Association Between Diabetes and Stroke Subtype on Survival and Functional Outcome 3 Months After Stroke

Data From the European BIOMED Stroke Project

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Background and Purpose—Although diabetes is a strong risk factor for stroke, it is still unclear whether stroke subtype, severity, and prognosis are different in diabetic and nondiabetic patients. We sought to evaluate stroke features, prognosis, and functional outcome in patients with diabetes compared with patients without diabetes.

Methods—In a European Union Concerted Action involving 7 countries and 4537 patients hospitalized for a first-in-a-lifetime stroke, defined according to the Oxfordshire Community Stroke Project criteria, we collected data on demographics, risk factors, clinical presentation, and outcome. We used logistic regression to examine the relationship between diabetes and outcome at 3 months (disability, handicap, and death), controlling for risk factors, clinical presentation, and demographics.

Results—Overall, diabetes was present in 937 patients (21%). Diabetic patients, compared with those without diabetes, were more likely to have limb weakness ($P<0.02$), dysarthria ($P<0.001$), ischemic stroke ($P<0.001$), and lacunar cerebral infarction ($P=0.03$). At 3 months, the case fatality rates were not higher in the diabetic groups ($P=0.33$). Handicap (Rankin Scale) and disability (Barthel Index) were significantly higher in diabetic patients ($P=0.005$ and $P=0.016$, respectively).

Conclusions—Stroke in diabetic patients has a specific clinical pattern and a poor prognosis in terms of motor function, which emphasizes the need for early diagnosis and treatment of every case of diabetes. **(*Stroke*. 2003;34:688-694.)**

Key Words: cerebrovascular disorders ■ diabetes mellitus ■ stroke ■ stroke management ■ stroke outcome ■ stroke prevention

Diabetes mellitus is a well-established independent risk factor for stroke and is associated with high mortality.[1–5] This increased risk has been linked to the pathophysiological changes seen in the cerebral vessels of patients with diabetes.[4]

The aim of the present study was to prospectively characterize stroke patterns in diabetic and nondiabetic stroke patients and to estimate recovery and prognosis in a large European sample of hospitalized stroke patients.[6]

Subjects and Methods

Inclusion Criteria

The European BIOMED I study included 12 centers (22 hospitals) in 7 European countries: England, France, Germany, Hungary, Italy, Portugal, and Spain.[6] The ethics committees of participating centers approved the study. Patient-based data collection began in the majority of hospitals in September 1993 and involved all first-in-a-lifetime stroke patients hospitalized in the subsequent year. Stroke was defined according to the World Health Organization (WHO)[7] with brain imaging confirmation. The variables identified for the questionnaires were similar to those that have been used in the MONICA (Monitoring Trends and Determinants in Cardiovascular Disease) Stroke Study[8] and in population registers.[1,9] Each stroke patient was investigated in a standardized manner. The assessments were comparable between hospitals. Patients were evaluated in the acute phase and 3 months after stroke. A complete description of all study variables has been given in detail elsewhere.[6]

Diagnosis of Diabetes

Patients were divided into 2 groups according to patient recall or medical records: (1) patients with no past history of diabetes and (2) patients with known diabetes, treated with either insulin therapy or oral hypoglycemic therapy or not treated, whatever the plasma glucose level at stroke onset. Patients with repeated fasting plasma glucose level performed in all centers >7.8 mmol/L (140 mg/dL)

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A list of the members of the European BIOMED Study of Stroke Care Group appears in the Appendix.

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were enrolled in accordance with the WHO diagnostic criteria for diabetes[10] used in 1993.

Clinical Assessment

Baseline Characteristics

Baseline characteristics included age, sex, living conditions, medication before stroke (antihypertensive, antiplatelet, and anticoagulant therapy), and prestroke level of handicap, as defined by the modified Rankin Scale.

Vascular Risk Factors and Comorbid Conditions

Vascular risk factors and comorbid conditions included hypertension (previous diagnosis, current treatment, or values >160/95 mm Hg); atrial fibrillation (history of chronic atrial fibrillation, confirmed by at least 1 ECG, or presence of the arrhythmia during hospitalization); previous myocardial infarction; transient ischemic attack (TIA) (acute neurological deficit of vascular origin, lasting <24 hours); smoking (current or former habit); and alcohol consumption.

