

The prognostic value of domain-specific cognitive abilities in acute first-ever stroke

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Abstract—Objective: To evaluate the prognostic value of domain-specific cognitive abilities in acute stroke with respect to long-term cognitive and functional outcome in addition to neurologic and demographic predictors. **Methods:** The authors evaluated 168 patients within the first 3 weeks after first-ever stroke. The prevalence of neuropsychological impairment was calculated vs 75 matched healthy controls. The authors also recorded demographic data, vascular risk factors, lesion characteristics, and clinical factors at admission. Independent predictor variables associated with long-term cognitive impairment (assessed with a follow-up neuropsychological examination) and functional impairment (assessed with the modified Barthel Index and the Frenchay Activities Index) were identified with stepwise multiple logistic regression. Areas under receiver operator characteristic curves were used to compare the predictive value of three models, i.e., a standard medical model, a purely cognitive model, and a model consisting of both medical and cognitive predictors. **Results:** Thirty-one percent of patients showed long-term cognitive impairment. Basic and instrumental ADL disturbances remained present in 19% and 24% of patients. Domain-specific cognitive functioning predicted cognitive and functional outcome better than any other variable. Moreover, the prediction of instrumental ADL functioning improved when cognitive predictors were added to the standard medical model ($p < 0.05$). Impairments in abstract reasoning and executive functioning were independent predictors of long-term cognitive impairment. Inattention and perceptual disorders were more important in predicting long-term functional impairment. **Conclusion:** Domain-specific cognitive abilities in the early phase of stroke are excellent independent predictors of long-term cognitive and functional outcome.

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Several factors have been identified as predictors for long-term disability and adverse outcome, such as initial stroke severity and lesion characteristics, functional status at admission with respect to activities of daily life (ADL), vascular risk factors, and demographic factors.^{1–5} While cognitive disorders are among the most frequent and devastating early consequences of stroke,^{6,7} few studies have examined the prognostic importance of these acute disorders.^{8,9} Moreover, most of these studies have used global cognitive screening measures in the early phase of stroke, although these measures demonstrate poor sensitivity in detecting cognitive impairment in stroke patients.¹⁰ Also, these global measures do not allow evaluation of cognitive performance in specific domains. Other studies on poststroke cognitive impairment have focused on the prognostic value of isolated impairments such as unilateral neglect,^{11,12} anosognosia,¹³ aphasia,¹⁴ or apraxia.¹⁵ A detailed

neuropsychological evaluation covering the whole cognitive spectrum in acute stroke has not been reported, probably because of uncertainty about the feasibility and reliability of such early testing.¹⁶ Therefore, it is unknown whether certain types of domain-specific cognitive impairment are more disabling in the long term than others.

We sought 1) to investigate whether a detailed neuropsychological examination in the acute stage after stroke contributes to the prediction of long-term cognitive and functional outcome in addition to well-known medical predictors, and 2) to examine whether certain types of domain-specific cognitive impairment are more related to outcome than others.

Method. Subjects. The population consisted of 228 consecutive patients with first-ever symptomatic stroke admitted to stroke units of three hospitals in the Netherlands (University Medical Center Utrecht, Tweesteden Hospital Tilburg, and St.-Elisabeth Hospital Tilburg) between December 2001 and January 2003. Patients were eligible if they had either ischemic stroke or primary intracerebral hemorrhage. The diagnosis of stroke was based on the presence of both an acute focal deficit and an associated lesion on CT or MRI. Patients with a normal scan underwent a second scan within the first week poststroke. Exclusion criteria were 1)

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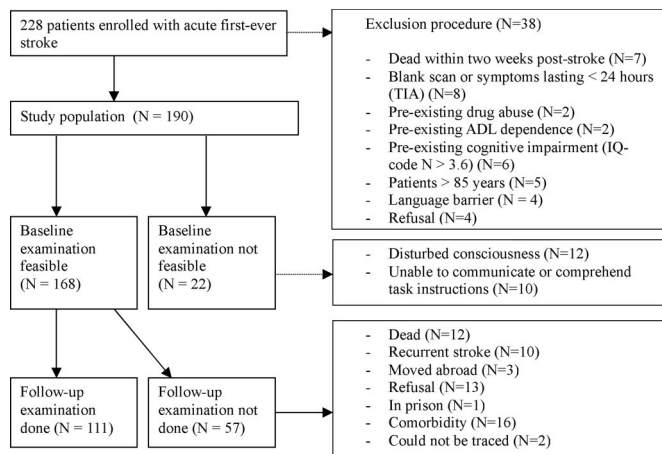


