MICROWAVE EFFECT ON RABBIT SUPERIOR CERVICAL GANGLION

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Abstract

Rabbit superior cervical ganglia were exposed to continuous wave 2450 MHz fields within a temperature controlled waveguide environment. Absorbed power densities between 2 and 1000 W/kg failed to significantly influence conduction latencies of responses recorded from postganglionic fibers due to stimulation of either B (myelinated) or C (unmyelinated) fibers in the preganglionic trunk.

Summary

The present work was designed to shed some light on the controversial topic of effects of microwave radiation on tissues of the central nervous system [1]. Recent work in this laboratory [2] showed that conduction characteristics of peripheral nerves were not affected by microwave radiation, as had been previously reported, if care was taken to control the temperature surrounding the nervous tissue during the exposure. It is our intention in this paper to report some measurements on an excised piece of the peripheral nervous system that contains synaptic connections, such as the superior cervical ganglion. A waveguide exposure system similar to that described previously [2] was used. The system permitted precise control of the temperature of the preparation while allowing exploration of microwave effects on nervous tissue more closely resembling the central nervous system in complexity. The superior cervical ganglion has been well studied by physiologists [3,4] and pharmacologists [5] and is known to have synaptic systems utilizing both acetylcholine and catecholamines as transmitters. This ganglion is of interest in its own right as a major output relay for sympathetic nervous system functions related to cardiac acceleration, vasoconstriction and secretion in the salivary glands, and pupillary dilation and vasoconstriction in the eye.

A silver plated S band WR284 waveguide flushed with 2.5 gal/min of temperature controlled mammalian Ringer's solution served as the exposure environment. The Ringer's was composed of 3.5 mM KCl, 3.9 mM $CaCl_2$, 15.7 mM $NaHCO_3$, 138.3 mM NaCl and 8.7 mM glucose and was equilibrated with 95% O_2-5%CO_2. Figure 1 depicts the ganglion stretched across the waveguide between a set of stimulating electrodes on the preganglionic side (outside the waveguide) and a suction electrode on the other (with a glass capillary projecting into the waveguide to make contact with the postganglionic nerve inside the waveguide). Right and left superior cervical ganglia were removed from 3 to 6 kg New Zealand white rabbits under urethane anesthesia (1500 mg/kg). The postganglionic nerve (internal carotid) was difficult to dissect out with a length of more than about 5 mm. Thus it was necessary to project the suction capillary tube into the guide so as to leave the ganglion proper in the center of the radiation fields. Continuous wave power sources operating at 2450 MHz were used to feed the waveguide. A directional coupler placed right in front of the coax to waveguide transition allowed constant monitoring of both forward and reflected power with microwave power meters (Hewlett-Packard 430C). Reflected power was found to be 1% or less of the forward power at all times.

Figure 2 illustrates the basic measurement made and the essentially negative results. Several records were averaged with a computer of average transients to eliminate some 60 cycle noise that was present. 4 to 8 volts of stimulation with 100 to 300 μsec pulses presented at 1 per second were sufficient to bring in the first B fiber mediated response. At higher strengths the longer latency C fiber mediated response appeared. Generally, stimulus strengths sufficient to excite both classes of preganglionic fibers were used and measurements of response latencies of both components (indicated by arrows) were made for various radiation levels. 2450 MHz radiation was applied at the indicated levels for periods of 1 min with 1 min between radiations allowed for control measurements. Only at absorbed power densities above 100 W/kg (50 mW/cm^2) did we observe temperature changes of 0.1°C or more in the solution just exiting the waveguide. The temperature dependence of the response latencies was also investigated and found to have typical changes of 0.6 msec/°C for the low threshold-short latency responses and 1.5 msec/°C for the high threshold responses.

Figure 3 summarizes averaged low threshold response latency measurements for 3 trials of CW radiation and the intervening 3 control periods for 3 different ganglia at several increasing radiation levels. 5% t-tests failed to reveal any significant differences between control and exposure period latencies. Standard errors were typically 0.1 msec for any one point on the graph except for the disparate third pair of points in the 11/12A experiment. Figure 4 illustrates, in a similar fashion, some measurements on the higher threshold-longer latency responses of the same three ganglia. Again no significant differences (at the 5% level) were found between averaged responses during exposure and control periods. The slight temperature rises that occur due to microwave heating are the same in Figures 3 and 4.

The work reported here is important for several reasons. First, in light of reports [6,7,8] of decreases in latency of synaptically mediated responses upon exposure to microwaves within the CNS where temperature changes cannot be easily controlled, we have shown that, within a temperature controlled environment where there is no temperature rise due to microwave absorption, latency changes are not observed in a mammalian synaptic system. Second, an important relay station (in vitro) for autonomic control of cardiovascular as well as other important physiological functions has been shown to be unaffected in any simple manner by CW microwave radiation. Finally, we have established that the temperature dependences of these two conduction latencies are 0.6 and 1.5 msec/°C, respectively, for the low and high threshold responses near 37°C.

