



Risk Factors Predicting Recurrence of Bilateral Chronic Subdural Hematomas after Initial Bilateral Evacuation

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BACKGROUND: Most patients with bilateral chronic subdural hematomas (bCSDH) undergo initial bilateral evacuation. Risk factors associated with the recurrence of bCSDH after initial bilateral evacuation have not been published to date. In this study, we aimed to identify risk factors related to recurrence of bCSDH after initial bilateral evacuation, and to develop a prognostic grading system for clinical reference.

METHODS: This study included 102 patients with bCSDH who underwent initial bilateral evacuation. Predictors of recurrence were identified via univariate analysis and multivariate logistic regression analysis. A prognostic grading system was created based on the independent predictors combined with a cutoff value. All cases were scored according to the prognostic grading system, and the recurrence rates of the different scores were reanalyzed.

RESULTS: Anticoagulant use (odds ratio [OR], 84.266; 95% confidence interval [CI], 13.113–541.522; $P < 0.001$), severe brain atrophy (OR, 11.551; 95% CI, 2.558–52.163; $P = 0.001$), and postoperative pneumocephalus volume (PostPV) (OR, 0.978; 95% CI, 0.957–1.000; $P = 0.049$) were independent risk factors for the recurrence of bCSDH after initial bilateral evacuation. The cutoff value of PostPV was $>20.9484 \text{ cm}^3$. A prognostic grading system was then developed, and the recurrence rates based on score were determined. Rates were 2.8% for a score of 0–1, 28.1% for a score of 2–3, and 100% for a score of 4–5, showing a

significant increase in risk with increasing score ($P < 0.001$).

CONCLUSIONS: Anticoagulant use, severe brain atrophy, and PostPV were identified as independent risk factors for recurrence of bCSDH after initial bilateral evacuation. The prognostic grading system for recurrence of bCSDH after initial bilateral evacuation is reliable and applicable for clinical reference.

INTRODUCTION

Chronic subdural hematoma (CSDH) is a frequently encountered posttraumatic disorder. Especially prevalent among the elderly, CSDH affects 8.2–17.6 per 100,000 individuals annually and the incidence increases with population ages.^{1–3} Patients with CSDH are usually considered for surgical evacuation. Between 3% and 33% of patients experience rebleeding after the initial operation.²

Numerous risk factors have been shown to contribute to the recurrence of CSDH after surgical treatment, including age,⁴ anticoagulant or antiplatelet use,^{5,6} midline shift,^{5,7} preoperative hematoma size,^{5,7,8} postoperative pneumocephalus,⁹ postoperative hematoma residual,^{4,7,8} cranial computed tomography (CCT) density,^{8,10} and bilateral hematomas.^{6,11,12} The decision to evacuate on a single side or both sides of bilateral chronic subdural hematoma (bCSDH) is generally based on hematoma size, mass effect, and lateralized clinical symptoms.^{13,14} Most

Key words

- Brain atrophy
- Chronic subdural hematoma
- Grading system
- Recurrence rate

Abbreviations and Acronyms

bCSDH: Bilateral chronic subdural hematoma

CCT: Cranial computed tomography

CI: Confidence interval

CSDH: Chronic subdural hematoma

HCR: Hematoma clearance rate

INR: International normalized ratio

OR: Odds ratio

PostHV: Postoperative hematoma volume

PostPV: Postoperative pneumocephalus volume

PreHV: Preoperative hematoma volume

PT: Prothrombin time

ROC: Receiver operating characteristic

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patients with bCSDHs undergo initial bilateral evacuation; however, the risk factors associated with recurrence of bCSDH after initial bilateral evacuation have not been published to date.

We therefore focused this retrospective analysis on identifying risk factors related to recurrence of bCSDH after initial bilateral evacuation, and on developing a grading system based on the independent risk factors, which can be applied as a clinical reference.

