Seasonal variation & Incidence of rupture of intracranial aneurysm : A prospective study & Literature review

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Abstract

Objectives: Some studies have found an association of incidence of aneurysmal Sub arachnoid hemorrhage (aSAH) with seasonal variations and weather patterns but others have refuted this. With conflicting reports in the literature, we tried to find out whether climatic conditions influence the incidence of aSAH.

Patients and Methods: This was a prospective single centre study involving patients with aSAH operated in a tertiary care hospital over one calendar year. Meteorological parameters like temperature, barometric pressure, humidity and sunshine hours were noted for 2 consecutive days prior to the ictus and on the day of ictus.

Results: 392 patients of aSAH who underwent clipping were enrolled. There was no significant difference in the incidence of aSAH across various seasons ($p > 0.05$). Pre ictus fall in temperature lead to a surge in number of cases. 241 patients (61.5%) were from geographical areas which had experienced a fall in temperature over preceding 2 days, with a mean fall in temperature of 1.1(SD 2.1) degree celsius ($p < 0.05$). The incidence of aSAH patients in low sunshine hour seasons (1.13 patients/day) was significantly more than that in higher sunshine hour seasons (0.9 patients/day) ($p < 0.05$).

Conclusions: Seasonal variation had no direct bearing on the incidence of aSAH. Pre ictus fall in temperature lead to a rise in number of cases. Also, higher incidence of aneurysmal subarachnoid haemorrhage was seen in lower sunshine hour seasons.

Keywords: Aneurysmal subarachnoid haemorrhage; Seasonal variation; meteorological parameters; Atmospheric pressure; Humidity; Temperature.

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INTRODUCTION

Many large volume centres have noticed a surge in the number of cases of aSAH during certain months of a year. Winter, spring and autumn seasons were found to be associated with a higher incidence[(1-7)]. However, this association has been refuted by many other studies[(8-11)]. Literature continues to have conflicting reports on the

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effect of seasonal variation on incidence of aSAH [1,12-20]. We investigated seasonal variation and association of meteorological parameters with the incidence of aSAH in a single large volume centre in North-western India. The potential advantage of having such a study is that the neurosurgical manpower can be better prepared to handle SAH emergencies in seasons having more incidence of disease. Also, during the season CTA can be widely applied even in suspects. This may further help in disseminating knowledge to public so that even they can be better prepared. In addition, we may gain some knowledge of factors associated with rupture. If these factor(s) can be clearly established an intervention in the form of prevention or treatment may be suggested.

MATERIALS AND METHODS

This is a prospective study for which prior approval from Institute ethics committee was taken. All good grade aSAH patients underwent CT angiography. Options of clipping / coiling were discussed with patients and family members. Those opting for surgical clipping in one whole calendar year were included in the study.

For these patients, meteorological parameters of their place of residence were recorded for two consecutive days prior to the ictus and on the day of ictus. These parameters included temperature, barometric pressure, humidity and number of sunshine hours. Sometimes where data for a particular village/town was not available, the data of the nearest place was taken. Number of aSAH patients in each month was recorded.

Months were further grouped as seasons as under:

Rainy season --	July/August/September –	92 days
Autumn --	October/ November –	61 days
Winter --	December/ January/ February –	90 days
Spring --	March/ April –	61 days
Summer --	May/June –	61 days

The data thus generated was analyzed in two ways.

The average (of 3 days) of temperature, pressure and humidity was calculated and was plotted against average number of SAH patients to look for relationship between incidence of SAH in various seasons.

Further, the relation of number of sunshine hours to the incidence of SAH was calculated. Summer months of May, June have more sunshine hours ; i.e. sun rises early and sets late. Conversely, winters in months of December, January, February have low sunshine hours. Another unique feature of Indian subcontinent is the rainy season known as monsoons when the axis of the earth favours more sunshine hours but due to near constant cloud cover, the effective number of sunshine hours is decreased.

We studied the climatic conditions prior to ictus for each patient. The difference in value of meteorological parameter on the day of ictus and 48 hours before ictus was calculated and analyzed with respect to SAH events. Data were summarized and analysed with SPSS 21 (IBM Corp., New York, USA). Mean, standard deviation, percentage and ratios of the demographic and meteorological paramenters were calculated.Their relationship was analyzed with respect to seasons and also amongst two sunshine hour groups. Preictal change in the metereological parameters were separately computed. Statistical analysis for corelation between the variables was carried out using the student t- test, chi square test as applicable. P-value <0.05 was considered statistically significant.

