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## Abnormal muscle tension as one of the main problems after a stroke

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### Abstract

**Background:** Stroke is a growing problem in an aging society. According to WHO data, it is the second most common cause of death. An increase in the number of strokes causes an increase in the number of patients struggling with its consequences. People who have suffered a stroke are dealing with various neurological defects. One of them is abnormal muscle tension.

**Material and methods:** Analysis of available literature, articles in the Google Scholar and PubMed database using keywords: stroke, muscle tension, spasticity.

**Results:** The problem of disturbed tension is common in people who have had a stroke. Spasticity, i.e. increased muscle tone in response to stretching, results from damage to the central nervous system. Direct and indirect methods are used to assess spasticity. In the fight against destroyed muscle tension, it is important to implement treatment as soon as possible. It is based on the use of various forms of therapy: pharmacotherapy and physiotherapy.

Physiotherapy and kinesitherapy treatments as well as specialized rehabilitation methods, such as PNF. The rehabilitation process should be supplemented with appropriate pharmacological treatment. Equally important is the implementation of stroke prevention. These activities are associated with the promotion of a healthy lifestyle, for example, regular exercise and stress reduction.

**Conclusion:** Muscle tension disorder, including spasticity, is a problem affecting many patients who have had a stroke. A timely diagnosis is important to get the right therapy. Treatment should have a holistic dimension and combine different methods. The goal of therapy is to normalize muscle tone and thus improve the patient's quality of life.

**Keywords:** stroke; muscle tension; spasticity

## **Introduction**

Stroke is a common disease entity that is one of the causes of disability, often with a severe and chronic course [1]. By 2030, it is predicted that stroke will increase by 25% in the US, mainly due to an aging population [2]. The direct effect of this phenomenon will be an increase in healthcare costs, i.e. the economic burden on the country. It is the case in other places around the world, as strokes affect about 15 million people every year [3].

The effects of stroke can include loss of motor function or the appearance of abnormal muscle tone in various parts of the body. Neurological deficits arising after a stroke require planning appropriate rehabilitation. To be able to start it, full diagnostics of the patient are needed. For this purpose, various neurological scales are used, which enable precise functional testing [4]. Early rehabilitation is crucial, because it reduces the patient's functional disability and decreases the risk of complications, thus increasing the patient's quality of life and restoring him to functioning before the disease occurred [5]. Complications after stroke may include: pneumonia, deep vein thrombosis, hypertension or simply death [1].

However, rehabilitation of patients with brain damage is not an easy task. It requires the involvement of all medical staff, as well as the patient and his family, so that the effects of actions bring satisfaction to all people participating in rehabilitation. Some effects of stroke are permanent and irreversible, so it is also important not to expect inadvertently spectacular results of treatment [6].

Among the more frequent consequences of stroke, there is excessive muscular tension in the extremities, which is referred to as spasticity. This disorder arises at various times after a stroke and appears in different parts of the upper or lower extremities [7]. Symptoms of spasticity are: pain, stiffness, limitation of mobility in joints, perceptible muscle tension by touch and vision, weakness of muscular strength and tendon retraction. Spastic tension has many factors and mechanisms that unfortunately impede the healing process [8]. Nevertheless, the use of physical therapy and pharmacological treatment is necessary to avoid worsening of the spasticity, which will be discussed in this article.

## **Stroke**

A stroke is a clinical syndrome characterized by a sudden focal and sometimes generalized brain disorder, in which symptoms last longer than 24 hours or earlier lead to death and have no other cause than vascular. According to the World Health Organization a stroke is the most common cause of disability in adults and the second leading cause of death in the world. The incidence of stroke in Poland is estimated at an average of 100/150 000 inhabitants, with the observed much more frequent occurrence in men, which is indirectly compensated in older age groups, due to the longer average [9, 10].

Stroke that affects approximately 85-90% of patients is the ischemic stroke. It is a condition that arises when an artery occlusion supplies the brain with blood. As a result, the blood does not flow through it or does it with a very small quantities that is not enough. The most common cause of ischemic stroke is atherosclerosis, in which atherosclerotic plaques consisting mainly of cholesterol accumulate in the walls of blood vessels. They gradually are blocking the artery's lumen leading to its complete blockage. Embolism also blocks the artery lumen through thrombus in the heart. It might happen after a heart attack or in people with an artificial heart valve. Thrombus may also form in the veins of the limbs [11, 12, 13].

Hemorrhagic stroke is a consequence of the rupture of the cerebral artery wall and the outflow of blood outside the vessel. The blood does not reach the brain tissue in the area supplied by the broken artery. During the stroke the flowing blood destroys the nervous tissue that is near the vessel and it increases the pressure inside the skull. The high pressure disturbs the functioning of the brain. Hemorrhagic strokes are divided into the intracerebral hemorrhages, where the damaged vessels are located inside the brain and the subarachnoid haemorrhages where the damaged vessel is located on the surface of the brain. The cerebral hemorrhage is usually caused by untreated or poorly treated hypertension. In contrast,

subarachnoid haemorrhage is the result of the rupture of a larger aneurysm or haemangioma due to defects in the vessel wall [10, 11].

