The European Stroke Scale

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Background and Purpose For detecting therapeutic effect and matching of treatment groups in stroke trials, a scale that meets the clinimetric criteria is of the utmost importance.

Methods The European Stroke Scale consists of 14 items selected for their specificity and their prognostic value. It is designed for patients with middle cerebral artery stroke. Interrater reliability, internal consistency, and time for completion were investigated in 74 patients. Intrarater reliability was studied in 38 patients. To establish concurrent validity, two trials were performed in 20 and 44 patients. The scale was correlated with the MCA Neurological Scale, the Canadian Stroke Scale, the Scandinavian Stroke Scale, the Barthel Index, and the Rankin Scale. Correlations were calculated by means of Spearman's correlation coefficient. The trial in 44 patients also investigated the prognostic validity of the scale for 1-month and 8-month neurological, functional, and handicap status. These data were analyzed by linear regression.

Results Interrater (κ value range, 0.62 to 0.85) and intrarater (κ value range, 0.65 to 1.00) reliability for each item was good, and internal consistency was excellent (Cronbach's α coefficient, 0.92). Mean time for completion was 8.2 minutes (range, 4 to 14 minutes). Correlations of the European Stroke Scale with other neurological scales ranged from 0.93 to 0.95. The correlation with the Barthel Index and the Rankin Scale was 0.84 and −0.86. The R^2 values for prognostic validity ranged from 0.45 to 0.81 ($P \leq .0001$).

Conclusions The European Stroke Scale has been developed according to the clinimetric criteria. (***Stroke*. 1994;25:2215-2219.**)

Key Words • cerebrovascular disorders • prognosis • stroke assessment

A number of interesting compounds are currently being developed for the short-term treatment of stroke, and several controlled studies are in progress or are planned in patients with middle cerebral artery (MCA) strokes. The use of a stroke scale that meets all the clinimetric criteria is of major importance in the analysis of these trials. The neurological scale should meet the following criteria.

(1) The items that compose the scale should be specific and be prognostic for outcome. Specificity is necessary for the relevance of a scale. Items that are rarely encountered should not be included. Prognostic value of the scale is required to stratify the patients before randomization or to classify them in a subset analysis in terms of likely prognosis for outcome. The best established predictors of outcome are level of consciousness, motor strength, gaze paresis, visual field deficits, and some aspects of postural control and language.[1]

(2) The scale should be reliable. Reliability is defined as intrarater and interrater reliability and internal consistency. Interrater reliability is best expressed with a coefficient of concordance. The kappa statistic quantifies the agreement over and above that expected by chance alone. A $\kappa \geq 0.60$ is considered a good level of reliability.[2] Internal consistency can be checked by a calculation of Cronbach's α coefficient.[3] Values are considered "good" if $\alpha \geq 0.80$.

(3) The scale should be valid. Three types of validity can be addressed: criterion, content, and construct validity.[4,5] Criterion validity is determined by whether the neurological scale can be used to estimate the current clinical status (concurrent validity) and to predict the future status (predictive validity) of the patient. Content validity is indicated by the extent to which a scale includes all the relevant dimensions of what is being measured.[6] Statistical methods should not be used for its calculation.[4] Construct validity can be demonstrated by examination of the relations between the neurological scales and other tests to show whether they measure the same construct (convergent validity) or not (discriminant validity). In view of the paucity of evidence that neurological deficit after stroke can be represented in a stroke scale as a single construct, the importance of this type of validity is debatable.[7]

The motor part of the scale should be validated separately because the specific effect of a compound on motor recovery is often targeted. Concurrent validity is best assessed by comparison with a sensitive, reliable, and valid motor scale that is based on the normal pattern of recovery after stroke: the Brunnstrom Fugl-Meyer Scale.[8] This scale evaluates both the strength and quality of movement (whether or not the movement is completely isolated).

