Д.С. Санитарный надзор за источниками электромагнитных излучений в окружающей среде.-К.: Здоровья, 1990.- 152 с.
4. Евстафьев В.Н., Шафран Л.М. Эколого-гигиеническая оценка источников электромагнитного излучения //Причорноморський екологічний бюллетень.-Одеса.-2002.-№ 3 (5).-С. 117-122
5. Белкин А.Д. О роли техногенных вращающихся электрических полей в эндо- и экзоэкологических взаимосвязях (Обзор литературы) // Медицина труда и промышленная экология.-1999.-№ 6.-С. 27-30
6. ГОСТ 12.1.006-84 «ССБТ. Электромагнитные поля радиочастот. Допустимые уровни на рабочих местах и требования к проведению контроля»
7. ГОСТ 12.1.002-84 «ССБТ. Электрические поля промышленной частоты. Допустимые уровни напряженности и требования к проведению контроля на рабочих местах»
8. ГОСТ 12.1.045-85 «ССБТ. Электростатические поля. Допустимые уровни на рабочих местах и требования к проведению контроля»
9. ДСанПіН «Державні санітарні норми і правила захисту населення від впливу електромагнітних випромінювань» № 239-96
10. ДСанПіН 3.3.2.-007-98 «Державні санітарні правила і норми роботи з візуальними дисплейними терміналами електронно-обчислювальних машин»
11. ДСанПіН «Державні санітарні норми і правила при роботі з джерелами електромагнітних полів" № 476-02
12. Санитарная паспортизация передающих радиотехнических объектов радиочастотного диапазона по электромагнитному фактору / А.Л.Бузов, Ю.И.Кольчугин, Ю.П.Пальцев и др. // Медицина труда и промэкология.-2004.-№ 5.-С. 39-43

Summary

ELECTROMAGNETIC IRRADIATION OF TRANSPORT MEANS AS A HYGIENIC PROBLEM

Yevstafiev B.N., Skiba A.B., Shein S.B.

In connection with the level of anthropogenic electromagnetic irradiation (EMI) increase they have carried out a trial of electromagnetic pollution on transport objects. The main directions of research projects for the workers and general population health protection from (EMI) have been determined also. The staff of the State Enterprise "Ukrainian Research Institute for Transport Medicine" have worked out normative and methodical documents both for the industrial personnel and general population and nearly 200 sanitary passports for radio-technical objects.

В связи с повышением в настоящее время уровня антропогенного электромагнитного излучения авторами проведено научно-техническое исследование электромагнитного загрязнения на объектах транспорта и определены основные направления научно-практических работ по обеспечению охраны здоровья работников и населения от воздействия ЭМИ. Сотрудниками ГП «Украинский НИИ медицины транспорта» разработаны нормативно-методические документы для производственного персонала и населения и около двухсот санитарных паспортов на

EFFECTS OF ELECTROMAGNETIC RADIATION ON INTACT BOVINE LENS EPITHELIUM IN CULTURE CONDITIONS

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Introduction

The detailed process which connects electromagnetic radiation and damage to cells is still not known. Richter et al (2000) reported increased risks for cancer in 20-37-year age group with exposures to high levels of RF/MW radiation for long periods. They recommended preventing exposures in the range of 10-100 microW/cm^2. Sandstrom et al (2001) did an epidemiological investigation on mobile phone use including 6379 GSM users and 5613 NMT 900 users in Sweden, and 2500 from each category in Norway. They observed a statistically significant association between calling time, number of calls per day and the prevalence of warmth around the ear, headaches and fatigue. Koivisto et al. (2001) measured the influence of pulsed radiofrequency (RF) electromagnetic fields of digital GSM mobile phones (902 MHz, 217 Hz pulse modulation) on subjective symptoms or sensations in healthy subjects in two single-blind experiments. The duration of the RF exposure was about 60 min in Experiment 1 and 30 min in Experiment 2. The symptoms rated were head-

