Physiological effects of auricular electropuncture

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SUMMARY

The paper investigates the effect of electrical stimulation with different frequencies of auricular points on the functional activity of the autonomic nervous system (ANS). To assess changes in autonomic regulation, registration of heart rate variability was used. The study involved 36 apparently healthy volunteer subjects and 18 people suffering from overweight and obesity stage 1-2. It was found that auricular electropuncture with different frequencies has a different effect on the tone of the ANS. Electropunctural action with a frequency of 77 Hz causes a pronounced sympathotonic effect, and this effect does not depend on the point of action. Electrical stimulation with a frequency of 10 Hz, when exposed to all tested auricular points, has a similar parasympathetic effect, however, depending on the point of stimulation, the humoral contribution is more or less pronounced.

Keywords: auricular electropuncture, frequency electrical stimulation, activity of the autonomic nervous system, heart rate variability.

It is known that auricular electropuncture has a number of advantages over the effect on corporal acupuncture points. First, because of the high efficiency and speed of the onset of response reactions from exposure. This is due to the rich innervation of the auricle and its powerful neuroreflex connections with the structures of the brain stem [3]. Another advantage of auricular electropuncture is the possibility of sufficiently accurate determination of the composition of points for exposure and periodic monitoring of treatment results using auricular diagnostics, which received new opportunities with the development of multivariate analysis technology [6].

When determining the parameters of electropunctural exposure using with alternating current devices, the choice of the pulse repetition rate is important. However, to date, there is no consensus on this issue due to the paucity of special studies devoted to optimizing the frequency of stimulation of the auricle points in the treatment of various pathological manifestations. For example, a number of reflexology guidelines recommend exposure to both auricular and corporal points with a low frequency current (from 1 to 10 Hz), and in the treatment of functional disorders of the central nervous system (neurasthenia), it is recommended to use stimulation frequencies corresponding to the alpha rhythm of the human EEG (8–12 Hz), while all auricular points included in the “recipe” are stimulated with the same frequency [7]. Meanwhile,

suggested using different frequencies to stimulate different anatomical zones of the auricle, based on the data of his studies:

- the inner part of the tragus and interguscular notch - 2.28 Hz;
- cavity of the shell - 4.56 Hz;
- the upper part of the curl and the upper leg of the antihelix - 125 Hz;
- the posterior part of the curl from Darwin's tubercle to the posterior ear furrow - 18.25 Hz;
- outer part of the tragus - 36.5 Hz;
- the back of the earlobe - 7.3 Hz;
- anterior part of the earlobe - 146 Hz.

However, the method of assessing the impact (by changing the pulse wave), used by P. Nogier, is not accurate enough and only a qualitative method. In addition, the effect on the same point with different frequencies often causes a multidirectional effect on the pulsation of the radial artery, and the absence of a change in pulsation does not yet prove the absence of the effect from the effect on the auricular point. Sanogenetic reactions when exposed to auricular points are realized through transformations of the functional activity of the CNS structures, which, in turn, change the activity of the sympathetic and parasympathetic divisions of the autonomic nervous system (ANS) [3]. This leads to a change in the pulsation of the radial artery and other effects. For a more accurate assessment of the results of stimulation of auricular points with different frequencies, it is necessary to use more accurate and modern research methods (for example, the functional activity of the ANS). As such a method, it is advisable to use the analysis of the state of the ANS, using the registration of heart rate variability (HRV). This research method has shown high information content in the analysis of the functional state of the body both in normal conditions and in many diseases that cause disturbances in neurovegetative regulation [1, 11].

The aim of this work was to study the effect of electrical stimulationauricular points with different frequencies on the functional activity of the ANS. To achieve this goal, we solved the following tasks:

1. Evaluation of the action of frequencies 200, 77, 10, 5 and 4 Hz, modes 77/10 and “wave swing "on the functional activity of the ANS;

2. Comparison of the effects of exposure to different frequencies on points of different anatomical regions and points of the same anatomical region of the auricle;

3. Determination of the minimum effective duration of exposure at stimulation with different frequencies of the points of the auricle.

