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REVIEW ARTICLE

CURRENT NEUROPHYSIOLOGICAL METHODS FOR THE ASSESSMENT OF MOTOR FUNCTION AND THERAPY IN PATIENTS TREATED FOR ISCHEMIC STROKE

AKTUALNE METODY NEUROFIZJOLOGICZNE OCENY FUNKCJI RUCHOWEJ I TERAPII U CHORYCH LECZONYCH Z POWODU UDARU NIEDOKRWIENNEGO

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ABSTRACT
Among the clinical methods of the motor function assessment in patients after ischemic stroke, in the light of the available literature, there is little to allow an appropriate, individualized determination of the rehabilitation algorithm using kinesitherapy and physical therapy methods. Considering the diversity of currently used methods of therapy, the aim of this review is to present modern forms of treatment, based on neurophysiological aspects, enabling fast and permanent improvement of mobility in stroke patients, also fulfilling the function of a diagnostic tool that reliably verifies the effectiveness of therapy.

Keywords: ischemic stroke, rehabilitation, diagnostics, neurophysiological methods

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STRESZCZENIE

Spośród metod klinicznych oceny funkcji ruchowej u chorych po udarach niedokrwiennych mózgu, w świetle dostępnej literatury, niewiele umożliwia odpowiednie, zindywidualizowane wyznaczenie algorytmu usprawniania z wykorzystaniem metod kinezyterapii i fizykoterapii. Biorąc pod uwagę różnorodność obecnie stosowanych metod terapii, celem tego przeglądu jest przedstawienie nowoczesnych formy leczenia, opartych na przesłankach neurofizjologicznych, umożliwiających szybką oraz trwałą poprawę sprawności ruchowej u chorych po udarach, spełniając również funkcję narzędzia diagnostycznego, rzetelnie weryfikującego skuteczność terapii.

Słowa kluczowe: udar niedokrwiennych, usprawnianie, diagnostyka, metody neurofizjologiczne

Introduction

Stroke according to the World Health Organization (WHO) is a state of rapid, progressive, focal or generalized neurological deficits, life-threatening, leading to disability (Erajfej *et al.,* 2017). Stroke may be caused by ischemia or bleeding in the central nervous system, and about 70–85% of strokes are ischemic. There are various qualifications of ischemic strokes due to the dynamics of symptoms, the area of ischemia and etiology (Giles and Rothwell, 2007).

Ischemic stroke can cause speech disorders, balance, cognitive, sensory and motor dysfunctions (Adams *et al.,* 2003), depending on location of the ischemic area occupied, in the vicinity of the motor cortex or subcortical centers. In the practice of clinical post-stroke rehabilitation, a number of scales measuring the degree of disability and symptoms of loss of sensory and motor function are used, such as Hospital Anxiety and Depression Scale (HADS), Mini-Mental State Examination (MMSE), Modified Ashworth Scale (MAS), National Institutes of Health Stroke Scale (NIHSS), Stroke Rehabilitation Assessment of Movement (STREAM), Barthel Index (BI), Berg Balance Scale (BBS), Modified Rankin Handicap Scale (MRS), Motor Assessment Scale (MAS), 10-Meter Walking Test (Peural *et al.,* 2002, Laufer *et al.,* 2011, Sabut *et al.,* 2011, Sahin *et al.,* 2012, Erajfer *et al.,* 2017, Guo *et al.,* 2018). The results of evaluation of patients after ischemic stroke using the assessment scales listed above, however, do not provide indications for the introduction of specific therapeutic procedures for kinesitherapy and physical therapy as well as pharmacological treatment (ESO Guidelines, 2008).

Aim

Considering the diversity of currently used methods of therapy, the aim of this review was to present modern forms of treatment based on neurophysiological aspects, enabling fast and permanent improvement of mobility in stroke patients, also fulfilling the function of a diagnostic tool that reliably verifies the effectiveness of therapy.

Methods

Pharmacologically, most patients with well-recognised ischemic stroke are treated with antiplatelet drugs, mainly acetylsalicylic acid, and in cases of contraindications to treatment with ASA, thienopyridine drugs such as clopidogrel are used. In a patient admitted to hospital treatment in a so-called "therapeutic window" (that is, up to 4.5 hours from the onset of symptoms) and without contraindications to intravenous injection of tissue plasminogen activator (Alteplase). In special cases, mechanical thrombectomy may be used during acute ischemic stroke due to large vessel intracranial occlusion.

