Rehabilitation of limb apraxia improves daily life activities in patients with stroke

Abstract—We randomly assigned 33 patients with left hemisphere stroke, limb apraxia, and aphasia to an apraxia or a control (aphasia) treatment group. Before and after each treatment, patients underwent a comprehensive neuropsychological testing battery and a caregiver evaluation of patient's activities of daily life (ADL) independence. Apraxia severity was related with ADL independence. Control (aphasia) treatment improved patients' language and intelligence performance. Apraxia treatment specifically improved praxic function and ADL.

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Limb apraxia (LA) affects the purposeful execution of learned movements (gestures). This impairment cannot be accounted for by sensory loss, weakness, poor movement coordination, or poor comprehension of commands and typically affects the limbs bilaterally.[1] The relative frequency of LA in patients with stroke is 51.3% after left hemisphere lesions and 6.0% after right hemisphere lesions.[2] There are two main forms of LA, ideational (IA) and ideomotor (IMA). Although LA tends to improve in natural contexts, patients often present a defective planning of actions during activities of daily life (ADL) and their dependence from caregivers is related to apraxia severity.[3,4] Despite indications that LA may have disabling effects,[5] research on therapeutic strategies for treating LA is scarce. In this study we assessed if a rehabilitation program for LA[6] may increase not only praxic ability, but also independence from caregivers during ADL.

We also assessed the relationship between apraxia severity and independence from caregivers during ADL.

Methods. *Patients.* We selected 41 patients with radiologic (CT) and clinical evidence of left-sided unilateral vascular lesions (table 1 and figure; table E-1 on the *Neurology* Web site at www.neurology.org).

Inclusion criteria were presence of LA (IA or IMA) lasting at least 2 months. Exclusion criteria were history of previous cerebrovascular attacks or other neurologic disorders, age over 80 years, uncooperativeness, presence of orthopedic or other disabling disorders. Neurologic severity was assessed according to a standard procedure.[7] All patients were informed about the experimental nature of the study and gave their consent for participation. The study was approved by the local ethics committee. Patients were randomly assigned to a study or a control group. The study group underwent a rehabilitative treatment for LA. The control group received a conventional treatment for aphasia. All patients received 30 treatment sessions, three per week, each lasting 50 minutes.[6]

Testing procedure. Before and after treatment, patients underwent verbal comprehension, intelligence, oral apraxia, constructional apraxia, IA, IMA, and gesture comprehension tests.[6] All patients were evaluated by the same examiner who was blind with regard to treatment. Before and after treatment, a patient's caregiver completed an ADL questionnaire about the degree of assistance required by the patient during the most basic personal care tasks (details in appendix E-1). This test showed a good inter-rater (Kendall T = 0.989; $p < 0.001$) and intersession (Kendall T = 1; $p < 0.001$) reliability.

Nine patients in the study group and eight patients in the control group were submitted to a further evaluation 2 months after the end of the treatment (2 months FU). The outcome measures used in the follow-up evaluation were the IA, IMA, gesture comprehension tests, and the ADL questionnaire.

Statistical analysis. We used the statistical package SPSS for Windows, version 11.0. Wilcoxon signed ranks tests on the pre-post-treatment scores and on the post-treatment-follow-up scores, for the different outcome measures, were carried out in each group of patients. The Mann-Whitney test was used for comparing the effects of treatment in the two groups and for testing homogeneity of the groups before study. The Pearson correlation test was used in order to evaluate the relationship between the severity of IA, IMA, and gesture comprehension and the ADL questionnaire score. The alpha level for significance was set at $p < 0.05$. The Bonferroni correction was used in multiple comparisons ($p < 0.025$).

Results. Age, education, handedness, neurologic severity, length of illness, intelligence, verbal comprehension, oral apraxia, constructional apraxia, ADL performance, IA, IMA, and gesture comprehension were not significantly different between the two groups, before treatment.

A correlation was found between performance in the IA, IMA, and gesture comprehension tests and the ADL questionnaire (ADL-IA: R = 0.65, $p < 0.001$; ADL-IMA: R = 0.48, $p < 0.01$; ADL-gesture comprehension: R = 0.37, $p = 0.034$).

A significant improvement in performance after the apraxia treatment was found in the IA, IMA, and gesture-

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Table 1 Demographic and clinical features of the two patient groups

	Study group, n = 18	Control group, n = 15
Age, y		
Mean (SD)	65.67 (9.83)	65.73 (8.78)
Range	41–77	48–77
Male/female	12/6	11/4
Education, y		
Mean (SD)	6.61 (3.53)	6.33 (2.87)
Range	4–13	4–13
Hand preference (–24, +24)		
Mean (SD)	23.11 (1.23)	23.87 (0.52)
Range	20–24	22–24
Neurologic severity (0–18)		
Mean (SD)	6.94 (5.83)	6.07 (4.30)
Range	0–15	0–16
Duration of stroke, mo		
Mean (SD)	10.39 (7.96)	17.4 (24.07)
Range	3–32	2–36
Lesion (ischemic/hemorrhagic)	17/1	12/3
Ideational apraxia (0–14)		
Mean (SD)	9.17 (4.16)	11.07 (3.37)
Range	0–14	2–14
Ideomotor apraxia (0–72)		
Mean (SD)	27.67 (14.68)	34.93 (12.19)
Range	0–47	13–48
Gesture comprehension (0–10)		
Mean (SD)	6.22 (2.29)	7.07 (2.09)
Range	0–9	3–9

comprehension tests and in the ADL questionnaire (table 2 and table E-2). A trend to a significant improvement was found in the constructional apraxia test. No significant variations in performance in the intelligence, verbal comprehension, or oral apraxia tests were observed.

