Comparison of Motor Function and Skill between Stroke Patients with Cerebellar and Non-cerebellar Lesion in Sub-acute Stage

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Purpose: The cerebellum is a region of brain structure that plays an important role in calibrating two different information of neural signal from descending motor commands and from ascending sensory inputs. Damage of the cerebellum shows a variety of classic motor symptoms such as postural and locomotor dysfunctions. Therefore, we tried to investigate motor function and skill in stroke patients with cerebellar lesions in sub-acute stage, and compare with these functions of patients with non-cerebellar lesions.

Methods: Total twelve stroke patients with cerebellar lesion and 130 stroke patients with non-cerebellar lesions were retrospectively recruited in this study. For evaluation of motor strength, Motricity index (MI) for upper and lower limbs was tested. For measurement of motor skill function, the modified Brunnstrom classification (MBC), Manual function test (MFT), functional ambulatory category (FAC), and Barthel index were adopted.

Results: In comparison of motor strength and motor skill function between two groups, statistical differences between the two groups were significantly observed only in upper MI and FAC. Although no significant differences were found in other variables, stroke patients with cerebellar lesion had higher scores in lower and total MI, MBC, and MFT, whereas they had lower scores in FAC and Barthel index.

Conclusion: Our results showed that stroke patients with cerebellar lesion had greater impact on movement functions related to hand motor and walking ability in activities of daily life, compared with patients with non-cerebellar lesion, in spite of similar degree of motor function and skill between the two different lesioned-groups.

Keywords: Stroke, Cerebellum, Motor activity, Brain lesion

I. Introduction

Stroke is one of major neurological disease to remain permanent motor sequela which aggravates life quality of individuals.¹,² It is well known that neurological symptoms related to motor function consisted of spasticity, muscle weakness, abnormal synergic movement pattern, loss of coordination, and so forth. These movement-related neurological problems are caused by dysfunction of neural cells in association with motor ability due to cerebral infarction or hemorrhage. Many previous studies suggested that critical motor disability was attributed to damage of brain architectures such as primary motor cortex, basal ganglia, internal capsule, corona radiate, cerebral peduncle, medulla oblongata, and cerebellum.³⁵⁶ Because these motor-related areas take blood circulation that is supplied by main branches of cerebral artery, stroke can reflect a variety of motor dysfunctions according to its inherent neural function in each of damaged areas.³ For improvement of these motor dysfunctions, numerous clinical therapeutic approaches have been tried and investigated in the field of rehabilitation.

Cerebellum, which is located at the bottom of the brain and the anterior portion of the brainstem, is a particular region of brain structure that plays an important role in movement...
control. Recently, it is also concerned with cognitive functions such as emotion, attention, and language. The main neurophysiologic function of the cerebellum is to compare motor command from higher neural centers related to motor system with proprioception information from peripheral sensory system, and to send back the error-corrected information toward the higher motor structures. Therefore, stroke patients with cerebellar lesion have typical problem of motor control, in terms of loss of precision, erratic motor action, uncoordination, and incorrectly timed movement. According to previous studies, 15% of all patients with cerebral stroke have an infraction in their cerebellum. The classic cerebellar symptoms including dysfunction of postural and locomotor control result in having difficulties of limb movement, postural stability, and walking ability.

However, to our knowledge, studies that investigated the motor skilled function of patients with cerebellar lesion in acute or sub-acute stage are rare. In clinical neurological physical therapy, stroke patients with cerebellar lesion usually have been referred to take therapeutic intervention. Understanding neurological symptoms in patient with cerebellar lesion can provide physical therapist with good clinical information for precise evaluation and treatment plan. Therefore, in the current study, we attempt to investigate motor skill function of stroke patients with cerebellar lesions within sub-acute stage, and compare with motor skill functions of stroke patients with non-cerebellar lesions.

II. Materials and Methods

1. Subjects
We collected clinical data such as medical record and physical examination, whose of 237 stroke patients with cerebral or cerebellar lesion due to infarction or hemorrhage were referred to rehabilitation center of a university hospital for past 3 years. According to the following inclusive criterions: (1) first-ever stroke due to hemorrhage/infarction of cerebral or cerebellar hemisphere, who diagnosed by neurologist or neurosurgery, (2) sub-acute stage within two month since stroke onset, (3) patients who are possible to perform motor skill functions such as Motricity index (MI), the modified Brunnstrom classification (MBC), Manual function test (MFT), and functional ambulatory category (FAC), (4) no cognitive function impairment (above 18 points with Mini Mental Status Examination [MMSE]). Finally, twelve stroke patients with cerebellar lesion (men, 6; mean age, 66.00±4.32) and 130 stroke patients with non-cerebellar lesions (men, 79; mean age, 66.05±6.67) were recruited in this study.

