Risk Factors for Early Recurrence After Ischemic Stroke
The Role of Stroke Syndrome and Subtype

Joan T. Moroney, MD, MRCPI; Emilia Bagiella, PhD; Myunghee C. Paik, PhD; Ralph L. Sacco, MD, MS; David W. Desmond, PhD

Background and Purpose—Information regarding risk factors for early recurrence is limited. Our aim was to identify the clinical predictors of early recurrence after ischemic stroke.

Methods—We prospectively examined 297 patients (mean age, 72.0±8.4 years) hospitalized with ischemic stroke to identify recurrent strokes occurring within 90 days of the index stroke. Survival free of recurrence was estimated using Kaplan-Meier analysis stratified by demographic variables; vascular risk factors; stroke syndrome, subtype, vascular territory, and severity; scores on the Barthel Index and Mini-Mental State Examination during hospitalization; blood pressure on admission; and selected laboratory data. We estimated the relative risk (RR) of early recurrence associated with those variables using proportional hazards analysis.

Results—We identified 22 recurrent events in the first 90 days after the index stroke, resulting in an early stroke recurrence rate of 7.4%, and death occurred immediately after recurrence in 6 of the 22 patients. A major hemispheric stroke syndrome (RR=2.9; 95% confidence interval [CI]=1.2 to 7.1), atherothrombotic stroke mechanism (RR=3.3; CI=1.3 to 8.3), and atrial fibrillation (RR=2.2; CI=0.8 to 6.1) were independent predictors of early recurrence, after adjustment for demographic variables.

Conclusions—Early recurrence was frequent and resulted in increased mortality. Attention to the clinical features of the index stroke, including the presenting syndrome and the ischemic mechanism, and the recognition of atrial fibrillation may help in the selection of patients for the initiation of targeted interventions to prevent early recurrence and subsequent mortality. (Stroke. 1998;29:2118-2124.)

Key Words: mortality ■ risk factors ■ stroke, ischemic ■ stroke outcome

Although many studies have emphasized strategies for the primary prevention of stroke,1,3 the prevention of recurrent stroke has received less attention. Given that stroke incidence is stable or increasing in our aging population and that stroke-related mortality is declining,5 however, the prevention of recurrent stroke becomes critical to the accomplishment of initiatives in the United States and Europe that seek to significantly reduce the cumulative public health burden associated with stroke.5,7 Recurrent stroke occurs most frequently in the early period after ischemic stroke, with estimates ranging from 1.2% to 9%.8 Recurrence in the immediate poststroke period is known to prolong hospital stay and substantially increase neurological disability and death,5 underscoring the need to better understand the factors that predispose to early recurrence. Previous studies of risk factors have tended to focus on long-term recurrence,10-15 often with contradictory findings, and the need for more accurate predictors has been emphasized.16 Identification of the factors that increase the risk of early recurrent stroke would facilitate the selection of high-risk subgroups who may benefit from targeted interventions to prevent recurrence and the associated increases in disability and mortality.

We have previously found that stroke-related dementia, cardiac disease, and female sex were independent risk factors for long-term stroke recurrence in older individuals hospitalized with acute ischemic stroke.17 We hypothesized that patients with early recurrent stroke would represent a distinct subgroup, with a different set of risk factors that might hold different therapeutic implications, compared with patients with late recurrence. Thus, the aims of this study were to identify the clinical predictors of recurrent stroke occurring within 90 days of acute ischemic stroke and contrast them with those that we previously identified in our work on long-term stroke recurrence.

Subjects and Methods

Subjects
As part of a prospective study of stroke and dementia,18 we examined 297 patients admitted within 30 days of onset of ischemic stroke to Columbia-Presbyterian Medical Center (CPMC). The mean age of