MATERIALS AND METHODS

Patients and Clinical Parameters

This retrospective study included 102 consecutive patients with bCSDH who were admitted to Yijishan Hospital, Anhui Province, China, between November 2012 and October 2018. All patients underwent initial bilateral evacuation under general or local anesthesia. Subdural hematoma on each side was defined as a single case. All patients with bCSDH were diagnosed using CCT. Patients age <18 years, those with bCSDH caused by vascular disorder, and those who had undergone other intracranial surgery within 6 months before the diagnosis of bCSDH were excluded. The following clinical characteristics were analyzed: age, sex, Glasgow Coma Scale score at admission, Glasgow Outcome Scale score at discharge, antiplatelet use, anticoagulant use, and history of trauma.

CCT Imaging Analysis

CCT scans were routinely performed before and within 3 days after surgery in all patients. Radiologic parameters measured included hematoma density, brain atrophy, preoperative hematoma volume (PreHV), postoperative pneumocephalus volume (PostPV), postoperative hematoma volume (PostHV), and hematoma clearance rate (HCR). Brain atrophy was classified as severe atrophy, moderate atrophy, and no or mild atrophy, as described previously.⁵ Hematomas were categorized into 5 types based on their CCT findings: 1) homogeneous (homogeneous isodense, homogeneous hyperdense, and homogeneous hypodense), 2) laminar, 3) separated or gradation, 4) trabecular,¹⁰ and 5) mixed type. Hematomas containing irregular combination of 2 or more of types 1-4 were defined as type 5, mixed type (Figure 1). PreHV, PostPV, and PostHV were calculated as described previously,¹⁵ as: $\text{volume} = \sum [\text{Area of each layer} \times \text{Layer thickness}]$. Image J software was used to measure the area. HCR was calculated as $(\text{PreHV} - \text{PostHV})/\text{PreHV}$. All radiologic parameters were measured by 2 neurosurgeons and 1 neuroradiologist, who were blinded to the study details.

Surgical Procedures

Prothrombin time (PT) and international normalized ratio (INR) were measured in all patients before surgery, vitamin K was administered intravenously, and the PT and INR were reexamined if the PT/INR was >1.5. Vitamin K was readministered if the PT/INR was still >1.5 in the reexamination. After anesthesia, every hematoma received a single burr hole craniotomy (without bone flap craniotomy) at the thickest layer. The hematoma cavity was rinsed with warm saline using a silicone catheter, which was reserved in the hematoma cavity and connected a closed drainage

system, the closed drainage system was hung at the head level of the patient and withdrawn within 72 hours.

Follow-Up and Definition of Recurrence

The duration of follow-up exceeded 3 months in all patients. During the follow-up period, deterioration in neurologic status or appearance of new neurologic symptoms prompted an urgent a CCT scan. We defined "CSDH recurrence" as an increased hematoma volume detected on follow-up CCT scans that necessitated additional surgery.

Statistical Analysis

Continuous variables were presented as mean \pm standard deviation (SD) and compared using Fisher's exact test or the χ^2 test. Categorical variables were described as numbers of patients (percentages) and assessed by using the Student t test. Variables with a P value <0.05 were recruited into a multivariate logistic regression model. A predictive receiver operating characteristic (ROC) curve was produced based on the independent risk factors obtained from the multivariate logistic regression model. The cutoff value (for continuous variables), 95% confidence interval (CI), and area under the ROC curve were all analyzed. A prognostic grading system was created based on the independent risk factors combined with the cutoff value. All cases were scored according to the grading system, and the recurrence rates of different scores were reanalyzed. All statistical analyses were performed using SPSS version 22.0 (IBM, Armonk, New York, USA). A P value <0.05 was considered to indicate statistical significance. MedCalc version 14.8 (MedCalc Software, Ostend, Belgium) was used to analyze the ROC curves.

