Effect of Untreated Hypertension on Hemorrhagic Stroke

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Background and Purpose—Stroke is the third leading cause of death and the leading cause of disability in the United States. Intracerebral hemorrhage and subarachnoid hemorrhage represent ~20% of all stroke cases and have a mortality rate of 40% to 50%. Hypertension is an important risk factor for these subtypes of stroke. We sought to determine whether untreated hypertension carries a different risk from treated hypertension for hemorrhagic stroke.

Methods—Cases of hemorrhagic stroke in the greater Cincinnati region were identified by screening all area hospital emergency rooms, radiology reports, and International Classification of Diseases 9 codes. Medical records were reviewed for risk factors and medication use. Cases of hemorrhagic stroke were approached for enrollment into the genetic sampling and interview arm. If subjects agreed, the case was matched by age, race, and gender to population-based controls.

Results—Between May 1997 and December 2002, we recruited 549 cases of hemorrhagic stroke, of which 322 were intracerebral hemorrhage and 227 were subarachnoid hemorrhage. Untreated hypertension was found to be a significant risk factor for hemorrhagic stroke (odds ratio [OR] = 3.5 [2.3 to 5.2]; P < 0.0001) as was treated hypertension (OR = 1.4 [1.0 to 1.9]; P = 0.03). Insurance status of “self-pay” or Medicaid was a significant risk factor for untreated hypertension (OR = 2.7 [1.6 to 4.4]). We estimate that 17% to 28% of hemorrhagic strokes among hypertensive patients would have been prevented if they had been on hypertension treatment.

Conclusion—Untreated hypertension is highly prevalent and an important risk factor for hemorrhagic stroke. We estimate that among hypertensive subjects, approximately one fourth of hemorrhagic strokes would be prevented if all hypertensive subjects received treatment. (Stroke. 2004;35:1703-1708.)

Key Words: stroke ■ intracerebral hemorrhage ■ subarachnoid hemorrhage ■ hypertension

Hemorrhagic stroke, which includes intracerebral hemorrhage (ICH) and subarachnoid hemorrhage (SAH), occurs in ~71 000 to 77 000 persons annually in the United States.1 The mortality rate has been reported as 40% to 50% for these stroke subtypes, and survivors are often affected by significant morbidity.1,2 Taylor et al estimate that the aggregate lifetime costs of 1 year of SAH and ICH cases are $5.6 billion and $6.0 billion, respectively.3

Previous studies have shown that hypertension is a significant and independent risk factor for ICH and SAH.4,5 Treatment of hypertension has been demonstrated to be the most important factor in reducing the incidence of stroke6 as well as decreasing the risk of cardiovascular disease.7 We examined the hypothesis that untreated hypertension was a significant risk factor for hemorrhagic stroke. The importance of identifying the population-attributable risk for untreated hypertension provides an estimate of the number of hemorrhagic strokes that may be prevented if all hypertension cases were treated. The ability to include genetic and environmental risk factors gives our study a unique opportunity to examine this important question.

Methods

All patients in the greater Cincinnati/northern Kentucky region who have a potential ICH or SAH are identified by surveillance of all 16 adult hospital emergency and radiology departments and through hospital discharge diagnoses (International Classification of Diseases 9: 430 to 438.9). Cases are eligible for the study if they are ≥18 years of age, have a first-ever SAH or ICH, reside within a 50-mile radius of the University of Cincinnati, and have no evidence of trauma or brain tumor as the cause of hemorrhage. Cases were excluded if contact was not made within 90 days of stroke because some subjects may not be able to accurately recall details beyond 90 days. This study was approved by the institutional review boards at all participating hospitals, and informed consent was obtained from all subjects undergoing direct interview and genetic sampling.

The definitions for ICH and SAH are adapted from the Classification of Cerebrovascular Disease III-1989.8 ICH was defined as nontraumatic abrupt onset of severe headache, altered level of...
consciousness, or focal neurologic deficit that is associated with a focal collection of blood within the brain parenchyma, as observed on computed tomography (CT) or during autopsy, and is not caused by hemorrhagic conversion of a cerebral infarction. SAH was defined as the nontraumatic abrupt onset of severe headache or altered level of consciousness that is associated with blood in the subarachnoid space, as observed on CT or during autopsy, or a clinical history and examination consistent with SAH in which xanthochromia and increased red blood cells are found in the cerebrospinal fluid.

