Dementia
and Geriatric Cognitive Disorders

Changes in Cognitive Function over 3 Years after First-Ever Stroke and Predictors of Cognitive Impairment and Long-Term Cognitive Stability: The Erlangen Stroke Project

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Abstract
Background and Purpose: Cognitive impairment (CI) is frequent after stroke, but data from population-based stroke cohorts on the natural course of CI are limited. The purpose of this study was to determine changes in cognitive status over 3 years after stroke. ***Methods:*** Data were collected from the Erlangen Stroke Project, an ongoing population-based stroke registry. The Mini-Mental State Examination (MMSE) for assessing global cognitive function was used; CI was defined as an MMSE score <24. ***Results:*** From February 1998 to January 2006, 630 patients with first-ever stroke were included. Prevalence rates of CI at 3 months, 1 and 3 years were 15, 13, and 12%. In multivariable analysis, stroke severity, i.e. Barthel index (p < 0.001), age (OR = 1.03; 95% CI = 1.00–1.05) and diabetes mellitus (OR = 2.03; 95% CI = 1.13–3.67) were associated with CI at 3 months. Recovery rate from CI at 3 months after stroke was found to be 31% over the following 3 years. Intact cognitive function rate was 71% over 3 years and inversely associated with age (OR = 0.96; 95% CI = 0.96–0.94) and stroke severity (p < 0.001). ***Conclusion:*** CI is frequent

among stroke survivors and associated with age, stroke severity, and diabetes mellitus, but recovery occurs in approximately one third of the patients over the course of 3 years. Factors affecting intact cognitive function over time are increasing age and stroke severity.

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Background

Cognitive impairment (CI) is a frequent complication in stroke survivors and predicts post-stroke death, dependency, and institutionalization [1, 2]. Data from unselected population-based stroke cohorts on the frequency of post-stroke CI and its long-term natural course in follow-up are scarce. Previous studies on the prevalence of post-stroke CI show conflicting results with prevalence rates varying from 12 to 60% [1, 3–7]. Most longitudinal studies have focused on post-stroke dementia with a wide spread of prevalence estimates from 6% to more than 30% in stroke survivors [8]. Potential explanations for these variations are heterogeneity of studies and differences in the method of diagnosis [9]. Previous studies found several sociodemographic, clinical and stroke-related factors associated with post-stroke cognitive decline

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[4, 10, 11], but factors related to cognitive recovery and its frequency are not fully understood. There are a few mainly hospital-based studies investigating cognitive recovery after post-stroke CI [12–14]. However, reported factors related to recovery from CI are controversial, and there is a lack of longitudinal population-based studies examining long-term changes in post-stroke cognition. This study investigates the frequency and predictors of CI in a large sample from a population-based stroke registry. Moreover, we aimed to obtain novel findings on the prevalence and factors associated with cognitive recovery and cognitive stability over the long term after stroke.

Subjects and Methods

Study Population

Data were collected from the Erlangen Stroke Project (ESPro). The ESPro is an ongoing prospective, population-based stroke registry covering a total source population of 103,000 inhabitants in Erlangen (census 2006), Germany. The study population, design and methodology of the ESPro have previously been described in detail [15–18].

Case Ascertainment

All hospitalized and nonhospitalized patients in the study area with suspected fatal or nonfatal stroke, transient ischemic attack, or sinus venous thrombosis are regularly identified. To ensure completeness of case ascertainment, standardized criteria were applied [17]. Details regarding the case ascertainment were previously described [18]. Stroke diagnosis was defined by a study clinician according to the WHO criteria [19]. Patients with first-ever lifetime stroke were included in the study.

Data Collection and Clinical Variables

Data were collected prospectively. Specially trained research nurses took interviews using standardized questionnaires. Patients were followed up at day 7, after 3 months, and then yearly.

The Mini-Mental State Examination (MMSE) was used to measure global cognitive function after stroke as previously described [1, 3, 7, 20]. Cognitive status was assessed during follow-up examination at 3 months, 1 and 3 years after stroke. CI was defined as an MMSE score <24 according to previously defined cut-off points [12, 21].

