

## PHYSICAL THERAPY IN NERVE INJURIES

Przemysław Lisiński

Clinic for Rehabilitation, University of Medical Sciences, Poznań, Poland

### SUMMARY

Nerve injuries are commonly observed in clinical practice both in surgery and on rehabilitation wards. Most often effects of nerve injuries are muscle weakness and pain sensation. When mentioned clinical symptoms occur, electrotherapeutic procedures are commonly used not only for pain treatment but also for strengthening of weak muscles to restore and improve transmission of impulses via motor or sensory fibers of damaged nerves. However, their efficiency is still disputed by many authorities and practitioners. Aim of this study is a summary, supported by literature recommendations, of contemporary theory and practice of electrotherapy to other than physiotherapy and rehabilitation specialists.

**Keywords:** upper extremity, nerve injury, electrotherapy

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### Introduction

Nerve injuries are a serious health problem and result in longlasting disabilities. There is little information about their frequency of occurrence and good practice in treatment (Scholz *et al.* 2009). Upper extremity nerve injuries can occur during sport or occupational activity. This pathology seems to be real when pain, weakness, or paresthesia appears in the absence of other tissues in upper extremity injuries (Neal and Fields 2010). Other reason for described pathology is the perioperative nerve traction. Particularly patients undergoing shoulder or

## FIZYKOTERAPIA W USZKODZENIACH NERWÓW

Przemysław Lisiński

Klinika Rehabilitacji Uniwersytet Medyczny w Poznaniu

### STRESZCZENIE

Uszkodzenia nerwów są powszechnie obserwowane na oddziałach chirurgicznych jak i rehabilitacyjnych. Najczęstszymi objawami są w tych przypadkach niedowład mięśni i ból. Gdy wspomniane objawy występują stosuje się najczęściej elektroterapię, aby przywrócić lub poprawić przewodnictwo we włóknach ruchowych lub czuciowych nerwów. Jednakże efektywność tych metod jest ciągle kwestionowana przez wiele autorytetów i lekarzy praktyków. Celem tej pracy jest sumaryczne, poparte aktualnym piśmiennictwem, przybliżenie teorii i praktyki dotyczącej elektroterapii, innym niż fizjoterapeuci i lekarze specjalistom.

**Słowa kluczowe:** kończyna górna, uszkodzenie nerwu, elektroterapia

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elbow surgical interventions are in a group of risk (Plastaras *et al.* 2014). The incidence of nerve injury coexisting with upper limb trauma occurs approximately at 1.64%. Most often nerve injury is connected with a crush injury (Taylor *et al.* 2008). In most cases initial treatment should be nonsurgical. One of the most common conservative procedures used at the beginning of the treatment is electrotherapy. Theoretically, when weakness, pain, and/or paresthesia appear, voltage-dependent conductive properties of nerves allow to apply the chosen

electrotherapeutic procedures not only for pain or paresthesia treatment but also for strengthening of weak muscles to restore and improve transmission of impulses via motor or sensory fibers of damaged nerves. However, their efficiency is still questionable by many authorities and practitioners.

### Aim

Aim of this study is, supported by literature recommendations, summary of contemporary theory and practice of electrotherapy to other than physiotherapy and rehabilitation specialists.

### Patients and method

Research of MEDLINE database was chosen as a method. Keywords in following order were entered: upper extremity, nerve injury, and electrotherapy. Only researches from 2000 to 2016 were taken under consideration.

### Results

Finally 33 papers have been identified. Treatment of pain was described in 15 papers, procedures of muscle electrostimulation resulting in strength improvement were presented in 9 papers, and studies of nerve repair neural transmission were described in 9 papers. Generally, effects of electrotherapy in treatment of upper limb nerve injuries are described in these three categories.

#### *Pain modulation*

Electrotherapy is mentioned as one of the oldest methods of pain treatment. History of this method, effectively applied by different nations and cultures in past centuries, started in ancient times. Our medical antecedents probably accommodated for medical practice the natural, biological phenomena. Theoretical basis for direct stimulation of peripheral nerves is the theory of the “gate control” by Melzack and Wall from 1965. Since then, this idea has been applied to the treatment of different painful conditions (Henderson 2008). Effectiveness of other

electrotherapeutic modalities (diathermy, iontophoresis or transcutaneous electrical nerve stimulation), which aim to reduce pain, are based on an increase of total electrical energy into the body of a patient. Their analgesic, physiological effect is explained generally by modification of the nociceptors function, dorsal root ganglia cells and spinal ascending tracts excitability (Page *et al.* 2014). Only few classic electrotherapeutic modalities are described in current literature as effective in the case of upper extremity pain occurrence. Most often transcutaneous electrostimulation (TENS) is used in treatment of pain in patients with rotator cuff injuries or carpal tunnel syndrome (Page *et al.* 2016). Parameters of TENS application are often individual-dependent because of the variety in threshold excitability of proprioceptors and nociceptors in an area of pain. However, optimal output parameters should be: 100Hz frequency, 80ms width of single pulse and a duration of stimulation session for 30 minutes (Casale *et al.* 2013). Location of electrodes in patient with pain originated from rotator cuff injury is presented in Figure 1.



