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ORIGINAL ARTICLE

Functional Recovery after Rehabilitation in Patients with Post-stroke Severe Hemiplegia

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Objectives: Stroke patients with hemiplegia can sometimes achieve independent life at home or in light care facilities after rehabilitation. This study examined the outcomes of rehabilitation in stroke patients with severe hemiplegia. **Methods:** This study included 50 patients with Brunnstrom recovery stage I–II hemiplegia at the start of rehabilitation for stroke. Good outcome after rehabilitation was defined as independent life with functional independence measure (FIM) score of 100 or greater. Predictors for post-rehabilitation functional recovery were statistically analyzed. **Results:** FIM scores of 100 or greater in 12 of 50 patients (24%) allowed independent life after stroke rehabilitation. According to univariate analysis, factors associated with a FIM score of 100 or greater and good prognosis after rehabilitation were younger age (<70 years), paralysis caused by intracerebral hematoma (ICH), no cortical lesions, short time from admission to comprehensive inpatient rehabilitation (CIR) for stroke (within 1 month), and good status at the start of early rehabilitation and CIR. Eleven of the 12 patients with good prognosis (FIM ≥100) had ICH and a basal ganglia lesion with no cortical damage. Analysis of the location of lesions suggested that many patients with basal ganglia ICH lesions and little cortical involvement have good prognoses. **Conclusions:** Stroke patients with severe hemiplegia showed a slightly different distribution of lesions between ICH and cerebral ischemia. Cortical involvement may be a prognostic factor for outcome after rehabilitation in stroke patients with severe hemiplegia. More aggressive rehabilitation interventions may be important for patients with severe hemiplegia, especially without cortical involvement.

Key Words: hemiplegia; intracerebral hemorrhage; ischemic stroke; rehabilitation; stroke

INTRODUCTION

Each year, more than 250,000 patients suffer from acute stroke in Japan and 20%–30% of them face severe impairment.[1] According to previous reports, 70%–90% of all stroke cases involve ischemic stroke, while 10%–20% involve intracerebral hemorrhage (ICH), meaning that ischemic stroke generally predominates.[1,2] In a large community-based stroke population study, the severity of the initial stroke was very severe in 19% of patients, severe in 14%, moderate in 26%, and mild in 41%.[2] Two-thirds of all stroke survivors require some type of rehabilitation management. After completing rehabilitation, 20% were severely or very severely disabled, 8% were moderately disabled, and 26% were mildly disabled based on an assessment of their activities of daily living (ADL).[2] Consequently, prediction of the outcome for ADL after rehabilitation is important for the adequate provision of social care.[3]

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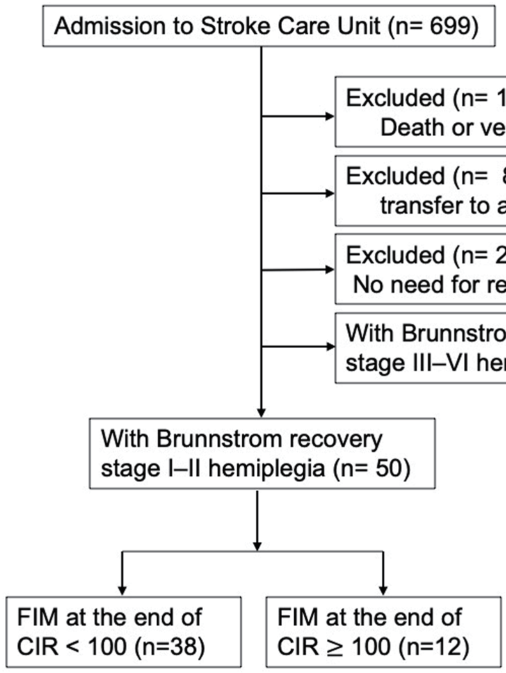

Fig. 1. Course of acute treatment and rehabilitation in stroke patients in this study.

Prediction of functional prognosis after stroke rehabilitation has been extensively investigated. The relationship between imaging findings and the functional prognosis,[4,5] status of ADL before the onset,[2] and prognosis prediction based on a scoring system have all been evaluated.[6] The established prognostic factors for acute stroke rehabilitation are generally accepted to be age and the severity of the onset of paralysis.[7] Ween et al. reported that patients younger than 55 years or with a Functional Independence Measure (FIM) greater than 80 on admission were almost universally able to return home, while those with a FIM less than 40 were closely associated with discharge to a nursing home.[8] Weimer et al. reported that age and the National Institutes of Health Stroke Scale (NIHSS) total score were identified as independent predictors of functional recovery.[9] Salvadori et al. revealed age and initial stroke severity as the main prognostic factors of functional recovery.[10] Jørgensen et al. reported initial stroke severity as the all-important prognostic factor.[11] In summary, patients with initial neurological severity tended to have a poor prognosis.

