Study of brain activity in the process of dynamic electroneurostimulation

M.V. Koroleva, E.E. Meysers
(Institute of Reflexology of the Federal Scientific Clinical experimental center for traditional methods of diagnostics and treatment of Roszdrav, Moscow city)

Dynamic electroneurostimulation (DENS) is not only an effective reflex method of treatment, but also a powerful means of increasing the general level of adaptation of the body [5]. There are numerous data on the use of DENS in the treatment of various syndromes [6, 9]. At the same time, there is still clearly insufficient attention to the study of the sanogenetic mechanisms of this type of reflexotherapy, there is no data on the effect on the electrical activity of the human brain.

In this regard, it is of interest to study the effect of DENS on both the operational and stationary systems of energy-informational relations of the brain and control of neurophysiological processes in the body. To assess the electrical activity of the operational control system, it is advisable to use EEG analysis.

The use of modern computer methods for processing an electroencephalogram using spectral and coherent analysis allows assessing the effect of DENS on the functional activity of the brain at a qualitatively new level [3]. To assess the activity of a stationary control system, it is informative to study the energy metabolism of the brain by registering the level of constant potential (UPP).

UPP is a type of slow electrical processes that integrally reflects the intensity of energy metabolism of the human brain [8, 12]. Electrophysiologically, this indicator corresponds to changes in the membrane potential of nerve and glial cells, the potential difference at the border of the blood-brain barrier and electrical processes in the vascular system of the brain. By virtue of its origin, UPP is associated with a complex of biochemical processes that characterize the intensity of the energy metabolism of the brain tissue and, consequently, the functional state of the adaptive systems of the body [8].

The purposeresearch was the study of the dynamics of cerebral energy-informational processes, by analyzing the characteristics of the UPP and EEG in the process of DENS-therapy of patients with pain syndromes.

Material and research methods

The study of the electrical activity of the brain was carried out in 19 patients with dorsalgias of various localization (15 women and 4 men) aged 32 to 65 years. Reflexology was used in complex treatment as the main method. DENS in labile and labile-stable variants was performed in segmental zones of the spine, zones of local pain, in acupuncture points on the extremities in accordance with the topic of the affected segments of the spine, in corporal points of general action and auricles. The current strength was selected individually,

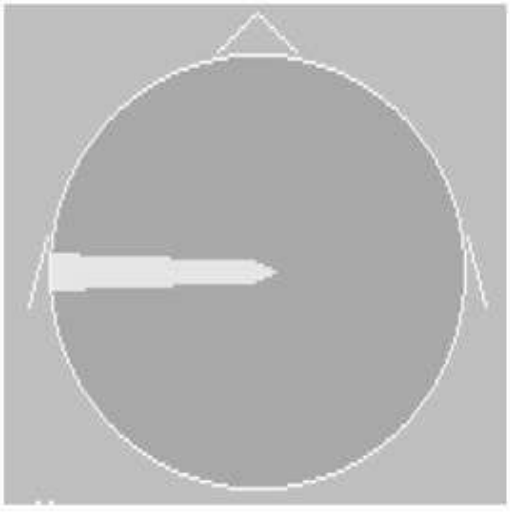
frequencies 10 and 77 Hz. The total time of the procedure is 30–40 minutes. The treatment was carried out using the "DiaDENS-T" apparatus, the course consisted of 10 daily sessions, excluding weekends.

The UPP registration was carried out before and after the 1st procedure, as well as after the DENS-therapy course. The UPP was recorded using the Neuroenergon hardware and software complex (Russia) in 5 standard leads (Fz, Cz, Oz, T3, T4) according to the 10–20 system. EEG registration was performed using the Brainsys hardware-software complex (Russia) in 16 standard leads according to the 10-20 system. EEG processing was carried out using software packages for spectral and coherent analysis, as well as statistical data processing packages. In 9 patients, AMR and EEG were also studied in a follow-up study one month after the end of the course of treatment. During the examination, the patients were in a darkened room with their eyes closed in a state of calm wakefulness.