(4) The scale should be sensitive. The different scores should cover the whole range (normal to maximal deficit) of the item, even when the scale is designed for

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The European Stroke Scale

LEVEL OF CONSCIOUSNESS		
- alert, keenly responsive		☐ 10
- drowsy, but can be aroused by minor stimulation to obey, answer or respond		☐ 8
- requires repeated stimulation to attend, or is lethargic or obtunded, requiring strong or painful stimulation to make movements		☐ 6
- cannot be roused by any stimulation, does react purposefully to painful stimuli		☐ 4
- cannot be roused by any stimulation, does react with decerebration to painful stimuli		☐ 2
- cannot be roused by any stimulation, does not react to painful stimuli		☐ 0
COMPREHENSION		
Verbally give the patient the following commands:		
1. Stick out your tongue	- patient performs 3 commands	☐ 8
2. Put your finger (of the unaffected side) on your nose	- patient performs 2 or 1 commands	☐ 4
3. Close your eyes	- patient does not perform any command	☐ 0
Important: Do not demonstrate!		
SPEECH		
The examiner makes a conversation with the patient (how is the patient feeling, did he/she sleep well, for how long has the patient been in hospital,...)	- normal speech	☐ 8
	- slight word-finding difficulties, conversation is possible	☐ 6
	- severe word-finding difficulties, conversation is difficult	☐ 4
	- only yes or no	☐ 2
	- mute	☐ 0
VISUAL FIELD		
The examiner stands at arm's length and compares the patients field of vision by advancing a moving finger from the periphery inwards. The patient must fixate on the examiners pupil. (First with one and then with the other eye closed)	- normal	☐ 8
	- deficit	☐ 0
GAZE	- normal	☐ 8
The examiner steadies the patients head and asks him/her to follow his finger.	- median eye position, deviation to one side impossible	☐ 4
The examiner observes the resting eye position and subsequently the full range	- lateral eye position, return to midline possible	☐ 2
of movements by moving the indexfinger from the left to the right and vice versa.	- lateral eye position, return to midline impossible	☐ 0
FACIAL MOVEMENT		
The examiner observes the patient as he/she talks and smiles, noting any asymmetrical	- normal	☐ 8
elevation of one corner of mouth, flattening of nasolabial fold. Only the muscles in the	- paresis	☐ 4
lower half of the face are assessed.	- paralysis	☐ 0
ARM (maintain outstretched position)		
The examiner asks the patient to close the eyes and actively lifts the patient's arms	- arm maintains position for 5s	☐ 4
into position so that they are outstretched at 45° in relation to the horizontal plane with	- arm maintains position for 5s, but affected hand pronates	☐ 3
both hands in mid-position so that the palms face each other. The patient is asked to	- arm drifts before 5s pass and maintains a lower position	☐ 2
maintain this position for 5s after the examiner withdraws the arms. Only the affected	- arm can't maintain position but attempts to oppose gravity	☐ 1
side is evaluated.	- arm falls	☐ 0
ARM (raising)	- normal	☐ 4
The patients arm is rested next to the leg with the hand in mid-position.	- straight arm, movement not full	☐ 3
The examiner asks the patient to raise the arm outstretched to 90°.	- flexed arm	☐ 2
	- trace movements	☐ 1
	- no movement	☐ 0
EXTENSION OF THE WRIST	- normal (full isolated movement, no decrease in strength)	☐ 8
The patient is tested with the forearm supported and the hand unsupported,	- full isolated movement, reduced strength	☐ 6
relaxed in pronation. The patient is asked to extend the hand.	- movement not isolated and/or full	☐ 4
	- trace movements	☐ 2
	- no movement	☐ 0
FINGERS		
The examiner asks the patient to form with both hands and as strongly as possible	- equal strength	☐ 8
a pinch grip with the thumb and forefinger and to try to resist a weak pull.	- reduced strength on affected side	☐ 4
The examiner checks the strength of this grip by pulling the pinch with one finger.	- pinch grip impossible on affected side	☐ 0
LEG (maintain position)	- leg maintains position for 5 s	☐ 4
The examiner actively lifts the patient's affected leg into position so that the thigh forms	- leg drifts to intermediate position by the end of 5 s	☐ 2
an angle of 90° with the bed, with the shin parallel with the bed. The examiner asks the	- leg drifts to bed within 5 s, but not immediately	☐ 1
patient to close the eyes and to maintain this position for 5 s without support.	- leg falls to bed immediately	☐ 0
LEG (flexing)	- normal	☐ 4
The patient is in supine position with the legs outstretched. The examiner asks the	- movement against resistance, reduced strength	☐ 3
patient to flex the hip and knee.	- movement against gravity	☐ 2
	- trace movements	☐ 1
	- no movement	☐ 0
DORSIFLEXION OF THE FOOT	- normal (leg outstretched,full movement,no decrease in strength)	☐ 8
The patient is tested with the leg outstretched. The examiner asks the patient	- leg outstretched, full movement, reduced strength	☐ 6
to dorsiflex the foot.	- leg outstretched, movement not full or knee flexed or foot in supination	☐ 4
	- trace movements	☐ 2
	- no movement	☐ 0
GAIT	- normal	☐ 10
	- gait has abnormal aspect and/or distance/speed limited	☐ 8
	- patient can walk with aid	☐ 6
	- patient can walk with the physical assistance of one or more persons	☐ 4
	- patient cannot walk, but can stand supported	☐ 2
	- patient cannot walk nor stand	☐ 0