Clinical State at Time of Maximum Impairment Within the First 7 Days

Clinical state was assessed by level of consciousness (subsequently divided into 2 categories of coma or noncoma); confusion during the first week after stroke; presence of limb weakness (slight motor deficit) or paralysis (heavy motor deficit); speech or swallowing problems as a result of stroke; and urinary incontinence.

Use of Major Diagnostic Tests or Therapeutic Interventions

Major diagnostic tests included brain imaging, angiography, Doppler sonography, and echocardiography; therapeutic interventions included neurosurgery, carotid surgery, and other vascular surgery.

Pathological Subtypes of Stroke

Pathological subtypes of stroke were defined as cerebral infarction, cerebral hemorrhage, subarachnoid hemorrhage, or unclassified stroke according to the results of brain imaging. Clinical subtypes of ischemic stroke were rated according to the Oxfordshire Community Stroke Project criteria[11] as total anterior circulation infarct (TACI), partial anterior circulation infarct (PACI), posterior circulation infarct (POCI), and lacunar infarct (LACI).

Outcome Data 3 Months After Stroke Onset

Outcome data included information on vital status, handicap (Rankin Scale), and disability (Barthel Index)[12]. The assessment was usually made through a direct or proxy face-to-face interview, except at 1 UK center, where follow-up was made by a previously validated postal questionnaire. In case of death, date and cause were registered by gathering the information from relatives or general practitioners.

Statistical Analysis

The relationships between baseline and clinical variables and diabetes were analyzed with the χ^2 test and t test for categorical and continuous variables, respectively.

Disability at 3 months was defined as a Barthel Index score of ≤14. Handicap at 3 months was defined as a Rankin Scale score of ≥2. The relationships between diabetes and survival status, disability, and handicap at 3 months were examined by logistic regression after adjustments for each country. A multivariable model for each outcome was then selected with the use of backward stepwise logistic regression to identify the baseline and clinical variables most strongly related to each outcome. Because the variability between the countries was larger than that between the centers, we adjusted the multivariate models to the countries and not to the centers to reduce the number of parameters of the model.

All probability values quoted were 2-tailed. Data were analyzed with BMDP statistical software.

TABLE 1. Clinical Characteristics of Stroke Patients With and Without Diabetes, and Diagnostic Techniques and Resources

	Diabetes		
Variable	Yes (n=937)	No (n=3544)	*P*
Age mean±SD, y	70.7±10.2	71.7±13.1	0.930
Female	50.9%	49.9%	0.580
Institutionalized	4.7%	5.8%	0.175
Alcohol intake	25.6%	31.7%	<0.001
Current or previous smoking	34.9%	37.6%	0.134
Previous TIA	12.6%	12.3%	0.791
Hypertension	59.1%	45.5%	<0.001
Antihypertensive therapy	43.4%	37.2%	<0.001
Prestroke Rankin score (2–5)	29.6%	25.6%	0.014
Atrial fibrillation	15.2%	18.7%	0.012
Antiplatelet therapy	17.9%	17.2%	0.606
Anticoagulant therapy	3.9%	3.8%	0.843
Motor deficit			<0.02
Weakness	42.3%	37.6%	
Paralysis	32.8%	34.0%	
Dysarthria	37.7%	30.3%	<0.001
Aphasia	28.3%	32.4%	0.014
Swallowing problems	22.1%	27.0%	0.002
Urinary incontinence	40.0%	41.4%	0.457
Confusion	26.4%	26.8%	0.771
Coma	14.5%	16.1%	0.249
Brain imaging	82.6%	80.5%	0.145
Doppler	39.1%	38.0%	0.555
Echocardiogram	24.7%	27.1%	0.138
Angiography	4.5%	8.3%	<0.001
Neurosurgery	0.6%	2.6%	<0.001
Carotide surgery	0.6%	1.0%	0.320
Other vascular surgery	0.1%	0.6%	0.104

Results

Clinical Characteristics

During the 12-month period, a total of 4537 consecutive patients with acute stroke were included in the study, and 4481 (50.1% female; mean age, 71.7±12.6 years; range, 13 to 102 years; 1347 aged ≥80 years) had complete data.

