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Research article

Significance of Nutritional and Swallowing Factors in the Rehabilitation for Patients with Cerebrovascular Diseases

Katsuo Usuda[1,*], Takahiko Uesaka[1], Takeshi Okubo[1], Tetsuya Kimura[1], Takashi Shimada[1], Chieko Shimada[1], Haruhide Ito[1], Ryota Takaoka[1], Risa Murata[1], Maki Morishita[1], Shiori Kajita[1], Nanami Tuchida[1], Norihito Douko[1], Takuya Aoki[1], Asami Onojima[1], Kenshiro Ikemoto[1], Kengo Kitagawa[1], Mayumi Takada[1], Naoaki Itamoto[1], Osami Shimada[1]

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1 Department of Rehabilitation Medicine, Shimada Hospital, Fukui, Japan

* Correspondence: usan930@gmail.com

Abstract: To clarify nutritional and swallowing factors which influenced FIM at admission or FIM gain for the rehabilitation for patients with cerebrovascular diseases. The results of 200 patients rehabilitation were anaylzed. Nutritional status was evaluated using GLIM, PNI, GNRI, Wakabayashi's malnutrition and clinical factors, and swallowing status using FOIS. Average calorie intakes were 1,326±322 Kcal at admission and 1,448±273 Kcal at discharge. Average protein intakes per Kg were 0.92±0.24 g/Kg at admission and 1.02±0.19 g/Kg at discharge. GLIM, PNI, GNRI and Wakabayashi malnutrition criteria all indicated that patients with no malnutrition kept higher FIM at admission and higher FIM at discharge than the other groups. The more FOIS Level at admission increased, the more FIM at admission increased. Multiple regression analysis determined that the significant factors which influenced FIM at admission were FOIS, serum albumin and body weight. The analysis also determined that significant factors which influenced FIM gain at dis-charge were albumin gain, protein intake gain, protein intake gain per kg, calorie intake gain per Kg, calorie intake gain, and FOIS gain. FOIS, albmin, body weight, albmin gain, protein intake gain, calorie intake gain, FOIS gain were closely related to efficient rehabilitation of cerebrovascular diseases.

Keywords: cerebrovascular disease; malnutrition; dysphagia; GLIM (Global Leadership Initiative on Malnutrition); FOIS (Functional Oral Intake Scale)

1. Introduction

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017 announced 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].We reported that significant factors that contributed to FIM gain were duration of hospitalization, FIM gain at 4 weeks after admission, age, and disability severity [4]. FIM scores and FIM gains could predict rehabilitation outcomes [4]. Significant functional recovery may develop in the first 3 months following the episode [5].

Malnutrition is prevalent in stroke rehabilitation patients, and has serious negative effects on outcomes. 37% of stroke patients experienced malnutrition, reaching up to 52% in those who had an impaired nutritional status [6,7]. A recent systematic review and meta-analysis [8] demonstrated that malnutrition is also associated with poor functional outcomes after stroke. It is necessary to assess nutritional status early and, if needed, provide appropriate nutritional intervention to improve patient outcomes. A

multidisciplinary approach is strongly recommended in this setting; as such, high-quality clinical evidence regarding clinical nutrition in stroke rehabilitation. Aggressive nutritional management at the early stages of stroke onset may be effective in improving prognosis [9]. In a retrospective cohort study, Sato et al. showed that high energy nutritional intake during the first week post-stroke was associated with high rates of discharge from the hospital to home [10]. One study reported that the presence of malnutrition, diagnosed with the Global Leadership Initiative on Malnutrition (GLIM) criteria, is associated with a lower recovery of activities of daily living in stroke survivors [11]. Dysphagia occurs in about 50% of these patients, with an incidence increase depending on whether bedside or instrumental diagnosis is performed [12]. Dysphagia can result in aspiration and might lead to aspiration pneumonia as well as malnutrition, dehydration, and increased mortality [13].

The purpose of this study was to evaluate the nutritional status of patients with cerebrovascular diseases, to determine the usefulness of several malnutrition screening tools, and to clarify nutritional and swallowing factors which influenced FIM at admission and FIM gain at discharge after rehabilitation.

2. Materials and Methods

2.1 Study 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 study and conducted at a single institution. Patients who suffered from cerebrovascular diseases such as 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.

2.2 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. To capture the overall picture of cerebrovascular diseases occurring within a certain period, we did not exclude any cases and included all cases that underwent brain rehabilitation in our analysis. Patients who refused rehabilitation treatment within 1 week after admission were excluded. A total of 233 patients were screened for eligibility, and 200 patients were ultimately included in the study (Table 1). Participants were independent and did not suffer from any mental illness before the onset of the disease. 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 etiology, sex, age, history of cerebrovascular diseases, disability severity, cognitive dysfunction, period of hospitalization and period from onset to rehabilitation were determined.