Figure 1. Characterization of patient cohort at baseline and at follow-up.

pre-existing impairment or history that might influence cognitive or functional outcome, i.e., history of drug abuse, pre-existent dependence in activities of daily living, or pre-existent cognitive decline (as defined by a score of 3.6 or higher on the short Informant Questionnaire on Cognitive Decline in the Elderly–IQCODE Dutch version),¹⁷ 2) age older than 85 years, and 3) inability to be examined within the first 21 days poststroke due to severe disturbances in consciousness or inability to comprehend task instructions. This exclusion procedure resulted in a study population of 190 patients with acute stroke, of which 168 patients (88%) could be neuropsychologically examined.

Finally, patients with a recurrent stroke or who developed comorbidity that might affect outcome (i.e., cancer, myocardial infarction, CABG, or psychiatric illnesses) between the first and the second examination were excluded from follow-up examination. Figure 1 presents a chart showing the number of patients who were included and excluded from this study.

A control group was assembled as a reference sample for the neuropsychological examination, consisting of 75 subjects living in the community. The controls were either spouses or family of patients, or volunteers who came to our attention through advertising in newspapers or by word of mouth. Control subjects were carefully matched to the stroke patients with respect to age, education, and sex. Moreover, they performed both examinations with the same time interval as the patients to control for potential practice effects.

Predictor variables. On admission, demographic factors, vascular risk factors, factors associated with medical status at admission, CT/MRI characteristics, and domain-specific cognitive abilities were obtained as candidate predictor variables. All except the continuous predictor variables were dichotomized in order to reduce the number of variables and for clinical clarity. Demographic factors included age (years), level of education (scored with 7 categories ranging from 1 = did not finish primary school to 7 = university degree, and dichotomized at the median),¹⁸ and sex. Vascular risk factors comprised previously diagnosed diabetes mellitus, hypertension, hypercholesterolemia, TIA, smoking during the last 5 years, and alcohol consumption of more than 2 units per day. Factors associated with the patients' medical status on admission were body temperature > 38°C in the first week during hospital stay, admission glucose level, total serum cholesterol level at admission, systolic and diastolic blood pressure, stroke severity (assessed by means of the NIH Stroke Scale [NIHSS]),¹⁹ and categorized as severe if NIHSS > 7),²⁰ functional dependence (assessed by means of the modified Barthel Index [MBI]),²¹ and categorized as present if MBI < 19),²² and weakness of either arm or leg (categorized as present if NIHSS items for either arm or leg > 1). An experienced stroke neurologist (H.B.v.d.W.) who was blind to the clinical data evaluated the patients' stroke type (categorized as cerebral infarct or intracerebral hemorrhage) from CT or MRI, in addition to the location of the lesion (classified into three categories: involvement of left hemisphere, right hemisphere, and brain stem/cerebellum), the main affected territory of vascular blood supply (classified as anterior, middle, or posterior

cerebral artery, or vertebrobasilar arteries), the presence of silent infarcts (classified as present when an infarct was found in the brain without the description by the patient, family, or medical record of a prior stroke episode),²³ the presence of cerebral atrophy (classified as present when a generalized dilatation of cortical sulci was found, with or without associated ventricular enlargement),²³ leukoariosis (scored as present if patients obtained a score > 0 on the van Swieten scale),²⁴ and the volume of the lesion, calculated using Leica Q500 MCP image analysis software by manual tracing of the lesion on each slice showing the infarct or hemorrhage, followed by multiplying lesion area by slice thickness in all slices showing the lesion. This method has been shown to have a high inter-rater reliability and is described in detail elsewhere.²⁵