Follow-up data included survival, institutionalization and stroke severity. Stroke severity was assessed using the Barthel index and determined by stratifying patients into prespecified categories [22]: very severely (Barthel index 0–4), severely (5–9), moderately (10–14), or mildly (15–19) disabled or nondisabled (20 of 20). The Barthel index was measured at day 7, at 3 months and then yearly. Stroke subtype was classified into ischemic stroke and other (intracranial and subarachnoid hemorrhage). Clinical variables assessed in the present study were: (1) arterial hypertension as reported or measured blood pressure being systolic >140 mm Hg or diastolic >90 mm Hg, or patient's self-report of treated hypertension, (2) diabetes mellitus (fasting blood glucose level >120 mg/dl, patient's self-report of diabetes, or use of antidiabetic

drugs), (3) cardiac disease (history of coronary artery disease or myocardial infarction, arrhythmia, congestive heart failure). For sensitivity analyses, the cumulative number of these comorbidities was calculated for individual stroke patients, and categorized into three prespecified categories (0–1, 2, or 3–4 comorbidities). Patients with evidence of pre-stroke dementia as diagnosed by a primary care physician or at initial clinical examination were excluded from analyses.

Statistical Analysis

Independent predictors of the occurrence of CI 3 months after stroke and for cognitive stability at 3 months to 3 years after stroke were assessed using backward stepwise logistic regression analysis including sociodemographics, stroke severity, living condition, and comorbidities (hypertension, diabetes mellitus, coronary artery disease, atrial fibrillation). For sensitivity analysis, a second logistic regression model was performed including sociodemographics, stroke severity, and number of comorbidities. Multivariable analyses were restricted to patients without missing values in the respective category; variables were eliminated by backward elimination procedure. For missing MMSE scores at later time points, the last-observation-carried-forward method was used. Missing values for MMSE at 12 and 36 months were 24 and 22%, respectively. All tests were two-tailed, and statistical significance was determined at an alpha level of 0.05. Statistical analyses were performed with PASW software (version 18, SPSS, Chicago).

Ethics

The design of the study was approved by the local ethics committee. Patients or their legal representatives gave their written informed consent to participate.

Results

Between February 1998 and January 2006, 1,631 patients with first-ever lifetime stroke were included in the ESPro. After exclusion of the patients who were dead, aphasic, lost to follow-up or had disturbed consciousness, 890 patients were eligible for MMSE examination and 653 (73.4%) were actually assessed. At 12 months, 893 were eligible and 630 (75.1%) were cognitively assessed. At 36 months, out of 678 eligible patients, 458 (67.0%) underwent MMSE. After exclusion of patients with a history of pre-stroke dementia, 630 patients at 3 months, 600 at 12 months, and 448 patients at 36 months after stroke were assessed for further analyses, respectively. Prevalence rates of CI among survivors after stroke were 93 out of 630 (14.8%) at 3 months, 90 out of 600 (13.3%) at 1 year, and 53 out of 448 (11.8%) at 3 years after stroke as shown in table 1.

