1 **Research Article**

2 How Are FIM Gains Improved after Intensive Rehabilitation for 3 Cerebrovascular Diseases?

4 FIM gains after rehabilitation in cerebrovascular diseases

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Abstract

Objective: Not only functional independence measure (FIM) gain after intensive rehabilitation for cerebrovascular diseases but also the effect of dementia and higher brain dysfunction to FIM gain are not well to be understood. The purpose of this study was to determine FIM gains based on clinical factors after intensive rehabilitation for cerebrovascular diseases. *Patients:* A number of 181 patients were suffered from stroke 161 (cerebral infarction 107, cerebral hemorrhage 41**,** subarachnoid hemorrhage 12, subdural hematoma 1**),** traumatic brain injury 12, and others 8. *Methods:* Dementia**,** higher brain dysfunction, etiology, sex, age**,** history of cerebrovascular diseases, and location involvement were analyzed using FIM. *Results:* There was a significant relationship of the correlation coefficient 0.772 between FIM-total gain 4 weeks after admission and FIM-total gain at discharge. FIM-total gain (23.6 ± 18.4) in patients without dementia was significantly higher than that (14.1 ± 12.4) of patients with dementia. FIM-total gain (23.5 ± 18.4) in patients with higher brain dysfunction tended to be higher than that (18.5 ± 16.2) of patients without higher brain dysfunction. Patients with FIM-total (41-80) on admission showed significantly higher FIM-total gain of **(**28.6 ± 17.2) than that **(**18.7 ± 22.2**)** of patients with FIM-total (40 or lower), or than that **(**17.2 ± 8.69**) o**f patients with FIM-total (81 or higher). FIM-total gains were decreased according to increasing ages. FIM-total gain (29.3 ± 19.8) of cerebral hemorrhage was significantly higher than that (19.2 ±15.5) of cerebral infarction. FIM-total gain decreased according to incidents of cerebrovascular diseases in the past. *Conclusion:* FIM gain scores after rehabilitation in cerebrovascular diseases were correlated with no dementia, higher brain dysfunction, younger ages, intermediate FIM score (41-80) on admission, cerebral hemorrhage, and no history of cerebrovascular diseases. FIM-total gain at discharge can be extrapolated from FIM-total gain 4 weeks after admission.

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]. These patients show improvement after rehabilitation programs, however, the quality and rate of this improvement vary in these patients. Stroke represents the most common cause of adult disability and the second major cause of dementia. Significant functional recovery may develop in the first 3months following the episode [4]. Afterward, recovery is associated with cerebral plasticity and cortical reorganization, in great part stimulated by rehabilitation programs [5]. The functional independence measure (FIM) is the most widely used standardized outcome measure for rehabilitation in the world. Most patients with severe stroke do not achieve FIM motor ≥70 after inpatient rehabilitation [6]. Older patients and patients with lower admission FIM motor require more attention [7].

In this article we aim to take a comprehensive look at not only the rehabilitation of stroke patients but also of patients with other cerebrovascular diseases, traumatic brain injuries, brain tumors, and meningoencephalitis. We determined the characteristic of FIM gain after intensive rehabilitation for stroke, traumatic brain injury**,** brain tumor or meningoencephalitis. We also evaluated the effect of dementia and higher brain dysfunction to FIM gain after rehabilitation.

2. Methods

2-1. 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 project 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 from May 2021 to October 2022 were included in this study.

2-2. Participants

All the patients with cerebrovascular diseases who were treated in the full-time treatment program of rehabilitation 7 days/wk from May 2021 to October 2022 were eligible for this research. 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 therapy 40 minutes, occupational therapy 40 minutes, speaking therapy 40 minutes). Patients who died from complications during their hospitalization, or whose FIM on discharge were lower than on admission, were excluded. Finally 181 patients were registered in the study (Table 1). Ninety patients were male and 91 were female. Their mean age was 76.7 years old (range 40 to 102). There were 161 strokes **(**cerebral infarction 107**,** cerebral hemorrhage 41, subarachnoid hemorrhage 12, subdural hematoma 1), 12 traumatic brain injuries, 6 brain **t**umors and 2 meningoencephalitis**es.**