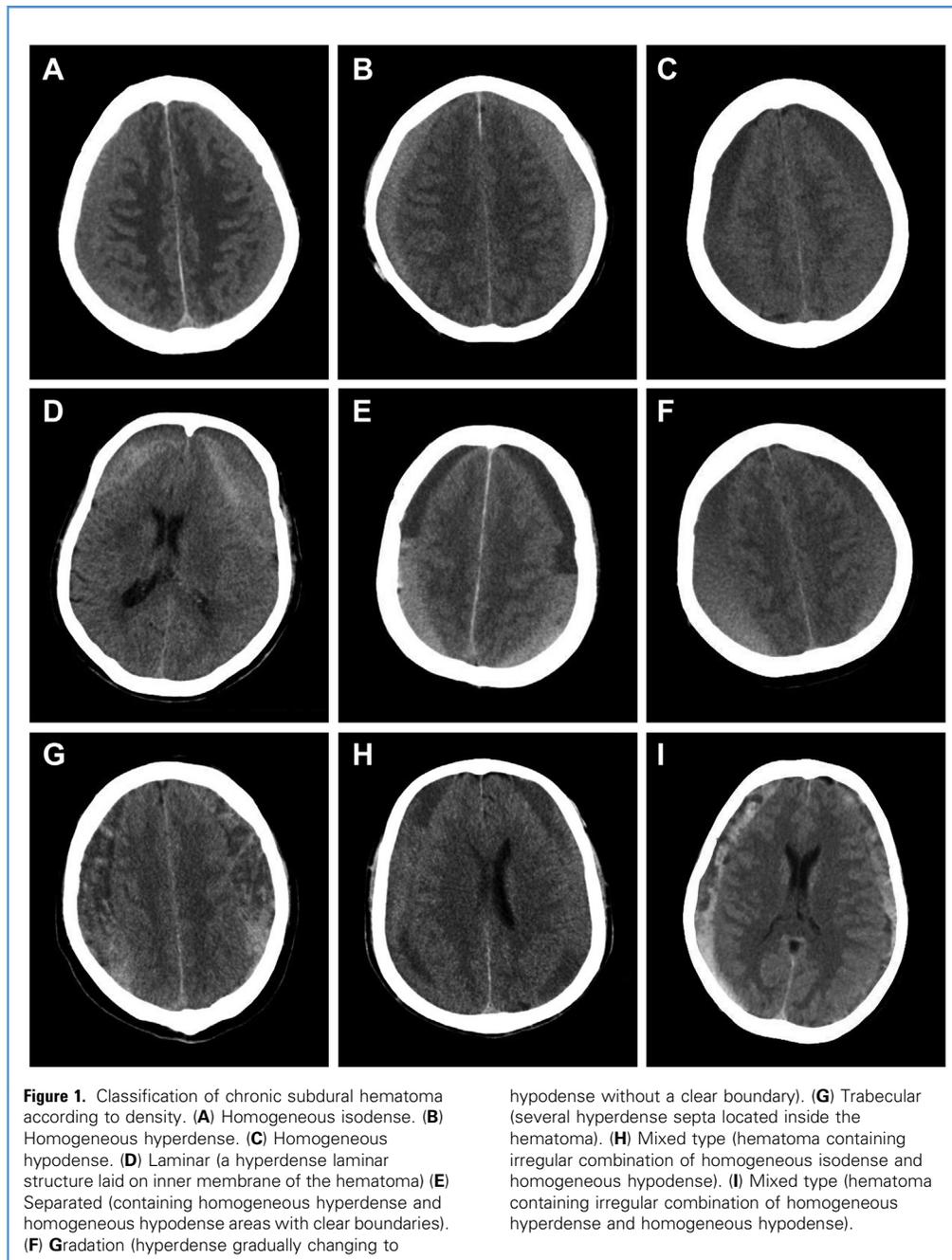
RESULTS

Baseline Patient Characteristics

The study cohort comprised 23 women (22.55%) and 79 men (77.45%), ranging in age 40 to 90 years (mean age, 70.76 years). Head trauma was observed in 49 patients (48.04%); the average interval between the initial operation and trauma was 53.8 days. Six patients had received preoperative antiplatelet therapy, and 5 patients had received preoperative anticoagulant therapy. Headache was observed in 45 patients, motor weakness in 54 patients, hemiplegia in 19 patients, and altered consciousness in 10 patients. No patient died during the study period. Recurrence was unilateral in 14 patients and bilateral in 5 patients. The overall recurrence rate was 18.63%. To further explore the effect of radiologic parameters on the recurrence of bCSDH after initial bilateral evacuation, subdural hematoma on each side was considered as a single case, with a recurrence rate of 11.76% (Table 1).

