ASIA LIFE SCIENCES 29(1): 1-9, 2020
The Asian International Journal of Life Sciences

A study on the physical therapy intervention techniques for the enhancement of upper extremity functions of ischemic stroke patients

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The aim of this study was to understand conventional physiotherapies to enhance the upper extremity functions of ischemic stroke. This is a literary study with articles and papers. We think that the upper extremity function of ischemic stroke can be improved by physical therapy that can facilitate the healing process. Physical therapy techniques such as stretching, hydrotherapy, cryotherapy, hyperthermia, vibration stimulation and constraint induced movement therapy, orthosis and electrotherapy are applied in basic ways to treat stroke patients. Thus, a systematic approach of various methods is required to improve the upper-extremity bodily functions of patients.

Keywords: ischemic stroke, spasticity, upper extremity function, physical therapy

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Received 18 December 2019; Accepted 18 January 2020

Printed in the Philippines

INTRODUCTION

Many people suffer long-term sequelae after stroke and have difficulty in performing independent activities because of the loss of functional abilities. Most stroke patients experience impairment of upper extremity motor skills, and 80% of hemiplegic patient experience hand function disorder (Maciejasz et al. 2014; Yoo et al. 2015). The deterioration of the upper limb bodily functions in stroke patients is associated with the spasticity of the upper extremities. The spasticity of the upper extremities mostly appears 1 year after stroke, which acts as a critical factor that interferes with the independent life of stroke patients (Watkins et al. 2002). Spasticity is a general characteristic of the upper motor neuron syndrome and ischemic stroke. A fast joint movement in spastic ischemic stroke patients increases the tension of the muscle by stretch reflex, which reinforces the jerk phenomenon of tendons; thus, it is a movement that should be avoided by spastic patients (Lance 1980).

In the United States, more than 800,000 people suffer brain damage every year. Among them, approximately 600,000 develop brain damage for the first time and approximately 180,000 experiences a recurrence (Gracies et al. 2010). According to the Health Insurance Review and Assessment Service, there are 486,000 patients who are receiving treatment for ischemic stroke in South Korea (Health Insurance Review & Assessment Service, 2018). Korea is expected to become a super-aged society by 2026, surpassing 20.8%. Such rapid population growth will be caused by advances in science and technology and changes in living standards (Cho et al. 2019, Yang et al. 2017). An increase in the elderly population will result in an increase in stroke patients, and plans for evaluation and treatment of stroke patients are important. According to a study of Wizzle, spasticity develops within 6 weeks after onset in one in four stroke patients, primarily in the humeroulnar joint (79%), radiocarpal joint (66%), and tibiotarsal joint (66%) (Gracies et al. 2010). It has been reported that the spasticity pattern in the upper extremities appeared as medial rotation and adduction of the gleno-humeral joint, flexion of the humero-ulnar joint, and flexion of the radiocarpal and interphalangeal joint in the upper extremities, and the adduction and extension of the knee and equinovarus of the foot in the lower extremities (Hefter et al. 2012, Marciniak 2011). Another study reported that spasticity of the upper extremities appears within the first 1 year in 4 to 38% of stroke patients, and impairment of the arm function appears in 25 to 46% (Lundstrom et al. 2008, Urban et al. 2010, Wissel et al. 2010).

Unlike the lower extremities, the upper extremities have many functional aspects and play critical roles in functional daily living activities, such as eating, bathing, dressing, using the toilet, washing face, and taking a shower, and special functional activities, such as using a computer and writing. Securing the upper extremity function is critical because stroke patients with bilateral paralysis must lead daily life by making the best of the upper extremity functions (Lee et al. 2019).

Despite medical development, the prevention and treatment of stroke is still a challenge of modern medicine, causing severe sequelae, serious functional disorders, and mental and psychological anxiety, with adverse effects on everyday

life. Furthermore, the cost and time required for treatment are a huge burden on the remnant life of patients.

The current treatments applied to stroke patients include medication, transcutaneous electrical nerve stimulation (TENS), functional electrical stimulation (FES), traditional physical therapy such as stretching to improve the visco-elasticity of muscles, task-oriented training to enhance functional performance, and orthoses to prevent muscle shortening. However, there are still limitations in the physical therapy approach to recover the upper limb functions of spastic stroke patients. Therefore, this study re-examined various literatures because it is necessary to understand the upper extremity bodily functions of spastic stroke patients, and a physiotherapy intervention is required to recover the upper extremity functions of these patients.

MAIN DISCOURSE

1. Occurrence of spastic ischemic stroke. There are only a few studies dealing with spasticity. Somerfield et al. (2004) conducted the Modified Ashworth Scale (MAS) test for 95 first-stroke patients and found that spasticity appeared in 21% of all patients and 26% of 77 hemiplegic patients within 5.4 days on average. Furthermore, spasticity appeared within 3 months in 19% of the 95 subjects and in 28% of 64 patients who still had hemiplegia. The MAS scores of the patients stayed the same in most cases in 5 days and 3 months after onset, and only one patient changed from 1 to 4 points. These results suggest that the prevalence in all patients did not increase from 5 days to 3 months, but only increased slightly in the hemiplegia group.