The symptoms occurring in stroke depends on which part of the brain has been damaged. Symptoms may become more severe and then disappear within a dozen or so hours, and then increase again. Symptoms that disappear spontaneously within 24 hours are considered an episode of transient cerebral ischemia. The most common signs includes: visual impairment, problems with balance and coordination of movements, facial muscle paresis, e.g. a drooping mouth, weakening of the lower or upper limb, or both simultaneously. There also might appear a very strong headache, weakness of the tongue and throat muscles causing difficulties in speaking and swallowing food, loss of consciousness – a widespread stroke makes the patient very sleepy and his speech is usually illogical also the patient does not know what is happening to him or he is completely unconscious [9, 10].

### **Causes of stroke**

Central nervous system vascular diseases are the most common cause of cognitive and motor impairment in people over 50 years of age. Annually, about 15 million people worldwide experience a stroke, among them as many as 5 million die, and another 5 million experience permanent disability. The mortality rate after stroke is primarily dependent on the cause of the stroke, for example it is three times higher in the case of intracranial bleeding than in ischemic stroke [14, 15, 16, 17].

The causes of stroke may be many, but the most important issue from a medical and social point of view is effective, primary and secondary prevention. The risk of stroke increases with age, therefore, it is very important to systematically monitor the basic medical parameters, i.e. arterial pressure, because arterial hypertension increases the probability of cerebrovascular disease by 3-4 times [14, 15].

Ischemic stroke is still one of the leading causes of death and disability among adults. The most common cause of this type of stroke, which is approx. 85% of all vascular diseases, is the cerebral ischemia resulting from narrowing or closing of the blood vessel to the brain. The closure of an anterior or intracranial vessel may occur as a result of an embolus with an atherosclerotic base or the deposition of material from the heart cavities. Artificial heart valve or atrial fibrillation are examples of diseases that can lead to the formation of blood clots in the heart, which together with the bloodstream, accumulate in the vessels leading to obstruction of the arteries. Rarely, ischemic stroke occurs as a result of lowering blood pressure caused by dehydration, cardiac arrhythmias or taking medicines that lower blood pressure. The most

abnormal factor affecting the occurrence of vascular obstruction is the abnormal connection of veins with arteries so-called arteriovenous malformations [14, 18].

Perennial untreated hypertension can lead to damage to the walls of blood vessels and, as a consequence, lead to the formation of an aneurysm. Bursting of the intra-cerebral vessel is a common cause of cerebral hemorrhagic stroke. As a result of thrombolytic treatment and hemorrhage of an ischemic stroke, a hemorrhagic stroke may occur which may pose a threat to human life [14].

The most important risk factors for stroke are, among others: hypertension, diabetes, disorder of lipid and carbohydrate metabolism, overweight and obesity associated with improper diet, i.e. rich in salt, saturated fats and cholesterol. Also, the lack of physical activity, alcohol abuse, smoking and the use of certain drugs and psychoactive substances can affect the occurrence of a stroke. According to data from all risk factors, the most important is hypertension, which accounts for about 50% of all cases [14].

### **Characteristic symptoms and diagnostics**

According to the WHO definition, a stroke is a sudden life-threatening condition that manifests in focal or generalized brain dysfunctions, persisting longer than 24 hours and requiring absolute hospitalization [19]. The cause of stroke is acute cerebral insufficiency of various etiologies, resulting in reduced cerebral perfusion in the course of ischemia or hemorrhage [19]. Clinical signs of stroke include: paresis or hemiplegia; halitic sensory disorder; speech disorders of the type of aphasia – inability to say words and understand simple commands; visual impairment – one-eyed vision (amaurosis fugax), double vision; visual field disorders; dizziness and headaches with centrifugal feeling, nausea, vomiting; balance disorders [19, 20].

Spasticity is a movement disorder associated with various damage of the central nervous system (strokes and spinal cord, multiple sclerosis, anoxic damage – after cardiac arrest, hereditary spastic paraplegia, injuries, cerebral palsy). Spasticity is one of the forms of increased muscle tone. The growing tension of the muscle depends on the speed of its stretching, the resistance increases to a certain point, after which the tension decreases. The increase in tension in the occupied limb increases and suddenly disappears during her passive stretching. This is a characteristic “clasp knife” symptom. Spasticity was first described by Lance in 1980. According to its definition, it is movement disorder characterized by a speed-dependent increase in tonic stretching reflexes (muscle tone) with exaggeration jerks of

tendons, resulting from the hyperactivity of the episode reflex, as one of the elements of the upper motor neuron syndrome [21].

As mentioned earlier, stroke is the second leading cause of adult disability in the world. Upper extremity deficits are very common, while 33 to 66% complain about lack upper limb activities after six months of stroke. As a consequence, daily activities such as lifting a glass of water and closing zips are difficult, if not impossible for many people after stroke [20]. Muscle spasticity is a common complication after stroke and occurs with a frequency of 17% to 38%. Spasticity of the upper limb can cause deformity, functional impairment and chronic pain [23].

