■ ORIGINAL ARTICLE

The prognosis of stroke patients regarding ADL based on the SIAS and FIMC Preparation of the "Stroke ADL Prognostic Assessment Set (SAPAS)"

Takashi Ishikura[1)], Toshiyuki Wataki[2)], Soichiro Hara[3)], Hiroyuki Nara[4)], Keisuke Hasegawa[5)]

1) Department of Rehabilitation Science, Osaka Health Science University: 1-9-27 Temma, Kita-ku, Osaka, 530-0043, Japan. TEL +81-6-7506-9463
2) Department of Rehabilitation, Miki-Sanyo Hospital
3) Department of Rehabilitation, Kojima-Seikoh Hospital
4) Department of Rehabilitation, Miyoshi Medical Center
5) Department of Rehabilitation, Shibata Hospital

JAHS 1(2): 1-10, 2010. Submitted Apr. 10, 2010. Accepted Jun. 1, 2010.

ABSTRACT: We prepared a tool for making a prognosis in stroke patients regarding ADL (activities of daily living), the "Stroke ADL Prognostic Assessment Set (SAPAS)", which facilitates the simple formulation of the prognosis regarding ADL in the initial phase of evaluation and the assessment of individual ADL parameters, to establish an objective, individualized ADL prognosis. The subjects were 210 primary stroke patients during rehabilitation. They consisted of 101 males and 109 females, with a mean age of 74±12 years. Cerebral infarction was observed in 144 patients, and cerebral hemorrhage in 66. The right brain was affected in 111 patients, and the left in 99. Sites of brain injury included the corona radiata, thalamus, and putamen (total: 11 sites). Blood vessels such as the lenticulostriate, thalamogeniculate, and central arteries were affected (total: 23 blood vessels). We employed the SIAS (Stroke Impairment Assessment Set) and FIMC (Functional Independence Measure Cognitive Item) as input variables, and the BI (Barthel Index) and interval from the onset until a plateau was reached as target variables. As basic information, gender, age, handedness, the affected side of the brain, and hemorrhage/infarction were also included in input variables. These measurements were continued once a month until a plateau was reached. We prepared a model formula using the NNW (Learning Internal Representation by Error Propagation of Neural Network) based on the input and target variables, and completed the SAPAS to facilitate automatic calculation via development on a spreadsheet.

Key words: Stroke, ADL, Prognostic Assessment

PURPOSE

In current rehabilitation practice, a prognosis regarding ADL (activities of daily living) is made in accordance with empiric regulations. We do not rule out the empiric regulations, but it is necessary to carefully evaluate/treat individual patients and accumulate data supporting the results over a long period in order to make a prognosis based on such regulations alone. Furthermore, it is impossible to make a prognosis regarding ADL associated with many motor/cognitive functions based on experience alone. However, currently, it is obligatory to prepare a "rehabilitation protocol", in which the ADL prognosis and a treatment program to achieve it are presented at the completion of initial assessment to obtain consent from patients; we must provide patients with objective, accurate information. In current rehabilitation practice, it is impossible to estimate "the timing and degree of amelioration"; the ability to make an experience-based, non-objective prognosis is limited. A method for objectively making an ADL prognosis should be developed. To overcome this, many international studies have been conducted. Based on the SIAS (Stroke Impairment Assessment Set), FIM (Functional Independence Measure), and CT (computed tomography) findings on admission, Otsuka[1] estimated the total FIM score on discharge. Liu et al.[2] and Sonoda et al.[3] also predicted the total FIM score on discharge using scales for concomitant diseases in addition to these parameters. In the literature, Koyama et al.[4] estimated each FIM item using a logarithmic curve. Which ADL item is necessary depends on disabled persons' lives and social backgrounds. Even if patients show the same BI (Barthel Index) and total FIM scores, we cannot regard them as achieving similar outcomes in their daily lives. The ADL prognosis should be made with respect to individual items. We prepared a tool for making a prognosis in stroke patients regarding ADL, the "Stroke ADL Prognostic Assessment Set (SAPAS)", which makes it possible for all rehabilitation staff to simply make a prognosis regarding ADL in the initial phase of evaluation and assess individual ADL parameters, in order to establish objective, individualized ADL prognosis.