Table 1. Patients characteristics

Age		40 ～ 102 （Mean ± S.D. : 76.7 ± 12.0）			
Sex	Male	90	Past history of cerebrovascular disease	No incident	127
	Female	91		One incident	47
Etiology	Cerebral infarction	107		Two incidents	7
	Cerebral hemorrhage	41	Side involvement	Right-sided	75
	Subarachnoid hemorrhage	12		Left-sided	83
	Subdural hematoma	1		Not determined	23
	Traumatic brain injury	12	Dementia	Positive	33
	Brain tumor	6		Negative	148
	Meningoencephalitis	2	Higher brain dysfunction	Positive	122
Location involvement	Over the tent	141		Negative	59
	Under the tent	26	Discharge	Home	127
	Not determined	14		Hospital, nstitution	54

2-3. Data collection

Clinical and demographic features including these etiology, sex, age, history of cerebrovascular diseases, side involvement, location involvement, disability severity, dementia and higher brain dysfunction were analyzed. Functional status was evaluated by using the functional independence measure (FIM) at admission. The FIM items are broadly

classified into total, motor and cognitive categories (FIM-total, FIM-motor, FIM-cognition). 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). FIM scores were recorded at admission, 4 weeks, 8 weeks, and 12 weeks after admission.

2-4. 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. 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

Length from onset to the start of rehabilitation were 0 to 41 days (2.2 ± 4.4). The hospitalization at the first hospital that treated the patients in the acute phase was 6 to 114 days (27.3 ± 14.8). The hospitalization at our convalescent hospital for intensive rehabilitation for patients was 10 to 178 days (75.0 ± 34.7).

For 181 patients, FIM-motor gain was 18.3±15.4, FIM-cognitive gain was 3.5 ± 4.0 and FIM-total gain was 21.8 ± 17.8. There was a significant correlation between FIM-total on admission (A) and FIM-total on discharge (B) ($B = 22.62 + 0.99 \times A$, the correlation coefficient (r) = 0.857) (Figure 1a). There were not any correlations between FIM-total on admission and FIM-total gain, FIM-motor gain, or FIM-cognition gain on discharge (Figure 1 b-d).