However, stroke patients with severe neurological deficiencies can sometimes gain an independent life after rehabilitation. In a study by Dam et al., 14% of patients with very severe stroke and 34% of patients with severe stroke were discharged home after rehabilitation.[12] However, few studies have examined the characteristics of patients with severe stroke and paralysis who were able to lead independent lives after rehabilitation. Therefore, the present study examined the relationship between the clinical characteristics at the start of rehabilitation and the post-rehabilitation prognosis for stroke patients with severe hemiplegia.

MATERIALS AND METHODS

A total of 699 patients (median age, 72.0 years; interquartile range [IQR], 61.0–80.0 years) were admitted to the stroke care unit of our hospital under a diagnosis of newly developed acute cerebral stroke between April 1, 2014 and September 30, 2017. Rehabilitation was initiated according to the general rehabilitation program for stroke patients in Japan.[13] Bedside rehabilitation (early rehabilitation) combined with treatment for stroke dynamics and stabilization of the general condition were provided in the hyperacute phase after admission to the stroke care unit (n=699). Sixty-two patients (8.9%) died during acute treatment, and 45 patients (6.4%) were transferred in a vegetative state to a medical treatment hospital without rehabilitation indication. Another 210 patients (30.0%) had mild symptoms and did not need rehabilitation. A total of 301 patients were transferred to a convalescent rehabilitation hospital, and comprehensive inpatient rehabilitation (CIR) for stroke was initiated (**Fig. 1**).

This study included 50 patients with Brunnstrom recovery stage I–II hemiplegia at baseline at the start of early rehabilitation (26 women [52%], 24 men [48%]; median age, 70.5

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years; IQR, 60.8–78.0 years). This study was reviewed and approved by the institutional review board. All procedures performed in the study were in accordance with the 1964 declaration of Helsinki and its later amendments or comparable ethical standards. The study protocol was approved by the Gunma University Hospital Clinical Research Review Board and informed consent was obtained by an opt-out method (HS2017-039).

Clinical data were reviewed and included: age, sex, side of stroke lesions, volume of lesions, type of stroke (hemorrhage, infarction), time from admission to start of rehabilitation, Japan Coma Scale (JCS) score on admission, Glasgow Outcome Scale (GOS), surgical intervention, and aphasia. The patient status was estimated by assessment score before and after the stroke rehabilitation program. The Stroke Impairment Assessment Set Motor score (SIAS-M) was mainly used for evaluating motor functions after stroke. The FIM was used to evaluate ADL in general after stroke. Assessments were performed by trained physical therapists or occupational therapists. The destination after discharge was also recorded as one of the important outcomes (**Table 1**).

Consciousness on admission was classified using the JCS. JCS scores of 1–3 were classified as mild consciousness disorder and scores of 10–300 were classified as severe consciousness disorder.[14] The evaluation of the type of stroke reassessed the entire medical history, especially for patients with subarachnoid hemorrhage (four patients, 8.0%). Patients with mainly primary damage from hematoma caused by ruptured middle cerebral artery aneurysm were assigned to the hemorrhage group, whereas patients with mainly ischemic lesions caused by delayed vasospasm were assigned to the ischemic group (two patients in hemorrhage group, two patients in ischemic group). Cases that were difficult to judge were not included in this series.

In-hospital picture archiving and communication systems were used to measure the size of the lesion. The volume of intracerebral hematoma (ICH) was calculated using the ABC/2 formula for the size of the lesion at maximum during the course as demonstrated by head computed tomography. The size of the ischemic lesion at maximum during the course was calculated using the ABC/2 formula as demonstrated by diffusion-weighted imaging.[15] The lesion size was classified as 44 mL or more or less than 44 mL with reference to the overall median of 44.3 (IQR, 19.6–84.9) mL. The location of the lesion was classified as the cortex, corona radiata, putamen, thalamus, or brain stem with reference to the previous classification.[4] The rehabilitation program for stroke provides physical therapy, occupational therapy, and speech-language hearing therapy daily in accordance with the Japanese Guidelines for the Management of Stroke 2015,[16,17] with a daily maximum limit according to the Japanese national system for diagnosis and treatment. All participants underwent the usual rehabilitation provided in each CIR program, 7 days per week. Rehabilitation time was standardized across CIR programs to a maximum of 3 hours per day if there were no contraindications. The length of hospital stay during CIR was evaluated. Patients with severe paralysis could not participate in regular gait training. Therefore, in acute-care hospitals, the patients were weaned from bed early to prevent disuse syndrome, and standing and gait training using a knee–ankle–foot orthosis was started as early as possible. In CIR, when it was predicted that the patient would be able to walk, a custom-made orthosis was made at an early stage.