Reliable information about diabetes could not be obtained in 56 patients (1.2%); they had severe strokes and were unconscious on admission and died before we could establish whether they had diabetes. Compared with the rest of the patients, they were significantly older (mean age, 80.5 years [SD 6.8] versus 76.8 years [SD 11.2]; $P<0.005$). The sex ratio was similar.

Diabetes was identified in 937 (21%) of the patients (51% female). Clinical characteristics of the cohort are reported in Table 1. Diabetic patients had a mean age and sex distribution similar to those of nondiabetic patients. Diabetic patients reported a significantly lower alcohol intake but no difference in smoking habits. The prestroke institutionalization rate did

TABLE 2. Stroke Pathological Types and Clinical Stroke Classification of Ischemic Stroke According to Diabetes Status

	Diabetes		
Variable, %	Yes	No	*P*
Stroke type	n=937	n=3544	<0.001
Cerebral infarction	77.5	71.9	
Cerebral hemorrhage	8.5	11.5	
Subarachnoid hemorrhage	0.5	2.1	
Unclassifiable	7.3	6.7	
Clinical syndromes of ischemic stroke	n=432	n=1605	0.031
TACI	12.2	13.3	
PACI	12.6	13.2	
POCI	8.4	7.6	
LACI	12.9	11.1	

TACI indicates total anterior circulation infarct; PACI, partial anterior circulation infarct; POCI, posterior circulation infarct; LACI, lacunar infarct.

not differ between the 2 groups. Diabetic patients reported a distribution of prestroke TIA similar to that of nondiabetic patients. Diabetic patients more frequently had a history of hypertension ($P<0.001$), used antihypertensive therapy ($P<0.001$), and showed a higher prestroke level of handicap, as defined by the Rankin Scale ($P=0.014$). However, atrial fibrillation was less frequent in the diabetic group ($P=0.012$). No details on the treatment of diabetes were available.

When we analyzed the single variables separately for each country, the major findings of the present study were essentially confirmed.

Stroke Characteristics and Use of Diagnostic and Surgical Procedures

Table 1 reports stroke characteristics and in-hospital use of diagnostic resources and surgical procedures. There was a significant difference between the diabetic and nondiabetic groups in motor deficits. There was an increased proportion with limb weakness in the diabetic group (42.3% versus 37.6%; $P<0.02$). Dysarthria was more frequent in the diabetic group (37.7% versus 30.3%; $P<0.001$), although aphasia was less frequent (28.3% versus 32.4%; $P=0.014$). Swallowing problems were less frequently present in the diabetic group (22.1% versus 27.0%; $P=0.002$). There was no difference between the 2 groups in the frequency of urinary incontinence and loss of consciousness. The use of diagnostic investigation was similar except for angiography, which was less frequent in diabetics. Neurosurgery was also less common in the diabetic group.

A comparison of the distribution of pathological types of stroke showed a significant difference between patients with and without diabetes ($P<0.001$) (Table 2). The diabetic patients were more likely to have an ischemic stroke (77.5% versus 71.9%) and less likely to have a hemorrhagic stroke than nondiabetic patients (8.5% versus 11.5%). There was a difference ($P=0.031$) in the distribution of ischemic stroke subtypes[11]: there were more POCI and LACI syndromes in the diabetic group and more TACI and PACI syndromes in the nondiabetic group.

Stroke Recovery and Outcome

Follow-up information was completed for 3558 patients (79% of the total study sample; 78% in the diabetic group and 79.6% in the nondiabetic group). At 3 months, the case fatality rates in the 2 groups were comparable (20.2% versus 21.8%; $P=0.318$). Among survivors, handicap was significantly increased in patients with diabetes according to Rankin Scale score between 2 and 5 (73.3% versus 66.9%; $P=0.007$), but no significant difference was found in the disability according to Barthel Index score of <14 (28.2% versus 25.3%; $P=0.20$).

