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► **To cite this version:**

Y. Launey, G. Le Gac, P.-J. Le Reste, Jean-Yves Gauvrit, X. Morandi, et al.. Role of bioclimate conditions on cerebral aneurysm rupture in the Brittany region of France. *Neurochirurgie*, 2019, 10.1016/j.neuchi.2019.11.001 . inserm-02444403

HAL Id: inserm-02444403

<https://inserm.hal.science/inserm-02444403>

Submitted on 7 Mar 2022

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Title page

Title: Role of bioclimate conditions on cerebral aneurysm rupture in the Brittany region of France

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Authorship

Conception and design of the study: YL, GL, PJJ. Acquisition of data: GL. Analysis and interpretation of data: YL, GL, PJJ, PS. Drafting the article or revising it critically for important intellectual content: JYG, XM, PS. Final approval of the version to be submitted: YL, PS.

Financial support: None

Conflict-of-interest statement: None

Manuscript word count: 4,394

Abstract word count: 213

References count: 48

1 **Role of bioclimate conditions on cerebral aneurysm rupture in the Brittany region of**
2 **France**

3

4 **Abstract**

5 Introduction: Subarachnoid hemorrhage (SAH) from intracranial aneurysm rupture is an
6 unpredictable event responsible for significant morbidity and mortality. Despite
7 inconsistencies, some studies suggest a potential role of climate conditions in SAH onset. The
8 purpose of this study was to determine the impact of climatic and lunar factors on onset of
9 SAH in an oceanic climate such as that of Brittany, France.

10 Methods: All adults with SAH admitted to the neurosurgery department and intensive care
11 unit of the University Hospital of Rennes (France) between January 1st, 2011 and December
12 31st, 2012 were included. Meteorological variables, their variations, lunar phases and tidal
13 coefficients were compared between days with and without SAH.

14 Results: We retrospectively included 295 patients with SAH. Mean minimum temperature
15 was significantly lower during days with SAH ($7.7\pm 4.7^{\circ}\text{C}$ versus $8.3\pm 4.6^{\circ}\text{C}$; $p = 0.039$);
16 temperature variation between 2 successive days was significantly greater for days with SAH
17 ($8.6\pm 4.1^{\circ}\text{C}$ versus $7.9\pm 3.8^{\circ}\text{C}$; $p < 0.01$). Multivariate analysis showed that a 2-day
18 temperature drop greater than or equal to 8°C was associated with 35% increased risk of SAH
19 (odds ratio 1.35 [1.03 – 1.77]). There were no significant effects of other meteorological
20 variables, lunar phase or tidal coefficient on SAH occurrence.

21 Conclusion: Low temperature and sudden temperature drop were associated with increased
22 occurrence of SAH in Brittany, France.

23

24 **Keywords**

25 Subarachnoid hemorrhage; cerebral aneurysm; climate conditions; meteorological variables

26

27 **Introduction**

28 Aneurysmal subarachnoid hemorrhage (SAH) is a common pathology, with incidence ranging
29 from 6 to 20 per 100,000, and is responsible for significant morbidity and mortality [1–5].
30 Several individual risk factors for aneurysm rupture are well-known, such as female gender,
31 age >50 years, alcohol consumption, smoking and hypertension [6,7]. However, onset of
32 aneurysmal SAH is unpredictable, often described as “a bolt from the blue”. Some studies
33 suggested that climate or the Moon may influence humans and animals and the occurrence of
34 various diseases [8–10]. A prospective study suggested that atmospheric pressure positively
35 impacts absolute intracranial pressure in humans [11]. More specifically, some authors
36 suggested a role of climate conditions in intracerebral hemorrhage and SAH [12–18], but
37 reported conflicting results. Some found an association between onset of SAH and
38 atmospheric pressure changes [18,19], or the season and low temperature [14], while other
39 studies found no association between these diseases and climatic conditions [13,20–22]. To
40 explain these inconsistencies, we hypothesized that geographic location had an impact on
41 aneurysm rupture according to the type of climate. In geographic regions without significant
42 meteorological variations, or in large enough regions subject to various climate types, several
43 studies showed no association between SAH onset and climatic conditions [13,22]. Moreover,
44 statistical tools and analysis differed, and studies mainly analyzed climate data as isolated
45 variables without considering them as closely intertwined values composing a climate profile.
46 Similarly, it has been suggested that the phases of the Moon influence SAH onset. The New
47 Moon phase seems to be associated with increased SAH onset [23], but studies investigating
48 the role of the Moon are scarce and reported inconsistent results [21,24]. Moreover, these
49 studies considered only illumination phase and not the interaction between Moon phase and
50 tidal coefficient.

51 The purpose of this study was to determine the impact of climatic factors and the Moon on
52 new onset of SAH in a region with oceanic climate (Brittany, France).

