

## Influence of a 6 mT static magnetic field on apoptotic cell phagocytosis depends on macrophage differentiation

The interest in the biological effects of non-ionizing electromagnetic fields (EMFs) and static magnetic fields (SMFs) on the whole organism, as well on cellular systems, has noticeably increased in recent years in consideration of their increased production (from the generation and transmission of electricity, to domestic appliances and industrial equipment, to telecommunications and broadcasting) and the possible health risk for humans. About one century ago, associated with the wide use of electricity, artificial electric and magnetic fields became a part of our living environment. The use of technology in communication, entertainment, industry and science enhanced our quality of life. On the other hand, the biological effects of the electric and magnetic fields associated with this technology are not well understood.

In the work published on page 1432 of this issue of *Experimental Biology and Medicine*, Dini and co-workers have incorporated nanotechnology, material science and the clinical imaging modality MRI, to create a nano-sized probe capable of non-invasively visualizing and quantifying the blood vessel growth in tumors in a preclinical model. The work was carried out by Elisa Panzarini, as part of his postdoctoral research, working together with Luciana Dini and other colleagues, at the University of Salento, Department of Biological and Environmental Science and Technology, Lecce, Italy.

Dr Dini stated 'Taking into account that innate immunity is based on macrophage phagocytosis of non-self microorganisms and particles, the exposure to SMF could interfere with a correct immune response. Indeed, phagocytosis of apoptotic cells represents the endpoint of apoptosis, allowing the fast removal of dead cells by neighbours and macrophages. For phagocytosis of apoptotic cells to proceed correctly requires the action of a number of genes greater than those involved in the induction of the apoptosis itself. Impaired phagocytosis of apoptotic cells is the cause of several diseases.'

The research team studied the effects of 6 mT SMF on the phagocytosis process of differentiating macrophages by using human Kupffer cells, Raw 264.7 macrophages and 12-*O*-tetradecanoylphorbol-13-acetate [TPA]-differentiated THP-1 monocytes and U937 promonocytes. Indeed, macrophage phagocytosis is the basis of innate immunity and the exposure to SMFs could interfere with a correct immunoreponse. In particular, with this study, the researchers aimed to verify the effect of 6 mT SMF on the phagocytosis mechanism and to compare these effects with those on other internalization processes, like endocytosis.

For many years, this research team has focused its interest on the study of the biological effects of SMFs, in particular,

moderate intensity (ranging from 1 mT to 1 T) SMF that represents the lowest intensity able to interfere with the apoptotic process in relation to apoptotic cell death. Results obtained indicating that (1) SMF significantly influences the phagocytosis of apoptotic cells and latex beads, and to a lesser extent, fluid phase endocytosis and that (2) the effect of SMF is dependent on the degree of macrophage differentiation, validate that the primary site of action of SMF is at the plasma membrane. Indeed, the plasma membrane has a pivotal role in the recognition of apoptotic cells and for their engulfment through connection with the cytoskeleton. A 6 mT SMF is able to modify cell surface morphology, distribution of plasma membrane proteins, receptors and sugar residues and disarrange the cytoskeleton.

Dr Dini said 'On the basis of the results obtained in this study in human primary macrophages, even if it is not yet possible to foresee application in medicine, it follows that it is better to avoid exposure of patients bearing a wound, inflammatory foci or abnormal production of apoptotic cells to machinery (including medical equipment) producing moderate intensity SMF. The reason being that recruitment of monocytes from the blood could be delayed and thus the rescue of the tissue from inflammation postponed, or a chronic condition could be favored.'

Several studies have suggested a potential cause-effect relationship between removal of dead cells and the onset of human pathologies. Indeed, diseases such as lupus erythematosus, cystic fibrosis, chronic obstructive pulmonary disease, atherosclerosis, encephalomyelitis autoimmune and multiple sclerosis are correlated to the delayed or inefficient removal of apoptotic cells, which can cause persistency of inflammation and tissue damage leading to the onset of immune response. The results obtained in the current study suggest that the exposure to 6 mT SMF affects fluid-phase endocytosis and phagocytosis in monocyte/macrophages in a differentiation degree-dependent manner. Thus, even if the underlying biological mechanisms are still for the most part unclear, this work could help to explain the effects of exposure in support of a possible causal relationship between SMF and differentiation degree.

Steven R Goodman, Editor-in-Chief of *Experimental Biology and Medicine*, said 'This interesting study by Dini and colleagues suggests the need of thoughtful consideration of the level of SMF exposure that is appropriate for patients bearing a wound and resulting inflammation.'

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