Univariate Analysis

Table 2 presents the results of univariate analysis of factors related to recurrence of bCSDH after initial bilateral evacuation. Age, sex, history of trauma, Glasgow Coma Scale score at admission, Glasgow Outcome Scale score at discharge, antiplatelet use, and HCR were not associated with CSDH recurrence. The recurrence rate of different types of hematoma density were not applicable for statistical analysis owing to our small sample size. We then



divided the CSDH into homogeneous density and other types. The recurrence rate was not statistically significant different between the 2 groups ($P = 0.369$). Patients with anticoagulant use have a significant higher recurrence rate ($P < 0.001$). Brain atrophy was significantly associated with CSDH recurrence ($P = 0.005$). PreHV, PostHV, and PostPV were significantly greater in the recurrence group compared with the no recurrence group ($P = 0.025, 0.022, \text{ and } 0.03$, respectively).

Multivariate Logistic Regression Analysis

In the multivariate logistic regression model, anticoagulant use (OR, 84.266; 95% CI, 13.113–541.522; $P < 0.001$), severe brain atrophy (OR, 11.551; 95% CI, 2.558–52.163; $P = 0.001$), and PostPV (OR, 0.978; 95% CI, 0.957–1.000; $P = 0.049$) were identified as independent risk factors for the CSDH recurrence. No other factors were significantly associated with the CSDH recurrence (Table 3).

Table 1. Bilateral Chronic Subdural Hematoma Recurrence Rate in Patients and Cases after Initial Bilateral Evacuation

	Unilateral Total	Bilateral Recurrence	No Recurrence	Recurrence Rate (%)	
Patients, n	102	14	5	83	18.63
Cases, n	204	24	180	11.76	

ROC Model of the Independent Risk Factors

The independent risk factors obtained from the multivariate logistic regression analysis were then entered into a ROC model (Figure 2). The area under the curve, standard error, and 95% CI of the independent risk factors were presented in Table 4. The PostPV cutoff value was $>20.9484 \text{ cm}^3$, meaning that PostPV $>20.9484 \text{ cm}^3$ is associated with a higher recurrence rate.

Prognostic Grading System

We have developed a grading system on the basis of the independent risk factors and cutoff value of PostPV to predict the recurrence of CSDH. This grading system has 3 components: PostPV, severe brain atrophy, and anticoagulant use. The scoring is based on the strength of the OR values. To make more simple, practical and easier for clinical reference, the PostPV cutoff value was set at 20 cm^3 , meaning that PostPV $>20 \text{ cm}^3$ was assigned 1 point, and severe brain atrophy and anticoagulant use were each assigned 2 points. The total score ranges from 0 to 5 (Table 5). All patients in this study were scored according to this grading system. Rates were 2.8% for a score of 0–1, 28.1% for a score of 2–3, and 100% for a score of 4–5, showing a significant increase in risk with increasing score ($P < 0.001$) (Table 6).

DISCUSSION

For bCSDH, there are no uniform indications for unilateral evacuation or bilateral evacuation. The decision for initial surgical evacuation on 1 side or both sides was generally based on the hematoma volume, lateralized clinical symptoms, and radiologic clues such as brain shift, subfalcial herniation, compressed ventricles, and compressed gyri and sulci. In previous study, we identified the volumes of the contralateral hematoma both before and after surgery as risk factors for contralateral hematoma enlargement after unilateral bCSDH evacuation.¹⁵ However, to the best of our knowledge, the risk factors for recurrence of bCSDHs after initial bilateral evacuation have not been reported until now. In the present study, we have identified anticoagulant use, severe brain atrophy, and PostPV as independent risk factors for recurrence of bCSDH after initial bilateral evacuation.

bCSDH accounts for 22% of all cases of CSDH,³ and bilaterality has been identified as an independent risk factor for CSDH recurrence. The recurrence rate of unilateral CSDH is significantly lower than that associated with bCSDH.^{6,11,12} One explanation for this may be the greater brain reexpansion rate in unilateral CSDH compared with bCSDH.¹⁶ Another possible factor is the existence of statistical bias. Previous studies did not describe operative and postoperative details for bCSDH, such as unilateral

Table 2. Univariate Analysis of Factors Related to Recurrence of Bilateral Chronic Subdural Hematoma after Initial Bilateral Evacuation