A detailed cognitive examination was performed within 3 weeks poststroke (mean time from onset to examination, 8.3 ± 4.5 days). An extended evaluation took place after a minimum of 6 and a maximum of 10 months poststroke. Both the baseline and the follow-up examination covered seven major cognitive domains consisting of verbal and nonverbal neuropsychological tasks (tasks added to the follow-up examination are italicized).¹⁶ Reasoning was assessed with the Raven Advanced Progressive Matrices (short form) and Similarities (Wechsler Adult Intelligence Scale [WAIS]-III). Verbal memory was measured by means of the Rey Auditory Verbal Learning Test, the Digit span (WAIS-III), and the *Wechsler Memory Scale-story recall A*. Executive functioning was assessed with the Brixton Spatial Anticipation Test, the Visual Elevator (Test of Everyday Attention),²⁶ letter fluency, the *Stroop Color Word test*, *Semantic Fluency*, and the *Zoo test (BADS)*. Visual perception and construction was assessed with the Judgment of Line Orientation (short form), the Test of Facial Recognition (short form), the Rey-Osterrieth Complex Figure-copy, and the *WAIS-III block patterns*. Visual memory was measured with the Corsi Block span, the Rey-Osterrieth Complex Figure-delay, the *Wechsler Memory Scale-Visual Reproduction*, and the *Location Learning Task*.²⁷ Language was assessed with the Token Test (short form), the Boston Naming test (short form), and the *Chapman reading task*. Finally, unilateral neglect was measured with the Star cancellation (BIT) and the *Line Bisection Schenkenberg*.

The neuropsychological examination in the early phase of stroke was considered feasible if patients were able to perform at least 10 of the 15 tasks, which allowed evaluation of the majority of the cognitive domains. Patients who were able to reach this criterion but who were unable to perform one or more tasks were given the minimum score on the tasks they could not perform. In this way, both patients with aphasia and unilateral neglect could be included in our study. The procedure of administering multiple neuropsychological tasks within one cognitive domain allowed us to transform raw test scores of patients on individual tasks into compound z-scores based on the means and standard deviations of the control group on the first and second examination to control for potential practice effects. Subsequently, we averaged z-scores of tasks belonging to the same cognitive domain. Cutoff scores for cognitive impairment within each domain were determined by a performance that differed from the control mean at the 0.05 level of significance ($Z < -1.65$).²⁸ This approach was used for both (acute and follow-up) neuropsychological examinations.

Outcome measures. Two distinct types of outcome were used in the present study, i.e., long-term cognitive outcome and functional outcome in terms of ADL.

Cognitive outcome was assessed with the abovementioned neuropsychological examination at follow-up and classified as cognitively intact (defined as no impairment on any of the cognitive domains) vs cognitively impaired (defined as an impairment in at least one cognitive domain).

Functional outcome was assessed with two separate ADL measures: basic and instrumental ADL. Basic ADL instruments assess straightforward activities such as personal hygiene and dressing, whereas instrumental ADL instruments assess more complex ADL, such as grocery shopping, household management, and social activities. In this study, basic ADL was determined with the modified Barthel Index (MBI).²¹ A MBI value ≥ 19 was used as an indication of intact basic ADL function.²² The Frenchay Activities Index (FAI)²⁹ was used to assess instrumental ADL. In total, the scale comprises 15 individual activities summed to give an overall score ranging from 0 (inactive) to 45 (very active). Intact instrumental ADL function was defined as FAI ≥ 15.³⁰

All outcome measures were dichotomized in order to provide clear and interpretative information for both clinicians and patients. Outcomes were assessed blind to the predictor variables.

Statistical analyses. First, to determine whether any selection bias occurred between patients who were re-examined at follow-up and those who were not, we performed Student's *t*-tests for continuous data, Mann-Whitney *U* test for ordinal data, and χ^2 analyses for categorical data on a range of baseline characteristics of patients.

Second, univariate analyses of potential predictor variables were undertaken for the three outcome measures. Those variables with a univariate association at $p \leq 0.1$ were considered for entry into forward stepwise multiple logistic regression analysis. Three multivariate prediction models were produced for each outcome measure. A standard medical model was developed entering all variables associated with outcome in the univariate analyses, except for the early cognitive predictors. The cognitive model included only cognitive factors associated with outcome in the univariate analyses. The combined model included both medical and cognitive predictors. Receiver-operator characteristic (ROC) curves were used to compare the information content of the different models for all outcome measures.³¹ The larger the area under the ROC curve (AUC), the higher the information content of the model. The Hosmer-Lemeshow goodness-of-fit statistic³² was used to determine if the models provided a good fit for the data. Models are well calibrated and fit the data if the goodness of fit statistic is large ($p > 0.05$).

