Stroke Rehabilitation Outcome Depending On Different Anatomical Distributions

Amela Čičkušić,[1] Maida Zonić-Imamović[1] , Renata Hodžić,[2] Azra Delalić,[1] Adnan Čičkušić, [3]
Institutions
[1]Department of Physical Medicine and Rehabilitation
[2] Department of Neurology
[3] Department of Neurosurgery
University Clinical Center Tuzla, Bosnia and Herzegovina
Corresponding author
Amela Čičkušić
[1]Department of Physical Medicine and Rehabilitation
University Clinical Center Tuzla, Bosnia and Herzegovina
Trnovac bb, 75000 Tuzla
Bosnia and Herzegovina
Phone: +38761895510
Email:cic-amela@hotmail.com

ABSTRACT

Introduction: One of the most important goals in patients affected by stroke is re-establishing independent movement by activating as many motor patterns as possible and changing existing preexisting abnormal motor patterns.

Objective: To determine recovery level with the accent on motor functions recovery in a patient affected by an ischemic stroke for the first time. Study included patients with anterior circulation syndrome, posterior circulation syndrome and lacunar syndrome in the acute and post-acute phase of rehabilitation.

Material and methods: This was a prospective study, which included a total of 90 patients with first time ischemic stroke. The first group consisted of 30 patients with the complete anterior circulation syndrome of; the second group of 30 patients with the posterior circulation syndrome and the third group of 30 patients with lacunar syndrome. At the beginning of their early rehabilitation treatment at the Clinic of Physical Medicine and Rehabilitation, the Bamford Scale was used in the initial assessment of the clinical classification of stroke, followed by the Allen Score for prognosis after the stroke. After the rehabilitation treatment and six months after the stroke, an assessment of motor functions and improvement in overall functionality was performed using a six-minute walk test.

Results: By using Allan score in after stroke recovery prognosis, we found significant difference in patients with anterior circulation syndrome compared with a group of patients with posterior circulation ($p = 0.001$) and lacunar syndrome ($p = 0.003$). Patients with anterior circulation syndrome had a significantly more frequent score below 0 and worse overall recovery compared to other two groups. The six-minute walk test in all the studied groups showed significant improvement six months after the stroke compared to testing done immediately after their rehabilitation treatment ($p = 0.01$ anterior circulation, $p = 0.05$ posterior circulation, $p = 0.01$ lacunar syndrome). The six-minute walk test was significantly better in patients with lacunar syndrome compared to patients with posterior circulation syndrome after the rehabilitation treatment ($p = 0.005$) and six months after stroke ($p = 0.02$).

Conclusion: The importance of rehabilitation in acute and post-acute phase of ischemic stroke is evident. Patients with anterior circulation syndrome have a significantly worse overall recovery rate according to Allen score compared to other two groups. The six-minute walk test in all studied groups showed significant improvement after six months post-stroke period compared to post-rehabilitation testing. The results were statistically significantly better in patients with lacunar syndrome compared to patients with posterior circulation syndrome after the physical treatment and the time period of six months after the stroke.

Keywords—ischemic stroke, rehabilitation, anatomic distribution

INTRODUCTION

It was previously believed that injuries of brain tissue caused by stroke are permanent in their nature and that only the brain functions expected to recover were those caused by brain edema. In the last few decades, with the intensive development of neuroscience, it has been increasingly accepted that there is a process of Central Nervous System - CNS regeneration and re-structuring, so called neuroplasticity, that ends after 2 years. Numerous studies, although based on experiments done in animals, suggest that early CNS stimulation after the stroke is of particular importance in re-structuring and regeneration (1). In order to understand after stroke recovery mechanisms, it is important to identify suitable biomarkers that will enable reliable monitoring of recovery process in individuals taking part in

rehabilitation programs. Reliable biomarkers are also necessary in order to predict treatment outcome and optimize procedures used during the rehabilitation process. Numerous studies using different experimental models have shown that an ischemic lesion leads to an increase in neural stem cells and subsequently an increase in the generation of new neurons via compensatory neurogenesis. After the stroke resting microglia activates, changes its phenotype and from its resting ramified state microglial cells progress in to hyper-ramified state. In animal models with ischemia, exposure to a sensory-enriched environment and exercise, has shown a reduced activation of microglia and macrophages, which may be the basis for better functional recovery (2,3). Such observations may further support the clarification of the molecular basis for the positive effects of early rehabilitative treatment of ischemic brain lesions and better functional recovery compared to individuals not included in early rehabilitation treatment (4,5).

