FIFTH ANNUAL INTERNATIONAL SYMPOSIUMON MAN AND HIS ENVIRONMENT IN HEALTH AND DISEASE

Dallas, TX. 1987

PRESENTATION

Role of Electromagnetic Energy in Disease

Andrew A. Marino
Department of Orhhopaedic Surgery
LSU Medical School in Shreveport

Summary. I will discuss electromagnetic fields in the environment from the viewpoint of their potential clinical significance. My conclusion will be the evidence continues to show that these fields have an important role in both acute and chronic disease.

1. The electromagnetic spectrum consists of an infinite range of frequencies, including zero. Cosmic and geological processes create some energy at almost every frequency, but most of the electromagnetic energy in our environment is man-made. Beginning about 1875, man learned to build the machines that made this energy. In the slide I've indicated the frequencies of some of the most common forms of man-made electromagnetic energy. The mammal has only one established receptor mechanism—the eye—which is sensitive to only a very narrow range of frequencies immediately below the ultraviolet range. Electroreceptor cells have been identified in various marine species, and magnetoreceptors have been discovered in bacteria. Twenty years ago, when the subject that I am discussing today began, the absence of a discrete biological structure that could detect non-light frequencies in humans was presumed to establish that these frequencies had no biological significance. Insofar as I can tell, virtually all of the proponents of this view have retired.

2. This slide shows a clinical system for use in treating bone fractures with electromagnetic energy. This application, like the one we heard about from Dr. Nordenstrom today, and others that I could point to that are in clinical use, involve the *local* application of electromagnetic energy. My talk today will deal not with local application of electromagnetic energy, but rather with systemic application. As I shall discuss, health implications of environmental electromagnetic energy derive from their stimulatory effect on the neuroendocrine system, and activation of this system is usually associated with systemic exposure.

3. What are the sources of electromagnetic fields that contribute the greatest amount of exposure to a typical patient? High-voltage powerlines are an important source of such fields. The zone of influence of the highest voltage lines presently operating in the United States extends for almost one mile on each side of the line. Within the zone of influence, the fields are present continuously.

4. Video display terminals are a prolific source of electromagnetic fields, particularly within several meters of the device.

5. Most radar detectors have superheterodyne circuits which means that they actually generate a microwave signal that is close in frequency to the signal from the police radar. Thus the user is directly and continuously exposed to the signal produced by the detector. The situation is akin to the use of walkie-talkies in which the radiating antenna is typically only a few inches from the head, resulting in the highest exposure that I have seen in non-occupational environments.

6. Microwave ovens are permitted, by federal law, to leak substantial amounts of electromagnetic energy before they are deemed unsafe. The hazard is compounded by the fact that many of the inexpensive devices sold to detect oven leakage do not work properly.

7. This slide shows a microwave communications link used by the telephone company for long-distance communications. A typical installation consists of a receiving antenna, an amplifier, and a transmitting antenna. Individuals who lie in the path of the transmitted beam, of which there are many hundreds of thousands in the United States, experience significant exposure to the microwave beam.

8. This is an antenna farm, that is, a group of radio and television towers usually situated on a relatively high point near the city that they serve. Living in the vicinity of such farms results in significant exposure.

9. Perhaps the only form of exposure that is worse from a clinical viewpoint is that provided by electric blankets and heated waterbeds.

10. What does this man-made energy do? The best way to find out is to simulate it in a laboratory setting and see what effect it has on animals. This slide shows what happens to brain electrical activity in rats when an electromagnetic field is applied. What is being measured is the total electrical activity. When the field was applied, a transient change in brain activity was observed. When the field was turned off a smaller, but still significant, transient change was seen. The measured parameter exhibited a kind of adaptive response to the field. I saw a similar phenomenon in mice when I measured the concentration of red blood cells. Animals that went from no field to field exposure exhibited a drop in red blood cell concentration, and another group of animals that had been adapted to living in the field also exhibited a decrease in red blood cell concentration when they were *removed* from the field.

11. This data was obtained from two groups of volunteers who lived in specially designed rooms. In the middle of the test period, unknown to the subjects, the field was applied (shown by cross-hatching). You can see that the average level of the triglycerides in the blood of the exposed patients rose markedly compared to the controls.

12. I performed an experiment in which three generations of mice lived continuously in an electromagnetic field. This is a picture of a control and exposed mouse from the third generation. This is not the largest control and the smallest experimental. These are representative animals from each group.

13. Electromagnetic fields are used frequently to make bones heal, but I produced the opposite result when I applied the fields systemically. We surgically induced a fracture in the rat fibula and examined the amount of healing present 14 days later in exposed animals compared to control animals. Healing in the exposed animals was significantly retarded behind the corresponding controls.

14. The most pragmatic way to interpret the animal data is that the applied electromagnetic field constitutes an additional factor adding to the animal's total load. The animal's response to the presentment of the field is the same as its response to any other factor in its environment—if the total instantaneous load is below capacity, the reaction is adaptive.

15. What happens if capacity is exceeded? Well, you know what happens, the animal gets sick. The phenomenon has been demonstrated in innumerable experiments. This is one. When a tumor is implanted in mice it grows at a known rate (lower curve). When the animals are given a specific stress by being rotated for several hours on two successive days the rate of tumor growth is greatly accelerated. The animals can adapt to less stressful amounts of rotation, and in those cases, no effect on tumor growth is seen.

16. Not all stressors are somatic—some are neurogenic. This data shows the mean episodes of respiratory illness in two patient populations that differed only in the extent of self-perceived stress in their lives (determined by use of questionnaires).

17. Well, if stressors promote disease, and fields are stressors, then fields should be correlated with human disease. They are. This is one example. In a group of 272 children in the Denver area who died from cancer, 101 children lived near powerlines, whereas only 55 would have been expected to live near powerlines if the powerlines were not a factor in the incidence of the disease.

18. Another study performed two years later found the same result for adult cancer. That is, more cancer cases occurred near powerlines than would be expected to occur there.

19. This summarizes the results of three studies involving men who were occupationally exposed to electromagnetic fields. They worked at such occupations as electrical engineers, power company employees, and so forth. In each case, the incidence of cancer was greater than that expected based on an analysis of the control group.

20. This is an outline of the city of Wichita, Kansas, and it shows the location of two airports whose radars blanket the city. Because the topography of the city varies from place to place, some areas are shielded from the line of sight radars, where others are not shielded. The red area indicates the portion of the city that is not shielded, blue indicates the portion that is shielded from one airport radar, and green indicates the portion that is shielded from both airport radars. The investigators found that the incidence of cancer was highly correlated with the shield. The highest cancer levels occurred in the red area, and the lowest cancer levels occurred in the green area.

21. It is not always cancer that is correlated with field exposure, but it is usually something for which we have complete, and easily obtainable public-health statistics. Each dot here depicts the location of a suicide victim in the Midlands section of England. When we

examined the distribution of suicide cases in regard to high-voltage powerlines, we found a high correlation. More suicides occurred in regions of high electromagnetic fields than would have been expected, based on control data, if the field was not related to the suicide.

22. It seems to me that the present state of the development in this area is both exciting and frustrating. The excitement stems from the fact that we now have a new handle on what causes disease—something that the physician can consider and remove from the environment of a particular patient. On the other hand, the data that we have relating fields to disease is statistical—it relates to a group—and it does not provide much help with regard to individual patients. There have not yet been any systematic studies of the avoidance/challenge design.

23. Electromagnetic fields are a relatively recent addition to man's environment. It's clear that we are simply scratching the surface regarding our understanding of the direct effect that they produce, and the effect that they may produce in synergy with other environmental contaminants.