Thermoencephaloscopy of Brain Responses to Emotionally Significant Visual Stimuli in Depressive Patients

A. F. Iznak and M. B. Nikishova

Mental Health Research Center, Russian Academy of Medical Sciences, Moscow, 113152 Russia

Received October 9, 2006

Abstract—The thermoencephaloscopic study of patients with reactive depression during exposure to emotionally significant visual stimuli detected a functional change in the state of the frontal associative area of the right hemisphere and the parietal associative area of the left hemisphere and the activation of the left temporal area, closely related to the limbic system. The data obtained may be used for the elaboration of new methods of diagnosis and therapy of reactive depressions.

DOi: 10.1134/S0362119707030152

The problems of brain thermophysiology have been discussed since the beginning of the 20th century; Hans Berger, the founder of electroencephalography, attempted to relate the heat formation in the brain to its functional activity; however, in contrast to electrophysiology, this direction of research has been developed only recently. Thermoencephaloscopy results obtained in experiments with animals indicate that the observed changes in the temperature responses of the brain are determined by both the activity of metabolic processes and the rate of the systemic and local cerebral circulation. A special method of multichannel dynamic radio mapping was developed to study thermal processes of the human brain [1, 2].

The purpose of this study was to analyze the dynamics of the radiothermal radiation of the cerebral cortex in nine patients (eight women and one man aged 35–47 years) with reactive depression developing against the background of a heavy loss (the death of a child) in response to the presentation of visual stimuli emotionally significant for them. A 12-channel radiothermograph with the following parameters was used: operational wavelength, 38 cm; fluctuation sensitivity (Kelvin scale), 0.1 K (at a time constant of 1.2 s); and time of scanning all 12 antennas, 28 s. Contact applicator antennas of the radiothermograph were placed using a special helmet at points corresponding to the international 10–20 system [3]. The study of deep brain temperatures using these methods ensured the recording of the distribution of deep brain temperatures after interpolation over the head surface was outputted to the display. The radiothermal study was performed by specialists from the Institute of Radio Engineering and Electronics, Russian Academy of Sciences. As a stimulus material, an album of reproductions of fragments of Poussin’s paintings was used [4]. The fragments included subjects neutral in terms of associations with the psychic trauma (landscape elements and animals), as well as babies and scenes of death of ancient heroes (biblical subjects), associated with the loss. During the experiment, several successive “frames” of the cerebral temperature dynamics were fixed that corresponded to examination of individual album pages by subjects during 30 s (the time of scanning all 12 antennas of the radiothermograph). Changes in the functional state of the brain under the effects of emotional responses to these stimuli were assessed by comparing the time characteristics of changes in radiothermal radiation in different regions of the brain differing in blood flow and metabolism.

The results of the studies demonstrated that, when reproductions with indifferent subjects were examined, the brain temperature changed insignificantly, while, during the presentation of emotionally significant visual stimuli, considerable fluctuations in the temperature were recorded. In different cortex zones, the temperature changed differently: in the left parietal area and in the right middle temporal area, the temperature decreased by 1–2 degrees; in the left middle temporal area, it increased by approximately 1 degree. In the left parietal area $P_1$ (lead 2) and in the right middle temporal area $F_8$ (lead 7), the temperature decreased, while in the left middle parietal area $T_3$ (lead 4), it increased (figure). In accordance with data on the relationship between brain hemodynamics and metabolism and brain temperature, this means that, during the exposure to emotionally significant visual stimuli, the functional

370
state of the frontal (frontotemporal) associative area of the right hemisphere and the parietal associative area of the left hemisphere decreased, while the left temporal area, closely connected with the limbic system, was activated. Thus, a switchover from neocortical (analytical and synthetic) processing of information to limbic (emotional) processing occurred. Considering current concepts on the location and hemispheric specialization of the mechanisms of emotion control (the relationship of the left-hemispheric cerebral structures with positive emotions and the right-hemispheric cerebral structures with negative emotions [5]), one may expect that the aforementioned temperature dynamics during the presentation of the corresponding visual images reflects the development of strong, mixed emotional feelings (the combination of pleasant recollections with the bitterness of loss). On the other hand, the absence of distinct topographic differences in temperature (circulation and metabolism) in the background state and during the presentation of indifferent visual stimuli, as well as the absence of respective foci of slow-wave and rapid activities on the topographic maps of the initial EEG of patient C., whose indices are shown in the figure, suggests that the degree of activation of the putative focus of the stagnant pathological excitation (pathological dominant) is small in the background state; however, it increases every time (with a tendency toward accumulation) during the presentation of corresponding emo-

Dynamics of radiothermal radiation in different zones of the cerebral cortex in patient C. during the presentation of emotionally significant visual stimuli. (a) Temperature dynamics in leads 2 (area T3, left parietal region) and 7 (area P3, left middle temporal region). The abscissa shows the time (min) with markers of the beginning (odd numbers) and end (even numbers) of presentation of successive reproductions. The ordinate shows the temperature changes (Kelvin scale). (1–2) A fragment of the painting Cupid Hunting depicting a dog; (3–4) a fragment of Landscape with Polyphemus depicting a tree on a mountain slope; (5–6) a fragment of The Holy Family in Egypt with a depiction of storks; (7–8) a fragment of Cupid and Geniiides depicting a baby; (9–10) a fragment of The Holy Family with St. Elizabeth and John the Baptist depicting the Madonna and Child; (11–12) a reproduction of The Descent from the Cross; (13–14) a fragment of Tancred and Erminia depicting the scene of Tancred’s death. (b) On the left, the topographic map of the temperature distribution at the moment of presentation of the last reproduction (markers 13–14); on the right, the plots of temperature dynamics in leads 2 (P3, the left parietal region) and 4 (T3, the left middle temporal region).