53

54 **Material and methods**

55 A retrospective study was conducted in Rennes University Hospital, a tertiary hospital
56 managing most cases of SAH in Brittany. Brittany is a French region with 3.26 million
57 inhabitants in 2012. It has an area of 27,208km²; the climate is temperate oceanic, influenced
58 by 2 seas (the Channel and the Atlantic Ocean) [25]. Rennes and Brest are the two main cities
59 in Brittany, with 318,127 and 314,844 inhabitants in 2012 respectively. Patients initially
60 admitted to Brest hospital and secondly transferred to Rennes for coiling were also included.
61 The study was submitted to the local review board of Rennes University Hospital, which
62 judged that patient consent was not required under French law.

63

64 **Objectives**

65 The primary objective of this study was to determine whether atmospheric pressure variation
66 influenced new onset of SAH on global analysis of the weather in Rennes and Brest,
67 comparing days with or without SAH onset.

68 Secondary objectives were to identify other climatic factors (temperature, humidity, wind
69 speed) potentially responsible for SAH onset on global analysis, to determine impact on SAH
70 severity according to the WFNS (World Federation of Neurological Societies) scale, and
71 aneurysm location and size based on individual data analysis. Finally, the influence of the
72 Moon and the related tidal coefficient was studied.

73

74 **Patient Data**

75 All adult patients (>18 years) with aneurysm or spontaneous non-aneurysmal SAH admitted
76 to the neurosurgery department and intensive care unit of the Rennes University Hospital
77 between January 1st, 2011 and December 31st, 2012 were included. Patients with SAH due to
78 trauma, ruptured arteriovenous malformations, vasculitis or other structural lesions were
79 excluded. Patient data comprised age, gender, known SAH risk factors (hypertension,
80 smoking and alcohol consumption), geographical location and date of SAH onset (defined as
81 date of onset of headache or of admission in case of coma), hospital stay, and mortality.
82 General and SAH-specific severity scores were calculated: Glasgow Coma Score, Simplified
83 Acute Physiology Score II (SAPS II) [26], Fisher score and World Federation of
84 Neurosurgical Societies (WFNS) score. Cerebral aneurysm was characterized by location
85 according to 6 regions (anterior, medium, posterior, vertebrobasilar, carotid, or *sine materia* if
86 no aneurysm were visualized on cerebral CT-scan). Aneurysm size in millimeters, type of
87 aneurysm treatment (surgical clipping, coiling or abstention), and complications (intracranial
88 pressure, re-bleeding, cerebral vasospasm) were reported.

89

90 **Meteorological data**

91 For individual analysis, the season, the maximum, minimum and change in barometric
92 pressure, relative humidity and air temperature, maximum and average wind speed during the
93 day of SAH onset and the day before were collected from the regional climate website
94 "<http://www.meteo-bretagne.fr>". If data were not available for the exact geographical area of
95 the SAH occurrence, data from the closest area were used.

96 For global analyses, the maximum and minimum values and variation (defined as maximum
97 minus minimum value over 24h) were used for the following parameters: barometric pressure,
98 relative humidity and air temperature. For each day, the maximum and average wind speed in
99 Rennes and Brest during the study period were collected.

100

101 Moon and tide data

102 Since the tidal coefficient is representative of the global effect of the Moon on the Earth,
103 including oceans, land masses and atmosphere, we considered variations in tidal coefficient to
104 be negligible at the scale of Brittany. Each day was matched with the corresponding Moon
105 phase and tidal coefficient of the nearest harbor (e.g., Saint-Malo harbor for the Rennes
106 region, representing the influence of the Channel, and Brest harbor for the Brest region and
107 southern Brittany under the influence of the Atlantic Ocean). All data were extracted from the
108 website "<http://maree.info>". A lunar cycle lasts 29.5 days, corresponding to one complete
109 revolution of the Moon around the Earth, and is divided into 8 phases (New Moon; Waxing
110 Crescent; First Quarter; Waxing Gibbous; Full Moon; Waning Gibbous; Last Quarter;
111 Waning Crescent). Tidal coefficients were collected twice a day, in the morning and in the
112 afternoon, then the maximum of the 2 values was classified in 9 categories (≤ 39 ; 40 – 49; 50
113 – 59; 60 – 69; 70 – 79; 80 – 89; 90 – 99; 100 – 109; ≥ 110).

114

115 Statistical analysis

116 Statistical analysis was performed with SAS software version 9.4. T-tests were used for
117 quantitative climatic variables (air temperature, barometric pressure, relative humidity, mean
118 and maximum wind speed, and their variations. Climatic variation was defined by a rise or
119 fall in a climatic variable over 2 successive days, calculated as the maximum for one day
120 minus the minimum for the day before, a rise having a positive value and a drop a negative
121 value.