According to the rules of the healthcare system of Japan, standard rehabilitation protocol for cerebrovascular disease were performed: Patients who were 78 years or younger underwent 3 hours of professional stroke rehabilitation per day (physical

Table 1. Patients' characteristics

Factor			Number of cases	n = 200
Sex	Male		98	
	Female		102	
Etiology	Cerebral infarction		123	
	Cerebral hemorrhage		43	
	Subarachnoid hemorrhage		11	
	Traumatic brain injury		15	
	Brain tumor		5	
	Meningoencephalitis		2	
	Subdural hematoma		1	
Past history of cerebrovascular disease	No incident		145	
	One incident		48	
	Two incidents		7	
Side involvement	Right-sided		80	
	Left-sided		91	
	Not determined		29	
Disability severity	severe disability	FIM 18 - 40	51	
	intermediate disability	FIM 41 - 80	80	
	mild disability	FIM 81-126	69	
Cognitive dysfunction	negative		72	
	positive		128	

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). The rehabilitation programs were comprised of mobilization, strength training, range of motion exercises, swallowing training, speech training, ADL (activities of daily living) training and cognitive function training. The protocol stated that the content of rehabilitation could change during treatment as more effective rehabilitation was needed for each individual patient. 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. The content of each daily program was thus decided by the staff member in charge of rehabilitation.

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.

2.3 Data analysis details

Several nutritional factors were detected at admission and at discharge. Data from within one week after admission was used for admission data, and data from within two weeks before discharge was used for discharge data. Then their gains at discharge were determined. Food intake was measured by staff and evaluated. The following factors were used in the analysis: daily calorie intake (calorie intake) [Kcal/day], daily calorie intake per kg of body weight (calorie intake/ kg) [Kcal/kg/day], daily protein intake (protein intake) [g/day], daily protein intake per kg of body weight (protein intake per kg) [g/kg/day], body weight [kg], body mass index (BMI) [kg/m^2], hemoglobin (Hb) [g/dL], total protein (TP) [g/dL], serum albumin (Alb) [g/dL], peripheral blood lymphocyte [cells/mm^3].

FIM at admission, FIM gain at discharge and FIM at discharge were assessed using the Global Leadership Initiative on Malnutrition (GLIM), Onodera's prognostic nutritional index (PNI), Geriatric Nutritional Risk Index (GNRI), Wakabayashi's malnutrition and the Functional Oral Intake Scale (FOIS). Correlations between FIM at admission, FIM gain at discharge and nutritional / swallowing factors were determined.

GLIM criteria were classified as no malnutrition, moderate malnutrition and severe malnutrition [14]. For the GLIM analysis, severe malnutrition, moderate malnutrition, and no malnutrition were assessed using a score of 1 to 3.

Onodera's Prognostic Nutritional Index (PNI) was defined as follows according to Onodera T's definition [15,16]: PNI = 10 × Alb (g/dL) + 0.005 ×peripheral blood lymphocytes. PNI scores > 38 points reflect normal nutrition status, PNI scores of 35-38 indicate moderate malnutrition, and PNI scores < 35 indicate severe malnutrition [17].

The Geriatric Nutritional Risk Index (GNRI) [18] was calculated using the body weight [BW (kg)], height [H (m)], ideal body weight [IBW = H^2 x 22], serum albumin [Alb (g/dL)]. GNRI = 14.89 x Alb + 41.7 x BW / IBW. GNRI was classified according to Zheng X, et al. [19] : no nutritional risk (GNRI ≥98), low nutritional risk (92 ≤ GNRI <98, moderate nutritional risk (82 ≤ GNRI <92) and high nutritional risk (GNRI <82).

Wakabayashi's malnutrition [20] was defined if the patients had 1 or more abnormal nutritional variables of a body mass index<18.5 kg/m^2, hemoglobin level<10.0 g/dL, serum albumin level<3.0 g/dL, or total lymphocyte count<1200 cells/mm^3.

FOIS was used to assess the oral intake of the patients classified by an ordinal rating scale, including seven levels [21]. Different ranges of non-oral feeding are subsumed in levels 1–3, whereas different ranges of total oral feeding are included in levels 4–7. For details, Level 1 describes patients with no oral intake, Levels 2–3 describe tube-dependent patients, Levels 4–6 are for patients who have not yet reached oral diet expansion, and Level 7 is for patients who have fully reached diet expansion [21]. It has been the most commonly used scale for the rating of the range of oral intake by patients suffering from dysphagia. In the FOIS analysis, levels 1–7 were assessed using a score of 1–7.

Functional independence measure (FIM) is the most widely used standardized outcome measure for rehabilitation in the world [22]. FIM can be used freely, without additional payment in medical research conditions. FIM was widely applied to evaluate participation after stroke [22]. The FIM items are broadly classified into total, motor and cognitive categories (FIM, 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 task (7 = totally independent and 1 = totally dependent or not testable).

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. Multiple regression analysis was applied to determine factors that influenced FIM at admission and FIM gain at dischage. 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.

