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INFLUENCE OF ELECTROMAGNETIC RADIATION ON SELECTED ORGANS IN RATS

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Abstract
The immediate whole body electromagnetic radiation was used to investigate testicular and kidney structure of the Wistar rats. Sexually mature (48 days old) rats were subjected to pulsed electromagnetic fields at frequency of 2.45 GHz and mean power density 2.8 mW/cm^2 daily applications of 3 h per 3 weeks. Histological structure of the testicular and kidney parenchyma was evaluated in 3 hours after the last irradiation. The light microscopy revealed diffuse degenerative changes in both examined organs in experimental animals. The testes contained irregular seminiferous tubules, the seminiferous epithelium showed the signs of cellular sloughing, and sex cells were often degenerative or even necrotizing. The kidney parenchyma manifested degenerative changes within all nephron components as well as collecting tubules. The necrotizations were extremely intensive mainly within the medullary region. The interstitium showed the signs of inflammation. These findings confirmed an adverse effect of EMR, and the evidence that the testes and kidneys are amongst the most susceptible organs to the EMR.

Key words: electromagnetic radiation, testes, kidney, rats

Introduction

Nowadays, human population is unavoidably influenced to the constant electromagnetic fields produced from variety of different sources. Frequencies between 30 kHz and 300 GHz are commonly used for telecommunication, including broadcast radio and television, and involve the radio frequency band which can be classified to as non-ionizing radiation in the microwave range. Mobile telephone systems exactly operate at radiofrequency electromagnetic waves, RF-EMW 900MHz and 1800MHz. Such the levels are far below the high frequency EMW of X-rays and gamma rays ionizing radiation. Although the low level of energy of non-ionizing radiation cannot break the covalent bonds in biological molecules, the human body due its electrical properties such the permittivity and conductivity is able to receive and induce electrical fields and currents inside the tissues (Sysoev et al., 2013). Thermal and non-thermal effects are the main mediators of EMW interaction with biological systems. The tissue damage in this case is caused due to tissue´s inability to eliminate the excessive heat. Non-thermal or direct effect is not completely understood, and comprises a wide range of various metabolic pathways. It is often associated with the plasma membrane injury, cellular signal transduction effects, nervous system excitability perturbation, neuroendocrine and immune system injury (Bhat, 2013, Zecca et al., 2006). However the testis and kidneys depend chiefly on surface admittance rather than blood flowage for temperature regulation, which performs an interesting aspect of thermal effect of RF-EMW, the mode of action of RF-EMW will be probably a combination of the thermal and nontermal effects. However many works showed that RF-EMR from a mobile phones, Wi-Fi, microwaves or other devices affected negatively male fertility (Lukac et al., 2011, Hales et al., 2005),or general health (Braune et al., 2002), a number of studies in contrast did not note any abnormalities (Dasdag et al.,2003; Chung et al., 2005).
This study investigated the possible effect of immediate whole body irradiation by pulsed EMF on testis and kidney structure of rats.

Materials and methods

The research material consisted of 40 male albino rats strain Wistar. At the begining of the experiment, animals were randomly divided into two groups – the control and experimental (20 rats in each). Animals were kept in ordinary cages under controlled temperature of 21±1ºC, and had *ad libitum* access to food and water. The lighting was turned off or on under a 12 h cycle. Experimental rats were irradiated by a pulse-wave EMF of 2.45 GHz, at mean power density 2.8 mW/cm^2 in a purpose-designed chamber (Orendac et al., 2005), in 3 h daily applications per 3 weeks. Uniformity of the EMF was analysed with a spectral analyser to determine the optimal placement of animals. 3 hours after the last irradiation the animals from experimental and control groups were anesthetized by i.p. injection of xylazine+ketamine, and subsequently perfused with 4% paraformaldehyde solution in phosphate buffer (0.1 M, pH 7.3). The tissue excisions of size 1 mm^3 were fixed by immersion in 3% glutaraldehyde and postfixed in 1% osmium tetraoxide (both in 0.15 M phosphate buffer, pH 7.3). After dehydration in acetone they were transferred to propylene oxide and embedded in Durcupan ACM. Semi-thin sections of specimen were cut using an ultramicrotome LKB Nova, stained with toluidine blue and examined under a light microscope Zeiss Axio Lab A1, and documented with camera Axio Cam ERc 5. The use and care of animals were approved by the Animal Care Committee of the Institute of Neurobiology, Slovak Academy of Sciences.