The diagnosis of spasticity is based on the use of a number of different tests. The assessment of spasticity can be direct and indirect. The indirect method assesses the effects of spasticity. For evaluation spasticity can be used by subjective and objective methods. For objective methods include dynamometric studies, quantitative analysis of gait phases, evaluation of muscle tone in the lower limb, assessment of upper limb and gait efficiency, and postural control. These methods also include EMG and goniometric tests. The subjective methods are: assessment of tension, assessment of daily life activities, evaluation of spasms frequency and assessment of general motor skills [23].

The pendulum test was used in 1950 by professor of neurology Robert Wartenberg as a qualitative diagnostic test. However, this test was attempted to use diagnostics a little earlier, at the beginning of the century [8]. One of the most important applications of goniometry (in pendulum test) concerns spasticity. The pendulum test was used in patients with multiple sclerosis to assess the pharmacological treatment of spasticity with tizanidine [23]. The pendulum test allows to obtain a quantitative and qualitative image of the intensity of spasticity.

The Ashworth Scale distinguishes four degrees of increased muscle tone: 1 – a slight increase in tension when the limb is moved, 2 – more increased tone, but the limb is easily flexed, 3 – a significant increase in tension, passive movement is difficult, 4 – rigid in affected areas of limbs. In the pendulum test the goniometer measures the temporal function of changing the angle between the axis of the thigh and the lower leg, which oscillates freely in the knee joint of the lower limb. For evaluation the severity of muscle tone in the group of muscles of the hip joint should be Adductor Tone Rating Scale. It is a scale that includes degrees from zero to 4. On this scale: 0 – the tension is not increased, 1 – the tension is slightly increased, visiting to an angle of 45 degrees easy, 2 – visiting to a 45 degree angle requires light effort, 3 – visiting up to a 45 degree angle requires moderate effort, 4 – visiting to a 45 degree angle requires 2 people.

The scale, which is used to assess the frequency of spasms is the Penn Spasm Frequency and Snow Scale. On the Penn scale, the patient determines how many spasms he has observed in one hour. Snow Scale it is used to assess the frequency of spasms throughout the day. In the assessment of motoriness, are effective scales like: Brunnstrom, Fugl-Meyer, Rivennead and Sodring [23].

The hand function assessment applies dynamometric tests evaluating muscle strength. Various skill tests are also used, such as the test of a board with pins (Purdue test). In the Jebsen and Taylor test, writing, drawing grids, flipping pages, attempting to grip a large light object and a large heavy object are assessed. What's more, The Duncan-Ely test and the Thomas test are used to assess lower limb muscle tone. To assess the patient's walk and control the body measures the time that the patient needs to get up from the chair, walk 10 meters, execute return and re-seated. And the Berg Balance Scale is used to assess the patient's balance. The EMG test allows, among others, for assessment of mutual relations between agonists and antagonists [21].

Depending on the site of injury, there may be different clinical images of spasticity. The posture of Wernicke Mann is characteristic for patients after stroke. It is characterized by internal rotation of the upper limb in the elbow, wrist joint, metacarpophalangeal and interphalangeal joints accompanied by pronation of the forearm. Sometimes wounds and maceration of the skin form in the lower elbow. Excessive flexion in the wrist joint may cause secondary tibial puncture syndrome due to increased pressure in the wrist canal. In the patient after stroke in the lower limb there is an image of the clubfoot. A special form of spasticity is a hammer-like toe or a gigantic toe (hitchhiker's great toe) [23].

### **Rehabilitation and its main assumptions**

Independence is an important term for everyone, so after a stroke it is essential not to forget about rehabilitation. The person after a stroke does not have to learn to do everything on their own, but it is important to give them the opportunity to return to a normal life. Therefore, the main goal of motor rehabilitation of a person after a stroke is to recreate as much as possible the lost motor functions, taking into account his or her needs, interests and motivation [24, 25].

In order to improve the patient's functionality, an appropriate plan of the rehabilitation programme should be drawn up, therefore it is the physiotherapist's task to select appropriate exercises, which the patient is able to perform alone or with help, as well as skills that will allow him/her to improve the level of functional efficiency [24, 26].

In the first days after the stroke, a wide range of passive movements should be undertaken in order to prevent painful contractures in the joints. After a few days, when the

patient's condition allows adapting to a sitting, then standing and walking position, these are the main activities that rehabilitation undertakes. The majority of patients should walk alone or with help within 3-6 months. The main problems in improvement include paresis, deep sensory and visual-spatial disturbances. Speech rehabilitation should be introduced from the beginning of the therapy. Rehabilitation should be achieved through occupational therapy and exercises leading to improved patient self-service [27].