Table2. Data of patients at admission and their gains at discharge

Data at admission	Mean ± S.D.	Data at discharge	Mean ± S.D.
Calorie intake at admission (Kcal/day)	1,326 ± 322	Calorie intake at discharge (Kcal/day)	1,448 ± 273
		Calorie intake gain (Kcal/day)	122 ± 245
Calorie intake/ Kg at admission (Kcal/kg/day)	24.7 ± 6.2	Calorie intake per kg at discharge (Kcal/kg/day)	27.2 ± 5.0
		Calorie intake gain per Kg (Kcal/kg/day)	2.5 ± 4.7
Protein intake at admission (g/day)	49.2 ± 12.4	Protein intake at discharge (g/day)	54.0 ± 10.3
		Protein intake gain (g/day)	4.8 ± 9.7
Protein intake /Kg at admission (g/kg/day)	0.92 ± 0.24	Protein intake per Kg at discharge (g/kg/day)	1.02 ± 0.19
		Protein intake gain per Kg (g/kg/day)	0.10 ± 0.19
Body weight (kg)	54.78 ± 10.93	Body weight gain (kg)	- 0.65 ± 2.44
BMI (kg/m^2)	22.15 ± 3.51	BMI gain (kg/m^2)	- 0.25 ± 1.0
Hb (g/dL)	12.88 ± 1.75	Hb gain(g/dL)	- 0.51 ± 1.22
TP (g/dL)	6.94 ± 0.56	TP gain (g/dL)	- 0.25 ± 0.63
Alb (g/dL)	3.72 ± 0.57	Alb gain (g/dL)	- 0.05 ± 0.46
Peripheral blood lymphocyte (cells/mm^3)	1328 ± 597	Peripheral blood lymphocyte gain (cells/mm^3)	238 ± 482
Prognostic nutritional index (PNI)	43.92 ± 6.87	PNI gain	0.62 ± 5.27
Geriatric Nutritional Risk Index (GNRI)	97.41 ± 11.67	GNRI gain	-1.28 ± 7.50
FOIS at admission	5.0 ± 1.7	FOIS at discharge	5.8 ± 1.6
		FOIS gain	0.77 ± 1.43

3. Results

Nutritional and swallowing data of patients at admission, at discharge and their gains at discharge were presented in Table 2. Average daily calorie intakes were 1,326 ± 322 (Kcal/day) at admission and 1,448 ± 273 (Kcal/day) at discharge, resulting average daily calorie intake gain at discharge was 122 ± 245 (Kcal/day). Average daily calorie intake per kg were 24.7 ± 6.2 (Kcal/kg/day) at admission and 27.2 ± 5.0 (Kcal/kg/day) at discharge, resulting average daily calorie intake gain per kg at discharge was 2.5 ± 4.7 (Kcal/kg/day). Average daily protein intakes were 49.2 ± 12.4 (g/day) at admission and 54.0 ± 10.3 (g/day) at discharge, resulting average daily protein intake gain at discharge was 4.8 ± 9.7 (g/day). Average daily protein intake per kg were 0.92 ± 0.24 (g/Kg/day) at admission and 1.02 ± 0.19 (g/Kg/day) at discharge, resulting average daily protein intake gain per kg was 0.10 ± 0.19 (g/Kg/day). Mean scores of FOIS were 5.0 ± 1.7 at admission and 5.8 ± 1.6 at discharge, resulting FOIS gain at discharge was 0.77 ± 1.43.

However, mean score of weight gain at dischage was - 0.65 ± 2.44 (Kg). Mean score of BMI gain at dischage was - 0.25 ± 1.0 (kg/m^2). Mean score of Hb gain at dischage was - 0.51 ± 1.22 (g/dL). Mean score of TP gain at dischage was - 0.25 ± 0.63 (g/dL). Mean score of Alb gain at dischage was - 0.05 ± 0.46 (g/dL). Despite nutritional management, the patients' body weight, BMI, Hb, TP, and Alb at discharge were the same as or slightly lower than those at admission.

According to the GLIM criteria, the FIM score at admission of the 110 patients with no malnutrition was 76.7±28.3, which was significantly higher than the scores of 51.6±21.3 of the 40 patients with moderate malnutrition ($p<0.0001$) and 49.4±21.3 of the 50 patients with severe malnutrition ($p<0.0001$)(Figure 1). The FIM gain for the patients

with no malnutrition was 20.7±14.0, which tended to be lower than 25.7±15.6 for the patients with moderate malnutrition and 25.9±21.8 for the patients with severe malnutrition. The FIM score at discharge for the patients with no malnutrition was

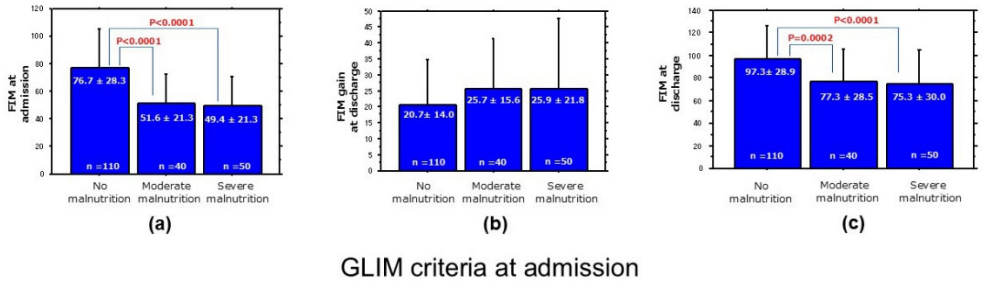

Figure 1. Correlations between GLIM criteria at admission and FIM at admission (a), FIM gain at discharge (b), FIM at discharge (c)