Results and discussion

Histopathological evaluation of the testicular parenchyma

The testicular parenchyma of experimental rats exibited various degenerative changes. Seminiferous tubules had irregular shape, and the seminiferous epithelium contained many empty spaces as the sign of the cellular sloughing. Sloughed cells were found within the lumina of the tubules (Fig. 1).

At a higher magnification, the Sertoli cells appeared to be normal in their structure, but the individual cells of different developmental stages of the spermatozoa were often affected. Many spermatogonia were shrunk and they possessed very dark cytoplasm. The spermatocytes were mostly normal, but some possessed vacuolar cytoplasm. Rarely, the spermatocytes were completely destroyed. Elongated spermatids had normal structure, however their amount was decreased. Many empty spaces within the seminiferous epithelium may be considered to as sign of cellular sloughing (Fig. 2).

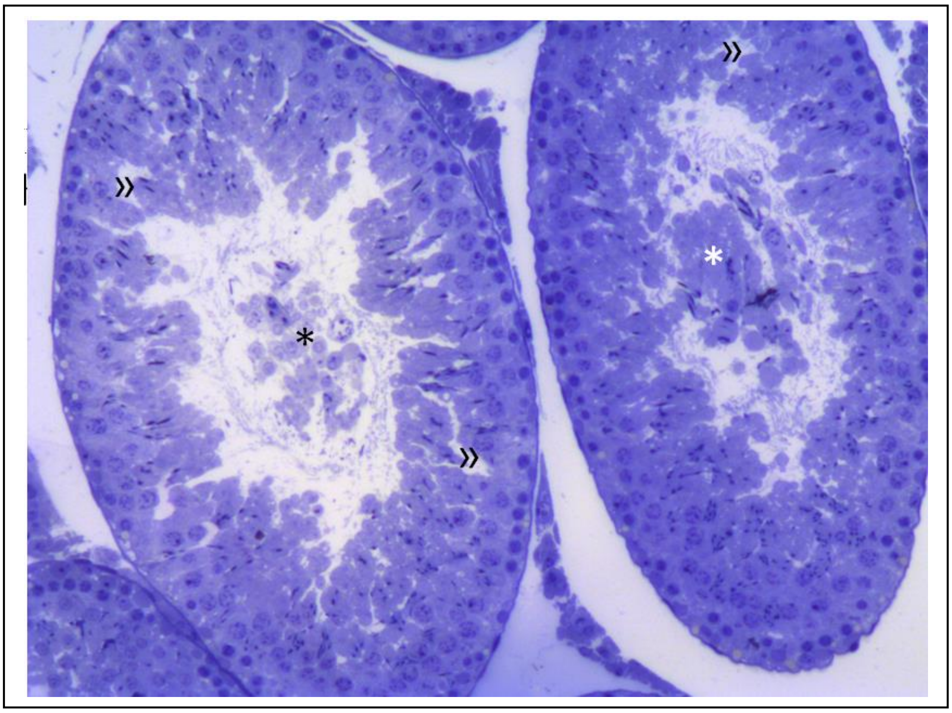

Fig. 1.

Seminiferous tubules after 3 weeks exposure to EMF (semi-thin section, toluidine blue).

