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PREDICTIVE VALIDITY OF THE SØDRING MOTOR EVALUATION OF STROKE PATIENTS (SMES)

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ABSTRACT. The Sødring Motor Evaluation of Stroke Patients (SMES) has been developed as an instrument for the evaluation by physiotherapists of motor function and activities in stroke patients. The predictive validity of the instrument was studied in a consecutive sample of 93 acute stroke patients, assessed in the acute phase and after one year. The outcome measures were: survival, residence at home or in institution, the Barthel ADL index (dichotomized at 19/20), and the Frenchay Activities Index (FAI) (dichotomized at 9/10). The SMES, scored in the acute phase, demonstrated a marginally significant predictive power regarding survival, but was a highly significant predictor regarding the other outcomes. The adjusted odds ratio for a good versus a poor outcome for patients in the upper versus the lower tertile of the SMES arm subscore was 5.4 (95% confidence interval 0.9–59) for survival, 11.5 (2.1–88) for living at home, 86.3 (11–∞) for a high Barthel score, and 31.4 (5.2–288) for a high FAI score. We conclude that SMES has high predictive validity.

Key words: assessment, cerebrovascular disorders, motor activity, physical therapy, prognosis, validity.

Motor deficits are present in most stroke patients (13), and a systematic assessment of stroke patients should include a motor evaluation. A method for evaluation of motor function and activities after stroke, the Sødring Motor Evaluation of Stroke Patients (SMES), has been developed for the fulfilment of two basic requirements: firstly, to fit in with the physiotherapeutic approach to stroke rehabilitation by being relevant and informative enough to be used as a tool for physiotherapists in their clinical work; secondly, to be sufficiently sensitive and clinimetrically sound for use in stroke research. None of the existing assessment methods for motor function in stroke (1, 2, 4, 7, 15, 16) were felt to fulfil both criteria. The main characteristics of the SMES are that the rating reflects quality as well as quantity of performance, and that it measures the patient's ability to carry out the activities unassisted. Assessment methods in which the patient is helped into position for the test, measure the patient's and the physiotherapist's effort in combination. Since the amount of assistance given is difficult to measure, we believe that such instruments will be less valid. The SMES has been thoroughly described elsewhere (25, 26).

In an earlier study (26) we explored the construct validity of the SMES in a sample of stroke patients, and compared the test results with those of the Birgitta Lindmark Motor Assessment (BL) (16). The BL method was chosen as comparator because it has structural similarities with the SMES, and has been validated. With some distinctive exceptions, we found a high degree of agreement between the two assessment methods. In this paper, we present the one-year follow-up of the patients, and examine the predictive validity of the SMES scored in the acute phase of stroke. We also compare the predictive validity with that of the BL.

MATERIALS AND METHODS

Ullevaal Hospital serves a defined population of approximately 175,000 people, and admits virtually all patients within this population who are hospitalized due to stroke. All stroke patients admitted during the period from 1 September 1992 to 28 February 1993 were registered prospectively. Criteria for inclusion were verified cerebral stroke according to the WHO definition (9) with onset not more than 14 days prior to admission, subarachnoid haemorrhage being excluded. The inclusion criteria were fulfilled by 165 patients. Of these, 16 died and four left the hospital before they had been assessed. A further 46 could not be evaluated due to an unstable medical condition, and six refused to participate. Thus, 93 patients (mean age 75 years, 48% women) took part in the study. Of these, 41 had a right hemisphere lesion, 50 a left hemisphere lesion, and two a brainstem stroke. Seven patients received a diagnosis of intracerebral haemorrhage and 79 one of cerebral infarction, whereas 7 cases remained unclassified. The stroke was a recurrent one in 16 patients and a first ever stroke in 69, whereas in 8 cases it was unknown whether the patient had suffered an earlier stroke. Fifty-four of the patients were admitted on the same day as the stroke occurred, 20 on the following day, and 18 after two or more days.

