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Correlation between seasonal and meteorological factors with the monthly frequency of intracranial aneurysms rupture in northeast Mexico

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ABSTRACT

Intracranial aneurysms are considered acquired lesions, occur with an incidence of 3–5% in general population. Subarachnoid hemorrhage (SAH) due to ruptured aneurysms represents 85 of all spontaneous subarachnoid hemorrhages and this represents 15% of all cerebral vascular events. Risk factors for aneurysmal rupture are age, gender, size and location of the aneurysm, hypertension, smoking, and alcoholism. Whether seasonal or meteorological factors influence the likelihood of aneurysm rupture is controversial. An observational, retrospective, cross-sectional and non-comparative study of male and female patients over 18 years old who were admitted to our unit in northeast Mexico with the diagnosis of spontaneous SAH due to aneurysmal rupture from January 2014 to March 2020. Climate information was obtained from data of the climate history of the different airport stations in the northeast of the country and the information was correlated to determine if meteorological variables interfere in the incidence of SAH due to aneurysm rupture. Our study showed a significant seasonal fluctuation on the occurrence of aneurysmal SAH. A statistically significant relationship between temperature, humidity and aneurismal SAH. The atmospheric pressure did not show a statistically significant relationship with SAH incidence due to aneurysm rupture.

1. Introduction

Intracranial aneurysms are considered acquired injuries characterized by a localized structural deterioration of the arterial wall, with loss of the internal elastic lamina and disruption of the middle layer that occur with age. Intracranial aneurysms occur between 3 and 5% of the general population [1]. Subarachnoid hemorrhage (SAH) is the most common form of presentation of aneurysmal rupture. SAH due to aneurysm rupture accounts for 85% of all spontaneous subarachnoid hemorrhages and represents 15% of all cerebrovascular events. According to the standard criteria, SAH is defined as a severe headache of rapid onset, decreased level of consciousness, with or without signs of neurological deficit, with evidence of hemorrhage in the subarachnoid space demonstrated by tomography, MRI, lumbar puncture or autopsy. Aneurysmal SAH has 45% mortality rate at the first 30 days of clinical onset. Approximately 30% of the survivors will have moderate to severe impairment [2]. Known risk factors for aneurysmal rupture are age, gender, size and location of aneurysm, hypertension, smoking, and alcohol intake.

A common observation is the variation in the incidence of patients admitted to hospitals with SAH due aneurysm ruptured during certain periods of the year with a seasonal variation. Seasonal climate or meteorological factors have been studied in recent decades due to their probable influence on cerebral vascular disease. However, it is still a controversial. In this study, we performed a statistical analysis of the incidence of SAH due to aneurysm rupture and its relationship with seasonal and meteorological factors in northeast Mexico.

2. Materials and methods

2.1. Patients

The Neurosurgery Department of the University Hospital "Dr. José Eleuterio González" from Monterrey, Nuevo León, Mexico is a referral center for neurosurgical patients in northeast Mexico, attending patients from the state of Nuevo Léon and its surroundings (such as Tamaulipas,

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Coahuila, San Luis Potosí and Zacatecas), including patients with aneurysmal SAH.

Patient information was collected from January 1st, 2014 to March 31st, 2020. All patients included in the database presented to the hospital with clinic of aneurysm rupture and evidence of SAH in an imaging study, either tomography or magnetic resonance imaging, and with diagnosis of intracranial aneurysm by cranial angiotomography and/or diagnostic cerebral angiography. We correlate the information with the meteorological variables of the weather history reports from the closest airport [3]. Meteorological factors collected were temperature at the time of symptoms onset, minimum and maximum temperature on the day of symptom onset (° C), relative humidity (%) and atmospheric pressure (hPA).

2.2. Statistical analysis

Frequencies and percentages were reported for categorical variables. For numerical variables, measures of central tendency and dispersion (mean / median and standard deviation / interquartile range according to their distribution) were reported. In the inferential statistics, the distribution of the sample was evaluated by means of the Kolmogorov-Smirnov test. Quantitative variables were compared between the seasons of the year by means of the Kruskall-Wallis test. Quantitative data such as temperature, atmospheric pressure, humidity, time of day of the aneurysmal rupture, and the occurrence of aneurysmal rupture were correlated by means of the Rho Spearman correlation coefficient test due to the non-normal distribution of the data. The X^2 test was used to compare the distribution of aneurysmal rupture occurrence with a uniform distribution. The SPSSv24 statistical package was used. Values of $p < 0.05$ were considered significant.