**Figure 1.** TENS procedure in the case of patient with rotator cuff injury.

We can very often observe in clinical practice that myofascial pain syndrome in neck and shoulder region which coexists with pain arising from rotator cuff injury. In this case a variation of classic TENS, a method called simply pulsed neuromuscular stimulus (PENS), applied in trigger points treatment is equally effective (Iodice *et al.* 2016). Based on my experience, I would like to recommend the interferential current as a safe electrotherapeutic option for the treatment of pain in rotator cuff injuries (see Figure 2). The neural fibers transmitting pain sensation are blocked, due to their position, relative to the electrodes, the modulation frequency and the strength of the stimulus (Agharezaee and Mahnam 2015). During the interferential current therapy I have noticed less incidences of complications like arrhythmia or hypertension which are sometimes observed when the TENS near chest is used. Additionally, the interferential current is recommended in treatment of pain connected with the carpal tunnel syndrome (Koca *et al.* 2014).



**Figure 2.** Interferential current therapy in the case of rotator cuff injury.

Electroacupuncture is another very interesting application of electrotherapy which

was explored last decade. Although this method is mostly used in deactivation of active trigger points in patients with myofascial pain syndrome, some instances of upper limb nerve injuries treatment resulting in pain decreasing are mentioned in the literature. Its mechanism of action is explained by regulation of COX-2 expression in nociceptive sites leading to decrease of inflammatory edema and hyperalgesia. Further, commonly known term “functional electrostimulation (FES)” is routinely used for activation of paralyzed muscles in patients with spasticity after stroke, cerebral and spinal cord injuries. Application of FES in peripheral pain treatment is described as an effective method only once, in the case of regional pain syndrome as a consequence of compound upper extremity trauma (Planitzer *et al.* 2014). This serious complication can be successfully treated by electrical neuromodulation of the dorsal root ganglia (DRG), decreasing intensity of all sensorimotor, vascular and trophic changes (Van Buyten *et al.* 2015). New possibilities of improving pain treatment in cases of upper extremity nerve injuries are connected to application of advanced technologies. For example, motor cortex stimulation (MCS) seems to be effective in treatment of chronic neuropathic pain in upper extremity (Fagundes-Pereyra *et al.* 2010). Its anti-pain actions is explained by direct alteration of brain activity. The only efficient method of chronic pain treatment found in the literature is the transcranial direct current stimulation (tDCS) with short-term effects, so the further investigations are necessary (O’Connell *et al.* 2011). Implanted periodically or permanently peripheral nerve stimulator is also the “future” of treatment in chronic, neuropathic pain associated with brachial plexus injuries (Stevanato *et al.* 2014).

#### *Muscle strenght Improvement*

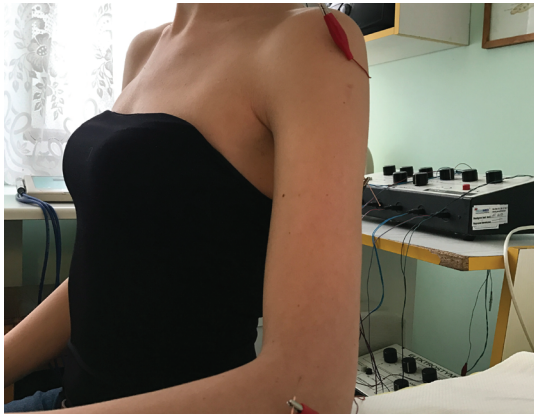
Electrostimulation with different parameters like a shape of singular pulse, its