The patients were assessed by means of the SMES and the BL methods between the first and the ninth day (median 4 days) after admission. All assessments were made by the same physiotherapist (K.M.S.). The patients were then followed for one year. At the follow-up, 16 of the patients had died, a further 6 had suffered a new stroke, and 6 refused further participation. For the remaining 65, we assessed the degree of independence within the primary activities of daily living (ADL) by means of the Barthel index (18, 27), and social activities and instrumental ADL tasks by the Frenchay Activities Index (FAI) (10, 23). The same occupational therapist (U.S.) made all the Barthel scorings (by testing/observation) and the FAI scorings (by interview). A few patients did not complete all the tests, and some of the analyses are therefore based upon a lower number of patients.

The SMES has 32 items distributed on three subscales, measuring arm function (16 items), leg function (4 items), and functions and abilities concerning trunk, balance and gait (12 items). Eighteen of the items are scored 1/2/3/4/5, while the remaining 14, for clinimetrical reasons, are scored 1/3/5 (26). The ranges of the sumscores are 16–80 (arm), 4–20 (leg) and 12–60 (trunk, balance, gait); the highest sumscores indicating the best function. For analytical purposes, the sumscores were categorized according to tertiles.

The BL motor assessment (16, 17) is a modified version of the Fugl-Meyer scale (7), where each item has an ordinal scoring with four levels (0/1/2/3). The arm and leg part ("part A+B") of the BL has previously been evaluated regarding content, concurrent and predictive validity, and contains three subscales: arm tests, leg tests with the patient in supine or sitting position, and leg tests with the patient standing (17).

The Barthel index (18, 27), consisting of 10 items with a maximum sumscore of 20, was dichotomized at 19/20, thus dividing the population into those who were independent and those who were to any extent disabled in the primary ADL domains. Patients who died during the observation period were given a sumscore of zero on the Barthel index at follow-up.

We modified the FAI (10, 23) slightly by omitting the item "gardening", because a high percentage of our patients had no garden. The 14 remaining items were scored 0/1/2/3 according to the recommendations of Wade et al. (28), giving a sumscore ranging from 0 (inactive) to 42 (highly active). The sumscore was dichotomized at the median into the score groups of 0–9 and 10+. Deceased patients were given a zero sumscore.

We used exact statistical methods, i.e. methods based on the actual probability distribution of the data rather than on an approximation to this. This was done in order to handle the low number of cases and on account of the ordinal nature and skewed distribution of the data. We also constructed Receiver Operating Characteristics (ROC) curves for the predictive power of the SMES arm subscore as well as the BL arm subscore. A ROC curve illustrates the relationship between the sensitivity and specificity of a test at various cutpoints. A curve near the straight diagonal from the lower left to the upper right corner of the diagram means that the test is useless, while a curve approaching the upper left corner indicates high test credibility (22). Statistical analysis and data management were performed with the BMDP (6), LogXact (19), and Epi Info (5) programs.

RESULTS

The relationship between the SMES score in the acute phase and the outcome after one year was first evaluated by means of table analyses. The three subscales of the SMES were considered separately as explanatory variables. The results (Tables I–IV) are presented as the odds ratio (with exact 95% confidence interval) for a good versus a poor outcome after one year for patients with intermediate and high motor scores, respectively, when compared with the group with the

Table I. *Predictive validity of the Sødring Motor Evaluation of Stroke Patients (SMES) with respect to one-year survival*

		No. of patients		Bivariate analyses		Multivariate analyses	
Subscales	Score levels	Alive	Dead	OR	95% CI	OR	95% CI
Arm	64–80	26	2	6.5	1.2–65	5.4	0.9–59
	22–63	26	4	3.3	0.8–16	2.9	0.6–15
	16–21	20	10	ref.		ref.	
Leg	17–20	29	4	3.7*	1.1–12	3.6*	1.0–14
	13–16	25	3				
	4–12	21	10	ref.		ref.	
Trunk, balance and gait	30–60	21	2	4.3*	1.2–20	3.4*	0.9–16
	13–29	21	2				
	12	29	12	ref.		ref.	

Multivariate analyses with adjustment for the effect of age were performed by logistic regression with exact methodology. OR = odds ratio. CI = confidence interval.
* The medium and upper score groups were combined because they showed a nearly identical OR.