122 Qualitative variables (lunar phase, tidal coefficient, patient characteristics) were analyzed
123 using chi-square test. Multiclass variables were analyzed by ANOVA and results expressed as
124 odds ratio (OR) and 95% confidence interval (95%CI). Tidal coefficients were analyzed as a

125 quantitative and as a qualitative variable after allocation to categories. Multivariate analysis
126 and ROC curves were built from the logistic model to determine the most relevant variable
127 and a threshold for SAH risk. Multivariate analysis by ANOVA and logistic regression
128 determined whether climate variations influenced SAH severity, assessed on WFNS score.
129 The secondary objective was to determine the effect of climate on aneurysm location.
130 Variables influencing the size of ruptured aneurysms were analyzed by a generalized linear
131 model. A p-value <0.05 was considered statistically significant.

132

133 **Results**

134 *Patient characteristics*

135 We retrospectively included 295 patients from Rennes and Brest, admitted for SAH. Patient
136 characteristics and SAH risk factors are summarized in Table 1 and severity scores associated
137 with stratified mortality in Table 2. Mean age was 53 ± 13 years, with a female rate of 0.64.
138 Overall mortality was 8%, the mean ICU stay 7.7 ± 8.2 days, and hospital stay 22.7 ± 24.9 days.

139

140 *Aneurysm characteristics*

141 Aneurysm locations were mostly in the anterior (anterior communicating artery; anterior
142 cerebral artery: 34%) and middle cerebral network (middle cerebral artery: 22%). Mean
143 aneurysm size was 5.8 ± 3.2 mm. Most intracranial aneurysms were managed by interventional
144 radiological coiling, and the others by surveillance or surgical clipping (Table 3).

145

146 *Monthly and seasonal SAH incidence*

147 SAH occurred on 259 (26%) of the 731 screened days. The highest rates were in July (n = 29
148 days; 47%) and January (n = 28 days; 45%) (Figure 1), and the lowest rates in May and
149 August (n = 16; 26%) (Figure 1). Winter was the season with the highest rate (n = 80; 27%)

150 while Spring had the lowest rate (n = 65; 23%). However, no significant statistical differences
151 in SAH occurrence were found between months (p = 0.26) or seasons (p = 0.54).

152

153 *Global analysis*

154 Minimum temperature was significantly lower on days with than days without SAH
155 ($7.7\pm 4.7^{\circ}\text{C}$ versus $8.3\pm 4.7^{\circ}\text{C}$; p <0.04). There were no significant differences between days
156 with and without SAH for maximum temperature, maximum and minimum barometric
157 pressure, relative humidity, or average or maximum wind speed (Table 4). Two-day
158 temperature drop was significantly greater for days with than without SAH ($8.6\pm 4.1^{\circ}\text{C}$ versus
159 $7.9\pm 3.8^{\circ}\text{C}$, p <0.01). No significant differences between days with and without SAH were
160 observed for other climate variations (Table 5).

161 On multivariate analysis, a 1° drop in temperature increased the risk of aneurysmal SAH by
162 7% (OR 1.07; 95%IC [1.03-1.10]). The higher the maximum temperature, the lower the risk
163 of SAH (OR 0.97; 95%IC [0.95-0.99]). On ROC curves, for a threshold of 8.0°C , a $\geq 8.0^{\circ}\text{C}$ 2-
164 day temperature drop was associated with a 35% increase in SAH risk (OR 1.35; 95%IC [1.03
165 – 1.77]).

166

167 *Individual analysis*

168 No influence of climatic variables or their variations on SAH severity was found (Table 6).
169 Variables significantly associated with higher WFNS score comprised: age >50 years (OR
170 1.90 [1.21 – 2.99]), female gender (OR 2.06 [1.25 – 3.39]) and alcohol consumption (OR 2.41
171 [1.02 – 5.71]).

172 No effects of climate variations on SAH onset were observed according to aneurysm location.
173 For aneurysm size, a season-related gradient was observed: $5.9\pm 3.7\text{mm}$ in Winter, $5.3\pm 3.8\text{mm}$
174 in Spring, $4.9\pm 3.3\text{mm}$ in Summer and $4.8\pm 2.9\text{mm}$ in Fall (p<0.01). Interestingly, smoking and

175 diabetes were associated with ruptured aneurysm size, which was larger in smokers
176 ($5.7\pm 3.2\text{mm}$ versus $4.9\pm 3.6\text{mm}$; $p < 0.04$), and smaller in diabetic patients ($2.0\pm 2.8\text{mm}$ versus
177 $5.3\pm 3.4\text{mm}$; $p < 0.04$).

178

179 *Moon and tide data*

180 There was no evidence of an influence of lunar phase on the SAH onset ($p = 0.11$) (figure 2).

181 Mean tidal coefficient was similar between days with (70.5 ± 19.2) and without SAH (72.2
182 ± 20.8) ($p = 0.21$), whatever the level of the tidal coefficient (figure 3) ($p = 0.12$).

183

184 **Discussion**

185 This study showed that low temperature and sharp drop in temperature over 48 hours was
186 associated with risk of SAH. However, we did not find any associations between SAH onset
187 and other meteorological variables or their variations, although previous studies have
188 suggested some.