Magn. 100x; » - empty space, * - sloughed cells

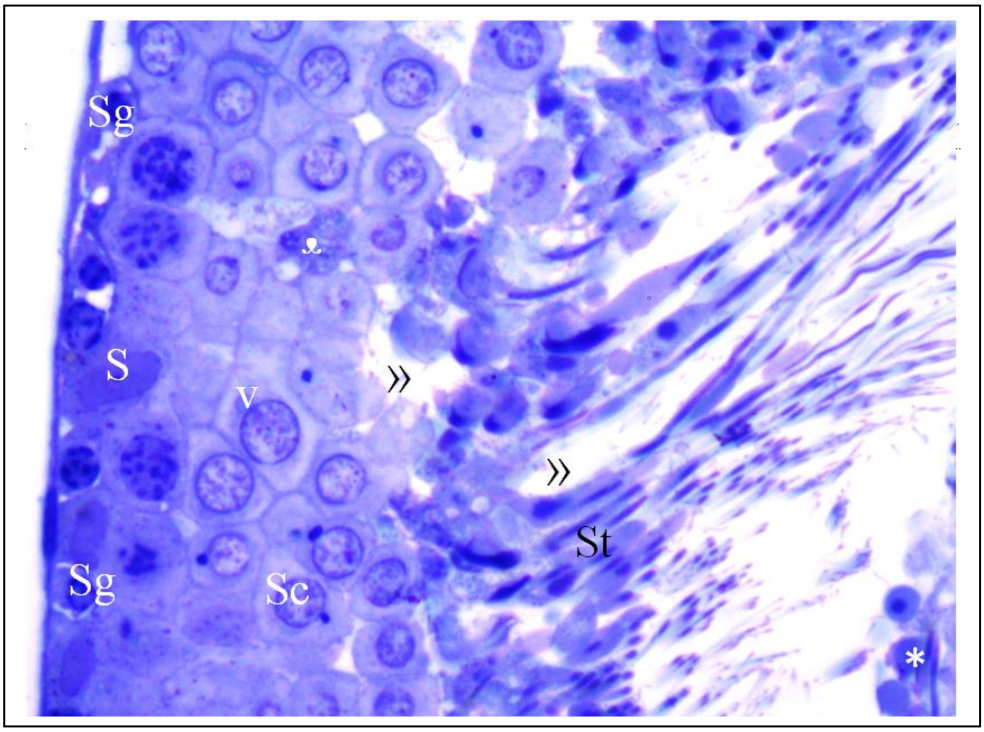

Fig. 2.

Seminiferous epithelium after 3 weeks exposure to EMF (semi-thin section, toluidine blue).

Magn. 400x; » - empty space, * - sloughed material, ᴥ - destroyed cell, S – Sertoli cell, Sg – spermatogonium, Sc – spermatocyte, St – spermatid, v - vacuole

The peritubular myoid cells as well as interstitial spaces had characteristic structure. The Leydig cells appeared to be unaffected, and the adjeacent blood vessels had continuous endothelial lining (Fig. 3).

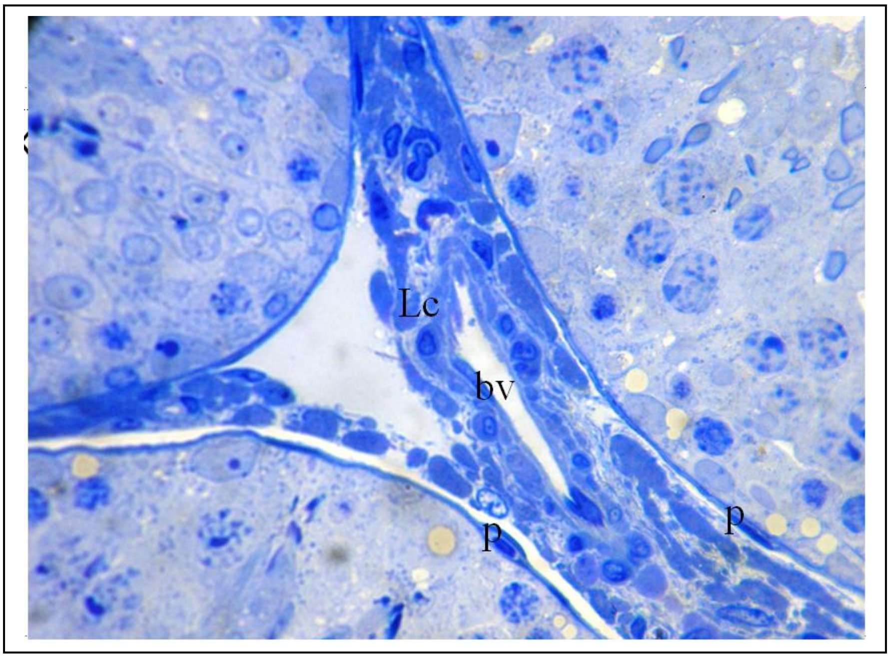

Fig. 3.

