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Sensitivity of different ADL measures to apraxia and motor impairments

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Objective: To determine whether specifically designed activities of daily living (ADL) observations can measure disability due to apraxia with more sensitivity than the Barthel ADL Index, a conventional functional scale. **Design:** Cross-sectional study. **Setting:** Rehabilitation centres and nursing homes. **Subjects:** One hundred and six left hemisphere stroke patients with apraxia, hospitalized in rehabilitation centres and nursing homes. **Measures:** ADL observations, Barthel ADL Index, an apraxia test, Motricity Index, Functional Motor Test. **Results:** Multivariate analyses showed that the specific ADL observations were associated with severity of apraxia (and not with motor impairments). The Barthel ADL Index was associated with motor impairments (and not with severity of apraxia). **Conclusion:** The assessment of disability in stroke patients with apraxia cannot rely only on the Barthel ADL Index. In addition, the specific ADL observation procedure is needed to measure disability due to apraxia.

INTRODUCTION

Stroke is an important cause of morbidity in the elderly, resulting not only in physical impairments but also significant cognitive impairments.¹ These impairments, both physical and cognitive, influence functional ability after stroke.¹⁻⁵

Several scales (e.g. the Barthel ADL Index) have been developed to measure patients' functional ability and level of independence. These functional scales generally focus on basic activities of daily living (ADL) that healthy adults are required to perform, such as self-care, sphincter control and ambulation.^{2,6} Although these scales are valuable in assessing rehabilitation outcome for different categories of patients, it can be questioned whether these scales are sensitive to disability as a result of the patients' cognitive impairments.^{2,7,8} Cognitive impairments may affect functional activity in a way that is not adequately measured by conventional functional scales, which are biased towards the assessment of physical disability.

Apraxia is a common cognitive impairment after a left hemisphere stroke that influences ADL performance directly, and of specific interest is in this context.^{4,5,9-11} Apraxia is the inability to carry out learned and purposeful activities. This inability cannot be explained by primary motor or sensory impairments, or deficits in motivation, memory or comprehension.^{9,11} Because conventional functional scales are not expected to appropriately measure disability due to apraxia, van Heugten *et al.*^{12,13} developed an assessment procedure that specifically addresses disability as a consequence of apraxia. In this procedure the performance of standardized ADL tasks (e.g. washing the face and upper body,

putting on a blouse or shirt) is observed and scored for independence and specific deficits in performance (initiation, execution, control).^{12,13} Their study on the validity of this procedure showed a strong association between a neuropsychological test of apraxia and the ADL observations. Furthermore, they found that motor impairments were closely related to the Barthel ADL Index and less so to the ADL observations.¹³ These findings suggest that the ADL observations indeed measure disabilities which are due to apraxia; in addition, it seems that the Barthel ADL Index measures disability due to motor impairments and not disability due to apraxia. The study by van Heugten *et al.* was, however, based on a relatively small sample of patients ($n = 45$). Hence, replication of these findings in a new and larger patient population is needed. A replication would significantly contribute to our knowledge of the assessment of disabilities in daily activities after stroke.

The aim of the current study was to determine whether the specifically designed ADL observations are able to measure disability due to apraxia with more sensitivity than the Barthel ADL Index, a conventional functional scale. It was expected that:

1. severity of apraxia was strongly associated with the ADL observations but less so with the Barthel ADL Index
2. motor impairments were strongly associated with the Barthel ADL Index and less so with the ADL observations.

METHODS

Patients

Patients were selected by occupational therapists to participate in a randomized clinical trial into the effectiveness of strategy training in left hemisphere stroke patients with apraxia (November 1996–July 1999). Forty-nine institutions (15 rehabilitation centres and 34 nursing homes) in the Netherlands participated in the study. The patient inclusion criteria were: (1) a left hemisphere stroke, (2) apraxia and (3) staying on an inpatient care unit. Exclusion criteria were: (1) a history of apraxia before current stroke; (2) stroke had occurred less than four weeks or more than two years ago; (3) age younger than 25 years or older than 95 years; (4) a history of traumatic brain damage in combination with a period of coma lasting longer than 15 minutes or a period of post-traumatic amnesia existing longer than two hours; (5) a history of brain tumour; (6) no working knowledge of the Dutch language; (7) premorbid or present pathologies such as: a psychiatric or psycho-geriatric history, addiction to alcohol, medical or other drugs; (8) premorbid personality, intellectual or learning disorders; (9) a history of serious consciousness impairments; and (10) the treating physician, the occupational therapist and/or the patient did not judge the treatment of apraxia to be necessary.