Results. *Clinical characteristics of patients not examined at follow-up.* As shown in figure 1, 111 of 168 (66%) patients were re-examined. The interval between the early examination and follow-up did not differ between controls (7.4 ± 1.3 months) and patients (7.4 ± 1.0 months). Patients who were not examined at follow-up were older, more impaired on the MBI at baseline, and experienced more deficits in executive functioning, visual memory, and visual perception and construction at baseline. The failure to be re-examined was also related to the presence of silent infarcts and white matter lesions, whereas no association with vascular risk factors or characteristics directly related to the stroke lesion could be demonstrated (table 1).

Prevalence of adverse outcome on the long term. Of the included patients, 48.6% showed cognitive impairments in the first 3 weeks poststroke, whereas 30.6% of patients showed cognitive impairment at follow-up in at least one cognitive domain, indicating a decline in the number of patients with cognitive impairment ($p < 0.001$). For descriptive purposes, the prevalence of domain-specific cognitive disorders at baseline and at follow-up is shown in table 2.

Remaining basic ADL disturbances were found in 18.7% of patients, whereas 24.3% demonstrated instrumental ADL disability. Associations among the three outcome measures are presented in figure 2. A total of 54.9% of patients demonstrated a complete recovery with respect to all outcome measures, whereas 10.8% of patients demonstrated an incomplete recovery with regard to all three outcome measures.

Determinants of cognitive impairment on the long term. Univariate analyses showed that cognitive impairment on the long term was associated with older age, lower education, female sex, no regular alcohol consumption, lower MBI at baseline, body temperature $> 38^\circ\text{C}$, glucose level at admission, large lesion volume, and impairments in all cognitive domains at baseline (all $p \leq 0.1$) (see table E-1 on the *Neurology* Web site at www.neurology.org). These predictor variables were introduced into multivariate stepwise logistic regression analysis to find independent predictors

Table 1 Comparison of characteristics between patients included and not included for follow-up

Characteristics	Included	Not included
Demographics		
Age, mean \pm SD*	60.1 \pm 14.2	67.9 \pm 12.5
Education, median (range) ¹⁶	4 (0–7)	4 (2–7)
Male	54.1	40.4
Stroke type		
Infarct	90.1	89.5
Hemorrhage	9.9	10.5
Lesion location		
Left hemisphere	43.8	44.6
Right hemisphere	41.0	44.6
Brainstem/cerebellum	15.2	10.7
Vascular supply area		
Anterior	3.0	6.1
Middle	66.0	57.1
Posterior	15.0	22.4
Vertebrobasilar	16.0	14.3
Silent infarct(s)*	13.7	27.5
White matter lesions*	15.3	38.6
Cerebral atrophy	10.7	17.6
Stroke severity and functional status at baseline, median (range)		
NIHSS score	5 (0–18)	5 (1–18)
MBI*	17 (1–20)	15 (1–20)
Vascular risk factors		
Hypertension	40.0	47.4
Diabetes mellitus	10.9	19.3
Hypercholesterolemia	17.3	10.7
Transient ischemic attack	14.5	15.8
Cognitive impairments at baseline		
Abstract reasoning	24.5	30.9
Language	20.9	32.1
Verbal memory	20.9	32.1
Visual memory*	16.8	32.7
Executive functioning*	30.3	50.0
Visual perception and construction*	31.2	49.1
Unilateral neglect	10.9	14.0

Values are within-group percentages unless indicated otherwise. Some within-group percentages are based on incomplete samples due to small amounts of missing data. Analyses are χ^2 analyses or Fisher exact tests (categorical data), Mann-Whitney *U* tests (ordinal data), or *t*-tests (continuous data).

* $p < 0.05$.

NIHSS = NIH Stroke Scale; MBI = modified Barthel Index.

of long-term cognitive impairment. In the medical model, cognitive impairment was associated with a large lesion volume, female sex, and older age, whereas the cognitive model yielded two independent predictors, i.e., impairments in executive functioning and abstract reasoning (see table E-2). In the combined model cognitive impairment on the long term was associated with impairments in executive functioning and abstract reasoning, and female sex.

