Relationship Of Aneurysmal Subarachnoid Haemorrhage And Climatic Conditions: A Retrospective Population-Based Study

E Shenouda, L Pobereskin

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Abstract

The objective of this study was to investigate the relationship between climatic conditions and aneurysmal subarachnoid haemorrhage (SAH).

All patients with a diagnosis of SAH in the years 1992 - 1996 were identified. Data on these patients were obtained from a retrospective population-based study. Days with and without incidents were compared with data obtained from the Met Office; hourly barometric pressure changes, temperature, and humidity. Groups were compared with student's t test and the X^2 test for continuous variables and proportions respectively.

Eight hundred cases of SAH were identified in the time period studied. There were 516 (64%) women and 284 men. The mean age at diagnosis was 61 (SD ± 15) years. Forty six percent of patients were over 65 years of age. SAH was more likely to occur on days with higher barometric pressure (P 0.031) however; the actual pressure differences were negligible. There was no relationship between temperature, humidity, and SAH. There was no seasonal variation in the incidence of SAH. There was no association between the severity of SAH and climatic conditions or the day of the week. SAH is less likely to occur over the weekend particularly Saturday 0.735 (0.611-0.885), (relative risk (95% confidence interval). SAH was more likely to occur on Tuesday with a relative risk of 1.153 (1.001 - 1.327).

There is a statistically significant relationship between SAH and barometric pressure but not with either temperature or humidity. The day of the week does influence the incidence of SAH. The underlying reasons remain uncertain.

INTRODUCTION

Hippocrates (460-370 BC) observed that apoplexy was more common in rainy weather and in winter ([2]). This observation has prompted many researchers to investigate the relationship between the occurrence of stroke and climate changes. There have been many anecdotal reports of patients presenting with SAH and other cerebrovascular disorders particularly after abrupt changes in weather ([8, 19, 22, 24, 31, 33, 39]). However, all these studies were based on hospitalised patients and mortality statistics. Little is known about the relationship of climate changes and SAH among the general population ([36]). At our institution, a retrospectively acquired population-based database of all patients with SAH has been obtained for the years between 1992 and 1996. Using this data and the local atmospheric pressure, temperature, and humidity readings obtained from the Met Office, we have investigated the relationship between SAH and climate changes in the population of two English counties. Our hypothesis was that a rise in the incidence of aneurysmal SAH occurs when the weather conditions change, especially atmospheric pressure.

METHODS

ETHICS

Ethical approval was obtained from the south and west Devon Health Authority ethics committee.

STUDY AREA

The two counties of Devon and Cornwall have an area of 10 347.4 Km2. The population in 1992 (1991 United Kingdom census) was 1 475 634 and in 1996 (midcensus estimate, Office of National Statistics (ONS)) it was 1 504 847, an increase of less than 2%. The population is overwhelmingly white (99.27%) (1991 United Kingdom census) The study area is isolated on a peninsula and is served by five district general hospitals and one tertiary referral centre for Neurosurgery. During the study period there was a CT unit at each of the hospitals in the two counties. A modern ambulance service, as well as two helicopters, operated in the study area.

Patients with sudden neurological catastrophe were first taken to the nearest hospital where they were stabilized and scanned. All tertiary care was provided at the Neurosurgery department at Plymouth.

METEOROLOGICAL DATA

Meteorological data were obtained from three different stations in the peninsula. These included daily statements of three variables, barometric pressure, temperature, and humidity. Each variable was provided in four readings; minimum, maximum, difference, and mean.

DATA ANALYSIS

We compared days with and without incidents with data obtained from the Meteorological office; barometric pressure changes, temperature, and humidity. Groups were compared with Student's t test and the X^2 test for continuous variables and proportions respectively. The null hypothesis was rejected when $p< 0.05$.

Data handling was performed using Microsoft Access V 7.0 and analysis carried out with SPSS V 8.0 on a personal computer.

CASE ASCERTAINMENT

The details of case ascertainment can be found in our previous study ([30]). Briefly, a total of 901 medical records were reviewed. Cases were excluded for the following reasons: arteriovenous malformation (24), primary head injury (18), previous subarachnoid haemorrhage (13), primary intracerebral haemorrhage (10), and lack of verification by CT, lumbar puncture, or necropsy (five). The medical records of 31 patients could not be found. Eight hundred cases of first ever subarachnoid haemorrhage were identified during the 5-year study period. Computerized Tomography (CT) verified subarachnoid haemorrhage in 609 (77%) patients, autopsy in 181 (22%), and a typical history and lumbar puncture in 10 (1%).

RESULTS

STUDY PARTICIPANTS

There were 516 (64%) women and 284 men. The mean age at diagnosis of the cohort was 61 (SD 15) years. Women were significantly older than men ($p<0.0005$). The mean age for women was 63 (range 11-96) years and for men it was 57 (19 - 91) years. Forty six percent of patients were over 65 years of age.

There were 1827 days during the study period. There were 800 events during this period and 106 days had two events, 20 days had 3 events and on one day 4 events occurred. In total, an event occurred on 651 of the days in the study period.