A left hemisphere stroke was diagnosed when acute clinical symptoms of a focal dysfunction of the left hemisphere were present; when these signs and symptoms lasted at least 24 hours, and when there was no other than a vascular origin.¹⁴ The diagnosis of apraxia consisted of two steps. First, a clinical diagnosis of apraxia was made by the patient's treating medical team. The patient was diagnosed as apraxic if (a) the patient showed an inability (or restriction in ability) to carry out purposeful activities and (b) this inability was not the result of a primary motor or sensory impairment, or deficit of comprehension or motivation.^{9,11} Second, before the final inclusion in the study, patients were tested for apraxia with a recently developed neuropsychological apraxia test¹⁵ by a trained researcher. Patients who showed no or minimal apraxic symptoms on this test (score above 87; see measurement section) were excluded from the study. All patients (and their families) received verbal and written information about the study and gave verbal as well as written consent to participate.

From 139 patients selected by the occupational therapists, 26 patients were eventually not included in the randomized clinical trial because they scored above 87 on the apraxia test ($n = 13$), withdrew their consent ($n = 5$) or were discharged from the institute ($n = 8$). In addition, seven patients dropped out of the study just before ($n = 5$) or during ($n = 2$) the first assessments. In total 106 patients with a left hemisphere stroke diagnosed as apraxic participated in the present study ($n = 106$).

Measurements

Apraxia

The apraxia test¹⁵ to measure the severity of apraxia is based on tests of De Renzi⁹ and consists of two subtests assessing a patient's ability to use or pantomime objects (9 items) and the ability to imitate gestures (6 items) using their unaffected ipsilateral arm. The maximum score of the total test is 90 (6 per item), indicating no apraxic difficulties. The internal consistency and the validity of the test is good.¹⁵

Motor functioning

The Motricity Index¹⁶ measures voluntary movements of the limbs on the affected contralateral side. The test consists of six items (three concerning arm/hand function and three leg/feet function). The maximum score of the total test is 100. The Motricity Index has been shown to have good validity and reliability with stroke patients.^{6,17}

The Functional Motor Test is a simplified version of the Action Research Arm Test¹⁸ and measures the voluntary functional ability to pinch, grip and grasp with the arm and hand of the affected contralateral side. It consists of four items and the maximum score of the total test is 12 (3 per item). The internal consistency is found to be good, Cronbach's alpha in this study is 0.88.

ADL functioning

The ADL observations^{12,13} are a set of standardized observations specially developed to assess disabilities due to apraxia. Four activities are scored on four different measures: an independence score and three scores to indicate the type of deficits in the performance (deficits in the initiation, execution and control of the activity). The four observed activities are (1) wash the face and upper body, (2) put on a shirt or blouse, (3) prepare and eat a sandwich, and (4) prepare a cup of hot chocolate. All scores range from 0 to 3, from totally dependent to totally independent. In this study the overall mean score of the observations is used (add up the four scores of the four activities and divide this by 16). The internal consistency and inter-observer reliability of this observation procedure are found to be good.^{12,13}

The Barthel ADL Index^{19,20} is a widely used and standard measure of ADL functioning. The patient's dependency is scored on 10 basic daily functions/activities (bowels, bladder, grooming, toilet use, feeding, transfer, mobility, dressing, stairs, bathing). The Barthel ADL Index expresses disability on a scale ranging from 0 (totally dependent) to a maximum score of 20 (totally independent). It is found to be a reliable instrument.^{19,20}

In addition, information on demographic and clinical characteristics of patients was recorded: gender, age, handedness, type of stroke, hemiplegia/ hemiparesis (yes/no), disease duration and type of institute.

Testing procedure

The data in the present study were collected at baseline, i.e. when patients entered the trial. The apraxia test was administered by the researcher as part of the inclusion procedure (see Patients section). The ADL observations and motor tests were administered by a trained research assistant. The Barthel ADL Index was administered by the occupational therapists using – if necessary – additional information from the nursing staff. All tests and observations were administered within one week.