3. Results

A total of 230 patients (76 men, 33%; 154 women, 67%) diagnosed with spontaneous subarachnoid hemorrhage due to aneurysm rupture were obtained. The female: male ratio was 2: 1, the mean age of the patients was 54.4 ± 14.9 years. The modifiable risk factors for aneurysm rupture were arterial hypertension (58.7%), type 2 diabetes mellitus (24.3%), smoking (37.4%), and alcohol history (29.1%).

Regarding the location of the aneurysms, 95% of the cases were anterior circulation, with 5% posterior circulation. The most frequent site of aneurysms was in the internal carotid artery (48.4%), of which communicating segment (C7) was the most found, followed by the anterior communicating artery (26%), middle cerebral artery (17.6%) and the anterior cerebral artery (2.9%). Multiple aneurysms were found in 10% of the patients (23 patients) with a female:male ratio of 4:1.

The seasons of the year were defined as spring (March 21st - June 20th), summer (June 21st- September 21st), autumn (September 22nd - December 20th) and winter (December 21st - March 20th). We found a marked distribution of SAH events throughout the year, with a higher incidence in the months of December, January, and February, and with a lower incidence in the months of June, July and August (Fig. 1).

The distribution by frequency of SAH for the seasons of the year (Table 1) showed a significant difference in the seasonal frequency of aneurysmatic SAH ($p \leq 0.05$). There is a greater frequency of SAH in winter and autumn seasons with a frequency of 33.5% and 29.1% respectively; and the lowest incidence was in spring and summer, with a frequency of 20.9 and 16.5% respectively.

Meteorological factors have shown statistical differences in correlation with the incidence of aneurysmal rupture. The statistical analysis of the temperature at the time of symptoms onset, minimum and maximum temperature on the day of the aneurysmal rupture, showed a statistical significant relationship between the mean temperature and the incidence of aneurysmal rupture. Therefore, we observed that the lower the temperature is, greater the frequency of aneurysm rupture. Statistical analysis of humidity and incidence of aneurysmal SAH showed a statistical significant positive correlation. Therefore, higher humidity we find more cases of aneurysm rupture. Regarding the statistical analysis of the atmospheric pressure and the frequency of aneurysmal SAH, there isńt statistical significant correlation. We found that higher atmospheric pressure more frequency of subarachnoid hemorrhage, however, it was not statistically demonstrated.

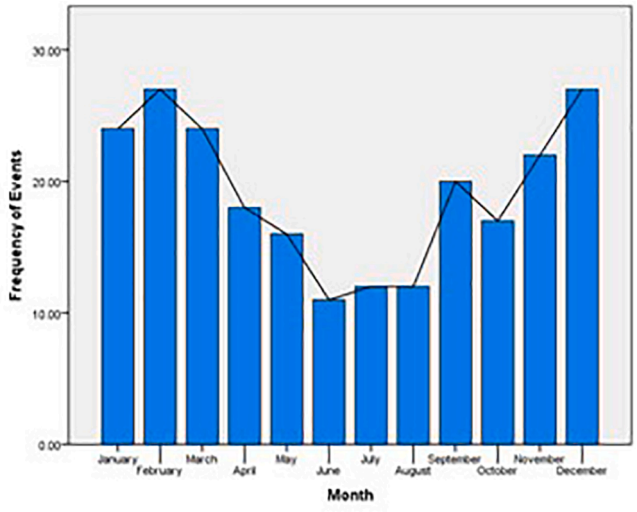

Fig. 1. Distribution of SAH events throughout the year.

A different distribution of SAH was also found during the day (Fig. 2). Two peaks of incidence were identified, in the morning between 7 and 10 h and at night between 20 and 22 h, with 9.6% of the cases occurring at 8:00 a.m., 8.3% occurred at 9:00 a.m., 9.1% at 10:00 a.m. As well as at night 6.1% at 8:00p.m., 6.5% at 9:00p.m., 4.8% at 11:00p.m. The lowest frequency of events was observed between 12 midnight and 7 a.m., with 2.2% of patients found at 00:00 a.m., 0.4% at 1:00 a.m., 1.7% at 2:00 a.m. 00 hrs, 2.6% at 3:00 a.m., 0.4% at 4:00 a.m., 1.3% at 5:00 a.m., and 2.2% at 6:00 a.m.

