CHANGES EFFECTED BY BITEMPORAL DIATHERMY IN THE ELECTRICAL ACTIVITY OF THE DIENCEPHALIC REGION AND THE CEREBRAL CORTEX OF RABBITS

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The bitemporal diathermy test has long been clinically employed to evaluate the functional condition of the diencephalic region [2, 4, 7, 10, 15]. The attempts to analyze the mechanism of this test from indirect indices (urine secretion, content of blood in diencephalic region) have not been wholly successful. Although the effects of many different agents on diencephalic electrical activity have been investigated [1, 3, 5, 6, 11], no direct encephalographic study of the bitemporal diathermy test has yet been conducted.

This paper gives results obtained in an experimental study of the bio-electric activity in the diencephalic and cortical regions of the brain before and after bitemporal diathermy; the purpose of this study was to furnish physiological grounds for the use of this test in neurological practice.

EXPERIMENTAL METHODS

Ten adult rabbits weighing 2.5-4 kg were investigated. Eight of these were subjected to diathermy; the electrical activity in the diencephalon and cerebral cortex of the other 2 rabbits was studied for 1½ months without diathermy. Electrodes were inserted in the left occipital or parieto-occipital region of the cerebral cortex and in the diencephalon. In the cortex, we used bipolar, steel electrodes, 0.4 mm in diameter, with a distance of 2-3 mm between electrodes; bipolar Nichrome wire electrodes insulated with bakelite were used in the subcortical regions (distance of 1-1.5 mm between electrodes). Both types of electrode were fixed to the skull with phosphate cement.

The location of the subcortical electrodes was determined histologically on frozen brain sections stained according to Nisal. In 4 rabbits, they were located in the hypothalamus (dorsolateral and supramammillary regions), in another 4 animals, in the subthalamus, and in the metathalamus in the last 2.

The experiments began 6-7 days after the electrodes were inserted. An 8-channel "Al'var" encephalograph was used to record the electrical activity of the brain. The photostimulator used to give light stimuli and the sound-generator used for the sound stimuli were manufactured by the same firm. Twenty-minute bitemporal diathermy was carried out with an electrode area of 9 cm^2, using a current of 0.04 A. We studied the original diencephalic and cortical electrical activity in the parieto-occipital region and the reactions to sound (crackling, 6 cps) and to light flashing at a rate of 3-30 flashes per sec. Recordings were made before bitemporal diathermy and 30 min, 2, 4 and 6 hr afterwards. The method proposed by V. A. Kozhevnikov [9], according to which the changes in the general level of electrogram (EG) potentials are determined by measuring the average voltage of the bio-electric potentials, was used to analyze the effect of bitemporal diathermy.

EXPERIMENTAL RESULTS

On the whole, the bio-electric activity of the diencephalic region and the parieto-occipital zone of the cortex observed (visual analysis of EG) in the experimental rabbits coincided with that described in the literature [3, 10, 13]. Changes in the spontaneous electrical activity and the reactions to exteroceptive stimulation were observed after bitemporal diathermy.

The greatest changes were observed in the spontaneous electrical activity of the diencephalon. In most of the rabbits, the general level of the potentials increased by a minimum of 12% (maximum, 260 %) after diathermy (Fig. 1).

These changes were most marked 1 and 2 days after diathermy, after which they gradually disappeared. The spontaneous electrical activity of the diencephalon decreased after diathermy in rabbit No. 5; however, the original voltage was much higher than in the other animals. A second diathermy performed on 3 animals (3-5 days after the first) produced a second wave of increase in the spontaneous diencephalic electrical activity of rabbit No. 3, increased this index in rabbit No. 5 (although the first diathermy had decreased it), and decreased the level of the potentials in rabbit No. 6 (electrical activity originally high). In half of the experimental animals, considerably increased background synchronization at a frequency of 5-6 waves per sec attended the increase in spontaneous diencephalic electrical activity (Fig. 2I), while no changes in frequency were observed in the other 50% (Fig. 2II). The changes in the