ache, dizziness, fatigue, itching or tingling of the skin, redness on the skin, and sensations of warmth on the skin. The results did not reveal any differences between exposure and non-exposure conditions, suggesting that a 30-60 min exposure to this RF field does not produce subjective symptoms in humans. Inskip et al (2001) examined the use of cellular telephones in a case-control study of intracranial tumours of the nervous system conducted between 1994 and 1998. Of 782 patients in hospitals in Phoenix, AZ; Boston CT; and Pittsburgh PA; 489 had histologically confirmed gliomas, 197 had meningiomas and 96 had acoustic neuromas. The 799 controls were patients admitted to the same hospitals as the patients with brain tumors for a variety of non-malignant conditions. There was no evidence that the risks were higher among persons who used cellular telephones for 60 or more minutes per day or regularly for five or more years. Their conclusion was that the data do not support the hypothesis that the recent use of hand-held cellular telephones causes brain tumors, but data are insufficient to evaluate the risks among long-term, heavy users and for potentially long induction periods. In our experimental study we exposed bovine lenses in organ culture conditions to electromagnetic radiation of 1.1 GHz-2.2mW for 192 cycles of 50 min irradiation and 10 min break and followed changes in lens epithelial enzyme activities.

Methods

Organ Culture System

Bovine lenses (1 year old) were used in this study. Each lens was placed in a glass and silicon rubber chamber containing 24ml of culture medium (M 199) with Earl's balanced salt solution, supplemented with 5.96g/L HEPES, 3% dialyzed fetal calf serum and antibiotics (penicillin 100 U/ml and streptomycin 0.1 mg/ml). Lenses were completely immersed in culture medium both below and above. The medium was changed daily. The lenses were incubated at 35°C. Experimental treatments started after preincubation of 24 hours (Dovrat et al 1986).

Electromagnetic radiation system

A computer-controlled microwave source was built. It consists of a voltage-controlled oscillator generating a constant microwave power. The output is attenuated by two attenuators: one is fixed and the other is variable, permitting the desired degree of freedom regarding the exposure intensity. The microwave signal is directed into a 30 dB amplifier which has a maximum output of 1 W. A four arm power-splitter provides each transmission line with a microwave signal attenuated by 7 dB relative to the output of the amplifier. The transmission lines generate uniform electric fields in the region of the lens. The lenses were exposed to 1.1GHz with power of 2.2mW for 8 days (Dovrat et al 2005)

Lens epithelium morphology and enzyme analysis

On day 12 of the culture period, lenses were taken for morphological analysis by Hematoxylin and eosin staining and enzyme analysis. Total flat preparations of the front capsule epithelium monolayer of lenses from the different treatments were evaluated. When evaluating the different grade of differentiation was taken into account, i.e. topographical features of central intermediate and equatorial zones. We followed the histochemical localizations of the enzymes: aldolase and glucose-6-phosphate dehydrogenase (G-6-PD) and analyzed SH-SS groups. For analysis we used the classical methods of Pearse A.G. (1972)

Quantitative analysis of the intensity of the reactions at epithelial central and equatorial zones was done by Image-Pro Plus program, Version 4.0 for Windows, by measuring optical density in each cell, following by mathematical processing in Microsoft Excel. A change was defined as significant if the difference between control and treated groups reached value of $P < 0.05$.

Results

Hematoxylin and eosin staining of lens epithelial cells on day 12 of the culture (Fig. 1) show for the control lens (Fig. 1A) round cells which contains homogenous blue staining of large nuclei. The cells for the electromagnetic radiation exposed lens (Fig. 1B) demonstrate smaller cells with condensed nuclei also damaged areas in the nucleus and cytoplasm indicating damage to the cells, pyknosis.

In contrast to the poor condition of the epithelial cells of lenses exposed to electromagnetic radiation aldolase activity increased in these cells (Fig. 2).

As a result of the electromagnetic exposure aldolase activities increased at the center and equators of the lens epithelium. Enzyme activation is greater at the center of the lens epithelium.

The effects of the electromagnetic radiation on G-6-PD activity are demonstrated in Fig. 3.

For G-6-PD electromagnetic radiation exposure reduced enzyme activity at the center of the lens epithelium and increased enzyme activity at the equators. The reduced color of the cells (Fig. 3ab) demonstrates damage to this area of the epithelial layer.

Concentration of SH-SS groups in proteins of the lens epithelial cells show reduction of SH groups at the center and also at the equators of the lens epithelium (Fig. 4 a).

