

Influence of Snowfalls as a Factor for Chronic Subdural Hematoma Recurrence: Regional Meteorological Analyses

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Abstract

Object: Chronic subdural hematoma (CSDH) is a disease that is observed frequently in neurosurgical practice. Although the weather has been considered to influence CSDH in Japan, there are no reports about the relationships between weather and CSDH.

Methods: We designed a single-center retrospective study. We categorized the year as Group I when snowfall occurred more than seven times from December to March of the next year, and as Group II when there was less snowfall. We retrospectively analyzed patients who were admitted to our institute with CSDH from 2011 to 2017. Possible variables related to CSDH were identified and analyzed according to the baseline characteristics.

Results: Significant differences were observed in recurrence (Group I, 31.7% vs. Group II, 13.0%; P-value = 0.02), the male sex (Group I, 84.1% vs. Group II, 63.0%; P-value = 0.01), smoking history (Group I, 3.2% vs. Group II, 13.0%; P-value 0.05), and alcohol consumption history (Group I, 20.6% vs. Group II, 7.4%; P-value = 0.04). Univariate analysis of association between CSDH recurrence and various variables showed significant differences were observed for snowfall (HR, 3.12; 95% confidence interval [CI], 1.20–8.12; P-value = 0.019). Multivariate analyses of the association between CSDH recurrence and variables after step down methods showed significant differences were observed for snowfall (hazard ratio [HR] 3.93; 95% CI 1.42–10.89; P-value = 0.008)

Conclusion: Snowfall events could be a novel predictive factor for CSDH recurrence.

Keywords: Chronic Subdural Hematoma; Incidence; Recurrence; Meteorological; Snowfall; Neurosurgery

Introduction

Chronic subdural hematoma (CSDH) is a disease observed frequently in neurosurgical practice; surgical burr-hole evacuation is the first-line treatment for symptomatic patients. The overall incidence is 8.2/100,000/years after 70 years of age [1] Risk factors are not limited to the age of the patient; they also include diabetes mellitus, liver disease, kidney disease, alcohol consumption, anticoagulant or antiplatelet agent use, and a previous history of craniotomy [2,3].

The weather has long been considered to influence CSDH in Japan; especially, snowfall could have strong relationships with CSDH. However, relationships between environmental risk factors, including the contributions of weather, and CSDH are not well characterized; there are no reports about relationships between snowfall and the characteristics of CSDH. In this report, we investigated relationships between snowfall events and various risk factors for CSDH. We used a single-center database to evaluate the effect of this meteorological event on CSDH in Tokyo, Japan.

Materials and Methods

Study setting

We designed a single-center retrospective study to test whether snowfall in Tokyo was associated with CSDH. Tokyo is located in the country of Japan on the continent of Asia. The latitude and longitude coordinates for Tokyo are 35°41'2.2"N, 139°41'30.16"E. We investigated the number of days of snowfall in Tokyo and the number of patients with CSDH in our hospital.

Meteorological analyses

The observational data for snowfall events in Tokyo were obtained from the Japan Meteorological Agency [4]. Snowfall events were defined as snow falling within a certain period. Snowfall events also included the precipitation of solids such as hail. We counted the numbers of days with snowfall events in each month. We defined the snowfall period from December to March in the next year because snowfall is rare during other months in Tokyo.

Patient data sources

The Nippon Medical School Hospital is located at Bunkyo-ku in the center of Tokyo. We retrospectively analyzed patients admitted to our institute with CSDH from 2011 to 2017. With respect to the snowfall periods, we included CSDH patients who were admitted from January to May in each year. Considering that there could be a time lag between the snowfall event and the onset of CSDH, we excluded cases in the first month of the snowfall period and included 2 months after the conclusion of the snowfall period. This lag covers the potentially delayed effects of snowfall and delayed presentations. CSDH was diagnosed radiographically and burr-hole drainage was performed within 24 hours of admission. Preoperative vital signs and laboratory examination results were recorded within 24 hours of admission. Hypertension, diabetes, and hypercholesterolemia were defined as the previous use of an antihypertensive, antidiabetic, or antihyperlipidemic

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medication, medical records indicating a history of hypertension, diabetes, or dyslipidemia, or a self-reported history by the patient or their guardian. These methods were used to determine other prior medical histories. Moreover, the recurrence of CSDH was defined as the recurrence of a hematoma based on computed tomography (CT) findings that required medical intervention within 6 months after the first burr-hole drainage.