Statistical analysis

Pearson's correlation coefficients were computed to examine the strength of the relationship between severity of apraxia, motor functioning and ADL functioning. Furthermore, two multiple regression analyses were performed with the disability measures as the dependent variable. The independent variables were entered as a group in the multiple regression analyses. Standardized regression coefficients (beta) and explained variance (R^2) are presented.

RESULTS

Patient characteristics

Patients' demographic and clinical characteristics are shown in Table 1.

[TABLE 1]

Table 2 shows the test results for apraxia, motor functioning and ADL functioning. All patients in our study were apraxic (inclusion criterion; see Methods section). The low mean scores on the Motricity Index and the Functional Motor Test show that most patients suffered from primary motor impairments concerning the affected limbs on the right side.

[TABLE 2]

Approximately 7% of the patients obtained the highest score of 20 (functional independence) on the Barthel ADL Index, 45% of the patients could be classified as (very) severely disabled (score below 10).^{21,22} The mean score on the ADL observations is 2.3, which is well below the mean score (2.8) found in a group of patients with a left hemisphere stroke without apraxia.^{12,13}

Due to fatigue and motivation it was not always possible to administer all the tests. Out of 106 patients, six patients declined to perform one or more tasks of the ADL observations and for three patients the Barthel ADL Index was not filled in within the time boundaries of the assessment period (despite reminders).

Preliminary analyses

There was a high correlation between the two measures of motor functioning ($r = 0.82$). Severity of apraxia was found to be significantly associated with poor performances on the motor tests ($r = 0.35$, $r = 0.30$). Furthermore, the two disability measures were significantly correlated with each other ($r = 0.56$; see Table 3).

[TABLE 3]

Relationship between apraxia, motor functioning and ADL functioning

The correlations between apraxia, motor functioning and disability measures are shown in Table 3. The results showed a significant correlation between the ADL observations and the apraxia test ($r = 0.39$) and a significant but weak correlation between the ADL observations and the Motricity Index ($r = 0.22$). The Barthel ADL Index showed the opposite pattern: a significant correlation with the motor tests ($r = 0.47$, $r = 0.35$), and a significant, but weak correlation with severity of apraxia ($r = 0.22$).

The results of the multiple regression analyses are shown in Table 4. Because the strong correlation between the Motricity Index and the Functional Motor Test could cause multicollinearity, it was decided to leave the Functional Motor Test from the analyses. As expected, the apraxia test and not the Motricity Index was significantly associated with the ADL observations (explained variance 15%). Furthermore, the Motricity Index and not the apraxia test was associated with the Barthel ADL Index (explained variance 22%).

[TABLE 4]

DISCUSSION

The results of the multivariate analyses showed a significant association between motor impairments and the Barthel ADL Index. Apraxia – a cognitive impairment – was not associated with the Barthel ADL Index. On the other hand, apraxia was associated with the ADL observations which were specifically designed to measure disability due to apraxia. There was no association between motor impairment and these specific ADL observations in the multivariate analyses. These results confirm our

hypotheses and support earlier findings by van Heugten *et al.*^{12,13} Furthermore, these results are in line with findings in earlier studies that functional scales that measure general ADL functioning are not necessarily sensitive to disability as a result of the patients' cognitive impairments.^{2,7,8} Different disability measures are sensitive to different impairments. On the basis of our results, we conclude that in order to assess disability in stroke patients with apraxia, one cannot rely only on the Barthel ADL Index. In addition, the specific ADL observation procedure should be applied.

Still there is some ground to be cautious when interpreting these findings. The studied patient group is a selected group and, therefore, we do not know if the conclusions also apply to other patient groups with apraxia or to patients with other cognitive impairments. Furthermore, the overall condition of the patients who participated in the study was poor, which meant that it was not always possible to administer all the tests (see Table 2).

All subjects in this study were left hemisphere stroke patients with apraxia. Thus, aphasia was quite frequent. Approximately 80% of the patients were aphasic. The apraxia test and the ADL observations depend in part on the understanding of language, whereas the Barthel ADL Index does not. Therefore it seems possible that part of the correlation between the apraxia test and the ADL observations was due to aphasia.

CLINICAL MESSAGES

- The measurement of ADL functioning in stroke patients with apraxia should not rely only on a conventional functional scale, such as the Barthel ADL Index.
- The Barthel ADL Index measures disability due to motor impairments, not disability due to apraxia.
- Instead, the ADL observations described in the present study seem to be an appropriate measure of disability due to apraxia.

