ORIGINAL ARTICLE

Meteorological factors and aneurysmal subarachnoid haemorrhage in Hong Kong

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Objective To evaluate the influence of meteorological factors on the onset of aneurysmal subarachnoid haemorrhage in Hong Kong.

Design Retrospective review of prospectively collected data.

Setting University teaching hospital, Hong Kong.

Patients A total of 135 consecutive patients with acute aneurysmal subarachnoid haemorrhage presenting to the hospital within 48 hours after ictus from October 2002 to October 2006.

Main outcome measures Occurrence of aneurysmal subarachnoid haemorrhage in relation to daily changes in atmospheric pressure, temperature, and humidity.

Results The peak incidence of aneurysmal subarachnoid haemorrhage occurred in winter (December to February), especially January. The mean (±standard deviation) daily atmospheric pressure change was significantly higher on days with aneurysmal subarachnoid haemorrhage onset as opposed to days without (1.75±1.47 hPa vs 1.48±1.28 hPa; P=0.032).

Conclusions A seasonal variation and relationship to atmospheric pressure change in aneurysmal subarachnoid haemorrhage was noted in the current study carried out in Hong Kong. The mechanism linking atmospheric pressure change and aneurysmal rupture remained to be explored.

Introduction

Although aneurysmal subarachnoid haemorrhage (SAH) accounts for only 3 to 4% of strokes, it forms a separate disease entity of great interest, due to its alarming mortality and discrete 'window' for intervention. Identification of triggering factors would be useful for understanding the pathophysiology underlying aneurysm rupture. A previous local study showed that the incidence of aneurysmal SAH in Hong Kong was similar to that reported elsewhere, other than in Finland and Japan,[1] although with smaller aneurysm dimensions.[2] Interest in the relationship between SAH and meteorological conditions has been revived in recent years.[3-16] However, for Hong Kong and southern China no data were available in this respect. The authors nevertheless had the impression that abrupt daily changes in meteorological conditions was linked to the onset of aneurysmal SAH. With this in mind, we carried out the current study.

Key words
Aneurysm, ruptured; Climate; Meteorological concepts; Seasons; Subarachnoid hemorrhage

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Methods

The Prince of Wales Hospital Neurosurgical Unit is the regional referral centre for spontaneous SAH in New Territories East, which has a population of 1.3 million. Most patients with spontaneous SAH are admitted or transferred to the neurosurgery unit for further management, if feasible. Since October 2002, a prospective registry was set up to record information on acute aneurysmal SAH. 'Acute' was defined as hospital admission within 48 hours of the ictus. Subarachnoid haemorrhage referred to the spontaneous haemorrhage in the basal cisterns. Onset time, demographic data, medical history, neurological condition, management, and outcome were recorded in the registry. Outcome was evaluated at 6 months using the Glasgow Outcome Scale.[10] Thus, 1 indicated death, 2 a vegetative state, 3 severe disability (ability to follow commands but unable to live independently), 4 moderate disability (ability to live independently, but not returning to work or school), and 5 indicated good recovery. Mortality at 30 days was also recorded. The registry also provided an opportunity to look into aspects such as onset time and

香港氣象因素與動脈瘤性蛛網膜下腔出血的關係

目的 探討香港氣象因素對動脈瘤性蛛網膜下腔出血的影響。

設計 把前瞻性搜集到的數據作回顧研究。

安排 香港一所大學教學醫院。

患者 2002年10月至2006年10月期間，連續135名出現急性動脈瘤性蛛網膜下腔出血而在48小時內被送院的病人。

主要結果測量 動脈瘤性蛛網膜下腔出血與每日的氣壓、溫度和濕度變化的關係。

結果 動脈瘤性蛛網膜下腔出血的病發高峰期在冬天（12月至2月），尤於1月為甚。日均氣壓變化在動脈瘤性蛛網膜下腔出血的日子（1.75±1.47 hPa），較沒有發生動脈瘤性蛛網膜下腔出血的日子（1.48±1.28 hPa）為高（P=0.032）。