Table 2 Prevalence of domain-specific cognitive deficits at baseline and at follow-up ($n = 111$)

	Baseline examination		Follow-up	
	Frequency	Percentage	Frequency	Percentage
Visual perception and construction	34 (1)	30.6%	10	9.0%
Executive functioning	33 (1)	29.7%	15	13.5%
Abstract reasoning	27 (6)	24.3%	20	18.0%
Verbal memory	23 (8)	20.7%	9	8.1%
Language	23 (7)	20.7%	16	14.4%
Visual memory	18 (1)	16.2%	9	8.1%
Unilateral neglect	12 (3)	10.8%	2	1.8%

Values are absolute frequencies and percentages. The number of patients who were assigned the lowest score because they could not be assessed for that domain at baseline is shown in parentheses. Note that patients may have multiple cognitive impairments at baseline or at follow-up.

Lesion volume and age dropped from this model because these variables failed to reach statistical significance. Patients with executive impairments at baseline nearly had sevenfold greater odds of being cognitively impaired 6 months later, whereas patients with early reasoning disturbances had fourfold greater odds of obtaining an adverse cognitive outcome (see table E-2).

All three models demonstrated an acceptable fit by the Hosmer-Lemeshow test. The combined model yielded the largest AUC, followed by the cognitive model (see table E-2). However, the difference among the three models did not reach significance.

Determinants of functional impairment on the long term. An MBI score < 19 at follow-up was univariately associated with older age, lower education, a higher score on the baseline NIHSS, a lower score on the baseline MBI, body temperature $> 38^{\circ}\text{C}$, admission glucose level, weakness in either arm or leg, large lesion volume, presence of cerebral atrophy, unilateral neglect, and impairments in language, verbal

memory, executive functioning, visual memory, and visual perception and construction at baseline (all $p \leq 0.1$) (see table E-1). In the medical model, remaining basic ADL disturbances were independently associated with stroke severity at admission, older age, body temperature $> 38^{\circ}\text{C}$, and admission glucose level. The cognitive model retained two independent predictors: visual memory and unilateral neglect (see table E-2). In the combined model, incomplete basic ADL recovery was associated with impairments in visual memory and unilateral neglect, and with admission glucose level. All other predictor variables dropped from this model because they failed to reach statistical significance. Patients with acute unilateral neglect had 18-fold greater odds and patients with acute visual memory impairments showed 22-fold greater odds for remaining basic ADL disturbances (see table E-2).

All models demonstrated an acceptable fit by the Hosmer-Lemeshow test. The combined and the cognitive model demonstrated the largest AUC (see table E-2). However, the difference among the three models did not reach significance.

Instrumental ADL impairment on the long term was associated with a low level of education, poorer NIHSS and MBI at baseline, body temperature $> 38^{\circ}\text{C}$, weakness in arm or leg, stroke location in the right hemisphere, lesion volume, unilateral neglect, and impairments in language, executive functioning, visual memory, and visual perception and construction at baseline (all $p \leq 0.1$) (see table E-1). In the medical model, instrumental ADL impairment was independently associated with a poor MBI at admission and a lesion location in the right hemisphere, whereas the cognitive model yielded only one predictor, i.e., visual perception and construction. In the combined model, instrumental ADL impairment was associated with impairments in visual perception and construction at baseline, poor MBI at baseline, and a lesion location in the right hemisphere. Patients with acute visual perceptual disorders demonstrated 27-fold greater odds of obtaining an adverse instrumental functional outcome (see table E-2).

The models demonstrated an acceptable fit by the Hosmer-Lemeshow test (no goodness-of-fit statistic could be calculated for the cognitive model as this model consisted of only one predictor). The combined model demonstrated a larger AUC than the medical model ($p < 0.05$) and the cognitive model ($p < 0.05$) (see table E-2).

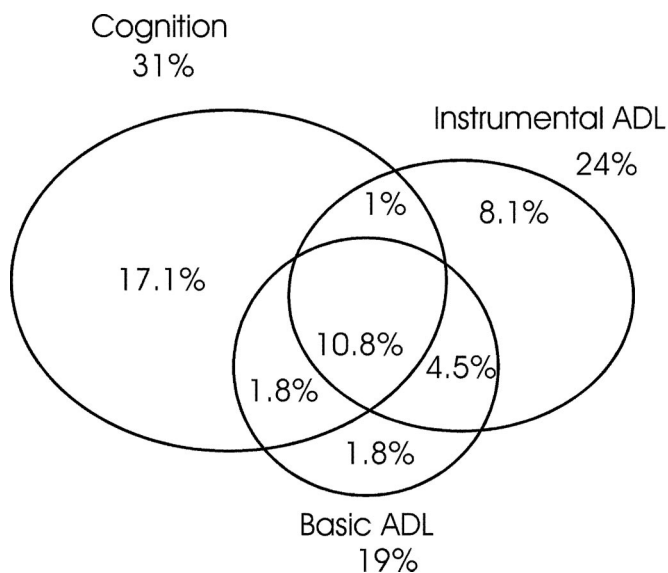


Figure 2. Association of outcome measures. ADL = activities of daily living.