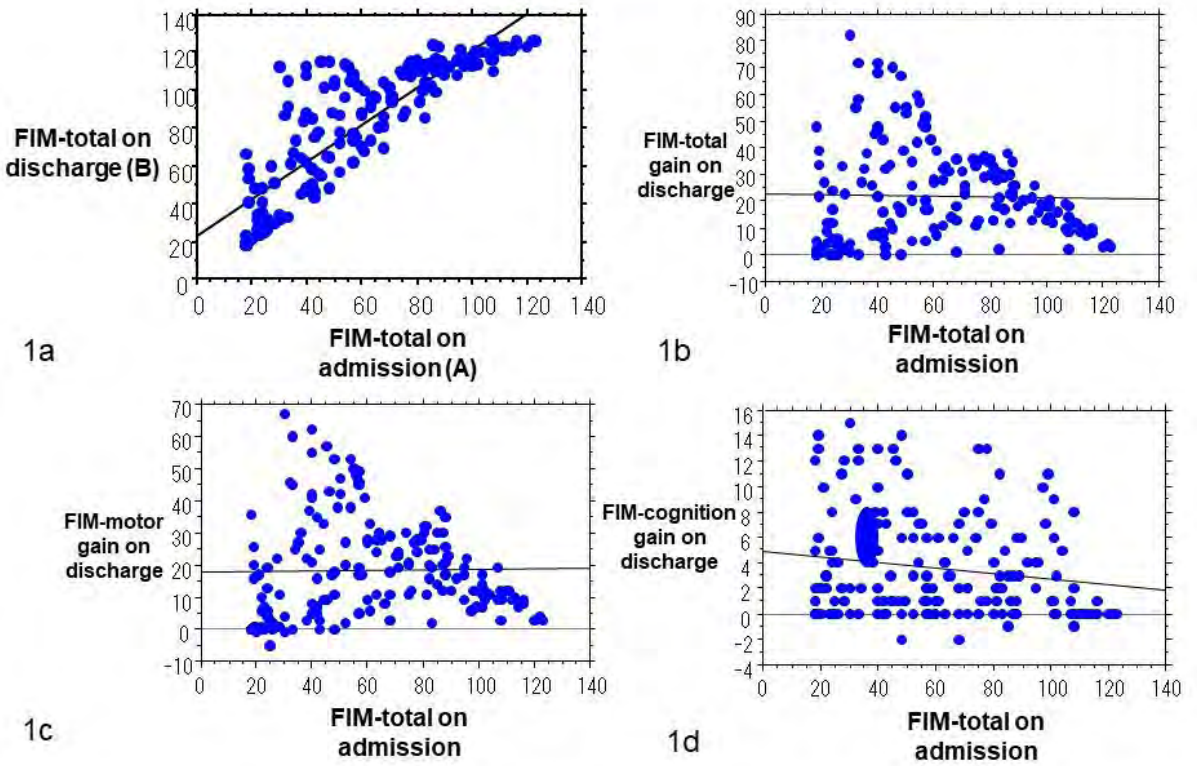

Figure 1a: Relationships between FIM-total on admission (A) and FIM-total on discharge (B) There was a significant correlation between FIM-total on admission (A) and FIM-total on discharge (B): B = 22.62 + 0.99×A, the correlation coefficient r =0.857. **1b-1d:** Relationships between FIM-total on admission and FIM-total gain, FIM-motor gain, or FIM-cognition gain on discharge. There were not any correlations between them.

There were significant relationships of the correlation coefficient 0.772 between FIM-total gain 4 weeks after admission and FIM-total gain on discharge, the correlation coefficient 0.769 between FIM-motor gain 4 weeks after admission and FIM-motor gain on discharge, and the correlation coefficient 0.820 between FIM-cognition gain 4 weeks after admission and FIM-cognition gain on discharge (Figure 2). There were significant relationships between them.

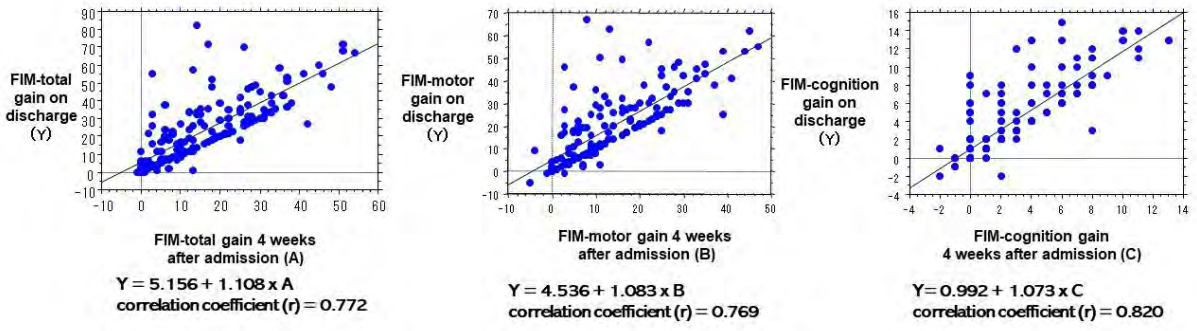

Figure 2: Relationships between FIM gain 4 weeks after admission and FIM gain on discharge There were significant relationships between them.

For dementia, FIM-total gain (23.6 ± 18.4) in patients without dementia was significantly higher than that (14.1 ± 12.4) of patients with dementia (p=0.0053) (Figure 3a). FIM-motor gain (19.8 ± 15.8) in patients without dementia was significantly higher than that (11.5 ± 11.4) of patients with dementia (p=0.0053). FIM-cognition gain (3.8 ± 4.2) in patients without dementia tended to be higher than that (2.4 ± 2.7) of patients with dementia (p=0.069). Conversely, FIM-total gain (23.5 ± 18.4) in patients with higher brain dysfunction tended to be higher than that (18.5 ± 16.2) of patients without higher brain dysfunction (p=0.076) (Figure 3b). FIM-motor gain (19.4 ± 15.8) in patients with higher brain dysfunction tended to be higher than that (16.0 ± 14.5) of patients without higher brain dysfunction (p=0.167). FIM-cognition gain (4.0 ± 4.2) in patients with higher brain dysfunction were significantly higher than that (2.4 ± 3.4) of patients without higher brain dysfunction (p=0.011). FIM-total gain (25.4 ± 18.7) was highest in patients with dementia plus without higher brain dysfunction (Figure 3c). FIM-motor gain and FIM-cognition gain were highest in patients without dementia plus with higher brain dysfunction. FIM-total gain (13.9 ± 10.6) was lowest in patients with dementia plus without higher brain dysfunction.