Material and research methods

The study involved 36 apparently healthy volunteers and 18 people suffering from overweight and obesity stage 1-2. With each subject, from 4 to 20 studies were carried out, and the electrical stimulation of the auricular points with different frequencies was carried out on different days in order to avoid the effect of summation.

For auricular stimulation, we used devices that implement the method of dynamic electroneurostimulation (DENS) [9]. We used electropuncture with a pulse frequency of 200, 77, 10, 5 and 4 Hz, as well as in the 77/10 and “wave swing” modes. The combined 77/10 Hz mode was carried out with frequency modulation, in which the stimulating pulses were sequential bursts of 250 ms duration with a frequency of 77 Hz and 10 Hz. The "wave swing" mode was performed in the frequency range from 1 to 10 Hz. The points were electrostimulated with an external coaxial point electrode for 2 minutes at a comfortable energy level. HRV was recorded using the hardware-software complex "Orto-Scince" and "Orto-expert" (Russia) in the background, during electrical stimulation of the auricular points and 1–30 minutes after the termination of stimulation. The indicators in the background and after stimulation were analyzed using the Orto-expert software. The following indicators of heart rate were assessed: fashion, amplitude of fashion (AMo), index of tension of regulatory systems (IN), average heart rate (HR), indicators of spectral analysis of heart rate - spectral powers of high-frequency (HF), low-frequency (LF) and ultra-low-frequency (VLF) components, as well as the ratio of the power of slow and fast rhythms (LF / HF); the square root of the sum of squares of the differences of adjacent cardiointervals (RMSSD) and the total power of the spectrum of the wave structure of the heart rate (TF) in the sitting position and after standing up. Comparison of indicators in a sitting and standing position made it possible to assess autonomic reactivity and autonomic support of activity [1, 11].

When studying the effects of different frequencies of electropuncture, points of different anatomical zones were used: the three-sided fossa, the upper leg of the antihelix, the zone adjacent to the pedicle of the curl, the concha bowl, the concha cavity, the tragus, and the earlobe [8]. When determining the required duration of exposure to obtain the effect of changing the functional activity of the ANS, we used the program of the OrtoScince complex for continuous recording of heart rate parameters. The impact on the auricular points was carried out from 1 to 5 minutes at a comfortable energy level. Parametric and nonparametric methods were used for statistical processing. The results obtained were processed using the "STADIA" statistical package.

Research results and their discussion

Evaluation of the action of a frequency of 200 Hz was carried out in a group of 22 people. The impact was carried out on the points of different anatomical areas. In the zone of the three-sided fossa, the impact was carried out on auricular points (AT) 55 (shen-men) and AT58 (uterus), the upper leg of the antihelix AT49 (knee joint), in the area adjacent to the leg of the curl on AT87 (stomach), AT88 (duodenum) and AT91 (large intestine), in the area of the shell bowl on AT92 (bladder), in the area of the shell cavity on AT100 (heart) or AT101 (lungs), AT103 (trachea), in the lobe area on AT10 (tonsil) and AT8 (eyes). Electrical stimulation was carried out for 3 minutes. On the day of the study, only one point was stimulated. The aftereffect was evaluated within 30 minutes. In general, for the group of significant changes as a state

vegetative regulation, and vegetative reactivity and vegetative support of activity were not revealed. There was also no significant difference in the indices when stimulating points in different zones.