But, additional analyses showed quite similar significant correlations between aphasia and apraxia, ADL observations and Barthel ADL Index (respectively $r = 0.42$, 0.34 and 0.38). In addition, multivariate analyses, which included aphasia, showed that aphasia did not explain more variance in the ADL observations than in the Barthel ADL Index. Thus, it is highly unlikely that aphasia explains the differential association of the ADL measures with apraxia and motor impairments.

The ADL observations are a set of standardized observations specially developed to assess disabilities due to apraxia. Four activities are scored on four different measures: an independence score and three scores to indicate the type of deficits in the performance (deficits in the initiation, execution and control of the activity). This makes the ADL observations an instrument which measures independency as well as quality of the performance. The ADL observations are focused on the level of assistance (verbal or physical) the patient needs to perform all phases in the activity (initiation, execution and control) successfully. Does the patient need verbal or physical assistance to start, execute or control the whole activity? Such a detailed distinction between verbal or physical assistance and between different phases in the activity (initiation, execution and control) is not made in the Barthel ADL Index. This probably makes the ADL observations, more than the Barthel ADL Index, sensitive to disability due to apraxia.

The ADL observations were not associated with motor impairments, while the Barthel ADL Index did show an association with motor impairments. Again, the qualitative difference between the observations and the conventional scales seems to explain this pattern. For example, a patient who cannot dress himself due to his hemiparesis (without being apraxic) will obtain a low score on the Barthel ADL Index with respect to this item. On the other hand, on the ADL observations the same patient will score better because he is still able to perform two of the three qualitative phases successfully, namely to initiate and control the activity. This example demonstrates that the ADL observations do not (or only to a limited extent) assess disability due to motor impairments. Thus, while being a measure of disability due to apraxia, the ADL observations are not a measure of disability due to motor impairments.

In conclusion, we studied the relationships between severity of apraxia, motor impairments and measures of disability in a large group of 106 left hemisphere stroke patients with apraxia. We found that ADL observations are associated with severity of apraxia and that the Barthel ADL Index is associated with motor impairments. These results support earlier findings by van Heugten *et al.*¹³ suggesting that these specific ADL observations measure the disabilities due to apraxia, while the Barthel ADL Index measures disability due to motor impairments.

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TABLES

Table 1 Demographic and clinical characteristics of the study population ($n = 106$)

Gender, n (%)		
Male	61 (57.5%)	
Female	45 (42.5%)	
Age, mean (SD)	65.3 (11.6)	range: 38–93
Type of institution, n (%)		
Rehabilitation centre	73 (68.9%)	
Nursing home	33 (31.1%)	
Type of stroke, n (%)		
Haemorrhage	15 (14.2%)	
Infarction	83 (78.3%)	
Otherwise/unknown	8 (7.5%)	
Time since stroke		
Median in days (25–75%)	95 (74-130)	
Recurrent stroke, n (%)	20 (18.3%)	
Hemiplegia/hemiparesis	95 (89.6%)	
Right-handedness, n (%)	97 (91.5%)	

Table 3 Pearson correlations between apraxia, motor functioning and disability measures

	ADL observations	Barthel ADL Index
Apraxia	0.39**	0.22*
Motor functioning		
Motricity Index	0.22*	0.47**
Functional Motricity Test	0.17	0.35**
ADL functioning		
ADL observations	–	0.56**
Barthel ADL Index	0.56**	–

* $p \leq 0.05$; ** $p \leq 0.01$.

Table 2 Test results of apraxia, motor functioning and ADL functioning

	n (106)	Mean (SD)	Range
Apraxia	106	60.2 (19.6)	8–87
Motor functioning			
Motricity Index	106	46.2 (30.8)	0–100
Functional Motricity Test	106	5.9 (3.7)	0–12
ADL functioning			
ADL observations	100	2.3 (0.5)	1.3–3.0
Barthel ADL Index	103	11.0 (4.9)	2–20

Table 4 Multiple regression with disability measures as dependent variables and impairments as independent variables

Dependent variable	Independent variables	Regression coefficient beta	r-square
ADL observations	Apraxia	0.34**	0.15**
	Motricity Index	0.11	
Barthel ADL Index	Apraxia	0.06	0.22**
	Motricity Index	0.44**	

* $p \leq 0.05$; ** $p \leq 0.001$.

