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Effectiveness of Family-Engaged Multidimensional Team Planning and Management for Recovery in Patients With Severe Stroke and Low Functional Status

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Objective To evaluate the effectiveness of family-engaged multidimensional team planning and management for patients with severe stroke and low functional status and to identify factors predictive of improved outcome at 1 month after admission.
Methods We retrospectively evaluated 50 patients who underwent family-engaged multidimensional rehabilitation for recovery from severe stroke due to primary unilateral cerebral lesions. The rehabilitation consisted of three phases: comprehensive multidimensional assessment, intensive rehabilitation, and evaluation. Functional Independence Measure (FIM) scores were calculated and used to predict the patients' status at discharge.
Results Although all FIM scores significantly improved after 1 month of rehabilitation, the motor FIM (mFIM) score improved the most (from 20.5±1.0 to 32.6±2.0). The total FIM (tFIM) and mFIM scores continued to improve from the first month to discharge (mean mFIM efficiency, 0.33). The high-efficiency patient group (mFIM efficiency ≥0.19) had a significantly higher discharge-to-home rate (44% vs. 13%), lower frequency of hemispatial neglect, and more severe finger numbness than the low-efficiency patient group (mFIM efficiency <0.19). The regression analyses revealed that besides lower mFIM and cognitive FIM scores at admission, unilateral spatial neglect, systemic comorbidities, and age were predictive of worse 1-month outcomes and tFIM scores (conformity, R^2=0.78; predictive power, Akaike information criterion value=202).
Conclusion Family-engaged multidimensional team planning and management are useful for patients with severe stroke and low functional status. Furthermore, FIM scores at admission, age, unilateral spatial neglect, and systemic comorbidities should be considered by rehabilitation teams when advising caregivers on the probability of favorable outcomes after rehabilitation.

Keywords Stroke, Cerebrovascular disorders, Symptom assessment, Rehabilitation, Dependency

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INTRODUCTION

Stroke is a major cause of physical and mental disabilities worldwide and is becoming an increasingly important problem in Japan because of the continuously increasing elderly population [1]. Stroke in the elderly is typically severe because it is often complicated by preexisting chronic and degenerative diseases and associated comorbidities that adversely affect the outcome [2,3]. In addition, difficulties in performing activities of daily living (ADL) and psychological adjustments on discharge to home limit the effectiveness of rehabilitation strategies in these patients [3-5]. Patients with severe stroke are particularly known to have delayed recovery and poor outcomes after rehabilitation [6-8], resulting in prolonged hospitalization and high healthcare costs. Early recovery and discharge are of critical importance in Japan, where the current healthcare system requires patients with stroke to be discharged from the acute-phase hospital and transferred to a convalescent rehabilitation ward within 2 months of stroke onset, and then discharged from the convalescent rehabilitation ward within 6 months of stroke onset.

Therefore, recovery-stage rehabilitation for patients with stroke is designed to facilitate early return to independent living, and use of convalescent rehabilitation wards is encouraged to predict prognosis and quality of life after hospital discharge. Several studies have shown that early discharge is associated with favorable long-term outcomes in patients with stroke [9-14]. Hence, rehabilitation strategies are often designed to improve early-phase functional recovery and promote early hospital discharge [11]. Some of the drawbacks of classical, comprehensive rehabilitation are as follows: the patient's family and lifestyle are not considered; the patient plays only a passive role; and the strategies are not tailored according to the individual patient's needs. A previously proposed family-engaged multidimensional rehabilitation strategy with a team-based approach for elderly patients with stroke is more advanced than the standard goal-oriented, team-based comprehensive strategy because it uses multiple perspectives to determine a path to recovery and improvement for each patient [13]. It allows patients and their families to actively participate in the decision making for goal setting and to contribute to the course of action. Furthermore, the short-term goals are set to 1 month, whereas classical rehabilitation involves both short- and long-term goals. As rehabilitation in the current rapidly aging society is functionally differentiated, reexamination of the traditional holistic approaches to rehabilitation is crucial. Interventions selected in clinical settings should be flexible and situation dependent, and should consider the varied and complex problems of patients. Therapy should focus on the recovery and improvement of physical and mental functions, and on motivating patients to become more active. The family-engaged multidimensional approach has shown promise by identifying specific rehabilitation needs in a diverse and complex patient population, while simultaneously allowing for individualized rehabilitation strategies specific to the needs of each patient.

Although earlier supported discharge services have been shown to reduce hospital stay, long-term dependency, and admission into institutional care in patients with stroke, the greatest benefits were observed in patients with mild or moderate disability [10,12]. We expect that the implementation of this family-engaged multidimensional strategy will improve rehabilitation outcomes in patients with severe stroke, as these patients are subjects of the greatest concern of rehabilitation teams and hospital administrators. The goals of this study were (1) to develop and evaluate the effectiveness of family-engaged multidimensional team planning and management in patients with severe stroke and low functional status, and (2) to identify factors predictive of improved outcome at 1 month after admission in patients with severe stroke.