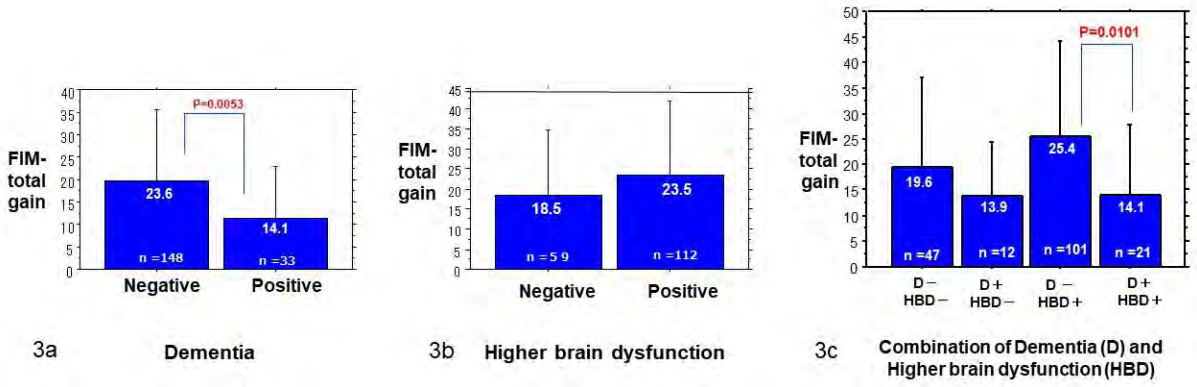

Figure 3a: FIM-total gain in patients without dementia were significantly higher than that of patients with dementia. **3b:** FIM-total gain in patients with higher brain dysfunction was tended to be higher than that of patients without higher brain dysfunction. **3c:** FIM-total gain was lowest in patients with dementia plus without higher brain dysfunction. FIM -total gain was highest in patients without dementia plus with higher brain dysfunction.

For patients, length of stay in our convalescent rehabilitation ward varied: 10 to 178 days (75.0 ± 34.7). FIM-total scores were 60.3±30.1 for admission (n=181). 75.0±33.5 for 4 weeks (n=124), 75.0±33.5 for 8 weeks (n=124), and 70.0±35.1 for 12 weeks (n=69). FIM-total gains were 15.2±30.1 for 4 weeks (n=179), 22.9±17.0 for 8 weeks (n=124), and 26.1±21.3 for 12 weeks (n=69). FIM-total gains significantly increased with the length of admission.

FIM-total gain (21.6 ± 18.6) of males were the same as that (22.1 ± 17.1) of females. FIM-total gains decreased in relation to an increase in age. FIM-total gains were 35.0 ± 21.7 for patients of 49 years old or younger, 31.8 ± 20.4 for 50-59 years old, 29.5 ± 20.3 for 60-69 years old, 22.1 ± 17.3 for 70-79 years old, 18.2 ±14.3 for 80-89 years old, 14.0 ± 17.0 for 90-99 years old, and 8.0 for 100 years old or more (Figure 4a). FIM-motor gains decreased according to the increase in age as same as FIM-total gains. FIM-cognition gain (5.2 ± 5.1) was highest in patients of 60-69 years old. For past history, FIM-total gains were 23.9 ± 18.9 in patients with no history of cerebrovascular disease, 18.0 ± 13.8 in patients with a history of one incident, and 9.3 ± 12.1 in patients with a history of two incidents (Figure 4b). FIM-total gain decreased according to the number of incidents of cerebrovascular diseases. FIM-total gain (22.6 ± 18.4) of left-side involvement tended to be higher than that (19.8±16.1) of right-side involvement, but there was no significant difference. FIM-total gain (25.7 ± 20.8) of the involvement without the laterality tented to be higher than those of the involvement with the laterality. FIM-total gains (21.5 ± 18.2) in organs involved over the tent was as same as that (21.4 ± 14.6) in organs involved under the tent.