METHODS

[Aspects of SAPAS preparation]

In establishing the SAPAS, we prepared guidelines regarding various aspects. We considered that an ideal set for prognostic assessment could be prepared by summarizing the limitations of conventional methods to make an ADL prognosis and strategies to overcome them.

Aspect 1: As necessary ADL items depend on disabled persons' lives and social backgrounds, each ADL item should be assessed to make a prognosis.

Aspect 2: When making an ADL prognosis, "the timing of acquiring the ability" is also important; therefore, the maximum interval until amelioration should be estimated.

Aspect 3: Input variables should include necessary, minimum parameters of manifold stroke-related functional disorder[5]. A clinically acceptable method that facilitates simple assessment in a short period should be selected.

Aspect 4: Concerning target variables, evaluation methods in which the score interval is small, making it impossible to manage errors in the results of prediction, should be avoided. An evaluation method that facilitates the accurate evaluation of independent, with-help, and dependent, which may be the most important to make an ADL prognosis, must be employed.

Aspect 5: To make a prognosis regarding ADL associated with many motor/cognitive functions, statistical procedures to analyze the relationship should be employed.

Aspect 6: As the reference timing of prognostic assessment, the timing of the disappearance of the reversible influence of mass effects, brain edema, and penumbra on the brain[6] must be established. The timing of subject selection/variable measurement should also be considered from this aspect.

Table 1 Brain damage locus and the damage brain arteries of the subjects

Damage Artery	Damage Locus
Basilar A (11)	Pons (11)
Prefrontal A (1)	Frontal Lobe (47)
Anterior Parietal A (11)	Parietal Lobe (34)
Posterior Parietal A (11)	Temporal Lobe (32)
Precentral A (11)	Occipital Lobe (2)
Lenticulostriate A (90)	Corona radiata (55)
Superior cerebellar A (2)	Cerebellum (3)
Posterior inferior cerebellar A (1)	Watershed (6)
Thalamogeniculate A (36)	Thalamus (40)
Angular A (11)	Putamen (43)
Central A (15)	Posterior limb of
Anterior cereblral A (18)	internal capsule (2)
Middle Cerebral A (28)	
Recurrent artery of Heubner (1)	
medial striate A (5)	
anterior choroidal A (2)	
Temporo-occipital A (3)	
calcarine A (1)	
Premammillary A (2)	
Paramedian thalamic A (2)	
Posterior cerebral A (8)	
Anterior inferior cerebellar A (3)	
Insular A (1)	

Numerical Value in a parenthesis expresses a total of several.
"A" is abbreviation of Artery.

[Subjects]

The subjects were 210 primary stroke patients during rehabilitation, with an interval of 1 month or more after the onset of stroke[6], when the reversible influence on the brain early after onset may disappear based on Aspect 6. They consisted of 101 males and 109 females, with a mean age of 74±12 years. Cerebral infarction was observed in 144 patients, and cerebral hemorrhage in 66. The right brain was affected in 111 patients, and the left in 99. Sites of brain injury included the corona radiata, thalamus, and putamen (total: 11 sites). Blood vessels such as the lenticulostriate, thalamogeniculate, and central arteries were affected (total: 23 blood vessels) (Table 1).

[Methods]

Based on Aspect 3, we employed the SIAS and FIMC (FIM-Cognitive item) as input variables. Based on Aspects 2 and 4, we used the BI and interval from the onset until a plateau was reached as target variables. As basic information, gender, age, handedness, the affected side of the brain, and hemorrhage/infarction were also included in input variables. These measurements were continued once a month until a plateau was reached. However, we excluded patients with recurrent attacks during follow-up and those in whom rehabilitation was discontinued. For statistical analysis to induce a predictive model based on these input/target variables, we employed the NNW (Learning Internal Representation by Error Propagation of the Neural Network)[7], in which a single signal is output based on the relationship among several input signals, considering Aspect 5. To make an ADL prognosis with respect to BI items based on Aspect 1, we established a predictive model with respect to each item, and extracted individual prognostic factors regarding the ADL and factors for predicting the interval until amelioration. In addition, we calculated the influence (weight) of these factors on

prediction, and prepared a predictive model formula to facilitate automatic calculation via development on a spreadsheet. The formula is presented in Fig. 1. Concerning values calculated using this formula, we converted the FIMM (FIM-motor item) score into the BI score using the formula shown in Fig. 2, and examined the grade of BI to which the value corresponds based on the FIMM grading and contents. Thus, we prepared a conversion table between the calculated values and BI scores so that BI prediction might be possible.

