Determination of the optimal parameters of electrical stimulation of anatomical auricle zones based on heart rate analysis

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Auricular electropuncture is an effective method reflex treatment of various diseases. This is due to the rich innervation of the auricle and its powerful neuro-reflex connections with the structures of the brain stem [2]. When determining the parameters of electropunctural exposure using devices - alternators, the choice of the pulse repetition rate is of great importance. However, today there is no consensus on this issue due to the paucity of special studies.

The purpose The present work was to study the effect of electrical stimulation with different frequencies of auricular points on the functional activity of the autonomic nervous system (ANS), using the registration of heart rate variability (HRV). To achieve this goal, we solved the following tasks:

1. Evaluation of the action of frequencies 200 Hz, 77 Hz, 77/10 Hz, 10 Hz, 5 Hz, 4 Hz and mode "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 methods

The study involved 36 apparently healthy volunteer subjects. 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, electropuncture was used with a pulse frequency of 200 Hz, 77 Hz, 10 Hz, 5 Hz, and 4 Hz, as well as in the 77/10 Hz 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. Electrical stimulation of the points was carried out with an external coaxial point electrode for 3 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

high-frequency (HF), low-frequency (LF) and ultra-low-frequency (VLF) components, as well as the power ratio of slow and fast rhythms (LF / HF); 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 a sitting position and after standing up. Comparison of the indices obtained in the sitting and standing positions of the subjects made it possible to assess the autonomic reactivity and autonomic support of the activity [1, 5].

When studying the effects of different frequencies of electropuncture, points various anatomical zones: three-sided fossa, upper leg to the pedicle antihelix, zone adjacent concha, of the curl, shell bowl, cavity tragus and earlobe [4].

When determining the required duration of exposure to obtain the effect of changing the functional activity of the ANS, the program of the Orto-Scince complex was used 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.

Results and its 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 the auricular points (AT) AT55 (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). On the day of the study, only one point was stimulated. The aftereffect was evaluated within 30 minutes. In general, in the group of significant changes, both the state of autonomic regulation and autonomic reactivity and autonomic support of activity were not revealed.

The study of the effect of the frequency of 77 Hz was carried out in a group of 25 people. The impact was carried out on the same points as with electropuncture, with a frequency of 200 Hz. The data obtained indicate that the frequency of 77 Hz has a pronounced sympathotonic effect, as when the points of the zone adjacent to the pedicle of the curl, the bowl of the shell, the cavity of the shell (AT 100, 101, 103, 92, 88, 91), and points of the lobe (AT 10, 8), points of the three-sided fossa (AT 55, 58) and the point of the upper leg of the antihelix (AT 49). When registering heart rate variability, this effect manifests itself in a reliable ($p < 0.05$) an increase in the heart rate (HR), an increase in the amplitude of the mode (AMo) and an increase in the stress index (TI) of the heart rate. The analysis of the spectral characteristics revealed a significant ($p <0.01$) increase in the LF / HF index (the ratio of the power of slow and fast rhythms), which also indicates sympathetic activation, and a significant ($p <0.01$)

an increase in the power of the infraslow component of the spectrum - VLF, indicating an increase in the humoral contribution to the regulation of the ANS activity. Thus, 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 [3]. Perhaps, frequencies in this range are able to "control" endorphin, serotonin or other
mediator mechanisms of the brain 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, decrease in AMo and IN, as well as a significant ($p < 0.01$) increase in the high-frequency component - HF in the 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 AT 100 (heart) parasympathotonic effect
it is mainly realized due to neural mechanisms, and points - AT 10 (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. When electropuncture using
of this mode, there was also a decrease in heart rate S, IN, AMo ($p < 0.05$), indicating a decrease in sympathetic RMSSD - VNS tone, increase indicator, the increase of which associated with activation parasympathetic influences. But, unlike the frequency of 10 Hz, electropuncture in the 77/10 Hz mode causes reliable (p 0.01) an 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.

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 - decrease in heart rate ($p < 0.05$), decrease in IN ($p < 0.01$), increase in RMSSD ($p < 0.05$). 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 state of the ANS. This effect was manifested during the electropunctural action on the auricular points of all anatomical zones.

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 anomalies of the point (and, consequently, possible pathology relevant authority). Thus, when the AT49 point (knee joint) in the area of the upper leg of the antihelix was affected, 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 persons 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; these frequencies are unfavorable to influence this point.

The use of HRV registration for assessing the effects of electropuncture on auricular points 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 effect of stimulation. With the help of the program "OrtoScince" 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.

Using this approach, we analyzed the required exposure time 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. There was also revealed a significant positive correlation between the minimum required duration of stimulation and point electroanomality. The results obtained can be explained by an increase in 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.

Literature

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