A significant improvement after the aphasia treatment was found in the intelligence and verbal comprehension tests (table 2). A trend to a significant improvement was found in the constructional apraxia test. No significant changes in performance were observed in the other outcome measures.

The effects of the two treatments (represented by the difference of performance with respect to pre-therapy levels) differed between the two groups in the IMA test, in the gesture comprehension test, and in ADL questionnaire (IMA: U = 69.00, p = 0.016; gesture-comprehension: U = 64.00, p = 0.018; ADL: U = 53.50, $p < 0.01$).

In the follow-up evaluation, performance in the limb praxic functional tests and in the ADL questionnaire did not show any significant change in comparison with the post-treatment evaluation (table E-3).

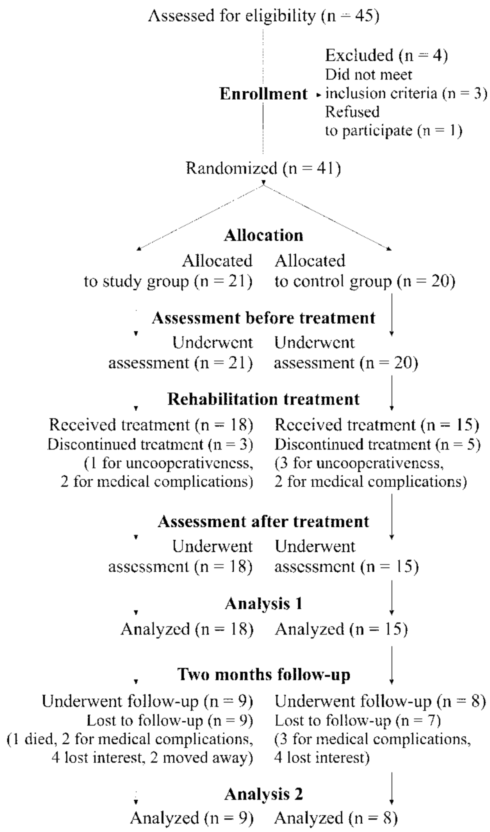

Figure. Profile of the clinical trial.

Discussion. We found that the severity of limb apraxia is associated with dependence on caregiver assistance in the context of ADL. We also found that rehabilitative treatment in patients with LA after stroke can bring about a significant improvement in performing and recognizing both transitive and intransitive gestures. Moreover, amelioration of praxis functions generalizes to ADL functioning. The specificity of the rehabilitation treatment is confirmed by the fact that patients in the control group did not show any change in either the ADL or in limb praxic performance. The significant improvement of performance in the intelligence and verbal comprehension tests in the control patients who underwent conventional treatment for aphasia further supports the specificity of this effect. Furthermore, as indicated by the follow-up evaluation, the overall duration of the treatment benefits is encouraging.

Limitations of the study are the small sample size of patients and the number of treatment sessions needed to achieve an improvement of LA.

The widely held notion that LA ameliorates in a natural environment and has little negative impact on patients[8] may explain the limited number of attempts to rehabilitate this disturbance. However, recent studies have found that LA can emerge also in natural contexts and that severity of apraxia is crucially linked to ADL disabilities.[3-4] Our study confirms this finding and suggests that LA rehabilitation can help the management of patients with stroke. An interesting finding of our study is

Table 2 *Results of comparisons before–after treatment*

	Before–after
ADL (0–80)	
Study	$p < 0.001$
	Z = –3.72
Control	NS
Ideational apraxia (0–14)	
Study	$p < 0.01$
	Z = –2.69
Control	NS
Ideomotor apraxia (0–72)	
Study	$p < 0.01$
	Z = –3.21
Control	[p = 0.084]
	[Z = –1.73]
Gesture comprehension (0–10)	
Study	$p < 0.01$
	Z = –3.14
Control	NS
Oral apraxia (0–20)	
Study	NS
Control	NS
Constructional apraxia (0–14)	
Study	[p = 0.038]
	[Z = –2.08]
Control	[p = 0.048]
	[Z = –1.93]
Raven test (0–36)	
Study	NS
	$p < 0.01$
Control	Z = –2.96
Token test (0–36)	
Study	NS
	$p < 0.01$
Control	Z = –3.01

ADL = activities of daily living; NS = not significant; [ ] = trend to significance; ( ) = test score.

that patients improved not only the ability to produce a wide range of gestures,[6] but also gained functional independence from caregivers during ADL. Thus, training effects may also extend to untreated tasks. Previous studies report that improvement of apraxia contingent upon rehabilitation tends to be restricted to the items included in the training program.[9,10] This seeming discrepancy can be explained by methodologic differences across studies. Indeed, while most of the training tasks were largely aimed at treating a limited number of error types,[9] or consisted of a limited number of tasks,[10] our rehabilitative training was devised to treat a wide range of gestures and to reduce several types of praxic errors (e.g., transitive, symbolic, and meaningless gestures). Furthermore, in most of the training items we used different contextual cues in order to teach patients how to produce the same gesture under different contextual situations.

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