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Research article

Evaluation and significance of cognitive dysfunction after cerebrovascular disease with convalescent rehabilitation. Assessment based on FIM, MMSE and HDS-R

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Abstract: To analyze the effectiveness of rehabilitation for patients with cognitive dysfunction after cerebrovascular disease at a rehabilitation hospital. 200 patients with cerebrovascular diseases who underwent rehabilitation were divided into two groups: 128 patients with cognitive dysfunction and 72 patients without cognitive dysfunction. The degree of the improvement was analyzed using FIM, MMSE and HDS-R. Cognitive dysfunction was classified in three groups: ①aphasia, ②disorders other than aphasia and ③aphasia + other disorders. The FIM scores (61.1±26.8) of patients with cognitive dysfunction at admission were significantly lower than those (71.5±30.4) of patients without cognitive dysfunction, but conversely, the improvement in FIM scores (24.8±17.5) of patients with cognitive dysfunction at discharge was signifi-cantly higher than that (19.7±14.7) of patients without cognitive dysfunction. Similar results were obtained for MMSE and HDS-R tests, and the improvement in MMSE and HDS-R scores of patients with cognitive dysfunction at discharge was remarkably, significantly higher than those of patients without cognitive dysfunction. The improvement of FIM scores at discharge tended to be lower for patients with aphasia and a FIM score is not enough for the assessment. MMSE and HDS-R can capture changes of cognitive dysfunction, especially aphasia. FIM, MMSE and HDS-R scores were efficient for cognitive dysfunction.

Keywords: cognitive dysfunction, higher brain dysfunction, mini-mental state examination (MMSE), Hasegawa dementia scale-revised (HDS-R)

1. Introduction

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017 reported that stroke was the third-leading cause of death and disability combined and the second-leading cause of death in the world in 2017 [1,2]. Stroke rehabilitation has, therefore, become the most important treatment in caring for stroke patients [3]. Poststroke cognitive impairment (PSCI) is a major complication following a stroke, encompassing a spectrum from mild cognitive impairment (without dementia) to poststroke dementia. PSCI can emerge early, even in the hyperacute stage of stroke, characterized by deficits in memory, attention, executive function, and language abilities. These deficits severely impact patients' daily living activities, social participation, and overall quality of life [4,5]. Epidemiological studies indicate that cognitive dysfunction affects approximately 61% of patients within 10 years post stroke [6], and up to 80% of survivors exhibit some form of cognitive impairment within the first few months following the event [7].

A retrospective study in China reported that 23.35% of patients with acute ischemic stroke experienced cognitive dysfunction within 3 months [8]. Despite the high prevalence, the precise mechanisms underlying PSCI are not fully understood, which complicates efforts to predict outcomes and implement effective interventions. The significant burden of PSCI not only affects patients and their families but also places substantial strain on health care systems and society due to the long-term care needs and associated loss of productivity.

We reported that significant factors to contribute FIM gain were duration of hospitalization, FIM gain at 4 weeks after admission, age, and disability severity [9]. FIM scores and FIM gains could predict rehabilitation outcomes [9]. Significant functional recovery may develop in the first 3months following the episode [10]. Rehabilitation is started early after the onset of cognitive dysfunction after cerebrovascular disease, but there are unknowns on the effectiveness of treatment for cognitive dysfunction. We intended to gain understanding in how to improve outcomes of patients with cognitive dysfunction after cerebrovascular diseases.

The purpose of this study was to determine the effectiveness of rehabilitation for cognitive dysfunction after cerebrovascular diseases at a convalescent hospital.

2. Materials and Methods

Design

The ethical approval of the study was obtained from Shimada Hospital Ethics Committee (No.2208). Informed consents were obtained from the patients who participated in the study. The research was conducted in accordance with the 2008 Helsinki Declaration of Human Rights. It was a retrospective research and conducted at a single institution. Patients who suffered from strokes, traumatic brain injuries, brain tumors or meningoencephalitis and received intensive rehabilitation by qualified physical therapists, qualified occupational therapists and qualified speech-language-hearing therapists.

Participants

The inclusion criteria for this study were patients aged 20 years or older who suffered from cerebrovascular diseases (stroke, traumatic brain injury, brain tumor, meningoencephalitis), were admitted to a convalescent hospital, and were undergoing a full-time rehabilitation treatment program 7 days a week from May 2021 to February 2023. Patients who refused rehabilitation treatment within 1 week after admission were excluded. Finally, 200 patients were registered in the study (Table 1). The 200 patients were divided into two groups: 128 patients with cognitive dysfunction and 72 patients without cognitive dysfunction. The degree of the improvement was analyzed using functional independence measure (FIM), Mini-Mental State Examination（MMSE）and Hasegawa Dementia Scale-Revised (HDS-R) to clarify the characteristics. Cognitive dysfunction was classified into three groups: ① aphasia, ② disorders other than aphasia (apraxia, agnosia, memory disorder, attention disorder, executive disorder, social behavior disorder, etc.), and ③ aphasia + other disorders.