Rehabilitation of patients after a stroke is carried out at all times, as in the acute stage, during a full recovery, but also in the chronic stage. During the acute period, care should be taken to ensure that the patient is properly positioned, that he or she frequently changes position and passively exercises, as well as in a few cases of breathing exercises. Patients who are deeply unconscious should be placed on the side or abdomen, where the head is lower than the trunk, in order to prevent secretion, collapse of the tongue and choking. Each patient's position should be changed after 2-3 hours to prevent pneumonia and decubitus ulcers. The limbs are protected against excessive stretching of the paralysed muscles, with additional pillows and sandbags respectively. The upper limb is placed in the shoulder joint ( $60^{\circ}$ - $90^{\circ}$ ) and bend in the elbow joint ( $90^{\circ}$ - $140^{\circ}$ ), with the hand in a slight dorsal bend with fingers slightly bent, this arrangement is used to prevent swelling and facilitates the outflow of venous blood. The lower limb shall be placed in a small bent in the hip and knee joints, with the foot converted and dorsally bent, in order to prevent a spastic club foot, which is very easily accepted in a paralysis condition. During this period passive and respiratory exercises are used.

The recovery period must take into account the general condition of the patient and the etiopathogenesis of the stroke. Depending on the type of stroke, appropriate rehabilitation is undertaken. Systematicity, which plays a role in helping to achieve visible functional improvement, is of great importance during this period. The patient's condition determines the continuation of therapy, passive exercises, as well as exteroceptive and proprioceptive stimulation, also active movement procedures, resistance exercises and relaxing training [28, 29].

Chronic rehabilitation concerns therapeutic gymnastics, which is used in people with central (spastic) paralysis of limbs. During exercise it is recommended to use strong proprioceptive stimuli, which mobilize motor cells and facilitate muscle contraction. In the late period, i.e. about a year after the disease, the condition of people after a stroke becomes almost stationary. Depending on the patient's adaptation to disability, their further rehabilitation will be continued [29].

Spastic muscle tension associated with severe hemiplegia requires various symptomatic treatment or orthopaedic supplies. Properly selected physical agents and pharmacology reduce the severity of spasticity.

Physical treatments include thermal treatments that expand blood vessels and lymphatic vessels, thus increasing blood flow. Warmth relieves pain and reduces muscle tension. It can be applied in the form of wraps: paraffin, gels, fango or with the use of Sollux lamp, short waves, massage in warm water. The second treatment is cold therapy, aimed at inhibiting directly the activity of the muscle and indirectly at stimulating antagonists. Cold compresses reduce the average amplitude of deep reflexes as well as the release and reduction of nerve conduction amplitude, additionally it has a positive effect on the exclusion of skin receptors and the release of neuromuscular conduction in sensory and vegetative nerves and influences the speed of chemical reactions. These procedures can be applied in the form of cold compresses or extreme low temperatures using mainly liquid nitrogen vapours, used locally or on the whole body [28, 29]. Transcutaneous electrical nerve stimulation (TENS), functional electrostimulation (STEP), Hufschmidt tonolysis using low-frequency current or Träbert currents were also used in spasticity. Biofeedback training plays an increasingly important role in patients with spastic paresis. These exercises are performed by the patient himself, and his muscular activity is monitored by an electromyographic device with the use of audio-visual aids.

Other physiotherapeutic forms, such as hydrotherapy in the form of whirlpool massages and warm baths, have found their application in the treatment of spasticity. In spasticity, water acts on muscles in a thermal, hydrostatic and mechanical way. Depending on the stimulus frequency – high frequencies (100-200Hz) were used on antagonistic muscles to induce reciprocal braking, while low frequencies (<70 Hz) relax spastic muscles [28].

### **The use of Proprioceptive Neuromuscular Facilitation (PNF) after stroke**

Rehabilitation of the consequences of a stroke is a very individual issue. Body dysfunctions after a stroke concern, among others, muscle work, body motor activity, posture stability, gait or sensory stimuli. It is often difficult for a patient to perform everyday activities. This contributes to the patient's dependence on family and other persons, often belonging to the medical staff [30]. For these reasons, during the traditional rehabilitation of the patient more and more often newer methods of rehabilitation are used, which would efficiently fight the effects of stroke. These include, among others, the concept of PNF (Proprioceptive Neuromuscular Facilitation) [31].

The PNF method was developed in 1946 by two scientists, neurophysiologist Herman Kabat and physiotherapist Margaret Knott. It was created as a result of the observation that everyday activities take place in more than one plane, but usually they are complex movements of diagonal and spiral character [32]. The method is based on complex movement patterns developed for individual parts of the body, such as the upper limb or the trunk. The applied PNF techniques include for example: stretch from beginning of range, rhythmic stabilization, stabilizing reversal or „contract-relax” technique. All techniques are aimed to return the patient to the physical functions of the rehabilitated parts of the body. Thanks to them, the main final goal of rehabilitation according to the PNF may be the patient's return to full independence [33].

