

## Electrostimulation in medicine – history and contemporary usage

**Abstract.** Some historical and contemporary aspects of the usage of electricity in medicine were presented in the paper. The using amber and electric fish in antiquity and medieval ages was described. The contemporary use of electricity in medicine is connected with the discovery Volta's battery and was shown from the first attempt in 19<sup>th</sup> century till today's medical practice. The last part of the paper was devoted to the lately discovered electric stimulation of fingerprints. Two clinical cases were shown as the examples of this stimulation.

**Streszczenie.** W artykule przedstawione zostały historyczne i współczesne aspekty stosowania elektryczności w medycynie. Przedstawiono historię wykorzystania bursztynu i ryb elektrycznych od starożytności do wieków średnich. Współczesne wykorzystanie elektryczności w medycynie wywodzi się od odkrycia baterii przez Voltę - pokazane zostały przykłady elektrostymulacji: od XIX wieku do dzisiejszej praktyki medycznej. Ostatnia część artykułu poświęcona jest metodzie stymulacji poprzez opuszki palców. Przedstawione zostały dwa przypadki medyczne z zastosowaniem tej metody. (Elektrostymulacja w medycynie – historia i współczesne wykorzystanie)

**Keywords** - electric stimulation, fingertip stimulation, Sudeck syndrome, textronics  
**Słowa kluczowe** – elektrostymulacja, stymulacja opuszków palców, syndrom Sudecka, tekstronika

### Introduction

The therapeutic applications of electricity, i.e. electric field, have their roots in the ancient ages. At the very beginning of this approach the stimulation has been done externally with unknown parameters. Nowadays, electric stimulations are being made both externally or internally by implanted electrodes. In spite of the fact that the usage of electricity in medicine is known from antiquity the mechanism of the interaction between human organs and electricity (or electric field) is still far from understanding. To make the understanding more probably the special studies are to be initiated and they should involve the researchers from physics and engineering as well as the researchers from the medicine. Both groups of researchers have quite different experiences in the area of electromedicine. Hence, the problem in question can be observed from a few points of view and therefore better understood.

### History of Electric Stimulation

The better understanding of the physical phenomena is strongly rooted in the history of their using and investigation. The same approach is necessary when one starts with the analysis of, widely understood, electromedicine. Indeed, the first evidences of it one can find in the ancient Rome where Plinius Maior (Pliny the Elder, 23-79) in his opus vitae „Historia naturalis”, published in the 1st century, mentioned amber as very useful in some mental diseases, like the attack of fury [1,2]. Finally, the importance of amber, as the medical remedy, diminished to a great extent as its electric power was too weak. Much powerful appeared to be electric fish.

The first evidences with a fish come from the ancient Egyptians who used the electrical catfish from the Nile river. According to some historians the precedence of using electric fish in therapy was Scribonius Largo, personal doctor of Emperor Claudius. At the end of 40<sup>th</sup> of the 1<sup>st</sup> century he used as the therapeutic tool the fish called Torpedo (Fig.1). His main therapeutic activity was concentrated on gut pain relief and according to some historians he succeeded in it. The therapy by use of Torpedo fish could be called nowadays as electroanalgesia.

Plinius Maior, mentioned above, and Galen (130-200), Roman doctor of Greek origin, were also engaged in the use of electric fish in the therapy, especially for the curing

the headaches as well as for the therapy helpful for the mood problems, including the hysteric distractions.



Fig.1 Electric fish (Torpedo)

In the middle ages Avicenna (980-1037), Persian doctor and philosopher and Averroes (1126-1198), Persian philosopher supposed that catfish can be useful in curing such diseases as migraine, melancholy and epilepsy. These methods were successfully used till the 16<sup>th</sup> century [3].

In 16<sup>th</sup>-17<sup>th</sup> centuries the inhabitants in Etiopia used the electric discharge from electric fish (in that case it was electric catfish) for the healing people from the bad ghosts.