Death at 3 Months

Table 3 reports the factors associated with 3-month death as determined by multivariable analysis in the whole group and in the 2 groups separately. When all study patients were considered (diabetics and nondiabetics), diabetes was not related to 3-month death (odds ratio, 1.21; 95% CI, 0.93 to 1.57; $P=0.33$). The following factors were significantly related to death: male sex, age (mainly ≥85 years), prestroke Rankin Scale score 2 to 5, coma, urinary incontinence, swallowing problems, and hemorrhagic stroke. When the 2 groups were examined separately (Table 3), we observed that diabetic men had a higher risk for death at 3 months and that coma was a stronger factor of death at 3 months in the nondiabetic group.

Disability (Barthel Index) at 3 Months

The analysis of the association between diabetes and disability, defined by the Barthel Index (scored from 0 to 14), is presented in Table 4.

Diabetics were more disabled at 3 months than nondiabetics (odds ratio, 1.39; 95% CI, 1.05 to 1.83; $P=0.016$). Female sex, old age, prestroke Rankin Scale score 2 to 5, confusion, swallowing problems, and urinary incontinence were significantly related to disability in total sample. In diabetic patients, only age, prestroke Rankin Scale score 2 to 5, and urinary incontinence were significantly associated with disability.

Handicap (Rankin Scale) at 3 Months

The analysis of factors related to 3-month handicap, defined as Rankin Scale score 2 to 5, is shown in Table 5. Diabetes was significantly related to handicap (odds ratio, 1.47; 95% CI, 1.13 to 1.91; $P=0.005$). Female sex, prestroke Rankin Scale score 2 to 5, living in an institution, myocardial infarction, atrial fibrillation, coma, aphasia, urinary incontinence, and swallowing problems were risk factors of handicap at 3 months. When the 2 groups were considered separately, in the diabetic group, female sex, prestroke Rankin Scale score 2 to 5, coma, and urinary incontinence were related to handicap at 3 months.

Discussion

The main purpose of this study was to evaluate the impact of diabetes on initial stroke type patterns and outcome in a large sample of stroke patients hospitalized in a European context.

TABLE 3. Association Between Baseline and Clinical Variables and 3-Month Death (From Multivariate Logistic Regression Models)*

	OR [95% CI]**		
		Diabetes	
Variable	Total (n=3084)	Yes (n=654)	No (n=2430)
Female	1	1	1
Male	1.50 [1.21–1.86]	2.20 [1.35–3.57]	1.33 [1.04–1.70]
Age			
≤64	1	1	1
65–74	1.93 [1.36–2.75]	1.59 [0.75–3.37]	2.04 [1.36–3.06]
75–84	3.15 [2.22–4.45]	2.93 [1.39–6.18]	3.23 [2.17–4.79]
≥85	5.66 [3.82–8.38]	8.10 [3.25–20.2]	5.38 [3.46–8.36]
Prestroke Rankin			
(0–1)	1	1	1
(2–5)	1.66 [1.31–2.10]	1.78 [1.05–3.01]	1.62 [1.24–2.11]
No hemorrhagic stroke	1	1	1
Hemorrhagic stroke	1.42 [1.11–1.83]	1.12 [0.63–1.98]	1.49 [1.13–1.97]
No coma	1	1	1
Coma	6.11 [4.55–8.20]	4.92 [2.43–9.96]	6.58 [4.74–9.15]
No urinary incontinence	1	1	1
Urinary incontinence	2.85 [2.24–3.63]	3.55 [2.10–6.01]	2.70 [2.05–3.54]
No swallowing problems	1	1	1
Swallowing problems	2.36 [1.85–3.01]	2.70 [1.52–4.79]	2.35 [1.79–3.09]
No diabetes	1		
Diabetes	1.21 [0.93–1.57]		

*Adjusted by country; **95% CI indicates 95% confidence interval.

Prestroke Clinical Characteristics

The prevalence of diabetes was 21%. In other studies, diabetes has been reported to be between 13% and 36%.[4,13–15] This large variation was probably caused by differences in the selection of patients, in the size of the cohorts, and in the definition of diabetes and methods of measuring glycemia.

