*MEDICALLY SIGNIFICANT EFFECTS OF ELECTROMAGNETIC ENERGY

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Electromagnetic energy has a role in clinical medicine, but unlike agents such as drugs, x-rays, or the surgeon's scalpel, many important aspects of how it functions in the living system remain unknown.

The impact of electromagnetic energy in clinical medicine is evolving in numerous studies that are exciting because they point to a new and previously unsuspected biology. But the studies are also disquieting because they indicate that some patterns of human exposure to man-made electromagnetic energy in the environment present a public-health problem.

A living organism can be subjected to local exposure to electromagnetic energy—a bone or a specific organ, for example—or to systemic exposure in which the entire organism is treated. Either method of exposure can produce local or systemic biological changes, and these changes can then interact with the effects produced by other physiologically significant parameters in the organism's immediate environment. As a consequence of this complicated interplay, it is difficult to conceptualize the exact physical nature of the link between the applied electromagnetic energy, and any specific physiological parameter that may be altered following exposure. Causation (in the statistical sense of a deviation from baseline of a physiological parameter beyond that ascribable to chance) has been demonstrated in numerous studies. In contrast, our knowledge

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regarding the means by which the interaction was actually mediated remains almost completely speculative.

Therapeutic use of electromagnetic energy in orthopaedics constitutes an important clinical application of electromagnetic energy. Numerous studies have shown that 5–50 microamperes of direct electrical current applied to bone in animals elicits an osteogenic response. This capability of direct current has been employed clinically to treat bone nonunions.

Practical clinical and economic considerations have led to the development of other forms of electrical energy for treatment of nonunions. Among these methods are time-varying magnetic fields, and alternating current (applied via electrodes in contact with the skin). Each technique has its particular advantages and disadvantages. Remarkably, the clinical success rate appears to be independent of the technique used.

One of the most promising areas for potential future development involves acceleration of fracture healing. If the normal healing process could be safely accelerated, then injured patients could be mobilized more quickly thereby resulting in a significant clinical benefit. The underlying effect of electromagnetic energy on bone is to increase the number of bone-building cells in the treatment area. In the typical animal model (which involves an acute osseous lesion) this response is manifested as an increased mass of bone at the treatment site compared to the control site. In human applications involving the treatment of nonunions, it is manifested as a relighting of the growth process, and it results in an appropriate number of cells to repair the osseous defect. Fracture healing might be accelerated by increasing the number of bone-building cells at the site of the lesion. This seems to be an ideal application for electromagnetic energy because it produces additional bone-building cells without significantly damaging the bone itself. Recent studies involving locally administered direct electric currents in an animal model strongly support this view.

Nonunions and fractures are two pathological conditions of bone that are remedied by the presence of active bone-building cells. Most other pathological conditions of bone are nonlocalized (osteoporosis, for example) or are a result of changes in other tissues (avascular necrosis). In such cases, merely increasing the number of cells would not constitute a rational therapy.

Electromagnetic energy applied locally in an appropriate manner can foster bone healing, but when applied systemically it can produce the opposite result. Systemic electromagnetic fields are biological stressors, and they elicit the typical adaptive response found following application of other stressors such as heat, cold, or trauma. Chronic stress is inimical to healing, and thus rats that have undergone fibular osteotomies heal the injuries more slowly than do nonexposed control animals.

Chronic systemic stressors are disease promoters because they tax adaptive capacity thereby rendering the exposed organism more susceptible to cancer and other diseases. High-voltage powerlines, radar, and other radiating structures produce significant levels of electromagnetic energy in their immediate vicinity, and are therefore a public health concern because they tend to promote disease via their impact as systemic stressors.