The natural course of cognitive function following stroke is presented in figures 1 and 2. Cognitive status was restricted to the categories CI (MMSE score <24),
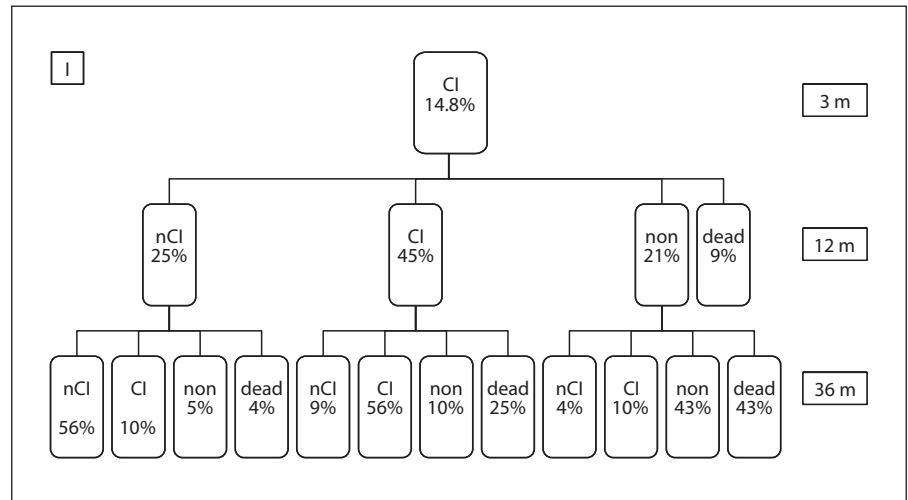
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Fig. 1. Flowchart describing the evolution of post-stroke cognitive function at 3, 12, and 36 months for subjects with an MMSE score <24 (CI). non = Non-eligible; m = months.
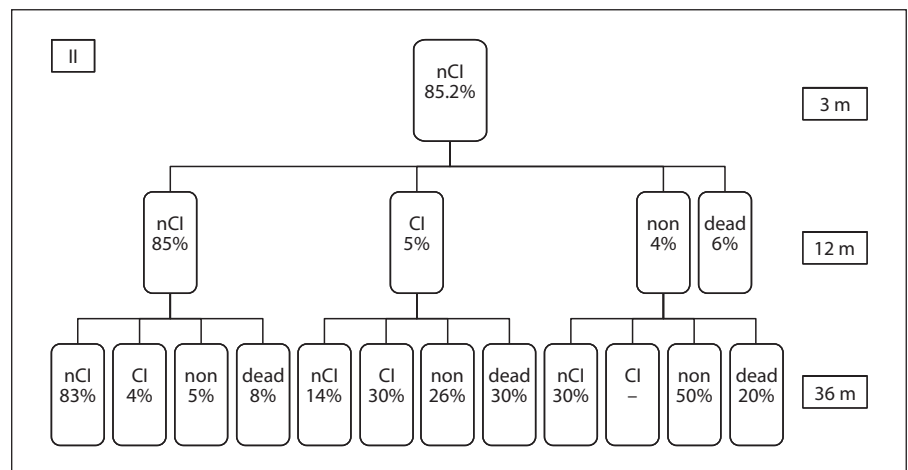

Fig. 2. Flowchart describing the evolution of post-stroke cognitive function at 3, 12, and 36 months for subjects with an MMSE score >24 (nCI). non = Non-eligible; m = months.

Table 1. Prevalence of CI in ESPro (February 1998 to January 2006)

	3 months	12 months	36 months
Total	1,631	1,631	1,631
Patients dead	252 (15.5%)	378 (23.2%)	559 (34.3%)
Patients alive at 3 months	1,379	1,253	1,072
Lost to follow-up	277 (20.1%)	234 (14.3%)	249 (15.3%)
Patients available to follow-up	1,102	1,019	823
Subject aphasic, disturbed consciousness	212 (19.2%)	180 (11.0%)	145 (8.9%)
Subject eligible for MMSE	890	893	678
Subjects with MMSE	653 (73.4%)	630 (75.1%)	458 (67.0%)
After exclusion of subjects with a history of pre-stroke dementia	630 (70.7%)	600 (67.1%)	448 (66.1%)
Cognitively impaired (MMSE score <24)	93 (14.8%)	80 (13.3%)	53 (11.8%)
Cognitively intact (MMSE score ≥24)	537 (85.2%)	536 (86.7%)	403 (88.2%)

Table 2. Univariate analyses: factors associated with CI 3 months after stroke

	Cognitively impaired	Cognitively intact	p value
Number	93	537	
Age (mean ± SD), years	74.4 ± 9.9	69.5 ± 13.1	
Age group, n			
<65	16 (17.0)	155 (28.9)	
65–74	25 (27.0)	160 (29.8)	
75–84	39 (42.0)	181 (33.7)	
85+	13 (14.0)	41 (7.6)	0.024
Female sex, n	50 (53.8)	274 (51.0)	0.62
Institutionalization			
before stroke, n	7 (10.0)	30 (7.0)	0.32
Barthel index days 5–7, n			
0–4	27 (29.7)	86 (16.6)	
5–9	22 (24.2)	53 (10.3)	
10–14	16 (17.6)	91 (17.6)	
15–19	12 (13.2)	125 (24.2)	
20	14 (15.4)	162 (31.3)	<0.001
Ischemic stroke, n	81 (87.1)	469 (87.3)	0.95
Comorbidities, n			
Hypertension	59 (74.7)	347 (72.7)	0.72
Diabetes mellitus	28 (33.8)	110 (23.8)	0.06
Atrial fibrillation	24 (33.3)	103 (22.9)	0.06
Coronary artery disease	13 (15.1)	73 (16.6)	0.79

Figures in parentheses are percentages. Analyses were restricted to patients without missing values in the respective category.