The study of the effect of the frequency 77 Hz was carried out in a group of 25 people. The impact was exerted on the same points as in electropuncture with a frequency of 200 Hz. The data obtained indicate that the frequency of 77 Hz has a pronounced sympathotonic effect, both when the points of the zone adjacent to the pedicle of the curl, the bowl of the shell, the cavity of the shell (AT100, 101, 103, 92, 88, 91), and the points of the lobe (AT 10, 8), points of the three-sided fossa (AT55, 58) and the point of the upper leg of the antihelix (AT49). When registering heart rate variability, this effect manifests itself in a significant ($p < 0.05$) increase in the heart rate - HR, an increase in the amplitude of the mode - AMo and an increase in the voltage index - IN of the heart rate. The analysis of the spectral characteristics revealed a significant ($p < 0, 01$) an increase in the LF / HF indicator (the ratio of the power of slow and fast rhythms), which also indicates sympathetic activation, and a significant ($p < 0.01$) increase in the power of the infraslow component of the spectrum - VLF, which indicates an increase in the humoral contribution to the regulation of ANS activity. This corresponds to the data of previous studies of the DENS effect with a frequency of 77 Hz on the cervical-collar zone and zones of segmental innervation of internal organs. These studies showed pronounced anti-inflammatory, antioxidant, analgesic and other effects, which allows DENS to be considered a variant of activation therapy with this frequency [2]. The results obtained indicate that the frequency of 77 Hz, in addition to the local effect, also has the effect of activation therapy, which does not depend on the area of application of stimulation and, apparently, due to the effect on the structures of the central nervous system of the brain stem. So, in a number of studies it was noted that the optimal analgesic frequency of electrical stimulation is close to 77 Hz, and when it is shifted within 10%, the analgesic effect decreases sharply [5]. It is possible that frequencies in this range are able to "control" endorphin, serotonin, or other mediator mechanisms of the brain's regulatory systems.

The use of a frequency of 10 Hz to stimulate the same points, on the contrary, causes a parasympathetic effect, which is expressed in a significant ($p < 0.05$) decrease in heart rate, a decrease in AMo and IN, as well as a significant ($p < 0.01$) increase in the high-frequency component of HF with spectral analysis of the wave structure of the heart rate. However, for some points, there is a certain specificity in the implementation of this effect. So, when stimulated with a frequency of 10 Hz AT100 (heart), the parasympatotonic effect is mainly realized due to neural mechanisms, and points - AT10 (amygdala) mainly due to the activation of humoral mechanisms. A similar, but more pronounced effect was obtained with stimulation of the auricular points in the 77/10 Hz mode. During electropuncture using this mode, a decrease in heart rate, IN, AMo ($p < 0.05$) was also observed, indicating a decrease in the sympathetic tone of the ANS, an increase in RMSSD is an indicator, an increase in which is associated with the activation of parasympathetic influences. But unlike the frequency of 10 Hz, electropuncture in the 77/10 mode causes

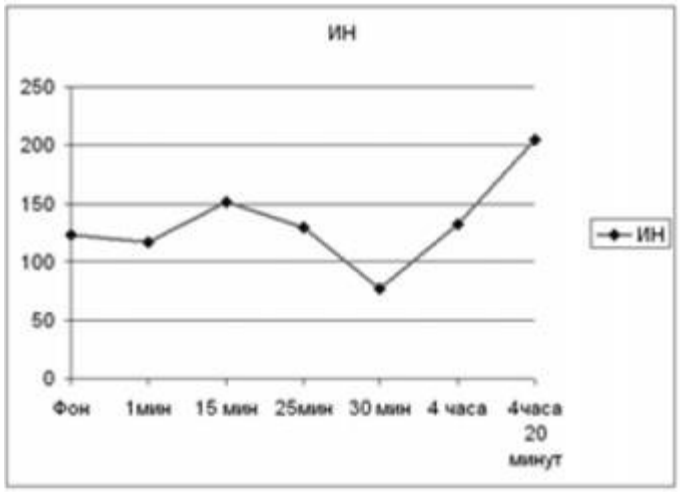
significant (p <0.01) increase in the TF indicator - the total power of the spectrum of the wave structure of the heart rate. From a physiological point of view, these data can be interpreted as a decrease in the centralization of heart rate control, which corresponds to a decrease in neuropsychic stress and an increase in the level of adaptation. A similar psychotropic effect of this mode has been described when stimulating the neck-collar zone [4].