Restoration of motor functions comes through the functional reorganization of interneuron system, the formation of alternative pathways, collateral branching, unmasking of ineffective synapses so-called "unmasking phenomena". The degree of restoration depends primarily on severity of the CNS lesions whether it is just diaschisis lesions or severe destruction of brain structures. Nowadays imagining techniques provides us with images that give us an objective confirmation of CNS neuroplasticity that comes with intensive rehabilitation (6).

One of the important goals of rehabilitation is to re-establish independent walk. Analyzing the intact nervous system during movement, we can see that the nerve impulses in different combinations that are directed towards the effector muscles. Isolated muscle activity is never used during movement, only muscle groups. Patterns of posture and movement in patients with hemiplegia are few and stereotypical. The patient always uses the damaged side of the body in the same way through abnormal motor patterns. The main goal of treatment is to activate as many motor patterns as possible and change the already present abnormal motor patterns.

PARTICIPANTS AND METHODS:

This was prospective study done at the Department of Neurology and the Department of Physical Medicine and Rehabilitation, during a two-year period. The study included a total of 90 consecutive patients who suffered ischemic stroke. Group I consisted of 30 patients with anterior circulation syndrome; group II 30 patients with the posterior circulation syndrome and group III of 30 patients with lacunar syndrome. Patients who have been in a coma for more than 48 hours, as well as hemodynamically unstable patients were not included in the study. Other exclusion factors were hemorrhagic stroke, recurrent strokes, patients who have been treated with thrombolytic therapy, and patients with aphasy. In addition to medical history and clinical examination, diagnosis of stroke was confirmed by the results of computer tomography (CT) and /or nuclear magnetic resonance (NMR) imaging of the brain. Patients were included in early rehabilitation treatment immediately after stabilization of their vital functions with continous monitoring of blood pressure, pulse and respiration. After the patients were discharged from the Department of Neurology, they were transferred to the Department of Physical Medicine and Rehabilitation where stationary rehabilitative treatment was conducted for up to 8 weeks. Re-testing of the patients was performed 6 months after the stroke. All the patients, during the planning and early rehabilitative treatment in the Department of Neurology and the Department of Physical Medicine and Rehabilitation, received individual exercise program, with appropriate electrotherapy and thermo procedures. **Bamford scale** was used for clinical stroke classification (7).

This scale represents the clinical-topographic classification of ischemic stroke and is divided into: Total anterior circulatory infarction (TACS); Anterior circulatory partial infarction (PACS); Posterior circulation infarction (POCS) and Lacunar infarction (LACS). The Allen score for after stroke prognosis (8) was used as the second test within the initial test. Age, state of consciousness, degree of motor deficit, loss of higher cerebral functions and the appearance of aphasia, sensory or visual disorders, deterioration of visuospatial function, loss of perception of the position of body parts, visual field defects were determined. Interpretation of the calculated scores, divided patients into those with a score below 0 and possible death or severe disability outcome and those with a score above 0 who were likely to survive and retain ability to move and be self-sufficient. After the rehabilitation treatment was conducted and six months after the stroke, an assessment of movement and progress in overall functionality and level of physical readiness was performed using a six-minute walk test [9]. More than one method can be used to assess the walking time. It can either be walking speed on a particular route, or endurance that is analyzed. As part of endurance test, two-minute, six-minute, and twelve-minute walks are monitored. Basically, the patient is asked to walk at the speed that suits him best, on a predetermined route, usually up to 20 m on his own or with any kind of help (including assistance) until the moment he is told to stop. The patient is also instructed to stop walking at any time if he feels unable to complete the test. Optimal testing time is **six-minutes** . The total distance reached during the test is being recorded.

RESULTS

In the group I, 9 patients had positive Allen score, while 21 had a negative score. In the group II, 24 patients had a positive Allen score and only 6 had a negative score. In the group III, 20 patients had a positive Allen score and 10 had a negative Allen score. Comparing the values of the Allen score between the groups, we found statistically significant difference in the Allen score values between group I and II (p = 0.001). A statistically significant difference was also found between patients with anterior circulation syndrome and lacunar syndrome (p = 0.003). No statistically significant difference was found in the Allen score between the group of patients with posterior circulation syndrome and lacunar syndrome (p = 0.2). The results of the Allen score in the examined groups are shown in the following table (Table 1).