ATMOSPHERIC PRESSURE

Comparing the days on which SAH occurred with days free of incidents, we noted that barometric pressure on days with SAH (mean value = 1016.95 Mb) was higher than on days without (1015.87 Mb) ($P= 0.031$).

AIR TEMPERATURE AND RELATIVE HUMIDITY

There was no significant relationship between humidity and temperature and the occurrence of SAH. This was true for comparisons of minimum, maximum and range of both variables. The results were the same when subgroup analysis was performed based on age and gender.

SEVERITY OF SAH

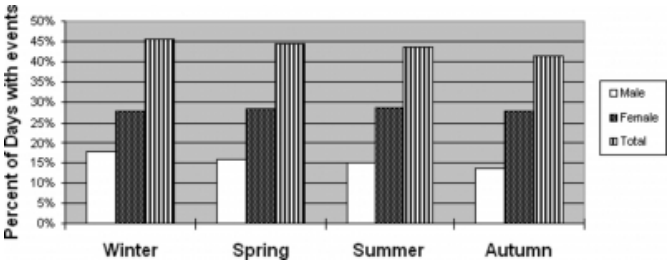
Patients with severe SAH were defined as those who died within 30 days (45%). We found no association between climactic conditions or day of the week and the severity of SAH.

SEASONAL VARIATION

Seasonal variations in the occurrence of aneurysmal SAH, stratified by sex are shown in Figure 1. In males there was a tendency for the incidence of SAH to fall from winter to autumn but this was not statistically significant. For females the percent of days with events was constant across the seasons.

Figure 1

Figure 1: Percent of days with events by season.

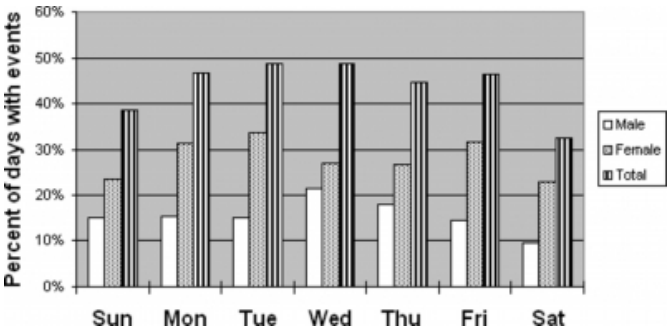


DAY OF THE WEEK

The distribution of SAH onset across the day of the week is shown in Figure 2. SAH is less likely to occur over the weekend particularly Saturday 0.735 (0.611-0.885), (relative risk (95% Confidence intervals). SAH was more likely to occur on Tuesday with a relative risk of 1.153 (1.001 - 1.327)

Figure 2

Figure 2: Percent of days with events by day of the week.



This retrospective population-based study suggests that the risk of SAH increases with atmospheric pressure. This agrees with previously published reports looking at either cerebrovascular accident in general or SAH in particular. Madzhibov et al. ([25]) was the first to show that atmospheric pressure changes may be important in the incidence of stroke. He found that most deaths occurred within 1-2 days of atmospheric pressure rise. Chen et al. ([7]) showed that the daily occurrence of intracerebral haemorrhage significantly increased on high pressure days compared with low pressure-days (P<0.005) whereas cerebral infarction increased slightly but not significantly on low-pressure days. Chyatte et al. ([8]) showed that changing climatic conditions, particularly maximum daily temperature and barometric pressure; precede aneurysm rupture in men but not in women. Jehle et al. ([19]) showed a significant association of SAH with “change days” (days with a change in barometric mean pressure (BMP) of more than 0.15 dpHg) (p <0.02) when compared with “flat days” (days with a change in BMP of =0.15 dpHg). This was true only during winter months. Landers et al. ([23]) identified four distinct clusters of SAH patient admission. In two of these, the BMP peak occurred within a 72-hour period. A remarkable temporal relationship to a BMP change was also seen in the doublets and those presenting singly. The significant increase in risk of aneurysmal SAH, however, only existed when there was a BMP change of > 9 hpa from the day prior to the ictus. Lejeune et al ([24]) in northern France reported a similar relationship. A low atmospheric pressure on the day before the ictus was significantly associated with aneurysmal SAH ($p < 0.05$). Buxton et al ([5]) noted that the atmospheric pressure was modestly correlated with the number of SAH cases per day (Spearman's rank test, $r = 0.33$, $p < 0.0001$), daily change in atmospheric pressure also correlated modestly with the number of cases ($r = 0.34$, $p < 0.0001$). It is clear from our data and previously published data that there is a relationship between BMP changes and aneurysmal SAH. The exact pathophysiological mechanism is however, still not clear ([8], [24]), and may never be fully elucidated. It may be due to rising atmospheric pressure causing increased peripheral resistance, venous return, cardiac output, and subsequently blood pressure and finally precipitating the aneurysmal SAH ([5]).