After electromagnetic exposure there is no difference between SH and SS groups at the center of the lens epithelium however at the equators there is difference between SH and SS groups (Fig. 4 b).

Discussion

Our results show that electromagnetic radiation has a clear impact on the eye lens.

Adey et al (2000) in a 2-year bioassay, exposed Fischer 344 rats to a frequency-modulated signal (836.55 MHz) and tested for effects on spontaneous tumorigenicity of central nervous system tumors in the offspring of pregnant rats and also for modified incidence of primary tumors in rats treated with a single dose of the neurocarcinogen ethylnitrosourea (ENU) *in utero*. Intermittent field exposures began on gestation day 19 and continued until weaning at 21 days, resuming thereafter at 31 days and continuing until experiment termination at 731-734 days. Energy absorption rates (SARs) in the rats' brains were similar to localized peak brain exposures of a phone user. Of the original 540 rats, 168 died before the termination of the experiment. In these rats, ENU significantly reduced survival. There were no effects on survival attributable to FM field exposure. Spontaneous tumor incidence in control groups was 1.1-4.4% but sharply higher in rats receiving ENU. Chou et al (1992) investigated the effects of long-term (25 months), low-level (144 mW) microwave irradiation on 100 male rats. They found significant changes in serum corticosterone and a near fourfold increase of primary malignancies.

Gos et al (2000) exposed yeast cells to 900-MHz fields at specific absorption rates (SAR) of 0.13 and 1.3 W/kg and examined the genotoxic potential. They claim that no mutagenic or recombinogenic effects were detected as compared with known mutagen. Li et al. (2001) exposed murine C3H 10T(1/2) fibroblasts to3.2-5.1 W/kg specific absorption rate (SAR) radio frequency fields. The cells in cultures were exposed to 847.74 MHz code-division multiple access (CDMA) and 835.62 frequency-division multiple access (FDMA) modulated radiations in radial transmission line (RTL) irradiators in which the temperature was regulated to 37.0 +/- 0.3 degrees C. The exposure time was: 2, 4 or 24 h. Their experiments show that these

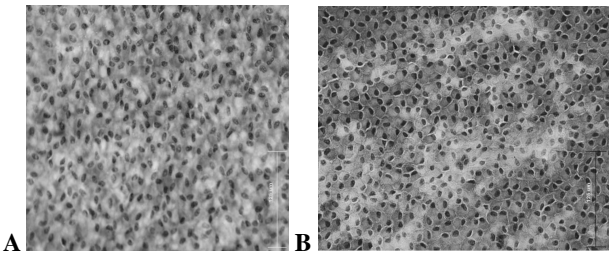

Fig. 1. H&E staining of lens epithelial center zone on day 12 of the culture (10x40)
A — Control lens
B — Lens exposed to electromagnetic radiation 192 cycles of 1.1GHz, 2.2mW

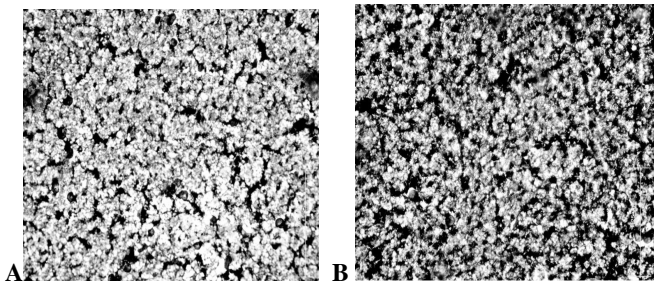

Fig. 2a. Aldolase activity at the lens epithelial cells of the center zone (10x40).