Table 1. Allen score

Group	Positive score N %	Negative score N %	Total N %
Anterior circulation syndrome	9 30	21 70	30 100
Posterior circulation syndrome	24 80	6 20	30 100
Lacunar syndrome	20 66.7	10 33.3	30 100

N=number of patients

Ambulance evaluation movement, and increase in overall physical reediness was analyzed using a six-minute walk test for all groups. In the group I, the value of the score of a six-minute walk ranged from 20 to 400 m after physical treatment, averaging 126 (SD +87.70). Six months after stroke, the value of the six-minute walk score in the group I ranged from 30 to 450m, averaging 199.66 (SD +129.80). In the group II, the value of the six-minute walk score ranged from 20 to 225 m after physical treatment, averaging 98.33 (SD +59.96). Six months after stroke, the value of the six-minute walk score in the group II ranged from 40 to 400 m, averaging 157 (SD +95.10). In the group III, the value of the six-minute walk ranged from 20 to 400 m after physical treatment, averaging 153.33 (SD +84.68). Six months after stroke, the value of the six-minute walk score in the group III ranged from 30 to 500 m, averaging 219 (SD +118.85) (Table 2).

Table 2. Assessment scale of 6-minute walk after physical treatment and six months after the stroke

Group of patients	6 minutes walk after the physical treatment	6 minutes walk six months after the stroke	p
Anterior circulation syndrome	126.00 ±87.70	199.66 ±129.80	**0.01**
Posterior circulation syndrome	98.33 ±59.96	157.00 ± 95.10	**0.005**
Lacunar syndrome	153.33 ±84.68	219.00 ±118.85	**0.01**

p=statistical significance

Comparing the score values of the six-minute walk between the individual groups, the following results were obtained, as shown in the following tables (Tables 3, 4 and 5).

Table 3. Assessment scale of 6-minute walk in groups of participants with anterior syndrome and posterior circulation syndrome

Group of participants	6minutes walk after the physical treatment	6minutes walk 6 months after the stroke
Anterior circulation syndrome	126.00 ±87.70	199.66 ±129.80
Posterior circulation syndrome	98.33 ±59.96	157.00 ± 95.10
p	0.15	0.15

p=statistical significance

Comparing the assessment score of the six-minute walk no significant difference was found between the group I and II. The difference was not statistically significant after physical treatment performed during treatment at the Department of Physical Medicine and Rehabilitation nor after six months of stroke (p = 0.15 after physical treatment; p=0.15 sixmonths afterstroke).

Table 4. 6-minute walk assessment scale in groups of participants with anterior circulation syndrome and lacunar syndrome

Group of participants	6minutes walk after the physical treatment	6minutes walk six months after the stroke
Anterior circulation syndrome	126.00 ±87.70	199.66 ±129.80
Lacunar syndrome	153.33 ±84.68	219.00 ±118.85
p	0.2	0.5

p=statistical significance

Comparing the assessment score of the six-minute walk between the group I and III, no statistically significant difference was found between the mentioned groups. Although the score was slightly better in participants with lacunar syndrome, the difference was not statistically significant either after physical treatment performed during treatment at the Department of Physical Medicine and Rehabilitation or six months after the stroke (p = 0.2 after physical treatment; p=0.5 six months after the stroke).

Table 5. 6-minute walk assessment scale in groups of participants with posterior circulation syndrome and lacunar syndrome

Group of participants	6minutes walk after the physical treatment	6minutes walk 6 months after the stroke
Posterior circulation syndrome	98.33 ±59.96	157.00 ± 95.10
Lacunar syndrome	153.33 ±84.68	219.00 ±118.85
p	**0.005**	**0.02**

p=statistical significance

If we compare the score of the six-minute walk assessment test between the group of participants with posterior circulation syndrome and lacunar syndrome, participants with lacunar syndrome have a statistically significantly better score compared to the participants with posterior circulation syndrome. The difference was statistically significant after physical treatment received at the Department of Physical Medicine and Rehabilitation as well as six months after the stroke (p = 0.005 after physical treatment; p = 0.02 six months after the stroke).