According to the rules of the healthcare system of Japan, patients who were 78 years or younger underwent 3 hours of professional stroke rehabilitation per day (physical therapy 1 hour, occupational therapy 1 hour, speaking therapy 1 hour). Patients who were 79 years or older underwent 2 hours of professional stroke rehabilitation per day (physical

Table 1. Patients characteristics

		Cognitive dysfunction Negative n=72	Cognitive dysfunction Positive n=128
Sex	Male	37	61
	Female	35	67
Etiology	Cerebral infarction	53	70
	Cerebral hemorrhage	10	33
	Subarachnoid hemorrhage	2	9
	Traumatic brain injury	4	11
	Brain tumor	2	3
	Meningoencephalitis	0	2
	Subdural hematoma	1	0
Past history of cerebrovascular disease	No incident	51	94
	One incident	17	31
	Two incidents	4	3
Side involvement	Right-sided	39	41
	Left-sided	24	67
	Not determined	9	20

therapy 40 minutes, occupational therapy 40 minutes, speaking therapy 40 minutes). When occupational therapy or speaking therapy was not necessary for patients, physical therapy was given instead. Based on the patient's clinical condition, rehabilitation was administered at the physician's request; however, no established rehabilitation protocol existed. The content of each daily program was thus decided by the staff member in charge of rehabilitation. The rehabilitation programs were comprised of mobilization, strength training, range of motion exercise, swallowing training, speech training, ADL (activities of daily living) training and cognitive function training.

Most patients suffered from diseases which needed various kinds of drugs. Patients with neurogenic bladders were treated with bethanechol chloride and/or distigmine bromide and patients with bowel dysfunction were treated with magnesium oxide. Patients who presented with insomnia, depression, agitation, delirium, or violence were given sleeping pills, sedatives, antidepressants, or antipsychotics.

Data collection

For these registered patients, rehabilitation for cerebrovascular diseases began at the initial hospital of admission and was then handed over to our convalescent hospital. Clinical and demographic features including these etiology, sex, age, history of cerebrovascular diseases, disability severity, dementia, cognitive dysfunction, duration of hospitalization and period from onset to rehabilitation were analyzed. Dementia is any decline in cognition that is significant enough to interfere with independent, daily functioning [11]. Alzheimer's disease is the most common cause of dementia. Cognitive dysfunction is a condition in which brain damage due to illness or accident that results in impairment of cognitive functions such as memory, attention, thinking, language, number operations, and emotional control. Cognitive dysfunction is having limited ADL and social activities due to cognitive impairment resulting from organic pathology in the brain [12]. FIM is the most widely used standardized outcome measure for rehabilitation in the world. FIM can be used freely, without additional payment in medical research conditions. FIM was widely applied to evaluate participation after stroke [13]. The FIM items are broadly classified into total, motor and cognitive categories (FIM-total, FIM-motor, FIM-cognition). FIM contains 18 items composed of 13 motor tasks (eating, grooming, bathing, upper body dressing, lower body dressing, toileting, bladder management, bowel management, bed to chair transfer, toilet transfer, shower transfer, locomotion [ambulatory or wheelchair level], stairs) and 5 cognitive tasks (cognitive comprehension, expression, social interaction, problem solving, memory). FIM scores were assigned according to a 7-point scale, and the score indicated the amount of assistance required to perform each item (7 = totally independent and 1 = totally dependent or not testable). For disability severity, FIM score on admission were classified in three groups: severe disability (FIM 40 or lower), intermediate disability (FIM 41-80) and mild disability (FIM 81 or higher) [9]. MMSE and HDS-R have a maximum score of 30 points, and an MMSE score of 23 or below and a HDS-R score of 20 or below indicate the possibility of dementia. In MMSE, it is difficult to evaluate in detail the elementary cognitive functions such as attention, understanding, and judgment [14]. MMSE is one of the most widely used neuropsychological tests in the world. MMSE is particularly suitable for its practicality and ease of administration, providing a quick, general overview of cognitive function across several domains. Its assessment include memory, orientation, calculation, language, and visual construction. The MMSE evaluates 5 cognitive domains—orientation, memory, attention and calculation, recall ability, and language skills. Higher scores indicate better cognitive function. The diagnostic criteria for cognitive impairment were adjusted based on educational levels, following established guidelines that account for the influence of education on MMSE performance [15]. HDS-R is also used for assessment of cognitive dysfunction. MMSE includes items that require not only memory but also language and visual construction functions. These cognitive functions cannot be evaluated by HDS-R. HDS-R places more emphasis on memory than the MMSE. FIM scores, MMSE scores and HDS-R scores of each patient were determined through discussions with qualified physical therapists, qualified occupational therapists and qualified speech-language-hearing therapists.

