Effects of Microwave Radiation and Strychnine on Cerebral Biopotentials in Narcotized Rats

A. V. Sidorenko and V. V. Tsaryuk

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 130, No. 9, pp. 259-262, September, 2000
Original article submitted April 20, 2000

Strychnine and microwave radiation produced changes in spectral parameters of electrocorticogram, correlation dimension, and Kolmogorov entropy, parameters calculated by the methods of nonlinear dynamics opposite to those induced by urethane. The modulatory effect of microwaves on bioelectric cerebral activity in narcotized animals was similar to the effect of strychnine and probably related to enhanced excitability of brain structures and complication of bioelectric processes.

Key Words: *rat; electrocorticogram; narcosis; microwave radiation; strychnine*

The effect of electromagnetic radiation on cerebral biopotentials was demonstrated in numerous experimental and clinical studies. We have previously showed that microwave irradiation modifies cerebral bioelectric activity (CBA) and thereby changes the functional state of the CNS and whole organism [2]. In particular, electromagnetic radiation in the millimeter range modified (synchronized) electrocorticogram (ECoG) of alert animals (appearance of slow waves and spindles). Changes in the parameters of nonlinear dynamic indicate decreased dynamism of neuronal processes. In narcotized animals, microwave irradiation induced an EEG-reaction manifested by an increase of high-frequency rhythms in the ECoG frequency spectrum.

It is interesting to compare the effects of microwave electromagnetic fields and other factors affecting the baseline bioelectric activity of CNS on cerebral biopotentials.

Our aim was to compare changes in ECoG parameters induced by microwaves, urethane (decreases CNS excitability), and strychnine (enhances CNS excitability and activates ECoG).

Belorussian State University, Minsk. ***Address for correspondence:*** A.Sidorenko@RFE.BSU.UNIBEL.BY. Sidorenko A. V.

MATERIALS AND METHODS

Experiments were carried out on 50 random bred rats of both sexes weighing 160-180 g. The rats were anesthetized with urethane (1 g/kg intraperitoneally) and fixed in the stereotaxic apparatus. Gold-coated electrodes with diameter of 0.8 mm were inserted into the somatosensory cortical area in both hemispheres. Urethane was chosen for narcosis because it suppresses locomotor reactions and induces high-amplitude slow waves in the cerebral cortex of both hemispheres and in the hippocampus [1], but does not prevent EEG-detected awakening reaction. Excitability of cerebral structures was enhanced with intraperitoneal strychnine (1 mg/kg). Rat head was exposed to low-intensity microwave radiation (42.2 GHz, 150 $\mu W/cm^2$) in continuous and impulse-modulated modes.

The electromagnetic fields was emitted by a funnel antenna with effective cross-section of 1.6 cm^2, directive antenna gain 22 dB with the beam width between half-power points 17° and 21° in the vector electromagnetic field plane. Irradiation was performed with the E-component of electromagnetic field oriented perpendicularly to the horizontal plane of the brain. The impulse-modulated mode of irradiation was provided by a modulator made on the basis of conductivity modulated *p-i-n* diode and an ESU-1 electric stimulator. Pulse recurrence rate was 1 Hz with relative pulse duration 30.

Bioelectrical activity was recorded on a previously described setup [5]. ECoG was analyzed with the spectral method and using the methods of nonlinear dynamics methods; power spectra within the ranges of 0.5-4 Hz (δ-rhythm), 4-8 Hz (θ-rhythm), 8-12 Hz (α-rhythm), 12-30 Hz (β-rhythm), maximal power spectrum frequency, correlation dimension, and standardized Kolmogorov entropy were calculated. Two latter parameters characterized different dynamic states of CNS. The data were analyzed statistically [4] using Student's t test ($p<0.05$).

RESULTS

Spectral correlation analysis revealed different changes in individual frequency components of the ECoG power spectrum induced by narcosis, microwave irradiation, and strychnine (Fig. 1).

Narcosis significantly decreased the power of β- and α-rhythms, but increased the power of δ- and θ-rhythms. Ten minutes after urethane administration, the maximum of ECoG power spectrum decreased 4-fold. These typical changes in ECoG were also observed by other authors [1]. The coefficient of correlation dimension also decreased 10 min after urethane administration, which was accompanied by a 21.5% decrease in standardized Kolmogorov entropy (Fig. 1). These changes attest to reduced lability (reactivity) of the brain during narcosis, when the inhibitory processes play the dominant role, and indicate attenuation of the CNS dynamism and its transition to a functionally "poor" state.

Microwave irradiation and strychnine induced changes in ECoG spectral parameters and nonlinear dynamic indices opposite to those induced by urethane (Figs. 1 and 2).