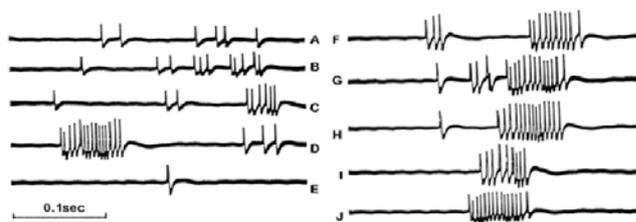


Fig. 2 The courses of electric discharge of electric fish.

The electricity of fish is quite big: the voltage of torpedo fish reaches 230 V, of catfish 350 V and the voltage generated by eel can reach up to 1000V [4]. Also the current generated is of 30-50 A. It is interesting that the electric fish produce the electric signal of pulse nature with the range of frequency 50-300 Hz with the total time of stimulation a few seconds (Fig.2). This situation resembles

the technique of electroshock and, maybe, therefore the neurological and behavioural dysfunctions were successfully treated by electric fish. This therapy has also a side effect: the relatively high current can heat or even burn the part of the body [5].

Electric organs in the electric fish, like Torpedo, catfish and eel, produce electricity of low power (Sach's organ) – in this case they serve as electronavigator, and those of big power and they have therapeutic features (Hunter's organ). Their location of the electric organs is illustratively shown in Fig.3 on the example of eel [5].

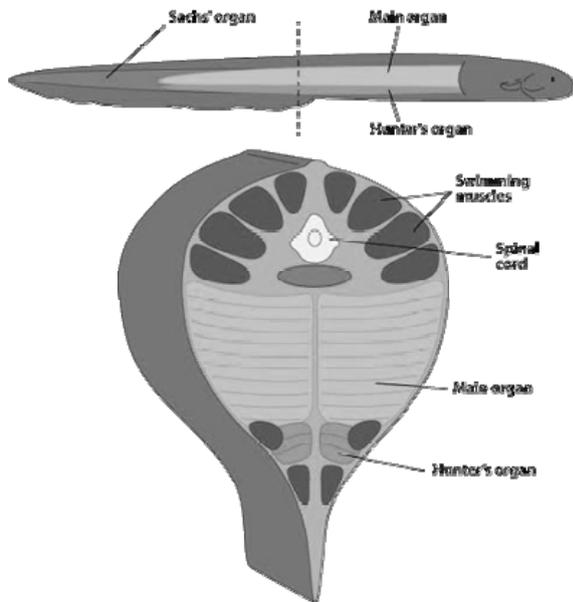


Fig. 3 The electric organs in electric eel [5]

The real scientific research of the electric medicine has started in 19th century when, after the discoveries of Volta, Galvani, Oersted, Faraday and the others. The people have got the ability to create electricity in an artificial way instead of use the natural sources. However, it has to be added that also Volta and Galvani experimented with the animal electricity at the end of 18th century.

In the modern history of electromedicine two names should be underlined: Guillaume Duchenne and Ugo Cerletti.

Guillaume Duchenne (1806 - 1875) – French neurologist, was fascinated with the effect of electricity over muscular fiber contraction. It was the spark that lighted his genius. Probably – as a side effect during experiments on himself, he would realize only later – the electric shock treatment reduced his depression and restored his will.

Almost one century later, in 1937, an Italian neurologist Ugo Cerletti (1877-1963) was studying epilepsy. He knew from medical literature that electric shocks produce epilepsy-like convulsions and wanted to cure the disease with Electroconvulsive Therapy (ECT). Cerletti's research was conducted against the research regarding insulin-provoked convulsions which were very similar to epilepsy. His idea was that electricity would annihilate epilepsy seizures. He came to this conclusion when he saw pigs being cataleptic after electroshocks before being slaughtered, and he was the first one to use electric shock therapy treatment. It should be added here that the Electroconvulsive Therapy is being used till nowadays. Although it is modernized and deprived of side bad effects to a great extent the main idea of electroshocks is still the same. [6-9]

Some historians suppose that the title of founding father of electrotherapy belongs to Johann Gottlob Kruger, Professor of Medicine at the University of Halle. They quote his sentence "...through electrification, changes in the deepest regions of the human body can be brought forth". He saw the importance of electricity in the curing of organ of motion.