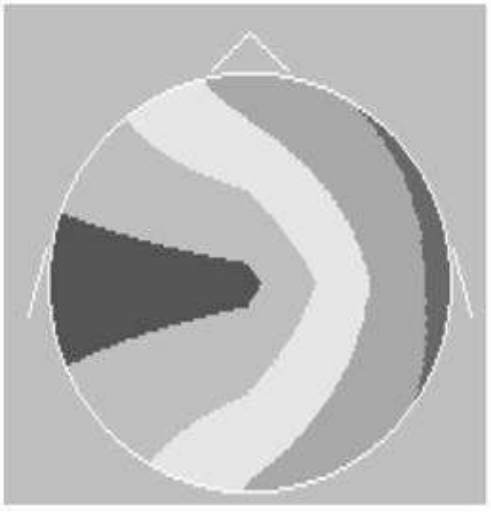
Results and discussion

Before the start of treatment, the average level of AMR (Xav.) In 12 patients was within the age norm, in 5 - moderately increased, in 2 - moderately decreased. At the same time, in 7 people there was a violation of the interhemispheric asymmetry (right-left) and in 5 - a violation of the ratio of the values of the ALC in the frontal and occipital regions (rostrocaudal asymmetry). However, there were no reliably large values in a particular hemisphere as a whole for the group.

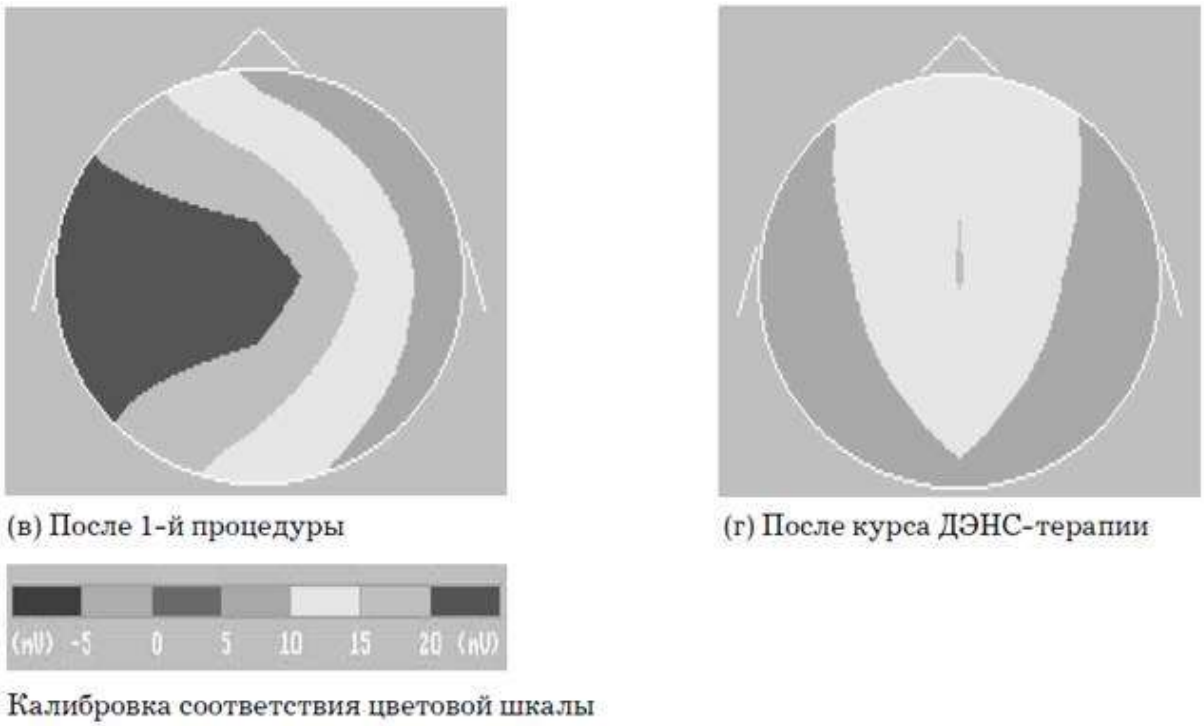
After the 1st procedure of dynamic electrical stimulation, there is a significant ($p < 0.05$) increase in the average level of energy metabolism of the brain as a whole in the group of patients, and in 8 patients the average level of energy exchange becomes significantly higher than the age norm (Fig. 1a, b, c). Moreover, in most patients, the most significant changes are observed in the dominant hemisphere (in 14 out of 19 - on the left). This causes an increase in interhemispheric asymmetry. Such a reaction of the brain's energy exchange is characteristic of stress reactions and tension of the regulatory mechanisms of homeostasis.