DISCUSSION

Allen score was used in the initial testing with purpose to predict prognosis of the after the stroke recovery. Interpretation of the calculated score divided the patients into those with a score below 0 with a possible death or severe disability outcome and those with a score above 0, that refers to a more positive prognosis of survival and mobility. Test results correlate with the size of the brain damage. The test can also be observed through its capacity to corelate and enable us to see the difference between complete and partial damage of cerebral circulation [8]. In this study, 9 participants had a positive Allen score in the group of participants with anterior circulatory syndrome, while 21 participants had a negative score. In the group of participants with posterior circulation syndrome, 24 participants had a positive Allen score and only 6 had a negative score. In the group of participants with lacunar syndrome, 20 participants had a positive Allen score and 10 participants had a negative Allen score. Comparing the values of the Allen score between the groups, a statistically significant difference can be seen between the Allen score of subjects with anterior and posterior circulation syndrome (p = 0.001). A statistically significant difference was also found between the participants with anterior circulation syndrome and lacunar syndrome (p = 0.003). Allen score showed no statistically significant difference in the between the group of participants with posterior circulation syndrome and lacunar syndrome. Participants with anterior circulation syndrome had a significantly more frequent score below 0 and poorer overall recovery compared to other groups.

In the original Allen study [8], the prognostic result was derived from a study that included 148 patients, who survived the first 24 hours after stroke. The test was performed on average, in the period between of 3 to 5 days after the stroke, and the above parameters were used. Retesting was done 2 months and 6 months after the stroke. Of all patients, the outcome was known in 93% after 2 months and 86% of patients after 6 months. The recovery was also influenced by other factors such as the social and emotional aftermath of the illness. The author suggests using these simple clinical criteria in the scoring system.

In a multicentric study by Nouir et al. [10] use of Allen and Siraraj scores and reliability of scores in the clinical determination of stroke subtypes, was analyzed. CT and NMR images determine the type of stroke very precisely. However, when these neuroradiological techniques are not available and it is necessary to provide first aid to the patient, the clinical diagnosis gains even more importance. Nouir et al. analized 300 patients with stroke. The informal clinical diagnosis was correct in 250 out of 300 patients (83.3%). The diagnostic sensitivity and positive

predictive value for ischemic stroke were 87.8% and 86.0%, and for intracerebral hemorrhage 75.7% and 78.5%. The data suggest that the clinical diagnosis of intracerebral hemorrhage and ischemic stroke when using Siriraj and Allen scores has higher sensitivity measured with Allen score. Allen score was a better indicator of th stroke type compared to the Siriraj score. However, the use of both tests is recommended in epidemiological studies as a screening test, of course with the use of other diagnostic procedures [11].

Kohar et al. talk about the poor diagnostic value in usage of Allen and Siraraj scores and their combination in distinguishing hemorrhagic and ischemic stroke. Siraraj score was applied adequately in only 66.25% of patients, and misdiagnosed in 22.01% of patients, and the scale does not show its usefulness. Adequate stroke management requires the gold standard for diagnosis which is only possible with CT. The Allen score is not helpful, as it can only be assessed after 24 hours from the onset of the stroke. [12]. In all tested groups, the six minute walk score used for motility and assessment of overall physical reediness was statistically significantly better six months after the stroke compared to the score obtained immediately after the physical treatment (in the group of participants with anterior circulation syndrome p = 0.01 , with posterior circulation syndrome p = 0.005, with lacunar syndrome p = 0.01). In the individual comparison of a six-minute walk between groups, participants with lacunar syndrome had a statistically significantly better score compared to participants with posterior circulation syndrome (p = 0.005 after physical treatment; p = 0.02 six months after stroke). One of the important goals is to re-establish independent walking. In the early phase of recovery or if recovery is limited to the of weak synergistic activity, walking will not be possible for several reasons. These are: poor postural control of the torso in a standing position, inability to achieve stable standing on the affected leg during walking in the supported phase and inability to initiate leg movement (selective movement) in the hip during walking in the phase of leg movement. In an immobile stroke at the beginning of kinesiotherapy, it is necessary to obtain and develop maximum torso control and introduce the exercises necessary to prepare the patient for walking such as posture, balance, weight transfer to the hemiplegic leg. As recovery progresses, the patient establishes better motor control, torso balance and improves muscle strength in the affected paretic leg. Walking improves as selective physical activity of walking muscles is established during the motor recovery. The patient should be especially instructed on how to the position the body, as there is a tendency to lean on the affected side. Due to the disturbed kinesthetic information about the position of the body, a mirror is used for the purpose of visual correction. In the lower extremities, the axial muscle chain is strengthened, which serves as a stabilizer of the upright posture; m. gluteus maximus and m. quadriceps femoris [13].

