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Local electrical stimulation: introduction to the problem

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Abstract

The term "local electrical stimulation" means the delivery, for therapeutic purposes, of electric current signals in the areola of the projections of acupuncture points. Among the varieties of this effect are electro- and electroacupuncture, as well as transcutaneous electrical neurostimulation. In the case of electropuncture, minimal skin areas are irritated, outside of the damage, by placing the sensors according to the projections of the points. In the electroacupuncture, current signals are sent to steel needles immersed in tissues, ensuring the activation of not only skin afferents, but also deeper afferents. Percutaneous stimulation consists of irritating large areas of the skin with the help of portable devices. The paper reveals the mechanisms underlying the therapeutic effect of these methods, and puts forward an assumption about the prevailing biological significance of low-intensity stimuli. In addition, specific examples of use of local electrical stimulation in a number of pathological conditions are also presented.

Key Words: acupressure stimulation, electropuncture, electroacupuncture, transcutaneous electrical nerve stimulation.

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This publication precedes a series of publications devoted to the problem of local electrical stimulation. By this term, we mean the supply, for therapeutic purposes, of electric current signals to the area of the location of acupuncture points. At the same time, there are several varieties of it in the form of electropuncture, electroacupuncture and Transcutaneous Electrical Neurostimulation (TENS). In electropuncture, minimal areas are irritated, outside the damage, by placing special sensors according to the skin projections of the points. In the case of electroacupuncture, current signals are sent to steel needles immersed in tissues to the depth of the points. The obvious advantage of this approach is the activation of not only cutaneous afferents, but also deeper afferents, contributing to the summation of therapeutic effects.[1] The third technique, percutaneous neurostimulation, consists in irritating extensive skin areas.

The therapeutic direction of interest is considered mainly as an anti-pain aid, but its effects are not limited to this.[1] In particular, based on the literature and our own data, the effect has been shown for various somatic and psychosomatic pathologies both independently and as part of detailed therapeutic and prophylactic regimens.[2-6]

To explain the effects observed in the course of its application, a series of hypotheses are involved, including the vegetative-reflex theory of A.E. Shcherbak. This system,

developed in the thirties of the last century in relation to physiotherapy, is in principle applicable to any type of physical stimulation. Based on this, in response to stimulation, local, segmental, and generalized, generalized responses are consistently implemented.

The local link is manifested by an axon-reflex, formed, among other things, by a developed perivascular reaction. Moreover, due to the lower threshold of excitability, pain receptors are the first to react to irritation, and then vegetative receptors, with the transmission of a signal to the spinal cord. The involvement of the structures of the latter determines the stimulation of various structures – muscle fibers, blood vessels, internal organs.[1,7]

Further propagation of impulses along the ascending nerve pathways is accompanied by the activation of subcortical formations and the cerebral cortex proper. The resulting triggering of neurohumoral and immune reactions ensures the implementation of a generalized protective and adaptive (compensatory) response. In particular, in this case, changes are traced in the hypothalamic-pituitary system, adrenal cortex, thyroid and gonads.[8,9]

Summing up, the local physical impact, being transformed into chemical, is transformed, in turn, into a single nervous-reflex and humoral process with the involvement of various body systems in responses.

In terms of methodology, the rules for performing electro- and electroacupuncture do not differ significantly from the principles of classical acupuncture. The preference for choosing a current of alternating polarity, noted in most sources, is explained by the prevention of possible electrocoagulation of tissues and corrosion of acupuncture needles used during the procedure. In addition, alternating current signals, especially sinusoidal signals, are close in characteristics to electrical impulses generated by nervous tissue.[7]

The criteria for choosing the intensity, frequency and duration of electrical stimulation are largely determined by the nature of the pathology. In particular, in algias of various origins, the subpain level of stimulation provides pain relief as a result of activation of thick myelinated fibers and the launch of "gate control". In the case of other pathological conditions, the sensations that arise during stimulation are close to conditionally "comfortable". The selected current strength also depends on the localization of the points, ranging from 50 (facial area) to 200 μA (torso and upper or lower extremity area). The duration of exposure varies from a few minutes to 1 hour, but an interval of 15-20 minutes is optimal.[1,7]

In terms of optimizing frequency characteristics, it is noted that in neurodystrophic changes, low-frequency signals of 3-5 Hz are used, muscular-tonic signals - 50-100 Hz.[10] Relief of vegetative-vascular disorders, especially with the dominance of the spastic component, is provided by a mixed mode of action (3/50 Hz). At the same time, favorable changes in peripheral hemodynamics are often complemented by reflex changes in the blood supply to specific organs.[11]

To prevent the adaptation of the point to electrical signals, a number of techniques are used. These include the rhythmic change of single signals by bursts of pulses or their deviation - a wave-like change in frequency and amplitude characteristics. The number of procedures performed in this case is up to 10 per course, in accordance with the general recommendations for the use of reflexology.[7] The techniques themselves are carried out with the help of stationary or portable equipment, usually 2-4 channels, which allows you to stimulate 4-8 points at the same time.