Interstitium after 3 weeks exposure to EMF (semi-thin section, toluidine blue).

Magn. 400x; Lc – Leydig cells, bv – blood vessels, p – peritubular cels

Our examination have proved an adverse effect of EMR on testicular structure in rats, which is highly consistent with observations of many authors who described similar degenerative changes of the testicular parenchyma often accompanied with altered sex hormones production after exposition to different forms and intensities of EMR (Lukac et al., 2011; Roychoudhury et al., 2009; Liu et al., 2006; Ribeiro et al.,2007; Salama et al., 2009).

Histopathological evaluation of the kidney parenchyma

After 3 weeks of the experiment the kidney parenchyma contained diffuse changes within the cortical as well as the medullary portion. The renal corpuscles, renal tubules and the cortical collecting ducts were constantly changed. The renal corpuscles had irregular shape, and their urinary spaces were often enlarged (Fig. 4). Cells of the proximal tubules showed high content of small vacuoles scattered within the cytoplasm, and their brush border was often altered (Figs. 4 and 5).

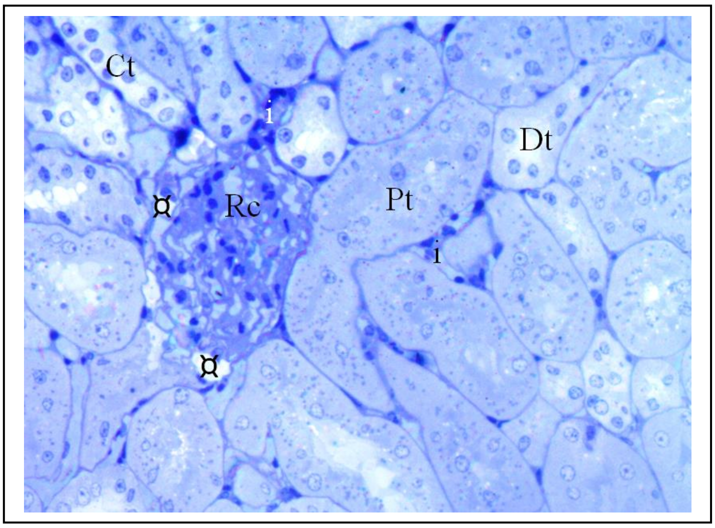

Fig. 4.

Renal cortex after 3 weeks exposure to EMF (semi-thin section, toluidine blue).

Magn. 100x; Rc – renal corpuscle, ¤ – enlarged urinary space, Pt – proximal tubule, Dt – distal tubule, Ct – collecting tubule, i – interstitium