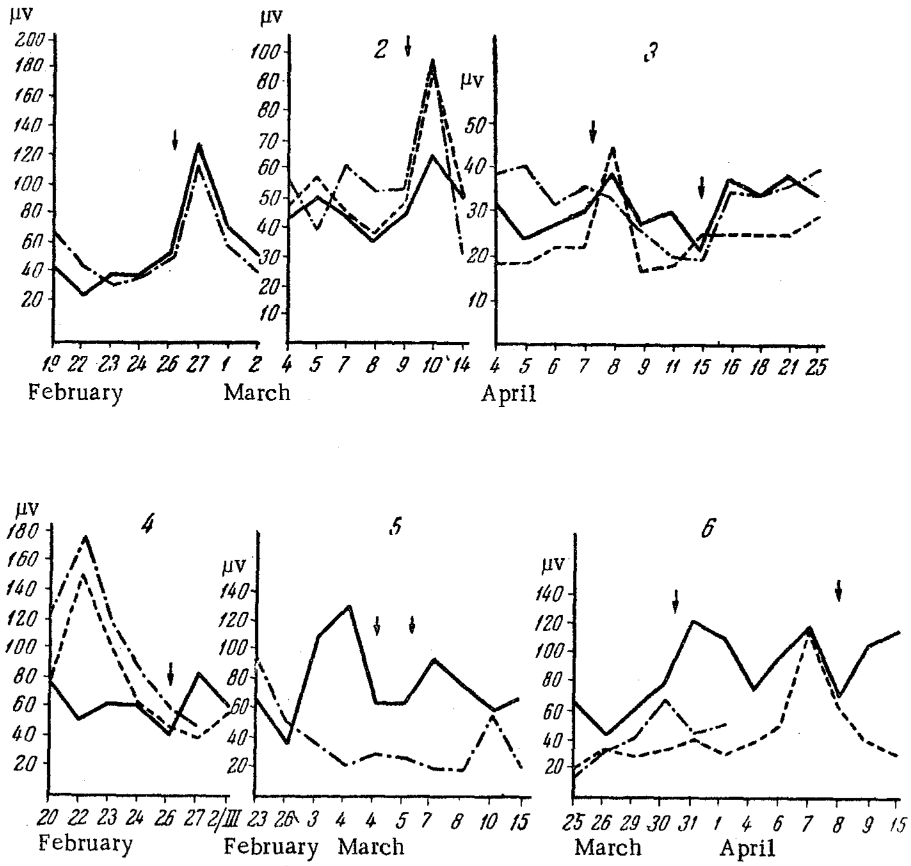

Fig. 1. Voltage changes in biological currents of diencephalic region and cerebral cortex following bitemporal diathermy. Abscissa: experiment date; ordinate: voltage of biocurrents (μv). Arrows shows bitemporal diathermy. Solid line: diencephalic region; dash line: left parieto-occipital zone of cerebral cortex; dot-dash line: same region of cortex on right; 1-6: rabbit No.

cortical potentials after the first and second diathermy were not as marked or as regular as in the diencephalon. Only in the 2 rabbits showing the greatest increase in the spontaneous diencephalic electrical activity did the cortical changes follow the same pattern as those in the diencephalon (Fig. 1, 1, 2). In the other animals, the amplitude of spontaneous electrical activity in the cortex could increase after diathermy (a little later than in the inner-brain, Fig. 1, 5) or even decrease (Fig. 1, 4).

The sound stimuli normally caused two types of reactions in the cortex and interbrain: desynchronization of electrical activity or synchronization at a rhythm of 5-6 waves per sec (usually in rabbits normally showing a tendency to synchronization). The reaction to sound was almost the same after bitemporal diathermy.

The reaction of the intact animals to flickering light stimulation depended on the flicker rate. Flickering light given at a rate of 3-6 flashes per sec caused assimilation of the flicker rates; 15-30 flashes of light per sec either increased the amplitude of the fast EG potentials or caused synchronization of electrical activity at a frequency of 5-6 waves per sec. These reactions were usually more marked in the cerebral cortex than in the diencephalon, where reactions to light stimulation were either indistinct or lacking before diathermy.

The reactions to light stimulation changed less than the spontaneous electrical activity in response to bitemporal diathermy. The changes in the former were as follows.