Table 3. Multivariable analyses: factors associated with CI 3 months after stroke

	OR	95% CI	p value
Age	1.03	1.00–1.05	0.03
Female sex	1.18	0.62–2.25	0.62
Barthel index days 5–7			0.001
0–4	1.00		
5–9	1.47	0.67–3.27	
10–14	0.57	0.25–1.30	
15–19	0.20	0.07–0.54	
20	0.43	0.19–0.97	
Pre-stroke institutionalization	1.22	0.44–3.67	0.70
Ischemic stroke	1.45	0.58–3.67	0.43
Comorbidities			
Hypertension	0.90	0.47–1.71	0.75
Diabetes mellitus	2.03	1.13–3.67	0.02
Atrial fibrillation	1.54	0.83–2.86	0.17
Coronary artery disease	0.63	0.27–1.49	0.29

Analyses were restricted to patients without missing values in the respective category; variables were eliminated by backward elimination procedure; OR and 95% CI were given just before removal.

intact cognitive function (MMSE score ≥24), noneligibility, and death at 12 and 36 months after stroke. Of 93 patients with an MMSE score <24 three months after stroke, 29 (31%) recovered within 3 years after stroke. Out of 537 patients who had an MMSE score ≥24 at 3 months, 383 (71%) remained cognitively intact over 3 years. The case fatality rate for subjects with an MMSE score <24 at 3 months was 32%, with 9 patients being dead after 12 months and 21 after 3 years. In subjects with an MMSE score ≥24 at 3 months after stroke, the case fatality rate over 3 years was 15%. Thirty-three patients died after 12 months and 46 after 3 years. In sensitivity analyses regarding different MMSE cutoff levels for CI used in previous studies [1], no major differences were found (data not shown).

Factors Associated with CI at 3 Months
Comparisons between cognitively impaired and intact subjects at 3 months are shown in table 2. Median MMSE scores were 20 for cognitively impaired and 29 for cognitively intact subjects (p < 0.001). The two groups of stroke survivors at 3 months were significantly different in terms of age and stroke severity. Borderline significance was found for diabetes mellitus and atrial fibrillation. In multivariable analysis, stroke severity on day 7, age (OR = 1.03; 95% CI = 1.00–1.05; p = 0.03) and diabetes mellitus (OR = 2.03; 95% CI = 1.13–3.67; p = 0.02) were associated with CI at 3 months after first-ever stroke (table 3). In additional multivariable sensitivity analyses, the number of comorbidities was also associated with CI at 3 months (p = 0.08).

Factors Associated with Cognitive Recovery and Intact Cognitive Function between 3 and 36 Months after First-Ever Stroke
Table 4 shows factors associated with changes in cognitive status between 3 months and 3 years after first-ever stroke. Median MMSE scores for cognitively improved and cognitively impaired subjects were 20 and 19.5 (p = 0.14) at 3 months and 26 and 17.5 (p = 0.3) at 36 months after stroke. Median MMSE scores for permanently cognitively intact subjects and subjects with cognitive decline after intact cognitive status at 3 months after stroke were 29 and 29 at 3 months and 29 and 21.5 (p < 0.001) at 36 months after stroke. It is important to note that the MMSE score for the 29 patients who recovered from an MMSE score <24 over 3 years had changed

Table 4. Factors associated with cognitive function between 3 and 36 months after first-ever stroke