All cases underwent medical record abstraction performed by trained nurse abstractors. All cases called “not a case” by the abstracter are reviewed by the study coordinator. A sample of cases called not a case by the coordinator are reviewed by study physicians to ensure complete ascertainment. In addition, ascertainment of cases of hemorrhagic stroke was compared with ongoing population-based stroke study for the year 1999 and >99% correlation was found.

Cases were approached for direct interview as well as genetic sampling. Those cases that consented to enroll into the interview arm were matched by age, race, and gender to 2 population-based controls identified through random digit dialing (response rate 49%). A highly structured interview was performed by trained interviewers in a direct face-to-face manner for cases and controls to ensure consistency. The interviews were not blinded to case or control. Blood work and medical records review were not performed on controls.

To determine how well medical record data compared with data gathered through direct interview, we determined percent agreement and κ-scores for those with an interview and medical record data abstraction in the first year of our study (1998). Percent agreement and κ-scores indicated excellent agreement (κ>0.7) for hypertension, diabetes, previous ischemic stroke, current smoking, and heart disease. Family history of hemorrhagic stroke, heavy alcohol use, and any history of smoking were reported with lower frequency in the medical record compared with interview but still demonstrated good agreement, with κ-scores between 0.5 and 0.7.

To examine how representative interviewed subjects compared with noninterviewed subjects, medical record data from interviewed patients were compared with data from eligible patients who were not interviewed during the first year of the study (1998). Because noninterviewed subjects were, on average, older than interviewed subjects (72 versus 61 years of age, respectively), and the prevalence of risk factors varies by age, the comparison was age adjusted. After adjusting for age, the prevalence of risk factors was not significantly different between interviewed and noninterviewed cases.

If a case or control was unable to pass a 4-question screening examination for competency, a proxy was interviewed. Because a greater number of cases underwent proxy interview than controls (29% versus 4%), we examined how reliable proxy data were among subjects who had direct and proxy interview. Agreement was excellent (κ>0.7) or good (κ=0.5 to 0.7) for most variables, with the exception of marijuana, aspirin, acetaminophen, or other antiinflammatory drug use (κ<0.5).

Risk factors of diabetes, hypercholesterolemia, hypertension, current and past smoking, and frequent alcohol use (>2 drinks per day on average) were defined by reported history for cases and controls. Body mass index was calculated from the reported weight and height. Race was determined by self-report for cases and controls. Four buccal brush samples were obtained from each case and control at the time of interview and stored at −20°C. After DNA is isolated, 2 µL is used to perform polymerase chain reaction (PCR) of apolipoprotein E (apoE) genotype. ApoE analysis is performed by PCR using established protocols.9 Our cases and controls were found to be in Hardy–Weinberg equilibrium.

To examine the uniformity of our controls, the prevalence of risk factors among our interviewed controls was compared with the prevalence of risk factors among residents of the greater Cincinnati/northern Kentucky population who participated in a 2000 telephone survey (response rate of 69%). We found that our interviewed controls matched to cases of hemorrhagic stroke had identical rates of hypertension and diabetes and similar rates of current smoking, previous smoking, and frequent alcohol use.

For cases, all medications taken at the time of stroke were recorded from medical record abstractions and direct interview. For interviewed cases and controls, all medications taken 2 weeks before the index date were recorded, and the drugs were sorted by drug name into generic categories, and then were classified into type of antihypertensive medication by physician review. Hypertension was defined as “history of hypertension” instead of actual blood pressure readings because hemorrhagic stroke is likely to elevate blood pressure among cases. “Treated hypertension” was defined as a history of hypertension and use of antihypertensive medications, whereas untreated hypertension was a history of hypertension but no use of antihypertensive medications. Subjects without a history of hypertension but on antihypertensive medications for other purposes (eg, migraine prophylaxis) were classified as “no hypertension.”