Statistical Analysis

The data is presented as the mean ± standard deviation. A non-parametric test (Mann–Whitney U test) was applied to compare the mean value of the two groups. Multiple regression analysis was applied to determine factors to contribute FIM gain. The statistical analyses were performed on StatView for Windows (Version 5.0; SAS Institute Inc. Cary, NC, USA). A p-value of < 0.05 was defined as statistically significant.

3. Results

The proportion of patients with severe disability (FIM 18-40) among patients with cognitive dysfunction was 30% (38/128), which tended to be higher than 18% (13/72) for patients without cognitive dysfunction (Table 2). The period from onset to rehabilitation of the patients with cognitive dysfunction was 2.5±4.6 days, which seemed to be longer than that (2.0±4.2 days) of the patients without cognitive dysfunction (Figure 1 A). The duration of hospitalization of the patients with cognitive dysfunction was 78.4±34.7 days, which was significantly longer than that (67.7±30.3 days) of the patients without cognitive dysfunction (p=0.029) (Figure 1 B).

Table 2. Distribution of disability severity based on cognitive dysfunction

		Cognitive dysfunction		
		Negative	**Positive**	
Disability severity	severe disability FIM 18 −40	**13** (18%)	**38** (30%)	51
	intermediate disability FIM 41—80	**29** (40%)	**51** (40%)	80
	mild disability FIM 81−126	**30** (42%)	**39** (30%)	69
		72 (100%)	**128** (100%)	200

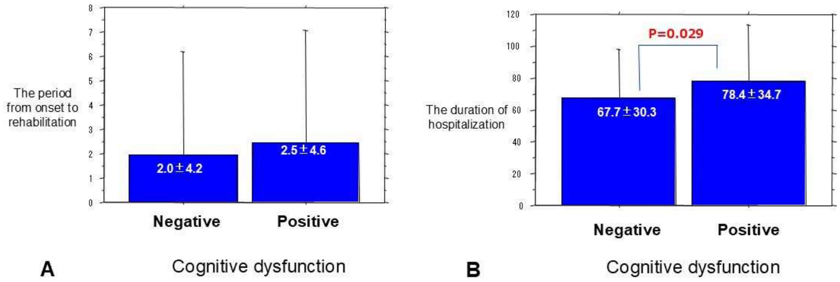

Figure 1. The period from onset to rehabilitation and the duration of hospitalization

