To the question of the physiological substantiation of the dosage of exposure with dynamic electroneurostimulation

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In recent years, dynamic electroneurostimulation (DENS) has become increasingly widespread in reflexology. The method consists in a therapeutic effect on reflexogenic zones and / or acupuncture points with short bipolar current pulses, the shape of which changes depending on the values of the total electrical resistance (impedance) of the tissues. DENS is carried out with the use of portable electrostimulators, which have the property of controlling the parameters of exposure, for example, the duration of a series of pulses, depending on the dynamics of the process of electrodermal reactions in the subelectrode zone. A design feature of a typical DENS-stimulator is an electrode built into its body, which implies moving it together with the device during treatment. This ensures the locality and selectivity of the impact on the functional state of internal organs and pain sensitivity, excludes uncontrolled spreading of current through the tissues during a treatment session, as occurs when using spaced electrodes. In a number of DENS devices, a dosage mode is provided, in which there is an automatic termination of stimulation upon reaching some threshold impedance values in the subelectrode zone [7].

A reasonable determination of the dosage of the effect on the reflexogenic zones is undoubtedly an urgent task, especially taking into account the widespread use of devices for dynamic electroneurostimulation at home. The effectiveness of stimulation was determined by the summation of multiple zonal influences until stabilization of the change in the capacitive impedance component in each local zone was achieved. However, as shown in previous studies [4; 6], the principle of determining the sufficiency of exposure, which is the basis of the dosage regimen, is not sufficiently substantiated in a number of devices.

Research conducted with using various methods objectification of the results of exposure, including the registration of electrical activity of the brain, indicators of autonomic homeostasis, skin temperature, hemodynamic parameters, biochemical parameters of blood and a number of psychological tests [4], showed that a single exposure to stabilization of the capacitive impedance component is not enough to obtain significant changes in the state of the body and stable preservation of the clinical and physiological effect. At the same time, repeated exposure sometimes leads to an unjustified increase in the duration of the procedures themselves.

Considering that, as a rule, indicators of the dynamics of the capacitive impedance component are used to determine the minimum exposure dosage in the sub-electrode zone [4], it is advisable to turn to the physiological mechanisms of this process. The reason for the change in the capacitive component is perspiration and the associated change in the dielectric constant of the salt solution in the sub-electrode zone. When stimulated, the process of moisture release is accelerated several times. This means that if only a fixed value of the parameter is chosen as the basis for the dosage and assessment criterion, which largely depends on such environmental factors as temperature and humidity, as well as on the individual characteristics of the organism, then such a choice can hardly be considered justified.

The algorithms that take into account the rate of impedance change are also doubtful. In such devices, stimulation stops as soon as this speed becomes equal to zero [8]. It is difficult to use a combination with the values of the active impedance component as a criterion, since this parameter, when using zonal electrodes, strongly depends on the force of pressure on the skin surface and can vary by orders of magnitude [9].

All this served as the basis for determining the parameters, based on the analysis of which it would be possible to form an algorithm for an effective minimum dosage of exposure, sufficient for a stable change in the psychophysiological state of the body.

As has been shown [4], perspiration is the reason for the increase in capacity, the level of perspiration, in turn, is determined by the level of activation of the autonomic nervous system at both the segmental and suprasegmental levels [1; 5]. Therefore, to resolve the issue of assessing the level of adaptation and reserve capabilities of the body, it is necessary to compare the electrical parameters of the skin with the indicators of autonomic regulation. The method that allows us to trace the dynamics of autonomic homeostasis during electrical stimulation is the method of variational cardiointervalometry.This method allows us to determine the level of activation of the central mechanisms of heart rate control and autonomic regulation in general (the predominance of subcortical nerve centers, autonomic nerve centers, central nervous system), reflecting the tension of regulatory mechanisms, providing the functional capabilities of the body [2; 3].

The aim of the study was to study the dynamics of autonomic homeostasis according to the data of variation cardiointervalometry during a single procedure of dynamic electroneurostimulation.