(а) Возрастная норма



(б) До лечения



Rice. 1. Dynamics of AMR of patient G. in the process of DENS-therapy

The figure shows that, before treatment, there is a pronounced violation of the interhemispheric asymmetry with a significant predominance of energy exchange in the left hemisphere. After the 1st DENS procedure, there is an increase in the average level of energy exchange and an increase in energy exchange in the left hemisphere. Against the background of the DENS-therapy course, there is a gradual decrease in energy exchange indicators to the norm and harmonization interhemispheric asymmetry.

It should be noted that against the background of the first DENS procedure, a pronounced increase in brain energy exchange is observed in patients with both high and low initial levels of energy exchange. After the course of treatment and in the follow-up examination in the group as a whole, there is a significant decrease in the average level of AMR ($p < 0.05$) compared to the indicators after the 1st procedure, while the interhemispheric asymmetry and asymmetry in the rostro-caudal direction are normalized. After the course of treatment, there is a dynamics towards approaching normal indicators. So, in patients with an initial increase, a decrease in the level of energy exchange is observed and vice versa. Thus, it can be assumed that the sanogenetic (taking into account the clinical dynamics) effect of electrical stimulation occurs initially due to the activation and stress mobilization of the energy resources of the brain.

At the same time, centralization increases, the participation of both cortical and diencephalic structures of the brain in the regulation of homeostasis increases, which is confirmed by the data of variational cardiointervalometry [1, 7].

In the future, there is a decentralization of the process and a decrease in the average level, as well as the normalization of the distribution of SCP. In many cases, after the course of treatment, there is a slight increase in the level of brain energy exchange in the frontal-central regions, which persists for a month or more after stopping treatment (Fig. 1d). Such changes may indicate an increase in the influence on the cortex from the side of the stem structures of the diencephalic level. This is confirmed by the results of EEG studies. It was in these patients that bilaterally synchronous flashes of theta rhythm were observed on the EEG, indicating activation

stem structures of the diencephalic level.

An analysis of the follow-up data in 9 patients showed that not all patients have positive changes persisting for a long time. In a number of patients, a month after the end of the course of treatment, the mean values of AMR and the indices of interhemispheric asymmetry practically did not differ from the initial values. Perhaps one course of treatment is not enough to obtain a stable therapeutic effect, because the body has not yet moved to a new level of adaptation.

