Association of Occurrence of Aneurysmal Bleeding With Meteorologic Variations in the North of France

Jean-Paul Lejeune, MD; Matthieu Vinchon, MD; Philippe Amouyel, MD, PhD; Thérèse Escartin; Didier Escartin; Jean-Louis Christiaens, MD

Background and Purpose Previous reports have established that the incidence of stroke may be influenced by meteorologic variations. However, no significant correlation was clearly demonstrated concerning aneurysmal bleeding.

Methods From January 1, 1989, to December 31, 1991, 238 patients with angiographically confirmed diagnoses of subarachnoid hemorrhage were registered in the North of France region. For each day, the weather variables were provided by the national meteorologic office (Meteo France). We compared the meteorologic variables of days when subarachnoid hemorrhage occurred with the variables of days without subarachnoid hemorrhage in a multivariate model.

Results We observed a seasonal pattern in the occurrence of subarachnoid hemorrhage, with a low frequency of rupture in June and July and maximum frequency in April and September (P<.05). The days of occurrence were associated with short duration of sunshine (P<.0006), low minimal level of hygrometry (P<.0002), low maximal temperature (P<.005), and low atmospheric pressure the day before the event (P<.05).

Conclusions Aneurysmal bleeding was significantly associated with weather variables. Cold-induced hypertension may explain these fluctuations in the occurrence of aneurysmal bleeding. (Stroke. 1994;25:338-341.)

Key Words • epidemiology • weather • subarachnoid hemorrhage

Subarachnoid hemorrhage (SAH) is usually a sudden and unexpected event, which may be influenced by causative factors such as raised arterial pressure levels or physical effort. Bokonjic and Zec have reported that the incidence of stroke, either ischemic or hemorrhagic, may be influenced by atmospheric pressure changes. Ischemic stroke occurs with a higher incidence in summer, and hemorrhagic stroke is more frequent in winter. In two different studies the incidence of stroke was related to variations of temperature and atmospheric pressure. Talbot found no correlation between the occurrence of aneurysmal bleeding and the season in an autopsy study. However, none of these reports has clearly demonstrated a significant correlation between weather variables and aneurysmal bleeding.

To detect an association between SAH and meteorologic variables, we compared the days when SAH occurred with the days when it did not. We considered the cases of ruptured intracranial aneurysms admitted in our hospital during a 3-year period.

Subjects and Methods

Selection of Subjects

Our institution is the only neurosurgical referral center in the North of France region (administrative division). The population is roughly constant during the year, without noticeable seasonal variations, in that arrivals and departures are balanced during the holidays according to the regional tourist information office.

The patients referred to our department for aneurysmal bleeding between January 1, 1989, and December 31, 1991, were reviewed. Patients who died before reaching our department were not included. Among the 296 possible diagnoses of SAH, an angiography was performed in 283 subjects. The most severe cases, with subjects in poor neurological condition, were excluded because angiography was not possible. For patients with SAH or intracerebral hemorrhage from an angiographically confirmed intracranial aneurysm, the month of bleeding was known for all patients, the precise day of bleeding for 238, and the moment of the day of bleeding for 155. Age, sex, and previous medical history were recorded.

Meteorologic Data

Data were obtained from the national meteorologic office (Meteo France). Meteorologic variables included atmospheric pressure (in pascals×100), temperature (minimal, maximal, and mean in degrees Celsius), hygrometry (minimal, maximal, and mean in percentages of air saturation), rainfall (duration in hours, quantity in millimeters), duration of sunshine (in hours), and frequency of occurrence of snowfall, hail fall, smog, and thunderstorm. These meteorologic data are recorded every 3 hours in four ground stations.

This region (Figure) is located on the 50th parallel and enjoys an oceanic, temperate climate. The meteorologic conditions are homogeneous throughout the region. Lille is the largest town in the region (1,150,000 inhabitants). For these two reasons, the meteorologic data recorded in Lille were chosen as a reference.

Statistical Analysis

A time-series analysis was conducted (BMDP statistical software, Los Angeles, Calif) for periods of 10 days to ensure...
enough events per time unit. Other statistical analyses were performed using SAS statistical software (SAS Institute, Cary, NC). Categorical data were compared with $\chi^2$ statistical tests. Quantitative data were analyzed using the general linear model procedure. A multivariate stepwise logistic regression model was used to compare the meteorologic data for the days with SAH to the days without SAH.