	CI at 3 months Cognitively recovered within 36 months			Cognitively intact at 3 months Cognitively stable within 36 months		
	yes	no	p value	yes	no	p value
Number	29	64		383	154	
Age (mean ± SD), years	73.3 ± 7.8	75 ± 10.7		67.6 ± 13.4	74.1 ± 10.9	
Age group, n			0.59			<0.001
<65	6 (20.7)	10 (15.6)		127 (33.2)	28 (18.2)	
65–74	8 (27.6)	17 (26.6)		126 (32.9)	34 (22.1)	
75–84	13 (44.8)	26 (40.6)		107 (27.9)	74 (48.1)	
85+	2 (6.9)	11 (17.2)		23 (6.0)	18 (11.7)	
Female sex, n	18 (62.1)	32 (50.0)	0.28	184 (46.7)	95 (61.7)	0.002
Institutionalized at 3 months, n	7 (25.9)	15 (27.3)	0.56	20 (5.6)	28 (21.5)	<0.001
Barthel index at 3 months, n			0.42			<0.001
0–4	3 (11.1)	10 (18.2)		5 (1.4)	14 (10.7)	
5–9	5 (18.5)	9 (16.4)		12 (3.4)	11 (8.4)	
10–14	3 (11.1)	10 (18.2)		18 (5.0)	9 (6.9)	
15–19	11 (40.7)	12 (21.8)		76 (21.2)	48 (36.6)	
20	5 (18.5)	14 (25.5)		247 (69.0)	49 (37.4)	
Ischemic stroke, n	27 (93.1)	54 (84.4)	0.25	339 (88.5)	130 (84.4)	0.20
Comorbidities, n						
Hypertension	21 (80.8)	38 (71.7)	0.38	248 (72.7)	99 (71.5)	0.56
Diabetes mellitus	7 (25.9)	20 (37.7)	0.29	81 (24.5)	29 (22.0)	0.34
Atrial fibrillation	5 (21.7)	19 (38.8)	0.15	68 (21.0)	35 (28.0)	0.11
Coronary artery disease	5 (20.0)	8 (16.7)	0.72	51 (16.1)	22 (17.9)	0.65

Figures in parentheses are percentages. Analyses were restricted to patients without missing values in the respective category.

by ≥2 points with a median change of 9 points. No significant differences in cognitive recovery were found in univariate analyses. In univariate analyses, patients who remained cognitively intact over 3 years were often younger and female and had a lower Barthel index. In multivariable analysis, factors inversely associated with intact cognitive function over 3 years were increasing age (OR = 0.96; 95% CI = 0.96–0.94; p = 0.01) and stroke severity (p < 0.001) (table 5). In sensitivity analyses, number of comorbidities was not associated with cognitive intact function over 3 years (p = 0.31).

Discussion

The present study shows that in our population-based stroke cohort CI remains a frequent condition with a prevalence of 15–12% from 3 months to 3 years after first-ever stroke. CI after 3 months was associated with age, stroke severity, and diabetes mellitus. Of note, we were able to show for the first time in a large, well-characterized cohort that cognitive recovery (MMSE score ≥24)

after CI at 3 months (MMSE score <24) is substantial and occurs in 31% of stroke survivors over 3 years. Long-term intact cognitive function was inversely associated with age and stroke severity. Up to now, 3 population-based studies [3, 4, 6, 12] and 1 hospital-based study [5] reported on the frequency of post-stroke CI defined as an MMSE score <24 within a year. Reported prevalence rates of an MMSE score <24 varied from 16 to 38% [3, 4]. One population-based study found the highest prevalence of CI at 3 months in 38% of stroke survivors from the South London Stroke Register. In our cohort, the prevalence of MMSE score <24 was considerably lower [4]. There are a few possible explanations for this heterogeneity in prevalence rates. Firstly, registry populations might differ in ethnicity, education, and socioeconomic status, which all have a major impact on the risk of post-stroke CI [4, 10]. Compared to the South London Stroke Register, the proportion of ethnic groups other than Caucasians is low in our population. Patel et al. [4] could show that CI at 3 months is associated with Caribbean, Black African, and Asian ethnicity and lower socioeconomic class. Further studies reported that Black Americans and

Table 5. Multivariable analyses: factors associated with permanent cognitive stability at 3 months up to 36 months after first-ever stroke

	OR	95% CI	p value
Age	0.96	0.96–0.94	0.01
Female sex	0.95	0.57–1.60	0.85
Institutionalized 3 months after stroke	0.53	0.19–1.48	0.22
Barthel index at 3 months			<0.001
0–4	1		
5–9	2.65	0.58–12.08	
10–14	3.37	0.77–14.80	
15–19	2.86	0.82–9.96	
20	8.77	2.55–30.49	
Ischemic stroke	1.24	0.55–2.80	0.61
Comorbidities			
Hypertension	1.28	0.75–2.21	0.27
Diabetes mellitus	1.78	0.96–3.28	0.06
Atrial fibrillation	0.72	0.40–1.28	0.26
Coronary artery disease	1.07	0.53–2.81	0.84

Analyses were restricted to patients without missing values in the respective category; variables were eliminated by backward elimination procedure; OR and 95% CI were given just before removal.

