



# Prevalence of and risk factors for recurrence of chronic subdural hematoma

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## Abstract

**Background** Chronic subdural hematoma (CSDH) is a common disease in neurosurgical practice with substantial recurrence rate. We aimed to estimate recurrence rate of CSDH and to identify risk factors for CSDH recurrence.

**Methods** We retrospectively studied consecutive cases with CSDH and performed surgical therapy in our hospital. Univariate and multivariate logistic regression analyses were performed to identify factors associated with recurrence of CSDH.

**Results** A total of 226 patients with CSDH were included; 34 patients recurred after surgery with a recurrence rate of 15.0%. Univariate analysis showed that the recurrence group had more patients with homogenous hyper-dense hematoma (20.6 vs 6.3%,  $p = 0.035$ ) and shorter duration of subdural drainage post-surgery ( $1.2 \pm 1.4$  vs  $1.5 \pm 0.9$ ,  $p = 0.022$ ) than the non-recurrence group. Logistic regression analysis revealed that duration of subdural drainage (OR = 0.66,  $p = 0.05$ ) and hyper-dense of hematoma (OR = 4.94,  $p = 0.012$ ) were independent predictors for CSDH recurrence.

**Conclusions** Homogenous hyper-dense of hematoma and duration of subdural drainage post-surgery were independent predictors for CSDH recurrence; longer duration of postoperative subdural drainage was associated with lower risk of recurrence.

**Keywords** Chronic subdural hematoma · Recurrence · Prevalence · Risk factors · Hematoma density

## Introduction

Chronic subdural hematoma (CSDH) is a common neurological disorder which often occurs in the elderly [9]. The incidence of CSDH in general population is estimated to range from 5 to 14 per 100,000 person-years [9, 16]. With the aging population, a significant increase in the incidence of CSDH is expected. Surgical evacuation, especially burr-hole craniotomy and drainage, is the most widely used technique for treating CSDH [12]. Most of the patients obtained great improvements in neurological function after surgery. However, some patients experienced a recurrence of hematoma requiring a reoperation. The prevalence of recurrence was reported to range from 2.5 to 33% in literature [1, 18, 24, 25]. Recurrence of hematoma often resulted in a complex clinical

situation, increased psychological burden, and poor outcomes of patients, which poses a major challenge for neurosurgeons. Furthermore, the mechanism that contributes to CSDH recurrence is elusive. Therefore, the identification of factors associated with recurrence of CSDH is important for the treatment and postoperative management of these patients. Although various potential risk factors have been proposed including age, body mass index (BMI), hematoma density, separated hematoma, and use of antiplatelet or anticoagulant agents, the results remain inconclusive [2, 4, 5, 15, 20].

Therefore, the aims of this study were to estimate the recurrence rate and to identify risk factors for CSDH recurrence by retrospectively reviewing the cases of CSDH treated in our institution.

## Methods

### Patient population

We retrospectively reviewed patients with CSDH admitted to the Department of Neurosurgery, First Affiliated Hospital, College of Medicine, Zhejiang University, between January

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2013 and September 2016. The study was approved by the ethics committee of the hospital and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Patients with CSDH were diagnosed by head computed tomography (CT) or magnetic resonance imaging (MRI). Inclusion criteria were (1) age of 18 years or older and (2) underwent surgical treatment. Cases with missing data or co-existed with severe multi-organ dysfunction were excluded from the study. The recruitment of patients is shown in Fig. 2.

### Treatment of CSDH

All patients underwent burr-hole craniotomy and drainage after admission, which is the standard of treatment for CSDH in our department. Briefly, a single burr-hole or two burr-holes over the maximum width of hematoma were drilled under local or general anesthesia. Hematoma was evacuated followed by irrigation of the subdural cavity using normal saline. A silicone catheter was inserted into the subdural space after irrigation, and a closed drainage system was connected to the catheter. The drainage system was properly fixed and maintained after the surgery. Catheters were usually removed 1 to 2 days later unless prolonged drainage was indicated. Postoperative head CT scanning was routinely performed 24 h after surgery, before discharge and 1-month post operation. Patients were

