ELECTRICAL STIMULATION OF ORGANS AND TISSUES
IN CLINICAL MEDICINE

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Electrical stimulation has become increasingly important in recent years. Numerous studies both at home and abroad have shown that by means of electrical impulses (similar in type to the nervous impulses controlling organ function) one can restore the activity of an organ which has lost its normal function. Electrical stimulation is used not only for therapeutic but also for diagnostic purposes, as for example in assessing the functional potentialities of individual organs. In the era of reconstructive surgery, transplantation, and prosthetic assistance of organs, electrical stimulation is indicated in cases where a pathological process has not yet caused structural changes in an organ but has led only to an impairment of its function, which may be restored, enhanced, or corrected by electrical controlling impulses of suitable parameters.

The solving of the problems associated with electrical stimulation of organs has been made possible only by the combined efforts of physicians, biologists, biophysicists, and persons working exclusively in the field of radioelectronics, the chemistry of polymers, etc.

The theoretical basis of stimulation consists in a knowledge of the mechanisms of control of the activity of body systems and individual organs, the ability to determine the natural controlling signals and to stimulate them by creating appropriate generators for electrical impulses, and methods of transmitting these impulses to the organ needing to be stimulated.

Some cases require temporary periodic stimulation, while others require continuous stimulation to replace the controlling signals. Here the electrical effect may be addressed to nerve centers or pathways (reflexogenic zones, nerves) or directly to organs. In either case the electrical stimulation may be effected nonsynchronously or synchronously with the activity of the organ in question, when the artificial impulses are emitted with the natural activity of the organ or of its nervous apparatus taken into account. The type where the biological signals control a system of artificial stimulation, i.e., a bioelectrical stimulation, is the most physiological.

Clinical observations which have accumulated in the domain of electrical stimulation, along with the special investigations carried out, point to the development of a new trend in clinical medicine, namely the electrical stimulation of organs.

The First All-Union Scientific Conference on Electrical Stimulation of Organs and Tissues, held in October 1975, reported the results of studies on this subject; it was shown that at a number of research institutes, medical teaching establishments, and therapeutic and prophylactic centers in our country, a good deal has been and is being done in this direction. The institutions of the Ministry of Health of the USSR, the Ministry of Medical Industry, and a number of other departments and ministries are engaging with success in the technical equipping of the new medical trend, namely the development of an electrostimulating technique.

It has been shown that electrical stimulation, complementing the range of existing therapeutic agencies and techniques, may be associated with them, as for example with drug therapy, and can often produce the desired therapeutic effect in cases where other methods have failed, especially when protracted continuous application is necessary.
As shown by world statistics, the implanting of cardiac pacemakers has so far saved the lives of more than one-half million patients with atrio-ventricular block and Stokes–Adams attacks. Electrical stimulation has also helped in other menacing disorders of cardiac rhythm, as for example after heart surgery, following an acute myocardial infarction, etc.

By the use of electrical stimulation of cerebral structures it is possible to perform complex stereotactic operations, to combat attacks of epilepsy and Parkinsonism, to block the arrival of painful impulses in the brain and thereby to control intolerable pain, the sequelae of spinal cord traumas, etc. There are wide possibilities and indications for temporary stimulation of the gastrointestinal tract, where it contributes to the reestablishment of intestinal peristalsis in chronic constipation, in pareses as a result of a pain syndrome, after abdominal surgery, etc. Electrical stimulation of sphincters has been shown to be effective in the treatment of fecal and urinary incontinence and for normalizing the function of the duodenum and pancreas. Electrical stimulation restores the functions lost as a result of paresis of the urinary bladder. Electrical stimulation of the uterus during pregnancy helps to strengthen or normalize its contractions, which is significant in protracted labor, atonic bleedings, etc. New rehabilitational and training possibilities are opened up by electrical stimulation of the locomotor apparatus, particularly the muscular system. New methods of electrical stimulation of tissues and organs are constantly passing from the stage of experimental study into clinical practice.

Recently however, there have been many problems whose inadequate solution has been hampering the further development of the science of electrical stimulation of organs. For instance, one of the main problems in the construction of electrostimulant systems is the establishing of the medicotechnical requirements, especially the selection of the optimal parameters of the electrical impulses. Unfortunately, insufficient study has been made to date of the mechanisms of the specific processes of excitation and propagation of the controlling signals in certain organs and tissues, especially in organs having a smooth muscle structure. The same may apply also to study of the features of the action currents of certain organs and their neural apparatus. This would to some extent explain why the parameters of the electrical impulses are sometimes selected empirically, and the electrical stimulation applied does not always yield the desired results.

Still more complex is the matter of biocontrolled electrical stimulation (with electrical stimulation of the heart as practically the only exception). When devising biologically regulated systems of electrical stimulation the determination of the signals typifying the functional state of the organ concerned is extremely important for securing feedback; however, these signals have not as yet been sufficiently well studied, and the technical possibility of their continuous automatic emission and processing has not been resolved. There is a lack of means of checking the functional state and the effectiveness of electrical stimulation of a number of internal organs available for routine practice. This particularly applies to the gastrointestinal tract, uterus, and respiratory system, notwithstanding the presence of diverse methods of recording the mechanical and electrical activity of these organs. In this domain there is much work to be done, especially in the area of clinical physiology. The presently available apparatuses for conducting sessions of stimulation of the gastrointestinal tract, urinary bladder, uterus, and locomotor apparatus as a rule exert a nonsynchronous influence on the activity of these organs. Despite the fact that good results have undoubtedly been obtained in the treatment of a number of pathological states and diseases, in our view it is necessary to have biocontrolled or biosynchronized electrostimulators. It will probably be possible at some future time, by analogy with the heart and other organs, to devise monitoring systems with an automatic electrostimulator operating on demand.

It is in general important for organ stimulation to study the processes of direct transmission of electrical impulses to the object, i.e., the problem of contacting between electrode and tissue. And here, there is need of continuation of biophysical researches. Of urgency in this context are such matters as decreasing the loss of electrical energy during impulse transmission, decrease or elimination of undesirable electrochemical processes and of the adverse effect on the tissues contiguous to the electrodes, and so on. A solution of these problems, along with improvement of the mechanical and electric qualities of the conductors and the determination of the optimal location and area of contact, will go a long way to improving the implanted electrodes, and one would be able to decide which methods and which apparatuses are best suited for general clinical use.

Apparatus for biocontrolled biosynchronized stimulation will be specific for certain organs, although in some cases it is quite feasible to evolve external universal stimulators serving the requirements of electrical stimulation of several organs. For example, it is possible to integrate stimulators for organs having smooth musculature with the proviso that they are equipped with different sets of special electrodes.