Statistical Analysis

Variables are shown as the median (IQR) and percentage. Some scoring variables used (GOS, JCS, SIAS-M, FIM) are shown as the median (IQR). We used the Mann–Whitney U test to compare data for the non-normally distributed variables for comparison between the two groups. Categorical variables were analyzed by Fisher's exact test. Data recorded in Excel were analyzed using SPSS version 26 (SPSS Inc., Chicago, IL, USA). Statistical significance was recognized at $P<0.05$.

RESULTS

The clinical characteristics of the 50 stroke patients with severe hemiplegia at early rehabilitation are shown in **Table 1**. Consciousness on admission was JCS 1–3 in 22 patients (44%), 10–30 in 20 patients (40%), and 100–300 in 8 patients (16%). The Glasgow Outcome Scale was 3 in 34 patients (68%) and 4 and 16 patients (32%). Aphasia was observed in 20 patients (40%). ICH was present in 31 patients (62%) and cerebral infarction was present in 19 (38%). The lesion side was the right in 21 patients (42%), left in 28 (56%), and bilateral in 1 (2%). Seventeen patients (34%) had cortical/subcortical lesions. Surgical treatment (evacuation of ICH, decompression for brain edema, clipping of cerebral aneurysm, drainage of cerebral ventricle, or acute mechanical thrombectomy) was performed in 26 patients (52%). Early rehabilitation was started 2.0 (IQR, 1.0–3.0) days after admission, and the stay in the stroke care unit was 13.5 (IQR, 9.0–17.0) days. The duration from admission to the start of CIR was 29.5 (IQR, 23.0–37.0) days. At the start of early

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Table 1. Summary of characteristics of 50 stroke survivors with hemiplegia

Characteristic	Value
Age, years [a]	70.5 (60.8–78.0)
Sex [b]	
Male / Female	24 (48) / 26 (52)
Japan Coma Scale on admission [b]	
1–3 / 10–30 / 100–300	22 (44) / 20 (40) / 8 (6)
Glasgow Outcome Scale on admission [b]	
3 / 4	34 (68) / 16 (32)
Aphasia [b]	
Yes / No	20 (40) / 30 (60)
Type of stroke [b]	
Intracerebral hemorrhage	31 (62)
Cerebral infarction	19 (38)
Side of lesion [b]	
Left / Right / Bilateral	28 (56) / 21 (42) / 1 (2)
Volume of lesion, mL [a]	44.3 (19.6–84.9)
Cortical or subcortical lesion [b]	
With / Without	17 (34) / 33 (66)
Treatment [b]	
Surgery	26 (52)
Removal of hematoma or decompression	13 (26)
Clipping or trapping	4 (8)
Acute mechanical thrombectomy	8 (16)
Drainage of cerebral ventricle	1 (2)
Conservative	24 (48)
Start of rehabilitation from admission, days [a]	2.0 (1.0–3.0)
Stay in SCU, days [a]	13.5 (9.0–17.0)
Time from admission to start of CIR, days [a]	29.5 (23.0–37.0)
SIAS-M at the start of early rehabilitation [a]	0.0 (0.0–0.25)
FIM at the start of early rehabilitation [a]	19.5 (18.0–30.0)
SIAS-M at the start of CIR [a]	1.0 (0.0–7.5)
FIM at the start of CIR [a]	36.5 (22.8–53.5)
SIAS-M at the end of CIR [a]	4.5 (0.0–6.25)
FIM at the end of CIR for stroke [a]	53.0 (33.5–94.5)
FIM at the end of CIR for stroke [b]	
≥100 / <100	12 (24) / 19 (38)
Length of stay in CIR, days [a]	113.5 (87.5–150.8)
Destination after discharge [b]	
Home	19 (38)
Care home	18 (36)
Others	13 (26)

[a] Data given as median (IQR).
[b] Data given as number (%).
SCU, stroke care unit.