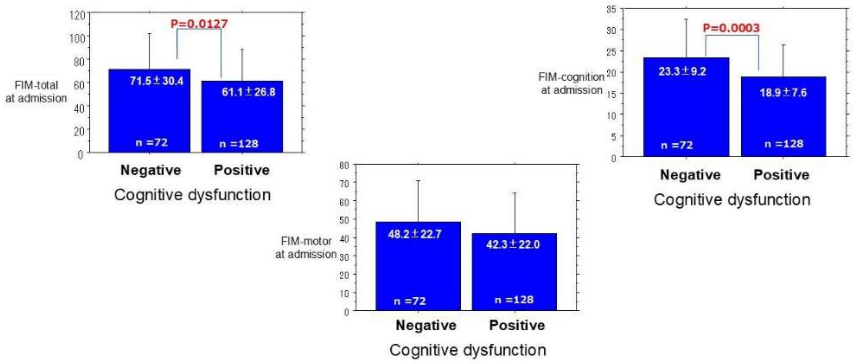

Figure 2. FIM-total, FIM-motor and FIM-cognition at admission

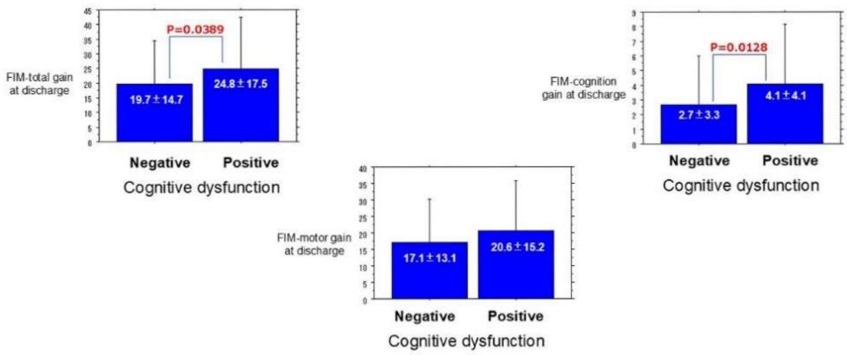

Figure 3. FIM-total gain, FIM-motor gain and FIM-cognition gain at discharge

The FIM-total score at admission for patients with cognitive dysfunction was 61.1±26.8, which was significantly lower than the score for patients without cognitive dysfunction (71.5±30.4) (p=0.0127) (Figure 2). The FIM-cognition score at admission for patients with cognitive dysfunction was 18.9±7.6, which was significantly lower than the score for patients without cognitive dysfunction (23.3±9.2) (p=0.0003).

The FIM-total gain score at discharge for patients with cognitive dysfunction was 24.8±17.5, which was significantly higher than the score for patients without cognitive dysfunction (19.7±14.7) (p=0.0389) (Figure 3). The FIM-cognition gain score at discharge for patients with cognitive dysfunction was 4.1±4.1, which was significantly higher than the score for patients without cognitive dysfunction (2.7±3.3) (p=0.0128).

The MMSE score at admission for patients with cognitive dysfunction was 17.9±9.4, which was significantly lower than that (21.6±8.2) for patients without cognitive dysfunction (p=0.0056) (Figure 4A). The HDS-R score at admission for patients with cognitive dysfunction was 16.8±10.1, which was significantly lower than the score (20.7±9.0) for patients without cognitive dysfunction (p=0.0087) (Figure 4B). The MMSE gain at discharge for the patients with cognitive dysfunction was 2.8±4.8, which was