結論 本研究發現動脈瘤性蛛網膜下腔出血的發生與氣壓變化有關，須進一步找出氣壓變化與動脈瘤破裂的關係。

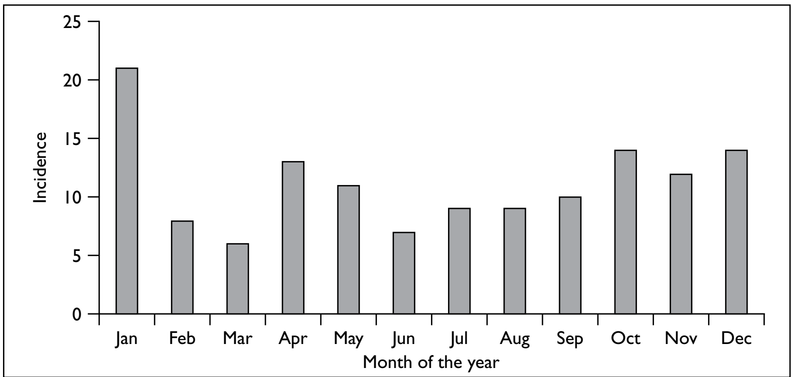

FIG 1. Number of patients with aneurysmal subarachnoid haemorrhage in each month

its relationship to factors such as meteorological conditions.

Daily meteorological parameters such as atmospheric pressure (in hectopascals [hPa]), humidity (percentage relative humidity), and temperature (in degree Celsius) were obtained by written request to the Hong Kong Observatory, for which we acknowledge their assistance. Daily change was calculated by subtractions of a particular day's value from the previous day's value.

We hypothesised that abrupt daily changes in meteorological parameter(s) could be related to onset of aneurysmal SAH in Hong Kong. We carried out a retrospective review of the registry and meteorological parameters over a 4-year period between October 2002 and October 2006.

TABLE 1. Location of ruptured aneurysms

Location	No. (%) of patients
Anterior cerebral artery	37 (27)
Internal carotid artery	48 (36)
Middle cerebral artery	29 (21)
Posterior circulation	21 (16)

TABLE 2. Number of patients with subarachnoid haemorrhage with reference to the three time periods

Time period	No. (%) of patients
08:00 to 15:59	51 (38)
16:00 to 23:59	61 (45)
24:00 to 07:59	23 (17)

Statistical analysis

Analysis was carried out with the Statistical Package for the Social Sciences (Windows version 15.0; SPSS Inc, Chicago [IL], US). A two-tailed P value of less than 0.05 was taken as statistically significant. Data were described as mean ± standard deviation (SD) unless specified otherwise. Between-group comparisons for meteorological parameters were made by the Mann-Whitney *U* test. A Chi squared analysis for equal proportions was used to compare the distribution in the three 8-hour periods: 08:00-15:59, 16:00-23:59, 24:00-07:59. The year was divided into seasons or quartiles based on similarities in the group months (spring: March to May; summer: June to August; autumn: September to November; winter: December to February). Seasonal and monthly distributions were analysed with Chi squared tests for trend.

Results

Over a 4-year period, a total of 135 patients were included in the current analysis. Their mean (±SD) age was 58±13 years. Moreover, as is usual in any aneurysmal SAH series, a female predominance (69%) was noted. The median presentation grade, according to the World Federation of Neurological Surgeons, was 4 with an interquartile range between 2 and 5. The Fisher computed tomographic grade was III in 116 (86%) of the cases; 60 (44%) of the patients had hypertension, 13 (10%) were smokers, and 5 (4%) had a history of irradiation. The distribution of aneurysm locations is shown in Table 1. The mean (±SD) aneurysm size was 5.6±4.9 mm, the 30-day mortality rate was 10%, and the 6-month mortality was 14%.

Circadian, monthly, and seasonal variations

Total incidence in relation to time of onset is depicted in Table 2. Onset of aneurysmal SAH between 24:00

and 07:59 hours was significantly less than that in the other periods (P<0.001). Monthly incidences over the 4-year period are depicted in Figure 1. The peak seasonal incidence ensued in winter (December to February) and peak monthly incidence in January (P=0.071 and P=0.090, respectively) using the Chi squared tests for trend. The 30-day mortality rate was highest in winter and lowest in summer (spring 10%, summer 4%, autumn 11%, and winter 14%; P=0.637) using the Chi squared tests empirically for trend.

