MICROWAVE EFFECTS ON CENTRAL NERVOUS SYSTEM ATTRIBUTED TO THERMAL FACTORS

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Abstract

Microwave-produced changes in CNS-evoked potentials appear limited to thermal effects, as evidenced by 1) similar changes being elicited by equivalent non-radiation heating, and 2) reduction or even reversal of radiation effects with concurrent brain cooling.

Summary

Previous work, Guy, Harris and Ho [1], and Johnson and Guy [2], has demonstrated alterations in central nervous system function, as evidenced by changes in latency (time interval between stimulus and response) of late components of an evoked thalamic response, with microwave illumination (>5 mW/cm^2) of the head area of cats. These changes are in the nature of decreased latency of late components of such evoked responses when absorbed powers (>5 mW/cc peak) are sufficient to cause temperature increases in the involved tissue. These effects are interpreted as being heating effects rather than radiation effects per se, largely because no such effects are apparent when radiation parameters are adjusted to preclude brain temperature increases.

The present report reinforces this interpretation by two lines of evidence: 1) Thalamic-evoked potential latency changes like those attendant to radiation heating can be shown with non-radiation heating of the central nervous structures involved; and 2) Nervous system changes resulting from microwave illumination heating can be counteracted or reversed with concurrent cooling of the affected tissue.

Methods

Cats comparable in size to those used in the Guy studies were anesthetized, placed in a stereotaxic instrument and acutely implanted with a glass microelectrode in the left nucleus ventralis posterolateralis of the thalamus and with a glass guide for introduction of a thermocouple into a homologous site in the contralateral brain hemisphere. The cats were further instrumented for the measurement of rectal temperature and electrocardiogram. Needle electrodes applied to the right forepaw provided shocks at the rate of one per second as stimuli to elicit activity in the thalamic recording site. The cats were tracheotomized and maintained by artificial respiration. To this point, the arrangement duplicated that used by Guy, Harris and Ho. However, the cats in the present study were then fitted with heat exchange devices. These were cylindrical tubes constructed of brass, for heating in the absence of microwave illumination, or of pyrex for experiments involving simultaneous radiation and cooling. The two types of exchangers were similar in configuration, both being 7mm in diameter and 40mm in length. They were applied to the base of the skull, using a transpharyngeal approach with division of the posterior palate and retraction of the soft tissues. The exchangers were attached by plastic tubing to the outlet and return ports of a Beckman constant temperature fluid circulator. Those cats subjected to microwave illumination were radiated with a controlled continuous wave source at 918 MHz and a cavity radiator positioned 8cm posterior to the occiput.

Net microwave power inputs to the radiator (10W and 15W) were selected on the basis of prior observations, for which the peak absorbed powers of 20 mW/cc and 30 mW/cc have been well defined as being sufficient to produce effective temperature rise and related evoked potential change within 15 minutes exposure (FIG. 1). These changes were verified within the present experiments. Because of animal-to-animal variation in the efficiency of thermal coupling between the exchange devices and the brain, the temperature of heating or cooling fluid was empirically determined for each experiment.

Results

Elevation of thalamic temperature by the circulation of heated fluid through an exchanger applied to the base of the skull resulted in evoked potential changes comparable to those produced by microwave heating of the same magnitude. In contrast to an earlier observation that heating of the whole cat by means of a heating pad yielded decreased latency in both early and late components of the evoked potential, the exchanger-heated cats showed changes only in late components. This is directly analogous to the microwave case. This demonstration supports the contention that the microwave effect is a thermal phenomenon. FIGs. 2 and 3 represent even more convincing support for this view. These figures show the sequential pattern of brain temperature and evoked potential latency with successive application of radiation alone, cooling alone, radiation combined with cooling and during periods in which the animals' own temperature compensation mechanisms are in operation (i.e., during "recovery" from a radiation elevation, or a coolant depression, of temperature). It is very evident that the evoked potential changes are associated with particular direction and magnitude of temperature change. With appropriate titration of coolant temperature against radiation energy, it is even possible to reverse the change that would be anticipated with radiation alone.

Conclusion

The present work supports the contention that evoked potential changes seen with microwave illumination of the central nervous system are limited to those that can be attributed to thermal loading.

References

1. Guy, A.W., F.A. Harris and H.S. Ho. "Quantitation of the Effects of Microwave Radiation on Central Nervous System Function." Proc. 6th Ann. Int. Microwave Power Symp., Monterey, California, May (1971).

2. Johnson, C.C. and A.W. Guy. "Nonionizing Electromagnetic Wave Effects in Biological Materials and Systems." Proc. IEEE, 60:692-717, June (1972).