189 Several studies suggested that SAH occurs more frequently in Winter, as we reported
190 [15,19,27], with a nadir in Summer, whereas in the present study the lowest SAH incidence
191 was in Spring. No significant difference in SAH incidence according to month or season was
192 observed, but the peak incidence in Winter could be explained by the influence of air
193 temperature and its variations. Some studies indicate an influence of temperature on SAH
194 occurrence [14,15,28]. For instance, Gill et al., in a cohort of 1,175 adult patients in
195 Maryland, showed that a decrease of 1°F was associated with a 0.6% increase in the risk of
196 SAH [14]. Rivera-Lara et al. also showed that SAH occurred on colder days with maximum
197 temperature less than 70°F (21°C) [15]. The underlying physiological explanation could be an
198 increase in blood pressure involving vasoconstriction, a modification of blood coagulation
199 [29–31], or inflammation. Bakes et al. investigated the role of influenza and cold temperature

200 on the incidence of SAH during Winter and found an increased incidence density ratio of
201 1.143 (95%CI 1.129-1.157) per 1°C temperature drop [28]. Similarly, cold weather was
202 reported to increase risk of other vascular diseases such as stroke or myocardial infarction
203 [8,30,32,33]. An explanation could be that colder days induced changes in behavior, physical
204 activity, smoking or alcohol consumption that are known risks factors of aneurysmal SAH
205 [10,34] and may increase blood pressure and induce a slight increase in the pressure gradient
206 between the intrasaccular region and cisternal compartment, affecting aneurysm wall tension,
207 although evidence is lacking.

208 Moreover, a role for other meteorological variables has been suggested. These studies mostly
209 showed that a steep shift in mean barometric pressure greater than 10hPa during the day
210 before SAH onset was associated with a significant risk of SAH [18,19,35]. Interestingly, in
211 a study including 71 SAH patients under oceanic meteorological conditions, Patrice et al.
212 suggested that a decrease in pO₂ may be the trigger of SAH during high atmospheric pressure
213 conditions [36]. The present study did not find any role of barometric pressure, but the mean
214 pressure variations were smaller than in the cited studies.

215 Several studies failed to bring out any link between climate and SAH [13,20,22]. However,
216 some limitations should be underlined. For instance, the day of SAH onset was determined
217 from national hospital databases in which the hospital admission day was assimilated to the
218 day of SAH occurrence; and the effects of microclimates in different zones were not
219 adequately addressed [20,22]. Similarly, climate changes in the study regions were limited,
220 and notably absolute changes in temperature between the day of SAH occurrence and the day
221 before were lower than in the present study, not exceeding 3°C [13]. Because of oceanic
222 influence (westerly wind, release of the heat accumulated by the ocean during Winter, and
223 warm and swift Atlantic currents prolonging of the Gulf Stream), Brittany experiences larger
224 climate variations than, for example, Düsseldorf (Germany) where the continental climate is

225 uninfluenced by the moderating effect of oceans and consequently shows fewer short climate
226 variations [13]. In line with our results, in Netherlands, a country with oceanic climate,
227 Backes et al. found an association of cold temperature and SAH occurrence [28].

228 As regards the role of aneurysm location, Hughes et al. [37] found that anterior
229 communicating artery aneurysmal SAH peaked in Summer whereas middle cerebral and
230 posterior communicating artery aneurysmal SAH peaked in Spring and Autumn. Although
231 our results differed from these findings, we did find a seasonal influence on aneurysm rupture
232 according to size: the largest aneurysms ruptured during Winter and the smallest during
233 Summer, which may support our results since aneurysm size is a risk factor for rupture [38].

234 Interestingly, as previously reported, smoking and diabetes seemed to influence aneurysm
235 size [39]. Smoking was associated with larger aneurysm; but no studies clearly showed a role
236 of diabetes in aneurysm size, whereas the present data suggested that diabetes might be
237 associated with smaller aneurysm size.

238 Finally, the role of the lunar cycle remains unclear. One study reported an increase in SAH
239 occurrence during the New Moon phase, but its design was retrospective with limited sample
240 size [23], whereas, in a larger cohort of 717 patients with SAH, Lahner et al. found no
241 association [24]. In an original strategy, we aimed to explore tidal impact, another aspect of
242 the Moon's influence on the Earth and climate; the findings, however, were not significant.

243 Obviously, our study had several limitations due to its retrospective design. Although we
244 identified the place and day of hospital admission, we failed to determine the exact time and
245 location of the SAH onset. In clinical practice, time-stamping aneurysm rupture is tricky
246 because of initial coma or frequent history of headache. We also cannot exclude climate
247 disparities over the Brittany region, as we considered 2 main climate zones with different
248 areas.

249 Moreover, not all SAH patients from Brest were included. During the study period, the
250 coiling procedure was not available in Brest University Hospital, and patients requiring this
251 treatment were transferred to Rennes University Hospital, while patients with *sine materia*
252 SAH or undergoing surgery were kept in the Brest hospital. 70% of patients admitted to the
253 Rennes hospital underwent coiling; assuming the same proportion in Brest, 29 patients failed
254 to be included.