Informed consent

The institutional review board of our hospital approved the study protocol and waived the requirement for informed consent because of the study's retrospective nature.

The relationship between snowfall and the incidence of CSDH

We could not assess the relationship between the incidence of CSDH and snowfall completely because not all patients with CSDH in Tokyo were admitted to our hospital. Therefore, we decided to assess statistical relationships between snowfall and various risk factors for CSDH; we divided patients with CSDH into two groups according to the extent of the snowfall.

Definitions of patient groups

All patients were divided into two groups: those who were admitted when snowfall events occurred more than seven times in a snowfall period (defined as Group I) and those admitted when snowfall events occurred less frequently (defined as Group II).

Statistical analyses

We compared differences between the two groups using Student's t test and the chi-squared test. Possible CSDH factors were analyzed according to the baseline characteristics. Next, we conduct univariate analyses of the association between CSDH recurrence and various variables followed by multivariate analyses of the association between CSDH recurrence and variables after step down methods. For statistical comparison tests, significance was defined as a P-value < 0.05 with no adjustments for multiple comparisons. All statistical analyses were conducted using SPSS version 23.0 (Japanese version; SPSS Japan Inc., Tokyo, Japan).

Results

Patient characteristics

A total of 117 patients who underwent a surgical evacuation procedure for CSDH during the study period were identified.

Meteorological analyses

The monthly distributions of snowfall events during each snowfall period are shown in (Table 1). From the Japan Meteorological Agency data, the 2010/2011, 2011/2012, and 2013/2014 snowfall periods were assigned to Group I, and the 2012/2013, 2015/2016, and 2016/2017 snowfall periods were assigned to Group II.

Baseline characteristics

The baseline characteristics of the study patients are shown in (Table 2). In the baseline comparison between the two groups (Group I vs. Group II), significant differences were observed for recurrence (Group I, 31.7% vs. Group II, 13.0%; P-value = 0.02), the male sex (Group I, 84.1% vs. Group II, 63.0%; P-value = 0.01), smoking history (Group

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I, 3.2% vs. Group II, 13.0%; P-value = 0.05), and alcohol consumption history (Group I, 20.6% vs. Group II, 7.4%; P-value = 0.04).

Univariate statistical analyses

Next, we conduct univariate analyses of the association between CSDH recurrence and various variables (Table 3). Significant differences were observed for snowfall (HR, 3.12; 95% confidence interval [CI], 1.20-8.12; P-value = 0.019)

Multivariate statistical analyses

Finally, we conduct multivariate analyses of the association between CSDH recurrence and variables after step down methods (Table 4). Significant differences were observed for snowfall (hazard ratio [HR] 3.93; 95% CI 1.42–10.89; P-value = 0.008), and diabetes mellitus (HR, 3.03; 95% CI, 1.06–8.67; P-value = 0.04).

Discussion

Significant differences

Our analyses of patients with CSDH and snowfall in Tokyo revealed that the number of days of snowfall was associated with an increased likelihood of several factors associated with CSDH: recurrence, the male sex, smoking history, and alcohol consumption history. Regarding these variables, we focused on recurrence for further evaluation.

The relationship between snowfall and CSDH recurrence

We conducted univariate analyses on CSDH recurrence. From the baseline characteristics, variables considered in the statistical analyses of factors associated with the recurrence of CSDH included snowfall, sex, diabetes status, kidney disease status, smoking history, alcohol consumption history, previous craniotomy, anticoagulant use, antiplatelet use, and bilateral hematomas. We excluded steroid therapy because of the very small number of cases (n = 2). Univariate and multivariate analyses showed significant differences between snowfall and CSDH recurrence. This revealed that the number of days of snowfall was related to CSDH recurrence. Snowfall extent could be a novel risk factor for CSDH recurrence.