MATERIALS AND METHODS

Patients

Patients with brain injury admitted to a convalescent rehabilitation ward (Kurashiki, Japan) who underwent team management assessment between April 2012 and December 2016 were retrospectively reviewed (Fig. 1). The inclusion criteria were as follows: (1) only primary unilateral cerebral lesions, including cases of infarction and hemorrhage; (2) independent prestroke ADL status (modified Rankin Scale [mRS] score <2) [15]; and (3) comprehensive written informed consent according to our institutional ethical procedures. The exclusion criteria were as follows: (1) prior stroke; (2) bilateral cerebral

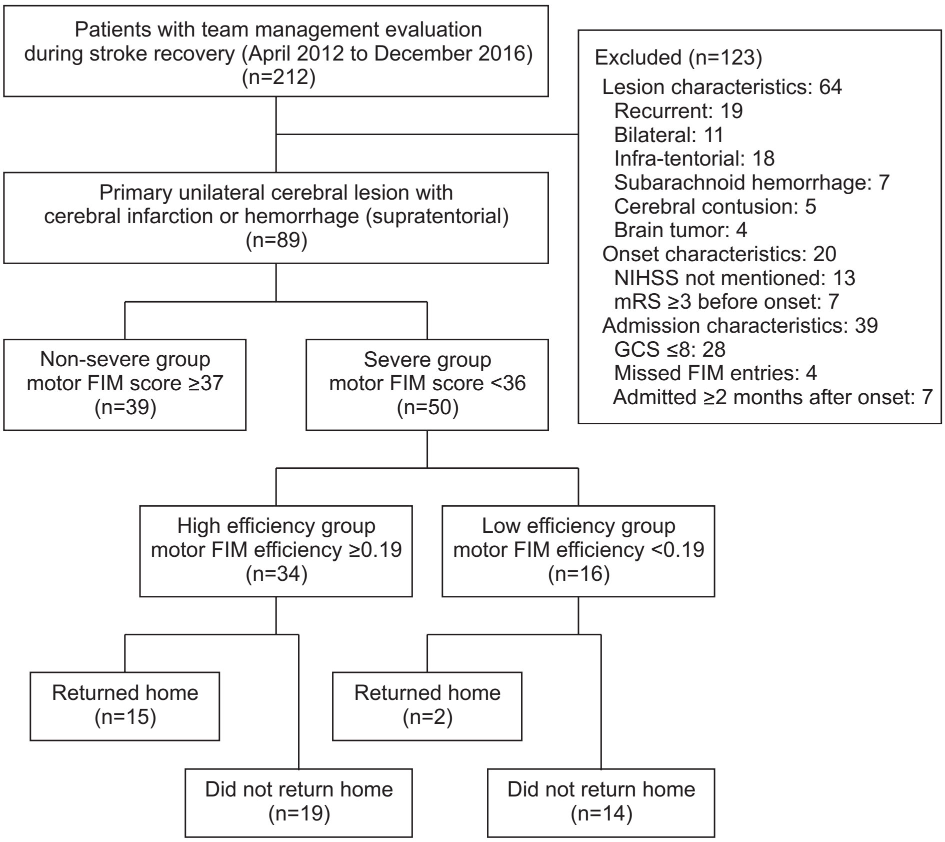

Fig. 1. Flow diagram showing the recruitment process (inclusion and exclusion criteria) and the classification of patients into study groups.

lesions, infratentorial stroke lesions, subarachnoid hemorrhage, cerebral contusion, or brain tumors; (3) time from onset to admission of >2 months; (4) low stroke severity, with a motor Functional Independence Measure (FIM) score of >36; (5) dependent prestroke ADL status (mRS score ≥3); (6) Glasgow Coma Scale score of >8 at admission; and (7) unrecorded FIM, National Institutes of Health Stroke Scale, or Hasegawa Dementia Scale-Revised score at admission. Patients with prior stroke were excluded through the examination of fluid-attenuated inversion recovery sequences on magnetic resonance imaging. This study was approved by the Ethical Committee of Kibi International University (No. 11-23).