A — Control lens
B — Lens exposed to electromagnetic radiation 192 cycles of 1.1GHz, 2.2mW

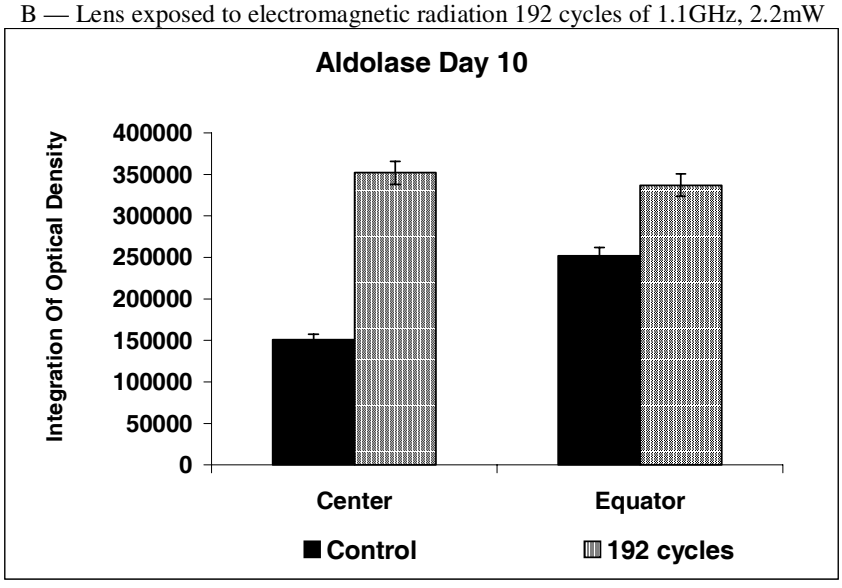

Fig. 2b. Integration of optical density of aldolase activities at the lens epithelial cells.

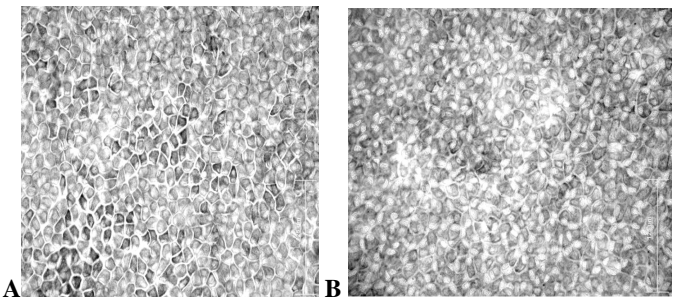

Fig. 3a. G-6-PD activities at the lens epithelial cells of the center zone (10x40).
A — Control lens
B — Lens exposed to electromagnetic radiation 192 cycles of 1.1GHz, 0.89mW

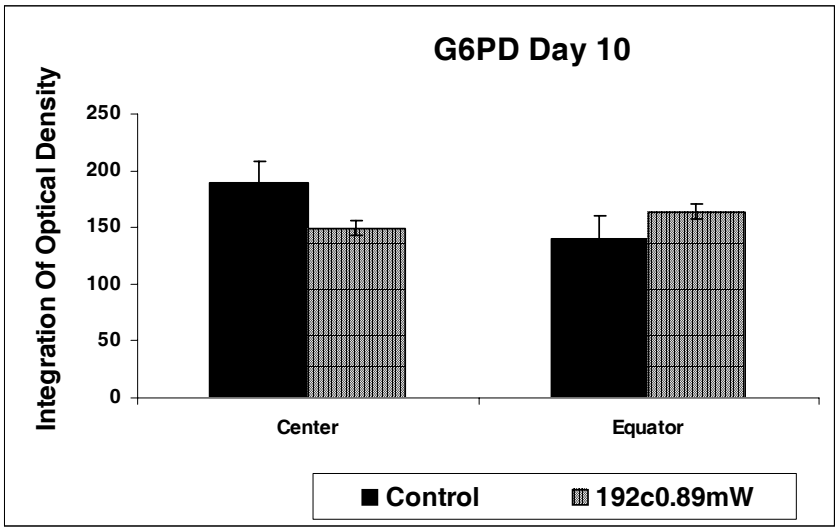

Fig. 3b. Integration of optical density of G-6-PD activities at the lens epithelial cells.