255 Variations in SAH incidence between geographical areas are large, ranging from 6/100,000 in
256 Finland to 20/100,000 inhabitants in Japan [5]; intracranial aneurysm incidence in the overall
257 population, however, is unknown. Some subjects develop cerebral aneurysm without any
258 aneurysm rupture throughout their life [40,41]. This could explain the differences between
259 studies. In the present study, SAH incidence was around 7/100,000 person-years, less than in
260 previous reports [5,18,42]. In addition, this incidence may have been slightly overestimated
261 because of the increase in the population of Brittany during the Summer vacation period.
262 Also, mortality was lower than in previous reports, where it was close to 30% [2–5]. More
263 recent studies showed lower mortality associated with SAH, at 25% [43,44]. Supporting our
264 results, in a nationwide American study in which intra-arterial coiling was predominant,
265 mortality was 13% [17], closer to the present findings (8%). Changes in the treatment of SAH
266 (e.g., intra-arterial coiling) and the exclusion of SAH cases dead on arrival could explain
267 these discrepancies.

268

269 **Conclusion**

270 Low temperature and sudden temperature drop greater than 8°C increased the risk of SAH
271 occurrence by 35% in Brittany, a French region with temperate climate. There was no
272 evidence that the other investigated meteorological variables influenced SAH occurrence.
273 While tidal influence cannot be excluded, the effects of Moon and tide seem to be more myth

274 than reality. Despite the weak influence of climate found in our study, further investigations
275 are needed to fully understand the pathophysiology and real impact of climate on cerebral
276 aneurysm rupture.

277

278 **Acknowledgments**

279 The authors acknowledge the provision of meteorological data by Mr. Jérôme Dréano,
280 president of the Météo Bretagne association, Saint-Malo, France.

281

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422 **List of abbreviations**

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424 SAH: subarachnoid hemorrhage