Table II. *Predictive validity of the Sødring Motor Evaluation of Stroke Patients (SMES) with respect to place of residence one year post-stroke*

		No. of patients		Bivariate analyses		Multivariate analyses	
Subscales	Score levels	Living at home	Not living at home	OR	95% CI	OR	95% CI
Arm	64–80	25	3	12.5	2.7–75	11.5	2.1–88
	22–63	23	7	4.9	1.4–17	4.4	1.1–19
	16–21	12	18	ref.		ref.	
Leg	17–20	28	5	7.8	2.1–31	10.7	2.2–67
	13–16	22	6	5.1	1.4–19	4.7	1.1–23
	4–12	13	18	ref.		ref.	
Trunk, balance and gait	30–60	21	2	} 14.8*	4.1–65	11.0*	2.7–57
	13–29	21	2				
	12	17	24	ref.		ref.	

Multivariate analyses with adjustment for the effect of age and gender were performed by logistic regression with exact methodology. OR = odds ratio. CI = confidence interval.
* The medium and upper score groups were combined because they showed an identical OR.

lowest score (reference group). The result is significant ($p<0.05$) if the 95% confidence interval does not include the value 1.0.

As can be seen from the bivariate analyses (Table I), a marginally significant relationship existed between placement in the highest score groups of the SMES, and the probability of survival after one year. Table II shows the odds of living at home one year post-stroke (versus being dead or permanently institutionalized). In the bivariate analyses, the SMES subscores predicted this outcome. Similar results were seen regarding the Barthel (Table III) and the FAI scores (Table IV).

Age is a predictor of outcome after stroke (20), and may therefore confound the results. We have also observed gender differences in stroke outcome that need to be adjusted for (Wyller T. B., Abstract no. 47 at the 8th Nordic Meeting on Cerebrovascular Disorders, Trondheim, Norway, 26–29 August 1995). The age (categorized into three bands, ≤ 69, 70–79, and ≥ 80) and gender variables were therefore entered into exact logistic regression analyses against the four outcomes, first separately and then simultaneously. Age had a statistically significant effect on all outcome variables, whereas gender had a significant independent effect on place of residence and Barthel score. We therefore performed multivariate analyses of the four outcomes by means of logistic regression, adjusting

Table III. *Predictive validity of the Sødring Motor Evaluation of Stroke Patients (SMES) with respect to score on Barthel's ADL Index one year post-stroke*

		No. of patients with Barthel sumscore		Bivariate analyses		Multivariate analyses	
Subscales	Score levels	20	0–19	OR	95% CI	OR	95% CI
Arm	64–80	20	6	10.0	3.0–36	86.3	11.7–∞
	22–63	13	12	} ref.*		31.3	4.3–∞
	16–21	0	27			ref.	
Leg	17–20	19	10	23.8	4.2–231	25.9	3.9–331
	13–16	12	13	11.5	2.0–115	11.2	1.7–135
	4–12	2	25	ref.		ref.	
Trunk, balance and gait	30–60	17	5	119.0	12–5103	69.4	6.9–3845
	13–29	11	7	55.0	5.7–2430	55.3	4.8–3418
	12	1	35	ref.		ref.	

Multivariate analyses with adjustment for the effect of age and gender were performed by logistic regression with exact methodology. OR = odds ratio. CI = confidence interval.
* The lower and medium score groups were combined to avoid empty cells.

Table IV. *Predictive validity of the Sødring Motor Evaluation of Stroke Patients (SMES) with respect to score on the Frenchay Activities Index (FAI) one year post-stroke*

Subscales	Score levels	No. of patients with FAI sumscore		Bivariate analyses		Multivariate analyses	
		10–42	0–9	OR	95% CI	OR	95% CI
Arm	64–80	21	4	40.3	6.7–282	31.4	5.2–288
	22–63	14	11	9.8	2.0–60	8.7	1.7–64
	16–21	3	23	ref.		ref.	
Leg	17–20	20	7	15.7	3.4–80	18.5	3.5–139
	13–16	13	12	6.0	1.4–29	5.9	1.2–36
	4–12	4	22	ref.		ref.	
Trunk, balance and gait	30–60	18	2	69.8	9.7–725	39.9	6.2–486
	13–29	11	7	12.2	2.5–65	12.2	2.5–79
	12	4	31	ref.		ref.	