In narcotized animals microwave irradiation induced a shift of the power spectrum to a higher fre-

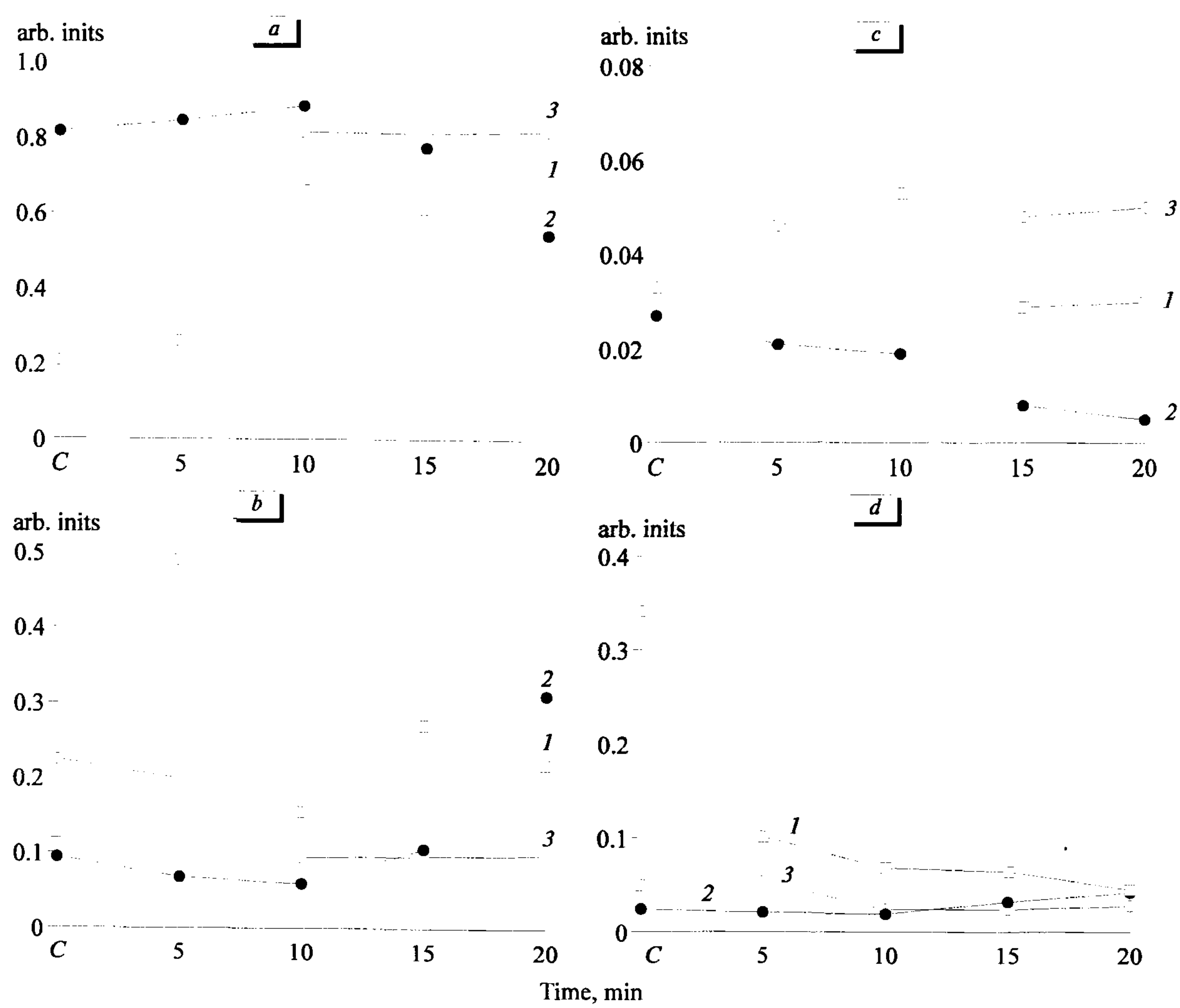

Fig. 1. Power spectrum of δ- (*a*), θ- (*b*), α- (*c*), and β- (*d*) rhythms of cerebral bioelectric activity in narcotized rats. Here and in Fig. 2: *1*) narcosis+strychnine; *2*) narcosis+microwave irradiation; *3*) narcosis; *C*) control.