2. Clinical motor tests

1) Motor strength
MI and grip power were used, for examination of muscle strengthening in the upper and lower extremity contralateral to damaged hemisphere. One evaluator who is over five-year experienced physical therapist completed to assess all participants through entire experiment for minimizing intra-rater bias. The MI is one of clinical measurement of muscle strength for patients with neurological disorders, which used the manual muscle test grades during performance of multiple actions to characterize overall motor strength in the upper and lower extremities. The MI includes three motor actions of the affected side in the upper or lower limb to indicate the degree of its paralysis. The MI of upper limb consisted of three motor such as shoulder abduction, elbow flexion, and pinch grasp, and one of lower limb involves hip flexion, knee extension, and ankle dorsiflexion. Scoring as described by Collin and Wade is to sum all scores for the three actions for each of upper and lower extremities, and each total scores is ranged from 0 (complete motor weakness) to 100 (normal strength).

2) Motor skill function
The degree of normal movement pattern separated from abnormal synergic pattern of the affected upper limb was evaluated according to the MBC. MBC was classified as following six stages: 1=unable to move fingers voluntarily, 2=able to move fingers voluntarily, 3=able to close hand voluntarily, and unable to open hand, 4=able to grasp a card between the thumb and medial side of the index finger, and able to extend fingers slightly, 5=able to pick up and hold a glass, and able to extend fingers, 6=able to catch and throw
a ball in a near-normal fashion, and able to button and unbutton a shirt.

MFT was used to assess motor ability of each segmental joint in the affected limb of stroke. MFT is consisted of 32 test items which measure the upper limb movement and hand manipulative activities, using eight measurement tools. Each of test items is scored as 1 when the test is completed successfully, and scored 0 when the test is failed. Finally, all of tested scores are added up, and the maximum of MFT is 32.

FAC was tested to evaluate ambulatory ability. The category are classified as following six grades, while stroke patient performs a 15 m walk: 0=no ambulatory, 1=requirement of consistent assistance by a person, 2=requirement of intermittent assistance by a person, 3=requirement of verbal instruction, 4=requirement of supervision or physical assistance on stairs and uneven surfaces, and 5=walk independently. The reliability and validity of all tests in terms of the MBC, MFT, and FAC are well established.17-19

For measuring the activities of daily life and mobility in stroke patients, the Barthel index including 10 items was adopted. The items consist of feed, move and return from wheelchair to bed, groom, transfer to and from a toilet, bath, walk on level surface, go up and down stairs, dress, and continence of bowels and bladder. The more dependently patients performed, and the more high score was given.

3. Statistical analysis
Statistical analysis of all data were performed using PASW 18.0 (IBM Co., Armonk, NY, USA), and p value set up below 0.05 as the criterion for statistical significance. A chi-square test was used to compare the differences of distribution of gender and damaged hemisphere between patients with cerebellar lesion and with non-cerebellar lesion. For comparison of demographic and dependent variables in term of age, onset time, MMSE, MI, MBC, MFT, FAC, and Barthel index, an independent t-test was conducted.

III. Results
Table 1 indicates demographic information of two stroke group (i.e., cerebellar stroke and non-cerebellar stroke) in terms of sex, age, time since onset, damaged hemisphere, and mini-mental status examination. An independent t-test showed that no significant differences between two groups were observed in demographic data. Table 2 indicates motor strength and motor function in two groups. In comparison of motor strength between two groups, stroke patients with cerebellar lesion had higher scores than patients with non-cerebellar lesion, in upper MI, lower MI, and total MI score. However, significant difference between the two groups was observed only in upper MI. In tests of motor function including MBC and MRT, higher scores were founded in patients with cerebellar stroke, compared with patients with non-cerebellar lesion. In terms of FAC and Barthel index, lower scores were shown in patients with cerebellar lesion than in patients with non-cerebellar lesion. However, statistical significance in comparison with both groups was found only in FAC.