For the measurement of variables, to avoid bias, the SIAS, FIMC, and BI were determined as a routine assessment without telling the examiners/examinees about the purpose. After the completion of measurement, the purpose and methods of their utilization were explained, and written informed consent was obtained. This study was conducted in accordance with the Helsinki Declaration, and the protocol was approved by the Ethics Review Boards of cooperative hospitals.

h1＝(Bias1)＋(Weight1×Predictive factor1)
　＋(Weight2×Predictive factor 2)＋・・・・・
H1＝tanh(h1)
h2＝(Bias 2)＋(Weight3×Predictive factor 1)
＋(Weight4×Predictive factor2)＋・・・・・
＋(Weight5×H1)
H2＝tanh(h2)
h3＝(Bias 3)＋(Weight6×Predictive factor 1)
＋(Weight7×Predictive factor 2)＋・・・・・
＋(Weight8×H1)＋(Weight9×H2)
H3＝tanh(h3)
OUT＝(Bias 4)＋(Weight6×Predictive factor 1)
＋(Weight7×Predictive factor 2)＋・・・・・
＋(Weight8×H1)＋(Weight9×H2)＋(Weight10×H3)
Predictive BI＝Transfer function f（OUT）

Fig. 1　Equation of Prognostic Predictive BI

Maximum BI score/6×FIMM－Maximum BI score/6＝BI

Fig. 2　Equation to convert FIMM into BI

RESULTS

As shown in Fig. 3, we prepared the SAPAS. For its usage, the basic information, SIAS, FIMC, BI, and interval from onset are measured 1 month or more after the onset of stroke, when the reversible influence on the brain early after onset may disappear. Subsequently, whether or not each item of the SIAS/FIMC can be ameliorated is evaluated based on the site of brain injury, localization of cerebral function, and cephalic CT/MRI (magnetic resonance imaging) findings. The maximum rate of improvement in the score for each item of the SIAS/FIMC is predicted. When these scores are input into the cell of a predictive model formula-developing spreadsheet, the prognosis regarding the BI and the maximum interval until amelioration are automatically indicated. The prognosis regarding the BI can be evaluated by converting calculated values to the BI score using the conversion table.

Concerning the prognostic precision regarding ADL, the adjusted coefficients of determination of feeding, transfers, grooming, toilet use, bathing, mobility, stairs, dressing, bowels, and bladder were 0.75, 0.75, 0.11, 0.63, 0.13, 0.59, 0.67, 0.53, 0.68, and 0.70, respectively, according to internal data on 30 patients. Based on external sample data on 30 patients, the values were 0.72, 0.70, 0.22, 0.58, 0.20, 0.76, 0.58, 0.72, 0.56, and 0.64, respectively (Figs. 4 and 5). No patient showed an interval until amelioration shorter than expected. The internal data were obtained from 30 patients randomly selected among the

Stroke ADL Prognostic Assessment Set: SAPAS
Ver.2.1

Name	
Diagnosis	
Medical Category	
Care Degree	

Initial Assessment Day	
Final Assessment Day	
Therapist	

Attention in Marking	
Sexuality	Male：0 Female：1
Handedness	Right：0 Left：1
Disorder side (Brain)	Right：0 Left：1
Hemorrhage /Infarction	Hemorrhage：0 Infarction：1
Finger-function test	0：0 1A：1 1B：2 1C：3 2：4 3：5 4：6 5：
U/E muscle tone	0：0 1A：1 1B：2 2：3 3：4
L/E muscle tone	0：0 1A：1 1B：2 2：3 3：4
U/E DTR (biceps or triceps)	0：0 1A：1 1B：2 2：3 3：4
L/E DTR (PTR or ATR)	0：0 1A：1 1B：2 2：3 3：4
Speech	0：0 1A：1 1B：2 2：3 3：4