4. Discussion

4.1. Relation between vascular event and season

Our series refers only to SAH related to aneurysm rupture. Ruptured aneurysms are the cause of SAH in 85% of patients, whereas 10% fit into the pattern of so-called non-aneurysmal perimesencephalic haemorrhage, a relatively innocuous condition. The remaining 5% are caused by various rare causes.

Previous research on the influence of weather and climate changes on the frequency of SAH yielded contradictory results. Research disenchanting the influence of season and weather on SAH incidence have been conducted using different research methods including long-term big data and deep learning analysis [4]. Our study show a different distribution between the months of the year and a significant seasonal fluctuation in the occurrence of aneurismatic SAH, identifying statistical differences in temperature and humidity among seasons. Regarding the hour of presentation, Feigin and colleagues conducted a study in Australia and New Zealand, they found that the risk of SAH was significantly higher in the morning (6: 00–12: 00 hrs) [5].

Despite different geographic regions and climatic conditions these seasonal fluctuations have been identified previously by other research groups. The climate of the state of Nuevo León and northeast of the country is generally dry and semi-dry climate in 68% of its territory, 20% is warm semi-humid, with an average annual temperature around 20° C. A climate with well-defined seasons and quite extreme conditions. Average humidity is 65% [6]. Summers are long, extremely hot and muggy; winters are short, cool and dry. During the year, the temperature

Table 1
Distribution of aneurismatic SAH through the seasons of the year.

Season	SAH frequency*	Max. Temperature* (°C)	Min. Temperature* (°C)	Temperature at the time of symptoms onset* (°C)	Humidity* (%)	Atmospheric pressure (hPa)
Spring	48 (20.9%)	31 (29–33)	20 (17–23)	24 (20–27.8)	60.50 (43.4–75.7)	1013.50 (1011–1016)
Summer	38 (16.5%)	34 (33–36.3)	23.50 (22–24.4)	25 (23.8–27.3)	58.50 (37.5–78)	1015 (1012–1017)
Autumn	67 (29.1%)	25 (20–30)	16 (10–20)	18 (13–23)	73.80 (51.8–88.2)	1019 (1014–1024)
Winter	77 (33.5%)	24 (20–27)	10 (7–14)	15 (10–21)	74.30 (56.9–87.5)	1021 (1014.5–1025)

*$p < 0.05$.

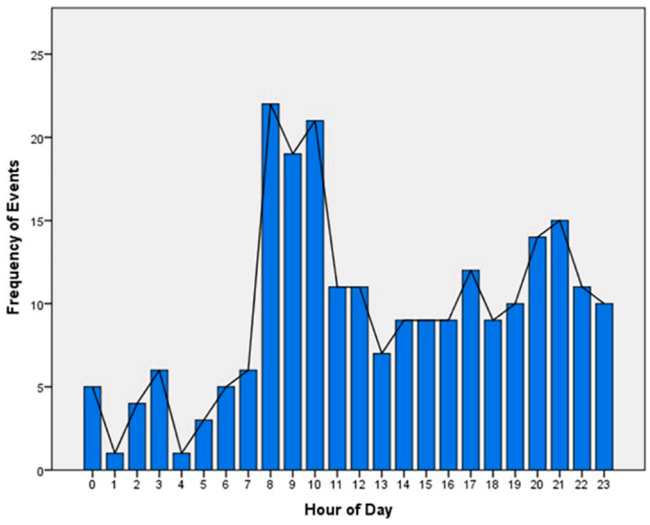

Fig. 2. Distribution of SAH events throughout the day.

generally ranges from 10 °C to 35 °C and rarely drops below 4 °C or rises above 40 °C. In the north hemisphere Inagawa et al. carried out in the city of Izumo, Japan (1991–1996), they found in patients with intracerebral hematoma a statistically significant climatic fluctuation with a peak in winter (November-April) and a drop in summer (June-August). However, for patients with spontaneous subarachnoid hemorrhage there was no significant difference [6]. Beseoglu et al. conducted a systematic review study of climatic conditions in the metropolitan area of Düsseldorf, Germany and their association with spontaneous SAH. The correlation analysis did not show an association of SAH with specific climatic conditions. Despite the fact that they found a slight increase in the incidence of SAH in spring, the X2 test did not identify statistical significance [7]. A study carried out in Mexico City by Olivares et al. in 1973, at the Hospital Centro Medico 20 de Noviembre of the Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE) to study the risk factors in the cerebrovascular disease, they found a peak in the frequency of cerebrovascular disease occurred in August and September, which is the beginning of the cold and dry climate, is the only study carried out in Mexico related to vascular cerebral events and their association with climatic factors [8]. In the other hand studies in the south hemisphere (Australia and New Zealand) showed an increased frequency of all cerebral vascular events including aneurismatic SAH in both sexes during June and July (winter in Australia) and decreased in February (summer in Australia) [9,10].