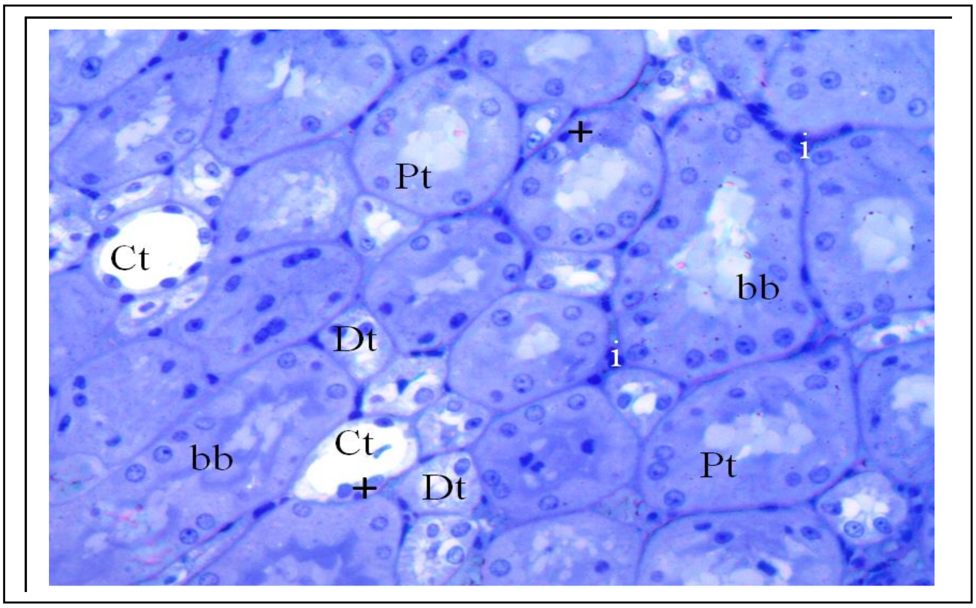

Fig. 5

Renal cortex after 3 weeks exposure to EMF (semi-thin section, toluidine blue).

Magn. 100x; Pt – proximal tubule, Dt – distal tubule, Ct – collecting tubule, i – interstitium, bb – brush border, + - necrotizing cell

The medullary region comprised of medullary collecting ducts, straight portions of the proximal as well as distal tubules and thin limbs of the loop of Henles with changed histological structure. The cells lining the over mentioned tubules possessed many vacuoles inside their cytoplasm and cellular necrotizations were much more obvious compared to the cortical portion in experimental animals (Fig. 6). Both cortical and medullary portions revealed high cellularity of the interstitial space as the sign of its inflammatory response, however the blood vessels appeared to as unchanged (Figs. 4, 5 and 6).

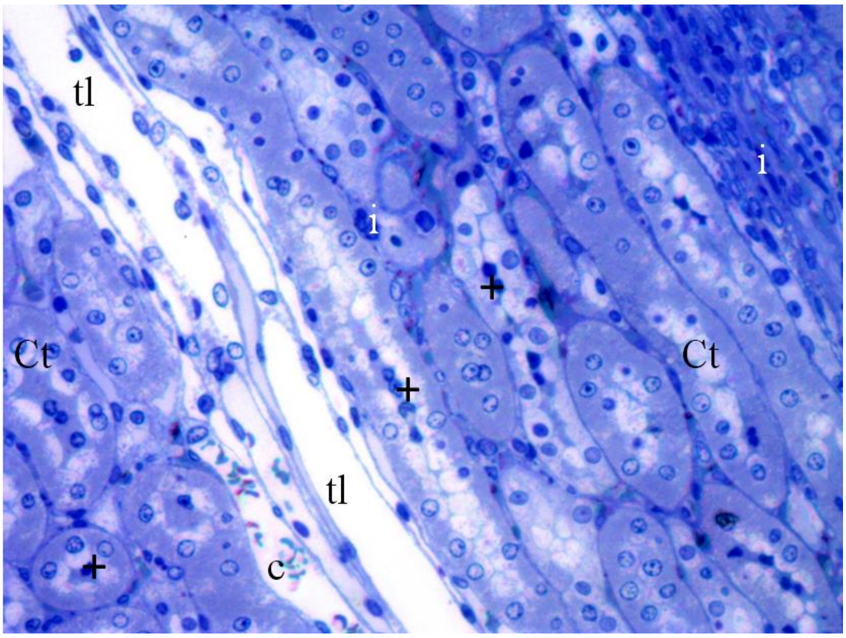

Fig. 6.

Renal medulla after 3 weeks exposure to EMF (semi-thin section, toluidine blue).

Magn. 100x; Ct – collecting tubule, tl . thin limb of the loop of Henle, i – interstitium, c – blood capillary, + - necrotizing cell

An adverse effect of EMR on the kidney is described in many works which have recorded intertubular inflammation, glomerular atrophy, cytoplasmic vacuolation of the renal tubules, pycnotic nuclei (Khayyat, 2011; Ozturk et al., 2003; Zare et al., 2007; Semra et al., 2007).

Conclusion

The immediate whole body pulsed electromagnetic radiation at frequency of 2.45 GHz and mean power density 2.8 mW/cm^2 in daily applications of 3 h per 3 weeks had clear adverse effect on testicular and renal structure in rats. Both examined parenchymatous organs revealed diffuse degenerative changes probably as the consequence of a combination of thermal and nontermal effect of electromagnetic radiation. The testicular parenchyma consisted of irregular seminiferous tubules, and the seminiferous epithelium contained many small irregular empty spaces as the sign of cellular sloughing. Spermatogonia and spermatocytes were often degenerative. The spermatids were less numerous compared to the control ones. Many individual developing sex cells were necrotizing. Interstitium was unchanged.