Relationships between onset of aneurysmal bleeding and mean daily atmospheric pressure, relative humidity, and air temperature

Mean monthly atmospheric pressure, relative humidity, and air temperature are depicted in Figure 2. The mean (±SD) daily atmospheric pressure was not significantly different between days with aneurysmal SAH onset (1014.5±6.4 hPa) and days without (1013.3±6.47 hPa) [P=0.06]. The mean (±SD) daily relative humidity was not significantly different between days with (77.4±10.7%) and without aneurysmal SAH onset (78.4±9.9%) [P=0.68]. The mean (±SD) daily air temperature was also not significantly different between days with aneurysmal SAH onset (22.5±5.2°C) and days without (23.3±5.1°C) [P=0.20].

Relationships between onset of aneurysmal bleeding and change in daily atmospheric pressure, relative humidity, and air temperature

The change in daily atmospheric pressure was significantly different between days with aneurysmal SAH onset (1.75±1.47 hPa) and days without (1.48±1.28 hPa) [P=0.032]. The change in daily relative humidity did not differ significantly on days with and without aneurysmal SAH onset (5.27±5.02% vs 5.01±4.61%; P=0.48). Nor did the change in daily air temperature differ significantly on days with and without aneurysmal SAH onset (1.244±1.25°C vs 1.034±1.01°C; P=0.16).

Discussion

Lejeune et al[17] reported a seasonal pattern of aneurysmal SAH in the North of France region in 1994. The finding of winter and/or spring peaking was later confirmed in population-based and hospital-based studies in Japan (Amami-Oshima, Izumo City, Toyama),[8,14,18] Australia (Adelaide, Hobart, Perth, Hunter Region of New South Wales),[9] New Zealand (Auckland),[4] Germany (Düsseldorf),[15] Denmark (Aalborg Stengade),[12] Switzerland (Zurich),[10] and the United States (Rochester).[6] An explanation of the possible seasonal link to aneurysmal SAH was offered by Setzer et al.[13] Hypertension was a well-known factor for aneurysmal SAH,[19] and it was known that arterial

