Background and Purpose: Seasonal variation in the incidence of cerebral hemorrhage has been previously demonstrated. In this study, we sought to identify the climatological data best correlated with this seasonal variation.

Methods: In a retrospectively studied sequential series of 236 patients with nontraumatic cerebral hemorrhage observed in Brussels over a period of 8 years, we cumulatively grouped the dates of stroke occurrence into a single calendar year.

Results: We found marked seasonal variation in incidence, with the highest value (23%) observed in November–December and the lowest (10%) in July–August. Seasonal variations in incidence of cerebral hemorrhage were shown to be correlated not only with the inverse of ambient temperature, but also with the inverse of hours of sunshine and with ambient humidity. We found no difference between hypertensive and normotensive patients.

Conclusions: Our study fails to bear out the hypothesis that the higher incidence of cerebral hemorrhage in late autumn and winter is due to the influence of low ambient temperature on blood pressure. (Stroke 1992;23:24–27)

Seasonal variation in the incidence of cerebral hemorrhage has long been postulated. It was documented for the first time by Aring and Merritt,1 who observed in the Boston area that the incidence of cerebral hemorrhage was highest in winter and lowest in summer. The same pattern was observed in Japan,2 Minnesota,4 Britain,5 and Iowa,6 but was not borne out in other investigations in Boston and Chicago,7 the Lehigh Valley,8 and Dijon.9

We conducted the present study of seasonal incidence of cerebral hemorrhage in the Brussels area, which has a mild maritime climate with little seasonal variation of temperature and high rainfall.

Subjects and Methods
Our department is mainly concerned with the diagnosis and rehabilitation of stroke cases. Most patients are referred from other hospitals, 88% of them from Brussels and the surrounding province of Brabant.

In a sequential series of 2,274 stroke patients discharged between January 1, 1983, and December 31, 1990, we identified 333 cases of nontraumatic cerebral hemorrhage. Diagnosis was confirmed by computed tomographic scan in all cases. For the present study, we excluded 83 cases of cerebral hemorrhage associated with vascular malformation (aneurysm, angioma, and cavernous angioma) and 14 strokes that occurred abroad. Our retrospective analysis included 236 cases: 116 male patients aged 61.5 ± 13.6 (range 13–83) years and 120 female patients aged 67.3 ± 12.9 (29–93) years.

Hypertension, defined as three systolic blood pressure values > 160 mm Hg or diastolic blood pressure values > 90 mm Hg at least 1 week after stroke, was present in 163 cases (69%) and was associated with signs of left ventricle hypertrophy at roentgenography, electrocardiography, or echocardiography in 121 cases (51%). Obesity, defined by the Quetelet index (weight in kilograms divided by the square of height in meters) as > 25 for females and > 27 for males, was present in 62 cases (26%). Diabetes (fasting blood sugar > 130 mg%) was present in 33 cases (14%), and abnormal prothrombin time (< 69%) was observed in 19 (8%).

The population under study was divided according to the location of the hemorrhage and its probable etiology (Table 1). We considered four locations (basal ganglia, lobar, cerebellum, and brain stem) and examined four probable etiologies: arterial hypertension associated with left ventricle hypertrophy; amyloid angiopathy or recurrent strokes, including lobar hemorrhage and dementia (this etiology was confirmed at necropsy or brain biopsy in seven cases); disturbance of coagulation, including seven cases of
TABLE 1. Classification of Cerebral Hemorrhage According to Location and Probable Etiology

<table>
<thead>
<tr>
<th>Location</th>
<th>Etiology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basal ganglia</td>
</tr>
<tr>
<td>Hypertension</td>
<td>92</td>
</tr>
<tr>
<td>Amyloid angiopathy*</td>
<td>3</td>
</tr>
<tr>
<td>Coagulation disturbances†</td>
<td>6</td>
</tr>
<tr>
<td>Undetermined</td>
<td>62</td>
</tr>
</tbody>
</table>

*Includes eight patients with chronic hypertension.
†Includes four patients with chronic hypertension.

warfarin excess, two cases of therapeutic thrombolysis, and one case of severe hepatic insufficiency; and indeterminate etiology.