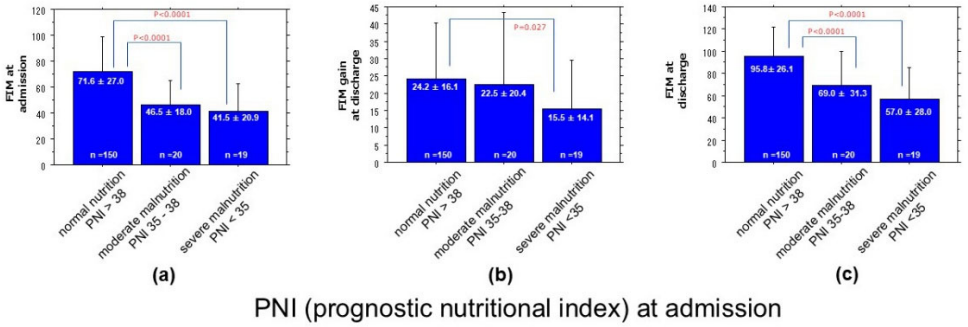

Figure 2. Correlations between PNI (prognostic nutritional index) and FIM at admission (a), FIM gain at discharge (b), FIM at discharge (c)

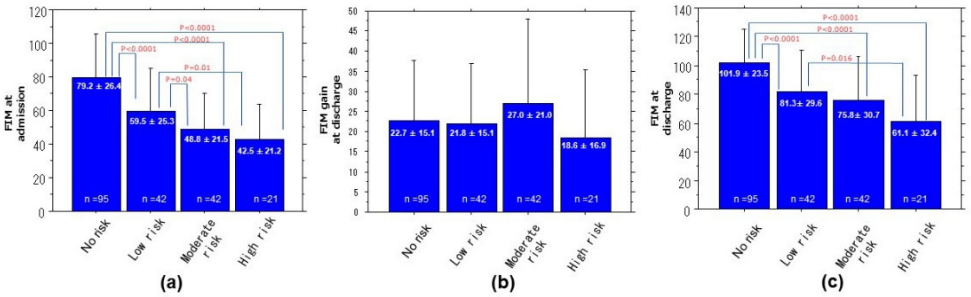

Figure 3. Correlations between GNRI (Geriatric Nutritional Risk Index) at admission and FIM at admission (a), FIM gain at discharge (b), FIM at discharge (c)

97.3±28.9, which was significantly higher than 77.3±28.5 for the patients with moderate malnutrition (p=0.0002) and 75.3±30.0 for the patients with severe malnutrition (p<0.0001).

PNI scores were analyzed in 189 patients because 11 patients had missing data. According to PNI score at admission, the FIM score at admission of the 150 patients of normal nutrition (PNI>38) was 71.6±27.0, which was significantly higher than the scores of 46.5±18.0 of the 20 patients with moderate malnutrition (PNI 35-38) (p<0.0001) and 41.5±20.9 of the 19 patients with severe malnutrition (PNI <35) (p<0.0001) (Figure 2). The FIM gain at discharge for the patients with no malnutrition (PNI>38) was 24.2±16.1, which tended to be higher than 22.5±20.4 for the patients with moderate malnutrition (PNI 35-38) and was significantly higher than 15.5±14.1 for the patients with severe malnutrition (PNI <35) (p=0.027). The FIM score at discharge for the patients with no malnutrition (PNI>38) was 95.8±26.1, which was significantly higher than 69.0±31.3 for the patients with moderate malnutrition (PNI 35-38) (p<0.0001) and 57.0±28.0 for the patients with severe malnutrition (PNI <35) (p<0.0001).

According to GNRI score at admission, the FIM score at admission of the 95 patients of no nutritional risk (GNRI ≥98) was 79.2±26.4, which was significantly higher than the scores of 59.5±25.3 of the 42 patients with low nutritional risk (92 ≤ GNRI <98) ($p<0.0001$), 48.8±21.5 of the 42 patients with moderate nutritional risk (82 ≤ GNRI <92) ($p<0.0001$), and 42.5±21.2 of the 21 patients with high nutritional risk (GNRI <82). (Figure 3). The FIM gains at discharge was 22.7±15.1 for the patients with no nutritional risk (GNRI ≥98), 21.8±15.1 for the patients with low nutritional risk (92 ≤ GNRI <98), 27.0±21.0 for the patients with moderate nutritional risk (82 ≤ GNRI <92) and 18.6±16.9 for the patients with high nutritional risk (GNRI <82). The FIM score at discharge for the patients with no nutritional risk (GNRI ≥98) was 101.9±23.5, which was significantly higher than 81.3±29.6 for the patients with low nutritional risk (92 ≤ GNRI <98) ($p<0.0001$), 75.8±30.7 for the patients with moderate nutritional risk (82 ≤ GNRI <92) ($p<0.0001$) and 61.1±32.4 for the patients with high nutritional risk (GNRI <82) ($p<0.0001$).