In the rabbits that did not show increased synchronization of the spontaneous electrical activity of the diencephalon after diathermy, assimilation of the light rhythms increased (Fig. 2, III, IV), especially in cases showing indistinct assimilation before diathermy.

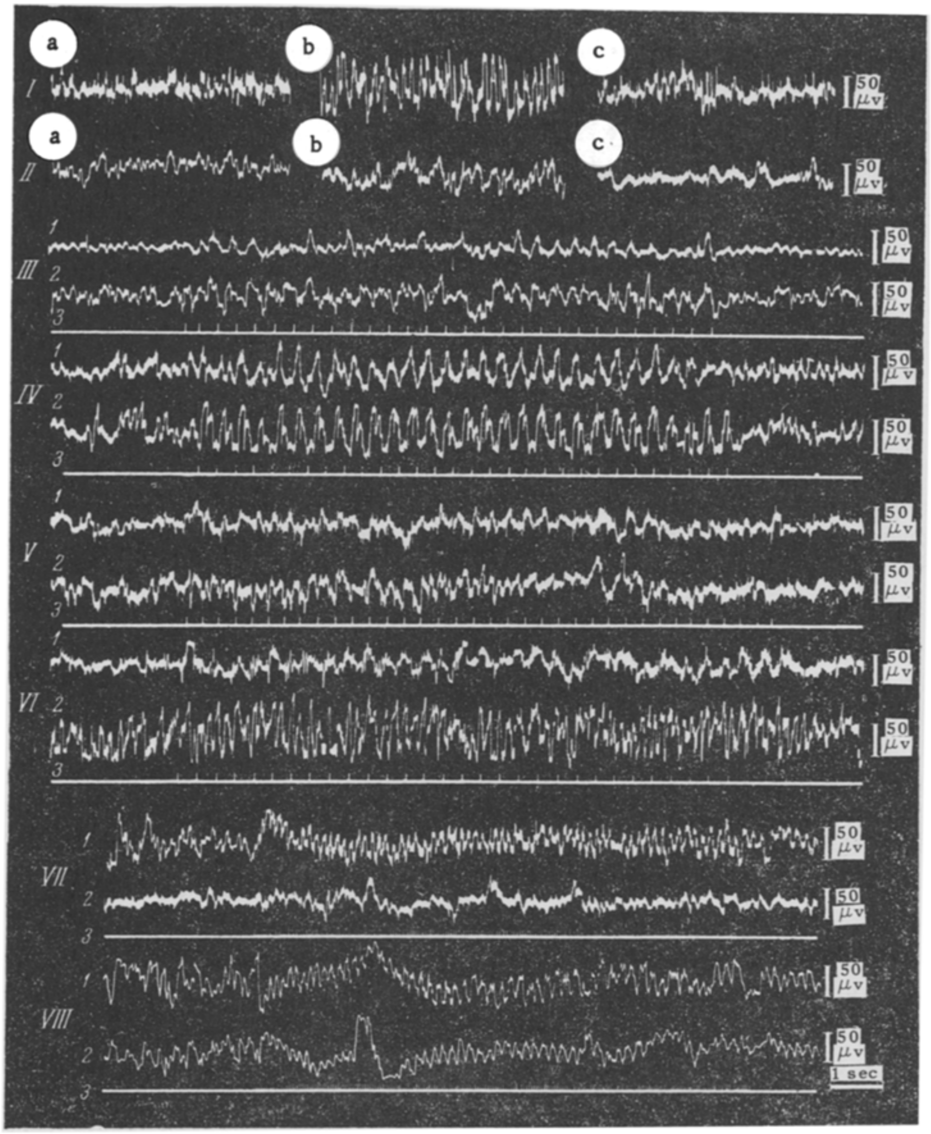

Fig. 2. Changes in bio-electric activity of diencephalic region and cerebral cortex following bitemporal diathermy. I) (Rabbit No. 6) and II) (rabbit No. 3) – EG of diencephalic region. On I and II: a) before diathermy; b) after, same day; c) 5th III) (rabbit No. 3) – before diathermy; IV) same rabbit 2nd day after second diathermy. On III, IV, V, and VI: 1) EG of left parieto-occipital zone of cerebral cortex; 2) EG of diencephalic region; 3) light stimulations. V) rabbit No. 6 before diathermy; VI) same rabbit after diathermy, same day; VII) rabbit No. 1 before diathermy; VIII) same rabbit after diathermy, same day. On VII and VIII: 1) EG of right parieto-occipital zone of cerebral cortex; 2) EG of diencephalic region; 3) light stimulations. Gauge shown on all curves – 50 μv.