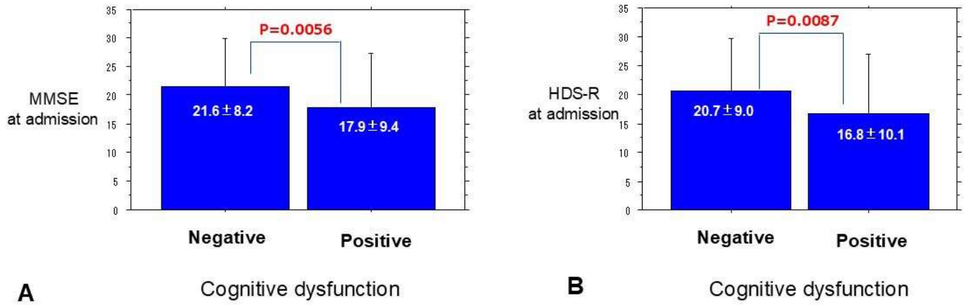

Figure 4. MMSE and HDS-R at admission

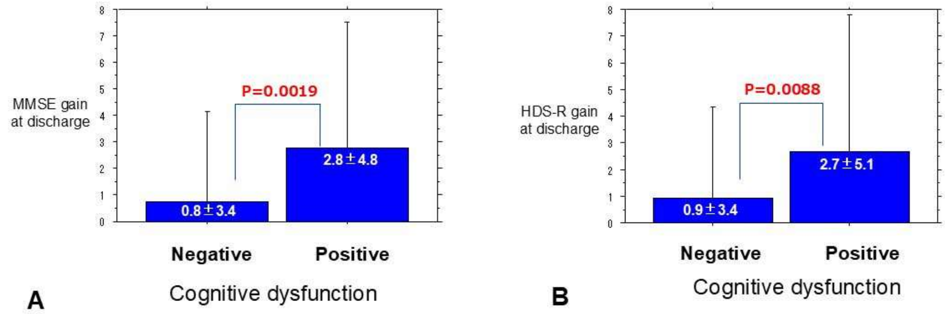

Figure 5. MMSE gain and HDS-R gain at discharge

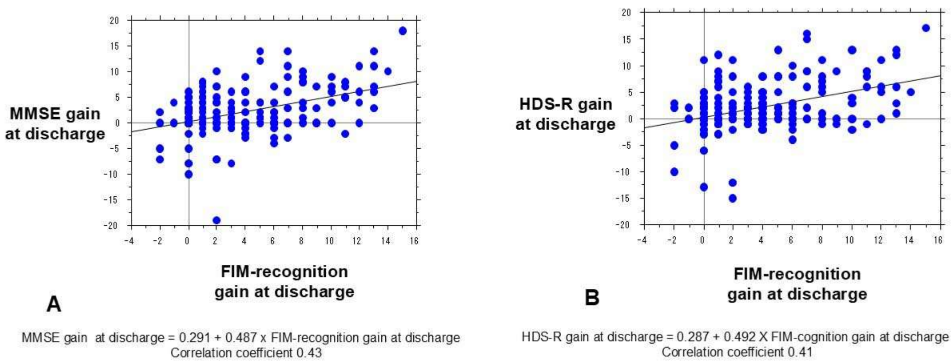

Figure 6A. There was a moderate correlation between FIM-recognition gain at discharge and MMSE gain at discharge (correlation coefficient 0.43). 6B: There was a moderate correlation between FIM-cognition gain at discharge and HDS-R gain at discharge (correlation coefficient 0.41).

significantly higher than that (0.8±3.4) for patients without cognitive dysfunction (p=0.0019) (Figure 5A). The HDS-R gain score at discharge for patients with cognitive dysfunction was 2.7±5.1, which was significantly higher than the score (0.9±3.4) for patients without cognitive dysfunction (p=0.0088) (Figure 5B).

There was a moderate correlation between FIM recognition gain at discharge and MMSE gain at discharge (Correlation coefficient 0.43) (Figure 6A). There was a moderate correlation between FIM-cognition gain at discharge and HDS-R gain at discharge (Correlation coefficient 0.41) (Figure 6B). There was a strong correlation between HDS-R gain at discharge and MMSE gain at discharge (Correlation coefficient 0.86) (Figure 7).

For subclassification of cognitive dysfunction, FIM-cognition gain (5.4±4.6) at discharge of ③aphasia + other disorders was significantly higher than that (3.6±3.7) of ②disorders other than aphasia (p=0.025), and seemed to be higher than that (2.8±4.0) of ①aphasia (Figure 8B). MMSE gain (4.6±4.8) at discharge of ③aphasia + other disorders

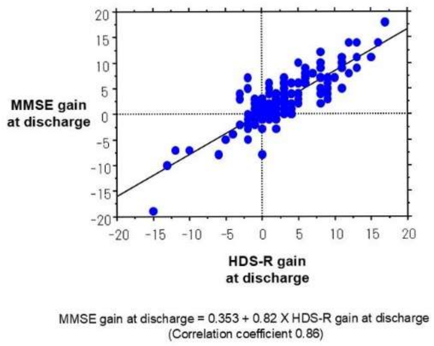

Figure 7. Correlation between HDS-R gain at discharge and MMSE gain at discharge (correlation coefficient 0.86)

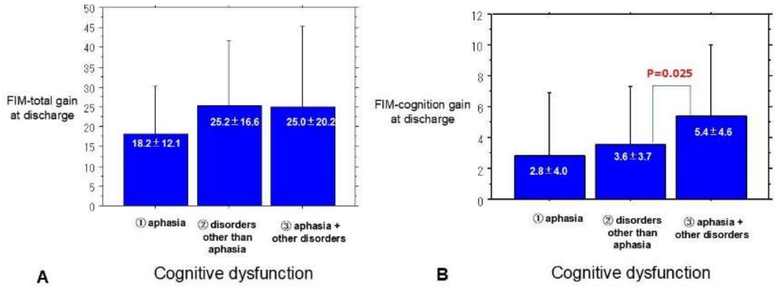

Figure 8. FIM-total gain and FIM-cognition gain based on subtypes of cognitive dysfunction

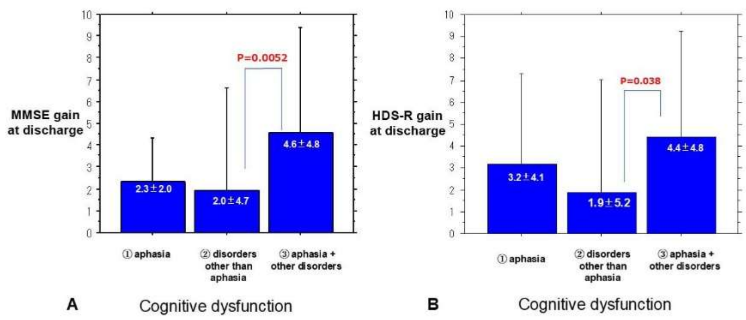

Figure 9. MMSE gain and HDS-R gain based on subtypes of cognitive dysfunction

was significantly higher than that (2.0±4.7) of ②disorders other than aphasia (P=0.0052), and seemed to be higher than that (2.3±2.0) of ①aphasia (Figure 9A). HDS-R gain (4.4±4.8) at discharge of ③aphasia + other disorders was significantly higher than that (1.9±5.2) of ②disorders other than aphasia (P=0.038), and seemed to be higher than that (3.2±4.1) of ①aphasia (Figure 9B).