Asians are both at higher risk for post-stroke dementia [23, 24]. Tatemichi [10] found an association of post-stroke CI with lower education. Secondly, in pooled analysis, pre-stroke dementia is present in about 10% of patients with first-ever stroke [25]. Most of MMSE-based studies did not exclude patients with pre-stroke dementia [3–5, 12], whereas others did not exclude aphasic patients [6].

We found that independent predictors of CI at 3 months were increasing age, stroke severity, and diabetes mellitus. The association between older age, stroke severity and CI has been consistently described before [4, 10, 26].

Diabetes is a known risk factor for dementia and mild CI [27]. Similar to our findings, diabetes mellitus was independently associated with post-stroke decline in previous hospital- and population-based studies [11]. Patel et al. [4] could show that diabetes mellitus was related to an MMSE score <24 in univariate analyses, but not in multivariable analyses. In pooled analysis, Pendlebury and Rothwell [8] could demonstrate that besides diabetes mellitus, atrial fibrillation is a strong predictor of cognitive decline, but not myocardial infarction or hypertension. In our stroke cohort, there was a borderline significance for atrial fibrillation and number of comorbidities in univariate analyses (p = 0.06), but multivariable models did not confirm any independent association, similar to the community-based study by Hobson and Meara [28].

An important purpose of this study was to determine whether and how often changes in post-stroke cognition over long term take place. We could show that in our cohort, 24 (25%) out of 93 patients recovered from post-stroke CI after 1 year and a total of 29 (31%) over 3 years. These results concur with those of Patel et al. [12] who found that about 18% of CI subjects at 3 months regained their global cognitive functioning after 1 year. However, comparable data on changes after 1 year in post-stroke MMSE score are scarce, and no study so far has conducted repeated follow-ups at 1 and 3 years after stroke. Tham et al. [29] found that 31% of stroke patients with CI non-dementia at 6 months were cognitively intact after 1 year. Furthermore, a Spanish study reported recovery rates in 44% with CI non-dementia and 19% with dementia over 2 years [13]. Desmond et al. [30] found long-term recovery in 19 of 151 (12.6%) patients with cognitive improvement in memory, orientation, and attention, but not language or abstract reasoning. Hochstenbach et al. [14] could show that cognitive improvement occurs in all cognitive domains and improvement rates vary from 3.3 to 37.5% in stroke survivors over 2 years depending on which neuropsychological test was performed. However, in most studies, complex neuropsychological test batteries were administered that include assessment of various cognitive domains such as memory, attention, language or constructive abilities. Thus, our findings have to be interpreted with caution. MMSE is known to be insensitive to mild CI. Although acceptable validity is found in some studies [3, 21, 31], other studies reported that MMSE is not an appropriate screening test for cognitive dysfunction in cerebrovascular diseases due to shortcomings regarding right-sided lesions [32, 33]. However, similar to Patel et al. [11], we could demonstrate that recovery from an MMSE score <24 after stroke is frequent, but we did not detect any clinical determinants of cognitive recovery probably due to the small sample size of the study.

In our study, increasing age and higher disability at 3 months affected intact post-stroke cognitive function over 3 years. This is in line with previous studies that found delayed cognitive decline and incident post-stroke dementia to be associated with age and stroke severity [34, 35]. However, we did not find comparable studies that have investigated factors associated with stable post-stroke cognitive function over the long term. In our study,

71% remained cognitively intact after having achieved an MMSE score ≥24 at 3 months after stroke. In a smaller cohort comprising 99 cognitively intact stroke survivors at 3 months, Patel et al. [12] reported that 43 (43%) remained cognitively intact over 3 years, which is substantially lower compared to previous studies. Compared to our cohort, the case fatality rate with 54% dead after 3 years and the prevalence of cognitively impaired subjects with 32% at 3 years were much higher. Nevertheless, clinical determinants for changes in post-stroke cognition and, in particular, factors associated with recovery from post-stroke CI need further investigation, due to the obvious major clinical relevance with regard to prevention of long-term cognitive decline.