MATERIALS AND RESEARCH METHODS

The study of electrical parameters and skin temperature in the healthy and affected area before, during and after stimulation and determination of the correspondence of these parameters to the physiological indicators of body homeostasis were carried out on a group of 10 volunteer test subjects aged 25 to 52 years and 10 patients aged 25 to 58 years with pain syndromes of various origins. For biophysical studies of the capacitive component of the surface impedance of the skin in a healthy and pathological zone at rest and during stimulation, a VELLEMAN PCS500 digital oscilloscope, a C1-99 oscilloscope was used, digital tester TES2360, electrostimulator "DIADENS".

To assess the nature of autonomic regulation, we used the method of variational cardiointervalometry (VKIM) with an assessment of such indicators as pulse rate, mode, mode amplitude, variation range, voltage index, power of slow waves of the VKIM spectrum. The electrocardiogram for the analysis of VKIM parameters was recorded using the Brainsys hardware-software complex in 1 standard lead.

Before conducting electrical stimulation, the background registration of VKIM was performed for 5 minutes, then the electrical stimulation procedure was carried out, continuing the recording of the cardiogram. After the termination of stimulation, the registration of VKIM was continued for another 10 minutes to determine the stability of physiological changes. Electrical stimulation was performed in the pain zone in patients with different localization of pain syndromes (extremities, spine) and in the neck-collar zone in healthy volunteers. A comfortable level of exposure intensity was selected in advance before the start of ECG recording. The stimulation was carried out at a frequency of 10 Hz. Two series of studies were conducted with each subject: the first series included stimulation at a comfortable level of exposure intensity, the second series included placebo treatment when the subject was told that stimulation is carried out with a subthreshold current intensity. In this case, the switched off device was installed in the same skin zones.

The values of the capacitive component in the sub-electrode zone were recorded every 30 seconds throughout the study.

RESULTS AND DISCUSSION

Figure 1 shows the timing diagrams of signals, where the plot "a" shows the time interval of stimulation, plot "b" is the nature of the change in the capacitive component of the impedance of the subelectrode area of the skin, plot "c" is the time interval of stimulation after stabilization of the impedance value, plot "d" - a typical graph of the change in the stress index.

Before the start of stimulation, the background indices of autonomic homeostasis differed in different subjects. The highest values of the stress index (TI) were observed in people with a history of cardiovascular disease and in patients with pain at the time of the study. This corresponds to the literature data that IN adequately reflects the general level of adaptation of the organism [2; 3]. During 5 minutes of background registration, IU stabilized, the curve of its change reached a plateau (Fig. 1, plot "d" to t_1, After turning on the stimulation (plot "a" at time t_1) in the main series of studies, most of the subjects first showed an increase in the stress index (plot "d" at time t_1, dotted line) by 10-35% and a change in the remaining indicators of autonomic regulation towards the prevalence of sympathetic activation and increased tension of autonomic regulation. In 5 healthy volunteers, after the start of stimulation (at time t_1), on the contrary, a slow decrease in the stress index and a decrease in sympathetic activation began. After stimulation, during the first 1-1.5 minutes, gradual decrease in the stress index (plot "d" to t_2) and a change in other indicators of autonomic regulation towards a decrease in voltage (decrease in the amplitude of the mode, increase in the variation range, shift of the vegetative indicator of the rhythm towards parasympathetic activation, etc.). Moreover, it should be noted that such a tendency to change the indices of autonomic regulation was observed during stimulation of both the cervical collar zone and peripheral zones on the extremities.