4. Discussion

Although cognitive dysfunction was reported to be associated with a poor rehabilitation outcome [16], our data showed an opposite result that cognitive dysfunction was associated with a better rehabilitation outcome, and strongly recommend rehabilitation. Patients of cerebrovascular diseases with cognitive dysfunction showed characteristic findings in FIM, MMSE, and HDS-R after rehabilitation compared to patients without cognitive dysfunction. The FIM-total scores (61.1±26.8) of patients of cerebrovascular diseases with cognitive dysfunction at admission were significantly lower than those (71.5±30.4) of the patients without cognitive dysfunction, but conversely, FIM-total gains (24.8±17.5) of the patients with cognitive dysfunction at discharge was significantly higher than those (19.7±14.7) of the patients without cognitive dysfunction. On the other hand, similar results were obtained for MMSE and HDS-R, and compared to the result of FIM, the improvement in MMSE and HDS-R in the patients with cognitive dysfunction at discharge was remarkably and significantly higher than that of the patients without cognitive dysfunction. MMSE and HDS-R scores were more efficient than FIM for assessment of the improvement of cognitive dysfunction.

The improvement in FIM score at discharge tended to be lower for patients with aphasia. On the other hand, the improvement in HDS-R score and MMSE score at discharge tended to be lower for patients with cognitive dysfunction other than aphasia. FIM score is useful for evaluation of the improvement of cognitive dysfunction other than aphasia, because FIM score dose not estimate real speaking ability. MMSE score and HDS-R score are useful for evaluation of the improvement of aphasia rather than other cognitive dysfunction because MMSE score and HDS-R score can estimate real speaking ability.

Cognitive dysfunction in lacunar stroke patients may commonly be overlooked in clinical practice but may be as important as motor and sensory sequelae [17]. Cognitive impairment is frequent before the onset of stroke among older people and may partially explain the very high frequency of cognitive impairment observed after stroke onset [18]. Cognitive dysfunction was present in 52% before stroke onset [18]. Cognitive impairment was highest at the acute stroke and improved during early recovery and the greatest rate of improvement occurred within 3 months [19]. Improvement was found in all cognitive domains [19]. Higher initial Montreal Cognitive Assessment (MoCA) scores (which reflect preservation of executive function) indicate better functional outcome in the subacute stroke phase [20]. The severity and frequency of some BPS (behavioral and psychological symptoms) are higher in patients with severe cognitive impairment than in those with mild cognitive impairment [21].

In our study there were significant relationships among FIM, MMSE and HDS-R. The improvement in FIM cognition and the improvement in MMSE were significantly correlated with a correlation coefficient of 0.43. The improvement in FIM cognition and the improvement in HDS-R were significantly correlated with a correlation coefficient of 0.41. The improvement in HDS-R and the improvement in MMSE were significantly correlated with a correlation coefficient of 0.86. FIM, MMSE and HDS-R scores were efficient for the improvement of cognitive dysfunction.

Although nutrition was not analyzed in our study, nutrition may be important for improvement of cognitive dysfunction. A low prognostic nutritional index (PNI) was independently associated with the occurrence of PSCI and the PNI scores were specifically associated with the scores of global cognition and attention domain [22]. It can be a promising and a straightforward screening indicator to identify the person with impaired immune-nutritional status at higher risk of PSCI [22]. Most patients with PSCI were malnourished; malnutrition on admission for rehabilitation was associated with poor improvement after PSCI [23]. Low hemoglobin levels are associated with an increased risk of PSCI. Targeted interventions in this population may reduce the incidence of PSCI and require further evaluation [24].

As a future initiative, repetitive transcranial magnetic stimulation (rTMS) would be useful for improvement of cognitive dysfunction [25]. rTMS has emerged as a promising treatment for mild cognitive impairment and Alzheimer's disease (26). The current limited evidence suggests that intermittent theta burst stimulation (iTBS) may be the optimal approach for improving cognitive and daily life abilities of stroke patients [25]. High-frequency TMS (HF-rTMS) stimulation has a better overall effect on improving cognitive functions and activities of daily living, such as attention and memory in stroke patients [27]. HF-rTMS stands out as the most promising intervention for enhancing cognitive function [28]. Dual-rTMS is highly recommended for improving ADL capacity [28]. In our hospital rTMS will be introduced in the near future.

