■ ORIGINAL ARTICLES

A prediction model for activities of daily living for stroke patients in a convalescent rehabilitation ward

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ABSTRACT: PURPOSE: To create a model to predict independence in the activities of daily living at discharge in stroke patients in the convalescence stage. The study also examined whether the predictability of functional independence at discharge would be improved by creating a specific prediction model for each rehabilitation facility. METHODS: To create the prediction model, data of 65 first stroke patients were analyzed using stepwise multiple regression analysis. Age, time post-stroke, Functional Independence Measure motor subscale score, Functional Independence Measure cognitive subscale score, Stroke Impairment Assessment Set, Berg Balance Scale, and Vitality Index at admission were selected as predictor variables of Functional Independence Measure motor subscale score at discharge. The accuracy of this model was compared with an existing prognosis model using data from 98 first-stroke patients, comparing the difference between actual and predicted Functional Independence Measure motor subscale score at discharge for each model. RESULTS: The prediction formula created included admission Functional Independence Measure motor subscale score, Vitality Index, age, and Stroke Impairment Assessment Set score. The adjusted R square value was 0.60. The prediction errors of the new and previous models were −2.5 ± 10.8 and −18.3 ± 18.7, respectively, which were significantly different. CONCLUSION: Our results suggest that prediction accuracy may be improved by creating prediction formulas specifically for each institution.

Key words: activities of daily living, convalescent rehabilitation ward, prediction model

INTRODUCTION

The Japanese guidelines for the management of stroke recommend that planning a rehabilitation program for a patient should take into account the patient's activities of daily living (ADL), functional impairment, complications, property, and social background in predicting the function, length of stay, and discharge destination[1]. The guidelines also state that it is desirable to use prediction methods that have been verified, and these should be used after understanding their accuracy and limits.

In our convalescent rehabilitation ward, we have used Sonoda's prognosis prediction formula[2] for stroke patients to assess their likely independence in ADL at discharge. This predicted value made it easier to imagine the patient's level of independence at discharge and to plan the rehabilitation program. The use of prognosis prediction in our ward has led to a greater improvement in the Functional Independence Measure (FIM) than for patients for whom it was not used[3]. However, we have sometimes experienced cases where there were large differences between the predicted and actual scores in stroke patients whose FIM scores were 96 points or less at admission and where there was a large improvement in FIM[4]. It is thought that this prediction error may be due to differences in the stroke treatment and maximum training time between the period of Sonoda's study[2] and the present. A further possibility is that patients' characteristics, such as age, time post-stroke, and institutional setting, may have influenced the accuracy of the prognosis prediction.

The purpose of this study was to create a prediction model for ADL independence at discharge in stroke patients in the convalescence stage and to examine whether the predictability of functional independence at discharge was improved by a new prediction model in each rehabilitation facility compared with using the previous research model.

MATERIALS AND METHODS

This study was a retrospective secondary analysis of data from a database. The study was approved by the institutional ethics review board of Northern Fukushima Medical Center (Fukushima, Japan; No.56).

1. Creation of the prediction model

The subjects included 65 stroke patients who were admitted to the Northern Fukushima Medical Center between December 2010 and August 2012. Inclusion criteria for this study were as follows: first cerebral infarction or hemorrhage, FIM score at admission (AFIM) < 96, and no absence in the data needed for the model. Stepwise multiple regression analysis was used to create the prediction model, with age, time post-stroke, FIM motor subscale score (FIM-m), FIM cognitive subscale score (FIM-c), Stroke Impairment Assessment Set score (SIAS), Berg Balance Scale score (BBS), and Vitality Index (VI) [5] at admission selected as predictor variables of FIM-m at discharge (DFIM-m). The free software R-2.8.1 (CRAN) was used for all statistical analyses. A p-value of <0.05 was considered statistically significant.

2. Validation of the prediction model

The accuracy of the new prediction model was compared with Sonoda's prognosis model[2], which is widely used. Sonoda's prediction formula is as follows: DFIM-m = 0.222 × AFIM-m + 0.606 × AFIM-c + (−0.106) × days from onset to admission + (−0.292) × age + 2.77 × SIAS proximal motor function of the lower extremity (L/E) (knee) score + (−3.43) × SIAS speech score + (−1.29) × SIAS range of motion of the upper extremity score + (−1.94) × SIAS quadriceps strength score + (−0.717) × SIAS distal motor function of the L/E score + (−1.65) × SIAS sensory function of the L/E (touch) score + 1.06×SIAS abdominal strength score + 82.3. The adjusted R square value for this was 0.60.

To compare the two models, 98 first stroke patients admitted between September 2011 and October 2013 with an AFIM score of 96 points or less were assessed, 53 using the Sonoda's prognosis prediction formula and 45 using the new prognosis prediction formula. All patients received the usual rehabilitation program.

The prediction error for each model, i.e., the difference between the predicted and actual DFIM-m values, was compared between the groups. Gender, age, type of stroke, time from onset to admission, length of stay, AFIM, AFIM-m, AFIM-c, SIAS, and VI, were compared between the groups using the χ^2 test, Mann-Whitney's U test, or Welch's t test. A p-value of <0.05 was considered statistically significant.

