Factors Predicting the Use of Paralyzed Upper Limbs in the Daily Life of Patients with Acute Stroke

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Abstract

Background and Purpose: In patients with stroke, predictors of the use of paralyzed upper limbs in each activity of daily life, including eating and toileting, are not clear. Therefore, we aimed to identify factors that predict the use of paralyzed upper limbs in specific activities of daily life in patients with acute stroke.

Method: This prospective observational study enrolled 155 patients with acute stroke. We used the paralytic arm participation measure (PPM) to evaluate the use of the paralyzed upper limb in daily life. Eating and toileting were assessed at admission and discharge. Factors that predicted the use of the paralyzed upper limb at discharge were analyzed by binomial logistic regression analysis.

Results: The predictors of the use of paralyzed upper limbs for eating at discharge were age [odds ratio (OR)=0.93, p=.011], paralysis of the dominant hand (OR=3.75, p=.044), and motor function of the paralyzed upper limb (OR=2.16, p<.001). For toileting, the predictors were motor function of the paralyzed upper limb (OR=1.75, p<.001), sensory function of the paralyzed upper limb (OR=1.66, p=.004), and muscle strength of the quadriceps on the non-paralyzed side (OR=3.65, p=.005).

Conclusion: These identified predictors may provide clues to interventions promoting the use of paralyzed upper limbs in the daily life of hospitalized patients with acute stroke. Observation and evaluation of each activity by an occupational therapist using the PPM is potentially useful in encouraging patients to consciously use the paralyzed upper limbs in daily life.

Keywords: activities of daily living; acute phase; predictor; stroke; use of paralyzed upper limb

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In addition, the acute phase is the period when paralysis of the upper limb improves the most [8]; thus, patients should be actively encouraged to use the paralyzed limb in this period. It is also necessary to investigate the status of use of the paralyzed upper limb in the acute phase to examine the method of intervention that will be appropriate for this period. Furthermore, eating and toileting are among the basic ADLs and are of the highest priority for intervention in the acute phase, based on our clinical experience.

Therefore, this study aimed to clarify the use of paralyzed upper limbs in actual activities of daily living, such as eating and toileting, and to identify the predictors of the use of paralyzed upper limbs in the above-stated activities at the time of discharge.

2. Materials and Methods

Design and setting

This prospective observational study was conducted in a regional core general hospital. The STROBE guidelines for observational studies were followed [9]. Patients with stroke were admitted to the hospital and received acute medical care. After the doctor’s examination, rehabilitation along with full-risk management and control was provided to patients from the day of admission or the next day. In occupational therapy, early intervention is required to achieve functional recovery of the affected upper limb and to improve the performance of ADLs. At our institution, the patients underwent rehabilitation for 20 or 40 minutes a day, 7 days a week, for a total of approximately 240 minutes. Upper limb function training included the following exercises, which were performed alone or in combination: instrument manipulation training, neuromuscular facilitation training, and therapeutic electrical stimulation.

Participants

Patients ≥20 years old, who were diagnosed with stroke, and admitted to the hospital between October 2018 and October 2019 were enrolled in this study. A diagnosis of stroke was confirmed by a physician based on clinical symptoms and findings on computed tomography, magnetic resonance imaging, and other diagnostic imaging techniques. The exclusion criteria of this study were (1) patients diagnosed with transient ischemic attacks; (2) patients with limited joint range of motion and muscle weakness in the paralyzed upper limb before the onset of stroke. This information was obtained through interviews and from patients’ medical records at the time of admission; (3) patients with a score of >100 in the Japan Coma Scale (score of >100 in the Japan Coma Scale indicates “unarousable by any forceful stimuli”); (4) patients who could not provide informed consent; (5) patients with recurrent stroke during hospitalization; and (6) patients with ataxia.

Clinical characteristics

The following patient characteristics were obtained from their medical records: age, sex, length of hospital stay, disease type, affected dominant hand, presence of ADL support before stroke onset, Glasgow coma scale score, National Institutes of Health Stroke Scale (NIHSS) score, and FIM score at admission. We used FIM to evaluate the actual continuous performance of ADLs in the ward. Additionally, the stroke impairment assessment set (SIAS) was used by occupational therapists to comprehensively assess the severity of the stroke. The SIAS is classified into the following nine types of impairments [10]: motor function (upper limb: 0–10, lower limb: 0–15), muscle tone (upper and lower limbs: 0–6 each), sensory function (upper and lower limbs: 0–6 each), range of motion (upper and lower limbs: 0–3 each), pain (0–3), trunk function (0–6), visuospatial function (0–3), speech (0–3), and non-paralyzed limb function (grip and muscle strengths of quadriceps: 0–3 each). A higher score indicates better function.