RESULTS

Over a period of 12 months, 392 patients who underwent clipping for ruptured intracranial aneurysm were included in the study. The mean age of the study population was 50.49 years with 57.9% patients being females.

Mean values of metereological parameters in various seasons and number of aSAH patients reporting in that season were noted (Table 1). 107 patients presented in the Rainy season, 67 in Autumn, 100 in Winter, 59 in Spring and 59 patients in Summer. This translated to an average incidence of 1.16 cases per day in rainy season, 1.09 in autumn, 1.11 in winter, 0.96 in Spring and Summer. (Table 1) This difference in avearge number of cases in each season was statistically not significant ($p > 0.05$).

The seasons were studied further on the basis of average number of sunshine hours. On this basis, seasons were divided into two groups. Group A (seasons with less sunshine hours) included Rainy, Autumn and Winter (July

Table 1: Meteorological parameters (mean values) and Incidence of aSAH in different seasons

Season	Tempearture (mean ± SD) (°C)	Pressure (mean ± SD) (mm Hg)	Humidity (mean ± SD) (%)	No. of patients	No. of days in season	Incidence (Events/day)
Rainy	29.95 ± 2.17	981.16 ± 60.85	72.68± 13.51	107	92	1.16
Autumn	25.01 ± 4.22	1000.21± 43.81	62.55± 17.77	67	61	1.09
Winter	15.37 ± 2.71	971.64 ± 88.71	65.36 ± 18.28	100	90	1.11
Spring	25.33 ± 3.22	969.99 ± 83.24	55.09 ± 12.81	59	61	0.96
Summer	35.19 ± 3.74	962.51 ± 80.72	48.68 ± 13.73	59	61	0.96

Table2: Meteorological parameters and incidence of aSAH in seasons with respect to sunshine hours

	Mean Temperature (°C)	Mean Pressure (mm Hg)	Mean Humidity (%)	Incidence of aSAH
Group A (Seasons with lower sunshine hours)	23.4234	982.3491	67.5365	1.13
Group B (Seasons with higher sunshine hours)	30.2627	966.2514	51.8879	0.9

to February) and group B (seasons with more sunshine hours) included Spring, Summer (March to June). In group A, sunshine hours were 1397 hours in a total of 243 days with an average of 6.11 hours per day. In group B, sunshine hours were 959 hours in 122 days with an average of 7.9 hours per day.

The incidence of aSAH patients in Group A (1.13 patients/day) was significantly more than that in Group B (0.9 patients/day) ($p < 0.05$).

Further analysis revealed that seasons with lower sunshine hours had statistically significant lower mean temperature, higher mean atmospheric pressure and higher humidity levels ($p < 0.05$). (Table 2)(Figure 1)

Further, the changes in metereological parameters like temperature, humidity and atmospheric pressure over duration of 2 days prior to the ictus were studied for each individual aSAH patient .

We found that if there was a fall/ sudden drop in temperature in the preceeding two days of ictus, in the place of residence of patient, there was a surge in the number of cases of SAH. (Fig. 1). 241 patients (61.5%) were from an area where there was a fall in temperature. In 60 patients (15.3%) there was no change in temperature in the locality. Only 17.6% (69 patients) had a reported from an place where there was a rise of temperature. ($p < 0.05$). (Fig.1) The mean pre ictal change in temperature was -1.1 °C (SD±2.1), range from -8°C to -1°C. On the other hand, changes in atmospheric pressure and humidity in the preceeding two days showed no significant association with the incidence of aSAH. (Figure 2 & 3)