### Contemporary applications

**Diadynamic current** is a low frequency current. It can be semi-wave and full-wave sinusoidal current, 50-100 Hz frequency. Combining frequency and strength and adding constant galvanic direct current you can have a few modulations.

**Transcutaneous Electrical Nerve Stimulation (TENS)** is a method of electrical stimulation which primarily aims to provide a degree of symptomatic pain relief by exciting sensory nerves, and thereby stimulating the pain gate mechanism and the opioid system. All parameters of such processes should be optimized using one or more different kind of optimization algorithms.

**Interferential electrical stimulation** is an unique way of physiotherapy which allows to mimic the low frequency therapy by use of two medium frequency currents. Because the skin impedance changes towards the frequency in inversely proportional way, thus the application of low frequency current to the patient body may evoke an unnecessary pain and discomfort. Allowing them to interfere in the patient body, one limits the patient discomfort and to stimulate the organ with the current of low frequency.

### Electric Stimulation of Fingertips

The new approach in electric stimulation has been mastered very recently. It is the electric stimulation of tips. The treatment is realized using two-directional pulse currents with long interval time between pulses. It is assumed that the stimulation of tips evoke some change in neuronal cells in the patient brain.

Technically, the stimulation is realized by five-finger glove with electrodes installed on the tips (Fig.5).



Fig.5 The stimulation glove (internal view)

### Case Studies

To confirm the validity of fingertip stimulation therapy the real diseases:

- complex regional real case syndrome (Sudeck complex),
  - hemorrhagic and ischemic stroke,
- were proceeded in the Military Institute of Medicine. [10].

### Complex regional real case syndrome (Sudeck complex)

The woman was subjected to treatment as Fig. 6.

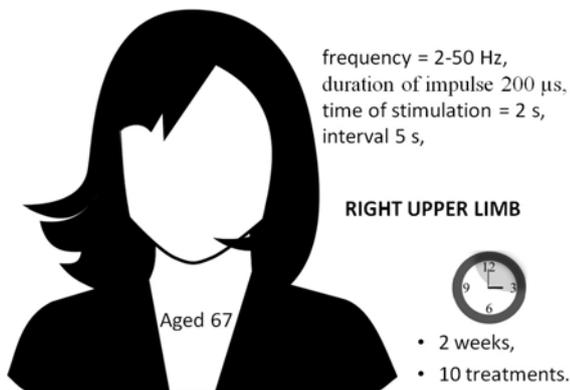


Fig. 6. Parameters of treatment in the case of Suedeck complex

The test of cold water has been carried out. At first the initial blood pressure  $p_0$  is measured, then the hands were immersed in the cold water (3 °C) for two minutes. The right difference between „before cooling” and „after cooling” for the right reactivity of autonomous system should be 15 mm Hg. The examination of the patient who was treated by the tip stimulation showed the perfect accordance with the theoretical expectation (fig. 6).[10]

#### Hemorrhagic and ischemic stroke

A 39 years old woman with pyramidal, left-sided hemiparesis resulting from the intracerebral haemorrhage from a rupture of cerebral aneurysms of the connecting anterior artery was surgically treated. Neurosurgical treatment with embolization resulted in secondary disease - ischemic stroke in the colossal commissure. As a result of the damage integration of information processes between hemispheres have been disturbed. In this case dysfunction of memory impairment and sensory-motor disorders of the upper limb were the main problem. The treatment started 4 weeks after the brain incident. Comprehensive rehabilitation as a kinesiotherapy, massage, neuro – logopaedics and neuro – psychological and hand therapy was applied. The rehabilitation process was supported by the use of percutaneous stimulation of sensory endings - *repetitive sensory stimulation* (rSS) during four weeks.