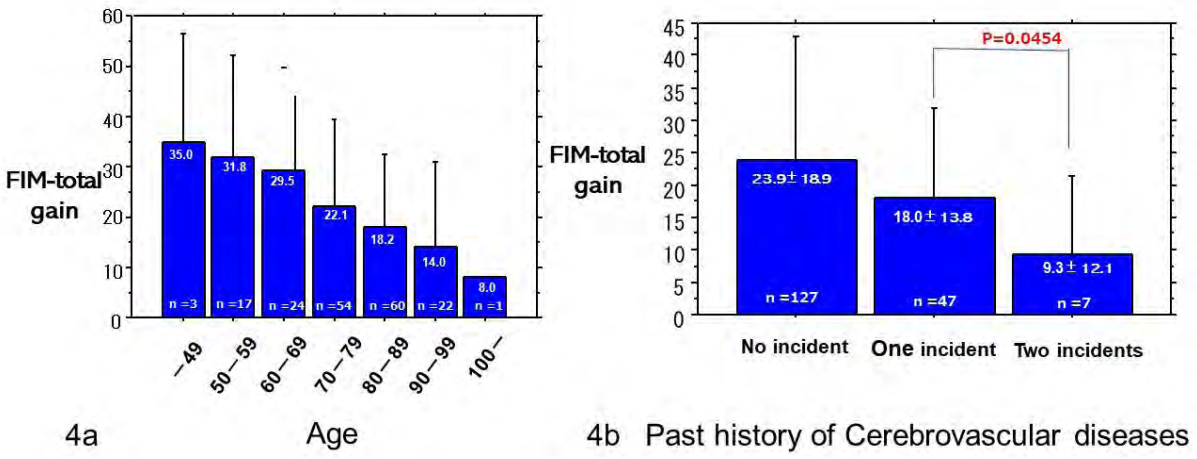

Figure 4a: FIM-total gains were decreased according to an increase in age. FIM-total gains were 35.0±21.7 for patients of 49 years old or younger, 31.8±20.4 for 50-59 years old, 29.5 ±20.3 for 60-69 years old, 22.1±17.3 for 70-79 years old, 18.2 ±14.3 for 80-89 years old, 14.0 ±17.0 for 90-99 years old, and 8.0 of 100 years old or more. **4b:** The FIM-total gains decreased according to incidents of past history of cerebrovascular diseases.

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). Patients with intermediate disability (FIM 41-80) on admission showed significantly higher FIM-total gain of (28.6 ± 17.2) on discharge than that (18.7 ± 22.2) of patients with severe disability (FIM 40 or lower) on admission, or than that (17.2 ± 8.69) of patients with mild disability (FIM 81 or higher) on admission (Figure 5a). FIM-total gains

were 19.2 ±15.5 for cerebral infarction, 29.3 ± 19.8 for cerebral hemorrhage, 26.8 ± 21.9 for subarachnoid hemorrhage, 21.3 ± 21.4 for traumatic brain injury, 20.5 ± 23.3 for meningoencephalitis, 13.0 ± 14.3 for brain tumor and 6.0 for subdural hematoma (Figure 5b). FIM-total gain of cerebral hemorrhage was significantly higher than that of cerebral infarction (p=0.0013). FIM-total gains tended to be higher in subarachnoid hemorrhage compared to cerebral infarction. FIM-motor gains were higher in cerebral hemorrhage and subarachnoid hemorrhage compared to cerebral infarction. FIM-cognition gains were significantly higher in meningoencephalitis compared with the other etiologies.

