Relationship Between Aneurysmal Subarachnoid Hemorrhage and Climatic Conditions in the Subtropical Region, Amami-Oshima, in Japan

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Abstract

Epidemiological studies of the relationship between climate and the onset of aneurysmal subarachnoid hemorrhage (SAH) have been reported in the temperate and subarctic latitudes. However, the relationship between the incidence of aneurysmal SAH and the climatic variations in the subtropical region remains uncertain. Epidemiological analysis requires study of an extremely isolated area. This study analyzed the relationship between the onset of aneurysmal SAH and climatic conditions in the isolated subtropical island of Amami-Oshima in Japan. During an 11-year period from 1986 to 1996, 210 patients with a primary diagnosis of aneurysmal SAH were identified by computed tomography and angiography. The mean annual age-adjusted incidence of aneurysmal SAH was 15.5 per 100,000 population (10.4 for males and 20.6 for females). No significant seasonal variations in the incidence of aneurysmal SAH and admission clustering were observed in males (p > 0.05) or females (p > 0.05). Furthermore, temperature, atmospheric pressure, and relative humidity were not significantly correlated with the monthly incidence of aneurysmal SAH. However, the occurrence of aneurysmal SAH tended to be higher in both females and the elderly during the winter and spring seasons and not during other seasons. This study indicates that seasonal and climatic conditions do not strongly contribute to the incidence of aneurysmal SAH in subtropical regions. However, elderly people are affected more by climatic conditions than young people.

Key words: subarachnoid hemorrhage, incidence, subtropical region, climate, seasonal variation

Introduction

The incidence of subarachnoid hemorrhage (SAH) in the temperate and subarctic regions of the Northern Hemisphere is about 6 to 8 per 100,000 people in recent studies in Western Europe and North America.2,12,17,18,21) Aneurysmal SAH occurs considerably less often, though approximately 5% of the adult population have cerebral aneurysms at autopsy.9,14,22,28,33) The potential mechanisms associated with aneurysm rupture are rheological factors, blood pressure, and hemodynamics.15,29,34,35) Seasonal and climatic variations are also connected to the incidence of aneurysmal SAH.3,4,6,7,10,11,13,16,30-32) However, the relationship between weather conditions and aneurysm rupture in subtropical regions has not been analyzed extensively.23,37) Moreover, reliable epidemiological analysis requires a study in an extremely isolated area. The present study analyzed the incidence of aneurysmal SAH and determined whether seasonal and climatic conditions are related in an isolated subtropical region.

Materials and Methods

This study was conducted at the Division of Neurosurgery of the Kagoshima Prefectural Oshima Hospital. The hospital is located on the Amami-Oshima Island in Japan, at a latitude of 28 degrees north and a longitude of 129 degrees east, in the East China Sea. This island and the surrounding small islands served by the hospital have about 133,000 inhabitants and are located in a geographically remote location, isolated from other areas by the sea. According to published decennial tabulations, the annual population movement into or out of Amami-Oshima Island is very small and negligible. Moreover, there is no other hospital or clinic with adequate neurosurgical or neurological facilities on
this island. Therefore, all patients with neurological disorders (such as stroke) are transferred to the prefectural hospital on Amami-Oshima Island at first, without leaving the island.

210 patients with aneurysmal SAH were identified by computed tomography (CT) and angiography between 1986 and 1996. Patients with a nonaneurysmal pattern of hemorrhage, so-called perimesencephalic hemorrhage by CT, or SAH by lumbar puncture who underwent angiography and were confirmed to have no aneurysm, were excluded from the present study. Monthly climatic condition data for Amami-Oshima Island from 1986 to 1996 were obtained from the Naze Weather Station (8-1 Minato-machi, Naze, Amami-Oshima Island, Kagoshima). The data included daily maximum, minimum, and mean temperature, mean atmospheric pressure, and mean relative humidity. The national census of the population reported in 1995 was used to calculate the annual age-adjusted incidence of aneurysmal SAH. The data sets were stored using computer system, and statistical analysis and graphing were performed using statistical software (Microsoft Excel version 5.1). The correlation coefficients between occurrence of SAH and climatic conditions were calculated, and were statistically analyzed. The statistical significance of monthly occurrence in hospital admissions for aneurysmal SAH was also determined by the "R" statistic of Roger's test to identify seasonal trends of SAH. The "R" statistic can be written in the useful form,

$$R = 2 \left( \frac{1}{12} \sum_{i=1}^{12} \text{Nisin}(\pi i/6) \right)^2 + \left( \frac{1}{12} \sum_{i=1}^{12} \text{Nicos}(\pi i/6) \right)^2 / \ln n$$

where \( i \): month, \( n \): total number of patients, and \( N_i \): monthly number of patients. This is approximately chi-squared with two degrees of freedom on the null hypothesis.