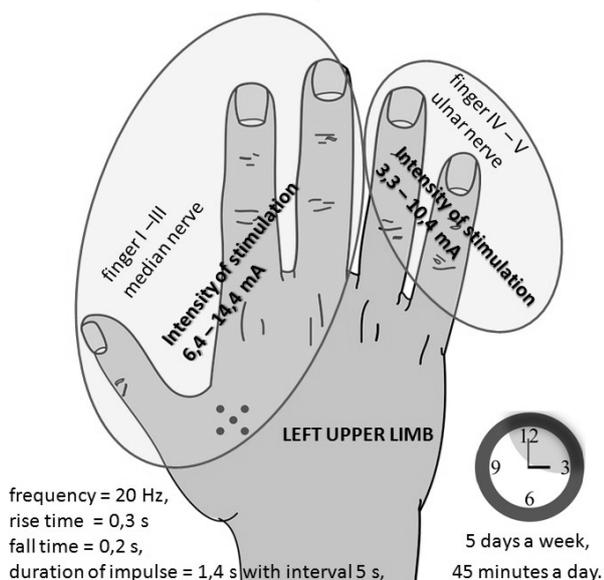


Fig. 7. Parametres of treatment in the case of hemorrhagic and ischemic stroke

The application intensity did not cause pain and was considered neutral or pleasant by the patient. The stimulation was not affected by sleep, rest or other activities

which do not impact directly the work of the device. At the beginning, in the middle and at the end of the therapy, tests of the affected and healthy hand function were performed. The tests concerned surface and deep feeling and muscle strength. The assessment of hand function showed that properly selected parameters of stimulation of sensory receptors induce and facilitate the reorganization of neuronal connection processes in the sensory cortex and central nervous system (CNS). This in turn led to the improvement of sensorimotor behaviours such as manual and writing skills or visual-motor coordination. Using this method we can strengthen the brain plasticity processes and improve treatment and rehabilitation effectiveness [10]. The performed clinical and functional examination showed that the rSS stimulation method can be an important element facilitating the rehabilitation process. In the future during the production process of the rehabilitation device, it is necessary to consider the possibility of a greater adaptation of the electrodes by changing their shape e.g. with the use of laser forming technology [11,12].

#### Discussion

The stimulation glove is one of the examples of textronics - new field of knowledge in which there is the combination between electronics, textiles, computer science and measurement [13]. Using this type of therapeutic tools, attention should be paid to the temperature of the electrodes so that local skin burns do not occur [14-16]. To avoid areas of increased heat dissipation, homogeneity of the electrode structure should be verified using e.g. a method such as laser interferometer diagnostics [17] or tomography [18- 20]. It is also important to take into account the change of resistance of electrodes during therapeutic treatment because the change of resistance is observed according to mechanical deformations [21].

it should be noticed that all parameters of treatment should be adjusted personally even using the complex optimization as [22-25].

#### Conclusions

On the basis of historical evidences and nowadays experience one can prove the effectiveness of electrostimulation in various diseases. Electrostimulation is widely used in physiotherapeutical treatments as well as in psychiatry and neurological ailments [25-26]. The main idea of electric stimulation is to input electric current into the body. Depending on the illness just cured the current is introduced at the proper place with the proper intensity. The new method, namely the electrostimulation of fingertips, stimulates the tips of fingers and then the electric signal is transmitted to the proper part of brain which is responsible for this or that sickness. The intensity of electric current in the method is rather small and hence the treatment is believed to be painless. The results of case studies, obtained in the Clinic of Rehabilitation of the Military Institute of Medicine indicate that the method can be successfully applied in two diseases of neurological etiology: Suedeck complex and hemorrhagic and ischemic stroke. It should be stressed here that the other medical cases have to be examined in order to prove the validity and reliability of the method. A special attention should be also directed to the examination of the character (frequency and shape) of electrostimulation to understand the mechanism of such a stimulation, and then to get the possibility of control it.

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