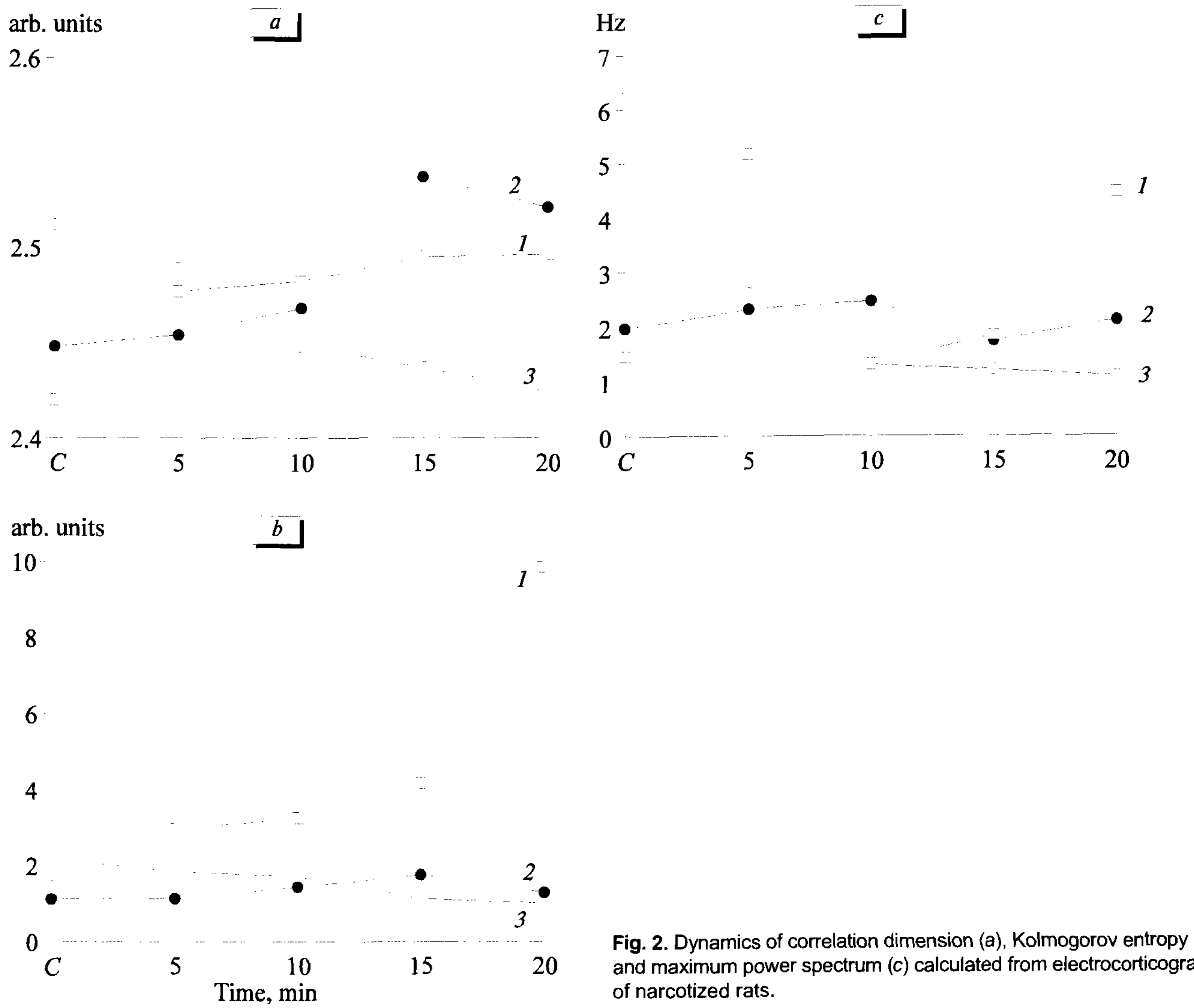

Fig. 2. Dynamics of correlation dimension (a), Kolmogorov entropy (*b*), and maximum power spectrum (*c*) calculated from electrocorticograms of narcotized rats.

quency range (α- and β-rhythms), while the θ- and δ-components characteristic of narcotized state were preserved. This determined small but significant increase in the maximum power spectrum frequency from 1.97±0.04 to 2.47±0.03 Hz observed 10 min after irradiation. Correlation dimension also increased during irradiation, although changes in calculated standardized Kolmogorov entropy were insignificant. It is possible that microwave irradiation complicates bioelectric processes and increases lability of CNS. There is evidence that the increase in correlation dimension may attest to complication of cerebral bioelectric processes [3].

Strychnine changed ECoG parameters in narcotized rats in the same direction as microwave irradiation, but these changes were more pronounced. As soon as 5 min after strychnine injection, the maximum of ECoG power spectrum increased 3-fold due to inhibition of δ-rhythm and enhancement of β-rhythm. ECoG always demonstrated desynchronization (decreased amplitude and increased oscillation frequency). The correlation dimension increased, and Kolmogorov entropy rose significantly, which probably indicates enhanced dynamism of the cerebral system.

Therefore, changes in ECoG induced by microwave irradiation in narcotized animals are similar to those produced by strychnine and are probably related to enhanced excitability of cerebral structures and complication of the dynamics of bioelectric processes. Calculation of ECoG parameters using nonlinear dynamics seems to be a perspective way for evaluation the functional state of CNS.

REFERENCES

1. J. Bures, O. Bureshova, and J. P. Huston, *Techniques and Basic Experiments for the Study of Brain and Behavior*, Amsterdam-New York (1983).
2. V. N. Gurin, A. V. Sidorenko, and V. V. Tsaryuk, *Dokl. Akad. Nauk Belarusi*, **43**, No. 5, 73-75 (1999).
3. N. N. Lebedeva and A. V. Sulimov, *Biomed. Electron.*, No. 7, 47-52 (1999).
4. P. F. Rokitskii, *Biological Statistics* [in Russian], Minsk (1992).
5. A. V. Sidorenko, *Zarubezh. Electron.*, No. 12, 57-61 (1996).