**Data Analyses**

The data were managed and analyzed using SAS version 8.2 (SAS Institute). Comparisons between interviewed and noninterviewed cases were made using data gathered through medical record abstraction, whereas comparisons between interviewed cases and interviewed controls were made using direct interview data to ensure that method of data ascertainment was the same for each comparison. Association between each risk factor of interest and hemorrhagic stroke or stroke subtype was performed using a matched logistic regression approach using PROC PHREG (SAS Institute) to account for the matching of controls. Odds ratios (ORs) and corresponding confidence intervals were calculated. A multivariable matched-logistic regression analysis was performed. Again using PROC PHREG (SAS Institute), all variables that were associated with ICH or SAH in bivariate analysis (P<0.20) were included in the initial model and then backward eliminated in a stepwise fashion retaining variables with P=0.10. All variables examined are listed in the tables. The other associated risk factors were treated as covariates in examining the associations with stroke. When the subgroups of ICH and SAH were considered, only those risk factors that were significant in bivariate analysis for those subgroups were included in the models for the subgroups. Significance in the final model was defined as P<0.05. Simple logistic regression was used to compare the risk of untreated hypertensives with treated hypertensives. Calculation of population-attributable risk was performed using equations from Levin.10

**Results**

Between May 1997 and December 2002, 3413 potential cases of hemorrhagic stroke were reviewed, but 1388 had at least 1 exclusion criterion: trauma (627); no hemorrhage (226); hemorrhagic conversion of ischemic stroke (188); hemorrhage into tumor (145); resident outside 50-mile radius (188); hemorrhage occurring outside of the study time period (11); and <18 years of age at time of stroke (3). Of the remaining 2025 cases, 1385 underwent medical record abstraction only, and of these, 692 expired before study nurse contact; 439 were not contacted before 90 days; 106 were unable to provide informed consent; and 148 declined enrollment into the interview arm of the study. Of the remaining 640, 29 were deemed not a case by physician review, and 51 did not have complete data at the time of analysis. The remaining 560 cases had direct medical interview, genetic sampling, and medical record abstraction. Of these, 11 had previous hemorrhagic stroke, yielding a total of 549 cases. Of these, 322 were classified as ICH, and 227 were classified as SAH.

Table 1 shows the rates of treated and untreated hypertension by race and gender among all cases of hemorrhagic stroke (both the interviewed and noninterviewed). There were
TABLE 1. Proportion of Hypertension and Untreated Hypertension Among All Cases of Hemorrhagic Stroke

<table>
<thead>
<tr>
<th></th>
<th>All Hemorrhagic Stroke</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HTN, n UHTN, n (%)</td>
<td>HTN, n UHTN, n (%)</td>
<td>HTN, n UHTN, n (%)</td>
<td></td>
</tr>
<tr>
<td>Men (n=813)</td>
<td>481 (59) 148 (18)</td>
<td>408 (63) 117 (18)</td>
<td>73 (44) 31 (19)</td>
<td></td>
</tr>
<tr>
<td>Women (n=1135)</td>
<td>651 (57) 166 (15)</td>
<td>494 (64) 115 (15)</td>
<td>157 (43) 51 (13)</td>
<td></td>
</tr>
<tr>
<td>Black (n=357)</td>
<td>252 (71) 82 (23)</td>
<td>201 (81) 61 (25)</td>
<td>51 (47) 21 (19)</td>
<td></td>
</tr>
<tr>
<td>Nonblack (n=1591)</td>
<td>880 (55) 232 (15)</td>
<td>701 (60) 171 (15)</td>
<td>179 (42) 61 (14)</td>
<td></td>
</tr>
</tbody>
</table>

HTN indicates hypertension; UHTN, untreated hypertension.

One person with missing gender data and 3 persons with missing race data were deleted for this purpose.

Twenty-three people who reported their race as unknown or unclassified were included in nonblacks.

no differences in the rates of hypertension or untreated hypertension between men and women. Blacks tended to have higher rates of hypertension and untreated hypertension than nonblacks. When considering only the subjects with hypertension, 33% of the blacks were not being treated for their hypertension compared with 26% of nonblacks (P=0.06).