The European Stroke Scale (facing page), designed for clinical stroke trials in patients with middle cerebral artery stroke, consists of 14 items selected for their specificity and prognostic value.

patients with a specific degree of deficit. Because the proximal and distal parts of a limb recuperate independently of one another, motor status needs to be graded separately.

(5) The scale should be easy to use. Given the urgent situation in which the scale needs to be completed and the frequency of the assessments, it must be possible to administer the scale within 15 minutes.

The European Stroke Scale (ESS) was designed for clinical stroke trials in patients with an MCA stroke (Figure). This scale can be used as an instrument for matching of treatment groups as well as for evaluation of the patient's level of impairment. The scale consists of 14 items selected on the basis of their specificity and their prognostic value. The 14 items are level of consciousness, comprehension, speech, visual field, gaze, facial movement, maintainence of arm position, arm raising, wrist extension, finger strength, maintainence of leg position, leg flexing, foot dorsiflexion, and gait. Because gait is part of the standard clinical neurological evaluation and can be considered as a mixture of different prognostic levels of impairments (ie, proximal and distal motor function of the leg, postural control), this item was included in the scale. This item is not evaluated as a function (eg, ability of the patient to walk 50 m or shift to the bed). This scale is heavily weighted toward motor function. The reliability, validity, sensitivity, and time needed to complete the EES are described below.

Subjects and Methods

Interrater reliability, internal consistency, and time needed to perform the ESS were investigated in 74 patients (41 women and 33 men). Mean age was 69.1 years (range, 19 to 89 years). The stroke had occurred on average 12.5 days before the assessments were made (range, 0 to 68 days). Five centers participated, mimicking the circumstances of a multicenter trial. Each patient was assessed independently by two neurologists with experience in stroke trials. The interval between the two evaluations was less than 3 hours. The ESS forms were filled out by the examiners during and/or immediately after the evaluation. The patients were not discussed afterward. The time needed to perform the ESS was recorded. For each item, interrater reliability was measured in terms of kappa statistics. The internal consistency of the scale was calculated by means of Cronbach's α coefficient.

Intrarater reliability was investigated in 38 patients (23 men and 15 women). Mean age was 68.5 years (range, 46 to 84 years). The interval between the two evaluations ranged between 1 to 2 hours. For each item, intrarater reliability was measured in terms of kappa statistics.

Concurrent validity and sensitivity of the ESS were investigated in 20 patients (10 women and 10 men; mean age, 69.5 years; range, 53 to 79 years) from four centers. Each patient was evaluated according to both the ESS and the MCA Neurological Scale (MCANS)[9-12] daily for the first 8 days after stroke onset and on day 28. The first evaluation was completed within 6 hours after stroke onset. One hundred seventy-three paired assessments were performed. The correlation between ESS and MCANS was calculated by means of Spearman's correlation coefficient. The sensitivity of the ESS was compared with the sensitivity of the MCANS by means of the number of steps registered (ie, different total scores) during the 28-day observation period and by a comparison of the number of patients with maximal score.

TABLE 1. Value* for Each Item of the European Stroke Scale

	κ	
Item	**Intrarater**	**Interrater**
Level of consciousness	†	0.69
Comprehension	†	0.72
Speech	0.82	0.79
Visual field	1.00	0.85
Gaze	0.65	0.81
Facial movement	0.94	0.62
Arm position, maintain	0.86	0.72
Arm raising	0.90	0.65
Wrist extension	0.82	0.77
Finger strength	0.69	0.78
Leg position, maintain	0.67	0.71
Leg flexing	0.70	0.69
Foot dorsiflexion	0.73	0.64
Gait	0.87	0.78

*Weighted.
†No κ value; all patients were scored identically.