IV. Discussion
In the current study, we investigated basic motor function

| Table 1. Demographic data of cerebellar stroke group and non-cerebellar stroke group |
|---------------------------------|----------------|------------------|-------|
| Sex (male/female)              | 6/6            | 79/51            | 0.544 |
| Age (yr)                       | 66.00±4.32     | 66.05±6.67       | 0.969 |
| Onset time (month)             | 0.75±0.75      | 0.27±0.68        | 0.578 |
| Damaged hemisphere (right/left)| 6/6            | 63/67            | 1.000 |
| MMSE (point)                   | 22.50±5.05     | 24.49±4.24       | 0.210 |

Values are presented as number or mean±standard deviation.
MMSE: Mini Mental Status Examination.
and motor executional skill in stroke patients with cerebellar lesion, in terms of MI, the MBC, MFT, FAC, and Barthel index, and compared the motor performance parameters with stroke patients with non-cerebellar lesion. For evaluation of motor strength, normal recovery degree out of abnormal synergic movement, hand motor skill, ambulatory skill, and functional level of activities of daily life, independent variables related to motor function and skill were adopted. As results, our findings showed that stroke patients with cerebellar lesion significantly had better performance of hand motor strength and walking skill than stroke patients with non-cerebellar lesion did. In addition, although statistical significant differences were not found, scores of total MI, MBC, and MFT were generally higher in cerebellar lesioned-stroke patients than in non-cerebellar lesioned-stroke patients. However, with respect to walking ability and functional level in activities of daily life, cerebellar lesioned-stroke patient had lower scores than non-cerebellar lesioned-stroke patient. Therefore, our findings suggested that stroke patients with cerebellar lesion had more high severity of functional activities related to hand function and walking ability in daily life, compared with patients with non-cerebellar lesion, although degree of motor function and skill are similar between two different lesioned-groups.

The cerebellum taken up only 10% of total brain volume is located at the bottom of cerebral hemispheres, which is divided into two hemispheres with centrally-located structure called the vermis.\textsuperscript{6,20} The most of neurons in the cerebellum is associated with the number of neurons in the cerebral hemispheres. However, the cerebellum is not directly related to brain structures, where are concerned in movement execution and motor output. Actually, the primary sensorimotor cortex is engaged in executing voluntary movement for the face, digit, hand, arm, trunk, leg, and foot.\textsuperscript{8} The projection patterns of corticospinal neurons and intrinsic connectivity were existed in primary motor cortex (M1), and a widespread project of single descending M1 neurons to multiple segments in the spinal cord that can span motor neuron pools across joints.\textsuperscript{21,22} Thus, because of this anatomical rationale, injury of the cerebellum does not generally induce motor paralysis of upper and lower limbs. In addition, numerous previous studies indicated that patients with cerebellar lesion had severe problems with motor control and balance performance.\textsuperscript{6,23,24} The motor-related symptoms include a loss of equilibrium resulted from damage to the flocculonodular lobe, dysfunction of skilled voluntary and planned movements due to damage to the cerebrocerebellum, and disrupted whole-body movements due to damage to the midline portion of the cerebellum.\textsuperscript{6,8} These symptoms are attributed to motor control error in the force, direction, speed, and movement amplitude, which are tested as hypotonia, dysarthria, dysmetria, dysdiadokinesia, and tremors.\textsuperscript{25} In general, the basic function of the cerebellum is not to initiate movements and to decide movement form to execute, but rather to calibrate the detailed form of a movement.\textsuperscript{8} Accordingly, our findings showed that stroke patients with cerebellar lesion had low independent functional abilities such as hand motor

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<th>Table 2. Motor and sensory functions of cerebellar stroke group and non-cerebellar stroke group</th>
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Values are presented as mean±standard deviation. MI: Motricity index, MBC: modified Brunnstrom classification, MFT: Manual function test, FAC: functional ambulatory category.
function and activities of daily life, in spite of rather good basic motor functions.

The cerebellum, which is located blow the both cerebral hemisphere and posterior to brainstem, is a region of brain structure that plays an important role in calibrating two different information of neural signal from descending motor commands and from ascending sensory inputs.\textsuperscript{8,23} Damage of the cerebellum causes to dysfunction of postural and locomotor control, and these symptoms makes patients with cerebellar lesion to have difficulty in performing independent activities of daily life.\textsuperscript{8,23,24} Our study indicated that stroke patients with cerebellar lesion in sub-acute stage had greater impacts on independent functional activities of motor function and skill, compared with non-cerebellar lesioned-stroke patients. We expect that this finding will provide physical therapist with good clinical information for establishment of evaluation and treatment plan. However, this study has limitations due to lesion size and specific location in the cerebellum architecture. Therefore, further study will be required to detect more detailed clinical findings in stroke patient with cerebellar lesion in sub-acute stage.

References