The effectiveness of rehabilitation of people after stroke by the PNF is scientifically confirmed by many scientific sources [30, 34, 35, 36]. Kaniewski et al. examined 20 patients after ischemic stroke. In the rehabilitation process, the philosophy of the PNF concept was applied, according to which the therapy was individual, the mobilization and reserves of the patient were used, and global motor functions were taken into account. The goal was to recreate the trunk's motor activities and re-education of the gait. After the intervention, one of the results of the research was the fact that thanks to the PNF, the degree of disability, for which the Rankin scale was used, was statistically significantly reduced [30]. In addition, Pasternak et al. showed that PNF rehabilitation resulted in a statistically significant improvement in as many as eight out of nine indicators that assessed patients' functional performance [34]. Similar conclusions were drawn during research by Kałużny et al. in which patients after ischemic stroke aged 47 to 78 took part. The use of the PNF in the patients significantly improved the functional status of them [35]. Wolny et al. also showed in the research of 96 people that the PNF concept significantly improved the functioning of respondents in everyday life, especially in terms of self-service and mobility. The PNF method in combination with tension mobilization of the paresis upper limb proved to be more effective than traditional methods and kinesitherapy [36].

To conclude, the PNF method is a modern way of treating stroke patients and has many advantages. It effectively improves patients' independence in everyday life and prevents asymmetry caused by less frequent use of the weaker limb due to stroke. It also counteracts muscular atrophy and joint's range-of-movement limitations [37]. It is worth emphasizing, however, that the PNF – like any other form of rehabilitation – can sometimes produce ambiguous results, which is why further studies are still needed [38]. Regular observation of scientific reports is important because there is a tendency to combine the PNF with other

methods of rehabilitation, such as kinesiотaping, elastic taping or virtual reality technology [31, 39, 40].

### **Pharmacotherapy**

Pharmacological treatment of stroke depends on the current situation of the patient. It should be taken into account that each medicine used has specific contraindications and may have side effects or interact with other medicinal substances that are taken simultaneously. In the case of older people who are more susceptible to the action of drugs, special attention must be paid to the type of substances used and how they affect the already damaged CNS. Pharmacological treatment after stroke is relatively short, aimed at controlling excessive difficulties during rehabilitation [41].

The consequences persistent after stroke prevent proper rehabilitation. Before starting the exercise, it is sometimes necessary to give painkillers [41]. Increased muscle tension makes exercise difficult. A well-known anti spastic drug is i.e. Baclofen. It was assumed that it works GABA-mimetic, which increases the presynaptic inhibition in spinal motoneurons. Baclofen reduces the excessive activity of monosynaptic reflexes, but also exerts a central effect, sometimes contributing to the feeling of initial stupefaction. The next anti-spastic medication is sodium dantrolene, which acts directly on skeletal muscles. It inhibits the release and capture of intracellular calcium, which is necessary for muscle contraction. When using high doses, it may be hepatotoxic, so it is important to perform liver function tests. As with baclofen, initially dizziness, nausea and diarrhea occur. Sodium dantrolene and baclofen act independently, having a different point of pharmacological handle, so in severe cases they can be administered together. In addition to the above, tizanidine is also an anti spastic medicine [42].

In order to improve the quality of sleep and sedation, patients are administered benzodiazepines. They reduce the tension of all skeletal muscles, unfortunately contributing to the feeling of tiredness and bewilderment, as well as the deterioration of sphincter function which can be troublesome for the efficiency of patients. For this reason, their use should be under constant control [42].

In the treatment of neuropathic pain, antiepileptic drugs and tricyclic antidepressants as well as SSRIs are taken. Depression impairs the process of improving the patient's health and is a very common complication after stroke. Patients with depression are often less functional and show a greater neurological deficit. Other pain states are treated by means of e.g. NSAIDs. In addition, paracetamol or topolignocaine are also used to achieve analgesia [43, 44, 45].

Patients on intensive care who have respiratory disease after stroke have to receive opioids intravenously [45].

For a long time, therapeutics aimed at increasing the regeneration of damaged CNS after stroke and supporting the achievement of rehabilitation in the cognitive and motor dimension were sought for. Despite the tests carried out, each drug should be used with caution, due to the possible occurrence of side effects [44].

## **Prevention**

There are many risk factors for stroke. Some of them are not subject to modification, such as age, gender, race or genetic factors, however, the influence on the majority is achievable. Appropriate knowledge and action will make the risk of stroke significantly reduced. Prevention is divided into primary and secondary. Primary prevention applies to people who have never had symptoms of circulatory failure. On the other hand, secondary prevention includes people who have suffered a stroke [46].

An important element of prophylaxis is controlling blood pressure. Long-term studies have shown that hypotensive effects bring satisfactory results. It is advisable to keep blood pressure lower than 140/90 mm Hg. People with hypertension are four times more likely to have a stroke. Research has shown that a reduction in blood pressure by 5-6 mmHg reduces the risk of stroke by up to 42% [46, 47].

As part of the prevention, the cholesterol has to be kept at an appropriate level. Studies have shown that an increase in cholesterol levels increases the risk of stroke in both women and men. The diet and the level of physical activity play an important role here [47].

Rejection of nicotine is an important part of prophylaxis. Research indicates that smokers are twice as likely to suffer from stroke as non-smokers. The number of cigarettes smoked in one day is important [46, 47]

It is recommended to regularly exercise moderate intensity physical activity. Such activity should last a minimum of 30 minutes. Recommended activities are: cycling, aerobics or a quick walk. This allows controlling your weight, keeping it at the appropriate level and preventing obesity, which significantly increases the risk of stroke [47, 48].