Factor	Recurrence	No Recurrence	P Value
Age (years), mean \pm SD	75.18 \pm 9.41	72.04 \pm 10.27	0.125
Sex, n (%)			0.83
Male	19 (12.03)	139 (87.97)	
Female	5 (10.87)	41 (89.13)	
History of trauma, n (%)			0.283
Yes	14 (14.29)	84 (85.71)	
No	10 (9.43)	96 (90.57)	
GCS score at admission, mean \pm SD	14.5 \pm 1.02	14.78 \pm 0.71	0.208
GOS score at discharge, mean \pm SD	4.71 \pm 0.55	4.79 \pm 0.47	0.409
Antiplatelet use, n (%)			
Yes	2 (16.67)	10 (83.33)	0.636
No	22 (11.46)	170 (88.54)	
Anticoagulant use, n (%)			<0.001
Yes	8 (80.00)	2 (20.00)	
No	16 (8.25)	178 (91.75)	
Brain atrophy, n (%)			0.005
No or mild	4 (9.52)	38 (90.48)	
Moderate	4 (4.65)	82 (95.35)	
Severe	16 (21.05)	60 (78.95)	
Hematoma density, n (%)			NA
Homogeneous	11 (9.91)	100 (90.09)	
Hypodense	9 (27.27)	24 (72.73)	
Isodense	2 (4.55)	42 (95.45)	
Hyperdense	0 (0.00)	34 (100.00)	
Laminar	2 (14.29)	12 (85.71)	
Separated	6 (18.75)	26 (81.25)	
Trabecular	3 (12.00)	22 (88.00)	
Mixed	2 (9.09)	20 (90.91)	
PreHV (cm^3), mean \pm SD	108.38 \pm 33.82	87.33 \pm 44.01	0.025
PostHV (cm^3), mean \pm SD	54.79 \pm 22.37	41.01 \pm 28.14	0.022
PostPV (cm^3), mean \pm SD	40.23 \pm 46.62	17.97 \pm 20.97	0.03
HCR, %, mean \pm SD	47.48 \pm 20.25	51.12 \pm 24.49	0.522

Significant P values are in bold type.

GCS, Glasgow Coma Scale; GOS, Glasgow Outcome Scale; HCR, hematoma clearance rate; NA, Not applicable; PostHCV, postoperative hematoma cavity volume; PostHV, postoperative hematoma volume; PostPV, postoperative pneumocephalus volume; PreHV, preoperative hematoma volume.

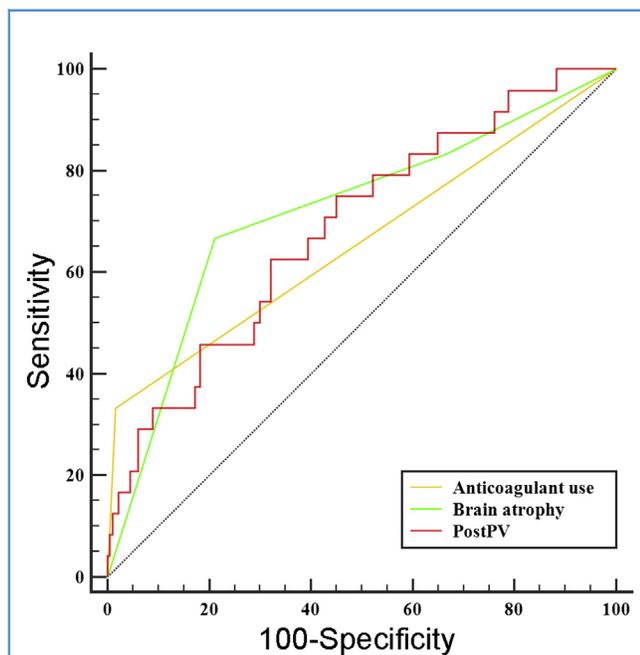
Table 3. Multivariate Logistic Regression Analysis of Risk Factors Related to Recurrence of Bilateral Chronic Subdural Hematoma after Initial Bilateral Evacuation

Factor	Adjusted OR	95% CI	P Value
Anticoagulant use	84.266	13.113–541.522	<0.001
Severe brain atrophy	11.551	2.558–52.163	0.001
PreHV	0.999	0.983–1.104	0.859
PostHV	1.002	0.981–1.023	0.879
PostPV	0.978	0.957–1.000	0.049