Assessment

The use of the paralyzed upper limb in daily life was assessed using the paralytic arm participation measure (PPM). Normally, motor activity log (MAL), [11, 12] and accelerometers [13, 14] are commonly used to evaluate paralyzed upper limb use. MAL is a self-assessment performed through interviews; thus, it is not very suitable for assessing patients with cognitive dysfunction or aphasia. Accelerometers can assess the amount of continuous activity, but they cannot be used to evaluate the specific type of activity performed. In this study, we used the PPM to observe and evaluate the actual performance of a particular ADL. This assessment measure was developed at Fujita Health University Nanakuri Memorial Hospital, and its reliability and validity are guaranteed [15, 16]. It consists of the following 15 items: dressing (8 items), toileting (2 items), shaping/cleaning (4 items), and eating (1 item). Each item was assessed using a 4-point scale from 0 to 3 points. The scoring criteria was as follows: 3 points, the paralyzed upper limb can smoothly perform the desired movement; 2 points, movement can be performed till the end, but is awkward and takes longer; 1 point, the limb is partially used; 0 point, totally not used. The criteria were based on the quality and extent of use of the paralyzed upper limb [15, 16]. We investigated the patients’ eating and toileting, which are high-priority activities in the acute phase. Eating was evaluated based on either holding a
| Characteristics                                   | Total (n=155) | Eating (n=72) | Toileting (lowering pants) (n=96) | Toileting (pulling up pants) (n=96) |
|--------------------------------------------------|---------------|---------------|-----------------------------------|-----------------------------------|
|                                                  | median (IQR)  | median (IQR)  | median (IQR)                      | median (IQR)                      |
| Age                                              |               | 80 (71-85)    | 71.5 (63.75-78.25) | 71.5 (63.75-78.25) |
| Sex                                              |               |               | 79 (70.5-85)        | 79 (70.5-85)        |
| Length of hospital stay                          | median (IQR)  | 29 (22-37.5)  | 11.5 (8.75-17.25)    | 11 (8.5-16.5)         |
| Disease type                                      |               |               | <0.001               | <0.001               |
| Affected hand                                     |               | 5 (6)         | 2 (2.1)              | 2 (2.1)              |
| Dominant hand                                     |               | 82 (98.8)     | 94 (98.9)            | 95 (99)              |
| Paralysis of the dominant hand                   |               |               | <0.001               | <0.001               |
| Precorbid dependence                             |               | 57 (95.0)     | 49 (50.5)            | 48 (50)              |
| GCS                                              |               | 13 (13-17)    | 15 (15-15)           | 15 (15-15)           |
| NIHSS                                            |               | 9 (9-16.5)    | 8 (8-16)             | 8 (8-16)             |
| Motor                                            |               | 13 (13-17)    | 13 (13-17)           | 13 (13-17)           |
| Cognitive                                        |               | 7 (7-17.5)    | 8 (8-20.5)           | 8 (8-20.5)           |
| Toilet transfer                                  |               | 1 (1)         | 5 (5-4)              | 5 (5-4)              |
| SIAS                                             |               |               | <0.001               | <0.001               |
| Upper limb motor function                        | 8 (3-10)      | 10 (8-10)     | 10 (8-10)            | 10 (8-10)            |
| Lower limb motor function                        | 12 (6.5-15)   | 15 (12.75-15) | 15 (13-15)           | 15 (13-15)           |
| Upper limb sensory function                      | 5 (2-6)       | 6 (5-6)       | 6 (5-6)              | 6 (5-6)              |
| Lower limb sensory function                      | 5 (2-6)       | 6 (5-6)       | 6 (5-6)              | 6 (5-6)              |
| Trunk function                                   | 4 (1-6)       | 6 (5-6)       | 6 (5-6)              | 6 (5-6)              |
| Vissuospatial function                           | 3 (1-3)       | 3 (3-3)       | 3 (3-3)              | 3 (3-3)              |
| Muscle strength of quadriceps on the non-paralyzed side | 3 (2-3)     | 3 (3-3)       | 3 (3-3)              | 3 (3-3)              |
| Grip strength on the non-paralyzed side          | 2 (1-2.5)     | 2 (2-3)       | 2 (2-3)              | 2 (2-3)              |

IQR, interquartile range; GCS, Glasgow coma scale; NIHSS, National Institutes of Health stroke scale; FIM, functional independent measure; SIAS, stroke impairment assessment set; PPM, paralytic arm participation measure; Use, PPM 1-3 points; No use, PPM 0
bowl or maneuvering chopsticks or a spoon. Toileting was evaluated based on two items: lowering the pants to the knees and pulling the pants up to the waist.