According to Wakabayashi's malnutrition, the FIM score at admission of the 95 patients with no malnutrition was 69.8±31.1, which was significantly higher than the scores of 60.2±25.4 of the 105 patients with malnutrition ($p=0.0182$). The FIM gain for the patients with no malnutrition was 22.1±17.8, which tended to be lower than 23.7±15.8 for the patients with malnutrition. The FIM score at discharge for the patients with no malnutrition was 91.9±31.4, which was tended to be higher than 84.0±30.1 for the patients with malnutrition.

The more FOIS Level at admission increased, the more FIM at admission increased (Figure 4): FIM scores at admission were 23.5±6.1 at FOIS Level 1 (n=15), 31.8±14.4 at FOIS Level 2 (n=5), 53.3±26.5 at FOIS Level 3 (n=10), 50.2±17.8 at FOIS Level 4 (n=13), 59.1±20.3 at FOIS Level 5 (n=95), 76.1±32.8 at FOIS Level 6 (n=11), and 94.6±17.9 at FOIS Level 7 (n=51). FIM gains at discharge were 18.0±22.7 at FOIS Level 1, 37.6±37.1 at FOIS Level 2, 26.1±17.8 at FOIS Level 3, 31.5±18.8 at FOIS Level 4, 24.0±15.7 at FOIS Level 5, 22.8±20.8 at FOIS Level 6, and 18.3±9.4 at FOIS Level 7. The more FOIS Level gain at discharge increased, the more FIM gain at discharge increased: FIM gains at discharge were 10.5±13.4 at -4 FOIS Level (n=2), 2.0 at -3 FOIS Level (n=1), 43.7±14.6 at -2 FOIS Level (n=3), 9.0±7.6 at -1 FOIS Level (n=3), 17.1±12.3 at same FOIS Level (n=111), 27.9±18.9 at +1 FOIS Level (n=17), 31.4±15.9 at +2 FOIS Level (n=48), 40.4±31.3 at +3 FOIS Level (n=5), 21.7±17.1 at +4 FOIS Level (n=6), 51.5±23.3 at +5 FOIS Level (n=2), and 47.0±11.3 at +6 FOIS Level (n=2).

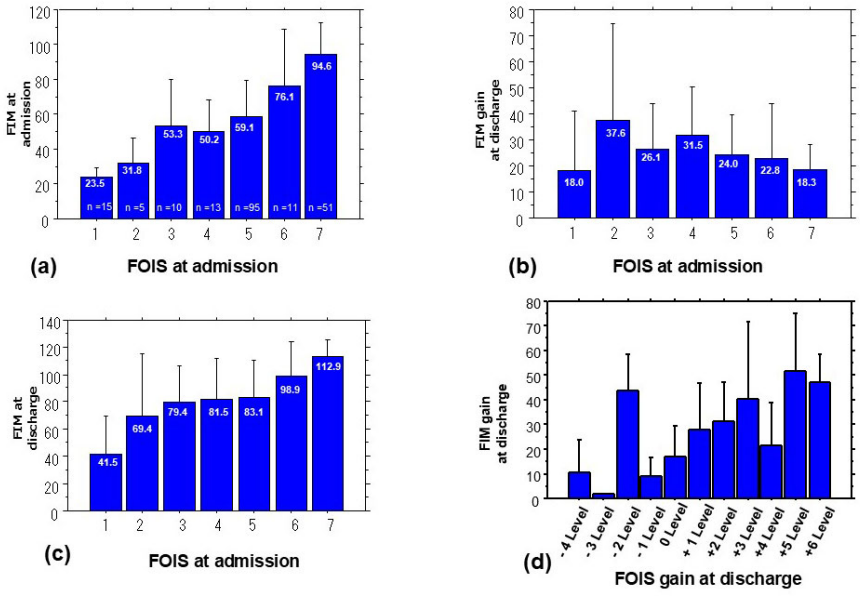

Figure 4 Correlations between FOIS (functional oral intake scale) and FIM: (a) FOIS at admission and FIM at admission, (b) FOIS at admission and FIM gain at discharge, (c) FOIS at admission and FIM at discharge, (d) FOIS gain at discharge and FIM gain at discharge

Multiple regression analysis determined that significant factors which influenced FIM at admission were FOIS (p<0.0001), albumin (p<0.0001) and body weight (p=0.0293) (Table 3). When checking correlation coefficients of these significant factors with FIM at admission, the correlation coefficient of FOIS was 0.693, that of albumin was 0.594, and that of body weight was 0.184 (Figure 5).

Multiple regression analysis also determined that significant factors which influenced FIM gain at discharge were albumin gain (p=0.0024), protein intake gain (p=0.004), protein intake gain per kg (p=0.0063), calorie intake gain per kg (p=0.0076), calorie intake gain (p=0.0082), and FOIS gain (p=0.0134)(Table 4). When checking correlation coefficients of these significant factors with FIM gain at discharge, the correlation coefficient of albumin gain was 0.359, that of protein intake gain was 0.210, that of protein intake gain / kg was 0.207, that of calorie intake gain /kg was 0.197, that of calorie intake gain was 0.184, and that of FOIS gain was 0.371 (Figure 6).