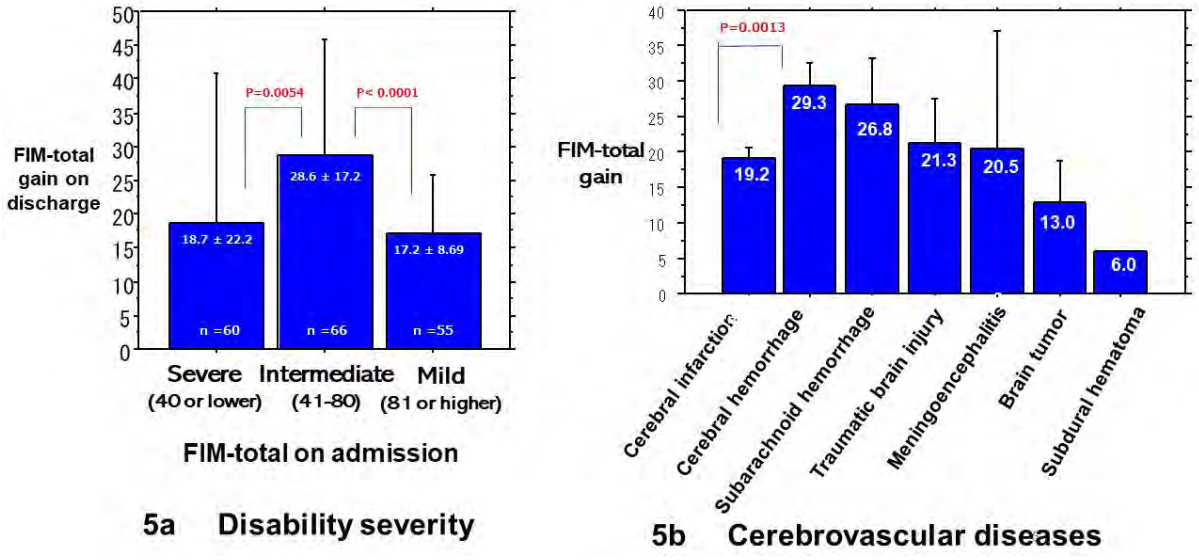

Figure 5a: Relationships between disability severity (FIM-total on admission) and FIM-total gain on discharge. FIM-total (41-80) on admission was significantly higher than that of FIM-total (40 or lower) or FIM-total (81 or higher). **5b:** FIM-total gains were 19.2 ± 15.5 for cerebral infarction, 29.3 ± 19.8 for cerebral hemorrhage, 26.8 ± 21.9 for subarachnoid hemorrhage, 21.3 ± 21.4 for intracranial trauma, 20.5 ± 23.3 for meningoencephalitis, 13.0±14.3 for resected brain neoplasm and 6.0 for subdural hematoma.

4. Discussion

4-1. FIM gain 4 weeks after admission

We realized that improving the physical condition of patients is based on FIM gain 4 weeks after admission, not on the FIM score on admission. There were significant relationships of the correlation coefficient 0.772 between FIM-total gain 4 weeks after admission and FIM-total gain on discharge. FIM-total gain 4 weeks after admission was revealed to be a prognostic predictor of cerebrovascular diseases.

4-2. Dementia and/or higher brain dysfunction

FIM-total gain, FIM-motor gain and FIM-cognition gain in patients without dementia were significantly higher than those of patients with dementia. Both total and motor FIM scores at admission and discharge, and their respective FIM gain scores at discharge were higher in non-pre-stroke dementia compared with pre-stroke dementia patients ($P < 0.001$) [7]. Despite severe neurologic impairment(s) and disability, cognitively impaired stroke patients made significant functional gains while undergoing rehabilitation and many can be regulated to getting better at home [8)]. The management of dementia can lead to better functional recovery during rehabilitation [9]. Most of the cognitive improvement took place within 6 months [10]. Conversely, FIM-total gain, FIM-motor gain and FIM-cognition gain in patients with higher brain dysfunction tended to be higher than those of patients without higher brain dysfunction. Higher brain dysfunction refers to deficits in intellectual functions, such as language, thinking, memory, behavior, learning, and concentration, resulting from organic brain lesions. Damage to neuronal networks in the bilateral frontal and temporal lobe appeared to play the most important role in higher brain dysfunction [11]. The results of this study showed that patients with dementia had significantly reduced FIM gains, and patients with higher brain dysfunction have a potential of cognition improvement and can improve FIM gains by intensive rehabilitation. Post-stroke cognitive impairment is associated with poorer outcomes and greater disability.

4-3. Clinical factors

The Intercollegiate Stroke Working Party (ICSWP) published the 5th edition of the *National clinical guideline for stroke* in October 2016 [12]. It provides the most up to date and comprehensive overview of the management of strokes available, covering the whole of the pathway from acute care to longer term management. In our research, in the acute phase in hospitals, early rehabilitation starts on 0 - 41 days (2.2 ± 4.4) after admission for patients with cerebrovascular diseases. The patients are treated by an intensive rehabilitation program for 2-3 hours every day, 7 days/wk. ICSWP recommends that stroke rehabilitation should begin 24-48 hours after a stroke and treatment and care should be reviewed at six months [12].

In this article we determined the important factors which influence the functional improvement of rehabilitation in cerebrovascular diseases: no dementia, higher brain dysfunction, younger age, intermediate disability (FIM 41-80), cerebral hemorrhage, no history of cerebrovascular diseases, and left-side involvement. Previous studies and systematic reviews reported that age, marital status, time from stroke onset to rehabilitation, aphasia, neglect, stroke severity presented in National Institutes of Health Stroke Scale,

cognitive function, and motor function such as walking distance were associated with the gain score in FIM after stroke rehabilitation [13-15]. And, factors influencing the rehabilitation results were age, cognitive impairment, unilateral spatial neglect, ADL before the illness, and time to hospitalization from the onset [16]. The significant predictors for "clinically significant functional gain" were also younger age <75 years old, higher Glasgow Coma Scale score at admission, hemorrhagic stroke, intermediate FIM- motor measure (MM) function group [17]. The important factors which influence the functional improvement of rehabilitation in cerebrovascular diseases would be younger age, intermediate FIM score, cerebral hemorrhage, no dementia and length from onset to the start of rehabilitation.