width, frequency of stimulation and its duration were analyzed through prism of their effectiveness in a treatment of muscle's weakness in past decades. At this time, the attention of researches is still turned to optimization of parameters of electrostimulation to achieve the strongest contraction without pain sensation and fatigue of stimulated muscle. One of the more interesting conceptions in this area is using the multi-contact electrodes for stimulation which allows for activation of different motoneurons of single peripheral nerve at the same time resulting in excitation of corresponding populations of motor units to produce strong, selective muscles' contractions (Fisher *et al.* 2013). Another solution serving the stated aim is the improvement of muscle activation through biofeedback. Commands and feedback signals are extracted from biopotentials recorded from muscles (EMG), nerves (ENG) or the brain (EEG). This model of electrostimulation seems to be the most natural and the least harmful but further investigations are needed (Sinkjaer *et al.* 2003; Baldwin *et al.* 2006). One of the most common complications observed after electrostimulations of muscles is their fatigue. According to some observations (Dreibati *et al.* 2011), the efficiency of electrical stimulation aiming to increase the muscle strength without corresponding fatigue seems to be possible to achieve with smaller number of contractions per one session with a higher level of force production, resulting in even more than 60% of maximal voluntary contraction. Additionally, better results are achieved when the asynchronous low-pulse-rate electrostimulation is applied (Maneski *et al.* 2013). Technical progress allows introducing to clinical practice new devices and technologies. Preliminary reports indicate that anodal transcranial direct current stimulation (tDCS) applied over the primary motor cortex (upgrade of the synaptic strength) can significantly improve the strength of grip (Saimpont *et al.* 2016; Karok and Witney 2013).

Strengthening of muscles may be a result of using the low-amplitude transcutaneous electrical peripheral nerve stimulation (TENS). This procedure by modulation of cortical and corticospinal excitability can enforce the final motor output resulting for example in improvement of grip strength or activity of trapezius muscle (Tataroglu *et al.* 2011).

#### *Nerves' regeneration*

Beside of pain and muscle weakness, the third very important symptom of nerve injury is parenthesis. Pathology, initially located in a site of injury secondarily evokes the degenerative changes in conductive elements of spinal cord (apoptosis). It was proved recently that electroacupuncture applied with the high-intensity and low-frequency, promotes functional motor nerve repair probably by increasing the secretion of neurotrophic factors in CNS (He *et al.* 2015). It seems to be real since the same determinant explains effectiveness of electrostimulation in enhanced sensory reinnervation after complete digital nerve transection (Wong *et al.* 2015). Positive effect of stimulation was observed when the biphasic electric current was applied (Kim *et al.* 2011). Axonal regeneration in humans (ENG studies) was proved when longlasting (1 hour) bipolar electrostimulation was applied with low frequency (20 Hz; bipolar) (Gordon *et al.* 2010). It should be reminded that electrostimulation diminishes misdirection of regenerating motor axons caused by end-organ deprivation (Gordon and English 2016). Effectiveness of electroacupuncture with direct current as a method for increasing the ulnar and medial nerves regeneration was also recently presented (Xia *et al.* 2013; Tang *et al.* 2016). Location of needles is presented in Figure 3.



**Figure 3.** Location of electroacupuncture needles directed for ulnar nerve regeneration.

### **Discussion**

Different electrotherapy applications such as: direct current (DC), electrostimulations (altering current; AC), interferential current (IC), functional electrostimulations (FES) are used commonly in patients with nerve injuries treated conservatively. According to the rules of Polish Concept of Rehabilitation, the electrotherapy is only a part of complex treatment in this situation. It should be applicable on a par with kinesiotherapy. In other countries the electrotherapy procedures are used alone without kinesiotherapeutic support. In this situation, the estimation of electrotherapeutic efficiency in clinical categories is difficult and very often these methods of treatment are rejected. A few decades ago, in 1970' and 1980', many papers were published and efficiency of many kinds of electrotherapy was postulated based on clinical observations. In recent years few interesting papers in the area of electrotherapy were published and their results were often proved by MRI images or neurophysiological studies, although clinical proofs still dominate.

### **Conclusion**

At the beginning of XXI century, according to concept of Evidence Based Medicine, we are creating a new approach to validation of electrotherapy. It is possible because new technologies and diagnostic tools like fMRI, EMG and ENG are available.

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*Author responsible for correspondence:  
Przemysław Lisiński  
Clinic for Rehabilitation  
University of Medical Sciences,  
Poznań, Poland  
28 Czerwca 1956 Str., No 135/147  
60-545 Poznań  
Poland  
plisinski@vp.pl*

*Autor odpowiedzialny za korespondencję:  
Przemysław Lisiński  
Klinika Rehabilitacji  
Uniwersytet Medyczny w Poznaniu  
ul. 28 Czerwca 1956, Nr 135/147  
60-545 Poznań  
  
plisinski@vp.pl*