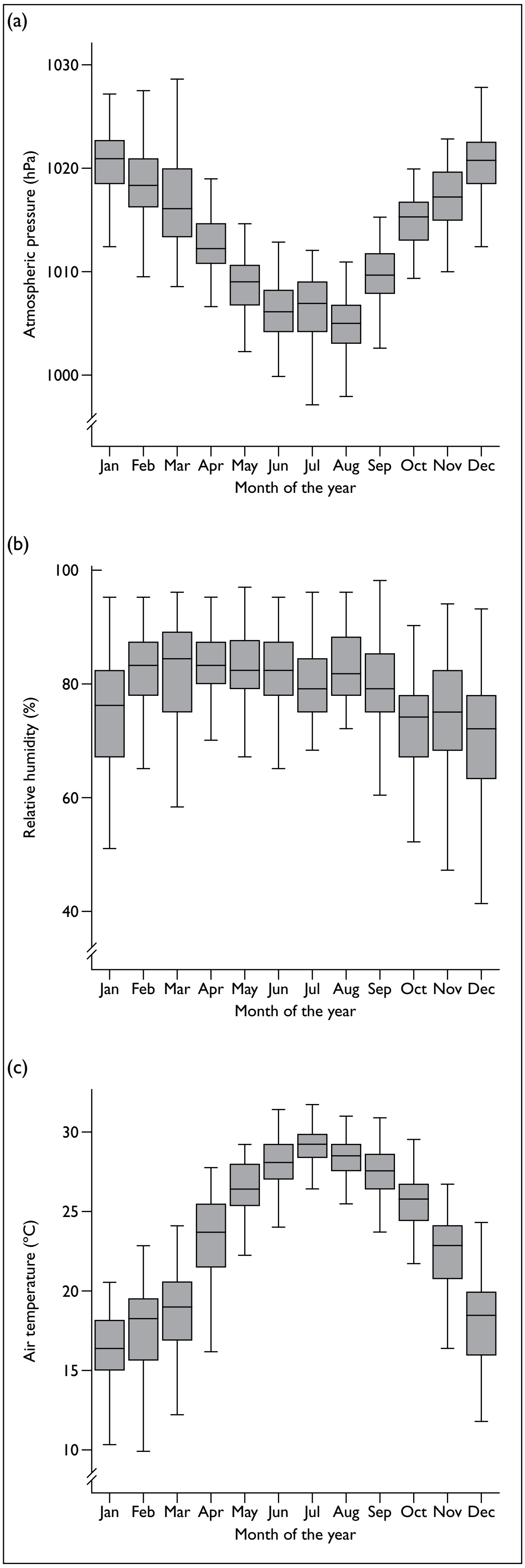

FIG 2. Mean daily (a) atmospheric pressure, (b) relative humidity, and (c) air temperature versus month of the year
Error bars denote standard deviations

blood pressure itself reveals a seasonal variation.[20,21] Because of a higher peripheral resistance, it was surmised that hypertensive derangements are more frequent in cold seasons, leading to higher incidences of ischaemic strokes and myocardial infarctions.[22-24] Although a higher incidence of aneurysmal SAH in winter (December to February) and particularly in January was observed, we were unable to show a statistically significant difference in seasonal variation, which might be related to our small sample size.

The link between high atmospheric pressure and change in atmospheric pressure with aneurysmal SAH, as noted in our study, remains speculative. In 1994, Jehle et al[25] reported an association between change in atmospheric pressure and the incidence of spontaneous SAH in a 76-patient study in New York. Abe et al[16] also found that high atmospheric pressure on the onset day was a significant risk factor for aneurysmal SAH. Their findings were confirmed by other groups.[5,13,26] It might be hypothesised that a change in atmospheric pressure might be associated with a change in inflammatory mediators. This is difficult to prove from the perspective of timing, yield, and invasiveness of measurements.

Circadian rhythm was another interesting phenomenon to consider. In 1997, Vermeer et al[27] reported that in their series the risk of aneurysm rupture was lower at night (from 12 pm to 6 am). Feigin et al[4] also concurred with this nocturnal dip from the pooled data of their three population-based incidence studies in Australasia. These investigators showed that the onset actually peaked in the morning between 8 am and 12 noon. The morning peak was further confirmed by studies in Düsseldorf and Tokyo.[15,16] In our study, we obtained similar results, with a lower incidence nocturnally. There were certain similarities between the diurnal incidence of aneurysmal SAH and blood pressure levels. A diurnal pattern of lowest blood pressure at night and highest values in the morning hours had been well studied and documented.[28-30] The similarities in diurnal patterns supported the hypothesis that an increase in blood pressure served as a trigger for cerebral aneurysm rupture.

There were several limitations to the current study. We only included hospitalised patients with acute aneurysmal SAH, as they yielded more reliable data for our analysis. Our sample size was limited as this was a single-centre local study. We assumed that response to acute changes in daily atmospheric pressure, daily temperature, and daily relative humidity would ensue on the same day rather than after a delay of days or even longer. Cumulative meteorological effects and intra-day changes were not taken into account. Moreover, the complexity of weather changes was reduced to mean meteorological values. Nevertheless, we were able to show that for Hong Kong and southern China, there was a seasonal variation in aneurysmal SAH, and there was a relationship between abrupt changes in atmospheric pressure and onset of aneurysmal SAH. This suggests that despite smaller aneurysm sizes, the underlying triggering factor for rupture could be similar to that observed in Japan and in other parts of the world.

Conclusions

As in other studies conducted in Japan, Australasia and Europe, seasonal variation in the incidence of aneurysmal SAH and its association with abrupt atmospheric pressure changes appear to occur in Hong Kong. This suggests a unified trigger mechanism for aneurysm rupture. However, the mechanism linking atmospheric pressure change and aneurysmal rupture remains speculative and deserves exploration.

Acknowledgement

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