CI, Confidence interval; OR, Odds ratio; PostHV, postoperative hematoma volume; PostPV, postoperative pneumocephalus volume; PreHV, preoperative hematoma volume.

or bilateral evacuation.^{6,11,12} There are some special situation: if unilateral evacuation of bCSDHs, the contralateral hematoma may enlarge after operation; if bilateral evacuation, the total number of hematomas is twice than that of a unilateral CSDH. Therefore, the direct comparison of recurrence rate between the unilateral CSDH and bCSDHs is inappropriate. In the present study, the recurrence rate was 18.63% in patients with bCSDH, but when we transferred each hematoma to a single case, the recurrence rate dropped to 11.76% (Table 1).

CSDH is prevalent among the elderly, who often have disorders requiring antiplatelet and/or antithrombotic treatment.¹⁷ Whether the use of antiplatelet and/or anticoagulant drugs increases the recurrence rate of CSDH is controversial, however. Our present

**Figure 2.** Receiver operating characteristic model of the independent risk factors obtained from the multivariate logistic regression analysis (PostPV, postoperative pneumocephalus volume).**Table 4.** Receiver Operating Characteristic Model of Independent Risk Factors

Variable	AUC	SE	95% CI	Cutoff Value
Anticoagulant use	0.658	0.0494	0.589–0.723	NA
Brain atrophy	0.718	0.0594	0.650–0.778	NA
PostPV	0.686	0.0587	0.617–0.749	>20.9484 cm ³

AUC, area under the curve; CI, confidence interval; NA, Not applicable; PostPV, postoperative pneumocephalus volume; SE, standard error.

results show that antiplatelet therapy did not increase the recurrence rate of bCSDH after initial bilateral evacuation, whereas anticoagulant therapy was associated with a significantly increased recurrence rate. This result is very similar to the findings of a recent systematic review of 7 studies that reanalyzed the recurrence rate of CSDH with antiplatelet and/or antithrombotic use and concluded that anticoagulant therapy increased the rebleeding risk in patients with CSDH, but antiplatelet therapy did not.¹⁸ A multicenter retrospective study including 719 patients with CSDH demonstrated that antiplatelet agents significantly increased the recurrence rate of CSDH,¹⁹ but in other studies, neither antiplatelets nor antithrombotics was associated with rebleeding in CSDH.^{11,12}

Another important issue meriting special attention is the time of resumption of antiplatelet and/or anticoagulant drugs after evacuation. Since antiplatelet drugs do not increase the risk of CSDH recurrence, they can be administered routinely after operation. Resumption of anticoagulant drugs at 3 days after surgery may be safe according to a retrospective cohort study.¹⁷ In a recent study, Fujitani et al.¹⁴ found that antiplatelet and anticoagulant treatment were not risk factors for contralateral hematoma enlargement after unilateral evacuation of bCSDH and suggested not discontinuing antiplatelet and/or anticoagulant treatment

Table 5. Prognostic Grading System for Recurrence of Bilateral Chronic Subdural Hematoma after Initial Bilateral Evacuation

Component	Points
PostPV	
>20 cm ³	1
≤20 cm ³	0
Severe brain atrophy	
Yes	2
No	0
Anticoagulant use	
Yes	2
No	0
Total possible score	5

PostPV, postoperative pneumocephalus volume.

Table 6. Recurrence Rate by Prognostic Grading System Score

Score	Recurrence (n)	No Recurrence (n)	Recurrence rate, %	P Value
0–1	4	139	2.80	<0.001
2–3	16	41	28.10	
4–5	4	0	100.00	

postoperatively to avoid cerebrovascular events. However, because anticoagulant drug use is associated with increased risk of recurrence of hematoma on the surgical side, this suggestion should not be recommended.