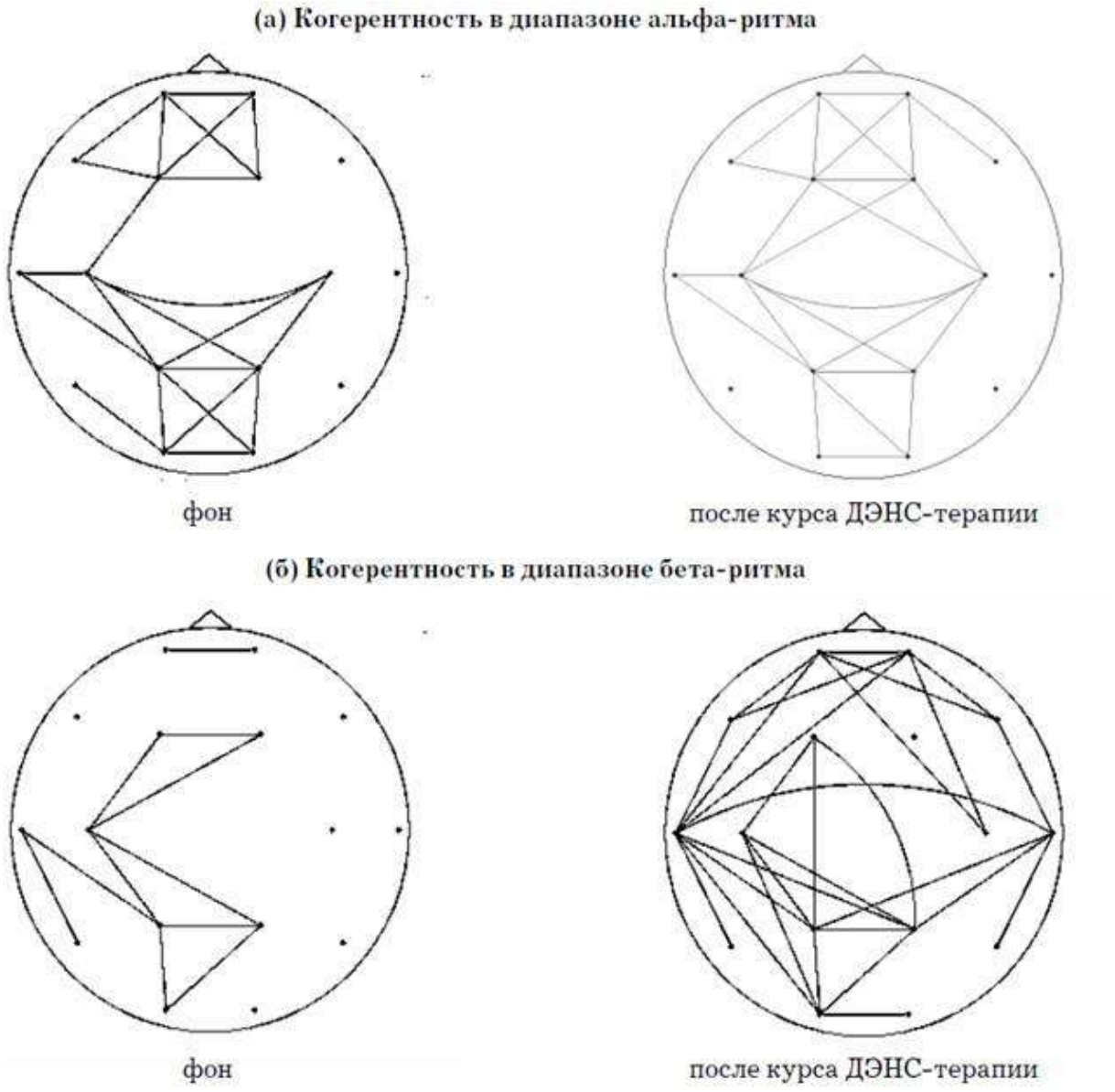
When studying the EEG before treatment, certain deviations from the norm were observed in 7 out of 19 examined patients, which were expressed in a flattening of the EEG curve, a decrease in the power of the alpha rhythm and a decrease in zonal differences. These changes may indicate a violation of the activating influences on the part of nonspecific stem structures. In 5 patients, these changes can be correlated with an increased level of anxiety according to the data of psychological testing [7]. In 2 patients, these changes are, apparently, a consequence of the sclerotization of the cerebral vessels, which is confirmed by the ultrasound scan data [7]. In 6 patients, pronounced interhemispheric asymmetry was observed not so much in the alpha rhythm (normally the power of the alpha rhythm is lower in the dominant hemisphere), but in slow rhythms - delta and theta. This also corresponds to the pronounced interhemispheric asymmetry according to the AMP data.

Such data may be due to the meteosensitivity of patients. All patients with pronounced pronounced interhemispheric asymmetry had headaches, weakness, irritability when the weather conditions changed. This is consistent with literature data [4].

After the course of treatment in the group as a whole, there is a significant ($p < 0.05$) increase in the power of theta and delta rhythm in the frontal-central leads. In most patients, these changes are detected only with a quantitative analysis of the EEG spectrum, but in patients with G. and K., after a course of treatment, bilateral synchronous flashes of theta rhythm with an amplitude of up to 70 μV in the frontal-central leads are noted. However, it should be noted that the amplitude of these flashes did not exceed the amplitude of the background activity, therefore, it was not a sign of pathology. These data indicate a moderate activation of the structures of the diencephalic level of the brainstem after the DENS course and are consistent with the results of the analysis of brain energy exchange - in all patients with a pronounced increase in the power of slow EEG rhythms, there is also an increase in AMR in the frontal-central regions.

So, when studying the dynamics of EEG in animals with dynamic electrical stimulation, other authors noted an increase in the level of activity of diencephalic structures and, in particular, the anterior part of the hypothalamus.

