VARIATIONS OF PAIN THRESHOLD AND NOREPINEPHRINE RELEASE IN RABBITS DUE TO MICROWAVE STIMULATION

Jian TENG, Hongqu YAN, Danielle VANHOENACKER, André VANDER VORST

Microwaves U. C. L., Bâtiment Maxwell, B-1348 Louvain-la-Neuve, Belgium

Abstract

Microwave irradiation can disturb the equilibrium between the processes of excitation and inhibition in the nervous system. Applying microwaves to stimulate some acupuncture points, analgesic effects are obtained on rabbits: microwave stimulation can increase the pain threshold and decrease the concentration of norepinephrine in the hypothalamic preoptic area at the same time.

1 Introduction

Some experiences prove that microwave irradiation can disturb the equilibrium between the processes of excitation and inhibition in the nervous system (1). For example, the microwave irradiation in rabbits produces alterations in the electroencephalogram(EEG). The changes in EEG tracing, measured during sleep or anesthesia, are interpreted as the inhibition phenomena of the higher fonction of the nervous system(2). Merritt et al observed a decrease in the rat hypothalamic norepinephrine (NE) and dopamine (DA) after a whole-body exposure to 1.6-Ghz microwaves at 20mW/cm^2 (3). The quantity of release of NE in the hypothalamus is proportional to pain sensitivity. Some experiments however prove that microwave exposure produces an excitational effect in the nervous system. It seems that the interaction between microwaves and the nervous system is determined not only by the parameters of microwave stimulation but also by the biological characters of the nervous cells and response of the nervous system to irradiation.

It is known that stimulating either the peripheral nervous system or the central nervous system can yield analgesia. The electric stimulation of the hypothalamic preoptic area (HPA) which is rich in NE can yield analgesia. Some acupuncture points can be stimulated to obtain analgesic effects by hand or electric stimulation. Applying microwaves to stimulate some acupuncture points, we observed that the pain threshold was significanlty increased(4). We also found that microwave stimulation can change the concentration of NE in HPA, by push-pull perfusion experiments(5).

2 Material and method

The experiment uses the techniques of brain push-pull perfusion. It is a kind of pharmacologic experimental method. Chinese scientists apply and develop this kind of method in the research of the acupuncture analgesic mechanism (6). We use the microwave applicators instead of the acupuncture needles and also replace the electric current by microwave energy to stimulate the points which are used in acupuncture analgesia.

In this *microwave stimulation - brain push-pull perfusion experiment*, the reflex act of the animal can be conveniently observed and, simultaneously, the variation of the concentration of neurotransmitter release in the sample perfusates which are collected in the experiment can directly reflect it in the brain. So, by measuring the level of neurotransmitter release, we can observe the response of the centre nervous system when the microwaves stimulation takes place in the peripheral nervous system. Microwaves stimulate the "HeGou" and "WaiGuan" acupuncture points, which are located in the two front limbs of the animal.

The microwave source used in our experiment is a transistor oscillator that delivers a set of spectral lines extending from 0.2 to 3.0 GHz. Most of the microwave energy is brought by the lines at 0.25 GHz, 0.5 GHz,0.75 GHz and 1.0 GHz, although the content respectively at 0.25 and 1.0 GHz is 10 dB lower than at 0.50 and 0.75 GHz (4). The output power can be controlled by adjusting the bias of the oscillator, with a maximum power of 2 watts.

Three different applicators were used.

(1) A flexible coaxial cable applicator. Microwave energy is led by a special coax-connector on one side of the cable and radiated by the extension of the center conductor of the coaxial cable and by the exposed external conductor. Using a hypodermic needle (Ø0.8mm), the dipole is led into the acupunture point. The needle is then drawn out and fixed upon the special coax-connector. The advantage of this applicator is that once the dipole is well located, we can easily glue the coaxial cable on the skin. Hence, small movements of the rabbit's legs will not move the dipole. The reflection coefficients of the applicator measured in various environments like albumin and raw meat have been published before (5).

(2) A standard applicator. The shape of the applicator and the reflection coefficients measured in different conditions have been published (4). A coaxial cable is terminated by a coaxial horn. An acupuncture needle can be inserted at the end of the central conductor, or replaced by a small flat surface. Hence, it can be used in the two different configurations. The frequency response is such that the applicator transmits adequately the line at 0.50 GHz, with a transmitted power level of the order of 0.5 W.