Received June 9, 1998; final revision received July 17, 1998; accepted July 17, 1998.
From the Department of Neurology (J.T.M., R.L.S., D.W.D.), the Gertrude H. Sergievsky Center (J.T.M., R.L.S.), and the Division of Biostatistics (E.B., M.C.P.), Columbia University, College of Physicians and Surgeons, New York, NY.
Presented in part at the 48th annual meeting of the American Academy of Neurology, San Francisco, Calif, March 27, 1996.
Reprint requests to Dr David W. Desmond, Stroke and Aging Research Project, Neurological Institute, 710 W 168th St, New York, NY 10032. E-mail dwd2@columbia.edu
© 1998 American Heart Association, Inc.
these patients was 72.0 ± 8.4 years, and their mean education was 10.0 ± 4.6 years. Males constituted 45.1% of the sample, and the cohort was of mixed race/ethnicity, with 39.7% black, 32.3% white, 26.3% Hispanic, and 1.7% of other race/ethnicity. Eligibility criteria included an age of ≥60 years, use of English or Spanish as a primary language, residence within 50 miles of CPMC, and a diagnosis of acute ischemic stroke of any subtype. Patients were excluded when certain clinical characteristics precluded a reliable assessment of cognitive function, such as severe aphasia (ie, a score ≤ 2 on the severity rating scale of the Boston Diagnostic Aphasia Examination)20 or persistent impairment in level of consciousness resulting from any cause. Additional exclusions were the presence of comorbid disorders that might limit survival or affect cognitive function, although patients were not excluded if a premorbid history of functional impairment suggested that they might also have Alzheimer’s disease. Index stroke was defined as the acute onset of a focal neurological deficit attributable to vascular disease of the brain that lasted > 24 hours and was supported by CT scan (normal or relevant infarct) performed within 1 week of symptom onset. A more extensive description of our recruitment procedures is available in an earlier publication on methods and baseline findings.18 Informed consent was obtained from subjects or their family members using procedures approved by the Institutional Review Board of CPMC. During hospitalization, medical and neurological histories were collected, and each patient underwent structured medical and neurological examinations by a neurologist specializing in stroke. A cognitive assessment using the Mini-Mental State Examination (MMSE)21 and a functional assessment using the Barthel Index (BI)22 were performed by trained research assistants. Among the 297 patients who were initially enrolled, all were eligible for this study of early recurrence.

**Recurrent Stroke**

Recurrent stroke was defined as a new cerebrovascular event that met one of the following criteria 9,14: (1) the event resulted in a neurological deficit that was clearly different from that of the index stroke, (2) the event involved a different anatomic site or vascular territory from that of the index stroke, (3) the event was of a stroke subtype different from that of the index stroke. This requirement was intended to ensure that systemic causes of clinical deterioration after an initial stroke (eg, hypoxia, hypotension, hyperglycemia, infection) or worsening symptoms because of progression of the initial stroke were not misclassified as a recurrent cerebrovascular event.23 We defined early recurrence as that which occurred within 90 days of the index stroke because there is no universally accepted definition of early recurrence and a similar criterion had been used by other studies of early recurrence.24,25 In addition, we wished to compare our findings with those of our previous study on long-term recurrence, in which we identified recurrences occurring > 90 days after the index stroke.26 Whenever possible, patients were examined and brain imaging was obtained at the time of the recurrence to support the diagnosis of recurrent stroke. Both ischemic and hemorrhagic strokes were included as recurrent cerebrovascular events. Based on combined clinical, laboratory, and neuroimaging information, the stroke mechanism for each recurrent event was determined with methods modified from the Stroke Data Bank.25 For those patients who had > 1 early recurrence, we considered only the first recurrence.

**Patient Follow-Up**

We confirmed cases of symptomatic recurrent stroke through in-person interview and neurological examinations performed ~90 days after the index stroke. If a patient was in a nursing home or unable to provide a reliable history, information regarding stroke recurrence was obtained from nursing home records, family contacts, and/or a field visit. In cases of death, medical records and death certificates were reviewed to screen for recurrent stroke. In addition, we performed continuous surveillance of admissions to our medical center to identify additional cases of recurrent stroke.