Data for four climatological parameters were collected during the study at the Institut Royal Météorologique in Brussels and included ambient temperature (in degrees Celsius), hours of sunshine, relative humidity (percentage), and atmospheric pressure (in millimeters of mercury). Lunar phase data during the same period were obtained from the Observatoire Royal de Belgique.

Comparisons of the seasonal incidence of cerebral hemorrhage were performed using the $\chi^2$ test. Pearson’s correlation coefficients were used to assess the relations between incidence and climatological data.

Results

The dates of stroke occurrence were known for all patients and were grouped into a single calendar year divided into six pairs of months. The seasonal differences in incidence between the periods were significant ($\chi^2=14.74$, $p<0.05$, df=5). The diagram of annual variation of incidence of cerebral hemorrhage was more or less sinusoidal, with the highest values (23%) in November-December and the lowest (10%) in July-August (Figure 1). We observed the same general sinusoidal variation during each of the 8 years of the study except 1989.

The seasonal variation of incidence was not different in patients with hypertension and cardiomegaly from the others (Figure 1). No significant difference was found in the annual variation of incidence of lobar and basal ganglia hemorrhage. When age and sex were taken into consideration, we found that male patients <65 years of age differed from the other subjects by a peak of incidence in the March-April period, but the difference was not statistically significant.

The seasonal variation in incidence of cerebral hemorrhage was different from that of other types of stroke. Analysis of the dates of occurrence of 1,854 cases of ischemic stroke (infarcts, emboli, and lacunes) in patients discharged from our department over a 7-year period from June 30, 1983, to June 30, 1990, showed that seasonal variations were not significant. The highest incidence (339 cases, 18%) was in May-June and the lowest (286 cases, 15%) in September-October.

In our cerebral hemorrhage population over the 8 years, the average bimonthly values of ambient temperature, hours of sunshine, relative humidity, and atmospheric pressure were plotted on diagrams and compared with the bimonthly incidence of cerebral hemorrhage over the same period (Figures 2A-2D). Ambient temperature varied little from one year to another, but the yearly variations for the other data were larger.

We found that the annual variation of incidence of cerebral hemorrhage was correlated with the inverse of ambient temperature ($r=0.843$, $p=0.035$), the inverse of hours of sunshine ($r=0.96$, $p=0.002$), and relative humidity ($r=0.874$, $p=0.023$). The correlation with atmospheric pressure was not statistically significant ($r=0.015$). We also found that variations of ambient temperature were correlated with those of hours of sunshine ($r=0.914$, $p=0.011$) and that the latter were correlated with those of humidity ($r=-0.863$, $p=0.027$). No correlation was found between the dates of occurrence of cerebral hemorrhage and lunar phases.

Two of our patients had strokes after being exposed to low ambient temperatures (patient 10 went outside at 5.9°C immediately after a bath, and patient 79 went into the garden inadequately clothed at a temperature of −10.2°C).

Discussion

For purposes of stroke prevention, the higher incidence of cerebral hemorrhage observed in late autumn and winter would be an important indication if a link to low ambient temperature could be proved. However, the late autumn and winter months are
characterized not only by low ambient temperature but also by fewer hours of sunshine and by high relative humidity.

The influence of cold on the incidence of cerebral hemorrhage was hypothesized by Caplan et al.\(^7\) in three patients who suffered cerebral hemorrhage after exposure to extremely low temperatures. The same sequence was observed in two patients of our series, but the majority of the strokes probably occurred indoors. Takahashi et al.\(^2\) analyzed Japanese statistics for mortality by cerebral hemorrhage in patients 30–59 years of age and noted a geographic distribution related to latitude. It was reasonable to postulate that the incidence of cerebral hemorrhage was correlated with mortality and had the same geographic distribution. The highest mortality was observed in the northeast of that country and the lowest in the southwest. The authors hypothesized that the difference was related to ambient temperature, but they noticed that Hokkaido Island, located north of the main island, had a rather lower mortality rate. The explanation for this apparent exception was that the island dwellers live in well-insulated houses, heated with iron stoves, and are thus in a warmer environment than most inhabitants of the northern part of the main island. In a smaller group of subjects, Takahashi et al.\(^2\) confirmed the correlation between low temperature and frequency of cerebral hemorrhage.