The present study showed that, as observed in other studies,[4] diabetic patients with stroke are the same age as nondiabetic patients. This may be explained by the fact that atheroma of cerebral vessels induced by diabetes occurs at the same rate as other vascular risk factors.[1,15,16]

There was no difference between the 2 groups in the sex ratio, suggesting that diabetes has the same impact on cerebral vessels in both sexes. Current or previous smoking was distributed equally between the 2 groups, but alcohol consumption was low in the diabetic group, implying that diabetes may modify behavior.

Hypertension was more frequent in diabetic patients, and antihypertensive therapy was prescribed in a greater proportion of diabetic hypertensive patients than in nondiabetic patients, in accordance with previous observations,[16] emphasizing the fact that diabetes and hypertension are associated.[17]

Antiplatelet and anticoagulant therapies were prescribed equally in both groups. These data show that practitioners did not consider diabetic patients differently than nondiabetic patients in 1993. Today there are recommendations by several organizations stating clearly that antiplatelet therapies and treatments of vascular risk factors should be used in diabetic patients. The characteristics of diabetic patients who did not receive such therapy were not different from those of nondiabetic patients, and if we compare data between centers, the proportion of patients treated with antiplatelet drugs was similar in diabetic and nondiabetic groups.

Atrial fibrillation may be a cause of more severe handicap by way of motor and cognitive deficits and pseudobulbar syndrome[18] induced by a higher risk of stroke.[19] However, atrial fibrillation was less frequent in the diabetic group, as reported previously,[4] suggesting that poststroke handicap in the diabetic group is due to another cause as well as microangiopathy induced by hypertension.

The proportion of previous TIA was similar in the 2 groups, suggesting that the effects of hypertension and atrial fibrillation are balanced equally in the 2 groups. There was no difference between the 2 groups in the percentage of institutionalized patients.

Clinical and Subtype Characteristics of Stroke

In diabetic patients, the neurological deficit was characterized by a predominance of motor deficit, especially weakness and dysarthria, but aphasia was more common in nondiabetic patients. Dysarthria may be interpreted as the consequence of bilateral small lesions affecting pyramidal corticonuclear tracts by means of lacunar lesions. These clinical features, similar to lacunar syndrome, were associated with more

TABLE 4. Association Between Baseline and Clinical Variables and Disability Defined as Barthel (0–14) at 3 Months (From Logistic Regression Models)*

	OR [95% CI]**		
		Diabetes	
Variable	Total (n=2202)	Yes (n=465)	No (n=1737)
Male	1	1	1
Female	1.35 [1.07–1.70]	1.18 [0.73–1.90]	1.37 [1.02–1.79]
Age			
≤64	1	1	1
65–74	1.33 [0.96–1.85]	2.19 [1.15–4.18]	1.08 [0.73–1.59]
75–84	1.81 [1.31–2.51]	1.32 [0.65–2.68]	1.95 [1.35–2.84]
≥85	4.18 [2.74–6.38]	4.62 [1.62–13.2]	4.02 [2.52–6.42]
Prestroke Rankin			
(0–1)	1	1	1
(2–5)	2.54 [1.94–3.34]	2.19 [1.26–3.80]	2.63 [1.92–3.60]
No confusion	1	1	1
Confusion	1.70 [1.28–2.26]	1.31 [0.71–2.44]	1.85 [1.33–2.55]
No swallowing problems	1	1	1
Swallowing problems	2.04 [1.50–2.77]	1.26 [0.62–2.56]	2.26 [1.60–3.19]
No urinary incontinence	1	1	1
Urinary incontinence	4.19 [3.23–5.43]	4.62 [2.68–7.96]	4.07 [3.02–5.48]
No diabetes	1		
Diabetes	1.39 [1.05–1.83]		

*Adjusted by country; **95% CI indicates 95% confidence interval.

cerebral infarcts in our diabetic patient group, as observed by Jorgensen et al[4] (5% versus 9%) and by Kiers et al[14] (13% versus 22%).