**Statistical Methods**

Using the Kaplan-Meier product-limit method, we estimated the proportion of patients surviving free of early recurrence in the overall sample and then in groups stratified by demographic variables (ie, age, education, sex, and race); vascular risk factors (ie, hypertension; diabetes mellitus; cardiac disease, with myocardial infarction, angina, congestive heart failure, valvular heart disease, and atrial fibrillation treated as separate cardiac conditions; hypercholesterolemia; cigarette smoking, defined as history of smoking ≥ 1 cigarette per day for ≥ 1 year; and alcohol consumption, classified as ≥ 200 versus < 200 g/week, with 1 standard drink [a can of beer, a glass of wine, or a single measure of spirits] representing the equivalent of 10 g of alcohol);6 history of prior stroke or transient ischemic attack (TIA); clinical features of the index stroke (stroke syndrome and subtype, see classification below; vascular territory, classified as internal carotid versus vertebrobasilar; the BI administered 7 to 10 days after the index stroke, with a score of ≤ 80 representing functional impairment);23 and the MMSE administered 7 to 10 days after the index stroke, with a score of < 24 representing cognitive impairment);24 blood pressure readings on admission, with systolic blood pressure classified as > 160 versus ≤ 160 mm Hg and diastolic blood pressure classified as > 100 versus ≤ 100 mm Hg; and selected laboratory data (ie, blood glucose > 140 versus ≤ 140 mg/dL on admission14 and cholesterol level > 240 versus ≤ 240 mg/dL determined 7 to 10 days after stroke).27 For the 7- to 10-day poststroke assessments (ie, MMSE, BI, and serum cholesterol), we excluded any patient who experienced an early recurrence before those assessments.

We classified the stroke syndrome based on the range and severity of neurological deficits in the acute phase after the index stroke. The 6 syndromic subtypes were defined by hemispheric laterality (dominant versus nondominant), severity of neurological impairment (major versus minor), and general cerebral location (hemispheric versus brain stem/cerebellar; superficial versus deep).24,25 Using all available diagnostic information from the index stroke evaluation and a diagnostic algorithm modified from the Stroke Data Bank,25,28 we diagnosed 4 major stroke subtypes: large-artery atherosclerosis (both hemodynamic and embolic), cardioembolic embolism, lacunar infarction, and cryptogenic infarction.

We investigated the standard MMSE cutoff of a total score < 24 as a possible predictor of early recurrence because in previous work we had identified dementia diagnosed 3 months after stroke based on comprehensive neuropsychological and functional assessments as an independent predictor of long-term recurrent stroke.29 Only the MMSE was administered as a measure of cognitive function in the early period after the index ischemic stroke as part of the present study. We chose to include patients with a history of prior stroke or TIA in our analyses because previous studies have identified both prior stroke and TIA as predictors of recurrence24,29 and we wished to examine their role in our sample.

Survival time was calculated from the date of onset of the index stroke, and hypothesis testing was conducted using the log rank test. Reasons for censoring included death unrelated to stroke recurrence, subject dropout, and survival free of recurrence through the end of the 90-day study period. To estimate the independent contributions of the above variables to the risk of stroke recurrence, we fitted Cox proportional hazards models, adjusting for demographic variables. Variables were selected for entry into the model based on the results of the log rank analyses (P < 0.1) or a priori hypotheses based on previously published studies.

**Results**

We identified 22 recurrent strokes in the first 90 days after the index stroke in our sample, resulting in a cumulative early recurrence rate of 7.4%. Of those 22 recurrences, 13 occurred in the first 30 days after stroke, resulting in a 30-day cumulative recurrence rate of 4.4%. The 90-day case-fatality rate was 31.8% in the group with an early recurrence (7 of 22 patients) compared with 2.9% in those without an early
recurrence (8 of 275 patients), with 6 of the 7 deaths in the early recurrence group due to the direct neurological sequelae of the recurrent stroke. Most recurrent strokes (21 of 22 events) were classified as ischemic based on the results of brain imaging obtained at the time of the suspected recurrence. In 1 patient, the type of recurrence remained unspecified because of lack of follow-up brain imaging. We had complete information regarding the features of the recurrent stroke for 18 of the 22 events. Of those 18 events, 13 were of the same type as the index stroke, 5 were of a stroke subtype different from that of the index stroke, 5 were of a stroke subtype different from that of the index stroke, and 16 involved an anatomic site or vascular territory different from that of the index stroke. Cumulative stroke recurrence rates stratified by demographic characteristics and selected vascular risk factors of the sample are presented in Table 1.