The relationship between drinking alcohol and stroke is unclear. It is believed that alcohol abuse increases the risk of stroke. However, a moderate amount of ethanol has a positive effect on blood clotting and lipid metabolism, which reduces the probability of stroke [49, 50].

## **Discussion**

In the first part of this article there a definition of a stroke was discussed. It is worth mentioning that this disease can be diagnosed not only when it lasts more than 24 hours but also when less if ischemic attack appears or patient dies [51]. Then, plenty of stroke's symptoms was mentioned, however also silent brain infarcts (SBI) occur. They are sometimes detected randomly in neurological studies and are mostly located in the basal ganglia and corona radiata. Furthermore, their main cause is arteriosclerosis which then leads to cerebral ischemia [52].

Next, rehabilitation post-stroke was thoroughly described. Nevertheless, brain computer interfaces (BCI) started to be used for this kind of therapy. The most important aim of this method is to promote the recruitment of specific brain areas and also to improve neural plasticity. Moreover, it helps to restore motor functions by letting patients to produce typical brain activity. Magnetoencephalography (MEG), electroencephalography (EEG), functional magnetic resonance imaging (fMRI) and functional near-infrared spectroscopy (fNIRS) are indicated as non-invasive procedures which let record the brain activity in a manner that is appropriate for BCI applications [53].

In the last parts of the results both pharmacotherapy and prevention of the brain stroke was outlined. Beneficial effects of neuroprotective agents were shown in the experimental models. However, there was no therapeutic efficiency of neuroprotective drugs in pharmacotherapy of stroke in clinical trials. The examples of these agents are: calcium channel blockers (CCB) - like nimodipine, glutamatergic transmission inhibitors, protease inhibitors, antioxidant drugs (for example tirilizad) and sodium channel blockers - to give an instance fosphenytoin [54]. Besides mentioned methods of prevention educating about brain stroke is also very important. It also should be connected with promotion of healthy lifestyle for instance exercising regularly, drinking lots of water and reducing stress [55].

## **Conclusions**

Stroke is a clinical syndrome that leads to disability and even death. The most common symptoms that occur in people with stroke are visual disturbances, problems with balance and coordination of movements, facial paresis of the muscles or weakness of the upper, lower limbs or both. Patients with stroke should be treated interdisciplinary, because this disease is not only physical but also mental. An important role in the successful treatment of stroke is rehabilitation. Initially, kinesitherapy is aimed at preventing painful articular contractures, then prepares the patient to perform basic daily activities. Physical therapy is used to reduce pain, inhibit or stimulate the patient's muscle reflexes. PNF exercises significantly improve patients'

independence in everyday life and prevent asymmetry caused by less frequent use of a weaker limb. Orthotics are used by people with stroke to prevent and treat distortion, by stabilizing, relieving stress, reducing pain, and preventing contractures. Pharmacotherapy is also used in strokes, most often to alleviate the distressing pain that accompanies patients, as well as medications that improve sleep and sedation. The treatment of people with stroke should have a holistic dimension and combine different methods of treatment and rehabilitation. The main goal of patient therapy by an interdisciplinary medical team is to normalize muscle tone, which aims to improve the patient's quality of life.

## **Bibliography**

1. Piskorz J., Wójcik G., Hłzecka J. Wczesna rehabilitacja pacjentów po udarze niedokrwiennym mózgu. *MONZ* 2014, 20(4): 351-355
2. Brewer L., Horgan F., Hickey A., Williams D. Stroke rehabilitation: Recent advances and future therapies. *Q J Med* 2013;106(1):11-25
3. Toman N. G., Grande A. W., Walter L. C. (2019). Neural Repair in Stroke. *Cell Transplantation*; 1-4
4. Wójcik G., Piskorz J., Bulikowski W. Klinimetryczne metody oceny chorych po udarach mózgu w planowaniu rehabilitacji w populacji osób dorosłych. *Hygeia Public Health* 2015; 50 (1), s. 54–58
5. Whitehead S. & Baalbergen E. (2019). Post-stroke rehabilitation. *South African Medical Journal*. 109(2): 81-83
6. Pasek J., Opara J., Pasek T., Sieroń A. Ocena czynności życia codziennego w zależności od przebytego podtypu udaru niedokrwiennego mózgu i przeprowadzonej wczesnej rehabilitacji. *Udar Mózgu. Problemy Interdyscyplinarne* 2009;11(2):41-49
7. Thibaut A., Chatelle C., Ziegler E., Bruno M.-A., Laureys S., Gosseries O. (2013). Spasticity after stroke: Physiology, assessment and treatment. *Brain Injury*, 27(10), 1093–1105
8. Doan QV, Brashear A, Gillard PJ, Varon SF, Vandenberg AM, Turkel CC, Elovic EP. Relationship between disability and health related quality of life and caregiver burden in patients with upper limb poststroke spasticity. *Polymyalgia Rheumatica* 2012;4:4–10
9. Anteck J., et al. Profilaktyka pierwotna i wtórna udaru niedokrwiennego mózgu w świetle obecnych zaleceń i rekomendacji, *Forum Medycyny Rodzinnej*. Vol. 12. No. 3. 2018
10. Kwolek A. *Physiotherapy in neurology and neurosurgery*, PZWL Medical Publishers 2012
11. Kroll M. E., et al. "Adiposity and ischemic and hemorrhagic stroke: Prospective study in women and meta-analysis." *Neurology* 87.14 (2016): 1473-1481
12. Johnston S., Claiborne, et al. "Clopidogrel and aspirin in acute ischemic stroke and high-risk TIA." *New England Journal of Medicine* 379.3 (2018): 215-225
13. Rejdak K., Słowik A., Pathogenesis of ischemic stroke - the possibility of neuroprotection and stimulation of brain plasticity; *Polish Neurological Review* 2018, Volume 14
14. Kwolek A. (red.), *Rehabilitacja w udarze mózgu*. Wydawnictwo Uniwersytetu Rzeszowskiego, Rzeszów 2011
15. Starost M., J. Redlicka, M. Brzeziński, M. Niwald, E.Mille - Stroke - risk of disability and the possibility of improving motor and cognitive functions ; *Pol Merkur Lekarski* 2016