The remaining results include only the interviewed subjects. Table 2 shows the results of bivariate analysis of risk factors for ICH and SAH, and Table 3 shows the results of multivariable analysis of risk factors for ICH and SAH after controlling for multiple genetic and environmental risk factors. In Table 2, hypertension (treated or untreated), smoking (current and previous), and education levels were compared among untreated hypertension patients than treated hypertension, and “education more than high school,” respectively. These bivariate comparisons to a reference group led to slightly different ORs than expected by a comparison of the prevalence rates between cases and controls, but are more appropriate for categorical variables such as these. Untreated hypertension was found to be associated with all hemorrhagic stroke and ICH and SAH subtypes. The results show a variation of risk factors for ICH and SAH and demonstrate the importance of hypertension and untreated hypertension for both subtypes of hemorrhagic stroke. In addition to these findings, hypercholesterolemia, in subjects with less than a high school education and previous ischemic stroke, was found to be associated with hemorrhagic stroke.

In Table 4, potential risk factors for untreated hypertension, including race, gender, education category, socioeconomic class, and insurance status, are examined in an unmatched comparison. Of these risk factors, insurance status of self-pay/Medicaid subjects was significantly more common among untreated hypertension patients than treated hypertension patients. In addition, women were more likely to have their hypertension treated than men. However, once insurance...
status and gender were accounted, blacks were not more likely to have untreated hypertension than whites. After further analysis, the rate of each antihypertensive class of medication was not different among cases versus controls (angiotensin-converting enzyme inhibitors 13% versus 14%; angiotensin II blockers 3% versus 3%; calcium channel blockers 13% versus 15%; β-blockers 12% versus 12%; and diuretics 15% versus 17%).

When we considered only the hypertensive cases and controls and performed a simple logistic regression of the probability of stroke against untreated hypertension (treated hypertension being the reference), adjusting for all the other variables that were used in the multiple logistic regression earlier, we found an OR of 2.6 for untreated hypertension. Using this OR, we obtain a population-attributable risk of 0.22 (95% CI, 0.17 to 0.28), which implies that 17% to 28% of all hemorrhagic strokes among hypertensive individuals could have been prevented if untreated hypertensives were treated for this gender, race, and age population.

**Discussion**

We report that untreated hypertension is an important risk factor for both ICH and SAH. Because of the importance of hypertension to both ICH and SAH, we examined its importance to the overall category of hemorrhagic stroke as well as the major subtypes. Given the important differences in risk factors on the basis of location of ICH (lobar versus nonlobar) and aneurysmal versus nonaneurysmal SAH, an in-depth analysis of the other risk factors for these subtypes is warranted on a separate basis and is beyond the scope of this article, which focuses on the general category of hemorrhagic stroke.

We also examined whether treatment of hypertension could explain the different rates of hemorrhagic stroke among blacks and whites and for the different rates of SAH among women and men. Although blacks were more likely to have untreated hypertension than nonblacks (Table 1), after controlling for insurance status, there was no significant difference in the rate of untreated hypertension by race. Men were more likely to have untreated hypertension than women after controlling for all other variables. Access to health care as represented by being self-pay for insurance or on Medicaid appeared to be a strong risk factor for untreated hypertension compared with Medicare or private insurance.

Hypertension, even if treated, was still a significant risk factor for hemorrhagic stroke. Thus, even if all hypertensive patients received treatment, there would likely still be an increased risk of stroke. Prior studies of the impact of hypertension on stroke have compared the rate of hypertension with no hypertension, which may be different from