Multivariate analyses with adjustment for the effect of age were performed by logistic regression with exact methodology. OR = odds ratio. CI = confidence interval.

for the effect of age in all the analyses and for the effect of gender where appropriate. The three score-levels of the explanatory variables were recoded into two dummy variables, as recommended by Hosmer & Lemeshow (11), and the intermediate and high score groups were compared with the lowest one.

The subscales of the SMES demonstrated a predictive power of marginal statistical significance regarding survival when age was adjusted for (Table I). The multivariate analyses demonstrated a strong ability for the SMES to predict living at home (Table II). The predictive power was especially high regarding independence in ADL after one year (Table III). As shown in Table IV, all the subscores predicted instrumental ADL/social activities measured by FAI.

The ROC curves for the ability of the arm subscores of the SMES and the BL to predict the four outcomes are presented in Figs. 1–4. The areas under the ROC curves for the SMES arm subscore are larger than those for the BL arm subscore, showing that the SMES predicted the four outcomes more accurately (22). In the acute phase, a distinct group of 11 patients achieved a relatively high BL score (BL arm subscore 15–55) and a low SMES score (SMES arm subscore ≤26) (26). The ROC curves were replotted after exclusion of these patients, and this caused the ROC curves for the two methods to become almost identical (curves not shown).

DISCUSSION

We have evaluated the ability of SMES in the acute phase to predict the one-year outcome of an unselected group of hospitalized stroke patients (patients with recurrent strokes as well as patients with first ever stroke). In other studies, motor function has been demonstrated to predict survival (8, 24, 29) and ADL function (3, 8, 14, 21, 24). Accordingly, such a predictive ability should be expected for a new instrument for motor assessment. In addition, we included place of residence and FAI score as outcome variables. Together, the four outcome variables cover a broad spectrum of clinically relevant endpoints.

According to the ICIDH-model of WHO (12), the

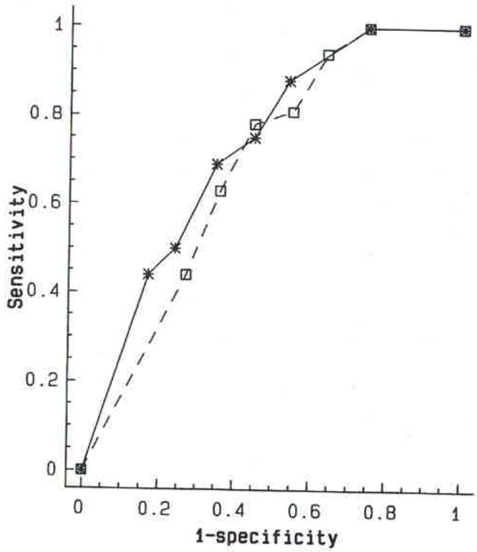

Fig. 1. Receiver Operating Characteristic (ROC) curve for the prediction of one-year survival. Continuous line: SMES arm subscore. Dashed line: BL arm subscore.

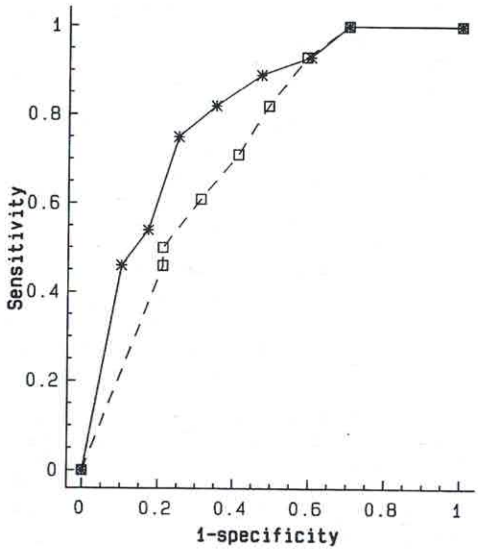

Fig. 2. Receiver Operating Characteristic (ROC) curve for the prediction of place of residence after one year. Continuous line: SMES arm subscore. Dashed line: BL arm subscore.