Family-engaged multidisciplinary team planning and management

The rehabilitation approach is described in Table 1. In phase I (week 1), a comprehensive multidimensional assessment was performed [13,16]. On the day of admission to the convalescent rehabilitation ward, a team consisting of rehabilitation specialists, the patient, and the patient's family assessed the clinical, functional impairment, psychological, and environmental aspects, and recorded the following patient characteristics: (1) basic attributes, including the prestroke living situation (premorbid ADL status); (2) clinical features related to the stroke; and (3) functional impairment status (Table 1). On the 3rd day of admission, the initial FIM score was measured, and a case conference was held to define the intervention methods and goals with the aim of promoting positive outcome expectancies. The case conference was attended by the patient's neurosurgical attending physician, the chief nurse, the lead author, therapists (physical, occupational, and speech therapists), and the patient's family in the early phase of admission [17]. On the basis of the multidimensional assessment, intervention points were identified in specific areas of ADLs that were expected to be improved by preferential and early interventions [13,16]. The intervention points were selected from 13 items in the motor FIM (mFIM) subscale, and targeted transfer, locomotion, self-care, and sphincter control. One-month goals were then set for all the intervention points.

In phase II (weeks 2–4), intensive rehabilitation was

Table 1. Process of family-engaged multidisciplinary team management for stroke patients in a convalescent rehabilitation ward

Phase I: week 0–1	Phase II: weeks 2–4	Phase III: end of week 4
Four aspects from joint assessments	Organized team management	Process assessment
Clinical features	Monitoring of intervention points	One-month outcome assessments
Functional impairment features	Optimal, individualized rehabilitation for recovery	Assistance for early discharge
Psychological aspects	Cooperation with hospital ward and adjustment of the environment	Projection of early discharge
Environmental aspects	Participation and instruction of family	
Four steps of intervention	Confirm possibility of reaching goals	
Confirmation of information and search for functions that can be brought back		
Observation of motions that can be performed and training tasks		
Examination of intervention points and goal setting		
Examination of outcomes that can be realistically expected		

provided on the basis of the defined intervention goals. Rehabilitation delivery and recovery were closely monitored. Incremental improvements in ADLs were recorded to predict the probability of achieving the desired treatment goals.

In phase III (end of week 4), the 1-month FIM score was calculated and used to predict the patient status at discharge by using statistical methods.

Outcome analysis

On the basis of the mFIM score (range, 13–91) at admission, the patients were classified into a severe stroke group (mFIM score <36) and a non-severe stroke group (mFIM score ≥37) [6]. The 1-month changes in total FIM (tFIM), mFIM, and cognitive FIM (cFIM) scores were calculated to evaluate the effect of the rehabilitation strategy. The severe stroke group was subdivided according to mFIM efficiency (change in mFIM scores per day), into a high-efficiency group (mFIM efficiency ≥0.19) and a low-efficiency group (mFIM efficiency <0.19) [18]. The differences in patient characteristics at admission, number of hospitalization days, and discharge destination were compared between the high- and low-efficiency groups. The patients were discharged to their homes or to residential/long-term nursing care facilities, or transferred to another hospital or ward [19].

Prediction of patient status at discharge

A backward stepwise regression analysis of the tFIM, mFIM, and cFIM scores at 1 month after admission was performed to determine the predictive ability of independent variables (patient characteristics at admission) [20,21]. The independent variables were chosen on the basis of earlier studies [21-23] that showed the influence of the variables on rehabilitation outcomes in patients with stroke. They included basic patient attributes (age, sex, and prestroke living situation), clinical features related to the stroke (stroke type, initial stroke severity, onset-to-admission interval, presence or absence of osteoarthritis, and systemic comorbidities), and functional impairment features at admission (unilateral spatial neglect, dementia, and mFIM, and cFIM scores at admission).

Statistical analysis

Data were analyzed using SPSS version 22 (IBM Corp., Armonk, NY, USA) and R version 2.8.1 (R Development Core Team 2008; R Foundation for Statistical Computing, Vienna, Austria), and significance was set at $p<0.001$. The values of the descriptive statistics are presented as mean±standard error. For comparison of two quantities (mFIM efficiency at 1 month and at discharge), normality was confirmed using the Shapiro-Wilk normality test, and the t-test and Wilcoxon test were performed when appropriate. For comparison of three quantities (FIM score at the time of admission, 1 month after admission, and the time of discharge), normality was confirmed using the Shapiro-Wilk normality test, and the Friedman test or Wilcoxon signed-rank test (with Holm correction for pairwise comparisons) was performed when appropriate. The chi-square test was used to compare the distributions of the numbers of patients, and adjusted R^2 was used to determine the conformity degree of the regression model equation. Furthermore, the Akaike information criterion (AIC) [24,25] was used to determine the predictive power of the variables.

RESULTS

Patients

A total of 212 patients with brain injury were admitted to the convalescent rehabilitation ward and underwent team management assessment (Fig. 1). Of these patients, 89 met the study criteria, with 39 and 50 of them classified into the non-severe and severe stroke groups, respectively. Of the 39 patients in the non-severe stroke group, 34 (87%) returned home after 82±6.4 days of hospitalization, whereas 17 (34%) of the 50 patients in the severe stroke group returned home after 124±9.1 days of hospitalization.