Where synchronization of spontaneous electrical activity increased after diathermy, assimilation of light stimulation given at a rate of 6 flashes per sec increased. A reaction not observed before diathermy appeared in the diencephalon in response to light flickering at a rate of 3, 15 and 30 flashes per sec: synchronization at a frequency of 5 waves per sec (Fig. 2, VII, VIII). In rabbit No. 6, the increased synchronization of background electrical activity after diathermy was so great that less assimilation of the 3, 15, and 30 per sec light frequencies was observed than before diathermy (Fig. 2, V, VI).

These changes lasted 4-5 days after diathermy, being maximal the 1st and 2nd days. Like the changes in spontaneous electrical activity, all changes in the reactions to light stimulation were more pronounced in the interbrain than in the cerebral cortex.

Therefore, bitemporal diathermy increases the average voltage of the EG potentials in the diencephalic and cortical regions causing either little change in their frequency or increased background synchronization at a frequency of 5-6 waves per sec; it also promotes stronger reactions to exteroceptive stimulation, as shown by the increased assimilation of the light flicker rate and by the appearance during light stimulation of synchronization unrelated to the frequency of the administered stimulation.

The increased average voltage of the biopotentials and increased synchronization of background electrical activity observed after diathermy were probably the result of an increased total excitability level in the experimental regions. This interpretation is in line with the data of L. A. Novikova and D. A. Farber [12], who concluded that the synchronization at a rate of 4-7 waves per sec which is part of the orienting reaction of the reticular formation and various cortical regions is associated with an increased total excitability level in a rabbit's brain. Our hypothesis is further confirmed by the fact that we observed greater assimilation of the light frequencies after diathermy. A marked change of frequency occurred in both the diencephalon and cortex in response to slow, average and fast stimulation frequencies. Bitemporal diathermy evidently increased both the total excitability level of the diencephalon and cortex and the lability of their cells.

Diathermy produced the opposite effect (the decreased amplitude of spontaneous diencephalic electrical activity observed in rabbit No. 5 after the first diathermy and in rabbit No. 6 after the second) when the original level of diencephalic electrical activity was high (115-130 μv, as compared to 25-60 μv in the other animals). This also was true of the amplitude of cortical electrical activity in some rabbits. The difference in the changes produced by diathermy in diencephalic and cortical electrical activity can be ascribed to the different original functional condition of these regions in the experimental animals. It may be that bitemporal diathermy causes changes in the higher autonomic centers of the hypothalamic region. This assumption, however, does not preclude the possibility of other encephalic effects.

Since all the changes observed were greatest in degree and duration in the diencephalic region (corresponding changes in the cortex being either later to develop or absent), one can assume that the changes in the diencephalon following bitemporal diathermy are primary. The changes in the cerebral cortex are a secondary effect of diathermy, realized through the diencephalic centers.

SUMMARY

As shown in chronic experiments on rabbits, bitemporal diathermy provokes the following changes in most of the animals within the first 24-48 hours after their treatment: 1) a rise of the total level of biopotentials of diencephalic area and of the parieto-occipital zone of the cortex of cerebral hemispheres both in intensification of background synchronization at the rhythm of 5-6 per sec , and in the absence of distinct changes in the frequency characteristics of the electrogram; 2) diathermy causes intensified perception of the rhythm of light flickering or the appearance of synchronization in applying light stimuli, irrespective of their frequency. A suggestion is made that bitemporal diathermy causes a rise of the total excitability level both of the diencephalic area and of the cortex, accompanied by increased lability of their cells. The more marked and constant character of the changes occurring in diencephalic area in comparison with that in the cortex of large hemispheres evidently shows that the changes in diencephalon are primary.

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