**Results**

The age and sex distributions of both all Japan and this island are indicated in Fig. 1. The distribution rate in the population of female aged above 70 years in this island is 11.1%, which is 2.1 times higher than that of all Japan. Therefore, a age-adjusted incidence of aneurysmal SAH was calculated. The mean annual age-adjusted incidence was 15.5 per 100,000 people (10.4 for males and 20.6 for females). The incidence in females was 2.0 times higher than in males. The incidence rate of female aged above 70 years was 3.1 times higher than that of male. The mean age of all patients was 64.3 years (range 29-92 for male, 32-87 for female).

The monthly distributions of daily maximum, minimum, and mean temperature, atmospheric pressure, and relative humidity are indicated in Fig. 2. The temperature ranged from 10.9°C to 32.7°C, and was never below 0°C during the period from 1986 to 1996. Figure 3 shows the monthly occurrence of SAH. There was no statistical significance in monthly occurrence of SAH by Roger's test in either males (\( R = 1.83 < 5.99 (0.05) \)) or females (\( R \)
The occurrence of SAH tended to be higher during winter and spring than during other seasons in females and elderly patients (≥ 65 years old).

Table 1 shows the correlation coefficients between monthly occurrence of subarachnoid hemorrhage and monthly climatic conditions (daily maximum, minimum, and mean temperature, atmospheric pressure, and relative humidity). There was no significant correlation between monthly occurrence and any climatic factor.

Discussion

The annual incidence of SAH is about 6 to 8 per 100,000 people in recent studies in Western Europe and North America, in which high proportions of patients were investigated with CT. The incidence of SAH has decreased as the number of patients examined by CT has increased. In the present study, the mean annual age-adjusted incidence of aneurysmal SAH was 15.5 per 100,000.
We studied whether there is a seasonal variation in the occurrence and mortality from cerebrovascular disease have been reported from various areas. There was a seasonal difference in the occurrence of all strokes in these studies. According to a population-based study from Japan, there is a significant seasonal difference in the occurrence of all strokes, intracerebral hemorrhage (ICH), and cerebral infarction. In a community-based stroke register study from Italy, cerebral infarctions were more frequent during winter, and primary ICH during autumn. The relationship of “stroke” to climatic conditions has been reported, but no studies have examined the correlation between the occurrence of aneurysmal SAH and climatic conditions in an isolated subtropical area. Another important unsolved problem that remains is whether climatic conditions are a risk factor for the occurrence of aneurysmal SAH.

We studied whether there is a seasonal variation in the occurrence of aneurysmal SAH and the correlation between SAH and climatic conditions. Previously, some significant relationships between season and occurrence of SAH were reported in Finland, Portugal, and Japan. Our results suggest that the occurrence of SAH tends to be higher during winter and spring than during other seasons. However, we found no significant relationship between seasons and SAH. Seasonal variations in other factors such as atmospheric pressure, humidity, and exposure to sunlight may also be involved in the occurrence of SAH, but we did not find a statistically significant correlation between the occurrence of SAH and temperature, atmospheric pressure, or relative humidity during winter and spring.

The present study demonstrated that a higher incidence of SAH during winter and spring in both females and elderly patients. Elderly female patients may be influenced by seasonal weather patterns. The biological reasons for the higher occurrence of strokes during winter are not known, but several mechanisms may be responsible. Aneurysmal formation and rupture may possibly be precipitated by the physiological response to cold of peripheral vasoconstriction and an increase in blood pressure. Low temperature may cause peripheral vasoconstriction more strongly in elderly people than in the young, and therefore this seasonal pattern could result. However, cases in young people outnumber those in elderly people in February, which is the coldest month temperature-wise. Also, meteorological factors vary day to day within a particular month. To resolve this contradiction, we need a more powerful analysis linking the day of hemorrhage to some values of the meteorological factors for that day.