Effect of rehabilitation on the FIM scores

The tFIM, mFIM, and cFIM scores continuously improved in all the patients with severe stroke from admission to discharge (Table 2). In the first month, the tFIM score increased from 35.4±1.8 to 49.1±2.5 (p<0.001), mostly owing to the increase in the mFIM score (from 20.5±1.0 to 32.6±2.0; p<0.001). The increase in the cFIM score from 14.9±1.0 to 16.5±1.0 (p<0.001) over the same period was significant but relatively smaller. The mean mFIM efficiency was 0.40±0.1 in the first month. The tFIM and mFIM scores continued to increase from the first month to discharge, and the mean mFIM efficiency in this period was 0.33.

High- and low-efficiency groups

A total of 34 and 16 patients were classified into the high- and low-efficiency groups, respectively, according to the mean 1-month mFIM efficiency (Tables 3, 4). Although the mFIM score continuously increased from ad-

Table 2. FIM score in patients with severe stroke before and after 1 month of rehabilitation (n=50)

	FIM score					
	At admission		1 month after admission		At discharge	
	Mean±SE	95% CI	Mean±SE	95% CI	Mean±SE	95% CI
Total	35.4±1.8[a,b]	31.9–38.9	49.1±2.5[a]	44.0–54.2	53.8±3.2[b]	47.3–60.2
Cognitive	14.9±1.0[c]	12.9–16.9	16.5±1.0[c]	14.6–18.4	16.8±1.1	14.6–19.0
Motor	20.5±1.0[d,e]	18.4–22.5	32.6±2.0[d]	28.7–36.6	37.0±2.5[e]	32.0–42.0
mFIM efficiency (1-day period)	-	-	0.40±0.1	0.31–0.49	0.13±0.0	0.09–0.18

FIM, Functional Independence Measure; SE, standard error; CI, confidence interval; mFIM, Functional Independence Measure, motor.
Same superscript letters indicate significant differences between the groups (p<0.001).

Table 3. mFIM scores and mFIM efficiency in the high- and low-efficiency groups of patients with severe stroke

	At admission		1 month after admission		At discharge	
	Mean±SE	95% CI	Mean±SE	95% CI	Mean±SE	95% CI
High-efficiency group (n=34)						
mFIM score	22.7±1.2[a]	20.2–25.2	39.7±1.8[a]	30.6–43.4	42.2±3.0[a]	36.2–48.2
mFIM efficiency	-	-	0.56±0.1[b,]**	0.47–0.65	0.16±0.0[b,]*	0.11–0.22
Low-efficiency group (n=16)						
mFIM score	15.7±1.3[c]	13.0–18.4	17.6±1.2[c]	15.0–20.2	26.0±3.3[c]	18.9–33.1
mFIM efficiency	-	-	0.06±0.0**	0.03–0.10	0.07±0.0*	0.02–0.11

mFIM, Functional Independence Measure, motor; SE, standard error; CI, confidence interval.
Same superscript letters indicate significant differences between groups.
*p=0.012, **p<0.001.

Table 4. Comparison of patient characteristics at admission in the high- and low-efficiency groups

	High-efficiency group (n=34)	Low-efficiency group (n=16)	p-value
Basic attributes			
Age[a)] (yr)	78.9±1.7	79.2±3.1	0.918
Sex, male[a)]	17 (50)	8 (50)	1.000
Prestroke living situation[a,b)]			0.318
mRS 0	24	9	
mRS 1–2	10	7	
Clinical features			
Stroke type[a)]			
Hemorrhagic	11 (32)	6 (38)	0.720
Infarction	23 (68)	10 (63)	
Subcortical injury[c)]	19 (56)	11 (69)	0.386
Initial stroke severity[a,d)]	17 (50)	11 (69)	0.213
Brain surgery	6 (18)	5 (31)	0.279
Onset to AI[a)] (days)	30.1±2.1	32.7±3.6	0.519
Osteoarthritis[a)]	12 (35)	6 (38)	0.880
Systemic comorbidities[a)]	23 (68)	13 (82)	0.318
Functional impairment features			
Unilateral spatial neglect[a)]	9 (26)	10 (63)	0.014
Aphasia	13 (38)	7 (44)	0.710
Dysphagia	15 (44)	8 (50)	0.697
Dementia (HDS-R≥20)[a,e)]	14 (uncertain, 3)	8 (uncertain, 1)	0.603
Psychiatric symptoms	5 (14)	2 (13)	0.834
Affected side	Right, 18; left 13; none, 3	Right, 7; left, 9	0.351
Right	18	7	
Left	13	9	
None	3		
Severe paralysis[f)]			
Upper limbs	11 (32)	9 (56)	0.108
Fingers	11 (32)	10 (63)	0.044
Lower limbs	11 (32)	8 (50)	0.230
Sensory disorders	14 (uncertain, 7)	7 (uncertain, 6)	0.286