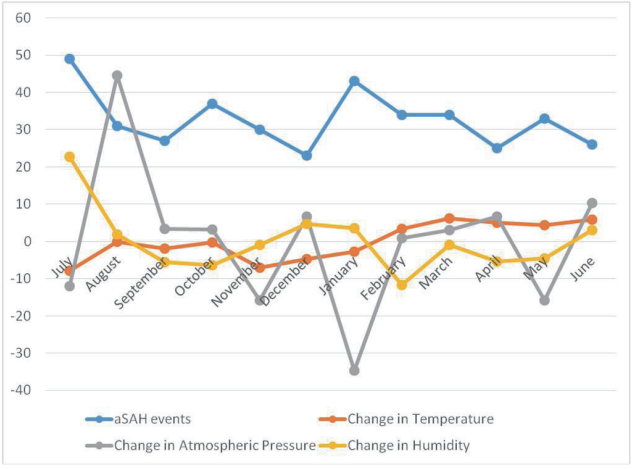

Image 1. Incidence of SAH across different seasons

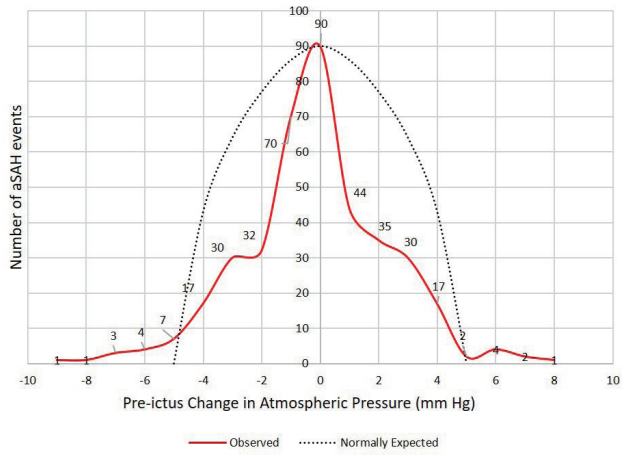

Image 2. Relation of pre ictal change in atmospheric pressure and number of SAH patients

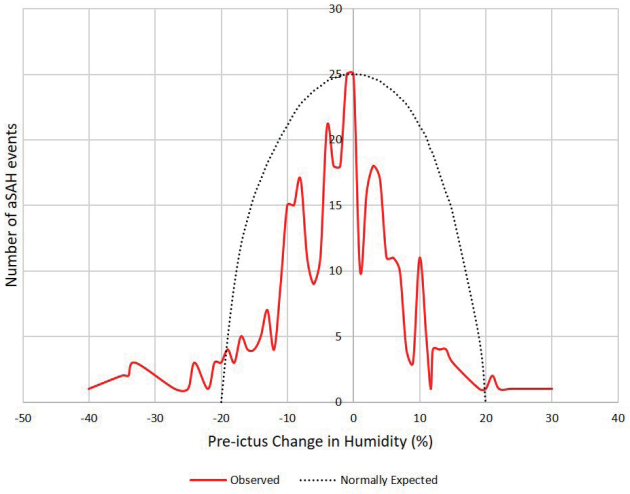

Image 3. Relation of pre ictal change in humidity and number of SAH patients

DISCUSSION

Weather is one of the most complex phenomenon in nature and so is etiology and risk fators of aSAH.For a disease which continues to have a high morbidity and mortality, it is imperartive to study risk factors. Reports of clustering of cases during specific seasons has lead investigators to look for reasons behind it and suggest any therapeutic or preventive intervention.

The present study is one of the largest prospective study of its kind in which 392 clipped patients of aSAH in one calender year were included. Various climatic features (of the geographical region of patient's residence) on days immediately preceding SAH were studied. These variables viz. temperature, humidity, atmospheric pressure and number of sunshine hours were then plotted against number of patients of aSAH reporting in different seasons.

We found no statistically significant difference in the incidence of aSAH in different seasons.

However, there were significantly higher number of cases in lower sunshine hour seasons than in higher sunshine hour seasons. This was accompanied with lower temperature, higher humidity and higher atmospheric pressure.

In addition, we found that pre ictus fall in temperature lead to a surge in number of cases. 61.5% of total patients had repoprted from an area where there was a fall in temperature in the pre ictus period. Fall / sudden drop in temperature in preceding days of ictus leading to increased incidence of SAH has been noted in two previous studies involving 1010 patients[2,3].