(3) A microwave needle applicator. An acupuncture needle is soldered at the inner conductor of a microwave connector (SMA). It is isolated form the external connector. The shape of applicator and the reflection coeffcients measured in different conditions are shown in Figure 1. The applicator transmits the line at 1.0 GHz, at a power level of about 50 mW.

The radiation diagram and the power density of the applicators were measured by the method of "Albumin coagulation": the applicators are put into albumin in which the microwave energy is radiated. With the coagulation of the heated albumin, we observe an opaque piece around the applicator, which shape corresponds to the radiation diagram.Further more, the dimensions of this opaque piece are directly proportional to the microwave density (5).

The animals chosen for the experiments are rabbits known as "Hollandais" (about 2 kg). Using the Sawyer Diagram, a push-pull cannula (5) is inserted into the HPA (A_{3-4}, $L_{0.5-3}$ or $R_{0.5-3}$, H_{-1--3}) and fixed on the cranium of the rabbit by means of a stereotaxic apparatus.

The experiment starts after the push-pull cannula is implanted for three days. The artifical cerebrospinal fluid is injected by the push cannula at a constant speed (0.1 ml/min), at a temperature of 37°C. The sample is collected from the pull cannula and the pain threshold is measured three times: before, during and after each of the stimulations. It is conserved at a temperature of -40°C. When the sample is collected, at the same time, the K^+ ions penetration is used for determining the pain threshold on rabbits(7).

The radioenzymatic assay is used to measure the levels of NE release in the sample perfusates. After the experiments, the position of the push-pull cannula in the HPA is identified by the morphological method.

3 Results

Table 1 and Figure 2 present respectively the changes of pain threshold and content of NE released from the rabbits' HPA before and during each of the different analgesic stimulations.

4 Discussions

Table 1 shows that the electric stimulation yields good antalgic results, similar to those obtained in China in the same kind of experiments. Both standard and needle microwave applicators are effectives.

The standard microwave applicator presents a twofold application, respectively with and without needle. The latter uses the same mechanism as the Moxa method, due to the discontinuities between the applicator and the human skin, which involves an overheating of epidermis and excites the acupuncture point located below. Due to the fur of rabbits, this method cannot be used. The applicator where the inner conductor is extended by a needle yields a bad contact, hence a large microwave transmission loss. So, the acupuncture point receives only a small part of the generator energy transmitted by the needle.

On the other hand, in the case of the microwave needle applicator, the needle is directly welded into the inner conductor which yields a good electric contact. The matching is acceptable between 1 GHz and 3.5 GHz. As the previous case, the energy available to excite the acupunture point is not very large.

The flexible coaxial cable applicator is not efficient with respect to the analgesic effect, because there is a good matching only in the 4 - 6 GHz band (Fig.1) and again the level of the generator output power is weak in this band. When the transmitted microwave energy is too weak, there is no analgesic effect: the level has to be high enough. This is similar to what happens with electric acupuncture.

Previously mentioned reflex act and push-pull perfusion experiments prove that microwave acupuncture stimulation has the same analgesic effect as electric acupuncture. It still needs to be verified by multiple experiments on a number of animals. Microwave acupuncture seems to be more efficient than traditional warm-needling and is much more convenient to operate.

Warm-needling has an interaction between the thermal stimulation and the thermal receptor of nerve cell. For the electric stimulation, the potential δV, provoked across the membrane of a nerve fibre, may excite the nerve cell. But microwaves, influencing the permittivity of the membrane, can change the bioelectric potential of the nerve cell; this effect cannot be neglected in microwave acupuncture. The microwave analgesic effect is the result of the interaction in the central nervous system between the nerve pulses produced by the microwave stimulation on acupuncture points and by noxious stimulation.

We shall apply microwave pulses stimulation and a new applicator to lower the level of microwave stimulation and to improve the adaptality. In future bioelectric experiments, we shall observe the changes of nerval discharge in the pain sensation site of the rabbit. The signals of noxious nerval discharge in the nuclei recorded by microelectrodes will be analysed by computer. Furthermore, the interaction between microwaves and the nervous system as well as the possibility of applying microwave stimulation analgesia for clinic usage will be studied. We expect to be able to present results of the electrophysiologic experiment at the conference.

5 References

(1) S. M. MICHAELON J. C. LIN: "Biological Effects and Health Implications of Radiofrequency Radiation", Plenum Press, New York, USA, pp.366-384, 1987.

(2) PRESMAN: "Electromagnetics Fields and Life", Dept of biophysics, Moscow University, Moscow, URSS, Transl. by F. L. SINCLAIR, ed. BROWN, PLENUM PRESS, 1970.