Study limitations I have to keep in mind that the research has three limitations. First, it was a retrospective research project and was conducted at a single institution. Second, the number of patients with cerebrovascular diseases were limited to only 200.

For a more accurate assessment, additional patients with cerebrovascular diseases are necessary. Third, selection bias might be present in the study. These patients with cerebrovascular diseases would be more interested in healthcare and want to get rehabilitation compared to the broader population with cerebrovascular diseases.

5. Conclusions

Our results showed cognitive dysfunction was associated with a better rehabilitation outcome, and strongly recommend rehabilitation. FIM, MMSE and HDS-R scores were efficient for the improvement of cognitive dysfunction. For aphasia, FIM scores are not enough for assessment. MMSE and HDS-R can capture changes of cognitive dysfunction, especially aphasia.

Supplementary Materials: none

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Informed Consent Statement: An informed consent was obtained from each patient participating in the study.

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References

1. Kyu HH, Abate D, Abate KH. Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017. a systematic analysis for the Global Burden of Di-sease Study 2017. Lancet 2018; 392: 1859–922.
2. Krishnamurthi RV, Ikeda T, Feigin VL. Global, regional and country-specific burden of ischaemic stroke, intracerebral haemorrhage and subarachnoid haemorrhage. a syste-matic analysis of the global burden of disease study 2017. Neuroepidemiology 2020; 54 (suppl 2): 171–79.
3. Langhorne P, Bernhardt J, Kwakkel G: Stroke rehabilitation. Lancet 2011; 377 (9778): 1693-702. doi: 10.1016/S0140-6736(11)60325-5.
4. Ding M, Xu Y, Wang Y, Li P, Mao Y, Yu J, et al. Predictors of cognitive impairment after stroke: a prospective stroke cohort study. J Alzheimers Dis. 2019;71(4):1139-1151. doi: 10.3233/JAD-190382
5. Kalaria RN, Akinyemi R, Ihara M. Stroke injury, cognitive impairment and vascular dementia. Biochim Biophys Acta. 2016;1862(5):915-925. doi: 10.1016/j.bbadis.2016.01.015
6. Delavaran H, Jönsson A, Lövkvist H, Iwarsson S, Elmståhl S, Norrving B, et al. Cognitive function in stroke survivors: a 10-year follow-up study. Acta Neurol Scand. 2017;136(3):187-194. doi: 10.1111/ane.12709
7. Brewer L, Mellon L, Hall P, Dolan E, Horgan F, Shelley E, et al. ASPIRE-S Study Group. Secondary prevention after ischaemic stroke: the ASPIRE-S study. BMC Neurol. 2015;15:216. doi: 10.1186/s12883-015-0466-2
8. Jia WL, Liu Q, Li SQ. Correlation between hemoglobin level at admission and post-stroke cognitive impairment in acute stroke patients. China Acad J. 2021;56(12):1346-1349. doi: 10.3969/j.issn.1008-1070.2021.12.020
9. Usuda K, Uesaka T, Okubo T, Shimada T, Shimada C, Ito H, Douko N, Aoki T, Takada M, Yokoyama K, Shimizu M, Kitagawa K, Itamoto N, Shimada O. How Are FIM Gains Improved after Intensive Rehabilitation for Cerebrovascular Diseases? Balneo and PRM Research Journal 2024:15(3) https://doi.org/ 10.12680/balneo.2024.721