No.	Assessment Items	Initial Actual Survey	Functional Prognostic	Arrival Actual Survey	Calculation Colum
Basic Information					Basic Information
1	Age				
2	Sexuality				
3	Handedness				
4	Disorder side (Brain)				
5	Hemorrhage/infarction				
SIAS					SIAS
6	Knee-mouth test				
7	Finger-function test				
8	Hip-flexion test				
9	Knee-extension test				
10	Foot-pat test				
11	U/E muscle tone				
12	L/E muscle tone				
13	U/E DTR (biceps or triceps)				
14	L/E DTR (PTR or ATR)				
15	U/E light touch				
16	L/E light touch				
17	U/E position				
18	L/E position				
19	U/E ROM				
20	L/E ROM				
21	Pain				
22	Verticality test				
23	Abdominal MMT				
24	Visuo-spatial deficit				
25	Speech				
26	Gripstrength				
27	Quadriceps MMT				
FIMC					FIMC
28	Comprehension				
29	Expression				
30	Sosial Interaction				
31	Problem Solving				
32	Memory				

Calibration Scale

Toilet Use

BI	FIMM	Calculation Value
10	6,7	8.34≦
5	2–5	1.67≦＜8.34
0	1	＜1.67

Feedinf, Stears, Dressing, Bowels, Bladder

BI	FIMM	Calculation Value
10	6,7	8.34≦
5	3–5	3.34≦＜8.34
0	1,2	＜3.34

Grooming, Bathing

BI	FIMM	Calculation Value
5	6,7	4.17≦
0	1–5	＜4.17

Transfers

BI	FIMM	Calculation Value
15	6,7	12.50≦
10	4,5	7.50≦＜12.50
5	3	5.00≦＜7.50
0	1,2	＜5.00

Mobility

BI	FIMM	Calculation Value
15	6,7	12.50≦
10	3–5	5.00≦＜12.50
0	1,2	＜5.00

ADL Prognostic Prediction

		Initial Actual Survey	Functional Prognostic	Arrival Actual Survey	ADL Prognostic Prediction
Feeding	BI				0.00
	FIMM(Reference)				
Transfers	BI				0.00
	FIMM(Reference)				
Grooming	BI				0.00
	FIMM(Reference)				
Toilet	BI				0.00
	FIMM(Reference)				
Bathing	BI				0.00
	FIMM(Reference)				
Mobility	BI				0.00
	FIMM(Reference)				
Stairs	BI				0.00
	FIMM(Reference)				
Dressing	BI				0.00
	FIMM(Reference)				
Bowels	BI				0.00
	FIMM(Reference)				
Bladder	BI				0.00
	FIMM(Reference)				