Values are presented as mean±standard deviation or number (%).
AI, admission interval; mRS, modified Rankin Scale; HDS-R, Hasegawa Dementia Scale-Revised.
[a)]Variables used in the regression analysis.
[b)]Premorbid activity of daily living status: mRS <2, independent; mRS ≥3, not independent.
[c)]Lesion site: supratentorial: subcortical hemorrhage and middle cerebral artery; and infratentorial: thalamus, putamen, and corona radiata.
[d)]Initial stroke severity (early National Institutes of Health Stroke Scale): severe >10.
[e)]HDS-R≥20, dementia.
[f)]Brunnstrom stages I–II: severe.

mission to discharge in both groups (p<0.001) (Table 3), the mFIM efficiency was statistically and significantly higher in the high-efficiency group than in the low-efficiency group over the entire rehabilitation period (p<0.001) (Table 3). The mFIM scores of both groups increased from hospitalization to discharge. The p-values of the repeated measurements and multiple comparisons are shown in Table 3. A unique finding at admission was that the low-efficiency group had significantly higher numbers of patients with unilateral spatial neglect (p=0.014) and severe finger paralysis (p=0.044) than the high-efficiency group, although no significant differences were found in basic patient attributes and clinical features between the high- and low-efficiency groups (Table 4).

Discharge outcomes

The time intervals from admission to discharge in the high- and low-efficiency groups were 121±6.6 and 130±9.3 days, respectively. Fifteen (44%) of the 34 patients in the high-efficiency group and 2 (13%) of the 16 patients in the low-efficiency group were discharged to their homes. Twelve patients (35%) in the high-efficiency group and 11 (69%) in the low-efficiency group were discharged to long-term nursing care facilities, and 7 patients (21%) in the high-efficiency group and 3 (19%) in the low-efficiency group were transferred to another hospital or ward.

Prediction of patient status at discharge

Of the 50 patients with severe stroke, 46 were considered for outcome analysis after excluding 4 patients with undocumented dementia status at admission. Stepwise regression analysis with backward elimination revealed that 5 of the 12 investigated independent variables were predictive of the 1-month FIM scores (Table 5). The mFIM score at admission, cFIM score at admission, unilateral spatial neglect, age, and systemic comorbidities were predictive of the 1-month tFIM scores (conformity, R^2=0.78; predictive power, AIC=202) as follows:

One-month tFIM scores=40.349+(1.193×admission mFIM)+(1.241×admission cFIM)+(-11.400×presence of unilateral spatial neglect)+(-0.329×age)+(-6.124×presence of systemic comorbidities).

Secondary analyses with 1-month mFIM or cFIM scores as dependent variables revealed the following relationships:

One-month mFIM score (conformity, R^2=0.67; predictive power, AIC=196)=32.828+(1.397×admission mFIM)+(-10.230×presence of unilateral spatial neglect)+(-0.318×age).

One-month cFIM score (conformity, R^2=0.91; predictive power, AIC=67)=2.497+(0.923×admission cFIM).

Table 5. Regression analysis (n=46)

Dependent variable	Independent variable	β	B	95% CI	p-value	VIF	Adj. R^2	AIC
tFIM 1 month after admission	Constant (intercept)		40.349				0.78	202.356
	mFIM score at admission	0.49	1.193	0.801–1.585	0.000	1.297		
	cFIM score at admission	0.48	1.241	0.826–1.656	0.000	1.305		
	Unilateral spatial neglect	−0.31	−11.400	16.950–5.850	0.000	1.121		
	Age	−0.17	−0.329	0.612–0.046	0.024	1.127		
	Systemic comorbidities	−0.15	−6.124	11.818–0.430	0.036	1.027		
mFIM 1 month after admission	Constant (intercept)		32.838				0.67	196.410
	mFIM score at admission	0.74	1.397	1.067–1.727	0.000	1.009		
	Unilateral spatial neglect	−0.36	−10.230	15.458–5.001	0.000	1.093		
	Age	−0.22	−0.318	0.584–0.052	0.020	1.093		
cFIM 1 month after admission	Constant (intercept)		2.497				0.91	67.394
	cFIM score at admission	0.96	0.923	0.836–1.010	0.000	1.000		

β, standardized partial regression coefficient; B, regression coefficient; CI, confidence interval; VIF, variance inflation factor; Adj. R^2, adjusted coefficient of determination R^2; AIC, Akaike information criteria; tFIM, mFIM, and cFIM, total, motor, and cognitive Functional Independence Measures, respectively.