CSDH recurrence

Some reports stated that the rate of recurrence after a CSDH operation ranged from approximately 5% to 33% [5,6]. Numerous studies have reported various potential risk factors for CSDH recurrence [7-12]. Moreover, preoperative CT findings were significantly related to CSDH recurrence [13-17].

The mechanisms of CSDH and CSDH recurrence

Several papers reported the mechanism of CSDH. Yamashita et al. proposed a mechanism in which veins rupture and venous blood pools into the subdural space when the veins that bridge the subdural

	December	January	February	March	Total (days)
2010/2011	1	4	7	1	13
2011/2012	0	4	5	1	10
2012/2013	0	2	3	0	5
2013/2014	1	3	6	1	11
2014/2015	2	4	3	1	10
2015/2016	0	2	3	1	6
2016/2017	0	2	4	0	6

 Table 1: Monthly distributions of days with snowfall during each winter season.

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Variable	Group I	Group II	Total	P value
Total number (%)	63 (53.8)	54 (46.2)	117 (100)	
Sex, male, number (%)	53 (84.1)	34 (63.0)	87 (74.4)	0.01*
Age (y; mean ± SD)	72.9 ± 10.9	76.6 ± 12.1	74.6 ± 11.6	0.09
Recurrence	20 (31.7)	7 (13.0)	27 (23.1)	0.02*
	Medical history, numb	ber (%)		
Hypertension	24 (38.1)	23 (42.6)	47 (40.2)	0.62
Hypercholesterolemia	10 (15.9)	11 (20.4)	21 (17.9)	0.53
Diabetes mellitus	10 (15.9)	16 (29.6)	26 (22.2)	0.08
Liver disease	2 (3.2)	5 (9.3)	7 (6.0)	0.17
Kidney disease	4 (6.3)	4 (7.4)	8 (6.8)	0.82
Heart disease	12 (19.0)	10 (18.5)	22 (18.8)	0.94
Cerebrovascular disease	6 (9.5)	3 (5.6)	9 (7.7)	0.43
	Prior history, numbe	er (%)		
Smoking	2 (3.2)	7 (13.0)	9 (7.7)	0.05*
Alcohol	13 (20.6)	4 (7.4)	17 (14.5)	0.04*
Trauma	31 (49.2)	29 (53.7)	60 (51.3)	0.63
Previous craniotomy	9 (14.3)	3 (5.6)	12 (10.3)	0.12
	Prior medication, num	ber (%)		
Anticoagulant	7 (11.1)	3 (5.6)	10 (8.5)	0.29
Antiplatelet agent	10 (15.9)	3 (5.6)	13 (11.1)	0.08
Steroid	1 (1.6)	1 (1.9)	2 (1.7)	0.91
	Modified Rankin Scale, n	nean ± SD		
Admission score	2.71 ± 0.68	2.87 ± 0.58	2.79 ± 0.64	0.19
Discharge score	1.98 ± 0.79	1.98 ± 0.69	1.98 ± 0.74	0.99
	Radiologic finding, nun	nber (%)		
Hematoma density on CT				
low-density hematomas	9 (14.3)	13 (24.1)	22 (18.8)	0.18
iso-density hematomas	35 (55.6)	26 (48.1)	61 (52.1)	0.43
high-density hematomas	5 (7.9)	5 (9.3)	10 (8.5)	0.8
mixed-density hematomas	14 (22.2)	10 (18.5)	24 (20.5)	0.62
Hematoma location on CT				
unilateral hematomas	40 (63.5)	37 (68.5)	77 (65.8)	0.43
bilateral hematomas	23 (36.5)	17 (31.5)	40 (34.2)	0.57
Hematoma layer on CT				
single-layer hematomas	47 (74.6)	42 (77.8)	89 (76.1)	0.69
double-layer hematomas	10 (15.9)	7 (13.0)	17 (14.5)	0.66
multiple-layer hematomas	6 (9.5)	5 (9.3)	11 (9.4)	0.75
	Preoperative laboratory data	a, mean ± SD		
Hemoglobin (g/dL)	12.9 ± 1.89	12.7 ± 1.74	12.8 ± 1.82	0.52
White blood cells (/µL)	6,867 ± 1,812	6,717 ± 1,941	6,797 ± 1,866	0.68
CRP (mg/L)	0.70 ± 1.52	0.48 ± 0.76	0.60 ± 1.23	0.34
Platelets (10×3/µL)	22.0 ± 6.35	21.6 ± 6.48	21.8 ± 6.38	0.72
Creatinine (mg/dL)	0.91 ± 0.59	0.97 ± 0.60	0.94 ± 0.60	0.56
CT: computed tomography; CRP: C-reactive protein; C	SDH: chronic subdural hematoma; SE): standard deviation		