Longest Recovery Period(Month)				1

MEMO

Fig. 3 Stroke ADL Prognostic Assessment Set

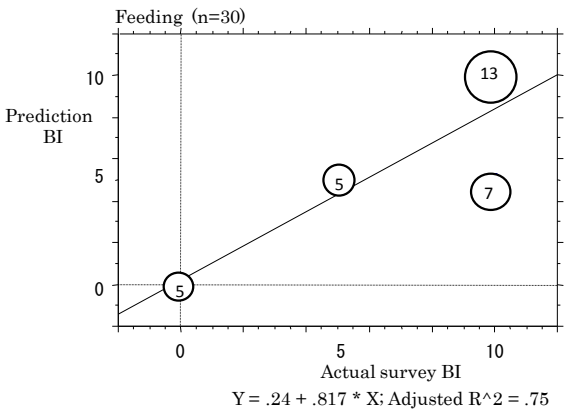

Fig. 4 Predictive precision of SAPAS in Feeding

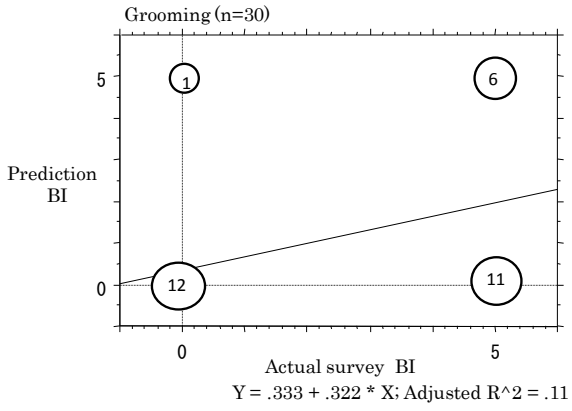

Fig. 5 Predictive precision of SAPAS in Grooming

subjects enrolled for SAPAS preparation. The external sample data were obtained from 30 patients in whom the SAPAS was actually used after its preparation. The determinant coefficient was calculated between the SAPAS-predicted and actual values in these patients.

DISCUSSION

The precision of making a prognosis regarding ADL is not high when evaluated based on the determinant coefficient. This is because the analysis of prognostic factors is insufficient. In this study, we established input variables under the following conditions: "Input variables should include necessary, minimum parameters of manifold stroke-related functional disorder. A clinically acceptable method that facilitates simple assessment in a short period should be selected." Therefore, items that should be selected as other important prognostic factors may be overlooked. Furthermore, the weight of prognostic factors regarding the preparation of a predictive model and calculated transmission function are included in parameters of NNW analysis. However, these should be additionally reviewed. Concerning BI items showing an extremely low precision of prediction, "grooming" and "bathing", there are only 2 assessment options: "independent" and "with help". The latter is frequently selected, leading to a bias in data. Concerning this, it must be confirmed whether or not under/over sampling to avoid a bias improves the precision of prediction. Furthermore, in the conversion table, the BI score is determined based on the FIMM grading and contents. Differences in evaluation criteria between the FIMM and BI may result in errors on calculation. With regard to this, the grade of BI to which the calculated value corresponds should be examined, and a unique conversion table must be prepared. Currently, a study is being conducted to overcome these limitations and improve the prognostic precision regarding ADL.

When employing the SAPAS, the SIAS, FIMC, and BI must be accurately measured. Currently, it is controversial whether or not therapists can accurately evaluate the SIAS, FIM, and BI. Furthermore, errors in input variables may also influence the precision of making a prognosis regarding ADL.

In addition, for such a prediction, therapists must make a functional prognosis regarding SIAS/FIMC tests. However, it is controversial whether or not the functional prognosis is accurately formulated based on scientific grounds. Therapists must not only present the SIAS/FIM scores, but also evaluate why the scores were obtained, considering the significance of examination and localization of the cerebral function, in order to provide appropriate treatment. In this sense, it may be straightforward for therapists to make an SIAS/FIMC functional prognosis. However, it should be reviewed whether the level of knowledge/techniques, including neurological knowledge and diagnostic imaging techniques, is sufficient to achieve this.

REFERENCES

1) Otsuka T: The contribution of brain CT findings in predicting stroke patients' prognosis for activities of daily living. Jpn J Rehabil Med 40: 443-452, 2003.
2) Liu M, Domen K, Chino N: Comorbidity measures for stroke outcome research: a preliminary study. Arch Phys Med Rehabil 78: 166-172, 1997.
3) Sonoda S, Chino N, Domen K, et al: Changes in impairment and disability from the third to the sixth month after stroke and its relationship evaluated by an artificial neural network. Am J Phys Med Rehabil 76: 395-400, 1997.
4) Koyama T, Matsumoto K, Okuno T, et al: A new method for predicting functional

recovery of stroke patients with hemiplegia: logarithmic modeling. Clin Rehabil 19: 779-789, 2005.
5) Chino N, Sonoda S, Domen K, et al: Stroke impairment assessment set (SIAS). In: Functional evaluation of stroke patients. (ed. by Chino N and Melvin JL), Springer-Verlag, Tokyo, pp.19-31, 1996.
6) Sakamaki M, Igarashi H, Nishiyama Y, et al: Effect of glycerol on ischemic cerebral edema assessed by magnetic resonance imaging. J Neurol Sci 15: 69-74, 2003.
7) Rumelhart DE: Learning internal representation by error propagation. Parallel distributed processing: Explorations in the microstructures of cognition 1: 318-362, 1986.