Table 3. Multiple regression analysis for FIM at admission

Factor	Unit	Regression coefficient	Standard deviation	Standard regression coefficient	P value
FOIS at admission	Level	8.613	0.915	0.5	<0.0001
Albumin at admission	g/dL	16.669	3.351	0.343	<0.0001
Body weight at admission	Kg	-1.022	0.465	-0.406	0.0293
Peripheral blood lymphocyte at admission	cells/mm^3	0.004	0.002	0.084	0.0852
Hemoglobin at admission	g/dL	-0.568	0.941	-0.603	0.547
Calorie intake at admission	Kcal/day	0.035	0.075	0.402	0.6474
Protein intake per Kg at admission	g/kg/day	-34.408	91.589	-0.297	0.7076
Protein intake at admission	g/day	-508	1.977	0.228	0.7976
Calorie intake per Kgat admission	Kcal/kg/day	-0.711	3.515	-0.158	0.8398
BMI at admission	kg/m^2	0.055	0.612	0.007	0.9281
Total protein at admission	g/dL	0.028	2.947	0.001	0.9923

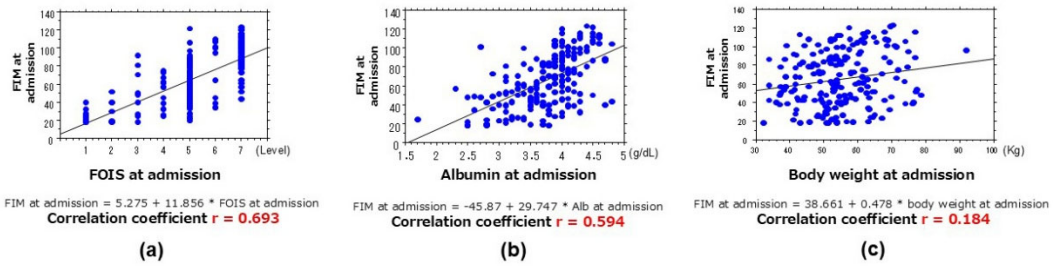

Figure 5. Correlations between FIM at admission and FOIS Level at admission (a), Albumin at admission (b), Body weight at admission (c)

Table 4. Multiple regression analysis for FIM gain

Factor	Unit	Regression coefficient	Standard deviation	Standard regression coefficient	P value
Albumin gain	g/dL	21.578	6.907	0.553	0.0024
Protein intake gain	g/day	8.456	2.862	5.064	0.004
Protein intake gain per Kg	g/kg/day	-376.92	134.565	-4.497	0.0063
Calorie intake gain per Kg	Kcal/kg/day	14.312	5.234	4.248	0.0076
Calorie intake gain	Kcal/day	-0.3	0.111	-4.595	0.0082
FOIS gain	Level	3.269	1.295	0.307	0.0134
Protein intake at admission	g/day	4.034	3.018	2.723	0.1849
Protein intake per Kg at admission	g/kg/day	-178.59	136.885	-2.525	0.1955
Peripheral blood lymphocyte gain	cells/mm^3	-0.004	0.003	-0.11	0.2344
Calorie intake per Kg at admission	Kcal/Kg/day	5.735	4.931	2.074	0.248
Calorie intake at admission	Kcal/day	-0.119	0.106	-1.981	0.2681
Hemoglobin gain	g/dL	-2.022	1.829	-0.14	0.2722
Peripheral blood lymphocyte at admission	cells/mm^3	-0.003	0.003	-0.085	0.3913
FOIS at admission	Level	1.014	1.482	0.094	0.4958
Total protein gain	g/dL	-3.245	5.15	-0.116	0.5302
Body weight at admission	Kg	-0.644	1.065	-0.387	0.5469
Albumin at admission	g/dL	2.091	4.196	0.072	0.6195
Total protein at admission	g/dL	1.819	3.694	0.061	0.6237
BMI gain	kg/m^2	-3.487	12.124	-0.226	0.7744
Body weight gain	Kg	1.244	5.152	0.194	0.8098
Hemoglobin at admission	g/dL	0.313	1.353	0.029	0.8173
BMI at admission	kg/m^2	0.201	0.912	0.043	0.8264