When studying the "wave swing" mode, a multidirectional effect was obtained in individuals with different types of autonomic regulation. Thus, in subjects with pronounced sympathicotonia, a weakening of sympathetic influences was observed - a decrease in heart rate (p <0.05), a decrease in IN (p <0.01), an increase in the RMSSD indicator (p <0.05). At the same time, in individuals with initially reduced indices of autonomic reactivity, they improved with an orthostatic test. Individuals with severe vagotonia showed some activation of sympathetic regulation in the form of a tendency to an increase in AMo, a significant increase in IN (p <0.05) and a decrease in RMSSD (p <0.01). At the same time, there was a significant decrease in the VLF index (p <0.01), indicating a decrease in the humoral and an increase in the nervous contribution to the regulation of the VNS state.

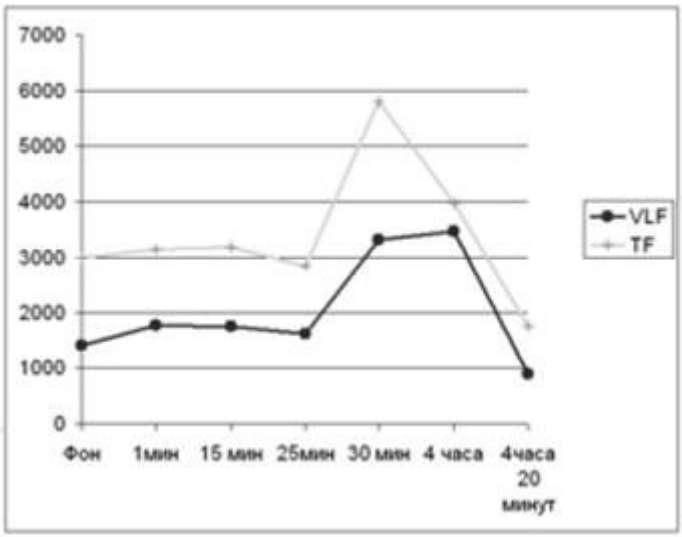
More complex and ambiguous effects were noted when studying low frequencies of 4 and 5 Hz. Here, the physiological effect and direction of changes in autonomic regulation depended on the point of stimulation and the presence of electrical anomaly of the point (and, consequently, on the possible pathology of the corresponding organ). Thus, when the AT49 point (knee joint) was applied in the area of the upper leg of the antihelix, no significant changes in autonomic regulation were revealed, and when the AT87 point (stomach) was exposed to a parasympathetic effect, the effect on AT100 (heart) caused multidirectional effects in individuals with a predominance of the initial sympathetic and parasympathetic tone of the ANS. At the same time, in all subjects, stimulation of this point with a frequency of 4–5 Hz caused a decrease in TF (total power of the wave spectrum), which indicates an increase in the centralization of regulation and a decrease in the level of adaptation, i.e. these frequencies are unfavorable for influencing this point.

Interesting data were obtained when the AT18 point (hunger) was stimulated with a frequency of 4 Hz. This point is used to reduce appetite and abnormal cravings for food in the treatment of overweight and obesity. When this point was stimulated with a frequency of 4 Hz for 3 minutes, the following data were obtained in 18 overweight subjects (Fig. 1 and 2). In the background before the start of stimulation, all subjects experienced hunger, because are on a low-calorie diet and last meal was 2–3 hours ago. The indices of autonomic regulation indicate a moderate increase in neuropsychic tension (TI about 130 conventional units) and a shift in the ANS activity towards sympathicotonia (LF / HF above 5 conventional units).

