## **CEM et Santé**

## Une sélection de quelques études présentées par le Prof Dr Stefaan Van Gool (\*)

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### The effect of pulsed electromagnetic fields on the physiologic behaviour of a human astrocytoma cell line.

Aldinucci C, Palmi M, Sgaragli G, Benocci A, Meini A, Pessina F, Pessina GP.

Biochim Biophys Acta. 2000 Dec 11;1499(1-2):101-108.

We evaluated the effects of 50 Hz pulsed electromagnetic fields (EMFs) with a peak magnetic field of 3 mT on human astrocytoma cells. Our results clearly demonstrate that, after the cells were exposed to EMFs for 24 h, the basal [Ca(2+)](i) levels increased significantly from 124+/-51 nM to 200+/-79 nM. Pretreatment of the cells with 1.2 microM substance P increased the [Ca(2+)](i) to 555+/-278 nM, while EMF exposure caused a significant drop in [Ca(2+)](i) to 327+/-146 nM. The overall effect of EMFs probably depends on the prevailing Ca(2+) conditions of the cells. After exposure, the proliferative responses of both normal and substance P-pretreated cells increased slightly from 1.03 to 1.07 and 1.04 to 1.06, respectively. U-373 MG cells spontaneously released about 10 pg/ml of interleukin-6 which was significantly increased after the addition of substance P. Moreover, immediately after EMF exposure and 24 h thereafter, the interleukin-6 levels were more elevated (about 40%) than in controls. On the whole, our data suggest that, by changing the properties of cell membranes, EMFs can influence Ca(2+) transport processes and hence Ca(2+) homeostasis. The increased levels of interleukin-6 after 24 h of EMF exposure may confirm the complex connection between Ca(2+) levels, substance P and the cytokine network.

#### Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones.

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Environ Health Perspect. 2003 June; 111(7): 881–883.

The possible risks of radio-frequency electromagnetic fields for the human body is a growing concern for our society. We have previously shown that weak pulsed microwaves give rise to a significant leakage of albumin through the blood-brain barrier. In this study we investigated whether a pathologic leakage across the blood-brain barrier might be combined with damage to the neurons. Three groups each of eight rats were exposed for 2 hr to Global System for Mobile Communications (GSM) mobile phone electromagnetic fields of different strengths. We found highly significant (p< 0.002) evidence for neuronal damage in the cortex,

hippocampus, and basal ganglia in the brains of exposed rats.



Figure 1. Cross-section of central parts of the brain of (A) an unexposed control rat and (B) an RF EMFexposed rat, both stained for albumin, which appears brown. In (A), albumin is visible in the central inferior parts of the brain (the hypothalamus), which is a normal feature. In (B), albumin is visible in multiple small foci representing leakage from many vessels. Magnification, about ×3.



Figure 2. Photomicrograph of sections of brain from an RF EMF-exposed rat stained with cresyl violet. (A) Row of nerve cells in a section of the pyramidal cell band of the hippocampus, among the normal nerve cells (large cells) are interspersed black and shrunken nerve cells, so-called dark neurons. (A) The cortex, top left, of an RF EMF-exposed rat showing normal nerve cells (pale blue) intermingled with abnormal, black and shrunken "dark neurons" at all depths of the cortex, but least in the superficial upper layers. Magnification, x160.

## Mobile phone emission modulates interhemispheric functional coupling of EEG alpha rhythms.

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Eur J Neurosci. 2007 Mar;25(6):1908-13.

We tested the working hypothesis that electromagnetic fields from mobile phones (EMFs) affect interhemispheric synchronization of cerebral rhythms, an important physiological feature of information transfer into the brain. Ten subjects underwent two electroencephalographic (EEG) recordings, separated by 1 week, following a crossover double-blind paradigm in which they were exposed to a mobile phone signal (global system for mobile communications; GSM). The mobile phone was held on the left side of the subject head by a modified helmet, and orientated in the normal position for use over the ear. The microphone was orientated towards the corner of the mouth, and the antenna was near the head in the parietotemporal area. In addition, we positioned another similar phone (but without battery) on the right side of the helmet, to balance the weight and to prevent the subject localizing the side of GSM stimulation (and consequently lateralizing attention). In one session the exposure was real (GSM) while in the other it was

Sham; both sessions lasted 45 min. Functional interhemispheric connectivity was modelled using the analysis of EEG spectral coherence between frontal, central and parietal electrode pairs. Individual EEG rhythms of interest were delta (about 2-4 Hz), theta (about 4-6 Hz), alpha 1 (about 6-8 Hz), alpha 2 (about 8-10 Hz) and alpha 3 (about 10-12 Hz). Results showed that, compared to Sham stimulation, GSM stimulation modulated the interhemispheric frontal and temporal coherence at alpha 2 and alpha 3 bands. The present results suggest that prolonged mobile phone emission affects not only the cortical activity but also the spread of neural synchronization conveyed by interhemispherical functional coupling of EEG rhythms.

# Examining the effects of electromagnetic fields emitted by GSM mobile phones on human event-related potentials and performance during an auditory task.

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Clin Neurophysiol. 2004 Jan;115(1):171-8.

OBJECTIVE: Due to the widespread use of mobile phones (MP), it is important to determine whether they affect human physiology. The aim of this study was to explore the sensitivity of auditory event-related potentials to electromagnetic emissions.