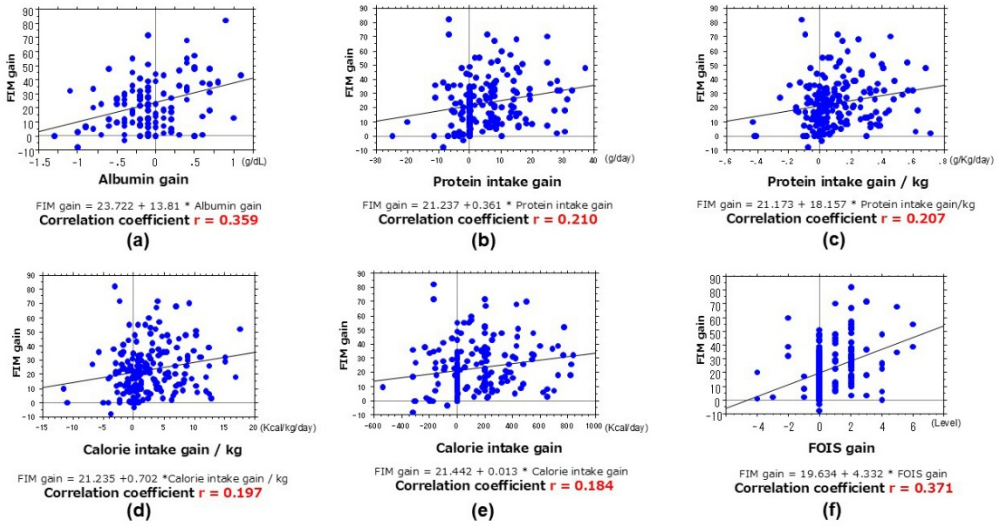

Figure 6. Correlations between FIM gain at discharge and Albumin gain (a), Protein intake gain (b), Protein intake gain per kg (c), Calorie intake gain per kg (d), Calorie intake gain (e), FOIS gain (f)

4. Discussion

It goes without saying that improving nutritional status and swallowing function are important to increase the effectiveness of rehabilitation treatment, but it is also extremely important to know which items to focus on and how to improve them. After a correct diagnosis of malnutrition at admission in a rehabilitation center, it is significant to appropriately track stroke patients' nutritional status during the rehabilitation period by regularly monitoring their dietary intake. In fact, this procedure allows us to detect nutritional deficiencies, to evaluate the risk of a patient's nutritional status, and to start or track the effectiveness of nutrition care plans [23].

GLIM criteria, PNI criteria, GNRI criteria and Wakabayashi malnutrition criteria for nutrition

GLIM criteria, PNI criteria, GNRI criteria and Wakabayashi malnutrition criteria were all indicated that patients with no malnutrition kept higher FIM at admission and higher FIM at discharge than the other groups. PNI and GNRI contains serum Alb evaluation, but on the other hand GLIM did not contain serum Alb evaluation. PNI or GNRI scores are easily obtained from laboratory data and can be used instead of GLIM, which is obtained in a more complicated way. In this study, serum Alb is revealed to be the most important factor for the nutrition of patients with cerebrovascular diseases.

Malnutrition with the GLIM criteria is negatively associated with ADL and is also associated with discharge destination in patients with acute stroke [24]. The GLIM criteria effectively assess malnutrition and predicts 30-day mortality in patients with severe stroke [25]. Identifying malnutrition using the GLIM criteria is useful for predicting the recovery of activities of daily living in older patients with post-acute stroke [26]. Multivariate linear regression analyses showed that malnutrition diagnosed using the GLIM criteria was predictive of the FIM-motor score at discharge ($\beta = -0.347$, $P < 0.001$) [26]. Most patients with post-stroke cognitive impairment (PSCI) were malnourished; malnutrition on admission for rehabilitation was associated with poor improvement after PSCI [27]. Malnutrition and reduced muscle mass, diagnosed using the GLIM criteria in patients with stroke undergoing convalescent rehabilitation, were found to suppress the improvement of depression symptoms [28]. Malnutrition assessed with the GLIM criteria at admission and food consumption are two important nutritional parameters to evaluate in post-stroke patients hospitalized for rehabilitation due to their association with recovery [29]. Results of multiple logistic regression showed that the risk of depression [OR 4.18, $p<0.001$], peptic ulcer disease [OR 2.73, $p<0.001$], past stroke [OR 1.71, $p<0.001$], cognitive impairment [OR 1.34, $p = 0.015$], and chronic pain [OR 1.23, $p = 0.046$] were independent correlates of malnutrition [30]. Those with GLIM-defined undernutrition had high NIHSS scores [31]. These reports are consistent with our data, which showed that malnourished patients have poor FIM scores on admission and also at discharge.

As an assessment tool for preoperative nutritional status, the PNI serves as an independent risk factor for adverse perioperative outcomes [17]. PNI, calculated from serum albumin concentration and peripheral blood lymphocyte count, serves as a simple yet effective marker of nutritional status, inflammatory activity, and overall prognosis [16]. Unlike other screening tools, PNI is readily available from routine preoperative laboratory tests. To date, PNI has been widely used to evaluate prognosis and disease progression in oncology [33,34] as well as cardiovascular disease [34,35]. Multiple regression analysis revealed that GLIM-defined undernutrition ($\beta = 0.136$, $p = 0.002$), risk of undernutrition according to the Mini Nutritional Assessment Short Form ($\beta = 0.160$, $p < 0.001$), and risk of undernutrition according to GNRI ($\beta = 0.081$, $p = 0.043$) were independently associated with increased NIHSS scores [31]. Severe malnutrition was associated with poorer functional outcome as expressed by FIM motor effectiveness [17].

Swallowing function for rehabilitation of cerebrovascular Diseases

FOIS at admission and FOIS gain at discharge was revealed to be important for improving FIM at admission and FIM gain at discharge. We realized improving swallowing function would be essential for improving nutritional status of patients, furthermore, combined improving of swallowing and nutritional condition of patients would lead to improve patient independence. In patients with oropharyngeal dysphagia after stroke, malnutrition at admission inversely affected their swallowing ability at discharge [36]. Dysphagia rehabilitation, including early nutritional intervention, may be effective in the recovery of swallowing ability [36]. The primary factors contributing to complete oral intake in dysphagic stroke patients with enteral feeding tubes were younger age, initial

stroke, higher swallowing and cognitive function, good nutritional status, and shorter stay in the acute care ward [37].