Another interesting EEG indicator that changes during therapy is the level of coherence of EEG derivations in alpha, beta1 and theta rhythm. After the DENS course, an increase in the level of EEG coherence is observed both in the direction of the forehead and the back of the head, as well as in symmetric right-left leads (Fig. 2). This change in the group as a whole is significant ($p < 0.05$) in leads C3-C4, F3-F4, F4-C4 in the range of alpha rhythm, C3-C4, C4-F4 in the range of theta rhythm and Fp1-Fp2, Fp2-F4, C3C4, C4-P4, C3-P3 in the beta1 rhythm range.



Rice. 2. Dynamics of EEG coherence in the range of alpha (a) and beta (b) rhythms in the process of DENS therapy.

In the figure, EEG leads are connected, the coherence between which is higher than 0.9. It can be seen that in the range of the alpha rhythm, the increase in coherence after the DENS course occurs mainly in the frontal-central leads, in the range of the beta rhythm - in almost all leads of both the left and right hemispheres.

In 6 patients, this pattern remains in the follow-up examination. It is known that EEG coherence reflects the level of intracerebral integration. In the literature, there are numerous data on changes in intracerebral integration in various functional states and many types of pathology of the central nervous system. Thus, the change in the level of coherence of slow rhythms at different phases of sleep has been shown [3]. An increase in intracerebral integration in the beta1-rhythm range was shown when memorizing words of abstract content. There is evidence of significant

an increase in coherence between the distant parts of the hemisphere (forehead-occiput) during human creative activity (thinking, activation of verbal, visual or musical variants of brain activity) [11]. These data are interpreted as the result of active participation in solving creative problems of long corticocortical fiber systems.

But in our study, both before and after treatment, the patients were in a state of calm wakefulness. There is evidence of changes in the level of EEG coherence in diseases of the autonomic nervous system [4]. Possibly, the increase in EEG coherence is associated with the tension in the regulation of autonomic homeostasis, which is confirmed by the results of variational cardiointervalometry at the beginning of the DENS course [7]. There is evidence of increased intrahemispheric coherence in the range of alpha, beta and theta rhythms during peripheral pain stimulation [10]. The results obtained to a certain extent contradict these data, since during treatment using dynamic electrical stimulation, all patients showed a decrease in pain syndrome almost after the first procedure, while the intrahemispheric level of EEG coherence increased similarly to the data given in [10]. However, these contradictions can be explained by assuming that in these studies, the increase in coherence was caused not by pain stimulation itself, but by the stress response to pain that almost always accompanies the pain sensation. The stress response increases the level of central nervous system activation and intrahemispheric coherence. This explanation may support the assumption that DENS causes an activation reaction at the physiological level, without causing pain. This leads to an increase in the centralization of the regulation of homeostasis processes and an increase in intrahemispheric integration. which almost always accompanies the painful sensation. The stress response increases the level of central nervous system activation and intrahemispheric coherence. This explanation may support the assumption that DENS causes an activation reaction at the physiological level, without causing pain. This leads to an increase in the centralization of the regulation of homeostasis processes and an increase in intrahemispheric integration. which almost always accompanies the painful sensation. The stress response increases the level of central nervous system activation and intrahemispheric coherence. This explanation may support the assumption that DENS causes an activation reaction at the physiological level, without causing pain. This leads to an increase in the centralization of the regulation of homeostasis processes and an increase in intrahemispheric integration.

Changes in the level of EEG coherence occurred to varying degrees in different patients, which is possibly associated with a different set of reflexogenic zones of exposure. It can be assumed that dynamic electrical stimulation of the cervical-collar zone causes the greatest changes in the EEG; therefore, it is necessary to compare the electrophysiological data with the clinical data and the formulation of exposure.

Thus, the results of EEG analysis in the course of DENS therapy indicate an increase in the level of brain activation with the inclusion of the brainstem structures of the diencephalic level and an increase in the centralization of regulatory processes in the central nervous system. Comparing the results of the analysis of the UPP and EEG during dynamic electrical stimulation, we can conclude that this is not just a method of pain relief reflexology. DENS causes a moderate stress reaction, which, in turn, triggers the mechanisms of mobilization of the internal reserves of the body and becomes a kind of "activation therapy" [2], increasing the level of adaptation of the body.

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