Discussion. In the present study, we examined the predictive value of a neuropsychological examination in the very early phase poststroke with respect to long-term cognitive and functional impairment. Although it has been suggested that during the acute phase after stroke patients are often unstable and difficult to test,^{14,16} our results show that an early neuropsychological examination is feasible in the majority of patients and has an important prognostic value regarding clinically relevant outcomes.

Of the included patients, 49% showed cognitive impairment in the first 3 weeks after stroke. Impairments in executive functioning and visual perception were the most frequent at this stage, whereas visual memory and neglect were present in less than 20% of patients. After the first 6 months poststroke, 31% of patients still showed cognitive impairment, which is

comparable to a previous hospital-based study that reported cognitive impairment in 35% of patients with first-ever stroke.³³ Nineteen percent of our patients demonstrated remaining disturbances in basic ADL on the long term, whereas 24% of patients were unable to keep up with more complex activities in daily life, such as grocery shopping, reading, and household management. The low prevalence of adverse functional outcome in our patient population together with the relatively low median NIHSS score at baseline indicates that our study population consisted of a rather mild stroke population. This was largely due to two factors: first, we only included patients with first-ever stroke because we wanted to rule out confounding factors related to outcome such as pre-existent cognitive impairment or ADL dependence. Second, patient attrition was inevitable given that we examined patients within the first 3 weeks poststroke. Neuropsychological examination was not feasible in 12% of patients with acute first-ever stroke due to severe impairments in communication and consciousness. Moreover, the 57 patients who were not examined at follow-up had more severe impairments at baseline than patients who completed follow-up. This selection bias most probably resulted in an underestimation of the frequency of cognitive and functional impairment on the long term after stroke. Therefore, our findings cannot be directly generalized to the whole population of first-ever stroke patients. Still, our results may be useful in clinical practice because in the early stage of stroke prognosis and adequate allocation of rehabilitation resources are often very difficult. Our study shows that an early detailed neuropsychological examination can provide important prognostic information on both cognitive and functional outcome in this stroke population, and for instrumental ADL outcome even beyond that of demographic factors, lesion characteristics, vascular risk factors, and clinical status at baseline. In contrast to previous studies that have either used cognitive screening instruments such as the Mini-Mental State Examination (MMSE)³⁴ or the CAMCOG,³⁵ or focused on isolated cognitive deficits in acute stroke,¹¹⁻¹⁵ we submitted patients to a detailed neuropsychological examination covering the whole cognitive spectrum. Therefore, we were able to provide specific information regarding which acute cognitive disorders have the largest prognostic power. Different cognitive deficits were found to be important for cognitive and functional outcome. Impairments in more complex cognitive functioning, i.e., reasoning and executive functioning, were independent predictors of cognitive impairment on the long term, while more perceptual and attentional dysfunctions were independent predictors of functional impairment at follow-up.

In our study, patients with executive impairments at baseline had nearly sevenfold greater odds of being cognitively impaired 6 months later than patients without executive disorders. The term executive function is used as an umbrella for various

complex cognitive processes (such as task-switching, planning, fluency, inhibition) involved in achieving a particular goal.³⁶ Tasks tapping executive functions not only activate prefrontal regions in the brain, but also subcortical structures (e.g., striatal structures and thalamus) and cerebellar areas.^{36,37} Executive performance has also been reported to be an excellent predictor of vascular dementia in vascular compromised patients and stroke patients.^{38,39} Interestingly, a recent study suggested that executive dysfunction might start insidiously before the first onset of symptomatic ischemic episodes in CADASIL.⁴⁰ It should be noted that global cognitive screening measures such as the MMSE often do not include items that assess executive functioning. Since executive dysfunction is one of the most frequent impairments in the early phase poststroke and an excellent predictor of long-term outcome, we recommend the assessment of executive functioning in the early phase of stroke.