425 SAPS II: Simplified acute physiology score II

426 WFNS: World Federation of Neurosurgical Societies

427 SD: Standard deviation

428 ICU: Intensive care unit

429 Max: Maximum

430 Min: Minimum

431 OR: Odds ratio

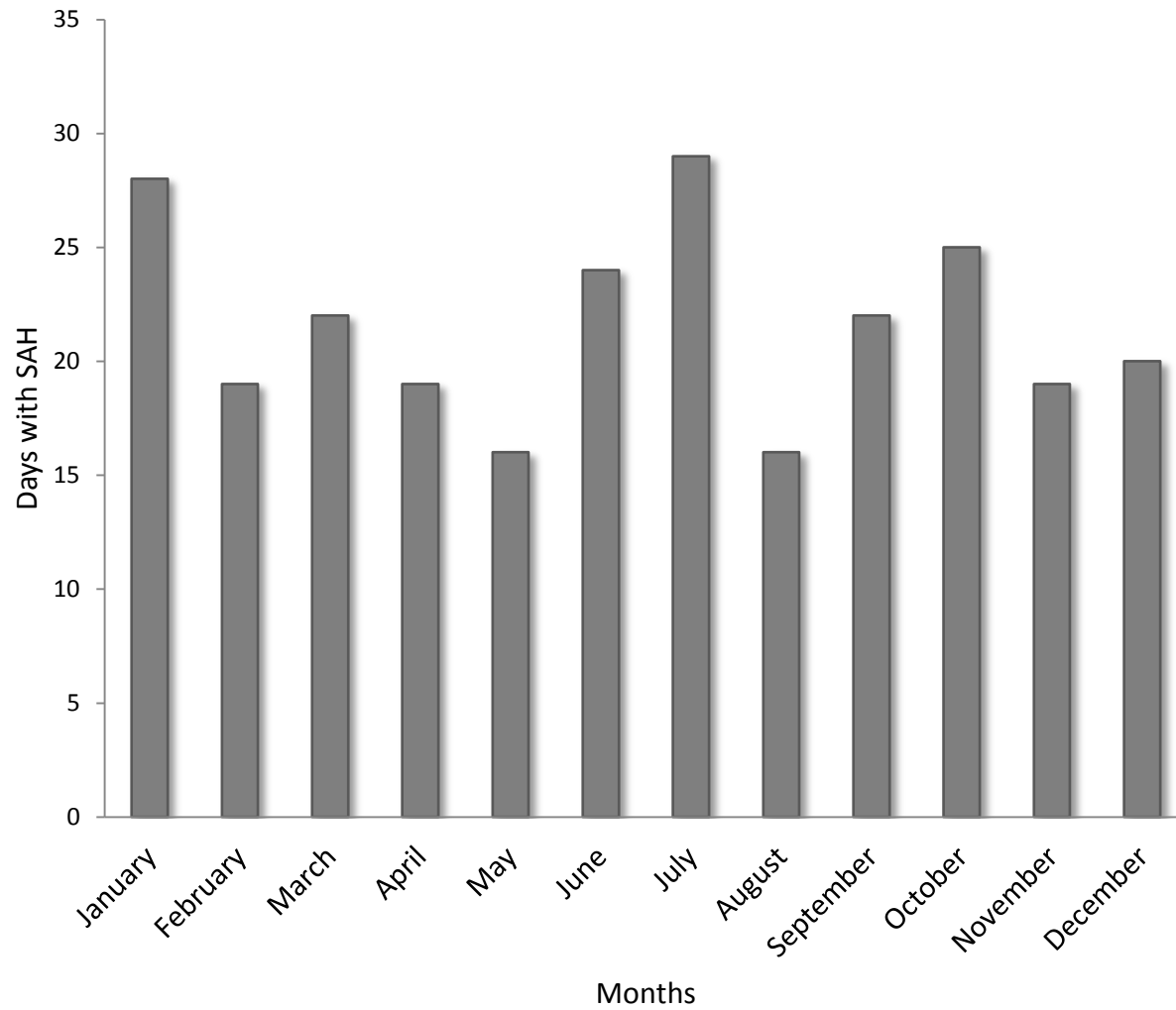
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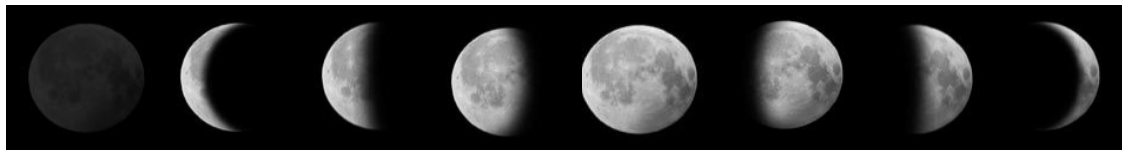
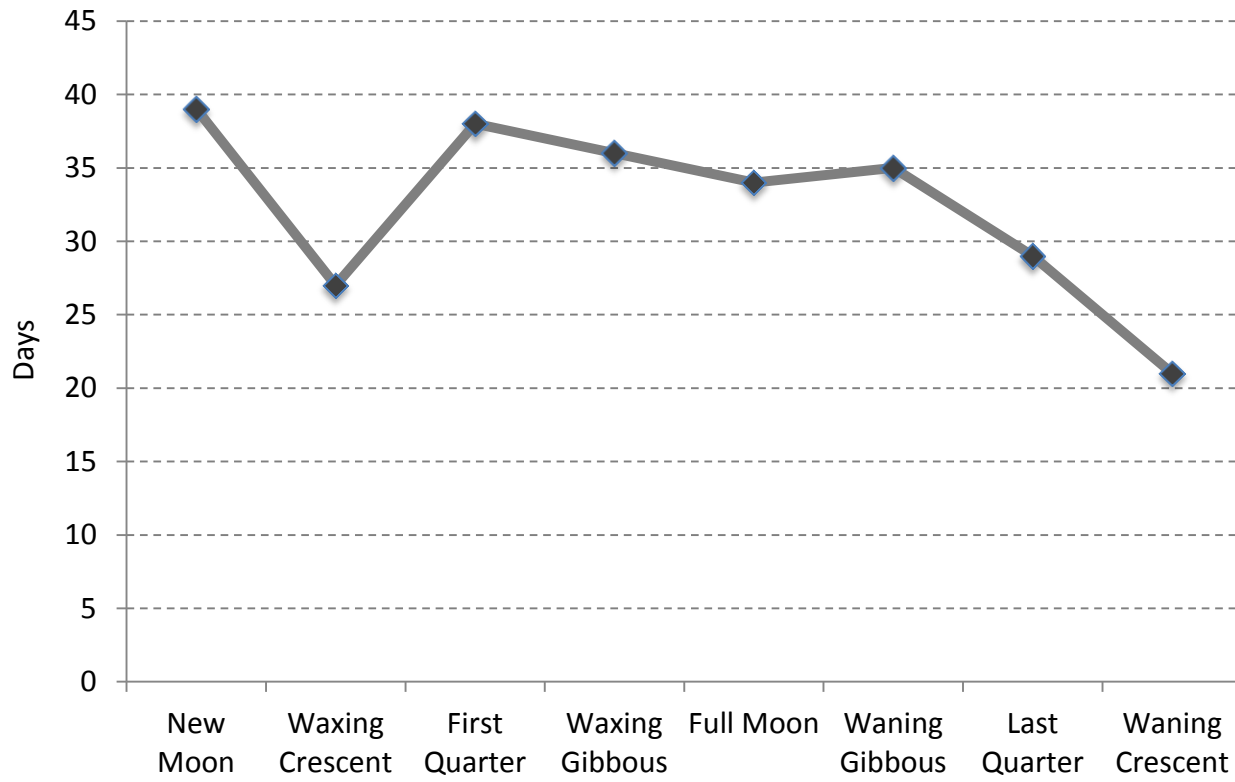
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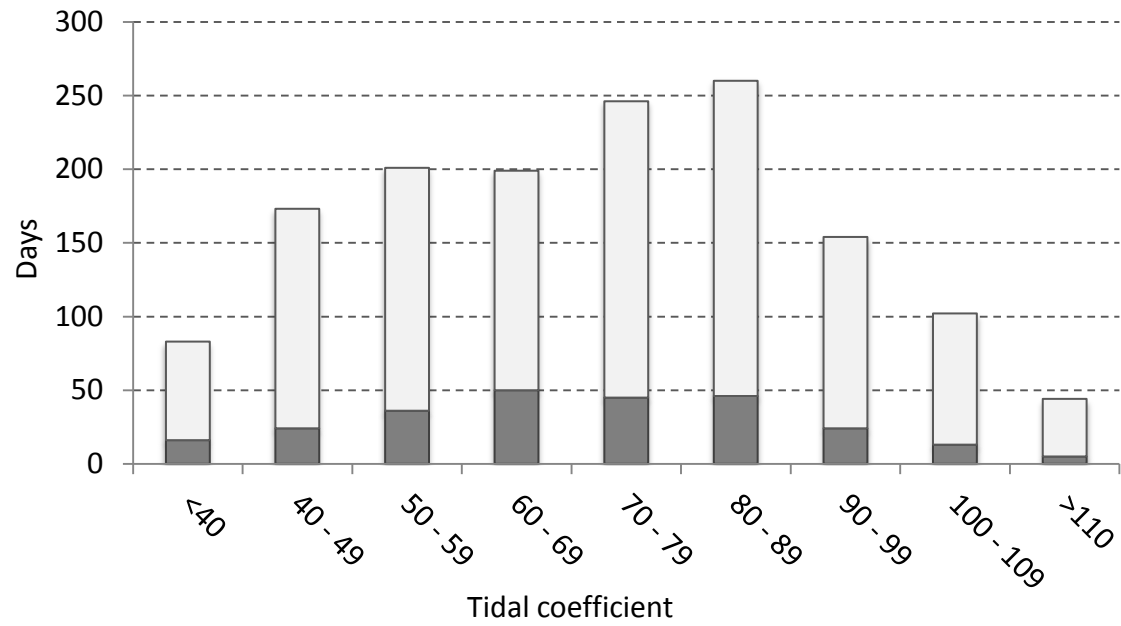
Figure 1: Comparison of incidence of subarachnoid hemorrhage on to a monthly scale ($p = 0.26$) between January 1st, 2011 and December 31st, 2012.