All three multiple regression analyses significantly predicted the patient outcomes (p<0.001). Adjusted R^2 values, which demonstrate the extent to which independent variables can explain dependent variables, ranged from 0.67 (for mFIM) to 0.91 (for cFIM). The variance inflation factor for the 5 independent variables ranged from 1.03 to 1.31, demonstrating the absence of collinearity between the variables [4,22]. Furthermore, the predictive power of multiple regression analyses, as shown by the AIC values, was high (AIC=67–202) (Table 5).

DISCUSSION

Patients with severe stroke are of great concern to rehabilitation teams and hospital administrators because of the associated poor outcomes, requirement for long hospital stay and institutional care, and long-term dependency. The needs of elderly patients with stroke are extremely complex and unique. To cope with this complexity, rehabilitation interventions are customized with flexibility considering the various aspects of patient needs. Although the interventions are customized, the complex patient problems can be divided into stroke conditions based on some invariant patterns in rehabilitation intervention. A previous study showed the need to consider not only clinical features but also the multidimensionality of the problems faced by elderly patients with stroke in rehabilitation interventions [13]. The results showed that a family-engaged multidimensional team-based rehabilitation strategy can significantly improve the tFIM, mFIM, and cFIM scores in patients with severe stroke after 1 month of rehabilitation, with a relatively high proportion (44%) of patients in the high-efficiency group returning to their own homes. These results differ from those of several earlier studies that showed little or no improvement in ADL in patients with severe stroke [6,8] or systemic comorbidities [5,26]. Our study highlights the benefits of an approach that combines family-engaged multidimensional team-based assessment with a targeted intensive early rehabilitation strategy in elderly patients with severe stroke, systemic comorbidities, and low ADL status.

In the family-engaged multidimensional team-based rehabilitation strategy, a team of medical professionals worked with individual patients and their families to understand the patient's problem areas from multiple viewpoints, including psychological and environmental aspects and the features of clinical and functional impairment. These joint assessments were instrumental in identifying patient expectations, designing targeted rehabilitation, and monitoring plans [19]. The involvement of the patient and the patient's family was found to be essential to providing efficient rehabilitation that improved the ADL status [11]. For example, we found that in patients with high mFIM efficiency, the intervention points, which were based on joint assessments, were primarily guided by the patients themselves. Unlike in patients with lower mFIM efficiency, the interventions in patients with high mFIM efficiency were largely geared toward creating a relationship with the caregiver and adjusting the environment to reduce the amount of assistance the patients needed. We also observed that demonstrating to a patient's family how aggressive rehabilitation in the first month of admission could lead to functional or ADL status improvements helped them appreciate the significance of rehabilitation. Accordingly, we found that a family-engaged multidimensional team-based rehabilitation strategy is essential for improved outcomes in this critical patient population. As earlier mentioned, early discharge is currently of great importance to the Japanese healthcare system, as it aims to avoid the health-care and economic burden of 'rehabilitation refugees', given that medical insurance covers only a maximum of 6 months of hospitalization [18,19]. The family-engaged multidimensional team-based rehabilitation strategy in this study resulted in a relatively short hospitalization period (82 and 124 days in patients in the non-severe and severe stroke groups, respectively), with a large proportion of patients (87% and 34% in the non-severe and severe stroke groups, respectively) returning home after discharge from the convalescent rehabilitation ward. Patients with high 1-month mFIM efficiency were discharged earlier (121 vs. 130 days) and had a higher discharge-to-home rate (44% vs. 13%) than patients with low 1-month mFIM efficiency. These results show the usefulness of 1-month assessments in predicting post-hospitalization outcomes in patients with severe stroke. However, it should be noted that patients in the low-efficiency group continued to show significant improvements, as evidenced by their mFIM scores after 1 month of rehabilitation, with 69% of them ultimately discharged to residential/long-term nursing care facilities. Patients in the low-efficiency group had significantly more severe clinical features and functional impairment than those in the high-efficiency group; however, the use of individualized intervention points and rehabilitation strategies enabled the attainment of goals and improved outcomes (Supplementary Table S1). In summary, our results show the positive impact of the family-engaged multidimensional team-based rehabilitation strategy on patients with severe stroke and support the strategy of early discharge for high-efficiency patients and continued rehabilitation for low-efficiency patients.