The concurrent and prognostic validities and the sensitivity of the ESS were investigated in a study in 44 patients (18 women and 26 men; mean age, 69.6 years; range, 46 to 84 years). Each patient was evaluated according to the ESS, the Canadian Neurological Scale (CNS),[5,6,13] the MCANS, the Scandinavian Stroke Scale (SSS),[14-17] the Brunnstrom Fugl-Meyer Scale, the Barthel Index,[18] and the Rankin Scale[19] at 3 days after stroke and at months 1 and 8. In total, 128 combined evaluations were performed. The correlation between the ESS and the other scales was calculated by means of Spearman's correlation coefficient. The sensitivity of the ESS was evaluated by a comparison with the sensitivity of the other neurological scales by means of the number of steps registered and by a comparison of the number of patients with maximal score. The concurrent validity of the motor part of the ESS was investigated by correlation of the total motor score of the ESS with the Brunnstrom Fugl-Meyer score. The prognostic validity of the ESS score and the ESS motor score for 1-month and 8-month outcomes (ie, ESS score, ESS motor score, Barthel score, and Rankin score) was investigated by means of a linear regression analysis. The R^2 value measures the extent to which changes in one variable can be explained by changes in another.

In all trials, only patients with an ischemic stroke in the territory of the MCA were included. Patients with stupor or coma or suffering from diseases that could interfere with the assessments (eg, depression, dementia) were excluded from the study. All patients or relatives of the patients gave their consent for participation.

Results

Interrater reliability, intrarater reliability, and internal consistency. The kappa values for the interrater reliability for the different items ranged from 0.62 to 0.85; for the intrarater reliability these values ranged from 0.65 to 1.00 (Table 1).

TABLE 2. Prognostic Validity of the European Stroke Scale as Expressed by a Linear Regression Coefficient (R^2 values)

	Outcome*	
	1 Month	8 Months
ESS score for		
ESS score	0.79	0.70
Barthel score	0.62	0.57
Rankin score	0.55	0.45
ESS motor score for		
ESS motor score	0.81	0.75
Barthel score	0.59	0.56
Rankin score	0.54	0.51

*$P \leq .0001$.

The internal consistency of the scale was reflected by a Cronbach's α of 0.92.

Time needed to complete the ESS. The average time needed to evaluate a patient was 8.2 minutes (range, 4 to 14 minutes).

Concurrent validity and sensitivity of the ESS versus other neurological scales. In the 4-week trial, Spearman's rank correlation coefficient between the ESS and MCANS was 0.95. In the 8-month trial, Spearman's rank correlation coefficients between the ESS and the other neurological scales were 0.93 (CNS), 0.95 (MCANS), and 0.94 (SSS).

The mean±SE number of steps registered in the 4-week recuperation of the patients was 4.6±1.5 for the ESS and 2.8±1.4 for the MCANS. Of the 63 evaluations that were scored maximally (ie, 100) with the MCANS, 27 (42.8%) were given less than the maximum score on the ESS. The corresponding ESS scores ranged from 82 to 99.

The mean±SE numbers of steps registered for the total neurological scores in the 8-month trial were 1.5±0.6 for the CNS, 1.8±0.5 for the ESS, 1.3±0.5 for the MCANS, and 1.8±0.5 for the SSS. Of the assessments that were scored maximally on the CNS (n=18), the MCANS (n=34), and the SSS (n=17), 55.5%, 29.4%, and 52.9% were scored maximally on the ESS, respectively. Of the patients who had the maximal score on the ESS (n=10), 100%, 100%, and 90% of the patients had a maximal score on the CNS, the MCANS, and the SSS, respectively.

Concurrent validity of the ESS versus the Barthel Index and the Rankin Scale. The correlation coefficients of the ESS score with the Barthel Index and the Rankin Scale scores were 0.84 and −0.86.

Concurrent validity of the motor part of the ESS. The correlation coefficient of the motor ESS score with the Brunnstrom Fugl-Meyer score was 0.92.