Figure 2: Effects of Moon phases ($p = 0.11$) on subarachnoid hemorrhage occurrence. SAH: subarachnoid hemorrhage.

Figure 3: Effects of tidal coefficients ($p = 0.12$) on subarachnoid hemorrhage occurrence. SAH: subarachnoid hemorrhage. Gray-filled bars: days with SAH; white bars: days without SAH







Characteristics	n = 295
Age (years)	53 ± 13
Sex ratio (Female/Male)	1.76 (188/107)
Hospital center	
Rennes	226 (77%)
Brest	69 (23%)
Cerebral aneurysm risks factors	
Hypertension	74 (25%)
Diabetes	6 (2%)
Familial SAH history	12 (4%)
Polycystic kidney disease	2 (1%)
Smoking	137 (46%)
Alcoholism	20 (7%)
SAPS II score	26 ± 15
Glasgow Coma Scale	13 ± 4
WFNS scale	2 ± 1
Fisher score	3 ± 1
Complications	
Intracranial Hypertension	33 (11%)
Hematoma	38 (13%)
Hydrocephalus	89 (30%)
Vasospasm	71 (24%)
Rebleeding	1 (0.3%)
Ischemia	15 (5%)
Infection	31 (11%)
Overall ICU Mortality	24 (8%)
Overall Hospital Mortality	24 (8%)
ICU stay (days)	7.7 ±8.2
Hospital stay (days)	22.7 ±24.9

Table 1: Patient characteristics. Data are expressed as n(%) or mean ±SD. ICU: Intensive Care Unit; SAPS II: Simplified Acute Physiology Score; SAH: Subarachnoid hemorrhage; WFNS: World Federation of Neurosurgical Societies

WFNS scale	SAH n = 295	Mortality n = 24[‡]
grade 1	163 (55%)	5 (3%)
grade 2	57 (19%)	4 (7%)
grade 3	23 (8%)	1 (4%)
grade 4	24 (8%)	6 (25%)
grade 5	28 (10%)	8 (28%)
Fisher classification		
grade 1	66 (22%)	2 (3.2%)
grade 2	47 (16%)	2 (4.5%)
grade 3	48 (16%)	2 (4.2%)
grade 4	134 (46%)	18 (13.5%)

Table 2: Subarachnoid hemorrhage (SAH) severity classification according to the World Federation of Neurosurgeons Society (WFNS) or Fisher scale, and corresponding in-hospital mortality according to grade. Data are expressed as *n* (%).