10. Hatem SM, Saussez G, Della Faille M, Prist V, Zhang X, Dispa D, et al. Rehabilitation of motor function after stroke: a multiple systematic review focused on techniques to sti-mulate upper extremity recovery. Front Hum Neurosci. 2016;10: 442.
11. Seth A Gale , Diler Acar, Kirk R Daffner. Dementia. Am J Med. 2018 Oct;131(10):1161-1169. doi: 10.1016/j.amjmed.2018.01.022. Epub 2018 Feb 6.
12. Hiraoka T. Interpretations and applications of the term, higher brain dysfunction. Jpn J Compr Rehabil Sci 2021;12: 1 - 3. (in Japanese)
13. D. Chumney, K. Nollinger, K. Shesko, K. Skop, M. Spencer, and R. A. Newton, "Ability of Functional Independence Measure to accurately predict functional outcome of stro-kespecific population: systematic review," Journal of rehabilitation research & deve-lopment, 2010; 47 (1): 17-30.
14. Yoshiyuki Kono: The significance and challenges of cognitive function testing in de-mentia assessment. Cognitive Neuroscience 2015; 16 (3, 4): 200-208. (in Japanese)
15. Crum RM, Anthony JC, Bassett SS, Folstein MF. Population-based norms for the mini-mental state examination by age and educational level. JAMA. 1993;269(18):2386-2391.
16 Diamond PT, Felsenthal G, Macciocchi SN, Butler DH, Lally-Cassady D. Effect of cog-nitive impairment on rehabilitation outcome Am J Phys Med Rehabil 1996;75(1):40-3. doi: 10.1097/00002060-199601000-00011.
17 Jacova C, Pearce LA, Costello R, McClure LA, Holliday SL, Hart RG, Benavente OR. Cognitive impairment in lacunar strokes: the SPS3 trial. Ann Neurol. 2012; 72(3): 351-62. doi: 10.1002/ana.23733.
18. Gutiérrez Pérez C, Sävborg M, Påhlman U, Cederfeldt M, Knopp E, Nordlund A, As-trand R, Wallin A, Fröjd K, Wijk H, Tarkowski E. High frequency of cognitive dysfunction before stroke among older people. Int J Geriatr Psychiatry. 2011; 26(6): 622-9. doi: 10.1002/gps.2573.
19. Dharmasaroja PA. Temporal Changes in Cognitive Function in Early Recovery Phase of the Stroke. J Stroke Cerebrovasc Dis.2021; 30(10): 106027. doi: 10.1016/j.jstrokecerebrovasdis.2021.106027.
20. Lim KB, Kim J, Lee HJ, Yoo J, You EC, Kang. Correlation Between Mon-treal Cognitive Assessment and Functional Outcome in Subacute Stroke Patients With Cognitive Dysfunction. J.Ann Rehabil Med. 2018; 42(1):26-34. doi: 10.5535/arm.2018.42.1.26.
21. Ito D, Mori N, Shimizu A, Narita A, Sakata S, Honaga K, Kondo K, Otaka Y. Presence and Characteristics of Behavioral and Psychological Symptoms in Subacu-te Stroke Patients with Cognitive Impairment. Behav Neurol. 2023 28; 2023:6636217. doi: 10.1155/2023/6636217. eCollection 2023.
22. Wang Y, Zhang G, Shen Y, Zhao P, Sun H, Ji Y, Sun L. Relationship between prognos-tic nutritional index and post-stroke cognitive impairment. Nutr Neurosci. 2024; 27(11):1330-1340. doi: 10.1080/1028415X.2024.2330786.
23. Tsutsumiuchi K, Wakabayashi H, Maeda K, Shamoto H. Impact of malnutrition on post-stroke cognitive impairment in convalescent rehabilitation ward inpatients. Eur Geriatr Med. 2021; 12(1):167-174. doi: 10.1007/s41999-020-00393-0.
24. He W, Ruan Y, Yuan C, Luan X, He J. Hemoglobin, anemia, and poststroke cognitive impairment: A cohort study. Int J Geriatr Psychiatry. 2020 ;35(5): 564-571. doi: 10.1002/gps.5272.
25. Liu X, Li H, Yang S, Xiao Z, Li Q, Zhang F, Ma J. Efficacy of repetitive transcranial mag-netic stimulation on post-stroke cognitive impairment: A systematic and a network me-ta-analysis. Int J Geriatr Psychiatry. 2024; 39(7): e6117. doi: 10.1002/gps.6117.2
26 Chou YH, Ton That V, Sundman M. A systematic review and meta-analysis of rTMS effects on cognitive enhancement in mild cognitive impairment and Alzhei-mer's disease.Neurobiol Aging. 2020 ; 86: 1-10. doi: 10.1016/j.neurobiolaging.2019.08.020.
27. Yang Y, Chang W, Ding J, Xu H, Wu X, Ma L, Xu Y.26. Effects of different modalities of transcranial magnetic stimulation on post-stroke cognitive impairment: a network me-ta-analysis. Neurol Sci. 2024; 45(9): 4399-4416. doi: 10.1007/s10072-024-07504-w.
28 Yan M, Liu J, Guo Y, Hou Q, Song J, Wang X, Yu W, Lü Y. Comparative efficacy of non-invasive brain stimulation for post-stroke cognitive impairment: a network meta-analysis. Aging Clin Exp Res. 2024 Feb 12; 36(1): 37. doi: 10.1007/s40520-023-02662-x.