REFERENCES

- 1 Tatemichi TK, Desmond DW, Stern Y, Paik M, Sano M, Bagiella E. Cognitive impairment after stroke: frequency, patterns, and relationship to functional abilities. *J Neurol Neurosurg Psychiatry* 1994; **57**: 202–207.
- 2 Hajec VE, Gagnon S, Ruderman JE. Cognitive and functional assessments of stroke patients: An analysis of their relation. *Arch Phys Med Rehabil* 1997; **78**: 1331–37.

- 3 Maeshima S, Truman G, Smith DS, Dohi N, Itakuras T, Komai N. Functional outcome following thalamic haemorrhage: relationship between motor and cognitive functions and ADL. *Disabil Rehabil* 1997; **19**: 459–64.
- 4 Sundet K, Finset A, Reinvang I. Neuropsychological predictors in stroke rehabilitation. *J Clin Exp Neuropsychol* 1988; **10**: 363–79.
- 5 Bjerneby EI, Reinvang IR. Acquiring and maintaining self-care skills after stroke. *Scand J Rehabil Med* 1985; **17**: 75–80.
- 6 Wade DT. *Measurement in neurological rehabilitation*. Oxford: Oxford University Press, 1992.
- 7 Novack TA, Haban G, Graham K, Satter. eld WT. Prediction of stroke rehabilitation outcome from psychologic screening. *Arch Phys Med Rehabil* 1987; **68**: 729–34.
- 8 Oczskowski WJ, Barreca S. The Functional Independence Measure: its use to identify rehabilitation needs in stroke survivors. *Arch Phys Med Rehabil* 1993; **74**: 1291–94.
- 9 De Renzi E. Apraxia. In: Boller F, Grafman J eds. *Handbook of neuropsychology*, Volume 2. Amsterdam: Elsevier Science Publisher, 1989: 245–63.
- 10 Donkervoort M, Dekker J, Ende E van de, Stehmann-Saris JC, Deelman BG. Prevalence of apraxia among patients with a .rst left hemisphere stroke in rehabilitation centres and nursing homes. *Clin Rehabil* 2000; **14**: 130–36.
- 11 Rothi LJG, Heilman KM. *Apraxia: the neuropsychology of action*. Hove: Psychology Press, 1997.
- 12 Heugten CM van, Dekker J, Deelman BG, Stehmann-Saris JC, Kinebanian A. Assessment of disabilities in stroke patients with apraxia: internal consistency and inter-observer reliability. *Occup Ther J Res* 1999; **19**: 55–73.
- 13 Heugten CM van, Dekker J, Deelman BG, Dijk AJ van, Stehmann-Saris JC, Kinebanian, A. Measuring disabilities in stroke patients with apraxia: a validation study of an observational method. *Neuropsychol Rehabil* 2000; **10**: 401–14.
- 14 World Health Organization. Special Report: Recommendations on stroke prevention, diagnosis and therapy. *Stroke* 1989; **20**: 1407–31.
- 15 Heugten CM van, Dekker J, Deelman BG, Stehmann-Saris JC, Kinebanian A. A diagnostic test for apraxia in stroke patients: internal consistency and diagnostic value. *Clin Neuropsychol* 1999; **13**: 1–11.
- 16 Demeurisse G, Demol O, Robaye E. Motor evaluation in vascular hemiplegia. *Eur Neurol* 1980; **19**: 382–89.
- 17 Collen FM, Wade DT, Bradshaw CM. Mobility after stroke: reliability of measures of impairment and disability. *Int Disabil Stud* 1990; **12**: 6–9.
- 18 Lyle RC. A performance test for assessment of upper limb function in physical rehabilitation treatment and research. *Int J Rehabil Res* 1981; **4**: 483–92.
- 19 Collin C, Wade DT, Davies S, Horne V. The Barthel ADL Index: a reliability study. *Int Disabil Stud* 1988; **10**: 61–63.
- 20 Wade DT, Collin C. The Barthel ADL Index: a standard measure of physical disability? *Int Disabil Stud* 1988; **10**: 64–67.
- 21 Wade DT, Hewer RL. Functional abilities after stroke: Measurement, natural history and prognosis. *J Neurol Neurosurg Psychiatry* 1987; **50**: 177–82.
- 22 Wolfe CDA, Taub NA, Woodrow EJ, Burney PGJ. Assessment of scales of disability and handicap for stroke patients. *Stroke* 1991; **22**: 1242–44.