In the present study, both severe brain atrophy and PostPV were identified as independent risk factors for recurrence of bCSDH after initial bilateral evacuation. Patients with bCSDH tend to have serious brain atrophy, which may lead to postoperative pneumocephalus and cerebrospinal fluid accumulation in the hematoma cavity, both of which restrict brain reexpansion after the surgery and can lead to hematoma recurrence.^{6,16}

PreHV and PostHV have been identified as independent risk factors for CSDH recurrence in previous studies,^{4,5,7,8} and to a significantly greater degree in the recurrence group compared with the no recurrence group in the present study, but not as independent risk factors for recurrence of bCSDH after initial bilateral evacuation. We speculate that this difference may be related to the fact that the previous studies were only general investigations of risk factors for CSDH recurrence. In our series of studies, we divided CSDH into unilateral CSDH, bCSDH that underwent unilateral evacuation, and bCSDH that underwent bilateral evacuation. This classification of CSDH to study the risk factors for recurrence may lead to different conclusions, but we believe that the conclusions drawn from such a classification system may reduce statistical bias and be more rigorous. Another possible explanation is that both the amount of hematoma on the single side of bCSDH and brain shift in bCSDH were relatively lower compared with unilateral CSDH, and thus the relationship between the hematoma volume and the recurrence is not as close.

Various CCT-detected densities have been proposed to be associated with recurrence of CSDH^{8,10}; however, we and others have found no correlation between hematoma density and CSDH recurrence.^{5,12,19} Furthermore, the types of the hematoma density described previously¹⁰ do not include all hematomas. Two or more types of CCT density may appear in a single layer or in different layers of a hematoma, and we assigned these hematomas to the mixed type category (Figure 1H and I). Midline shift was

strongly associated with CSDH recurrence in the previous studies,^{5,7,20} but was not applicable to bCSDH.

Only 2 grading systems have been published previously. Stanišić et al.⁸ presented a 3-component grading system for CSDH recurrence after surgery comprising PreHV (cutoff value of 130 mL), PostHCV (cutoff values of 80 and 200 mL), and CT imaging findings (hyperdense, isodense, separated, and laminar types of hematoma). Jack et al.²¹ developed a grading system based on PreHV (cutoff value of 160 mL), patient age (cutoff value of 80 years), and septation hematoma type. However, neither system included PostPV and PostHV values.

The conclusions from the multivariate logistic regression model in the present study differ from those reported in those previous studies, demonstrating the difference between our prognostic grading system and the 2 aforementioned grading systems. Our prognostic grading system comprises 2 components: PostPV, severe brain atrophy, and anticoagulant use. The PostPV was measured using Image J, which has the advantage of measuring irregular and scattered postoperative pneumocephalus and hematoma.¹⁵ Using our grading system, the recurrence rate increased significantly with increasing scores in our patients, showing that our prognostic grading system for hematoma recurrence of bCSDH after initial bilateral evacuation is reliable and applicable for clinical reference.

One limitation of the present study is that the small sample size and a single-center design. A multicenter study with a larger number of patients is needed. Another limitation was that our prognostic grading system was developed based on bCSDH after initial bilateral evacuation, and thus it is not suitable for unilateral CSDH or bCSDH treated by unilateral evacuation. Risk factors and prognostic grading system for recurrence of unilateral CSDH or bCSDH treated with unilateral evacuation should be evaluated separately in future studies.

CONCLUSIONS

In this study, we have identified anticoagulant use, severe brain atrophy, and PostPV as independent risk factors for recurrence of bCSDH after initial bilateral evacuation. By combining the independent risk factors and cutoff value of PostPV, we have developed a reliable and applicable prognostic grading system that be used as a clinical reference.

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REFERENCES

- Kolias AG, Chari A, Santarius T, Hutchinson PJ. Chronic subdural haematoma: modern management and emerging therapies. *Nat Rev Neurol*. 2014;10:570-578.
- Ducruet AF, Grobely BT, Zacharia BE, et al. The surgical management of chronic subdural hematoma. *Neurosurg Rev*. 2012;35:155-169 [discussion: 169].
- Rauhala M, Luoto TM, Huhtala H, et al. The incidence of chronic subdural hematomas from 1990 to 2015 in a defined Finnish population. *J Neurosurg*. 2019;22:1-11.
- Leroy HA, Aboukais R, Reyns N, et al. Predictors of functional outcomes and recurrence of chronic subdural hematomas. *J Clin Neurosci*. 2015;22:1895-1900.
- Chon KH, Lee JM, Koh EJ, Choi HY. Independent predictors for recurrence of chronic subdural hematoma. *Acta Neurochir (Wien)*. 2012;154:1541-1548.