Statistical analysis

Normal distribution was assessed using the Shapiro-Wilk test, according to which, our data were not normally distributed. Patients with mild-to-no motor paralysis were considered as having an SIAS motor function score of ≥8 points in the paralyzed upper limb. The Wilcoxon signed-rank test was used to compare the PPM score at admission with that at discharge. Regarding the use of the paralyzed upper limb, 1–3 points of PPM was defined as “use” and 0 point as “no.” Binomial logistic regression analysis was conducted to identify predictors associated with the use of the paralyzed upper limb at discharge. The explanatory variables common for eating and toileting were: age, sex, premorbid dependence, paralysis of the dominant hand, stroke type (lacunar infarction/other), cognitive FIM at admission, PPM at admission, and SIAS sub-items at admission (including motor function of the paralyzed upper limb, sensory function of the paralyzed upper limb, trunk function, and visuospatial function); variable unique to eating was: grip strength on the non-paretic side; and variables unique to toileting: toilet transfer FIM at admission and muscle strength of the quadriceps on the non-paretic side. Since motor function of the paralyzed lower limb had a multicollinearity problem with motor function of the paralyzed upper limb, we prioritized the upper limb and used it for the analysis. However, we also performed the analysis using motor function of the paralyzed lower limb, since it is also an important predictor.

For the extracted factors, a receiver-operating characteristic curve was drawn, and the cutoff value and area under the curve were calculated.

P-values of <0.05 were considered statistically significant. All statistical analyses were performed using EZR ver. 1.37 software (Saitama, Japan) [17].

Ethics

This study was conducted following the ethical standards of the Declaration of Helsinki and the ethical guidelines for medical and health research involving human subjects. This study was approved by the Ethics Review Committee of our hospital (approval number: 2; approval date: 2018/9/19). All patients in this study provided written informed consent.
3. Results

Altogether, 164 patients were enrolled in this study. In the analysis, 155 patients were included, as four patients who had recurrent stroke, three patients who had ataxia, and two who died after providing informed consent were excluded. The patients’ characteristics and the median interquartile range values for Glasgow Coma Scale, NIHSS, FIM, and SIAS are shown in Table 1.

The median PPM values for eating and toileting improved significantly (p<.001) from 0 (interquartile range: 0–3) at admission to 3 (interquartile range: 0–3) at discharge. Figure 1 shows the number and percentage of patients with specific PPM scores at admission and discharge. Nearly 60% of the patients were able to use the paralyzed upper limb normally at discharge for each item. The following was the distribution of patients with mild-to-no motor paralysis who did not use the paralyzed upper limbs: eating, 8 (8%); lowering pants to the knees, 9 (9%); and pulling pants up to the waist, 9 (9%).

The predictors and cutoff values that predicted the use of paralyzed upper limbs during eating and toileting are shown in Table 2. For eating, the independent predictors of the use of paralyzed upper limbs at discharge were age, paralysis of the dominant hand, and motor function of the paralyzed upper limb. For toileting, the results of logistic regression analyses for lowering the pants to the knees and pulling pants up to the waist were the same because patients who used the paralyzed upper limbs at discharge were matched. The independent predictors of the use of paralyzed upper limbs at discharge were upper limb sensory function and quadriceps muscle strength on the non-paralyzed side. The results obtained by substituting the motor function of the paralyzed lower limb for the motor function of the paralyzed upper limb were as follows: motor function of the paralyzed lower limb (odds ratio = 1.73, 95% confidence interval = 1.37–2.18, p<.001).

4. Discussion

Use of the paralyzed upper limb in patients with acute stroke

The PPM scores for eating and toileting were significantly higher at discharge than that at admission, indicating an improvement in the use of the paralyzed limbs. Additionally, the proportion of patients who used the paralyzed upper limb normally in daily life increased from nearly 30% at admission to nearly 60% at discharge. Since improvement in upper limb function in the acute phase is expected, upper limb function training and ADL training are important. However, the proportion of patients who did not use the paralyzed side upper limbs at discharge, despite mild to almost no motor paralysis, was 8% and 9% for eating and toileting, respectively. In the future, it is necessary to explore interventions to encourage the use of these limbs in these patients.