We came across14 studies involving data of 78299 patients that pointed towards an association of seasonal and climatic changes with incidence of aSAH. These studies stated that winter months, lower temperature, lower sunshine hours, higher barometric pressure, higher humidity had association with increased number of SAH cases [1-9,19,23-26] (Table 3)

Nyquist et al postulated that cardiovascular stresses occur during winter, particularly in regions with extremes of climate. During these extreme temperatures the human body experience stresses like deconditioning. Also the riutine physical activity tends to decrease in extremely cold environment. This may result in fluctuations in blood pressure, blood coagulability, and cardiovascular performance[16]. In colder weather people tend to have adverse lifestyle changes like tendency for increased smoking and alcohol consumption, which are known risk factors for rupture of intracranial aneurysmal[2]. Though this association was reported in several studies, the exact mechanism behind the association of lower temperature and rupture of aneurysm is not clear[2,9,11,12,16,18,19].

Systolic blood pressure is one of the documented risk factor and a precipitating cause for the rupture of aneurysm. Raised systolic blood pressure over diastolic pressure due to peripheral vasoconstriction in winters

Table 3 : Literature review about the effect of seasonal variations and meteorological parameters on the incidence of a SAH

S.No.	Authors	Place	Study period (Duration in years)	No of patients	Study type	Parameters studied	Conclusion
1	Hughes MA et al [25]	London	2003-2008 (6)	647	Retrospective/ Single centre study	Local temperature, atmospheric pressure, humidity	Non-significant bi-annual peak incidence in autumn and spring with nadir in summer. Positive correlation of incidence with higher humidity.
2	Lai PMR et al [17]	USA	2001-2010 (10)	16970	Retrospective/ National registry based study	Average daily temperature, precipitation, sunlight, relative morning humidity	Higher daily percentage sunlight and lower humidity were associated with decreased aSAH admission. Greater precipitation associated with reduced hospital mortality
3	Backes D et al [2]	Netherlands	1995-2010 (16)	18714	Retrospective/ National hospital registry based study	Weekly temperature	Incidence increased with colder temperature
4	Shenouda E et al [30]	Devon and Cornwall (UK)	1992-1996 (5)	800	Retrospective/ Population based study	Temperature, barometric pressure, humidity	Incidence of SAH associated with higher barometric pressure
5	Lejeune JP et al [19]	France	January 1989 – December 1991	238	Prospective/ Single centre study	Temperature, Atmospheric pressure, Humidity, Rainfall, Sunshine hours, Snow fall, Hail fall, Smog, Thunderstrom	Incidence associated with decline in sunshine duration, humidity, temperature, atmospheric pressure
6	Hakan T et al [11]	Istanbul	1994-2000 (7)	683	Retrospective/ Single centre study	Seasons	Incidence of aSAH is peak in winter and nadir in autumn
7	Launey Y et al [18]	France	2011-2012(2)	295	Retrospective/ Single centre study	Months of English calendar	Low temperature and sudden temperature drop were associated with increased occurrence of SAH
8	Fukuda H et al [9]	Japan	2012-2016 (5)	715	Multicentric		Temperature decline correlated with the incidence of spontaneous SAH,

Table 3 : Literature review about the effect of seasonal variations and meteorological parameters on the incidence of a SAH(Continue)

S.No.	Authors	Place	Study period (Duration in years)	No of patients	Study type	Parameters studied	Conclusion
9	Ishihara H et al [16]	Yamaguchi	1986-2005 (20)	5007	Retrospective/ Multi-centre study	Months of English calendar	In elderly patients incidence is high in December and January and in middle age women incidence is high in October
10	Moinuddin A et al [23]	Scotland	1986-2005 (20)	10113	Retrospective/ Population based study	Seasons	Higher incidence in winter and spring compared to summer
11	Rosenorn J et al [27]	Denmark	1978-1983 (6)	1076	Prospective/ multicentre study	Seasons	Incidence of higher in spring and autumn
12	Han MH et al [12]	Korea	2011-2014 (4)	21407	Retrospective/ National registry based study	Mean temperature, average diurnal temperature range, air pollution, seasons	Lower SAH occurrence in summer and higher SAH occurrence in January and change of seasons
13	Beseoglu K et al [3]	Germany	2003-2005	147	Retrospective/ Single centre study	Temperature, Atmospheric pressure, Humidity, Precipitation, Seasons	Peak incidence in Spring No variation with weather pattern
14	Chyatte D et al [4]	Connecticut	1981-1989 (9)	1487	Retrospective/ state based records	Hourly dew point, seasons	Male patients have higher incidence in late fall and female patients in late spring
15	Neidert et al [24]	Zurich	2004-2012 (9)	511	Retrospective/ Population based study	Surface pressure, 2m temperature, relative humidity, wind gust, sunshine, precipitation	No clear association with meteorological parameters
16	Cowperthwaite MC et al [5]	USA	2004-2008 ()	7758	Retrospective/ Multicentre study	Temperature, Atmospheric pressure, Humidity	No variation with weather pattern
17	Vulekovic P et al [31]	Novi Sad, Serbia	1998-2009 (12)	536	Retrospective/ Single centre study	Months of English calendar	Clustering of incidence present. No specific pattern observed.