16. Sabiniewicz M., Niwald M., Machnia M., Włodarczyk L., Miller E. Selected cognitive dysfunctions after brain stroke – clinical characteristics and diagnosis Aktualn Neurol 2015, 15 (1), p. 35–40
17. Sidaway M., Czernicka E, Sosnowski A., Neuroplastyczność i związane z nią procesy naprawcze w przebiegu usprawniania po udarze mózgu z uwzględnieniem Terapii Ruchem Wymuszonym Koniecznością. Postępy Rehabilitacji 2013; (2): 37–43
18. Olszewski J. Physiotherapy in selected areas of medicine; Wydawnictwo Lekarskie PZWL, Warsaw 2011
19. Mazur R., Świerkocka-Miastkowska M. “Udar mózgu- pierwsze objawy “ - Choroby Serca i Naczyń 2005, tom 2, nr 2, 84–87
20. Tedesco Triccas L., Kennedy N., Smith T., Pomeroy V. Predictors of upper limb spasticity after stroke? A systematic review and meta-analysis. Physiotherapy 2019, 105(2): 163–173
21. Hoffman J., Ozdarska K., Hoffman A., Sochanek M. Rehabilitacja kończyny górnej po udarze mózgu - Choroby XXI wieku - wyzwania w pracy fizjoterapeuty - pod redakcją M. Podgórną - wydawnictwo WSZ, Gdańsk 2017
22. Wang, M., Liu, S., Peng, Z., Zhu, Y., Feng, X., Gu, Y., ... Li, J. (2019). Effect of Tui Na on upper limb spasticity after stroke: a randomized clinical trial. Annals of clinical and translational neurology, 6(4), 778–787
23. Franek A., Błaszczak E., Taradaj J. Goniometryczny test wahadła w spastyczności, Postępy Psychiatrii i Neurologii 2004; suplement 2 (18): 17-21
24. Cieślak-Korfel A., Improvement after a stroke, Guidebook for therapists and primary care workers, translation, III edition, Kraków 2007, p. 14, 25
25. Desrosiers J., F. Malouin, D. Bourbonnais and co-author. Arm and leg impairments and disabilities after stroke rehabilitation: relation to handicap. Clinical Rehabilitation 2003;17:666-673
26. Laidler P. Rehabilitation after a stroke, Medical Publishing House 2004, p. 20-22
27. Członkowski A., Członkowska A. Treatment in neurology, Kompendium Wydawnictwo Lekarskie PZWL, wyd. II 2004, p. 58
28. Olchowik B., Sobaniec W., Sołowiej E., Sobaniec P. Clinical aspects of combating spasticity, Vol I. 18/2009, No 36, pp. 52-53
29. Prusiński A. Stroke of the brain State Department of Medical Publishing Warsaw 1978, p. 208-218
30. Kaniewski O., Suszyński K., Górka D., Kania D., Szelfer J., Dudek J., Doroniewicz I., Opala G., Kwiek SJ. (2014). Wpływ terapii PNF na proces poprawy motorycznej u pacjentów

po niedokrwiennym udarze mózgu zlokalizowanym w lewej półkuli w okresie ostrym rehabilitacji. *Ann Acad Med Siles*, 68(5):294-301

31. Guzik A. (2010). New directions in physiotherapy for patients after stroke. *Przegląd Medyczny Uniwersytetu Rzeszowskiego*. 8. 401-409

32. Opara J., Aktualne metody usprawniania ruchowego chorych po udarze mózgu. *Udar Mózgu. Problemy Interdyscyplinarne* 2002; 4(1):33-37

33. Galasińska K., Buchalski P., Gajewska E., Zastosowanie koncepcji PNF w rehabilitacji pacjentów po udarze mózgu. *Nowiny Lekarskie*, 2011; 80(2):126-133