Opheim et al. (2014) evaluated six times in 1 year for 117 patients with impaired upper extremity functions 3 days after the first onset of stroke and followed up 76 patients for 12 months. He reported that spasticity appeared in 25% of the patients in 3 days after onset, 44% in 4 weeks after onset, 38% in 3 months after onset, and 46% in 12 months after onset. These results demonstrate that a half of the patients with spasticity developed it in the first 3 days, and the other half in the first 1 month. The MAS scores of most patients ranged between 1 and 2 points, and only six patients showed very strong spasticity; all of them had strong spasticity of the elbow flexor.

According to a recent study, the morbidity rate of spasticity was not much different between the upper and lower extremities, but severe spasticity cases mostly appeared in the upper extremities (Sommerfeld et al. 2004). However, severe cases of spasticity are very rare.

2. Pathology of the upper extremities of spastic ischemic stroke patients. Spasticity of stroke patients is caused by the collapse of the relationship between sensory input and motor response, which leads to hypersensitive reaction of the compartmentalized central nervous system (Mayer et al. 2003). This is related to the intensity of the input sense, such as the strength of stretching, and to the location of damage in the central nervous system. If the balance between the inhibitory and excitatory nerve fibers is broken, various syndromes of the upper extremities can appear, such as hypotonia, dyskinesia and spasticity. Spasticity is caused when there

is a damage of the brain stem, the primary, secondary, and subsidiary movement regions of the cerebral cortex, and area 3 of the pyramidal tract of the spinal cord (Soyuer et al. 2007). The occurrence of spasticity can be explained by the reorganization of disorderly nerves after the brain is damaged. The reorganization of the pathological nerves increases the muscular activity and causes increased reflexes to peripheral stimuli (Ivanhoe et al. 2004). This overactivity depresses the reflex action, increases the normal reflexes of the deep tendon reflex, and activates the tensional stretch reflex (Pandyan et al. 2005).

Marque et al. (2001) claimed that the strong contraction of type II muscle fiber of the quadriceps femoris muscle can cause spasticity in hemiplegic patients and reported that the stimulation of H reflex was found at the site of spasticity of the quadriceps femoris muscle. The simultaneous activation of types I and II muscle fibers and increased signal intensity of the neural pathway can occur with changes in spastic semi-side paraplegic patients in the descending neural pathway. This can support the claim that overactivity of the spinal cord reflex increases spasticity.

The abnormal pattern of contraction and mobilization of motor units can be explained by the disorder of voluntary activity of the central nervous system (Newham et al. 2001). This is caused by the degradation of functional unit in the spinal cord and a serious drop in the contraction rate of motor units, which are voluntarily contracted in the paralyzed muscle (Gemperline et al. 1995). Furthermore, a change in the contraction rate of motor unit has a direct effect on the change in the characteristics of the spinal motor neurons.

ASSESSMENT OF SPASTIC ISCHEMIC STROKE PATIENTS

• (1) ***Modified Ashworth Scale.*** The MAS is a method of measuring the degree of resistance of passive motions. It cannot measure the passive motion speed of joints, angle of muscle contraction, and degree of potential resistance of tendons. The MAS is an assessment method that can be easily used in clinical practice and is widely used in many studies. However, it showed an average degree of reliability in validation research (Ghotbi et al. 2011). The reliability of the MAS is limited if the joint motions are reduced by contracture and is not affected by the joint movement speed. However, the MAS is established for assessing the contracture of the soft tissue and the combination of spastic myopathy and spasm (Gracies et al. 2010).

• (2) ***Modified Tardieu Scale.*** The Modified Tardieu Scale (MTS) is an assessment method for the passive joint motion speed and potential resistance of tendons. This assessment method classifies spasticity into three levels of speed: low, normal, and fast. It is a more accurate indicator than the MAS. The MTS is more sensitive because the muscle resistance and speed are measured after muscle contraction (Thakker et al. 2004).

• (3) ***King's Hypertonicity Scale.*** The King's Hypertonicity Scale is another assessment method for different symptoms of the upper motor neuron syndrome. It divides four grades: increase in muscle tone, range of active joint motion, alternate motion, and resistance of passive motion. Each unit is assessed individually, with 1 point for normal and 5 point for the worst case, and the total score ranges from

4 to 20. However, this method needs to be verified in a larger population for the reliability of assessment.

Table 1. Modified Ashworth scale (MAS).

Grades	Descriptions
0	Muscle tone not increased.
1	The tone of muscle increased slightly, and appears minimum resistance when the affected side at the end of the ROM moves to flexion or extension.
1+	The muscle tone is slightly increased, and appears as a catch, followed by minimal resistance throughout the remainder (less than half) of the ROM.
2	The increase in muscle tone was noticeable through most ROMs, but the affected side moved easily.
3	The muscle tone has increased considerably, making difficult to move passively.
4	Affected side rigidity appears throughout flexion or extension.

Table. 2 Modified Tardieu scale (MTS).

