Annals of Physical and Rehabilitation Medicine 62 (2019) 386–388

Available online at ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com

Letter to the editor

Late recovery of walking ability in a person with chronic stroke after an individualized rehabilitation program

Dear Editor,

Gait is a vital function for realizing independence in activities associated with daily living and for maintaining general health [1–3]. Therefore, regaining the ability to walk after a stroke is an important goal of neurorehabilitation. Generally, 70% to 80% of stroke patients are able to walk eventually, and the gait recovery phase after a stroke occurs within 3 to 6 months of stroke onset [3–5]. Regaining gait ability after a stroke requires postural control, power and tone of leg and trunk muscles, visuomotor coordination, and motor execution [3,6,7]. Many studies have reported on stroke patients who regained gait ability after a gait recovery phase following a stroke [7–12]. Among these studies, a few have demonstrated the importance of determining the patient's neurological potential for regaining gait ability in the chronic stage [8,9].

Diffusion tensor tractography (DTT), derived from diffusion tensor imaging (DTI), enables 3-D reconstruction of various neural tracts related to motor function including the corticospinal tract (CST) and corticoreticulospinal tract (CRT) [13,14]. Recent studies have demonstrated that stroke patients with complete injury of the CST in the affected hemisphere but preserved CST and CRT in the unaffected hemisphere were able to walk [15,16]. These observations suggest that elucidating the status of the CST and CRT in the unaffected hemisphere could be important in determining whether stroke patients can walk or not.

In this study, we report on a patient with late recovery of gait ability who had neurological potential to walk independently confirmed in the CST and CRT by using DTT. The patient regained the ability to walk after 3 months of individualized rehabilitation that began 3 years after intracerebral hemorrhage (ICH).

A 55-year-old female underwent external ventricular drainage at the neurosurgery department of a local hospital for spontaneous ICH on the right putamen. Three weeks later she was transferred to a specialized local rehabilitation hospital. Although she underwent rehabilitation with specialist physical and occupational therapists mainly for recovery of motor weakness and alleviating spasticity and contracture for 3 years after her ICH, she was unable to stand independently. After the 3-year period, she was admitted to the rehabilitation department of our university hospital. She did not show cognitive impairment, attaining a full score (30 points) on the Mini Mental State Examination. However, she had the following problems that affected her gait independence: severe motor weakness of the left leg (Manual Muscle Test: hip flexor, 1-; knee extensor, 0; and ankle dorsiflexor, 0); severe plantarflexion contracture of the left ankle (−20 degrees); increased muscle tone of the trunk and severe spasticity of the left leg (ankle plantar-flexor muscles: Modified Ashworth Scale: 3+ grade); poor postural control ability: she could not stand because of poor standing balance.

As a result, she was unable to walk (Functional Ambulation Category: 0 points, non-ambulatory) [17].

To determine her neurological status, DTI scans were obtained and revealed two motor neural tracts (CST and CRT) imaged by using DTT [14,18]. Although discontinuations at the subcortical white matter were observed in the right (ICH-affected side) CST and CRT, we concluded that the patient had the neurological potential to walk independently because the unaffected (left-side) CST and CRT, tracts closely related to gait potential, showed mostly intact configurations (Fig. 1B).

On that basis, we designed an individualized intensive rehabilitation program to resolve the above problems. The program entailed:

- movement therapy in a physical and occupational therapy session (twice per day, 40 min per time) to recover walking ability, including stretching exercises for spasticity and contracture of the left leg, muscle strengthening for motor recovery of the trunk and left leg, exercises for trunk stability and postural control, and static and dynamic balance training on sitting and standing positions;
- alcohol motor-branch blockage of the tibial nerve to relieve muscle spasticity of the left gastrocnemius muscle [19] and intramuscular alcohol wash to relieve muscle spasticity of the left tibialis posterior muscle [20];
- neuromuscular electrical stimulation of the left knee extensor and ankle dorsiflexor muscles;
- increasing doses of antispastic drugs (baclofen: 10 to >40 mg, and tizanidine: 1 to > 4.5 mg);
- other bedside rehabilitation programs (twice per day, 30 min per time) including standing balance training and ankle stretching by using a manual method and an ankle stretcher [21–24].