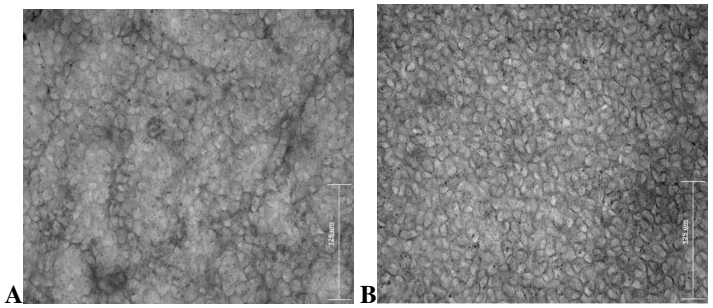

Fig. 4a.Concentration of SS-SH- groups in proteins of the lens epithelial cells (10x40).
A — Control lens
B — Lens exposed to electromagnetic radiation 192 cycles of 1.1GHz, 0.89mW

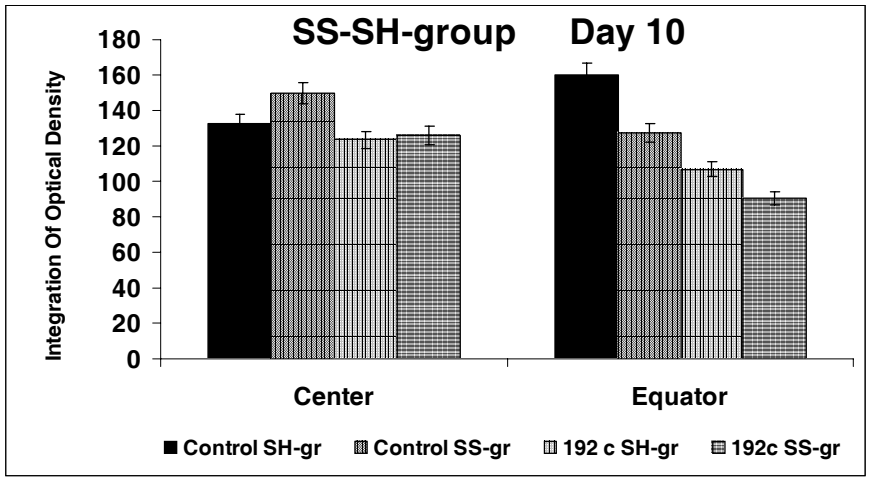

Fig. 4b. Integration of optical density of SS-SH-groups in the lens epithelial cells.

conditions did not induce measurable DNA damage. Also there is no evidence for induction of DNA single-strand breaks in human blood lymphocytes exposed for 2 h *in vitro* to pulsed-wave 2450 MHz radiofrequency radiation, as compared with cells exposed to gamma-ray source that were used as controls. The cells were tested either immediately or at 4 h after exposure. (Vijayalaxmi et al 2000.(Lai and Singh (1996) investigated the effects of acute (2h) exposure to pulsed and continuous wave 2450-MHz radiofrequency electromagnetic radiation on DNA strand breaks in brain cells of rat. The spatial averaged power density of the radiation was 2mW/cm^2, which produced a whole-body average-specific absorption rate of 1.2W/kg. They measured single and double-strand DNA breaks in individual brain cells at 4h post-exposure using a microgel electrophoresis assay.

In our study we showed that exposure to 1.1GHz, at power of 2.2mW affects lens epithelium as demonstrated by changes in cell structure and epithelial enzyme activities. Electromagnetic radiation has a clear impact on the eye lens. Exposure above specific energy levels affects lens epithelium.

References

1. Adey WR. Byus CV. Cain CD. Higgins RJ. Jones RA. Kean CJ. Kuster N. MacMurray A. Stagg RB. Zimmerman G (2000). **Spontaneous and nitrosourea-in-**

duced primary tumors of the central nervous system in Fischer 344 rats exposed to frequency-modulated microwave fields. Cancer Research 63:1857-60,

