Some cell types did not react at all. Among the sensitive cells were human glioblastoma cell lines. We observed exposure related DNA damage and in the same cells changes of the proteom. Cells that revealed no RF-EMF exposure related DNA-effect[2] also did not reveal relevant proteome changes.[3]

Short exposure does not lead to measureable RF-EMF related effects. However, the experiments confirmed the existence of a latency period (time between start of exposure and first occurrence of effects). Among the various investigated cell lines, the extent of DNA damage correlated with their metabolic activity.[4]

Furthermore, at least in one cell type the RF-EMF related DNA-damage seemed to change with freeze/thaw cycles or aging of the culture. Primary fibroblasts (ES-1) revealed significant exposure related DNA damage during passage 3-5,[2] the same cells showed still significant but less DNA-damage at later passages, and did not show significant effects, when reinvestigated 10 years later in passages 7 to 9.[1,4]

The exposure induced DNA strand breaks RF-EMF-correlated with oxidative damage and activated DNA repair. We observed the activation of specific DNA repair

pathways, which confirms that the cells sensed the DNA damages, and explains why after the exposure the induced DNA damages can be repaired within 2 hours. Both, proteome changes[3] and DNA damage[5] were indeed undetectable two hours after cessation of RF-EMF exposure.

Because the RF-EMF related DNA damage mechanism involves DNA oxidation, it can be expected that any other condition associated with reactive oxygen species (ROS) can be modulated by RF-EMF exposure.

4. Conclusion

The complexity of both, RF-EMF exposure on the one hand and biological systems on the other, renders research and the interpretation of subtle exposure effects difficult. The controversially discussed outcomes of the research so far, speak for systematic research programs before a deeper understanding of the interaction can be achieved.

The above described exposure related DNA damages did neither reveal a stringent dose response effect, nor a clear NOEL (No observed effect level), which could be the basis for revised exposure standards. Although DNA damage can be repaired, and therefore the results do not indicate acute adverse health effects, a long term risk associated with intermittent and continuous DNA damage resulting from misrepair [6,7] cannot be excluded.

In response to this situation, various institutional bodies recommend to apply the precautionary principle, to promote prudent use and preventive measures. The aim is to reduce the individuals' exposure by maximizing the distance to the RF-EMF emitting device and minimizing exposure duration.

In view of the evidence, either a moratorium for the launch of the so called 5G (fifth generation of mobile phone standard, after GSM, UMTS and LTE) or a coordinated research program for the assessment of its biological and health effects is recommended.

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