In this study, we used the Barthel index as a measure to determine stroke severity in the acute stage as well as in the follow-up period. No information on the National Institutes of Health Stroke Scale in the acute stage was available, which is a limitation of the study. The Barthel index is a reliable and valid severity measure in stroke and is often used to repeatedly assess outcomes and improvement in patients over time, whereas the National Institutes of Health Stroke Scale is more often used for early severity assessment, e.g. in the setting of clinical trials [36].

In our study, no significant differences in prevalence rates of CI were found between pathological stroke subtypes, i.e. hemorrhagic stroke versus cerebral infarction, as well as between etiological ischemic stroke subtypes according to the TOAST classification, e.g. lacunar versus other etiologies (data not shown). In contrast to previous studies showing differences in prevalence of CI between etiological stroke subtypes, particularly the association of lacunar stroke and small-vessel disease with cognitive decline [20], we were not able to find any significant influence of stroke etiology on CI prevalence. This might be caused by the fact that the number of patients over time in the different etiological stroke subtypes was limited.

Post-stroke CI is an important complication in stroke survivors and predicts poor outcome, disability, and institutionalization. Therefore, stroke survivors should be screened for global cognitive functioning to identify stroke survivors at high risk for developing post-stroke CI. Furthermore, we could provide more evidence that recovery from post-stroke CI is substantial, though associated factors have not been sufficiently evaluated yet. Future studies should investigate factors for cognitive recovery to develop therapeutic concepts and prevent long-term post-stroke CI. Short cognitive screening instruments to identify high-risk patients with milder CI should be evaluated and future studies should develop a predictive risk score to optimize stroke care and to prevent the overall burden of post-stroke cognitive decline.

There are limitations of the presented study. About 45% of all first-ever stroke survivors were not eligible for cognitive assessment due to being lost to follow-up, disapproval, death or disturbances of consciousness or aphasia. From the patients eligible for cognitive assessment, approximately 25% had no information on MMSE. Therefore, we cannot exclude that the estimates of the prevalence of CI were affected by this selection bias and that the true prevalence rate of CI was underestimated in our study. This could explain why the prevalence of an MMSE score <24 was considerably lower in our cohort compared to other studies. Secondly, the cognitive status was assessed only by the MMSE. Although the MMSE is the most commonly administered psychometric screening assessment of cognitive functioning and recommended by the American Heart Association [37], it has known shortcomings as mentioned above. A study by Pendlebury [25] could show that the MMSE underestimates the prevalence of CI in stroke patients, while other reported that the MMSE is inadequate to diagnose dementia. Recently, a study stated that the MMSE using a cutoff score of 23/24 is adequate in predicting dementia with an area under the curve of 0.94 [31]. Unfortunately, we were not able to use the DSM-IV criteria to diagnose post-stroke dementia due to study design aspects, which is a limitation of the study. However, the MMSE is a valid tool to assess global cognitive status and its course over time implemented in population-based stroke cohort studies [8].

Note that we did not intend to determine the prevalence and factors for post-stroke dementia, but to examine global cognitive functioning and its evolution in a large stroke cohort. Thirdly, we did not examine educational or socioeconomic status and post-stroke mood disorders. Previous studies demonstrated that both education and socioeconomic status as well as depression could negatively influence MMSE performance [21].

Conclusion

In conclusion, we clarified the natural course of cognitive function after stroke and have shown that CI is a common phenomenon among stroke survivors associated with age, stroke severity, and diabetes mellitus, but recovery also occurs in about one third of CI patients over

the course of 3 years. Future studies should especially focus on the investigation of predictors of cognitive recovery, an issue of major relevance for the prevention of long-term cognitive decline after stroke.

Disclosure Statement

The authors have no conflicts of interest to declare.

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