Factors predicting the use of paralyzed upper limb in daily life

With regard to eating, the predictors of the use of the paralyzed upper limbs at discharge were age, paralysis of the dominant hand, and motor function of the paralyzed upper limb. A previous study also reported that older age is a factor inhibiting the use of the paralyzed upper limb at discharge in the acute stroke phase [5]. Additionally, elderly patients with stroke have poorer functional recovery compared to younger patients [18]. The cutoff value for age obtained in this study was 80 years, suggesting that poor functional recovery due to
advanced age may further affect the use of the paralyzed upper limbs. Patients >80 years old face difficulty recovering the ability to perform ADL during the acute phase; thus, long-term rehabilitation and changing hand dominance should be considered. With regard to paralysis of the dominant hand, in a previous study, the paralyzed upper limbs of the dominant and the non-dominant sides were used almost equally in the daily life of patients with stroke [19]. However, our study results were different. Eating is an activity that is strongly influenced by the dominant hand. In Japanese eating etiquette, the dominant hand is used to hold spoons, chopsticks, and other devices, while the non-dominant hand holds the bowl. When the non-dominant hand is paralyzed, the food can be eaten with only the dominant hand because the bowl is fixed using a self-help bowl or a non-slip mat. Therefore, it is possible that patients with paralysis of the non-dominant hand eventually stop using that hand at all to eat, while patients with paralysis of the dominant hand try to use it to manipulate spoons and chopsticks. With regard to the paralyzed upper limb function, several reports have shown that the paralyzed upper limbs are not used by patients with severe motor paralysis [4, 6, 7], which is similar to our results. In this study, the cutoff value of the paralyzed upper limb function was 5 in all patients. The severity of motor paralysis in the early stage is a predictive factor for recovery from motor paralysis [20]. Patients with scores <5 points have poor motor function recovery, which may affect the use of the paralyzed upper limbs. Meanwhile, the sensory function of the fingers associated with fine manipulation of tableware was not extracted as a predictor of the use of the paralyzed upper limb for eating. It is possible that the sensory impairment of the upper limbs was compensated by the visual sense and the nature of the self-help tableware.

As for toileting, predictors of the use of the paralyzed upper limbs at discharge were motor function of the paralyzed upper limb at admission, motor function of the paralyzed lower limb at admission, sensory function of the upper limb, and muscle strength of the quadriceps on the non-paralyzed side. The severity of proprioceptive deficit of the paralyzed upper limb inhibits the use of the paralyzed upper limb in daily life [21]. Sensory impairment of the upper limb is associated with difficulties in fine manipulation [22]. Upper limb sensory impairment inhibits the use of the paralyzed upper limb in toileting because the sensory function of the fingers is required to lower and pull up the pants, especially because the part of the pants that is behind and the part that is hidden by the shirt cannot be visually confirmed. Regarding lower limb function, no studies have examined the relationship between quadriceps muscle strength on the non-paralyzed or paralyzed lower limb and the use of the paralyzed upper limb in toileting. When pulling up and lowering pants, it is necessary to maintain a stable standing position to exert the paralyzed upper limb function. Therefore, since the quadriceps muscle strength on the non-paralyzed side and the degree of paralysis of the lower limb on the paralyzed side affect the maintenance of a stable standing position, they were extracted as predictors in this study.

In the future, in order to promote the use of the paralyzed upper limb, it is necessary to examine occupational therapy approaches for the early stage of stroke using the predictors revealed in this study. For eating, interventions, such as those that enhance the motor function of the paralyzed upper limb and positive ADL instructions for using the paralyzed upper limb when the non-dominant hand is on the paralyzed side, are also important. For toileting, interventions that improve the stability of the patient while standing are necessary. A few effective interventions for sensory disorders have been reported [23, 24]; nonetheless, actively adopting them is important.

Limitations

This study has several limitations. First, it was conducted at a single institution and included only patients who provided consent to participate. Therefore, selection bias might have occurred. Our results should be cautiously generalized and interpreted. Second, we did not consider psychological factors, such as patients’ motivation or attention, as predictors. Therefore, a study with inclusion of psychological factors as assessment variables is warrant. Third, since there are other activities involved in toileting such as handling toilet paper and wiping the buttocks, it is necessary to investigate the use of paralyzed upper limbs for these activities in the future. Fourth, ADL activities such as cleaning and dressing are also important in the acute phase and are included in the PPM. However, implementing all PPM items within the therapy duration was difficult. Studies investigating the use of paralyzed upper limbs in the future should include these activities. Finally, this study was conducted in the acute phase. Long-term follow-up of the use of paralyzed upper limbs is required for patients who did not use the paralyzed upper limb in the acute phase.

In conclusion, the use of paralyzed upper limbs in eating and toileting in patients with acute stroke was significantly improved at discharge. Factors that predicted the use of the paralyzed upper limb while eating and toileting at discharge were also identified. The results of this study suggest that occupational therapy
promotes the use of paralyzed limbs while performing these activities. The predictive factors at admission and their cutoff values obtained in this study can be used to predict the use of the upper extremities on the paralyzed side at discharge in real life, and can be used to formulate treatment strategies. Evaluations using PPM, which is a movement-evaluation tool for real-life situations, can guide occupational therapists to encourage patients to consciously use their paralyzed upper limbs during activities of daily life. This may improve the frequency and quality of the patients’ use of their paralyzed upper limbs in daily life.

Declaration of Interest

No potential conflict of interest was reported by the authors.

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