Among the demographic characteristics, we found no effect for age, education, and race, but there was a trend toward a higher rate of early recurrence in women compared with men. Among vascular risk factors, there was a higher rate of recurrence among patients with hypertension, consistent cigarette use, and alcohol consumption ≥200 g/wk, but those differences failed to reach statistical significance. Among cardiac conditions, there was a trend toward a higher rate of early recurrence in patients with atrial fibrillation, but a significant effect was not found for other cardiac conditions. A history of clinically evident prior stroke or TIA did not significantly affect the early recurrence rate.

Table 2 presents the cumulative stroke recurrence rates stratified by the clinical features of the index stroke. A major hemispheric stroke syndrome, an atherothrombotic stroke mechanism, and a BI score ≤80 7 to 10 days after the index stroke were significant predictors of early recurrence in our sample. The cumulative proportion (±SE) of patients surviving free of recurrence stratified by the presenting stroke syndrome is presented graphically in Figure 1. Early recurrence was most frequent in the major hemispheric group, with 15% of those patients having a recurrent stroke during the follow-up period of 90 days, and least frequent in the lacunar group, which experienced no recurrences. Based on the log rank test, the survival curves were significantly different ($\chi^2=16.39$, df=3, $P<0.001$).
FIGURE 2. Kaplan-Meier analysis showing the cumulative proportion of patients surviving free of recurrent stroke stratified by the presenting stroke subtype (classified as large-artery atherothrombosis, cardiogenic embolism, lacunar, or cryptogenic infarction). The curves are significantly different by the log rank test ($P<0.003$).

Figure 2 depicts the cumulative proportion (±SE) of patients surviving free of early recurrence stratified by the index stroke mechanism. Early recurrence was most frequent in the large-vessel atherothrombotic group, with 13% of those patients having a recurrent stroke during the follow-up period of 90 days; intermediate in the embolic group, with 11% having a recurrent stroke; and least frequent in the lacunar group, with only 1% having a recurrent stroke. The survival curves differed significantly based on the log rank test ($\chi^2=15.98, df=4, P=0.003$).

A BI score ≥80 was also significantly more frequent in the group who experienced an early recurrence, with 11% of those patients having a recurrent stroke compared with only 2% of those with a BI score >80 ($\chi^2=6.44, df=1, P=0.011$). Although early recurrence was more frequent in patients with a carotid territory stroke and in those with a MMSE score <24, those differences failed to reach statistical significance.

Laboratory data and blood pressure readings on admission did not have a significant effect on the early recurrence rate. The initial Cox proportional hazards model was based on the 4 demographic variables alone and did not reveal any significant effects on the risk of early recurrence (model A, Table 3). The final model (model B, Table 3) was developed by adding other variables based on improvement in the log-likelihood ratio. A major hemispheric stroke syndrome (relative risk [RR] = 2.9; 95% confidence interval [CI] = 1.2 to 7.1) and an atherothrombotic stroke mechanism (RR = 3.3; 95% CI = 1.3 to 8.3) were identified as significant independent risk factors for early stroke recurrence in that model. Although a BI score of ≥80 was a significant univariate predictor of early recurrence, it was not retained in the final model, and further analysis revealed significant collinearity with a major hemispheric stroke syndrome. Based on the findings of prior studies, we entered atrial fibrillation into the final model. Although it was related to early recurrence (RR = 2.2; 95% CI = 0.8 to 6.1), it failed to reach statistical significance.

**TABLE 3. Relative Risk of Early Recurrent Stroke Based on Cox Proportional Hazards Models for Demographic Factors (Model A) and Relevant Clinical Variables (Model B)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Relative Risk (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (vs 60–69 y)</td>
<td></td>
</tr>
<tr>
<td>70–79 y</td>
<td>1.4 (0.5–3.3)</td>
</tr>
<tr>
<td>≥80 y</td>
<td>0.5 (0.1–2.5)</td>
</tr>
<tr>
<td>Education (vs 13 + y)</td>
<td></td>
</tr>
<tr>
<td>≥8 y</td>
<td>1.4 (0.4–5.5)</td>
</tr>
<tr>
<td>9–12 y</td>
<td>1.8 (0.5–7.2)</td>
</tr>
<tr>
<td>Sex (female vs male)</td>
<td></td>
</tr>
<tr>
<td>Major hemispheric syndrome</td>
<td>2.9 (1.2–7.1)</td>
</tr>
<tr>
<td>Atherothrombotic mechanism</td>
<td>3.3 (1.3–8.3)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>2.2 (0.8–6.1)</td>
</tr>
</tbody>
</table>