Subgroup analysis based on mFIM efficiency suggested that unilateral spatial neglect and severe finger paralysis were associated with low mFIM efficiency in the first month of rehabilitation. Regression analyses showed that apart from low mFIM and cFIM scores at admission, unilateral spatial neglect, systemic comorbidities, and age were predictive of poor 1-month outcomes. Our results agree with those of earlier studies that showed unilateral neglect as predictive of low mFIM scores and poor outcomes after rehabilitation [27,28]. Several studies have shown that the 1-month rehabilitation outcomes correlated with the post-discharge outcomes [29-31]. Thus, our results will enable the rehabilitation team to predict the rehabilitation outcomes in patients with severe stroke. This will allow the team to predict which patients are likely to have favorable outcomes, thereby informing the expectations of hospitals and caregivers. The rehabilitation team can therefore use multidimensional assessment to help reduce the length of hospital stay of patients. This information can also guide the rehabilitation plan and help in educating patients and their families on functional prognosis and the post-discharge process at admission [32].

The limitations of this study are its single-center design and the relatively small number of patients. Additional studies incorporating a multicenter design with larger patient populations and different patient characteristics, as well as comparing multiple rehabilitation approaches, are required to verify the findings of this study.

In conclusion, family-engaged multidimensional assessment and intervention point-based rehabilitation contribute to improved tFIM scores after 30 days in patients with severe stroke. The mFIM score at admission, cFIM score at admission, unilateral spatial neglect, age, and systemic comorbidities were found to be predictive of the 30-day FIM scores. We recommend that rehabilitation teams consider these parameters when advising caregivers about the probability of favorable outcomes after rehabilitation. We expect that these results will provide the necessary data to support care maps or clinical paths to stroke recovery, and will contribute to the development of an assessment system that will serve as the basis for the provision of high-quality rehabilitation.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTION

Conceptualization: Hiragami F. Methodology: Hiragami S, Inoue Y. Formal analysis: Inoue Y. Funding acquisition: Hiragami F. Project administration: Hiragami F. Visualization: Inoue Y, Hiragami S. Writing – original draft: Hiragami F, Hiragami S. Writing – review and editing Hiragami F, Hiragami S, Inoue Y. Approval of final manuscript: All authors.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.5535/arm.2019.43.5.581. Table S1. Four-aspect assessments, intervention points, goals, and outcomes after one month and at discharge for the low-efficiency group (cases with 5 highest motor FIM scores at admission, 5 cases with minimum scores).

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Table S1. Four-aspect assessments, intervention points, goals, and outcomes after 1 month and at discharge for the low-efficiency group (cases with 5 highest motor FIM scores at admission, 5 cases with minimum scores)

	Patient (age, sex)	Four-aspect assessment	Intervention points	Goal setting	Outcomes at 1-month discharge		
					Motor FIM items (admission/1 month), functional changes after 1 month	Admission→ 1 month→ Discharge (motor FIM item)[a)]	Hospital days, recovery
High scores	70, M	1. Infarct, right watershed region, 30, HT, HC 2. List impairment resulting from left (VI, V, VI) lesions 3. Enjoys and highly motivated to play golf 4. Lives with wife	Relax muscles, concentrating on consciously producing movement	Pinching movement of the left hand	Became able to tie shoelaces	89→89→89 (Transfer to bath 5)	97, own home
	70, M	1. Infarct, right MCA, 28 2. Right (I, I, VI), Sensory disorders present 3. Optimistic and not overly concerned by severe upper limb paralysis 4. Wife comes to hospital daily, daughter works in the hospital office	Increase awareness of upper limb paralysis using functional electrical stimulation	Regaining function in the upper limb proximal to the fingers	Stairs 5/7	85→87→87 (Bathing 5, Transfer to bath 5)	73, own home
	68, M	1. Infarct, right LSA (BAD) right medial crus posterius capsulae internae to corona radiata, 31, DM, HT 2. Left (V, IV, VI) 3. Works hard, highly motivated 4. Will pass self-run pipe-laying business to son after leaving hospital	Make use of healthy thumb function and sensory function	Set a goal of 20 kg grip strength in two months' time	Bowel movements 6/7, Dressing lower-body 6/7, Stairs 6/7, STEF (left): 1→21/100	84→87→89 (Bathing 5)	56, own home
	46, F	1. Hemorrhage, right putamen, 31, DM, HT, self-discontinued oral HC 2. Left (VI, VI, VI) 3. Strong desire to return to work for financial reasons 4. Lives on the third floor of municipal housing with her oldest and second daughters	Extend maximum duration of standing from 30 min to 5 h	Returning to home and work (noodle shop) at the earliest opportunity	Walking/wheelchair 5/7, Bathing 4/5, Stairs 5/7	83→88→89 (Bowel management 6, Transfer to bath 6)	63, own home