REFERENCES

1. C.C. Johnson and A.W. Guy, "Nonionizing Electromagnetic Wave Effects in Biological Materials and Systems," Proc. IEEE, vol. 60, pp. 692-718, 1972.

2. C.K. Chou, and A.W. Guy, "Effect of 2450 MHz Microwave on Peripheral Nerve," IEEE Int. Microwave Symp. Digest, Boulder, Colorado, June 1973.

3. R.M. Eccles, "Action Potentials of Isolated Mammalian Sympathetic Ganglia," J. Physiol., vol. 117, pp. 181-195, 1952.

4. B. Libet, "Generation of Slow Inhibitory and Excitatory Postsynaptic Potentials," Fed. Proc., vol. 29, pp. 1945-1956, 1970.

5. U. Trendelenburg, "Some Aspects of Pharmacology of Autonomic Ganglion Cells," Ergebnisse Der Physiologic, vol. 9, pp. 1-85, 1967.

6. A.W. Guy, 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, Calif., May, 1971.

7. A.W. Guy, J.C. Lin, and F.A. Harris, "The Effect of Microwave Radiation on Evoked Tactile and Auditory CNS Responses in Cats," Summary of Int. Microwave Power Symp., Ottawa, Can., May, 1972.

8. E.M. Taylor, A.W. Guy, B. Ashleman, and J.C. Lin, "Microwave Effects on Central Nervous System Attributed to Thermal Factors," IEEE Int. Microwave Symp. Digest, Boulder, Colo., June, 1973.

Acknowledgements

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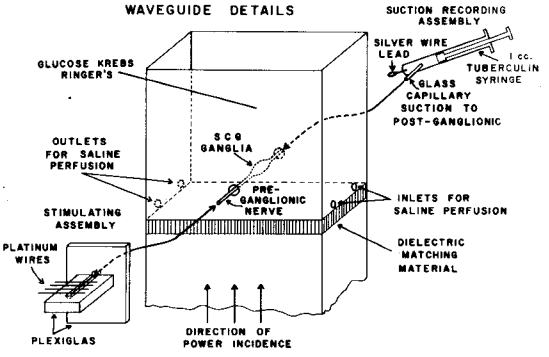

Fig. 1 Waveguide exposure facility for isolated nerve preparation showing the recording assembly.

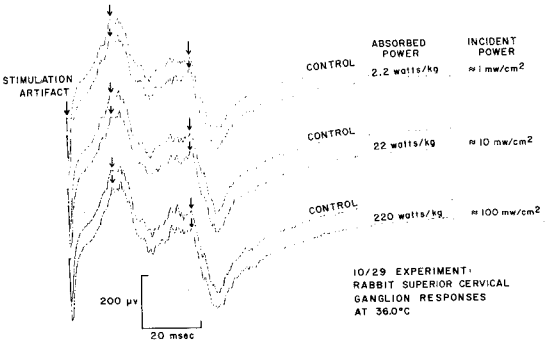

Fig. 2 Evoked responses of extracellular recording of isolated rabbit superior cervical ganglion exposed to 2450 MHz CW radiation.

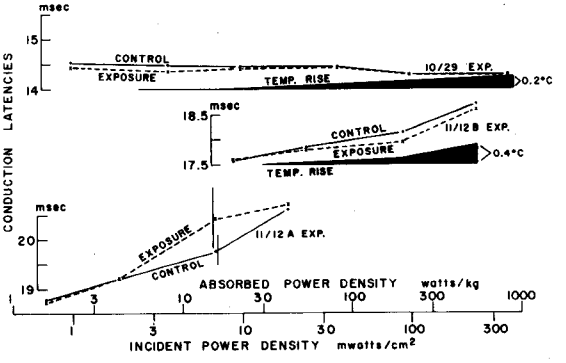

Fig. 3 Low threshold, fast response latencies of rabbit superior cervical ganglia exposed to 2450 MHz CW radiation.

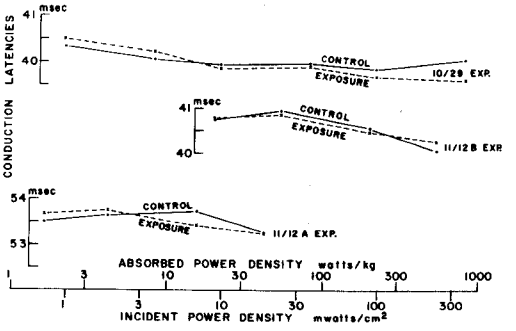

Fig. 4 High threshold, slow response latencies of rabbit superior cervical ganglia exposed to 2450 MHz CW radiation.