**Discussion**

Early recurrence was frequent in our sample, with a 90-day cumulative recurrent stroke rate of 7.4%, which is comparable to other prospective stroke series. Of the 22 recurrent events detected in the first 90 days after the index stroke, the majority (59.1%) occurred in the first 30 days, suggesting that this period carried the greatest risk. Early recurrence was associated with increased mortality, with a higher 90-day mortality rate among patients who experienced an early recurrence (31.8%) compared with those who did not (2.9%). The early mortality rate in patients without early recurrence was lower than that of other prospective stroke series, possibly because of the exclusion of patients with impairment in level of consciousness from our study, which is known to be associated with higher early mortality. A major hemispheric stroke syndrome and an atherothrombotic stroke mechanism were significant independent risk factors for early recurrence in our sample, while atrial fibrillation was weakly
related. Our findings serve to emphasize the higher mortality associated with the early recurrence of stroke and suggest that attention to the clinical features of the index stroke, including the presenting stroke syndrome and the ischemic stroke mechanism, may be of prognostic value.

The wide variation among previous studies in the reported rates of early recurrent stroke may be related to differences in study populations (eg, hospital versus community-based samples), study designs (eg, prospective versus case-control), and qualifying criteria for a recurrent event. Most of the studies have found that the early period after acute ischemic stroke carries the greatest risk of recurrence, however, and that mortality is increased among those with early recurrence. The Stroke Data Bank investigators prospectively determined the 30-day cumulative risk of early recurrence to be 3.3% and found that early recurrent stroke was associated with a higher 30-day case-fatality rate in their sample, with the majority of deaths in the early recurrence group directly attributable to the recurrent stroke. The risk of recurrent stroke was also greatest in the first 30 days after the index stroke in the Northern Manhattan Stroke Study, with a 6% recurrence rate and a doubling of 30-day mortality among those with versus without early recurrence (19% versus 8%).

Although the presenting clinical syndrome is a characteristic that can be determined quickly and potentially used by the clinician to predict early recurrence, few previous studies have investigated its effect on the risk of early recurrence. We found that patients presenting with a major hemispheric stroke syndrome, in part reflecting a larger volume of infarction, had a significantly higher risk of early recurrence than patients with other stroke syndromes. Although the pathogenic mechanisms underlying that association are currently unclear, potential contributors include the larger volume of the index infarction or the underlying pathophysiological mechanisms associated with that increased volume of infarction. Similar to our findings, control patients in the Chinese Acute Stroke Trial with large hemispheric stroke syndromes (eg, a combination of higher cerebral dysfunc tion, homonymous hemianopia, and a motor and/or sensory deficit due to a total anterior circulation infarct) had a higher frequency of death or nonfatal recurrent stroke during the 14-day study period than patients with other stroke syndromes, but the effects of the presenting stroke syndrome on the rates of fatal and nonfatal recurrence were not reported separately. In contrast to our findings, investigators in the Oxfordshire Community Stroke Project found that patients presenting with higher cerebral dysfunction alone (eg, aphasia, visuospatial disorder) or with a restricted motor and/or sensory deficit due to a partial anterior circulation infarct were significantly more likely to have an early recurrent stroke than patients with very large total anterior circulation infarcts. However, given that some of the stroke syndromes included in the Oxfordshire Community Stroke Project definition of partial anterior circulation infarcts met our definition of a major hemispheric stroke syndrome, we believe that the apparent differences in our findings may be attributable to the inconsistencies between the classification schemata used in the 2 studies.

Previous studies have investigated the effect of the pathophysiological stroke subtype on the rate of early recurrence. Consistent with our findings, the Stroke Data Bank investigators found that the 30-day cumulative rate of early recurrence was highest in the group of patients with large-vessel atherothrombotic stroke and lowest in the group with small-vessel lacunar infarction, with intermediate rates for cardioembolic and cryptogenic stroke subtypes. The higher rate of early recurrence in patients with large-vessel atherosclerosis compared with other infarct subtypes may be the result of cerebral microembolism from plaque ulceration and luminal thrombus. While we did not distinguish between extracranial and intracranial atherosclerosis in our classification of large-vessel disease, such a distinction may be important, given that patients with intracranial atherosclerosis are also at increased risk of early recurrence. In contrast, the low rate of early recurrence in patients with a lacunar mechanism of infarction found by us and others suggests that this subgroup may not require special efforts in the immediate poststroke period for the prevention of early recurrence.