34. Pasternak K., Gasztych J., Gworys K., Białkowska I, Gworys P, Kujawa J: Ocena skuteczności metody PNF (Proprioceptywne Nerwowo-Mięśniowe Torowanie) w rehabilitacji pacjentów po udarze niedokrwiennym mózgu – doniesienia wstępne. *Kwart Ortop*, 2012, 1:83-90

35. Kałużny K., Kałużna A., Kochański B., Cichosz M., Płoszaj O., Pawiła M., Zukow W., Hagner W. The influence of neurological rehabilitation on the functioning of patients after ischemic stroke – a retrospective analysis. *Journal of Education, Health and Sport*. 2016; 6(12):38-52

36. Wolny T., Saulicz E., Gnat R.: Ocena efektywności metody PNF w usprawnianiu czynności życia codziennego u pacjentów w okresie późnym po udarze mózgu. *Fizjoter. Pol.* 2009; 9, 1: 51–60

37. Yonghun K., Eunjung K., Wontae G. (2011). The Effects of Trunk Stability Exercise Using PNF on the Functional Reach Test and Muscle Activities of Stroke Patients. *Journal of Physical Therapy Science*. 23. 699-702

38. Gunning E., Uszynski M. K. (2018). The Effectiveness of the Proprioceptive Neuromuscular Facilitation Method on Gait Parameters in Patients with Stroke: A Systematic Review. *Archives of Physical Medicine and Rehabilitation*. Volume 100, Issue 5: 980-986

39. Park S. J. (2017). The immediate effects of proprioceptive neuromuscular facilitation with taping on gait parameters in patients with chronic stroke. *Journal of Physical Therapy Science*, 29(11), 2018–2021

40. Junior V., Santos M. S., Ribeiro N., Maldonado I. L. (2019). Combining Proprioceptive Neuromuscular Facilitation and Virtual Reality for Improving Sensorimotor Function in Stroke Survivors: A Randomized Clinical Trial. *Journal of central nervous system disease*, 11, 1179573519863826

41. Światowa Organizacja Zdrowia, Usprawnianie po udarze mózgu. Poradnik dla terapeutów i pracowników podstawowej opieki zdrowotnej. Elipsa-Jaim s. c., Kraków 2009

42. Blaszkowska A., Mazurka J., Rymaszewska J., Rehabilitation by the beauty – actual guidelines, *Doctor's News*; 2013, 82, 1,
43. Member A., Leśniak M., Pharmacotherapy in rehabilitation of patients after a stroke, "*Neuropsychiatry and Neuropsychology*"; 2010, 5, 3-4: 130-140
44. Jaracz K., Kozubski W., Quality of life after a stroke. Part II – clinical, functional and socio-demographic conditions, *Stroke of the Brain*; 2001, Volume 3, No 2, 63-70
45. Iżicka J., Kozak-Putowska D., Piskorz J., Wójcik G., Early rehabilitation of patients after ischemic stroke, *General Medicine and Health Sciences*; 2014, Vol. 20, No. 4, 351-355
46. Ryglewicz, D. (2005). Udar mózgu – profilaktyka. *Aktualności Neurologiczne*, 5(3), 189-193.
47. Strepikowska, A., & Buciński, A. (2009). Udar mózgu – czynniki ryzyka i profilaktyka. *Farmacja Polska*, 65(1), 46-50.
48. Guzik A., Nowe kierunki w fizjoterapii osób po udarze mózgu. *Przegląd Medyczny Uniwersytetu Rzeszowskiego i Narodowego Instytutu Leków w Warszawie* 2010; 4: 401–409
49. Mukamal, K. J., Chung, H., Jenny, N. S., Kuller, L. H., Longstreth Jr, W. T., Mittleman, M. A. & Siscovick, D. S. (2005). Alcohol use and risk of ischemic stroke among older adults: the cardiovascular health study. *Stroke*, 36(9), 1830-1834.
50. Goldstein, L. B. (2006). Is there a causal relationship between the amount of alcohol consumption and stroke risk?. *Stroke-a Journal of Cerebral Circulation*, 37(1), 1-2.\
51. Członkowska A., Niewada M.: Udar mózgu. *Interna Szczeklika 2018/2019*, *Medycyna Praktyczna*, Kraków, 2018, 366-367
52. Barzyk M., Roźniecki J.J.: „Nieme zawały ośrodkowego układu nerwowego” i ich możliwe implikacje kliniczne. *Neurologia Praktyczna* 2014; 1: 5-10.
53. Van Dokkum L.E.H., Ward T., Laffont I.: Brain computer interfaces for neurorehabilitation – its current status as a rehabilitation strategy post-stroke. *Annals of Physical and Rehabilitation Medicine*, 2015-02-01, Volume 58, Issue 1, 3-8, 2015
54. Rang H.P., Dale M.M., Ritter J.M., Flower R.J., Henderson G.: Rang i Dale *Farmakologia*, Wydanie 2, Elsevier Urban & Partner, Wrocław, 2014, 495-497.
55. Lee C.D., Folsom A.R., Blair S.N.: Physical activity and stroke risk: a meta-analysis. *Stroke*. 2003 Oct, 34 (10), 2475-81.