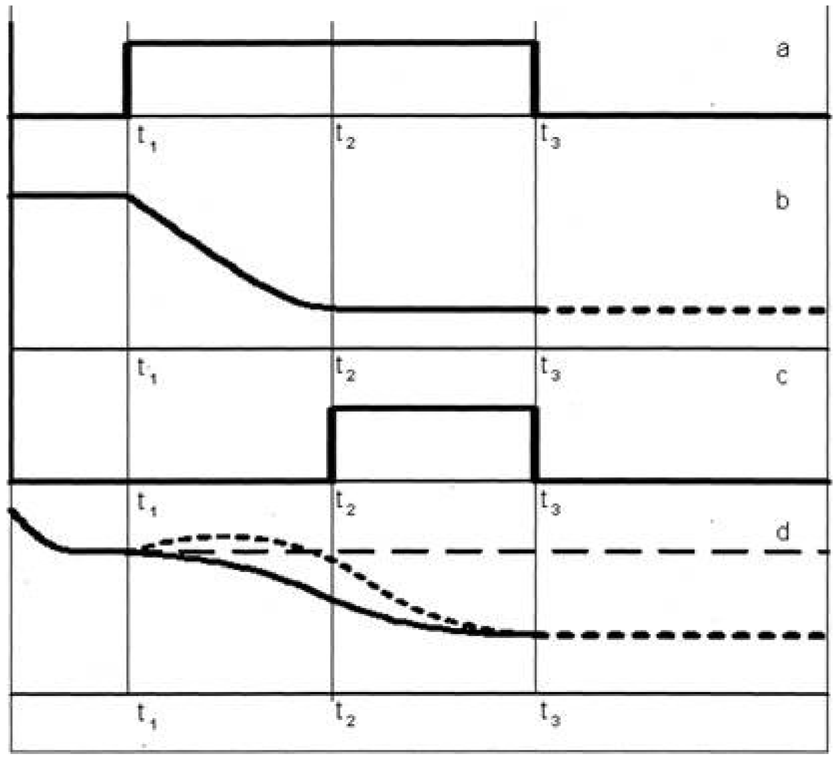

Fig. 1. Signal timing diagrams

Along with the dynamics of physiological parameters, there was a change in the electrical parameters of the skin. After the start of stimulation, an increase in the capacitance value in the sub-electrode zone was observed, and, consequently, a decrease in the impedance value (plot "b" from t_1 until t_2) until it stabilizes.

Starting from the moment of stabilization of the capacitive component (at the moment t_2), within 1-2 minutes of stimulation, the state always stabilized and the voltage index change curve reached a plateau (plot "d" until the moment t_3).

In parallel with the change in the parameters of the autonomic regulation of the electrical conductivity of the skin and in this time range, certain changes in the subjective sensations of the subjects were observed. Patients with pain syndromes at this time noted a decrease in the intensity of pain, healthy volunteers noted a subjective decrease in the amplitude of stimulation.

However, upon termination of stimulation immediately after reaching a plateau indicators of electrical capacity and autonomic regulation, the effect was unstable. After 1-2 minutes, patients with pain syndromes showed a slight increase in pain intensity; all subjects showed a gradual increase in the stress index and its values approaching the initial level. Persistent changes in both the parameters of autonomic regulation and subjective sensations were achieved only after a stimulation interval of 4-5 minutes (plot "c" from 1_2 until t_3) after the capacitance curve reaches a plateau (at time t_2).

It can be assumed that the exposure time required for reaching a plateau of autonomic regulation indices and capacity values is a correlate of changes in the functional state of the body as a result of dynamic electrical stimulation. However, this exposure time, apparently, is insufficient to stabilize the new functional state. To consolidate the obtained changes, it is necessary to continue stimulation for another 4-5 minutes.

In series placebo studies reliable differences indicators vegetative regulation in comparison with the background was not revealed (plot "d" from the moment t_1, dashed horizontal line). There was also no change in subjective sensations in patients with pain syndromes.

The results of this study clearly demonstrate the positive systemic effect of dynamic electrical stimulation on the human body. Indeed, in the process of stimulation, there is not only a decrease in pain in the local zone in patients with pain syndromes and a decrease in the subjective sensation of the intensity of stimulation in healthy volunteers, but also a decrease in the tension of autonomic regulation, and ultimately - an increase in the level of adaptation of the organism.

The correlation of the dynamics of the capacitive component of the skin surface impedance with the indices of autonomic regulation and the subjective sensations of the subjects indicates that this indicator can serve as a parameter, based on the analysis of which it is possible to create technical devices capable of determining the effective dosage of exposure.

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