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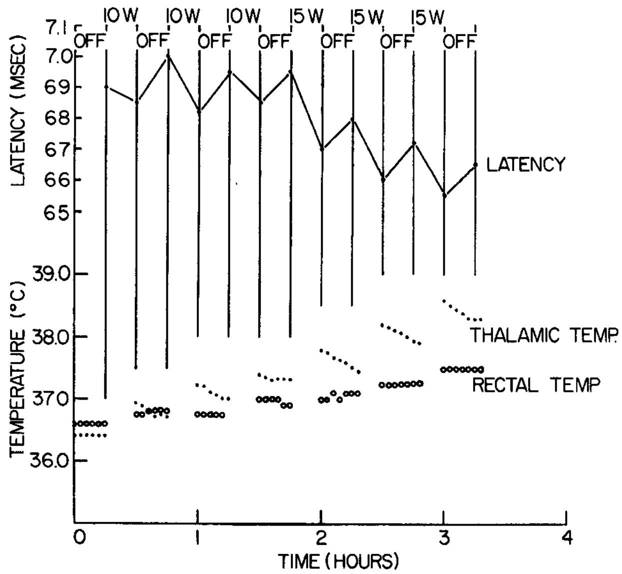

FIG. 1* Data from prior work of Guy, Harris, and Ho, indicating successive 15-minute periods of radiation heating and passive cooling with resultant changes in evoked potential latency.

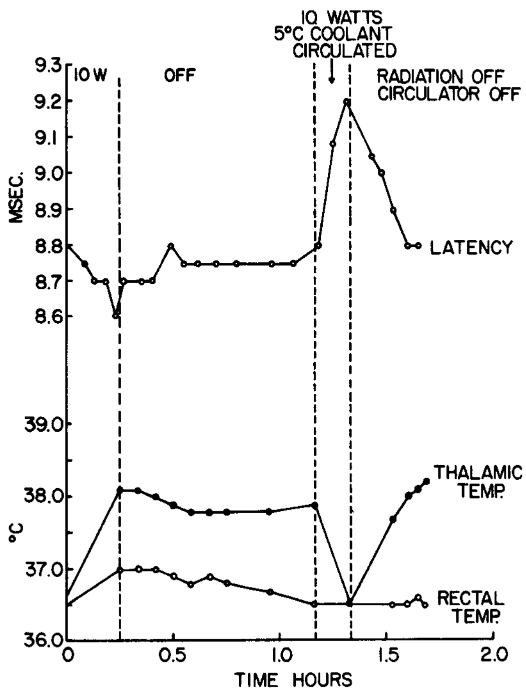

FIG. 2 Sequential microwave radiation (10W incident, 918 MHz cw). No-treatment periods and combinations of radiation heating and active cooling with related evoked potential latencies.

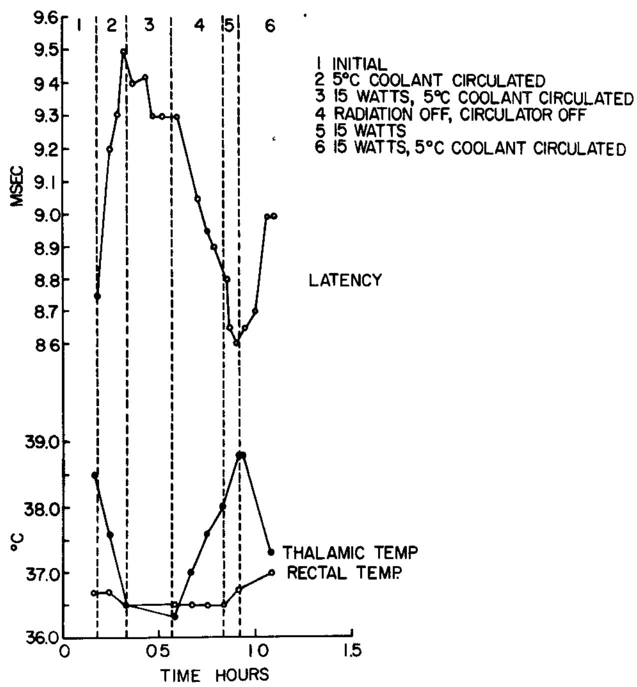

FIG. 3 Combinations of microwave radiation at 15W incident, 918 MHz cw, and active cooling and effect on evoked potential latencies.

*1W approximately equivalent to peak absorbed power density of 2 mW/cc in brain of cat and incident power density of 2.48 mW/cm^2 at unoccupied position of head.