The low frequency of hemorrhage in patients with diabetes is well known[4,5] and may be a true phenomenon, ie, a real pathophysiological association may exist in which the treatment of hypertension is not the main explanation.[4,5]

In our diabetic group, the distribution of the pathological subtypes of stroke[11] was slightly different, with more POCI and LACI syndromes. The fact that we observed more LACI syndromes in diabetic patients has not been reported in other studies,[20,21] which raises the problem of biases induced by small series, the definition of diabetes, and other methodological aspects.[4,21]

Death at 3 Months

Diabetes was not associated with death at 3 months, whereas male sex, old age, prestroke handicap, hemorrhage, coma, urinary incontinence, and swallowing problems were independently associated with death at 3 months. Our series does not identify diabetes as a determinant of early mortality (3 months), while in the literature, diabetes appears to be determinant of late mortality through coronary heart disease. We think that the increased presence of lacunes in diabetic patients may also explain the low mortality at 3 months.

Disability and Handicap at 3 Months

Our results show the effect of diabetes on disability and handicap in stroke patients. There is evidence of an adverse relationship between diabetes and both handicap (Rankin Scale) and disability (Barthel Index) at 3 months, with stronger evidence of the relationship with handicap.

Factors that increase the risk of handicap, measured by the Rankin Scale, and the risk of disability, measured by the Barthel Index, are female sex, old age (particularly for those aged ≥85 years), prestroke Rankin Scale score, dysphagia, and urinary incontinence. These factors have a similar value for the 2 scales. Confusion has a significant predictive value for a poor Barthel Index score, while coma, aphasia, atrial fibrillation, and myocardial infarction have a significant predictive value for a poor Rankin Scale score.

According to the results of the 2 groups, dysphagia is a stronger factor for handicap (Rankin Scale) than for disability (Barthel Index) in the diabetic group. The presence of atrial fibrillation or myocardial infarct is a weaker factor for handicap (Rankin Scale) in the diabetic group than in the nondiabetic group. However, coma and history of living in an institution are related to a poor Rankin Scale score in the diabetic group. These data also reflect the negative impact of multiple and repeated ischemic cerebral lesions.

Our data suggest that Barthel and Rankin scores are complementary, with the Barthel score identifying objective parameters of disability and the Rankin score identifying subjective parameters of disability and of global health index, with a strong accent on physical ability. As suggested by the Rankin Scale score at 3 months, diabetic patients recover more slowly than nondiabetic patients. This finding is supported by others.[4,13,21] Various mechanisms may account for

TABLE 5. Association Between Baseline and Clinical Variables and Handicap Defined as Rankin Score (2–5) at 3 Months (Logistic Regression Analysis)*

	OR [95%CI]**		
		Diabetes	
Variable	Total (n=2004)	Yes (n=401)	No (n=1606)
Male	1	1	1
Female	1.29 [1.04–1.60]	1.69 [1.03–2.80]	1.21 [0.95–1.54]
Age			
≤64	1	1	1
65–74	0.83 [0.63–1.08]	0.64 [0.35–1.19]	0.86 [0.63–1.15]
75–84	0.92 [0.69–1.21]	0.76 [0.39–1.49]	0.94 [0.68–1.28]
≥85	1.39 [0.88–2.18]	2.47 [0.48–12.6]	1.30 [0.81–2.11]
Prestroke Rankin			
(0–1)	1	1	1
(2–5)	2.38 [1.72–3.28]	2.50 [1.19–5.26]	2.40 [1.67–3.44]
Living conditions alone	1	1	1
At home not alone	1.18 [0.93–1.50]	1.54 [0.83–2.89]	1.12 [0.86–1.46]
Institutionalized	2.61 [1.25–5.43]	5.49 [0.60–49.9]	2.35 [1.07–5.17]
No atrial fibrillation	1	1	1
Atrial fibrillation	1.43 [1.05–1.94]	0.91 [0.42–2.00]	1.55 [1.11–2.17]
No myocardial infarction	1	1	1
Myocardial infarction	1.50 [1.05–2.16]	0.91 [0.43–1.97]	1.76 [1.16–2.67]
No coma	1	1	1
Coma	2.83 [1.27–6.29]	11.9 [1.40–102]	2.08 [0.86–5.01]
No aphasia	1	1	1
Aphasia	1.32 [1.03–1.69]	0.99 [0.55–1.80]	1.41 [1.06–1.86]
No urinary incontinence	1	1	1
Urinary incontinence	3.67 [2.68–5.04]	2.51 [1.25–5.04]	4.07 [2.85–5.82]
No swallowing problems	1	1	1
Swallowing problems	1.82 [1.25–2.63]	1.46 [0.54–3.94]	1.86 [1.24–2.79]
No diabetes	1		
Diabetes	1.47 [1.13–1.91]		