(3) J. H. MERRITT, R. H. HARTZELL J. W. FRAZER: "The effect of 1.6 Ghz on neurotransmitters in discrete areas of the brain", SAM-TR -76-3, USAF School of Aerospace Medicine, Aerospace Medical Division, pp.1-11, 1975.

(4) J. TENG, D. VANHOENACKER A. VANDER VORST: "Biological effects of microwave in acupuncture", 19th European Microwave Conference, pp.918-923, London, 1989.

(5) J. TENG, D. VANHOENACKER A. VANDER VORST: "Analgesic effects by microwave acupuncture stimulation in rabbits", 20th European Microwave Conference, pp.973-978, Budapest, 1990.

(6) J.M. ZHOU, W.X. LOU, J.W. JIANG, X.D. CAO: "The role of NE in the preoptic area of rabbit's brain under the acupuncture analgic effect", Acta Physiologica Sinica, vol 38(4), pp.415-421, Beijing, 1986.

(7) WANG YOUJING et al: "Influences of electroacupuncture on monoamine neurotransmetters in rat brain correlated with the voltage and the frequency applied", The Second National Symposium on Acupuncture and Moxibution and Acupuncture Anesthesia, Beijing, 1984.

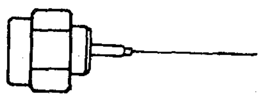

Fig.1(a). Applicator.

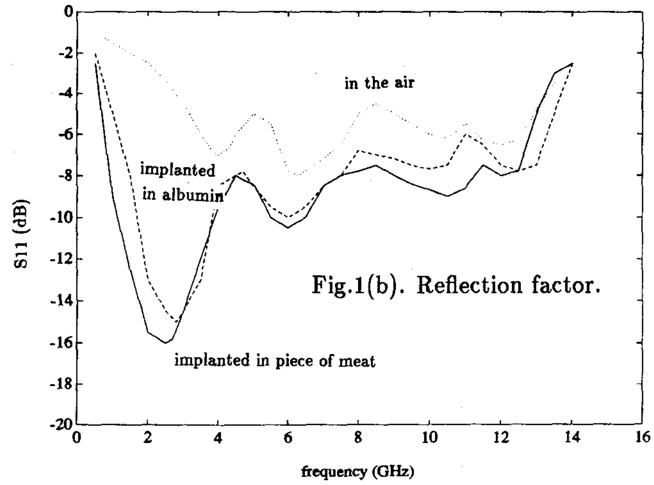

Fig.1(b). Reflection factor.

Fig.1. Microwave needle applicator.

	Pain threshold (mA)			NE released (pg/ml)		
	Before	After	Changes(%)	Before	After	Changes(%)
Acupunctoscop	0.54	0.98	+ 81.4	115.2	78.8	- 31.5
Standard microwave applicator	0.59	0.98	+ 66.1	113.1	82.5	- 27.1
Microwave needle applicator	0.56	1.10	+ 96.4	114.4	74.3	- 35.1
Supple coaxial cable applicator	(0.71)	(0.78)	(+ 9.9)	(113.5)	(117.1)	(+ 3.2)

Table 1. Quantitative analgesic resuts.

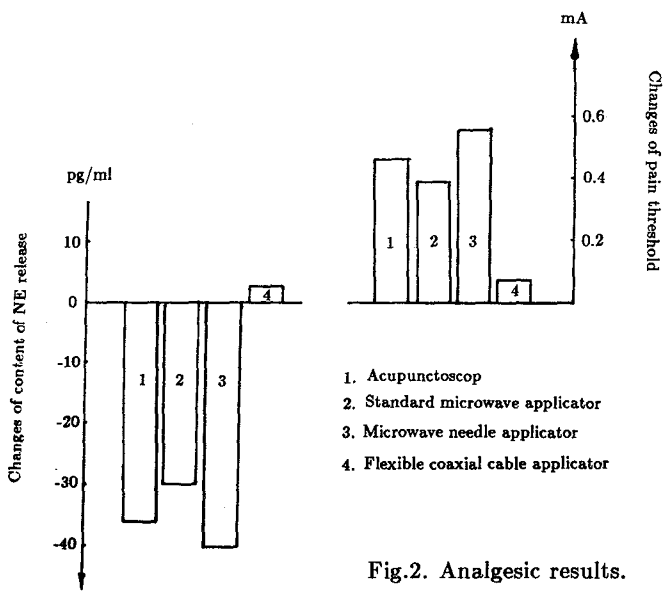

Fig.2. Analgesic results.