2. Chou, C.K. Guy, A. W. Kunz, L. L. Johnson, R.B. Crowley, J.J. and Krupp J.H. (1992) **Long-Term, Low-Level Microwave Irradiation of Rats**. Bioelectromagnetics 13:469-496
3. Dovrat A, Sivak JG, Gershon D (1986) **Novel approach to monitoring lens function during organ culture**. *Lens Research* 3:207-215.
4. Dovrat, A. Berenson, R. Bormusov, E. Lahav, A. Lustman, T. Sharon, N. and Schдchter, L. (2005) **Localized Effects of Non-Ionizing Electromagnetic Radiation on the Eye Lens.** Bioelectromagnetics 26:398-405.
5. Gos P. Eicher B. Kohli J. Heyer WD. (2000). **No mutagenic or recombinogenic effects of mobile phone fields at 900 MHz detected in the yeast Saccharomyces cerevisiae.** Bioelectromagnetics. 21:515-23,
6. Inskip PD. Tarone RE. Hatch EE. Wilcosky TC. Shapiro WR Selker RG. Fine HA. Black PM. Loeffler JS. Linet MS. (2001).**Cellular-telephone use and brain tumors**. New England Journal of Medicine. 344:79-86,
7. Koivisto M. Haarala C. Krause CM. Revonsuo A. Laine M. Hamalainen H. (2001) **GSM phone signal does not produce subjective symptoms.** Bioelectromagnetics. 22:212-215,
8. Li L. Bisht KS. LaGroye I. Zhang P. Straube WL. Moros EG. Roti Roti JL (2001). **Measurement of DNA damage in mammalian cells exposed in vitro to radiofrequency fields at SARs of 3-5 W/kg.** Radiation Research.156:328-32,
9. Lai H and Singh NP (1996**) Single and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromag-netic radiation**. International Journal of Radiation Biology. 69:513-21,
10. Pearse A.G. Everson. (1972) Histochemistry.Theoretical and Applied.3 editon.Ediburgh ahd London,
11. Richter E. Berman T. Ben-Michael E. Laster R. Westin JB. (2000).**Cancer in radar technicians exposed to radiofrequency/microwave radiation: sentinel episodes**. International Journal of Occupational & Environmental Health. 6:187-93,
12. Sandstrom M. Wilen J. Oftedal G. Hansson Mild K (2001) **Mobile phone use and subjective symptoms. Comparison of symptoms experienced by users of analogue and digital mobile phones**. Occupational Medicine (Oxford).51:25-35,
13. Vijayalaxmi. Leal BZ. Szilagyi M. Prihoda TJ. Meltz ML. (2000). **Primary DNA damage in human blood lymphocytes exposed in vitro to 2450 MHz radiofrequency radiation.** Radiation Research. 153:479-86,

Summary

Purpose: To investigate the effects of non-ionizing electromagnetic radiation on the eye lens using a lens organ culture system.

Methods: Bovine lenses were incubated in organ culture conditions for 10 days. 59 lenses were used in this study. Treated lenses were exposed to 1.1GHz, 2.22mW for 192 cycles of 50 minutes irradiation followed by 10 minutes pause. At the end of the culture period control and treated lenses were taken for enzyme analysis.

Results: Exposure to 2.22mW at 1.1GHz caused damage to the lens. The radiation damage appeared at the lens epithelial layer accompanied by activity changes of lens epithelial enzymes.

Conclusions: Electromagnetic radiation has a clear impact on the eye lens. Exposure above specific energy levels affects lens epithelium as demonstrated by changes in epithelial enzyme activities.

ВЛИЯНИЕ ЭМИ НА ЭПИТЕЛИЙ ХРУСТАЛИКА ГЛАЗА БЫКА В КУЛЬТУРЕ ТКАНЕЙ

Эльвира Бормусова, Ахува Добрат

Цель: исследовать влияние неионзирующего электромагнитного излучения на хрусталик глаза, с использованием культуры ткани хрусталика глаза.

Методы: Хрусталики бычьего глаза были культивированы в течение 10 дней. Изучено 59 хрусталиков. Обработанные хрусталики были облучены 1.1 GHz, 2.22mW в течение 192 циклов по 50 минут с паузой 10 минут. Затем в контрольных и обработанных культуральных клетках хрусталика определяли активность ферментов.

Результаты: Экспозиция 2.22mW и 1.1GHz повредила хрусталик глаза. Лучевое повреждение проявилось в эпителиальном слое хрусталика глаза, и сопровождалось изменениями активности эпителиальных ферментов.

Выводы: Электромагнитное излучение имеет выраженное воздействие на хрусталик глаза Экспозиция описанными выше уровнями удельной энергии воздействует на эпителий хрусталика глаза, что выражается в изменении активности эпителиальных ферментов.