METHODS: Twelve participants attended two sessions, 1 week apart. Participants performed an auditory oddball task while they were exposed to an active MP during one session and sham exposure during the other. Each condition lasted 1 h and order was counterbalanced. N100 and P200 latencies and amplitudes were analysed for non-target waveforms, and N200 and P300 latencies and amplitudes were analysed for target waveforms.

RESULTS: In real relative to sham exposure N100 amplitude and latency to non-targets were reduced, with the reduction larger over midline and right hemisphere sites. P300 latency to targets was delayed in the real exposure condition, however as this difference was greatest at left frontal and left central sites the interpretation of this result is unclear. Reaction time increased in the real relative to sham condition. No difference in accuracy was found.

CONCLUSIONS: The results suggest that MP exposure may affect neural activity, particularly in proximity to the phone, however caution should be applied due to the small sample size.

## Mobile phone affects cerebral blood flow in humans.

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<u>J Cereb Blood Flow Metab.</u> 2006 Jul;26(7):885-90. Epub 2006 Feb 22.

Mobile phones create a radio-frequency electromagnetic field (EMF) around them when in use, the effects of which on brain physiology in humans are not well known. We studied the effects of a commercial mobile phone on

regional cerebral blood flow (rCBF) in healthy humans using positron emission tomography (PET) imaging. Positron emission tomography data was acquired using a double-blind, counterbalanced study design with 12 male subjects performing a computer-controlled verbal working memory task (letter 1-back). Explorative and objective voxel-based statistical analysis revealed that a mobile phone in operation induces a local decrease in rCBF beneath the antenna in the inferior temporal cortex and an increase more distantly in the prefrontal cortex. Our results provide the first evidence, suggesting that the EMF emitted by a commercial mobile phone affects rCBF in humans. These results are consistent with the postulation that EMF induces changes in neuronal activity.

## The immune response of women with prolonged exposure to electromagnetic fields produced by radiotelevision broadcasting stations.

Boscolo P, Di Giampaolo L, Di Donato A, Antonucci A, Paiardini G, Morelli S, Vasile R, Spagnoli G, Reale M, Dadorante V, Kouri M, Di Gioacchino M.

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Int J Immunopathol Pharmacol. 2006 Oct-Dec;19(4 Suppl):43-8.

Twelve women, five of them housewives, exposed in their residences to electromagnetic fields (EMFs)emitted by radio-television broadcasting stations for a mean period of 13 years, were investigated. The EMFs in the balconies of the homes were (mean + S.D.) 4.3 + 1.4 V/m in the year 2000 and 3.7 + 1.3 V/m in 2005, while the exposure in the nearby area was <2.0 V/m. The EMF exposed women showed in 2000 reduced blood NK lymphocytes as well as PHA stimulated PBMC proliferation and IL-2 and IFNgamma release. In the year 2005, the EMF exposed women and 48 control women with similar ages(mean 43 years), smoking habits, atopy and social level were investigated. State (temporary) and trait(tendency of the personality) anxiety were determined by STAI I and II, respectively. Blood cytotoxic activity and lymphocyte subsets were also determined. The ratio STAI I/STAI II of the EMF exposed group was lower than that of the control group. The blood cytotoxic activity of the exposed women was lower (p<0.01), percent of B CD45+-CD19+ lymphocytes higher and percent of CD45+-CD3+-CD8+ cells lower (p<0.05). Moreover, cytotoxic activity/CD45+-CD16+-56+ NK lymphocytes of the controls was negatively correlated with STAI I and STAI II (p<0.001). In conclusion, this study demonstrates reduced blood cytotoxic activity and increased trait anxiety in relation to state anxiety in EMF exposed women. An effect of EMFs on immune functions, in part mediated by nervous mechanisms, may be hypothesized. However, the influence of lifestyle may not be excluded.

### Paternal occupational exposure to electromagnetic fields as a risk factor for cancer in children and young adults: a case-control study from the North of England.

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#### Pediatr Blood Cancer. 2007 Sep;49(3):280-6.

BACKGROUND: Numerous studies have implied that paternal occupational exposures, in particular electromagnetic fields (EMF) and ionizing radiation, may be involved in the etiology of childhood cancers. We investigated whether an association exists between paternal occupations at birth involving such exposures and cancer risk in offspring, using data from the Northern Region Young Persons' Malignant Disease Registry (NRYPMDR).

PROCEDURE: Cases (n=4,723) were matched, on sex and year of birth, to controls from two independent sources: (i) all other patients from the NRYPMDR with a different cancer, (ii) 100 cancer-free individuals per case from the Cumbrian Births Database. An occupational exposure matrix was used to assign individuals to exposure groups.

RESULTS: There was an increased risk of leukemia among the offspring of men employed in occupations likely to be associated with EMF or radiation exposures (OR 1.31, 95% CI 1.02-1.69), particularly in males aged less than 6 years (OR 1.81, 95% 1.19-2.75). No significant association was seen in females. Increased risks were also seen for chondrosarcoma (OR 8.7, 95% CI 1.55-49.4) and renal carcinoma (OR 6.75, 95% CI 1.73-26.0). These associations were consistent between control groups and remained after adjustment for socio-economic status.

CONCLUSIONS: This large case-control study identified a significantly increased risk of leukemia among the offspring of men likely to have been occupationally exposed to EMF, with differing associations between males and females. Increased risks of chondrosarcoma and renal carcinoma were also seen, although based on smaller numbers. Further detailed investigations in this area are required to understand this association.

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