Modern physiotherapeutic treatment of patients after ischemic stroke is based on the assumption of relearning the motor functions related to neuroplasticity, both at the level of spinal cord centers activity and at the supraspinal level centers (Woldag and Hummelsheim 2002, Wolf *et al.,* 2005). Therefore, the most commonly used form of kinesitherapy is PNF treatment, also called proprioceptive neuromuscular facilitation (Woldag and Hummelsheim 2002). The other treatments are individualized (Auchstaetter *et al.,* 2016), depending on the patient's psychophysical condition, but mainly include passive, supportive and active extremities exercises on the side of the paresis, exercises reducing the spasticity symptom (PIR - post-isometric relaxation procedures), stretching exercises, as well as procedures stimulating proprioreceptors. During the 10-day stay in the post-stroke rehabilitation ward, the patient is up righted to standing position with also training to sit down, teaching changes in position and global movements that are performed during everyday life (e.g. changing positions in bed, moving from a chair to a chair). Another element of rehabilitation is learning to walk (locomotion), including gait at the handrails and walk using orthopedic equipment ('balcony' support). Other exercises are respiratory and equivalent, in which the eyesight, hearing, receptors of touch, balance and deep sensation are activated.

Furthermore, physiotherapetic treatment mainly include 'warming therapy' and electrostimulation of paralysed muscles using the

algorithms of electrical stimuli normally supplied with electrotherapy equipment by manufacturers (Hara 2013, Stein *et al.,* 2015). The adaptation of the latter leaves much to be desired when it comes to individualization for the needs of the rehabilitated patient. Electrotherapy is sometimes enriched with functional stimulation of the muscles acting antagonistically at the level of the wrist and ankle joint (Lisiński *et al.,* 2008). In the studies of Lisiński *et al.* (2008), similarly to the studies of Kraft *et al.* (1992), who used combination of PNF and functional electrical stimulation (FES) in stroke patients, a significant improvement in the function of weak muscles of the symptomatic extremities was found, both upper and lower. Until now, however, studies in this area were performed in relation to a small group of patients after ischemic stroke (N = 24) in short-term observation (after 20 days of treatment) (Lisiński *et al.* 2008). In addition to electrostimulation treatments that are supposed to affect the efficiency of motor units or muscles themselves or improve the conductivity of nerve impulses in motor nerve fibers (Sharifi-far *et al.,* 2018), neuroplastic phenomena have been documented at the level of the sensory cortex after stimulation of sensory nerve fibers (Peurala *et al. ,* 2002, Laufer *et al.,* 2011). Other physical therapy procedures include treatments in the field of thermotherapy and electrostimulation that should induce lowering of muscle tone in patients after stroke with a symptom of spasticity (Collins *et al.,* 1986, Bell and Lermann 1987, Shields 2002, Garcia *et al.,* 2019).

One of the newest methods of therapy of patients after ischemic stroke is using the repetitive transcranial magneticstimulation with a series of magnetic stimuli (rTMS). The research on this therapy was conducted by Guan *et al.* (2017), who showed an improvement in motor function and a reduction of spasticity symptoms.

For a neurologist, rehabilitation doctor or physiotherapist, in a professional practice, a method perfectly suited to the treatment of ischemic stroke would be one that would allow precise quantification of muscle function and nerve impulses conduction, and on the other would be based on results obtained in a targeted manner from a patient's diagnostic tests. A proposition in the field of clinical neurophysiology, in conjunction with the principle of muscle electrostimulation based on the biofeedback principle, is the mentioned remarkable regulation of muscular actions acting antagonistically on the wrist joints and the ankle joints. The alternating muscular activity is regulated by the Ia inhibitory interneurone spinal cord system (Bhagchandani and Schindler-Ivens, 2012). In stroke patients, it is released from the control of supernatural centers. The electromyograms recorded with surface electrodes (sEMG) show disturbances, the range of which can be indexed on a scale of 5–1 (5 – alternating normal activity, 1 – no alternation) (Figure 1).

In patients after stroke, functional electrostimulation of the antagonistic muscles acting on the wrist and ankle joints can be used (Figure 2) using a personal, portable, 4-channel electrostimulation device.

The algorithm can be individually adapted for a patient with certain parameters based on previous sEMG and electroneurographic tests of nerve impulses in motor fibers, depending on the severity of pathological changes and the frequency of sEMG recordings during attempts of maximal contraction condition (usually at 40–70Hz). Contraindications to therapy are epileptic episodes and other consequences of direct craniocerebral injuries, serious cardiovascular dysfunction, pregnancy, ferromagnetic implants, electronic implants such as a pacemaker or a cochlear implant.

Conclusions

The modern methods of rehabilitation of stroke patients applied so far, in the majority of cases, are based on neurophysiological records, including those that use biofeedback, which seem to be the most suitable, because they meet the criteria of individualization in relation to the rehabilitated patient. Future studies verifying the effectiveness of electrostimulation procedures should focus on combining them with targeted kinesitherapy (Adams *et al.,* 2003; Duncac *et al.,* 2005).