Attempts to relate the occurrence of stroke in general or SAH in particular to climatic conditions have usually considered not only atmospheric pressure changes but also, atmospheric temperature ([1,2,6,7,12,34,36,38,40,44]), and humidity ([4,6,7,12,40]). Chyatte et al. ([8]) in 1994, in a hospital- based study (n = 1487) and Feigin et al ([12]) in 2000, in a population-based study (n= 64) found no correlation between temperature and humidity and incidence of SAH. We also found no significant difference in the occurrence of SAH in relation to either different levels of humidity or change in temperature. Tsementzis et al ([40]) in 1991 reported the result of a retrospective hospital based study including 430 patients with a diagnosis of SAH amongst other patients with different types of stroke. Using multiple regression analysis, they studied the relationship between temperature, humidity, pressure, rain, and sunshine and SAH. The most predictive meteorological variable for SAH was temperature, though it did not achieve significance. However, the most constant finding in previously published reports has been a significant inverse relationship between ambient temperature and humidity and the occurrence of stroke including SAH ([1, 2, 6, 7, 34, 36]).

Seasonal variations in the incidence of SAH have been investigated in many previous studies ([1,2,8,9,15,16,17,18,19,21,26,27,28,32,33,34,35,36,37,38,40,42]). However, there is still a considerable debate over this issue. Studies that have demonstrated significant seasonal variation in SAH have all been hospital-based ([8,9,15,19,24,27,28,33,40,42]). This is not surprising as the use of hospital based data to study seasonal variations of SAH occurrence is prone to bias because it does not include a substantial proportion (~15%) of patients who die from SAH before reaching the hospital ([10,35]) However, no statistically significant seasonal variation was observed in any of the population-based studies ([16,17,18,21,32,34,35,36,38]) but one ([10]). Feigin et al. ([10]) in 2001, published the results of a population-based study conducted in the Southern Hemisphere (Australia and Auckland) (n=783). This was the first study to show a significant seasonal fluctuation in the occurrence of SAH with a peak incidence in younger people (< 65) in the spring and in older people (= 65) in the winter. We were also unable to find any significant seasonal variation in the occurrence of SAH in the present study, even when we analyzed the results by age and sex. Two problems were encountered in previously published population-based studies. Firstly, statistical analysis was sometimes difficult because of the very small number of patients involved ([11, 17, 21, 32, 34, 36, 38]), and secondly, studies in which seasonal variations in the incidence of SAH due solely aneurysm rupture are extremely rare ([16, 35]). In the present study, we addressed the two issues. Jakovljevic et al ([18]) in 1996, published the results of the largest population-based study of SAH to date (n = 1105), the occurrence of SAH tended to be higher during the winter than during other seasons, but was unable to detect a significant difference between seasons. This study adds more support to our results.

There are only a few reports in the literature which have examined the possible relationship between day of the week and stroke ([3, 10, 14, 20, 21, 24, 29, 41]). Feigin et al ([10]) in 2001 (n=783), found that in all age and sex specific strata, the risk of SAH occurrence was almost equally distributed during the week, but on Sundays, the risk of SAH was higher than that on other days. Throughout the week, older subjects had a slightly higher risk than younger subjects. Kelly-Hayes et al ([21]) in 1995, in a community-based study (n=46), found that for men with SAH the events were clustered on Sunday and Monday, whereas for women the events were clustered on Friday and Saturday. Juvela et al ([20]) in 1993 (n=278) and Hillbom & Kaste ([14]) in 1982 (n=172) reported that a substantial proportion (~ 30%) ([20]) of the patients had their haemorrhage on weekends or holidays. We found that SAH is less likely to occur over the weekend particularly Saturday. SAH was more likely to occur on Tuesday for all age groups, of either sex. The severity of SAH was not influenced by the day of the week. Vermeer et al ([41]) and Lejeune et al ([24]) did not find a preferred day of the week for onset of SAH. Brackenridge ([3]) in 1981, in a community-based study in Australia, looking at stroke in general (n= 1,630), found no day of the week variation in the incidence of stroke; however, for hospitalised patients, Wednesday had the highest frequency (35%) and weekends the lowest (14%). It is clear from the literature that the evidence supporting the relation between the day of the week and occurrence of SAH is inconsistent. A number of hypotheses were put forward to explain certain patterns, as for example, a weekend increase in SAH related to alcohol intoxication ([14,20]), cigarette smoking was significantly associated with Monday onset of SAH ([21]), change of daily activities from the weekend to the weekday, particularly in workers and increased cerebrovascular accidents occurrence on Monday ([43]).

CONCLUSIONS

In conclusion, we found a statistically significant relationship between SAH and barometric pressure but not with either temperature or humidity. The day of the week does influence the incidence of SAH. However, there is obvious inconsistency in weather data and SAH in the literature. Publication bias may explain these apparent inconsistencies as negative data tend not to be published; the preponderance of published data supports some kind of association between weather and SAH ([13]). Further prospective epidemiological and physiological studies are warranted to clarify the influence of weather on SAH.

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CORRESPONDENCE TO

Mr Emad Shenouda Department of Neurosurgery Frenchay Hospital Bristol BS16 1LE, UK E-mail: emadshenouda@hotmail.co.uk

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Author Information

E. F. Shenouda
Department of Neurosurgery, Derriford Hospital

L. H. Pobereskin
Department of Neurosurgery, Derriford Hospital