**TABLE 3. Multivariable Risk Factors for Hemorrhagic Stroke**

<table>
<thead>
<tr>
<th></th>
<th>AHS (OR 95% CI)</th>
<th>P</th>
<th>All ICH (OR 95% CI)</th>
<th>P</th>
<th>All SAH (OR 95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated hypert</td>
<td>3.5 (2.3–5.2)</td>
<td>&lt;0.0001</td>
<td>3.9 (2.3–6.5)</td>
<td>&lt;0.0001</td>
<td>3.4 (1.8–6.5)</td>
<td>0.0002</td>
</tr>
<tr>
<td>Treated hypert</td>
<td>1.4 (1.0–1.9)</td>
<td>0.0271</td>
<td>1.4 (1.0–2.0)</td>
<td>0.0710</td>
<td>1.4 (0.9–2.4)</td>
<td>0.1701</td>
</tr>
<tr>
<td>History of hypercholesterolemia</td>
<td>0.52 (0.39–0.69)</td>
<td>&lt;0.0001</td>
<td>0.53 (0.37–0.75)</td>
<td>0.0004</td>
<td>0.48 (0.29–0.80)</td>
<td>0.0053</td>
</tr>
<tr>
<td>Increasing BMI (5 U)</td>
<td>0.84 (0.75–0.93)</td>
<td>0.0012</td>
<td>NS</td>
<td></td>
<td>0.75 (0.62–0.90)</td>
<td>0.0019</td>
</tr>
<tr>
<td>Use of anticoagulants</td>
<td>3.1 (1.8–5.3)</td>
<td>&lt;0.0001</td>
<td>3.6 (2.0–6.8)</td>
<td>&lt;0.0001</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Current smoker</td>
<td>1.6 (1.1–2.2)</td>
<td>0.0053</td>
<td>NS</td>
<td></td>
<td>2.6 (1.6–4.3)</td>
<td>0.0002</td>
</tr>
<tr>
<td>Former smoker</td>
<td>1.1 (0.8–1.5)</td>
<td>0.5773</td>
<td>NS</td>
<td></td>
<td>1.3 (0.8–2.2)</td>
<td>0.2670</td>
</tr>
<tr>
<td>Frequent alcohol use</td>
<td>2.5 (1.5–4.0)</td>
<td>0.0002</td>
<td>1.9 (0.9–3.6)</td>
<td>0.0738</td>
<td>4.2 (2.0–8.9)</td>
<td>0.0001</td>
</tr>
<tr>
<td>First degree relative with ICH</td>
<td>2.5 (1.1–5.3)</td>
<td>0.0229</td>
<td>4.1 (1.5–11.0)</td>
<td>0.0051</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>ApoE2*</td>
<td>NT</td>
<td>1.1 (0.8–1.7)</td>
<td>0.5752</td>
<td>NT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ApoE4</td>
<td>NT</td>
<td>1.5 (1.1–2.2)</td>
<td>0.0171</td>
<td>NT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school education</td>
<td>3.0 (2.1–4.4)</td>
<td>&lt;0.0001</td>
<td>2.8 (1.8–4.3)</td>
<td>&lt;0.0001</td>
<td>3.1 (1.7–5.8)</td>
<td>0.0004</td>
</tr>
<tr>
<td>High school</td>
<td>1.5 (1.2–2.0)</td>
<td>0.0020</td>
<td>1.7 (1.2–2.5)</td>
<td>0.0043</td>
<td>1.3 (0.8–2.0)</td>
<td>0.2488</td>
</tr>
<tr>
<td>Previous ischemic stroke</td>
<td>4.3 (2.3–8.2)</td>
<td>&lt;0.0001</td>
<td>4.4 (2.1–9.3)</td>
<td>&lt;0.0001</td>
<td>3.1 (0.9–10.7)</td>
<td>0.0816</td>
</tr>
</tbody>
</table>

AHS indicates all-hemorrhagic stroke; BMI, body mass index; NT, not tested.

*ApoE2 forced into the model for ICH.*

**TABLE 4. Risk Factors for Untreated Hypertension Among Interviewed Subjects With Hypertension**

<table>
<thead>
<tr>
<th></th>
<th>Treated Hypertension</th>
<th>Untreated Hypertension</th>
<th>OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing education category: less than high school education</td>
<td>112 (21)</td>
<td>38 (20)</td>
<td>0.88 (0.6–1.4)</td>
<td>0.81 (0.50–1.32)</td>
</tr>
<tr>
<td>Increasing education category: high school</td>
<td>216 (40)</td>
<td>73 (38)</td>
<td>0.88 (0.6–1.3)</td>
<td>0.87 (0.60–1.23)</td>
</tr>
<tr>
<td>Insurance: self-pay/Medicaid</td>
<td>51 (10)</td>
<td>42 (22)</td>
<td>2.7 (1.7–4.2)</td>
<td>2.7 (1.6–4.4)</td>
</tr>
<tr>
<td>Race: black</td>
<td>124 (23)</td>
<td>54 (28)</td>
<td>1.3 (0.9–1.9)</td>
<td>1.1 (0.7–1.6)</td>
</tr>
<tr>
<td>Gender: female</td>
<td>318 (59)</td>
<td>86 (45)</td>
<td>0.56 (0.41–0.79)</td>
<td>0.59 (0.42–0.83)</td>
</tr>
</tbody>
</table>

Reference levels: education, greater than high school; insurance, having insurance other than Medicaid; race, other (other than black/black-Hispanic); gender, male.
treated hypertension. If we assume that those with untreated hypertension had the same risk as those with treated hypertension, we estimate that 17% to 28% of all hemorrhagic strokes in those with hypertension would have been prevented each year.