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Table 2. Predictors of outcome after rehabilitation for stroke

Variable	FIM at end of CIR		Univariate analysis		
	<100 (n=38)	≥100 (n=12)	P	OR	95% CI
Age, <70/≥70 years	13 (34) / 25 (66)	11 (92) / 1 (8)	0.001*	21.154	2.454–182.336
Sex, male/female	20 (53) / 18 (47)	6 (50) / 6 (50)	1.00	1.111	0.303–4.071
JCS on admission, ≤3/≥10	16 (42) / 22 (58)	6 (50) / 6 (50)	0.743	1.375	0.374–0.055
Type of stroke, ICH/ischemia	20 (53) / 18 (47)	11 (92) / 1 (8)	0.018*	9.900	1.160–84.471
Side of lesion, left/right	21 (57) / 16 (43)	7 (58) / 5 (42)	1.00	1.067	0.285–3.989
Volume of lesion, <44/≥44 mL	19 (50) / 19 (59)	6 (50) / 6 (50)	1.00	1.000	0.273–3.662
Subcortical or cortical lesion, yes/no	16 (42) / 22 (58)	1 (8) / 11 (92)	0.039*	8.000	0.94–168.41
Surgery, no/yes	21 (55) / 17 (45)	5 (42) / 7 (58)	0.514	1.729	0.465–6.434
Time from admission to start of CIR, <1 month/≥1 month	16 (42) / 22 (58)	11 (92) / 1 (8)	0.003*	6.947	1.043–46.264
Aphasia, no/yes	16 (42) / 22 (58)	4 (33) / 8 (67)	0.740	1.455	0.373–5.679
SIAS-M at start of early rehabilitation, ≥2/<2	33 (89) / 5 (11)	6 (50) / 6 (50)	0.014*	6.600	1.515–28.747
FIM at start of early rehabilitation, ≥40/<40	37 (97) / 1 (3)	5 (42) / 7 (58)	0.001*	51.800	5.225–513.563
SIAS-M at start of CIR, ≥2/<2	23 (61) / 15 (39)	3 (25) / 9 (75)	0.091	3.846	0.973–15.207
FIM at start of CIR, ≥40/<40	30 (79) / 8 (21)	2 (17) / 10 (83)	0.001*	18.750	3.402–103.335
Length of stay in CIR, <114/≥114 days	19 (50) /19 (50)	6 (50) / 6 (50)	1.00	1.000	0.273–3.662
Destination after discharge (home/ others)	10 (26) / 28 (74)	9 (75) / 3 (25)	0.005*	2.947	1.086–7.998

Data for FIM groups given as number (%).
OR, odds ratio; CI, confidence interval.
* P < 0.05

rehabilitation, the median SIAS-M was 0.0 (IQR, 0.0–0.25) and the median FIM was 19.5 (IQR, 18.0–30.0). At the start of CIR, the median SIAS-M was 1.0 (IQR, 0.0–7.5) and the median FIM was 36.5 (IQR, 22.8–53.5). After CIR, the median SIAS-M was 4.5 (IQR, 0.0–6.25) and the median FIM was 53.0 (IQR, 33.5–94.5). Twelve patients (24%) had good ADL with a FIM of 100 or greater. The duration from the start to the end of CIR was 113.5 (IQR, 87.5–150.8) days. Nineteen patients (38%) were discharged to their homes.

The 12 patients who achieved FIM scores of 100 or greater were included in the good prognosis group. We compared these patients against the others and investigated the relationship with each clinical variable (**Table 2**). Univariate analysis showed better FIM scores were obtained at the end of stroke rehabilitation in the young group aged less than 70 years than in the elderly group aged 70 years and older (P=0.001). Patients with ICH had better prognoses than patients with cerebral ischemia (P=0.018). Cortical/subcortical lesions caused poor outcomes (P=0.039). Short hospital stay in the acute care ward or patients who were able to start CIR early had a good prognosis (P=0.003). A good SIAS-M or FIM at the start of early rehabilitation and a good FIM were also associated with a good recovery (P=0.014, 0.001, 0.001, respectively). The cut-off values of the SIAS-M and FIM were determined based on the median value and/or previous reports.[18] Many patients with a FIM score above 100 at the end of CIR were discharged to their own home (P=0.005).

Table 3 shows the characteristics of the 12 patients in the good prognosis group. The median age of this group was relatively young at 57.5 (IQR, 50.3–62.5) years. The group included equal numbers of men and women. Eleven of the 12 patients had ICH, including 9 with putaminal hematoma and 2 with thalamic hematoma (**Fig. 2**). The median hematoma volume in the 11 patients with ICH was 39.1 (IQR, 12.3–51.1) mL. Five patients underwent surgery and the median stay in the stroke care unit was 13.5 (IQR, 12.0–18.8) days. The period from admission to the start of CIR was 23.0 (IQR, 20.5–27.0) days. The median FIM score at the start of CIR was 67.5 (IQR, 57.8–78.5) and at the end of CIR was 111.5 (IQR, 109.0–116.3), showing a significant improvement.