Table 2: Summary of the baseline characteristics of Group I (frequent snowfall period) and Group II (less frequent snowfall period) in 117 patients with CSDH (*P < 0.05).

space are stretched excessively [18]. Then, the blood is encapsulated by a membrane of neovascularization on the inner surface of the dura mater. This membrane is fragile and causes an inflammatory reaction with a chemical mediator in the subdural fluid collection, which leads to frequent microbleeds [1]. Eventually, this reaction causes the encapsulation of the non-clotted hematoma [19]. CSDH recurrence is related to this process, ruptured veins, and the inflammatory reaction.

Influence of snowfall events on CSDH recurrence

Some factors possibly influence CSDH recurrence during snowfall events. First, one possible factor is falling accidents. From data on falling accidents in Japan based on fire department and ambulance statistics, more falls occurred from December to February during snowfall periods than in other seasons. Moreover, there were also more falls in December than in any other month [20]. Thus, falling accidents could be a potential etiology of CSDH recurrence due to the increase in head trauma. Other reports found that mechanisms underlying changes in snowfall affected several factors such as blood pressure, platelet count or viscosity, cholesterol, heart rate, plasma fibrinogen, and peripheral vasoconstriction, which could affect the inflammatory reaction [21-24]. Considering all these findings, possible mechanisms of increased CSDH recurrence risk from snowfall are as follows.

1) Snowfall could change the homeostasis of the human body through changes in blood pressure, platelet count or viscosity, cholesterol, heart rate, plasma fibrinogen, and peripheral vasoconstriction, which will affect the inflammatory reaction that is a predictive factor for CSDH recurrence.

2) Falling accidents increase the potential for head trauma, which

Variate	HR (95% CI)	P value
Snowfall	3.12 (1.20-8.12)	0.019*
Sex, Male	1.27 (0.46-3.53)	0.643
Diabetes Mellitus	2.15 (0.82-5.60)	0.118
Kidney disease	0.46 (0.54-3.88)	0.472
Smoking	0.95 (0.19-4.86)	0.949
Alcohol	1.48 (0.47-4.65)	0.504
Previous craniotomy	2.70 (0.78-9.31)	0.117
Anticoagulation	1.48 (0.36-6.17)	0.589
Antiplatelet agent	1.57 (0.44-5.55)	0.488
Bilateral hematomas	0.76 (0.30-1.94)	0.57
CI: confidence interval; HR: haza	ard ratio	

Table 3: Multivariate analyses of associations between snowfall and another variables (*P < 0.05).

Variate	HR (95% CI)	P value
Snowfall	3.93 (1.42-10.89)	0.008*
Diabetes Mellitus	3.03 (1.06-8.67)	0.04*

 Table 4: Multivariate analyses of the association between CSDH recurrence and variables after step down methods.

results in an increase in CSDH recurrence.

Limitations

There are some limitations to this study. First, our sample size was 117 patients, which was comparatively less than those in previous studies. The sample size and use of a logistic regression model to perform a multivariate statistical analyses of factors related to the recurrence of CSDH are relative weaknesses of the current study. Second, the generalizability of the findings to areas with different levels of snowfall remains to be investigated. Moreover, we could not completely assess the relationship between the incidence of CSDH and snowfall because not all patients with CSDH in Tokyo were admitted to our hospital. Finally, the relationships with other meteorological factors such as ambient temperature, atmospheric pressure, and day length remain unclear.

Conclusions

Snowfall events could be a novel predictive factor for the recurrence of CSDH. We expect this finding to be helpful in predicting CSDH recurrence in patients who undergo surgical treatment for CSDH during snowfall periods. In addition, further multicenter, multiregional studies are required to evaluate this topic.

Disclosures

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