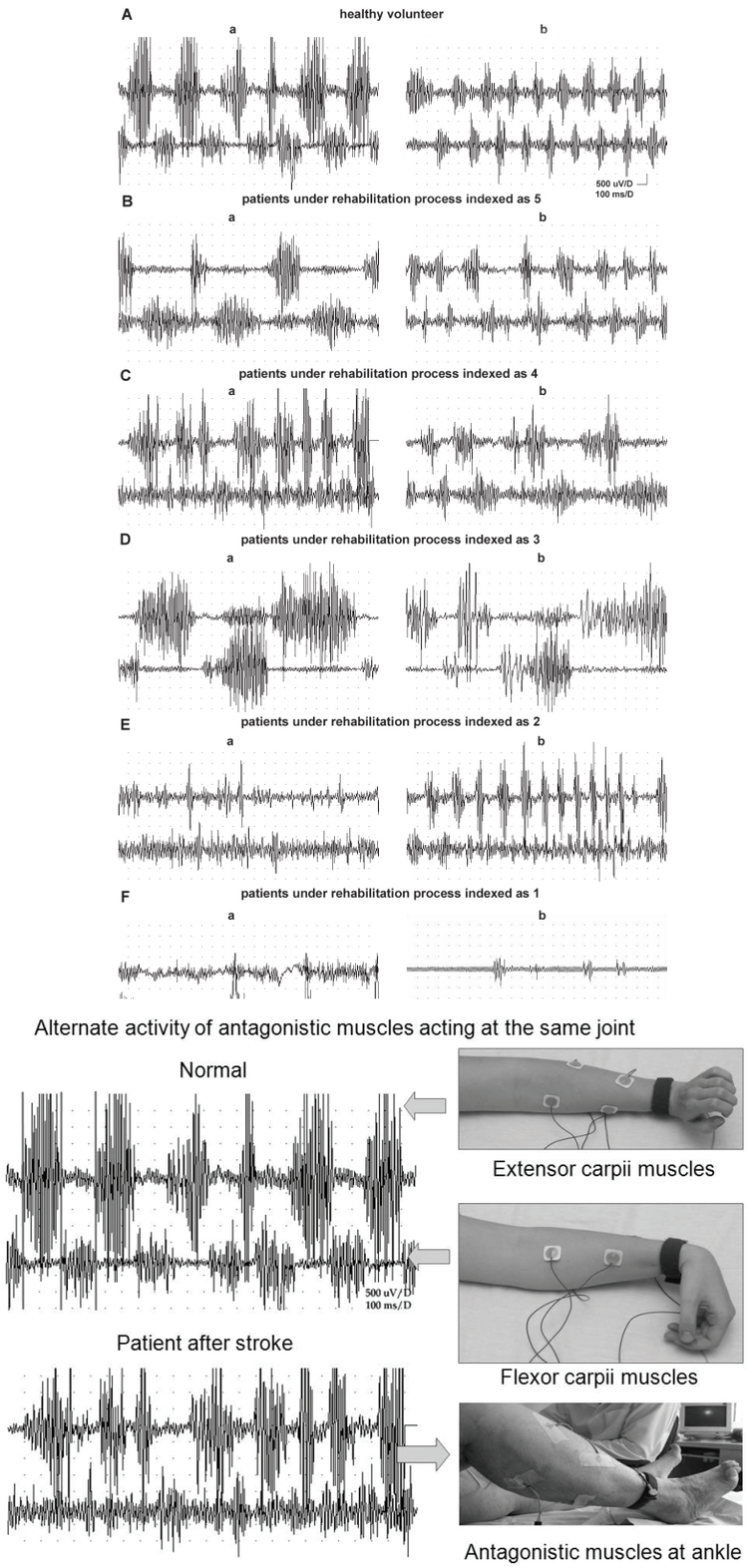

Figure 1. Recordings of electromyograms showing changes in motor unit function of antagonistic muscles of various degrees of severity (a – extensor carpii and flexores carpi muscles, b – tibialis anterior and gastrocnemius muscles) acting at the same joint in patients after stroke scored from 5 to 1 (A – (5) alternate, proper activity; E, F – (1) no alternation) (Lisiński *et al.* 2008, with permission).

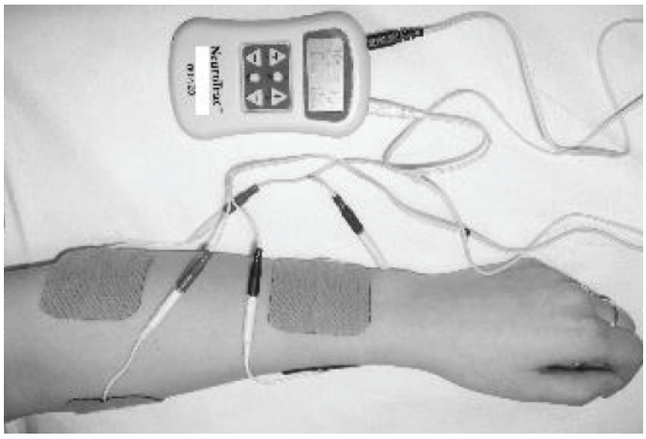

Figure 2. Photo of the apparatus for electrostimulation of antagonistic muscles acting on the wrist joint with the presentation of the location of stimulating electrodes. Source: Department of Pathophysiology of Locomotor Organs, University Medical Sciences in Poznań.

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