To examine the characteristics of the lesions in the good prognosis group, outcome and lesion type in 50 patients with

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post-stroke severe hemiplegia are shown in **Fig. 3**. The lesion locations were classified into the cortex, corona radiata, putamen, thalamus, and brain stem.[4] In addition, combinations were also found and classified into six categories: putamen, thalamus, putamen + thalamus, cortex, cortex + putamen, and brain stem. Eleven of the 12 patients in the good prognosis group had a basal ganglia-based ICH lesion and no cortical damage. Many patients with putaminal or thalamic lesions without cortical lesions had good prognoses, but patients with mixed ICH lesions (putamen and thalamus) had poor prognoses. Ischemic lesions cause severe hemiplegia often accompanied by cortical lesions and are generally associated with poor prognosis. In addition, brain stem lesions (mainly ischemic lesion) had poor prognoses. Examination of the association between the final FIM score and presence of a cortical lesion showed significant association (P=0.039).

Table 3. Characteristics of 12 patients with good outcome after CIR (FIM ≥100)

Case no.	Age/sex	Type of stroke	Lesion site	Side	Volume of lesion (mL)	Cortical/subcortical lesion	Surgery	Aphasia	Time from admission to CIR start (days)	SIAS-M at CIR end	FIM at CIR end	Destination after discharge
1	62/F	ICH	Putaminal	Left	12.3	No	Conservative	No	14	12	122	Home
2	32/F	ICH	Putaminal	Right	51.1	No	Hematoma removal	No	27	18	122	Home
3	54/F	ICH	Putaminal	Left	31.1	No	Conservative	No	23	21	117	Home
4	60/M	ICH	Putaminal	Right	21.2	No	Conservative	No	21	9	114	Home
5	56/F	ICH	Thalamus	Left	11	No	Conservative	Yes	34	21	114	Home
6	64/F	ICH	Putaminal	Left	49.4	No	Conservative	Yes	19	12	112	Home
7	44/M	ICH	Putaminal	Left	75	No	Hematoma removal	Yes	19	10	111	Home
8	59/M	CI	MCA embolism	Right	188.9	Yes	Conservative	No	23	9	109	Home
9	45/M	ICH	Putaminal	Right	80.6	No	Hematoma removal	No	24	4	109	Care home
10	52/M	ICH	Putaminal	Right	39.1	No	Hematoma removal	No	27	1	109	Care home
11	78/M	ICH	Thalamus	Left	9.2	No	Conservative	Yes	29	14	107	Home
12	65/F	ICH	Putaminal	Left	49.3	No	Hematoma removal	No	23	20	102	Care home

CI, cerebral ischemia; MCA, middle cerebral artery.

DISCUSSION

Many studies of functional prognosis predictors after rehabilitation examined clinical and imaging variables and various scoring systems. In general, the severity of the initial stroke determines the functional prognosis after rehabilitation. In the Copenhagen study by Jørgensen et al., the Scandinavian stroke scale including scores of the upper limb, lower limb, hand function, and gait dysfunction was used.[2] In the moderate to mild stroke severity group, 74%–93% were discharged to their own homes, but for those with very severe stroke and severe stroke, the rate of discharge to one's own home was significantly reduced to 14%–34%.[2] In the severe stroke group, the moderate to mild severity group has a relatively large dissociation in the prognosis. In the case of mild or moderate paralysis, the upper limb function of post-stroke patients is thought to exhibit a nearly fixed and proportional functional recovery for evaluation within 72 hours after stroke. However, proportional recovery cannot be obtained in a group of patients with severe initial paralysis.[19] Severe stroke patients with severe neurological disability may require special consideration when compared to those with other mild or moderate disabilities.