6. Torihashi K, Sadamasa N, Yoshida K, Narumi O, Chin M, Yamagata S. Independent predictors for recurrence of chronic subdural hematoma: a review of 343 consecutive surgical cases. *Neurosurgery*. 2008;63:1125-1129 [discussion: 1129].
7. Escosa Baé M, Wessling H, Salca HC, de Las Heras Echeverría P. Use of twist-drill craniostomy with drain in evacuation of chronic subdural hematomas: independent predictors of recurrence. *Acta Neurochir (Wien)*. 2011;153:1097-1103.
8. Stanišić M, Pripp AH. A reliable grading system for prediction of chronic subdural hematoma recurrence requiring reoperation after initial burr-hole surgery. *Neurosurgery*. 2017;81:752-760.
9. You CG, Zheng XS. Postoperative pneumocephalus increases the recurrence rate of chronic subdural hematoma. *Clin Neurol Neurosurg*. 2018;166:56-60.
10. You W, Zhu Y, Wang Y, et al. Prevalence of and risk factors for recurrence of chronic subdural hematoma. *Acta Neurochir (Wien)*. 2018;160:893-899.
11. Okano A, Oya S, Fujisawa N, et al. Analysis of risk factors for chronic subdural haematoma recurrence after burr hole surgery: optimal management of patients on antiplatelet therapy. *Br J Neurosurg*. 2014;28:204-208.
12. Bartek J Jr, Sjävik K, Kristiansson H, et al. Predictors of recurrence and complications after chronic subdural hematoma surgery: a population-based study. *World Neurosurg*. 2017;106:609-614.
13. Motiei-Langroudi R, Thomas AJ, Ascanio L, et al. Factors predicting the need for surgery of the opposite side after unilateral evacuation of bilateral chronic subdural hematomas [e-pub ahead of print]. *Neurosurgery*. 2018. <https://doi.org/10.1093/neuros/nyy432>, accessed March 12, 2019.
14. Fujitani S, Ishikawa O, Miura K, Takeda Y, Goto H, Maeda K. Factors predicting contralateral hematoma growth after unilateral drainage of bilateral chronic subdural hematoma. *J Neurosurg*. 2017;126:755-759.
15. Shen J, Shao X, Gao Y, et al. Risk factors for contralateral hematoma progression after unilateral evacuation of bilateral chronic subdural hematomas [e-pub ahead of print]. *World Neurosurg*. 2019. <https://doi.org/10.1016/j.wneu.2019.02.148>, accessed March 18, 2019.
16. Kung WM, Hung KS, Chiu WT, et al. Quantitative assessment of impaired postevacuation brain re-expansion in bilateral chronic subdural haematoma: possible mechanism of the higher recurrence rate. *Injury*. 2012;43:598-602.
17. Guha D, Coyne S, Macdonald RL. Timing of the resumption of antithrombotic agents following surgical evacuation of chronic subdural hematomas: a retrospective cohort study. *J Neurosurg*. 2016;124:750-759.
18. Nathan S, Goodarzi Z, Jette N, Gallagher C, Holroyd-Leduc J. Anticoagulant and antiplatelet use in seniors with chronic subdural hematoma: systematic review. *Neurology*. 2017;88:1889-1893.
19. Wada M, Yamakami I, Higuchi Y, et al. Influence of antiplatelet therapy on postoperative recurrence of chronic subdural hematoma: a multicenter retrospective study in 719 patients. *Clin Neurol Neurosurg*. 2014;120:49-54.
20. Schwarz F, Loos F, Dünisch P, et al. Risk factors for reoperation after initial burr hole trephination in chronic subdural hematomas. *Clin Neurol Neurosurg*. 2015;138:66-71.
21. Jack A, O'Kelly C, McDougall C, Findlay JM. Predicting recurrence after chronic subdural haematoma drainage. *Can J Neurol Sci*. 2015;42:34-39.

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Ethical statement: This retrospective study does not involve patients' privacy, and thus formal consent was not required.

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