Multiple regression analysis for factors contributing to FIM at admission and to FIM gain at discharge

FOIS ($p<0.0001$) and serum albumin ($p<0.0001$) significantly influenced FIM at admission and the third influencing factor was body weight at admission ($p=0.0293$). It is predictable to calculate FIM at admission by FOIS and albumin at admission. Albumin gain ($p=0.0024$), protein intake gain ($p=0.004$), protein intake gain per kg ($p=0.0063$), calorie intake gain per kg ($p=0.0076$), calorie intake gain ($p=0.0082$), and FOIS gain ($p=0.0134$) significantly influenced FIM gain at discharge. For improving FIM gain at discharge, it would be good to improve albumin, protein intake, calorie intake and FOIS.

Nutritional management in cerebrovascular rehabilitation

In our patient series, average daily calorie intakes were 1,326 ± 322 Kcal at admission and 1,448 ± 273 Kcal/day at discharge, meaning calorie intake gain was 122 ± 245 Kcal/day. Average calorie intakes /kg were 24.7 ± 6.2 Kcal/Kg/day at admission and 27.2 ± 5.0 Kcal/Kg/day at discharge, meaning calorie intake gain/ kg was 2.5 ± 4.7 Kcal/Kg/day. Average daily protein intakes / kg were 0.92 ± 0.24 g/Kg/day at admission and 1.02 ± 0.19 g/Kg/day at discharge, meaning protein intake gain/kg was 0.10 ± 0.19 g/Kg. It was possible that they were not getting enough calories or protein, because despite nutritional management, the patients' body weight, BMI, Hb, TP, and Alb at discharge were the same as or slightly lower than those at admission. This analysis revealed that, despite our efforts to manage nutrition in cerebrovascular rehabilitation, the intake of protein and calorie remained low, which was a disappointing outcome. Because we included patients who were unable to obtain sufficient nutrition and calories in our analysis, The results of the average calorie and protein intake of all patients was low. Average calorie intake / kg for patients would be recommended to be 30 Kcal/Kg and average protein intake /kg/day to be 1.2 to 1.5 g/Kg/day. For improving brain injury patients' ADL, we should restore patients' swallowing function and supply patients more calorie intake and more protein intake.

In the literature, the following reports are available. High energy intake was associated with higher FIM efficiency and nutritional status improvement at discharge among convalescent stroke patients [38]. Supplementary essential amino acids may reduce the occurrence of nosocomial infections in rehabilitation patients with brain injury [39]. Intensive nutritional supplementation improves motor recovery in previously undernourished patients receiving intensive in-patient rehabilitation after stroke [40]. There was a trend to lower mortality at 3 months in the supplemented group with two deaths (10%) compared with seven deaths (35%) in the control group ($p= 0.127$, relative risk 0.29) [41]. Early enteral nutrition support improves the short-term prognosis of acute stroke patients with dysphagia [42]. Individualized, nutritional treatment strategy can prevent clinically significant weight loss and improve QOL in elderly acute stroke patients at nutritional risk [43].

Study limitations I have to keep in mind that the research has five limitations. First, it was a retrospective research and was conducted at a single institution. Second, the number of patients with cerebrovascular diseases were limited to only 200. In the research, we intended to register all the patients with cerebrovascular diseases who were older than 20 yrs and were treated in the full-time treatment program of rehabilitation 7 days/wk from May 2021 to February 2023 to get a complete picture of patients undergoing rehabilitation. At the result it was found that the number of patients was low in some etiologies. A negative is the limited number of patients in some etiologies. For a more accurate assessment, additional patients with cerebrovascular diseases and more extended follow-up studies

are necessary. Third, this study did not have a control group. In private convalecent hospitals, it is rather difficult to add a control group with cerebrovascular diseases for comparison to a study group. In the control group patients cannot get rehabilitation. Most patients with cerebrovascular diseases want to get rehabilitation because there is evidence of the efficacy of this treatment. Forth, after discharge from our hospital, most patients underwent follow-up observation at their family doctors, while others were admitted to other hospitals or nursing homes. Long term outcomes of rehabilitation for cerebrovascular diseases are not clear yet, so we have work with their home doctors, hospitals and nursing homes, and evaluate the long-term outcomes. Fifth, 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

Although calorie intake gain, protein intake gain were increased, and swallowing ability were increased, the patients' body weight, BMI, Hb, TP, and Alb at discharge were the same as or slightly lower than those at admission. GLIM criteria, PNI criteria, GNRI criteria and Wakabayashi malnutrition criteria were all indicated that patients with no malnutrition kept higher FIM at admission and higher FIM at discharge than the other groups. The more FOIS Level at admission increased, the more FIM at admission increased. Multiple regression analysis determined that FOIS, serum albumin and body weight at admission significantly influenced FIM at admission. Also, albumin gain, protein intake gain, protein intake gain per kg, calorie intake gain per kg, calorie intake gain, and FOIS Level gain significanly influenced FIM gain at discharge.

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

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