Transcutaneous electrical stimulation, as mentioned above, consists of irritation of large skin areas.[1,12] At the same time, there are several types of technology. One of them is "traditional stimulation", which is characterized by a high frequency (50-120 Hz) and low intensity of exposure using short pulses of 50-100 μs. The parameters of the other, acupuncture-like variant are the opposite of the previous one and are represented by a combination of low frequency (2-4 Hz), high intensity (slightly below the pain threshold), and long pulses of 100-300 μs. In this case, it is believed that a multi-level compensatory mechanism is triggered, identical to acupuncture pain relief.[9] This approach is most effective for pain sensations that occur in deep structures (muscles, internal organs), or multiple sources of pain.

Also of interest is a biocontrolled technique performed by weak and low-frequency pulses of electric current.[5,8,13] The clinical effects observed here are directly correlated with the classical principles of accommodation - the formation of an orienting reaction by comparing the stimulus with the traces of previous stimuli. In turn, the shape of the signals used is consistent with the dynamics of changes in impedance (electrical resistance) in the subelectrode areas of the dermis. As for the implementation of the main therapeutic effects, the initially prevailing response of the nervous system in the form of a slow regulatory action is later replaced by the "activation" of humoral support factors.[3]

It is shown that the method has a direct effect on the myofascial component of the pathological process. Under the influence of irritation, there is an excitation of nerve fibers and passive contraction of innervated muscles, contributing to the growth of their initially weakened contractile function. In addition, the activation of metabolism ensures the restoration of conductivity and excitability of peripheral nerves and, as a result, accelerates their regeneration.[8]

In general, the effect of the presented techniques is largely determined by the "energy budget" of the body.[9] And since the work of any functional system is carried out at an extremely low energy potential, high-energy stimulation not only does not increase, but, on the contrary, inhibits individual functions. On the contrary, the analysis of the body's responses to the action of various factors testifies in favor of the prevailing biological significance of low and ultra-low intensity stimuli.[10]

Their influence on the human body fits into the canvas of general views on the principles of physiotherapy.[14] Thus, according to the principle of small dosage of physical factors, only in such a mode it is possible to activate the body's own defenses. At the same time, low-intensity stimuli, having a predominantly regulatory and training effect on various body systems, create the basis for self-healing processes. The resulting spatial and temporal summation of stimulation ensures the implementation of multi-level reflex and neurohumoral reactions, which leads to an increase in the compensatory and adaptive reactions of the body.[4,14]

In detail, the main effects of low-energy exposure include the following effects: i) hypoalgesia, up to analgesia; ii) release of endorphins and enkephalins in the structures of the brain and spinal cord, as well as serotonin in the nucleus of the suture and posterior horn of the spinal cord; iii) release of corticotropin and cortisone into the blood; iv) influence on the system of mediator metabolism (dopamine, acetylcholine, etc.); v) normalization of vegetative-endocrine functions; vi) improvement of microcirculation; vii) antispasmodic effect (mainly on smooth muscle structures); viii) increased immunological reactivity.

Here, we believe it will not be superfluous to refer to the statement of Prof. V.S. Ulashchik: "Deepening knowledge about the informational mechanism of action of therapeutic physical factors will increasingly create prerequisites for reducing the dosages of physical influences, and informational physiotherapy will replace the current physiotherapy based on energy approaches".[15]

In conclusion, we give several examples of successful use of TENS in various pathological conditions. Thus, it has been shown that the use of the method from the second day after surgery has anti-inflammatory and trophostimulating effects by improving nervous afferentation and microcirculation in the affected area.[13] Parallel enhancement of venous outflow ensures the removal of metabolic products, eliminates tissue hypoxia and edema by reducing the permeability of cell membranes.

If the technology is included in the complex therapy of patients with eczema and neurodermatitis, statistically significant results were noted in the form of normalization of skin temperature topography, improvement of microcirculation and function of the sebaceous and sweat glands in pathological foci in more than half of the cases.[16] Prospective follow-up over the next 8 to 12 months showed that supportive electrical stimulation prevented relapses of the disease.

In sensorineural hearing loss, the anti-inflammatory and anti-edematous effect of DENS on the mucous membrane of the middle ear and the Eustachian tube was noted, coupled with an improvement in the excitability and conductivity of nerve fibers.[17] As a result, there is an increase in the electrical activity of cochlear receptors and neurons of a specific auditory pathway.

The use of the method in deforming osteoarthritis is accompanied by a significant reduction in pain and swelling, an increase in the range of motion in the affected joints.[18]

It has also been shown that the prescription of TENS in the case of postherpetic ganglionitis and lumbar dorsopathies of the region significantly reduces the severity of pain syndrome. Accordingly, this results in a reduction in the rehabilitation time of patients in comparison with generally accepted programs.[8]

In general, the presented general and applied information is an incentive to continue and deepen research in this direction.

List of abbreviations

TENS, Transcutaneous Electrical NeuroStimulation

Contributions

LGA, TVK, MYY, LAM, TVA, NVG, VAV, AAM, development of the study design, data design, writing, review of publications on the topic of the article, data interpretation, statistical processing of data, data interpretation, supervision of the article; LGA, VAD, TEB, TVM, IAG, drafting the paper, revision of the article; LGA, TKC, EPI, supervision of the article.

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Conflict of interest

The authors declare they have no conflicts of interest.

Ethics approval and consent to participate

Not applicable.

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