Prognostic validity of the ESS. The R^2 values of the ESS score for the outcome parameters ranged from 0.45 to 0.79 (Table 2). For the ESS motor score these values ranged from 0.51 to 0.81. For all values, probability was less than or equal to .0001.

Discussion

The ESS was designed as a new stroke scale to be used in MCA stroke trials. This scale fulfills the clinimetric criteria of a good stroke scale: the items are fully described and are specific for a particular type of stroke (in this case, MCA stroke). The scale is reliable, sensitive, and easy to use and has prognostic value for outcome. Its concurrent validity was tested in terms of correlation with other neurological scales and with a motor, functional, and handicap scale. The high correlation coefficients with other scales indicate a high concurrent validity.

The ESS can be compared with the major existing stroke scales: the CNS,[5,6,13] the NIH Stroke Scale (NIHSS),[20,21] the Copenhagen Stroke Scale (CSS),[22] the Mathew Scale (MS),[13,23-25] the MCANS,[9-12] the SSS,[14-17] the Toronto Stroke Scale (TSS),[13,26,27] and the Hemispheric Stroke Scale (HSS).[28] Only the MCANS, NIHSS, HSS, and ESS indicate the type of stroke for which the scale was intended. All items in the ESS have prognostic value. The MCANS, CNS, SSS, and CSS also give attention to items with prognostic value; however, the MCANS and CNS both omit certain important prognostic factors, such as visual field defects. The scoring system in the ESS used to assess visual field was limited for sensitivity. This made "visual field" reliable enough (ie, $\kappa > 0.60$) to be included. Only the MCANS, CNS, NIHSS, and ESS give full descriptions of how the evaluations should be carried out. Many of the scales show profound deficiencies in their reliability. Because the interrater reliability of many stroke scales either has not been investigated or has been expressed by means of a percentage agreement or a correlation coefficient, the kappa statistic values on interrater reliability for the ESS can be compared only with data for the MS, the SSS, the CNS, and the NIHSS (Table 3). Only the SSS

TABLE 3. Overview of Neurological Scales for Which Interrater Reliability Was Determined by κ Value

	Mathew Scale	Scandinavian Stroke Scale	Canadian Neurological Scale	NIH Stroke Scale	European Stroke Scale
No. of patients	12	50	9/144*	24 (trial I) 20 (trial II)	74
Range of κ values	0.00-0.91	0.68-0.91	0.54-1	0.49-0.95 (trial I) −0.16-0.79 (trial II)	0.62-0.85
No. (percentage) of items with $\kappa \leq 0.60$	10 (77%)	0 (0%)	1 (11%)	7 (47%) (trial I) 8 (62%) (trial II)	0 (0%)

*The number of pairwise evaluations differs for the different items.

and the ESS have acceptable data available (κ>0.60) for all items.

The internal consistency of the ESS was excellent (α=0.92). For the other stroke scales, data on the internal consistency are available for the MS (α=0.54), the TSS (α=0.72), the CNS (α=0.79), and the HSS (α=0.88).

The sensitivities of many of the scales are inadequate. In the SSS, changes in the level of consciousness and language cannot be registered during the period following the start of the trial. The CNS gives only a 2-point rating scale to level of consciousness, so deterioration (from drowsiness to coma, for example) cannot be registered. The ESS is a sensitive scale with score possibilities covering the whole range of possible neurological deficits. Only the MCANS, CNS, HSS, and ESS distinguish between the proximal and distal parts of arms and legs. All the other scales assess each limb as a whole. With the exception of the SSS and the ESS, none of the scales consider qualitative as well as quantitative aspects of limb movements.

In a direct comparison, the ESS was found to be more sensitive than the MCANS, the CNS, and the SSS in that it distinguished a greater number of steps in the patient's neurological recuperation and/or gave fewer patients the maximum score.

The TSS requires longer than 10 to 15 minutes to perform because it includes items such as dementia. The HSS requires 15 to 30 minutes because of its large number of items. The other scales are all easy to perform and can be completed within 10 to 15 minutes. The average time needed for a patient to be evaluated with the ESS (8.2 minutes) indicates that this scale is also easy to use.

In conclusion, we offer the ESS as a new stroke scale to be used in MCA stroke trials. This scale meets the clinimetric criteria for a good scale.

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