In our patients, mean FIM-motor gain was 18.3 ± 15.4, mean FIM-cognitive gain was 3.5 ± 4.0 and mean FIM-total gain was 21.8± 17.8. Our results correlated with the results from a Shannon Janzen et al. experiment that stroke rehabilitation FIM-motor gain was 18.9 ± 14.0, FIM-cognitive gain was 2.7 ± 3.6 and FIM-total gain was 21.7 ± 15.5 [18]. Turner-Stokes L et al. also reported that after stroke rehabilitation FIM-motor gain was 18.4, FIM-cognitive gain was 4.2 and FIM-total gain was 22.6 [19]. Functional improvement was observed in all the groups in our study, but the improvement in the patients with intermediate disability (FIM score 41–80) was significantly higher than that in patients with severe disability (FIM 40 or lower) or mild disability (FIM 81 or higher). Inouye et al. divided their patients into 3 groups according to FIM admission score and found that the patients who were moderately affected at admission showed higher FIM gain levels than those who were severely affected [20]. Stroke patients in the intermediate FIM-motor function group generally had the best FIM-motor gain [21].

FIM-total gain (21.6 ± 18.6) of males were the same as that (22.1 ± 17.1) of females. FIM gain was decreased according to repeating cerebrovascular diseases. No history of previous cerebrovascular diseases was correlated with improved FIM-total gain. FIM-total gains decreased according to increases in age. FIM-total gains were 35.0 ± 21.7 for patients of 49 years old or younger, and 14.0 ± 17.0 for 90-99 years old. FIM-cognition gain was highest (5.2 ± 5.1) in patients of 60-69 years old. There was a report that the age group 65–74 years old were obviously not yet too old to be labelled with limited rehabilitation potential; this age group was associated with better functional gain when being compared with the age group 75-84 years old and the age group>85 years old [17]. Younger ages were associated with better functional gain in both univariate and multivariate analysis [22,23]. It is common that FIM improvement is constant in younger patients under 69 years old, and decreasing linearly in older patients over 70 years old [24].

FIM-total gain of left-side involvement tended to be higher than that of right-side involvement. FIM-total gain of the location without the laterality tended to be higher than that of locations with the laterality. FIM-total gains were same in organs involved under the tent and organs involved over the tent. Patients with bilateral hemiparesis had significantly greater FR (functional recovery) after stroke than patients with unilateral hemiparesis [25]. The magnitude of change was significantly higher for patients with bilateral hemiparesis [25].

FIM-total gain of cerebral hemorrhage was significantly higher than that of cerebral infarction. Krishnan RR et al. reported that functional improvements after rehabilitation of cerebral hemorrhage was better than that of cerebral infarction (FIM-hemorrhage Δ 27 vs. FIM-infarction Δ 21, $p = 0.05$), despite significantly worse initial stroke severity [26]. However, there is evidence that recovery was not limited to this time period alone. In the past, the observation of spontaneous recovery after stroke has misled some authors to believe that recovery of upper extremity function is intrinsic and that little can be done by therapists to influence it.

5. Limitations of the study

We must keep in mind that this research has two limitations. First, it was a retrospective research project and was conducted at a single institution. Second, the number of patients of cerebrovascular diseases were limited to only 181. For a more accurate assessment, additional cases of cerebrovascular diseases and a longer follow-up study are necessary.

6. Conclusions

Improved FIM gain scores after stroke rehabilitation in cerebrovascular diseases were correlated with no dementia, higher brain dysfunction, younger ages. intermediate FIM score (41-80), cerebral hemorrhage, no history of cerebrovascular diseases, left-side involvement. We can extrapolate FIM-total gain at discharge from FIM-total gain 4 weeks after admission.

Data Availability

Data include sensitive and personal information and will not be shared as supplemental or underlying data.

Conflicts of interest

The authors have no conflicts of interest to declare.

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