The patient provided written informed consent for use of the data.

After 3 months of this rehabilitation program, the patient was able to walk independently on an even floor with verbal supervision (Functional Ambulation Category: 3, requirement for verbal supervision only). Moreover, spasticity of the plantar-flexor muscles of the left ankle was alleviated (Modified Ashworth Scale: grade 1) and lower motor function was improved (hip flexor: 3, and knee extensor: 3). As a result, the caregiver's level of assistance in daily living activities related to dressing, transfer, and bathing was reduced.

In the current study, we report on a patient who regained gait ability after 3 months of intensive individualized rehabilitation that was started 3 years after her ICH. The status of the CST and CRT in the unaffected side is reported to be closely related to gait ability

https://doi.org/10.1016/j.rehab.2019.05.002

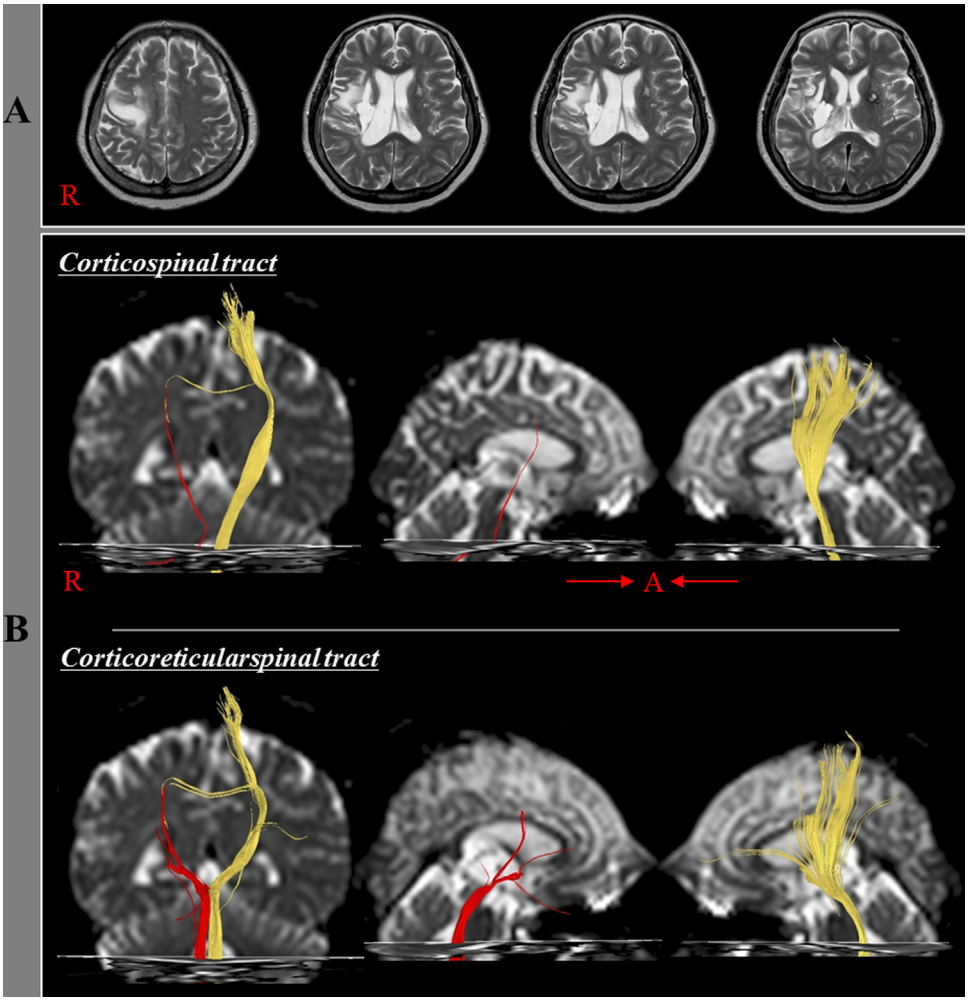

Fig. 1. A. T2-weighted brain MRI at 3 years after intracerebral hemorrhage in a 55-year-old woman shows leukomalactic lesions in the right cerebral cortex and subcortical white matter. B. The right corticospinal and corticoreticularspinal tracts show discontinuations at the subcortical white matter, whereas the left corticospinal and corticoreticularspinal tracts show almost normal configurations.

after stroke: Ahn et al. [2006] reported that stroke patients could walk after complete injury of the affected CST, and Jang et al. [2013] demonstrated that activation of the unaffected CRT was related to gait ability when the affected CST was completely injured [15,16]. These study results suggest that the presence of preserved CST and CRT in an unaffected hemisphere is required for gait ability. Before starting individualized rehabilitation at our hospital, we confirmed that our patient had the neurological potential to walk independently by confirming the presence of preserved CST and CRT in the unaffected hemisphere on DTT. The CST and CRT on the unaffected (left) side were mostly intact.

We identified 4 main problems associated with her gait inability: severe motor weakness of the left leg; plantar-flexor contracture of the left ankle; severe spasticity of the left leg; poor postural control ability.

We implemented an individualized intensive rehabilitation program to resolve these problems. After 3 months of rehabilitation, the patient was able to walk independently on an even floor with supervision.

In conclusion, our patient regained gait ability after 3 months of individualized intensive rehabilitation beginning 3 years after stroke onset. We believe our results and those from previous studies suggest the following take-home messages to physiatrists and therapists. First, regardless of post-stroke duration, the neurological potential for gait ability should be determined in stroke patients who cannot walk after expiry of the gait recovery phase [8,9]. For that purpose, analysis of neural tracts related to motor function, such as the CST and CRT based on DTT, is helpful. Second, physiatrists and therapists should try to determine the precise causes of the patient's gait inability (physical problems such as motor weakness, contracture, spasticity, postural control, etc.) and use those findings to design individualized intensive rehabilitation programs for patients who cannot walk despite being past the gait recovery phase. However, studies of larger numbers of stroke patients who cannot walk after the gait recovery phase are needed.

Funding

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2018R1A6A3A11043447).

Disclosure of interest

The authors declare that they have no competing interest.