Several studies indicate that patients with hemiparesis benefit the use of a treadmill during intensive walking exercise in kinesiotherapy with partial stability of the torso and pelvis with straps around the torso and pelvis, as help and safety from falling due to torso instability. Initially, the patient needs the help of one or more therapists to control the torso, pelvis, and weak legs. Walking exercises on the treadmill have proven to be more successful in the walking recovery than conventional kinesiotherapy. It has been proven that with the training of walking on treadmill, patients in outpatient rehabilitation, as well as those who have already walked, significantly improve their walking speed [14,15]. Clinical study from Gothenburg conducted year 2011 encountered 96 patients with the first time ischemic stroke, with the aim of assessing the risk of falls during the first year after the stroke. The authors state that 48% of patients had at least one fall during the first year. The predictive value of tests examining postural balance, walk quality, and motor ability were assessed. The study used Motor Assessment Scale-MAS a 10-meter walking test, a „time-up and go ”test, and the Berg balance scale. All tests are associated with a risk of falls. The 10-Meter Walk Test-MWT had the highest predictive value. Participants that were unable to conduct 10 MWT during the first week after stroke had a statistically significantly higher risk of falling (p <0.001). Clinical trials used during the first week after the stroke may to some extent identify those patients at risk of falling during the first year after stroke [16]. A study by Bijleveld-Uitman, van de Port and Kwakkela [17] analyzes whether walking speed or crossing a certain distance is a better indicator of movement function compared to daily walking or walking. A 5-meter walk and a 6-minute walk were tested, where speed and length of walking were measured. The study shows that the measurements of walking speed as well as crossing a certain distance are equally accurate and that both methods of measurement are strongly related to the results of daily walking with an accuracy in the range of 77-85%. A study by Ho-Jung et al [18] analyzed the effects of different training methods with the double task of walking with balance and walking of patients with chronic stroke. A 10-meter and a six-minute walk test were used. In the first group, motor training with walk training was done, in the second cognitive training with walk training, and in the third group motor and cognitive training with walk training. The results showed that the group with comparative motor and cognitive training showed the greatest progress. Namely, this training is more effective in improving the balance and quality of walking, than individual training of motor skills and walking or cognition and walking. The research emphasized the role of recognition and concentration during the dual task of holding and controlling during the walk as a paradigm of motor learning. The authors state that patients need to perform motor tasks and high cognitive function at the same time, as we do during daily activities when we perform several tasks at the same time. A similar study addresses the

problems of post-stroke patients who show a reduced ability to perform multiple tasks simultaneously while exercising walking function. Conventional rehabilitation does not sufficiently address this problem which can contribute to low levels of functioning and physical inactivity. The effectiveness of dual walk training tasks a year after stroke was analyzed. The effects of walking with motor and cognitive impairments during comfortable walking speed, during overcoming obstacles and during spontaneous physical activity were compared. A positive outcome was shown in performance and cognition during the unhindered walking. Also, the secondary outcome is the spatiotemporal and kinetic parameters of the walk. This study suggests that physicians should decide on the types of rehabilitation activities to improve the performance of dual tasks after a stroke [18]. It is important to choose tests that assess the motor recovery of the lower extremities during the acute phase of a stroke with the use of early rehabilitation treatment. There are few guidelines that suggest to clinicians the most optimal choice during the inpatient phase of treatment. A 2014 cohort study evaluated the effects of applying the 10-meter walk test, the MAS, and the Step test. The results show that the largest changes in discharge parameters were recorded in the part of the MAS that evaluates mobility, in 44% of patients. Other tests used also showed significant changes in motor recovery, but the MAS result related to mobility showed the largest changes [19, 20].

Conclusion: The importance of rehabilitation in the acute and post-acute phase in patients with the first time ischemic stroke is evident. Patients with anterior circulatory syndrome have a significantly poorer overall recovery according to the Allen score compared to other groups. The six-minute walk test in all examined groups was statistically significantly better six months after the stroke compared to test conducted after the physical treatment. The results are statistically significantly better in patients with lacunar syndrome compared to patients with posterior circulation syndrome after the physical treatment and six months after the stroke.

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