Other important independent predictors of long-term cognitive impairment in our study were lesion volume, age, and sex. The relation with female sex has been reported previously.³³ Lesion volume was an independent predictor of cognitive impairment, but no association with lesion location could be demonstrated. These findings are probably due to the fact that cognitive outcome was dichotomized as complete recovery vs remaining cognitive impairment, independent of how many and which specific cognitive domains were affected. It is likely that localized areas in the brain play a role in disparate specific cognitive impairments on the long term after stroke.⁶

The predictive value of unilateral neglect and perceptual-related impairments with respect to functional impairment has been reported previously.¹² However, this is the first study to examine the predictive power of these impairments in a model covering all major cognitive domains in combination with other important factors such as lesion volume or demographic characteristics. Neglect and perceptual impairments proved to be the most important independent prognostic factors of functional outcome. Interestingly, the presence of acute neglect predicted long-term functional outcome in a very strong way, even though 10 out of 12 patients (83%) with acute neglect spontaneously recovered by the time of the follow-up examination. These findings indicate that the long-term disability in the acute neglect group is not directly related to persistent neglect, in line with previous findings.⁴¹ Moreover, the prominent prognostic role of acute perceptual disorders cannot be explained indirectly by the fact that right hemispheric patients are at a greater risk of poor outcome, since both the location of the lesion and the presence of perceptual impairment were independent predictors of long-term functional impairment. Speculatively, the strong impact of perceptually related disorders on long-term functional outcome might have to do with the typical pattern of reduced awareness in these patients. Unfortunately, few studies

have addressed the prognostic value of reduced awareness or anosognosia after acute stroke.^{13,42} This is mainly due to the lack of instruments for evaluating anosognosia and because of the heterogeneous nature of the disorder.⁴³ Similarly, until this moment no scoring system for apraxia has been generally accepted. Diagnosis mainly relies on personal experience, clinical impression, and intuition. Future studies are warranted to evaluate the relative contribution of these cognitive disorders in predicting long-term outcome after stroke.

Finally, our study confirms the prognostic importance of the patients' glucose level at admission. Increasing admission glucose level was an independent predictor of basic ADL functioning on the long term as has been reported previously,^{44,45} and was also univariately associated with cognitive impairment on the long term. It is well established that acute stress situations such as stroke can cause hyperglycemia, which in turn may lead to infarct expansion in the case of ischemic stroke,^{44,45} or more profound brain edema and perihematomal cell death in the case of intracerebral hemorrhage.⁴⁶ Hyperglycemia in acute stroke often occurs without pre-existing diagnosis of diabetes mellitus.⁴⁴ Indeed, history of diabetes mellitus was not associated with functional or cognitive outcome in our study.

Finally, some limitations of this study should be addressed. In order to maximize comparability between CT and MRI, a rather basic method was used for rating cerebral atrophy. This method is less detailed than volumetric methods, and therefore the predictive value of cerebral atrophy regarding long-term cognitive or functional outcome might have been underestimated. Moreover, the results of this study must be considered to be preliminary given that the number of patients and more specifically the outcomes of interest on which our models were generated were relatively small. This may have resulted in false-positive predictor variables, or alternatively in important variables being missed because of multicollinearity or lack of power. Furthermore, these models have only been tested in the data set from which they have been derived. They have not been validated in an independent cohort of acute first-ever stroke patients. Validation of these models in similar patient populations is needed in future research.

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Ischemic optic neuropathy and carotid dissection

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A 53-year-old man with diabetes and hyperlipidemia developed blurry vision in his left eye, 24 hours after a neck massage. He had no other neurologic symptoms. The retina had normal appearance and an isolated afferent pupillary defect was found. Brain MRI with diffusion-weighted imaging revealed diminished flow voids in the left carotid artery. A cerebral angiogram showed a left internal carotid dissection (figure). Optic disc pallor was noted 3 months later, confirming a diagnosis of posterior ischemic optic neuropathy.

Posterior ischemic optic neuropathy rarely complicates carotid dissection^{1,2} and, as shown by this case, it may be its sole presenting symptom.

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Figure. Digital subtraction angiogram (lateral projection) shows an internal carotid artery occlusion secondary to dissection, as indicated by the typical flame-shaped appearance and location of the occlusion distal to the carotid bifurcation.