The observations in Japan were recently confirmed in the People's Republic of China.\(^10\) Stroke mortality is highest in the north of the country and lowest in the south. The figures are 441/100,000 in Harbin (46° north latitude) and 162/100,000 in Canton (Tropic of Cancer). Since one third (or even half) of all strokes in China are cerebral hemorrhage, the above proportions probably hold true for cerebral hemorrhage mortality and incidence.

The hypothesis of climatological influence on the incidence of cerebral hemorrhage is reinforced by the higher winter/summer ratio observed in regions with a continental climate as compared with our own study. Ramirez-Lassepas et al.\(^4\) studied 118 cases in Minnesota over a period of 6 years, but the values for mean ambient temperature were not recorded. Forty-four cases occurred in winter (January–March), 23 in spring (April–June), 25 in summer (July–September), and 26 in autumn (October–December). The winter/summer ratio was 1.76. Biller et al.\(^6\) also studied a population in a continental climate (Iowa),
looking at 214 cases over a period of 8 years. The temperature difference between winter and summer (29.2°C) in Iowa was greater than that in Brussels (12.9°C). Sixty-five of the cases occurred in winter, 58 in spring, 40 in summer, and 51 in autumn. The winter/summer ratio was, thus, 1.62. In our study, 62 cases occurred in winter, 54 in spring, 45 in summer, and 75 in autumn. The winter/summer ratio was 1.38.

Although the lowest monthly incidence occurred in August in Boston,1 Japan,2,3 and, in the present study, Belgium, it occurred in May in Minnesota.4 Also, in the present study, the January–March incidence (62 cases) was lower than the October–December incidence (75 cases), although the mean ambient temperature was lower in winter (3.73°C) than in autumn (7.63°C). Finally, studies conducted in the Boston and Chicago areas,7 in the Lehigh Valley,8 and in the Dijon area9 did not confirm the seasonal variation of cerebral hemorrhage incidence.

In the opinion of Takahashi et al.,2 both the geographic and the seasonal differences are related to the effect of cold on blood pressure. In some population samples, they recorded higher blood pressures in winter than in summer and a higher proportion of hypertensive individuals in poorly heated houses (48%) as compared with well-warmed houses (38.5%). They point out that Japanese farmers eat more rice and salt when the weather is cold; indeed, the authors measured higher sodium chloride values in urine in winter than in summer.

It is generally agreed that high blood pressure increases the risk of cerebral hemorrhage. Cold temperatures raise blood pressure in normotensive and hypertensive patients, but higher absolute values are probably reached in the latter. If the winter increase in cerebral hemorrhage incidence were due solely to the influence of cold on blood pressure, the difference would be more marked in hypertensive patients. Our results show that this is not the case. Other mechanisms can be hypothesized. Bull et al.11 found a correlation between cold ambient temperature and factors of coagulation in human subjects. They showed that cold lowers factor VII and increases the fibrinolytic activity of blood. We have no way of confirming this because, in our retrospective study, the only data we had for all cases was prothrombin time, which was normal in most.

So far, attention has been focused almost exclusively on temperature to explain the winter/summer differences of incidence of cerebral hemorrhage. Our results show that a similar, even higher correlation exists between cerebral hemorrhage incidence and hours of sunshine or ambient humidity. Further studies are needed to explain the influence of climate on the incidence of cerebral hemorrhage.

References

KEY WORDS • cerebral hemorrhage • climate • Belgium
Seasonal variation of cerebral hemorrhage in 236 consecutive cases in Brussels.
A Capon, G Demeurisse and L Zheng

*Stroke*. 1992;23:24-27
doi: 10.1161/01.STR.23.1.24

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1992 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/23/1/24

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/