Grades	Descriptions
0	No resistance in the passive movement.
1	Light resistance in the passive movement, no clear catch at correct angle.
2	Clear jam at correct angle, interfering the passive movement, then release.
3	Fatigable clonus (<10 seconds at pressure hold) occurring at exact angle.
4	Infatigable clonus (>10 seconds at pressure hold) occurring at exact angle.

PHYSICAL THERAPY OF THE UPPER LIMB IN SPASTIC ISCHEMIC STROKE PATIENTS

• (1) ***Basics of Physiotherapy.*** The basic principle of physical therapy for spastic patients is that limiting the muscle contracture and reducing over-activity at the least for a short-term can help them. The object of stretching is to enhance the viscoelasticity of muscles and tendons and increase the extensibility. However, stretching can increase the tension of the surrounding tissues, such as blood vessels, skin, connective tissues, and nerve tissues. The applied strength, time, speed, and frequency of stretching have not been agreed upon yet. A recent study systematically examined the effect of stretching to remove the muscle contracture of brain-damaged patients and concluded that stretching did not cause a significant change in joint mobility, pain, spasticity or limitation of activity (Gracies et al. 2000).

Other physical therapy methods are used to reduce spasticity and improve motor function. Hydrotherapy, cryotherapy, hyperthermia, vibration stimulation, inhibition of neurodevelopment, and treatment with a robot are utilizing to relax muscles and lower the spastic strength.

•(2) ***Constraint-Induced Movement Therapy (CMIT).*** Constraint-induced movement therapy (CIMT) is an exercise training course developed on the basis of the learned nonuse model and cortical relocation phenomenon. By prohibiting the use of the non-affected side, the use of affected side is enforced. The unaffected side is restricted for 90% of the wake time for 2 weeks, and intensive and repeated training is performed on the affected side (Taub et al. 1999). Developed by Taub, Uswatte, and Pidikiti (1999), the CIMT will conduct concentrated exercise of the affected side for 6 hours in 10 out of 14 days. The existing CIMT caused a sense of rejection because of long-term high-intensity training. Thus, they devised this as a modified CIMT. The modified CIMT has been reported to have an effect on getting better the skill of the upper extremity of hemiplegic patients.

The advantage of CIMT is that it can induce improvement of functions and prevent pain and overuse syndrome caused by the overuse of the unaffected side because it allows patients to train themselves, train functional activities, suppress the unaffected side, and force patients to use the affected side. However, CIMT can cause psychological anxiety and burden because it is a high-intensity training program for patients. Furthermore, it is difficult to perform training for 6 hours in treatment facilities. It is also difficult to live everyday life because restriction of the unaffected side and psychological burden increase as a result.

• (3) ***Orthoses.*** Orthoses are used to complement and assist physical therapy, reduce spasticity and pain, improve functions, give a sense of protection, and prevent deterioration. Their biggest advantage is that they have a long duration of effect because patients can be stay for several hours alone. However, orthoses have not been proved through a double-blind test, and no enhancements were checked in the spasticity of the wrist flexion muscle or movement of the entire hand (Basaran et al. 2010). In near Future, advanced sensor technologies can assist the patients and monitor the real time health state by many parameters such as electroencephalograph (EEG), electromyography (EMG), electrocardiogram (ECG), electro oculogram (EOG) (Debnath 2018, Kim et al. 2017, Kim 2018).

• (4) ***Transcutaneous Electrical Nerve Stimulation (TENS).*** TENS is a physical therapy method that injects electric signals according to the site of spasticity and the skin nerve control level of the spinal cord. It is effective in reducing the spasticity of the antagonist muscle. The effect of TENS seems to be associated with the production of β-endorphin, which reduces the activity of the muscle. According to the gateway control theory, it appears to reduce the input of new information by adjusting the delivery of pain signal. It has been suggested that TENS can promote the reorganization of the cerebral cortex synapses and accelerate the exercise output by increasing the sensory input by stimulating the Aβ-tissue of the large-diameter nerve fibers (Yan et al. 2009). More studies on TENS is required to define the most effective parameters and describe the mechanism that forms the basis of this theory.

DISCUSSION AND CONCLUSION

An evaluation or definition of quality of life is complex and difficult, but includes an assessment of the objective level of an individual's perception and health condition. Quality of life can be defined by various combinations of physical function, occupation, socioeconomic status, housing, income, pride, life satisfaction, etc. In the case of patients, the quality of life decreases greatly due to the deterioration of health and physical function (Chung et al. 2017, Kim et al. 2018, Lee, E.H. 2018; Lee, M.R. 2018; Lee & Lee 2018). Geriatric diseases are increasing with the increasing elderly population globally as well as in South Korea. In particular, stroke is a very dangerous disease and is the second most common cause of deaths among single diseases. Furthermore, stroke causes large individual, social, and economic losses because of serious sequelae that interfere with the daily life after survival, and the life quality of stroke patients is low as a result. The upper extremities are critical not only for the daily life of individuals but also for their social activities, and they are directly related to the work ability of individuals. Even though there are many treatments to enhance the upper limb functions of stroke patients, their therapeutic effects are not consistent. In the future, more diverse and systematic approaches to reinforce each joint of upper extremity functions of stroke patients would be necessary.

ACKNOWLEDGMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT)(No. 2019R1F1A1057731).

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