arm and leg parts of the SMES should be considered mainly as measures of impairment, while the trunk/balance/gait part mainly contains disability items. The Barthel index is a typical measure of disability, while the FAI covers aspects of disability as well as handicap (23). From this theoretical point of view, we would

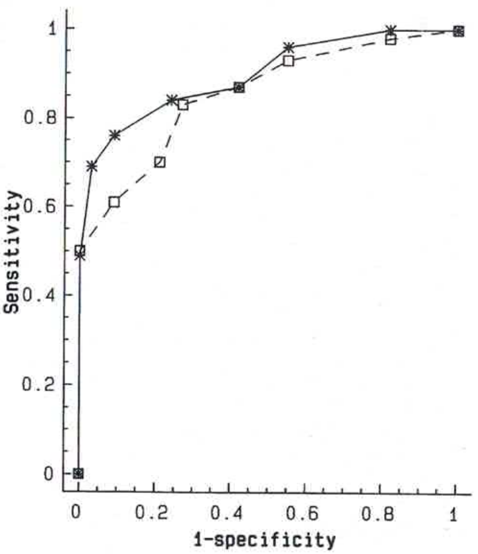

Fig. 3. Receiver Operating Characteristic (ROC) curve for the prediction of the Barthel sumscore (dichotomized at 19/20) after one year. Continuous line: SMES arm subscore. Dashed line: BL arm subscore.

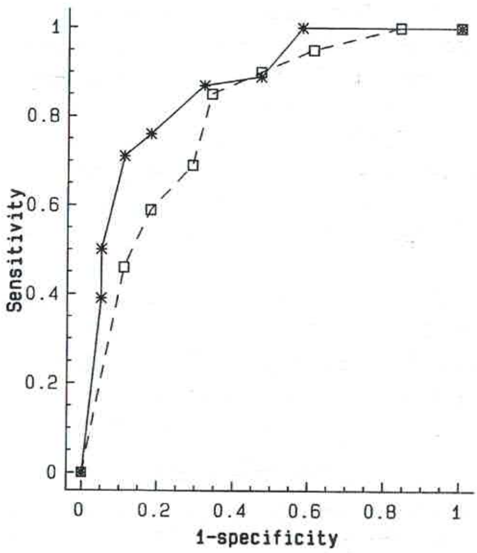

Fig. 4. Receiver Operating Characteristic (ROC) curve for the prediction of the FAI sumscore (dichotomized at 9/10) after one year. Continuous line: SMES arm subscore. Dashed line: BL arm subscore.

claim that the SMES predicts outcomes classified on higher functional levels.

The predictive power of the SMES was generally high, except for survival. The survival analyses have low power due to a small number of events, but even in this domain a consistent trend in the expected direction was found. The predictive power was particularly strong regarding the Barthel sumscore.

Our sample size was limited, and only 56% of the stroke patients could be included in the study. The procedure for inclusion was, however, prospective, and most of the exclusions were due to early death and patients being unassessable because they were medically unstable. Such exclusions are probably unavoidable when patients are to be tested during the first few days after a stroke. We are confident that the sample is representative of hospitalized stroke patients who are assessable in the acute phase. The confidence interval estimates were wide, but most of the results are nevertheless statistically highly significant.

The predictive power of the SMES was somewhat stronger than that of the BL (Figs. 1–4). One important difference between these two methods is that in the BL, but not in the SMES, the patient may be helped into the test position. This difference presumably explains the distinct group of patients with a relatively low SMES score and a relatively high BL score. For subjects unable to get into a sitting position unassisted, the SMES comes to a stop when the items performed in the lying position have been carried out (26). Exclusion of such discrepant cases from the material made the predictive accuracy of the two instruments nearly equal, indicating that the higher predictive power of SMES is, in part, attributable to the fact that this instrument evaluates unassisted movements only.

In conclusion, we find that the SMES, scored in the acute phase of stroke, demonstrates a strong ability to predict return home, independence in primary and instrumental ADL, and social function after one year.

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