**Results**

Patient characteristics are described in Table 1. The age of patients ranged from 16 to 85 years (mean, 49.1 ± 14.8 years). Arterial hypertension before SAH was present in 88 patients (31%). Thirty-three patients had multiple aneurysms (11.6%). Six patients had a family history of aneurysmal bleeding.

The frequency of SAH was lowest in June and July (4.2%) and highest in April (11.0%) and September (10.0%). We defined a unit of time as 10 days and analyzed the data as a time series. The series was nonstationary. No long-term linear trend was detected. The analysis of the autocorrelation function concluded that a significant 12-month seasonality existed ($P<.05$).

When the day of bleeding was known, the occurrence of SAH was equally distributed among the days of the week. Among the 155 patients for whom the hour of bleeding was known, SAH occurred more often within morning hours: 88 of these patients (56.8%; 95% confidence interval, 49.0% to 64.6%) bled between 6 AM and noon. This difference was highly significant ($\chi^2=5.7, 3 df, P<.0001$). This observation led us to analyze the association of the meteorologic data of the day of the event and the day before the event.

We conducted a univariate analysis on the meteorologic variables (Table 2). Because of the occurrence of several SAH on the same day, only 208 days with SAH were taken into account. Temperature variables were significantly lower the day an SAH occurred and the day before. A difference of more than 1 hour in duration of sunshine was observed the day of the event ($P<.0005$) and a lower atmospheric pressure the day before the event ($P<.05$). We performed a multivariate analysis to select the more relevant independent meteorologic variables. Two stepwise logistic regression models were fitted to the data (Table 3). The dependent variable was the day when an SAH occurred or did not occur. The independent variables were the meteorologic variables measured the same day or the day before. Sunshine duration, maximal temperature, and minimal humidity percentage in the air the day of the event, as well as atmospheric pressure and maximal temperature the day before the event, were retained. If we assume that the odds ratio is an approximation of the relative risk, 12% of the events are attributable to a reduction of 1 hour of sunshine duration, 3% to a decrease of 1% of the minimal humidity percentage in the air, 4% to a decrease of 1°C of the maximal temperature, and 2% to the reduction of 100 Pa of the atmospheric pressure the day before the event.

**Discussion**

This study supports the common belief that weather and SAH are associated. Some precise weather variables appear to be associated with SAH, namely, reduced atmospheric pressure the day preceding the SAH and lower maximal temperature, lower minimal hygrometry, and reduced duration of sunshine during the
was detected. Associations between aneurysmal rupture was not influenced by temperature and seasonal varia-
tions. Biller et al 2 reported a higher incidence of hem-
orrhage. Bokonjic and Zec1 reported that the most signif-
ificant meteorologic event related to stroke was a varia-
tion in atmospheric pressure with development of a
Physiological response to cold stress. It is unclear why the cold might
explain a higher incidence of SAH. Why blood pressure level rises in cold weather remains to be discussed.

The pathophysiological mechanisms underlying the
correlation between SAH and weather are unclear. Blood hypertension is commonly acknowledged as a factor influencing SAH. Blood pressure level is influenced by stress and activity, which could explain a lower incidence of SAH during summer holidays. However, the holiday period in our region takes place during July and August. Rose7 showed a seasonal cycle of blood pressure levels. Brennan et al, 8 during the follow-up of 17 000 hypertensive patients, pointed out that the blood pressure level rose when temperature was low and when it rained. These variations of blood pressure levels could explain a higher incidence of SAH. Why blood pressure level rises in cold weather remains to be discussed. Dunnigan and Harland9 postulated an annual cycle of blood pressure levels. Hata et al10 found that stroke rate was not influenced by temperature and seasonal variations. Bilzer et al12 reported a higher incidence of hemorrhagic stroke in winter, but no correlation with SAH was detected. Associations between aneurysmal rupture and weather are not frequently reported in the literature. Talbot11 found no significant seasonal variation. Rosenorn et al12 reported a higher incidence during spring and summer, but no precise meteorologic correlation was observed. Our series collected a relatively large number of patients with ruptured intracranial aneurysms during a 3-year period in a region where weather is homogeneous. Although this is not a population-based study, the lack of any other institutions for cerebrovascular surgery in our region makes it reliable for analysis.