The neurological status after severe stroke, unlike other spinal and peripheral nervous system disorders, is highly diverse and is often associated with relatively widespread brain damage.[20] Manifestations may include physical disorders of the limbs, reduced consciousness, dementia, reduced higher brain function, aphasia, unilateral spatial neglect, deep sensory disorder, reduced motivation, swallowing dysfunction, poor nutritional status, systemic comorbidities, and changes

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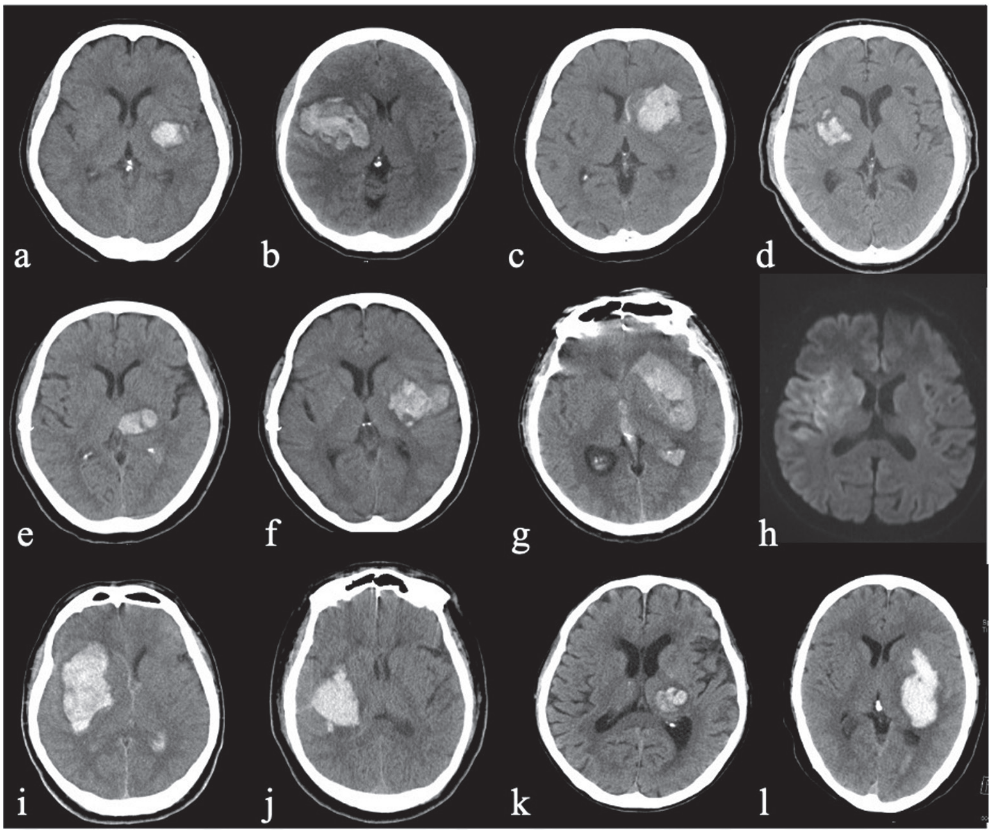

Fig. 2. Axial computed tomography images or diffusion-weighted magnetic resonance images on admission in 12 patients with hemiplegia but with good ADL prognosis after CIR for stroke. Panels a–l indicate images from Cases 1–12, respectively. Panel h (Case 8) shows cerebral infarction, whereas the other eleven images show ICH.

to original personality and lifestyle. Many of these factors may affect the prognosis after rehabilitation.[21)]

Few studies have examined the effects of rehabilitation in stroke patients with severe paralysis. The prognosis of severely paralyzed patients was predicted using a complex scoring system, but was not intended to examine the specificities of this population.[7)] Functional recovery after complete hemiplegia caused by severe stroke is very difficult to achieve by rehabilitation.[8)] Severe movement disorders are sometimes excluded from standard rehabilitation treatments such as restraint-induced exercise therapy and standard occupational therapy. The present and previous studies have found the improvement rate of paralysis in this population is extremely low. However, many patients have greatly improved ADL and adapted to society after rehabilitation.[12)] In the present study, we used FIM scoring to assess the final outcome of stroke patients with severe paralysis.[22)]

A FIM score of 100 or greater indicated recovery adequate to lead an independent daily life, and was obtained in 24% of all patients. Prognostic factors related to the achievement of this high FIM score (≥100) included age below 70 years, paralysis caused by cerebral hemorrhage, short hospital stay in the acute care ward (within 1 month), and good status at the start of rehabilitation. Age and good status at the baseline have been repeatedly identified as predictors of good outcome, and nearly all patients aged under 55 years and patients with an inpatient FIM score above 80 returned to home life.[7–9,23,24)] Age is an important prognostic factor associated with pre-symptomatic dysfunction, disability, and reserve capacity. The median FIM score at the start of CIR was 36.5 (IQR, 22.8–53.5) and the median SIAS-M score was 1.00 (IQR, 0.0–7.5) in our patients with severe paralysis, who are generally expected to have difficulty living at home. Baseline status was associated with post-rehabilitation prognosis even in patients with hemiplegia.[6)] In addition, early start of rehabilitation is considered to be important for predicting the effect of rehabilitation,[13,25)] although the definition of early rehabilitation may vary. Recently, increasing evidence has shown that starting rehabilitation within the first 2 weeks of stroke is beneficial.[26)] Simple bedside rehabilitation started