We found a trend toward an increased risk of early recurrence in patients with atrial fibrillation. Although it is possible that the exclusion of patients with severe aphasia or impairment in consciousness may have resulted in an under-estimation of the effect of atrial fibrillation on the risk of early recurrence in our cohort, it should be noted that the frequency of atrial fibrillation and other vascular risk factors in our sample was consistent with previous studies of hospitalized stroke patients. Patients with atrial fibrillation are at increased risk of first stroke, but its role as a risk factor for early recurrence is controversial. In the Framingham cohort, recurrence within 30 days of the index stroke was significantly more frequent among patients with atrial fibrillation (16.7%) than patients in sinus rhythm (1.7%), while a potential cardioembolic source was the only significant independent predictor of cerebral reinfarction occurring within 90 days of the index ischemic stroke in a separate series of patients hospitalized with acute ischemic stroke. In contrast, data from more recent studies, including prospective stroke registries and randomized clinical trials, have not consistently found an elevated risk of early recurrence in stroke patients with atrial fibrillation. Thus, further study is warranted to clarify the risk of early recurrent stroke associated with atrial fibrillation.

The limitations of our study include the potential for selection bias due to exclusion of patients with severe aphasia, impairment in level of consciousness, or comorbid disorders other than Alzheimer’s disease affecting cognitive function or limiting survival, which may limit comparisons with other stroke outcome studies. While a major hemispheric stroke syndrome may have been a surrogate for a larger volume of infarction in our sample, our focus was on the clinical predictors of early recurrence in this study. Thus, we did not investigate the effect of infarct volume on early recurrence. Our failure to find an association between cognitive impairment and early recurrence may have been due to limited statistical power and/or our reliance on only the MMSE as a measure of cognitive function in the early
poststroke period. It is possible that a more rigorous assessment of cognitive function with comprehensive neuropsychological testing might have allowed us to recognize a significant effect. In addition, subanalyses revealed a significant association between the MMSE score and a major hemispheric stroke syndrome, with 5 of 138 patients (3.6%) with a MMSE score of ≥24 having a major syndrome compared with 30 of 141 patients (21.3%) with a MMSE <24, possibly accounting for the lack of significance of the MMSE in our multivariate analysis.

Based on our findings, patients with a major hemispheric stroke syndrome and/or an atherothrombotic stroke mechanism are at increased risk of early recurrence and warrant special efforts for secondary prevention. In addition, atrial fibrillation may increase the risk of early recurrent stroke, but the balance of risk and benefit from immediate anticoagulation in patients with atrial fibrillation and acute stroke requires further study. While it is possible that some of the therapies currently under evaluation (eg, thrombolytic and/or neuroprotective agents) to reduce the volume of infarcted cerebral tissue in acute ischemic stroke may offer improved protection against early recurrence in selected patients with a major stroke syndrome and that surgical interventions (eg, carotid and vertebral surgery or angioplasty) in the acute phase of stroke may be of similar benefit in selected patients with large-artery disease, the development of a more effective approach to the prevention of early recurrence will ultimately depend on the results of randomized trials that include early recurrence as a primary outcome.

Acknowledgments

This study was supported in part by grants RO1-NS26179 and PO1-AG07232 and Mentored Clinical Scientist Development Award K08-NS02051 (Dr Moroney) from the National Institutes of Health. We thank Dr J.P. Mohr for reviewing the manuscript and the staff of the Stroke and Aging Research Project for their valuable assistance.

References


Risk Factors for Early Recurrence After Ischemic Stroke: The Role of Stroke Syndrome and Subtype
Joan T. Moroney, Emilia Bagiella, Myunghee C. Paik, Ralph L. Sacco and David W. Desmond

Stroke. 1998;29:2118-2124
doi: 10.1161/01.STR.29.10.2118

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1998 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/29/10/2118

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org//subscriptions/