In conclusion, we emphasize that there was no significant relationship between the season and the occurrence of aneurysmal SAH nor a significant correlation between the occurrence of aneurysmal SAH and temperature, atmospheric pressure, or relative humidity. However, this study suggests that elderly people are more strongly affected by climatic conditions than young people. Further study that takes into account seasonal variation in other factors such as exposure to sunlight, behavioral factors, and diet may help to explain the relationship between the occurrence of aneurysmal SAH and seasonal differences in climate. Seasonal variation of aneurysmal SAH also needs a daily analysis linking the day of hemorrhage to the meteorological factors, as seen in a previous study. Whether the incidence of aneurysmal SAH in subtropic regions is more frequent than in temperate and subarctic regions in Western Europe and North America remains uncertain. Further epidemiological analysis is especially important in subtropical regions, because the problem of global warming has become prominent recently, and changes in climatic conditions in the temperate and subarctic regions may occur in the future.

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Oyoshi et al. report an interesting and important study on the occurrence of aneurysmal subarachnoid hemorrhage (SAH), because the data are collected in the only neurosurgical service located in a strictly closed subtropical island. The authors found no significant relationship between incidence of aneurysmal SAH and the changes in the climate. It is commonly recognized that incidence of aneurysmal SAH is especially high in elderly females, although the exact incidence rate is not known. The authors report that the incidence of aneurysmal SAH in females is 2.1 times higher than in males. This might be explained by the predominant population of elderly females in Amami-Oshima. Therefore, the authors should have shown the age and sex distribution of the general population in the island. However, this report provides valuable information about the incidence of aneurysmal SAH obtained by a reliable epidemiological analysis.

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Seasonal variations in the occurrence of aneurysmal SAH have been an interesting issue in the epidemiological studies of cerebrovascular disease. In this hospital admission based study, the authors analyzed the correlation between the occurrence of aneurysmal SAH and climate condition from a population of an isolated subtropical island of Japan. No significant seasonal periodicity or meteorological variations of SAH can be found from this study. Although statistically insignificant, female and elderly patients have a tendency of higher incidence of SAH during spring and winter. In other reported studies from Europe, a higher incidence of SAH is also found during transitional seasons such as spring (ref. 27 of this article), or spring and autumn (ref. 10 of this article). In subtropical regions, temperature changes during the winter are similar to those of autumn in the temperate or subarctic regions and are considered transitional. The result of this study alone is insignificant, however it can further support the results of these previous studies. Future studies should be focused on drastic

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Oyoshi et al. studied the relationship between climate and the onset of aneurysmal subarachnoid hemorrhage (SAH) on Amami-Oshima Island. The results demonstrated that the occurrence of SAH tended to be higher in females and the elderly during winter and spring seasons. This is an interesting epidemiological study in the isolated subtropical region. However, the result above was not significant and other investigated subjects including temperature, atmospheric pressure, and relative humidity were not significantly correlated with monthly incidence of aneurysmal SAH. These results question any significant relationship between the occurrence of SAH and seasonal differences in certain climate, and the same is true of the results in other previous studies. In our clinical experiences, we feel sometimes that epidemiological factors may be related to the occurrence of aneurysmal SAH. Judging from the previous results including this study, seasonal and monthly investigations may be insufficient to elucidate the established factors. Recently, Landers et al. studied the daily changes and demonstrated a significant relationship between the incidence of onset of symptoms indicative of rupture of an aneurysm and a change in barometric pressure of >10 hectopascals from the previous day (p = 0.0247).1) As the authors mentioned, daily or more detailed analysis of climate changes will be required for epidemiological investigations of SAH and other cerebral vascular diseases.
changes in temperature as a risk factor of aneurysmal SAH.

Another finding of this study is that the annual age-adjusted incidence of aneurysmal SAH is about twice of that of other reports. The authors attribute this phenomenon to the subtropical climate condition. However, the facts that an unusual higher female ratio of the population on this island and a generally higher incidence rate of SAH in females were neglected in the discussion.

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