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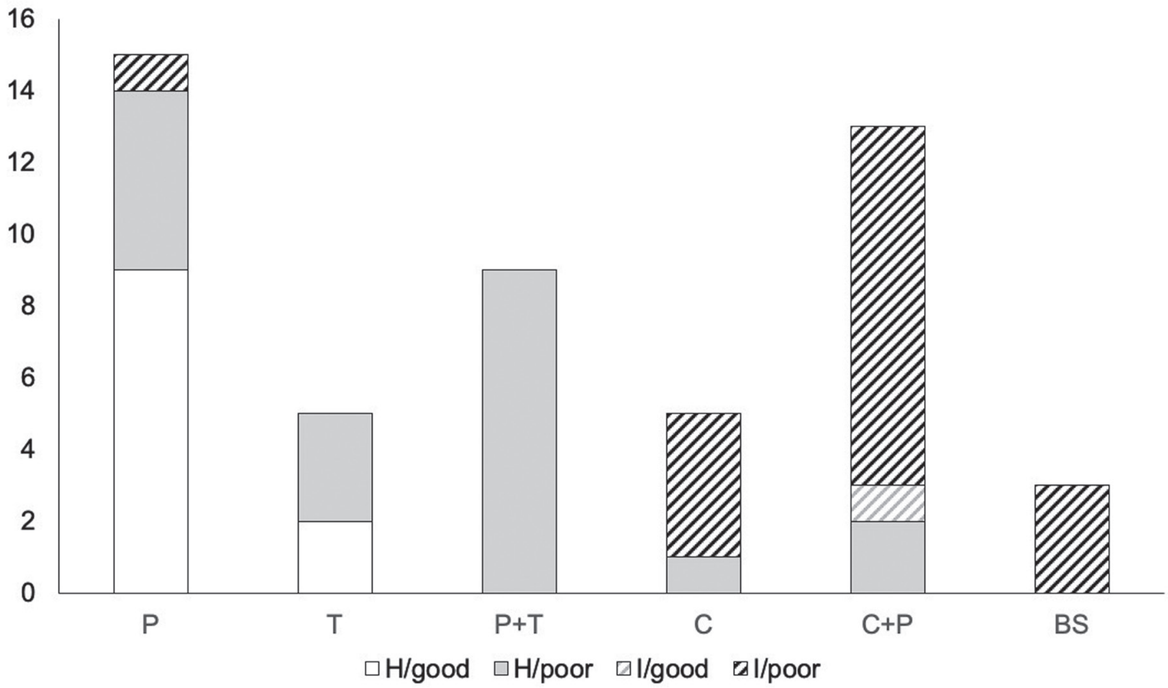

Fig. 3. Outcome and lesion type in 50 stroke patients with hemiplegia. Vertical axis shows the number of cases. H, ICH; I, cerebral infarction; P, putaminal lesion; T, thalamic lesion; P + T, mixed lesion in putamen and thalamus; C, cortical lesion; C + P, mixed lesion in putamen and cortex; BS, brain stem lesion. Many patients with putaminal or thalamic lesions without cortical lesion had good prognosis, but patients with mixed ICH lesions (P + T) had a poor prognosis. Ischemic lesions causing severe hemiplegia often accompanied by cortical lesion have a poor prognosis. In addition, brain stem lesions (mainly ischemic lesion) have a poor outcome.

within 2 days after the onset in most of these patients. Post-ischemic biological nerve recovery and cortical reorganization and regeneration begin to increase in 1–2 weeks and are thought to peak after about 1 month in many animal models. However, the period of active spontaneous recovery lasts longer in humans than in rodents.[24] In our series, patients with severe hemiplegia were transferred to the CIR program for stroke after waiting for recovery from surgery, improvement of general condition, and improvement of consciousness level. The median waiting time was about 1 month, which was affected by the availability of social resources, but the beginning of rehabilitation as early as possible may be related to the prognosis.