[‡] 2 missing patients for alive status.

Aneurysm characteristics	n = 295
Aneurysm location	
Anterior cerebral artery	100 (34%)
Middle cerebral artery	65 (22%)
Posterior cerebral artery	17 (6%)
Internal carotid artery	50 (17%)
Vertebro-basilar artery	25 (8%)
<i>Sine materia</i>	38 (13%)
Aneurysm size (mm)	
	5.8 ±3.2
Aneurysm treatment	
Coiling	226 (77%)
Surgical	23 (7%)
None	46 (16%)

Table 3: Aneurysm characteristics and type of treatment. Data are expressed as *n*(%) or mean± SD.

Climate variables	Days with SAH (n=259)	Days without SAH (n= 1203)	p-value
Temperature (°Celsius)			
Maximum	16 ±5.8	16.3 ±16.3	0.41
Minimum	7.7 ±4.7	8.3 ±4.7	<0.05*
Barometric pressure (hPa)			
Maximum	1,021.3 ±8.5	1,020.4 ±8.8	0.12
Minimum	1,015.8 ±9.8	1,014.7 ±10.1	0.10
Relative humidity (%)			
Maximum	95.4 ±4.4	95.8 ±4.0	0.26
Minimum	63.2 ±16.7	63.5 ±15.5	0.72
Wind speed (km.h⁻¹)			
Average	13.8 ±6.4	14.5 ±6.6	0.14
Maximum	41.2 ±15.4	40.0 ±14.4	0.22

Table 4: Effects of meteorological parameters on subarachnoid hemorrhage (SAH) occurrence. Data are expressed as mean ± SD.

Variations	Days with SAH (n=259)	Days without SAH (n= 1203)	p value
Temperature (°Celsius)			
D0max - D0min	8.3 ±4.3	8 ±4.0	0.20
D-1max - D0min	8.6 ±4.1	7.9 ±3.8	<0.05*
D0max - D-1min	8.1 ±4.7	8 ±4.3	0.84
Barometric pressure (hPa)			
D0max - D0min	5.5 ±3.6	5.7 ±3.8	0.31
D-1max - D0min	5.7 ±5.8	5.7 ±5.7	0.99
D0max - D-1min	5.5 ±5.8	5.7 ±6.2	0.75
Relative humidity (%)			
D0max - D0min	32.3 ±15.8	32.2 ±14.7	0.95
D-1max - D0min	32.3 ±16.5	32.3 ±15.5	0.99
D0max - D-1min	32.8 ±15.9	32.1 ±15.7	0.52

Table 5: Effects of meteorological variations on subarachnoid hemorrhage occurrence. D0max – D0min: variations of the climatic variable within a day; D-1max – D0min: drop in climatic variable between one day (D0) and the day before (D-1); D0max – D-1min: rise in climatic variable between one day (D0) and the day before (D-1). max: maximum; min: minimum; SAH: subarachnoid hemorrhage. Data are expressed as mean ±SD.

Climate variables	WFNS 1 (n=163)	WFNS 2 (n=57)	WFNS 3 (n=23)	WFNS 4 (n=24)	WFNS 5 (n=28)	p-value
Temperature (°Celsius)						
Maximum	15.7±5.8	15.8±5.6	15.1±6.4	15.4±4.8	13.5±5.7	0.74
Minimum	7.8±4.6	8.1±5.0	6.7±5.1	7.0±3.2	6.5±5.7	0.76
Variation	7.9±4.1	7.6±3.9	8.4±4.2	8.4±3.9	7.0±3.1	0.70
Barometric pressure (hPa)						
Maximum	1,016.4±10.9	1,015.9±9.6	1,014.0±8.8	1,015.0±9.7	1,014.4±9.8	0.43
Minimum	1,022.1±8.9	1,021.1±8.4	1,020.7±8.1	1,020.9±9.1	1,019.9±9.3	0.43
Variation	5.7±4.1	5.2±3.3	6.7±4.1	5.9±3.6	5.6±4.1	0.67
Relative humidity (%)						
Maximum	94.7±4.3	95.7±2.9	93.9±4.5	94.2±6.0	94.3±4.0	0.34
Minimum	63.0±16.1	65.7±16.2	62.3±15.1	60.4±16.7	64.5±13.4	0.67
Variation	31.7±15.2	30.0±15.8	31.6±14.6	33.8±14.6	29.7±13.3	0.83
Wind speed (km.h ⁻¹)						
Average	13.9±6.1	12.5±6.0	11.6±5.3	14.3±6.3	14.9±8.8	0.21
Maximum	40.1±15.0	36.0±14.1	34.1±11.2	40.4±15.2	44.1±20.3	0.07

Table 6: Effects of climatic variables and their variation on subarachnoid hemorrhage (SAH) severity score assessed by World Federation of Neurosurgical Societies (WFNS) score. Data are expressed as mean ± SD.