Table S1. Continued 1

	Patient (age, sex)	Four-aspect assessment	Intervention points	Goal setting	Outcomes at 1-month discharge		
					Motor FIM items (admission/1 month), functional changes after 1 month	Admission→ 1 month→ Discharge (motor FIM item)[a]	Hospital days, recovery
	87, F	1. Infarct, left MCA, 30 2. Right (VI, VI, VI), Unilateral spatial neglect, Aphasia, dysphagia, Dementia present: 13 points 3. Passive, with little indication of will 4. Second son works in medical device manufacturing	Begin with guidance to bathroom and work toward increased motivation	Attempting to use the toilet with the hospital call system	Walking/wheelchair 5/7, Stairs 5/6, Dressing lower-body 6/7	82→86→86 (Bathing 5, Transfer to bath 5, Stairs 6)	62, own home
Minimum scores	73, F	1. Infarct, right LSA, 18, DM 2. Left (IV, VI, IV), Unilateral spatial neglect, Dementia present: 7 points; sensory disorders present 3. Apathetic, varying levels of motivation 4. Devoted husband who has looked after patient for two years	Reduction of burden of care	Reduced assistance in transfers	Eating 1/4, Transfer to bed 1/2, Assisted walking possible if patient feels motivated to do so	13→17→18 (Grooming 1/2)	150, own home
	82, F	1. Infarct, inferior posterior branch of left MCA, 50, L2 compression fracture, HT 2. Right (VI, VI, VI), Aphasia, Dementia present; sensory disorders present 3. Refused rehabilitation after depression/social withdrawal two years previously 4. Plans to return to geriatric facility with assistance level II	Limit staff members and approach in a caring manner	Getting out of bed, avoiding exacerbation of depression or rejection	Eating 1/4, Willing to walk with assistance if helped by close relatives, staff members	13→16→16	105, geriatric facility

Table S1. Continued 2

Patient (age, sex)	Four-aspect assessment	Intervention points	Goal setting	Outcomes at 1-month discharge		
				Motor FIM items (admission/1 month), functional changes after 1 month	Admission→ 1 month→ Discharge (motor FIM item)[a]	Hospital days, recovery
86, F	1. Infarct, right MCA, ACA, neurosurgery, 17, RA, compression fracture, atrial fibrillation 2. Left (III, III, IV), Unilateral spatial neglect, aphasia, dysphagia, Dementia present: 13 points 3. Enjoys conversation, energetic, shows motivation 4. Assistance level I, could take a bath on her own by taking over 1 hour	Patient was watched and given verbal assistance, but no physical assistance	Could perform transfers on her own by taking 5 minutes	Grooming 1/3, Can sit up	13→15→42(+27)[b]	174, residential
92, F	1. Infarct, left MCA (all regions), 28, atrial fibrillation 2. Right (I, I, I), Aphasia 3. Quiet speech and nodding 4. Lives alone. Family does not want aggressive rehabilitation	Maintaining a seated position allowing the use of the left hand	Eating in a seated position	Eating 1/3, Increased freedom of hand on the unaffected side by improving maintenance of the sitting posture	13→15→18(+3)[c]	163, transferred
86, F	1. Infarct, right MCA, 29, HT, heart disease 2. Left (I, I, III), unilateral spatial neglect, dysphagia, sensory disorders present 3. Complains often, but full of energy 4. Lives together with 87-year-old wife, considering geriatric facility	Reduction of assistance by taking advantage of the unaffected side	Independent movement in a wheelchair	Transfers: bed 1/2, Walking/wheelchair 1/2, Able to maintain a standing position for 30 seconds	13→15→17 (Dressing lower body 1/2, Dressing lower body 1/2)	164, geriatric facility

Four-aspect assessment are following: 1. Clinical features, 2. Functional impairment features, 3. Psychological aspects, and 4. Environmental aspects. For the clinical features, a diagnostic numerical value is provided with time after onset (in days); 'Affected side of the body' is defined by Brunnstrom stage as upper limb, fingers, or lower limb. Cognitive effects scores are based on Hasegawa Dementia Scale for Revised. Information on the characteristics of psychological and environmental aspects was recorded after speaking with the patients' families and confirming the situation. ACA, anterior cerebral artery; MCA, middle cerebral artery; LSA, lenticulostriate artery; BAD, branch atheromatous disease; HT, hypertension; DM, diabetes mellitus; AD, Alzheimer's disease; PD, Parkinson's disease; RA, rheumatoid arthritis; STEF, Simple Test for Evaluating Hand Function; Residential, residential nursing care facility.

[a]Reduced point items for high-score cases, 1 month/discharge for minimum-score cases; [b]eating 1/6, grooming 3/4, bathing 1/4, dressing upper-body 1/4, dressing lower body 1/4, toileting 1/3, transfer to-bed 1/5, transfer to toilet 1/4, transfer to bath 1/3, wheelchair 1/2; [c]eating 3/4, dressing upper body 1/2, transfer to bed 1/2.