*Adjusted by country; **95% CI indicates confidence interval.

this, including more comorbidities, more prestroke disability, more ischemic lacunes, more motor problems, and diabetic neuropathy.

Conclusion

From this large prospective European multicenter study, stroke in diabetic patients was different from stroke in nondiabetic patients from several perspectives. In diabetic stroke patients, the frequency of intracerebral hemorrhage was lower, the rate of lacunes was higher, recovery of handicap by Rankin Scale score was worse, and mortality was not increased. Prevention and treatment of stroke in diabetic patients are major challenges facing those involved in health planning in Europe in the coming decades.

Appendix

Study Participants

Study participants include the following: O. Tofani, A. Rosselli, F. Ccordopatri, G. Giuntoli, M. Magherini, P. Penatti, S. Tatini, F. Trucco, E. Pieragnoli, F. Manetti, C. Mugnaini, L. Bagnoli, O. Marrazza, G.P. Menegazzo, and I. Meucci, S.M. Ospedale, Annunziata, Health Area 10, Florence, Italy; C. Cappelletti, M. Ricca, P. Adriani, and C. Bianco, Nuovo Ospedale S. Giovanni di Dio, Health Area 10, Florence, Italy; R. Beech, K. Tilling, C.D.A. Wolfe, Department of Public Health Sciences, King's College, London, England; A.G. Rudd, Department of Care of the Elderly, St Thomas' Hospital, London, England; S. Ebrahim, Department of Social Medicine, Bristol University, Bristol, England; D.H. Barer and Y. Ellul, Department of Medicine for the Elderly, Newcastle General Hospital, Newcastle, England; M. Ayana, P. Gompertz, R. Harwood, and P. Pound, Department of Primary Care and Population Sciences, Royal Free Hospital School of Medicine, London, England; H. Rogers, Center for Health Service Research, University of Newcastle, Newcastle, England; M. Giroud, M. Menassa, and M. Lemesle, Service de Neurologie, Center Hospitalier Regional et Universitaire de Dijon, Dijon, France; K. Kunze, Neurologischen Universittatsklinik, Hambourg-Eppendorf, Germany; J. Berger, Institute of Mathematics and Computer Science in Medicine, University Hospital Eppendorf, Eppendorf, Germany; B. Haussler, W. Mall, and N. Nolting, Institut für Gesundheits und Sozialforschung GmbH (IGES), Berlin, Germany; Z. Nagy, C. Ovary, and Z. Vokoq, National Stroke Center, Budapest, Hungary; M. Carrageta, J. Namora, I. Remidios, A. Santos, and J. Coisinha, Hospital Garcia de Orta, Almada, Portugal; J. Dias, Divisao de Epidemiologia, Direccao