RESULTS

1. Creation of the prediction model

Multiple regression analysis resulted in the following formula: DFIM-m = 0.539 × AFIM-m + 2.674×V.I + (−0.717) × age + 0.318 × SIAS + 54.5.

The adjusted R^2 value was 0.64. Because there were strong correlations between AFIM-m and BBS and AFIM-c and VI, BBS and FIM-c were rejected from the possible predictor variables in the multiple regression to avoid multi-collinearity.

2. Validation of the prediction model

The information at admission for both groups is shown in Table 1. There were no significant differences between the groups in gender, age, stroke type, stroke side, time post-stroke, length of stay, AFIM, FIM-m, FIM-c, SIAS, or VI.

The prediction errors of the new and previous models were -2.5 ± 10.8 and -18.3 ± 18.7, respectively. The difference between these is statistically significant ($p < 0.001$). The effect size was 1.01 (Table 2).

DISCUSSION

In convalescent rehabilitation, it is important to set appropriate rehabilitation goals, programs, and length of stay and for the rehabilitation team to take a comprehensive approach[6]. Setting the rehabilitation goal and program requires an overall understanding of a patient through interpreting all the available information, but this is not easy[7]. Therefore, various methods have been reported for predicting a stroke patient's prognosis, such as the level of ADL independence[2, 8-15], length of stay[9, 10], and discharge destination[4, 16].

In previous studies, prognosis prediction was based on variables, such as AFIM score[10, 16], age[10, 16], time from onset to admission[2, 8, 12, 13], SIAS score[2, 11], and weighted-comorbidity index[9] in many cases. However, the influence of each variable on the objective variable varies between reports. It is thought that these differences between predicting methods may be due to differences between institutions in exercise intensity and frequency, patient characteristics, or human and physical environments. Therefore, to carry out prognosis prediction with high accuracy that takes account of the influence of features of patients and institutions, it is necessary to create a new prognosis prediction specific to each institution. However, it has previously been pointed out that there are few reports that have compared the accuracy of two or more predicting methods[1], and it is unclear whether predictive accuracy improves by creating specific prognosis predictions for institutions, compared with the previous research model.

Our formula to predict FIM-m at discharge adopted AFIM-m, VI, age, and SIAS score as the explanatory variables, and the created model had a high coefficient of determination. It has been pointed out that the patient's apathy has affected the improvement of ADL in recent years[17]. However, the evaluation of the loss of volition, such as VI, is not widely used clinically[18], and to our knowledge there has been no report that has analyzed volition as an explanatory variable in prognosis prediction.

Table 1. Patient data on admission

	Existing model	New model	p-value
Number of patients (%)	Male 58 Female 42	Male 49 Female 51	n.s
Age (years)	74.1 ± 10.3	75.5 ± 12.6	n.s
Stroke types (%)	CI 74 CH 26	CI 80 CH 20	n.s
Stroke site (%)	Right 49 Left 51	Right 62 Left 38	n.s
Time post-stroke (days)	36.1 ± 17.1	32.4 ± 14.2	n.s
Length of stay (days)	88.7 ± 33.5	90.7 ± 56.4	n.s
FIM (points)	53.2 ± 23.7	54.6 ± 23.7	n.s
FIM-m (points)	32.7 ± 18.0	34.6 ± 16.3	n.s
FIM-c (points)	20.5 ± 8.7	20.0 ± 9.3	n.s
SIAS (points)	40.4 ± 17.0	44.5 ± 19.4	n.s
VI (points)	7.1 ± 2.3	7.5 ± 2.5	n.s

*Mean ± SD.
abbreviations: CI, cerebral infarction; CH, cerebral hemorrhage; FIM, Functional Independence Measure; FIM-m, Functional Independence Measure motor subscale score; FIM-c, Functional Independence Measure cognitive subscale score; SIAS, Stroke Impairment Assessment Set; VI, Vitality Index
There were no significant differences between the groups on admission.

Table 2. Comparison of the prediction error

	Existing model (N = 53)	New model (N = 45)	p-value	ES	95 % CI
Margin of error	−18.3 ± 18.7	−2.5 ± 10.8	p < 0.001	1.01	1.43–0.58

abbreviations: ES, Effect size; CI, Confidence interval.
The difference between the groups were statistically significant.

Our results indicate that the prognosis for ADL is affected by the loss of volition in stroke patients and it is necessary to evaluate volition for the prediction of ADL. Conversely, the time from onset to admission, which had been adopted as an explanatory variable in previous studies, was rejected in our study. The reason for its low sensitivity in predicting ADL prognosis in our case was probably because the time from onset to admission in our ward is almost one month, and variance in the data is very small.

We showed in this study that prediction can be improved by creating a specific prediction formula for each institution. Our results, therefore, suggest that a prediction formula should be created for each institution to predict correctly the level of independence in ADL at discharge. The prediction model of FIM which indicates the independence of overall ADL can be useful for the forecast of discharge destination. However, the prediction formula for ADL item such as eating, grooming, and dressing remain unclear. Those may be necessary to respond to the needs of the subjects and their family in future.

A limitation of our study is that we did not take into consideration the rehabilitation program, training time, or clinical experience of the therapists. Further analysis that includes these variables is needed to obtain a prediction formula with greater accuracy.

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