Table 3 : Literature review about the effect of seasonal variations and meteorological parameters on the incidence of a SAH(Continue)

S.No.	Authors	Place	Study period (Duration in years)	No of patients	Study type	Parameters studied	Conclusion
18	McDonald RJ et al [21]	USA	2001-2008 (8)	52379	Retrospective/ National hospital registry based study	Months of English calender, Average monthly temperature, climate zones	No significant association with temperature. Significant variation in different climate zones is present
19	Ingawa T et al [14]	Japan	1991-1996	123	Respective/ Community based study	Seasons, Diurnal variation	No seasonal variation, Bimodal diurnal variation
20	Oyoshi T et al [26]	Amami-Oshima (Japan)	1986-1996 (11)	210	Retrospective/ Single centre study	Temperature, atmospheric pressure, relative humidity, months of English calendar	No correlation with seasons or meteorological parameters
21	Present study	Northwestern India	July 2017-June 2018 (1)	392	Prospective/ Single centre study	Temperature, Atmospheric pressure, Humidity, Sunshine hours, months of English calendar, seasons	Seasons with less sunshine hours have higher incidence of aSAH. Pre-ictus fall in temperature > 1 degree Celsius is a risk factor for aSAH. Peak incidence seen in July and January.

leads to raised pulse pressure. High pulse pressure leads to increased stress on vessel wall, increased friction and shear stress. It has been observed that systolic blood pressure was significantly more in days with lower temperatures than higher temperatures[27]. In addition to the rasied systolic pressure, increased platelet and red cell counts, increased sympathetic discharge, decreased factor VIII, anti-thrombin III and platelet aggregation and increased fibrinolytic activity are other factors claimed to contribute to increased incidence of aSAH[28].

Incidence of aSAH was higher in seasons with lower sunshine hours in our study. Similar observations were made in retrospective nationwide study for a decade in USA[23].

In addition,we noticed that seasons with lower sunshine hours had significantly lower mean temperature, higher mean atmospheric pressure and higher humidity level ($p < 0.05$). These metreological parameters are described to be associated with higher incidence of aSAH in various other studies[23-26]. A proposed hypothesis for higher incidence of aSAH in lower sunshine hourse can be lower duration of UV light exposure. This in turn can result in decreased vitamin D and parathyroid hormones levels. Deficiency of vitamin D and parathormone leads to changes in vascular smooth muscle, intracellular calicium, adrenergic responsiveness and endothelial function[21].

These changes may make the vessel unstable leading to rupture of an aneurysm.

Had the effect of climate been so apparent on rupture of intracranial aneurysm, there should have been no studies to the contrary. In fact,we came across 6 studies with 61517 patients which failed to find any association of seasonal variation or climatic changes with incidence of aSAH[10-12,21,29]. (Table 3)

Sudden seasonal variation produces some kind of hemodynamic stress coupled with changes in properties of flowing blood. These changes predispose a pre existing aneurysm to rupture. The exact mechanism remains to be elucidated. We feel that since intracranial aneurysm is a multifactorial disease,there are some factors whose effect is stronger and are thus major risk factors like smoking and hypertension. the effect of others is not very strong and may be termed minor risk factors. External environmental factors might lie in this group of minor risk factors.

CONCLUSION

There was no direct effect of seasonal variation on incidence of aSAH. Higher incidence of aneurysmal subarachnoid haemorrhage was seen in seasons with lower sunshine hours. Pre ictus fall in temperature in the area of patient's residence lead to a surge in number of cases.

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