References

[1] Keenan MA, Perry J, Jordan C. Factors affecting balance and ambulation following stroke. Clin Orthop Relat Res 1984;165–71.
[2] Friedman PJ. Gait recovery after hemiplegic stroke. Int J Rehabil Res 1990;12:119–22.
[3] Jang SH. The recovery of walking in stroke patients: a review. Int J Rehabil Res 2010;33:285–9.
[4] Jorgensen HS, Nakayama H, Raaschou HO, Vive-Larsen J, Stoier M, Olsen TS. Outcome and time course of recovery in stroke. Part II: Time course of recovery. The Copenhagen Stroke Study. Arch Phys Med Rehabil 1995;76:406–12.
[5] Gilman S. Time course and outcome of recovery from stroke: relevance to stem cell treatment. Exp Neurol 2006;199:37–41.
[6] Patterson SL, Forrester LW, Rodgers MM, Ryan AS, Ivey FM, Sorkin JD, et al. Determinants of walking function after stroke: differences by deficit severity. Arch Phys Med Rehabil 2007;88:115–9.
[7] Jang SH, Kwon HG. Delayed regaining of gait ability in a patient with brain injury: a case report. Medicine (Baltimore) 2016;95:e4898.
[8] Kwon H, Jang SH. Delayed recovery of gait function in a patient with intracerebral haemorrhage. J Rehabil Med 2012;44:378–80.
[9] Seo JP, Lee MY, Kwon YH, Jang SH. Delayed gait recovery in a stroke patient. Neural Regen Res 2013;8:1514–8.
[10] Li L, Ding L, Chen N, Mao Y, Huang D. Improved walking ability with wearable robot-assisted training in patients suffering chronic stroke. Biomed Mater Eng 2015;26:S329–40.
[11] De Luca A, Vernetti H, Capra C, Pisu I, Cassiano C, Barone L, et al. Recovery and compensation after robotic assisted gait training in chronic stroke survivors. Disabil Rehabil Assist Technol 2018;1–13.
[12] Guzik A, Druzbicki M, Przysada G, Wolan-Nieroda A, Szczepanik M, Bazarnik-Mucha K, et al. Validity of the gait variability index for individuals after a stroke in a chronic stage of recovery. Gait Posture 2018;68:63–7.
[13] Kunimatsu A, Aoki S, Masutani Y, Abe O, Mori H, Ohtomo K. Three-dimensional white matter tractography by diffusion tensor imaging in ischaemic stroke involving the corticospinal tract. Neuroradiology 2003;45:532–5.
[14] Yeo SS, Chang MC, Kwon YH, Jung YJ, Jang SH. Corticoreticular pathway in the human brain: diffusion tensor tractography study. Neurosci Lett 2012;508:9–12.
[15] Ahn YH, Ahn SH, Kim H, Hong JH, Jang SH. Can stroke patients walk after complete lateral corticospinal tract injury of the affected hemisphere? Neuroreport 2006;17:987–90.
[16] Jang SH, Chang CH, Lee J, Kim CS, Seo JP, Yeo SS. Functional role of the corticoreticular pathway in chronic stroke patients. Stroke 2013;44:1099–104.
[17] Cunha IT, Lim PA, Henson H, Monga T, Qureshy H, Protas EJ. Performance-based gait tests for acute stroke patients. Am J Phys Med Rehabil 2002;81:848–56.
[18] Jang SH. Somatotopic arrangement and location of the corticospinal tract in the brainstem of the human brain. Yonsei Med J 2011;52:553–7.
[19] Carpenter EB, Seitz DG. Intramuscular alcohol as an aid in management of spastic cerebral palsy. Dev Med Child Neurol 1980;22:497–501.
[20] Jang SH, Ahn SH, Park SM, Kim SH, Lee KH, Lee ZI. Alcohol neurolysis of tibial nerve motor branches to the gastrocnemius muscle to treat ankle spasticity in patients with hemiplegic stroke. Arch Phys Med Rehabil 2004;85:506–8.
[21] Hesse S, Bertelt C, Schaffrin A, Malezic M, Mauritz KH. Restoration of gait in nonambulatory hemiparetic patients by treadmill training with partial body-weight support. Arch Phys Med Rehabil 1994;75:1087–93.
[22] Hesse S, Bertelt C, Jahnke MT, Schaffrin A, Baake P, Malezic M, et al. Treadmill training with partial body weight support compared with physiotherapy in nonambulatory hemiparetic patients. Stroke 1995;26:976–81.
[23] Saunders DG. Therapeutic exercise. Clin Tech Small Anim Pract 2007;22:155–9.
[24] Pereira S, Mehta S, McIntyre A, Lobo L, Teasell RW. Functional electrical stimulation for improving gait in persons with chronic stroke. Top Stroke Rehabil 2012;19:491–8.

Sung Ho Jang, Han Do Lee*
Department of Physical Medicine and Rehabilitation, College of Medicine, Yeungnam University, 317-1, Daemyungdong, Namku, Taegu, 705-717, Republic of Korea

*Corresponding author
E-mail address: lhd890221@hanmail.net (H.D. Lee).

Received 29 October 2018
Accepted 4 May 2019