| TABLE 2. Comparison of Meteorologic Data for Days With and Without Subarachnoid Hemorrhage |
|--------------------------|-----------------|------------------|-----------------|------------------|------------------|
| Day With SAH (n=208)    | Day Without SAH (n=887) |   P             |
| Atmosphere pressure, Pa × 100 | 1010.3 (10.8) | 1011.3 (9.9) | NS              | 1009.8 (10.8) | 1011.3 (9.9) | <.05
| Duration of sunshine, h  | 4.13 (3.87)     | 5.31 (4.48)     | <.001           | 4.69 (4.00)     | 5.18 (4.48)     | NS
| Maximal temperature, °C  | 13.3 (7.2)      | 15.6 (7.5)      | <.002           | 13.4 (7.4)      | 15.1 (7.5)      | <.003
| Minimal temperature, °C  | 6.2 (5.4)       | 7.1 (5.4)       | <.04            | 6.1 (5.3)       | 7.1 (5.4)       | <.02
| Mean temperature, °C     | 9.7 (6.1)       | 11.1 (6.2)      | <.01            | 9.7 (6.1)       | 11.1 (6.2)      | <.01
| Maximal hygrometry, %    | 91.9 (8.9)      | 91.5 (7.1)      | NS              | 92.2 (6.4)      | 91.4 (7.1)      | NS
| Minimal hygrometry, %    | 57.6 (18.7)     | 56.1 (19.3)     | NS              | 58.1 (18.5)     | 56.0 (19.3)     | NS
| Mean hygrometry, %       | 74.7 (11.7)     | 73.8 (12.1)     | NS              | 75.2 (11.3)     | 73.7 (12.2)     | NS
| Rainfall quantity, mm     | 2.0 (4.4)       | 2.0 (4.3)       | NS              | 1.8 (3.6)       | 2.1 (4.5)       | NS
| Duration of rainfall, h   | 2.34 (3.65)     | 2.02 (3.32)     | NS              | 2.27 (3.47)     | 2.03 (3.37)     | NS
| Presence of smog, %       | 17              | 18              | NS              | 15              | 19              | NS
| Presence of snow, %       | 4               | 2               | NS              | 3               | 2               | NS
| Presence of thunderstorm, %| 3               | 3               | NS              | 2               | 4               | NS
| Presence of hail, %       | 1               | 1               | NS              | 1               | 1               | NS

Values are mean (SD) when appropriate. SAH indicates subarachnoid hemorrhage; NS, nonsignificant.

### Table 3. Comparison of Meteorologic Data for Days With and Without Subarachnoid Hemorrhage by Multiple Logistic Regression

<table>
<thead>
<tr>
<th>Meteorologic Data</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day of SAH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction of 1 h of sunshine duration</td>
<td>1.13</td>
<td>1.06-1.20</td>
<td>&lt;.00006</td>
</tr>
<tr>
<td>Reduction of 1% of minimal humidity</td>
<td>1.03</td>
<td>1.01-1.04</td>
<td>&lt;.0002</td>
</tr>
<tr>
<td>Reduction of 1°C of maximal temperature</td>
<td>1.04</td>
<td>1.01-1.07</td>
<td>&lt;.005</td>
</tr>
<tr>
<td>Day before SAH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction of 1°C of maximal temperature</td>
<td>1.03</td>
<td>1.02-1.04</td>
<td>&lt;.002</td>
</tr>
<tr>
<td>Reduction of 100 Pa of atmospheric pressure</td>
<td>1.02</td>
<td>1.01-1.02</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; SAH, subarachnoid hemorrhage.
influence SAH only when mild and not when intense. Until now, no correlation between hypertension and other meteorologic variable has been reported.

In conclusion, our study suggests a significant association between specific weather variables and the occurrence of SAH. This correlation may be partly explained by changes in blood pressure levels related to meteorologic conditions. Further studies with larger numbers of patients, including SAH deaths, if possible, are needed to confirm these results.

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References


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J P Lejeune, M Vinchon, P Amouyel, T Escartin, D Escartin and J L Christiaens

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