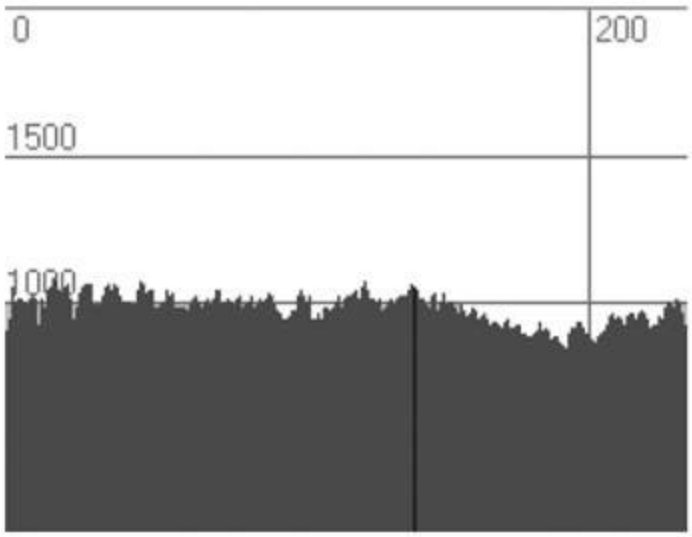
LF / HF, RMSSD reduction). Moreover, there is an activation of both the nervous and humoral components of sympathetic activation. This can be judged by the increase in TF indicators - the total power of the heart rate spectrum and VLF - the power of infraslow waves of the HRV spectrum. On the contrary, 15 minutes after stimulation, there is an increase in the activity of the parasympathetic system, a decrease in psychoemotional stress and an increase in the level of adaptation. This trend reaches its maximum 30 minutes after stimulation. It was at this time that most of the subjects felt a weakening of the feeling of hunger, a decrease in anxiety and irritation. The effect was observed within 3-4 hours after the termination of stimulation. Then there was a gradual return to the initial level of indices of autonomic regulation and psychoemotional state. The use of HRV registration to assess the effects of electropuncture on auricular points also made it possible to approach the solution of the question of the minimum required duration of exposure to different frequencies and the duration of the preservation of the stimulation effect. With the help of the Orto-Scince program, in a continuous mode of stimulation, the moment of changes in the nature of the rhythm and its wave structure (increased or decreased pulse rate, the appearance or disappearance of waves in the spectral structure, etc.) was monitored.



Rice. 1. Dynamics of IN after AT stimulation18. On the abscissa - time after termination of AT18 stimulation, along the ordinate - the value of IN in conventional units.



Rice. 2. Dynamics of the infraslow component (VLF) and total power (TF) HRV spectrum after AT18 stimulation. The abscissa is the time after termination stimulation AT18, on the ordinate - the value of the spectrum power in conventional units.



Rice. 3. Decrease in durationRR intervals and change in wave structure at 141 seconds of stimulation. The beginning of the change in rhythm indicators at 141 seconds marked with a vertical bar.

In fig. 3 shows the effect of AT18 stimulation with a frequency of 4 Hz. Using this approach, we analyzed the required exposure times for different points and frequencies. It was found that the higher the frequency of electropuncture, the faster the primary effect of stimulation occurs. For a frequency of 77 Hz, this time ranged from 18 to 45 s for different subjects, for a frequency of 10 Hz, from 34 to 89 s, and 4 Hz, from 58 to 156 s. A significant positive correlation was also revealed between the minimum required duration of stimulation and point electroanomality. The results obtained can be explained by the enhancement of reflex influences from the points of the auricle corresponding to the projections of organs with impaired function, with the structures of the central nervous system, through which the therapeutic effect of auriculotherapy is mediated.

Conclusions:

1. Different frequencies of auricular electropuncture have different influence on the tone of the ANS;

2. For some frequencies of electropuncture (for example, 77 Hz) it is set sympathotonic action and this effect of influence on the tone of the ANS does not depend on the point of action;

3. Electropuncture with a frequency of 10 Hz when exposed to all tested us points have a similar parasympathetic effect, however, depending on the point of stimulation, the humoral contribution is stronger or weaker;

4. Frequencies of electropuncture 4 and 5 Hz can cause multidirectional the effects of changes in autonomic regulation when exposed to different points;

5. Higher frequencies of electrical stimulation cause faster the effect of changing the vegetative tone;

6. The speed of the onset of the effect during electropuncture stimulation positively correlates with the level of electroanomality of the auricular point.

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