Treatment of hypertension, by our definition, meant only that subjects were on medication to lower blood pressure. We did not examine the effectiveness of such treatment. One would presume that greater control of blood pressure would lead to a greater reduction in risk of stroke. Although it may be argued that patients not on antihypertensive medication may not have severe enough disease to warrant treatment, evidence from the National Health and Nutrition Examination Survey (NHANES) study suggests otherwise. Those not on treatment had an average blood pressure of 144/88 compared with 135/83 for those on treatment and 117/71 mm HG for normotensives. We would expect that if our treated patients were divided into “good control” and “poor control” of blood pressure, an even greater difference may be seen in the risk of hemorrhagic stroke. In addition to access to health care, some individuals with prescriptions may not be compliant with the therapy (eg, missing doses, forgetting to refill medications or taking medication inappropriately).

Subjects willing to serve as controls tend to have a higher level of education, which may explain the low level of untreated hypertension among controls. Yet in our analysis of risk factors for untreated hypertension, we found no difference in the rate of untreated hypertension by education category after controlling for insurance status, race, and gender, suggesting that this was not a factor for our controls.

Hypercholesterolemia has been associated previously with a decreased risk of ICH, and low cholesterol levels have been associated with an increased risk of ICH. We have found that a history of hypercholesterolemia is associated with a decreased risk for ICH and SAH. A notable limitation of our study is the lack of cholesterol levels. Further study of hypercholesterolemia in both ICH and SAH is warranted.

A limitation of our analysis regarding hypertension is that we use a history of hypertension as our definition of hypertension (see Methods). Between 1960 and 1990, the percentage of hypertensives in the United States that were aware of their hypertension increased from 53% to 89%. Of those that were aware, the percentage that was on antihypertensive medication increased from 35% to 79%.

Approximately one third of our cases died before contact could be made, and an additional 106 subjects were unable to provide informed consent. These cases are likely to represent the most severely affected subjects and could have higher rates of untreated hypertension. We are unable to comment on whether untreated hypertension affects severity of stroke, but it is plausible that untreated hypertension is an even greater risk factor among those who died.

In addition, 439 cases were lost because of being out of the “time window” for the study. The 90-day limit was included as an exclusion criteria because subjects may be less likely to recall details of their stroke beyond that time frame, and additional funding would be required to increase the number of subjects enrolled. Nevertheless, the findings of our study should be verified through other data sets, including other epidemiologic studies as well as treatment trials of hypertension wherein the efficacy of hypertension treatment can be identified.

Population-based attributable-risk calculations from case control studies apply to a population similar to the control population. In our case, the control population was matched to our cases of ICH and SAH by age, race, and gender, which are different in demographic proportion from the general population. In addition, population-attributable risks are univariate estimates of attributable risk. It is possible that those with untreated hypertension have other effects that may be contributing to the increased risk of hemorrhagic stroke that have not been controlled for.

Finally, we had a moderate response rate on random digit dialing (49%) for identifying controls. To determine whether they were representative of our general population, we compared their risk factors with the results of a telephone survey with a 69% response rate and found identical rates of these risk factors, suggesting that our results may be as generalizable to our community as the results of the survey. In addition, our rate of untreated hypertension among controls with hypertension (18.4%) is similar to that identified by the NHANES III study (21%). Yet, it is possible that the nonresponders to either the survey or the random digit dialing may have a prevalence of risk factors different from that reported in our study.

Nevertheless, we report that untreated hypertension is associated with an increased risk of hemorrhagic stroke. Despite the lack of knowledge of adequacy of blood pressure control, our finding suggests that treatment of hypertension may prevent 17% to 28% of all hemorrhagic stroke and that this effect did not vary by type of treatment. Insurance status and male gender were significant risk factors for untreated hypertension. Future studies of the epidemiology of hemorrhagic stroke should include treatment or lack of treatment of hypertension in the analyses.

References
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