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References

1. Warlow CP. Epidemiology of stroke. *Lancet*. 1998;352(suppl 1):1–4.
2. Sacco RL, Wolf PA, Gorelick PB. Risk factors and their management for stroke prevention: outlook for 1999 and beyond. *Neurology*. 1999; 53(suppl 4):S15–S24.
3. Mantovsky B, Metzger B, Molitch M, Biller J. Cerebrovascular disorders in patients with diabetes mellitus. *J Diabetes Complications*. 1996;10: 228–242.
4. Jorgensen HS, Nakayama H, Raaschon HO, Olsen TS. Stroke in patients with diabetes: the Copenhagen Stroke Study. *Stroke*. 1994;25:1977–1984.
5. Tuomilehto J, Rastenyte D, Jousilahti P, Sarti C, Vartiainen E. Diabetes mellitus as a risk factor for death from stroke: prospective study of the middle-aged Finnish population. *Stroke*. 1996;27:210–215.
6. Di Carlo A, Lamassa M, Pracucci G, Basile AM, Trefoloni G, Vanni P, Wolfe CDA, Tilling K, Ebrahim S, Inzitari D, for the European BIOMED Study of Stroke Care Group. Stroke in the very old: clinical presentation and determinants of 3-month functional outcome: a European perspective. *Stroke*. 1999;30:2313–2319.
7. Report of the WHO Task Force on Stroke and Other Cerebrovascular Disorders. Stroke–1989: recommendations on stroke prevention, diagnosis, and therapy. *Stroke*. 1989;20:1407–1431.
8. Asplund K, Tuomilehto J, Stegmayr B, Wester PO, Tunstall-Pedoe H. Diagnostic criteria and quality control of the registration of stroke events in the MONICA Project. *Acta Med Scand*. 1988;(suppl 728):26–39.
9. Lemesle M, Milan C, Faivre J, Moreau T, Giroud M, Dumas R. Incidence trends of ischemic stroke and transient ischemic attacks in a well-defined French population from 1985 through 1994. *Stroke*. 1999;30:371–377.
10. World Health Organization. *WHO Study Group on Diabetes Mellitus*. Geneva, Switzerland: World Health Organization; 1985. Technical Report Series 727.
11. Bamford J, Sandercock P, Dennis M, Burn J, Warlow C. Classification and natural history of clinically identifiable subtypes of cerebral infarction. *Lancet*. 1991;337:1521–1526.
12. Mahoney FI, Barthel DW. Functional evaluation: the Barthel Index. *Md State Med J*. 1965;4:1–65.
13. Olsson T, Viitanen M, Asplund K, Eriksson S, Hägg E. Prognosis after stroke in diabetic patients: a controlled prospective study. *Diabetologia*. 1990;33:244–249.
14. Kiers L, Davis SM, Larkins R, Hopper J, Tress B, Rossiter SC, Carlin J, Ratnaike S. Stroke topography and outcome in relation to hyperglycemia and diabetes. *J Neurol Neurosurg Psychiatry*. 1992;55:263–270.
15. Woo J, Lam CWK, Kay R, Wong AHY, Teoh R, Nicholls MG. The influence of hyperglycemia and diabetes mellitus on immediate and 3 month morbidity and mortality after acute stroke. *Arch Neurol*. 1990;47: 1174–1177.
16. Lehto S, Rönnemaa T, Pyorala K, Laakso M. Predictors of stroke in middle-aged patients with non–insulin-dependent diabetes. *Stroke*. 1996; 27:63–68.
17. Stearne MR, Palmer SL, Hammersley S, Franklin SL, Spivey RS, Levy JC, Tidy CR, Bell MJ, Steemson J, Barrow BS, Coster R, Waring K, et al. Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. *BMJ*. 1998;317: 703–713.
18. Lin HJ, Wolf PA, Kelly-Hayes M, Beiser AS, Kase CS, Benjamin EJ, D'Agostino RB. Stroke severity in atrial fibrillation: the Framingham Study. *Stroke*. 1996;27:1760–1764.
19. Jorgensen HS, Nakayama H, Reith J, Raaschou HO, Olsen TS. Acute stroke with atrial fibrillation: the Copenhagen Stroke Study. *Stroke*. 1996;10:1765–1769.
20. Arboix A, Morcillo C, Garcia-Eroles L, Oliveres M, Massons J, Targa C. Different vascular risk factor profiles in ischemic stroke subtypes: a study from the "Sagrat Cor Hospice of Barcelona Stroke Registry." *Acta Neurol Scand*. 2000;102:264–270.
21. Devuyst G, De Freitas G, Van Melle G, Bogousslavsky J. Stroke subtypes in diabetics. *Cerebrovasc Dis*. 2000;10(suppl 2):4.