Despite conflicting results, there is a clear seasonal pattern in the admission of patients with spontaneous SAH in several studies conducted in the northern hemisphere, as well as in this large-population study conducted in the southern hemisphere. The consistent seasonal variations demonstrated in both hemispheres support the hypothesis that environmental changes play a significant role in the development of spontaneous SAH [10].

4.2. Explanation of the seasonal relation

The biological reasons why cerebrovascular events mostly occur during winter are not known; however, various mechanisms can be suggested. The seasonal variation of blood pressure is well known, this being higher during the winter, in addition to the peripheral vasoconstriction caused by the cold. Cholesterol and triglycerides tend to be higher in winter. Plasma fibrinogen concentration and viscosity show considerable seasonal variation, at least in the elderly, and there is evidence that fibrinogen is a predisposing factor for a cerebrovascular event. As well as infections, particularly influenza and other respiratory tract infections [9]. Given the similarity between the circadian and annual patterns observed in other studies of environmental factors in ischemic events, intracerebral hemorrhages, and myocardial infarctions, and together with our information, it suggests that the occurrence of major vascular events may be influenced by common triggers, therefore, having a clearer explanation of the implication of climatic factors can influence the incidence of SAH due to rupture of intracranial aneurysms.

The associations of external climatic factors with SAH may be explained by barometric pressure [10], atmospheric pressure changes, temperature and systolic blood preasure [11], activation of the sympathetic nervous system and catecholamine secretion may occur in response to cold stress increasing the peripheral vascular resistance, vasoconstriction in winter, humidity and expansion of plasma volume [12] and changes in physical activity and health-associated behaviors such as smoking, alcohol consumption and the physiologic response to exercise. There are also associations between colder temperatures and increased fibrinogen levels, inflammation, increased systemic infection rates, and increased risk of vascular disease such as stroke and myocardial infarction [13] homeostatic regulation, hormonal fluctuations and changes in human behavior, however further investigation is needed to elucidate these connections [14].

4.3. Aneurysm location and epidemiology

The ratio between men and women corresponded to the rest of the literature for SAH due to aneurysmal rupture. Regarding the location of intracranial aneurysms, according to "The international cooperative study on the timing of aneurysm surgery", in which neurosurgical centers from 14 countries around the world participated, they determined the most frequent location of aneurysms was in the anterior communicating artery/ anterior cerebral artery (39%), followed by the internal carotid artery (29.8%), the middle cerebral artery (22.3%), vertebrobasilar circulation (7.6%) [15].

In contrast, our study showed different distribution regarding aneurysm location compared to Anglo-Saxon population. In our population, the most frequent location is in the internal carotid artery (48.4%), followed by the anterior communicating artery (26%) and middle cerebral artery (17.6%). Similar to our results the study of Quezada et al. carried out in center Mexico found a 43% frequency of internal carotid artery aneurysms, followed by the anterior communicating artery in 18%, and the middle cerebral artery in 11% [16]. This is extremely important, as it forces us to think differently when

approaching a patient and when searching for the area of origin of the aneurysm.

4.4. Study limitations

The small number of collected patients and the different geographic origins around northeast Mexico represent the main limitation in this study.

5. Conclusions

Risk factors such as hypertension, diabetes, obesity, smoking, and alcoholism are well known and should remain the focus in preventive strategies for aneurysmal formation and rupture. Our study suggests that the risk of SAH due to aneurysm rupture exhibits an annual (incidence peaks in autumn and winter) and circadian rhythm (with a peak incidence in the morning 7–10 hrs.). This seasonal difference can be explained by a combination among cerebrovascular risk factors, pathophysiological and environmental variations. However, the precise mechanism by which they influence requires further research.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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