The type of stroke is generally believed to not affect the prognosis after rehabilitation.[11] However, the location and size of lesions are important because the functional prognosis is not related to the type of bleeding and ischemia,[27] whereas the relative frequency of ICH is known to increase exponentially with increasing stroke severity.[11] This study targeted patients with significant functional disabilities among patients admitted to the stroke care unit, without classifying the types of ICH and cerebral infarction. Therefore, ICH was the most common type of stroke (62%). In addition, patients with cerebral infarction showed serious damage because most had cerebral infarction of the cortical branches. Therefore, we suspected that patients with severe cerebral infarction tended to suffer this disorder.

Patients with stroke causing severe dysfunction show slightly different distributions of lesions between ICH and cerebral infarction. ICH basically occurs in the perforator region, except for subcortical hemorrhage, and sometimes causes direct damage to the pyramidal tract. In contrast, cerebral infarction in the basal ganglia region (lacunar infarction) carries a good prognosis. Severe cerebral infarction causing severe hemiplegia often includes a large cortical area. For example, an infarct lesion in the middle cerebral artery territory is associated with damage over a large cortical area. On the other hand, ICH is a common cause of serious hemiplegia. Any series of patients with severe paralysis at the start of rehabilitation, as in this study, tends to include a higher number of cases of ICH. Of course, bleeding breaks down the normal brain and progresses, so it is likely to cause

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severe hemiplegia. However, given that bleeding basically occurs from the perforating branch on the basal ganglia, some patients may have no or only mild cortical disorder. Even in the presence of variable pyramidal tract damage, rehabilitation may be effective if the cortical disorder is mild. In our series, many patients with good functional recovery after rehabilitation for post-stroke severe hemiplegia had presented with ICH in the basal ganglia region without cortical damage.

Various studies have investigated stroke lesions and their prognoses, but few have evaluated the presence or absence of cortical involvement.[15] The type and size of stroke are generally believed to not affect the effectiveness of rehabilitation. In addition, the association of spread of stroke lesion with diverse functional ADL is difficult to examine. However, stroke after ICH and cerebral infarction showed a clear difference in the vascular distribution responsible, and detailed classification of the range of spreading lesions was possible. Our study of stroke cases following severe functional disorder showed more ICH (62%) overall, but patients with less damage to the cortex could achieve a good outcome. Even if a patient has severe paresis before the start of rehabilitation, rehabilitation may be effective if the cortical disorders are mild. The relationship between more detailed stroke type and prognosis requires more investigation. More aggressive rehabilitation interventions may be important, even in cases with severe hemiplegia, especially in cases without cortical involvement.

The limitations of this study include the following. First, the relatively small number of patients may lead to failure to detect significant differences in outcomes. Second, we did not undertake a detailed evaluation of pyramidal tract disorders (especially the degree of internal capsule disorders) using special methods such as diffusion tensor magnetic resonance imaging. Clear damage to the pyramidal tract may be difficult to fully evaluate with ordinary computed tomography, and may not be directly related to the outcome of ADL evaluated by FIM. The involvement of cortical damage in the outcome of stroke rehabilitation using ADL as an index requires further investigation. Third, this study is a limited study that targeted only stroke cases with severe hemiplegia at onset. Only 12 patients had a good prognosis (FIM>100), so it was not possible to conduct more valuable statistical analysis that excluded confounding factors, such as multivariate analysis. In the future, it will be necessary to conduct a large-scale study to obtain more accurate statistical evidence. Fourth, long-term follow-up will be necessary to determine the final outcome of CIR for stroke. Fifth, there was no detailed evaluation of the area of the cortex and the extent of damage to the cortex. The involvement of cortical damage in the outcome of stroke rehabilitation using ADL as an index requires further investigation.

CONCLUSION

Twelve of 50 stroke patients with hemiplegia (24%) achieved independent life with a FIM score of 100 or greater after CIR for stroke. Univariate analysis showed that the factors associated with a good prognosis for ADL after CIR were age under 70 years, paralysis caused by intracerebral hematoma (ICH), no cortical lesion, short time from admission to CIR for stroke (within 1 month), and a good status at the start of early rehabilitation and CIR. Eleven of the 12 patients with good prognosis had basal ganglia-based hemorrhagic lesion and no cortical damage. A survey of the location of lesions in the 50 patients suggested that good prognosis occurred in patients with basal ganglia lesions and few cortical involvements caused by ICH. The presence or absence of cortical involvement was a prognostic factor for ADL in stroke patients with hemiplegia. More aggressive rehabilitation interventions may be important in patients with severe hemiplegia, especially in those without cortical involvement. The involvement of cortical damage in the outcome of stroke rehabilitation using ADL as an index requires further investigation.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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