The kidney parenchyma possessed degenerative and irregular renal corpuscles with enlarged urinary spaces. The main degenerative feature of the uriniferous tubules was the presence of vacuoles within the cytoplasm of cells, reduced or even totally destroyed brush border in proximal tubules as well as presence of nectotizing cells predominantly within the medullary portion of the kidney. The collecting tubules within the cortex and medulla contained cells with vacuolar cytoplasm. The necrotization within the collecting tubules was evident especially within the medullary region. The interstitium contained rich infiltrations with blood formed elements as the sign of inflammation.

Acknowledgements

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References

Bhat MA, 2013. Effects of Electromagnetic Waves Emitted by Mobile Phones on Male Fertility. Comp Engineering and Intelligent Systems, 4(3)

Braune S, Riedel A, Schulte-Monting J, 2002. Influence of a radiofrequency electromagnetic field on cardiovascular and hormonal parameters of the autonomic nervous system in healthy individuals. Radiation Res. 158: 352-356

Dasdag S, Zulkuf AM, Aksen F, 2003. Whole body exposure of rats to microwavws emitted from a cell phone does not affect the testes. Bioelectromagnetics (24): 182-188

Hales DB, Allen JA, Shankara T, Janus P, Buck S, Diemer T, 2005. Mitochondrial function in Leydig cell steroidogenesis. Ann NY Acad. Sci 1061: 120-134

Chung MK, Lee SJ, Kim YB, Park SC, Shin DH, Kim SH, Kim JC, 2005. Evaluation of spermatogenesis and fertility in F1 male rats after in utero and neonatal exposure to extremely low frequency electromagnetic fields. Asian J Androl. 7 (2): 189-194

Khayyat Latifa Ishaq, 2011. The histopathological effects of an electromagnetic field on the kidney and testis of mice. Eurasia J Biosci, 5: 103-109

Liu GW, Gong PS, Zhao HG, Wang ZC, Gong SL, Cai L, 2006. Effect of low level radiation on the death of male germ cells. Radiat.Res., 165:379-389

Lukac N, Massanyi P, Roychoudhury S, Capcarova M, Tvrda E, Knazicka Z, Kolesarova A, Danko J, 2011. J Envir Sci Health A Tox Hazard Subst Environ Eng. 46(12): 1417-1423

Orendac M, Fenik A, Mojzis M, Orendacova J, 2005. Biological effects of electromagnetic radiation on living systems with respect to the brain. Psychiatrie (2): 83-85

Ozturk A, Baltaci AK, Mogulkoc R, Oztekin E, 2003. Zinc prevention of electromagnetically induced damage to rat testicle and kidney tissues. Biol Trace Elem res. 96 (1-3): 247-254

Ribeiro EP, Rhoden EL, Horn MM, Rhoden C, Lima LP, Toniolo, 2007. Effects of subchronic exposure to radio frequency from a conventional cellular telephone on testicular function in adult rats. J Urol.177(1): 395-399

Roychoudhury S, Jedlicka J, Parkanyi V, Rafay J, Ondruska L, Massanyi P, Bulla J, 2009

Semra E, 2007. The effect of electromagnetic field (50Hz, 6 mT) on rat liver and kidney. Journal of Adnan Menderes Medical Faculty 8(1): 5-11.

Sysoev VN, Lukyanov GN, Serov IN, 2013. Electromagnetic Radiation Influence on Human Health. http://www.aires.spb.ru/docs/eng/36-1-eng.pdf

Zare S, Alivandi S, Ebadi AG, 2007. Histological studies of the low frequency electromagnetic fields effect on liver, testes and kidney in quinea pig. World Applied Sciences Journal 2 (5): 509-511

Zecca L, Mantegazza C, Margonato V, Cerretelli P, Caniatti M, Piva F, 2006. Biological effects of prolonged exposure to ELF electromagnetic fields in rats. Bioelectromagnetics 19(1): 57-66