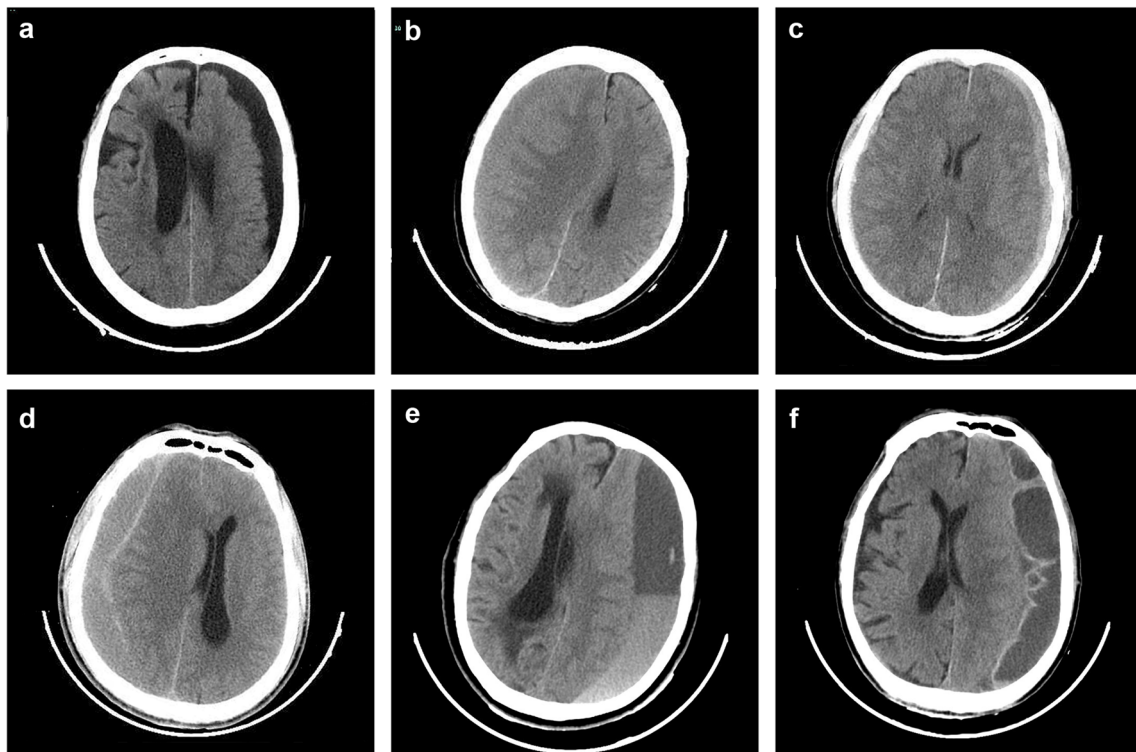
routinely followed up by telephone or out-patient department visits for 1 year after discharge from hospital.

### Data collection

Demographic and clinical data were extracted from case records: age, sex, height, weight, history of head trauma, Glasgow Coma Scale (GCS), head CT imaging, pre-existing diseases including hypertension, diabetes mellitus, and cardiac vascular disease, use of antiplatelet or anticoagulant agents, duration of postoperative subdural drainage, and the interval between recurrence and the first operation.

### Radiological imaging evaluation

Preoperative head CT imaging of each patient was assessed by two investigators blinded to patients' clinical conditions. Midline shift, location of hematoma, and hematoma density were reviewed. Hematomas were classified into four types according to their density on CT as previously described Nakaguchi et al. [14]: homogenous (including three subtypes, iso-dense, homogenous hypo-dense, homogenous hyper-dense), laminar, separated, and trabecular (Fig. 1). The laminar type was defined as a hematoma exhibiting a high-density layer along the inner membrane. The separated type contains two components of different densities, and a boundary lies between them. The trabecular type was defined as a hematoma



**Fig. 1** Head CT scans showing classification of chronic subdural hematoma. **a** Homogenous hypo-dense. **b** Homogenous iso-dense. **c** Homogeneous hyper-dense. **d** Laminar hematoma. **e** Separated hematoma. **f** Trabecular hematoma

with inhomogeneous contents, and the low-density to iso-dense hematoma was separated by high-density septa. Patients with bilateral CSDHs that displayed different types of hematoma were classified according to the hematoma that showed greater bleeding tendency [20].

### Definition of and treatment for recurrence

Recurrence of CSDH was defined as a re-accumulation of hematoma in the ipsilateral subdural space accompanied with neurological deficits, for which a reoperation was required. Reoperation also evolves a burr-hole evacuation of hematoma and closed drainage.

### Statistical analysis

Statistical analyses were performed by SPSS Statistics software (Version 17.0, Chicago, IL). Continuous variables were given as means and standard deviations or as medians and interquartile ranges. Continuous variables were compared by Student's *t* test if normally distributed or by Mann-Whitney *U* test if non-normally distributed. Categorical variables were expressed as numbers and percentages. Categorical data were compared by chi-square test. Binary logistic regression analysis was then performed to identify risk factors for CSDH recurrence. Multiple comparisons between recurrence rates of each hematoma type were conducted by chi-square tests and Bonferroni corrections. Variables that were significant in univariate analysis were included in logistic analysis. Statistical significance was determined at a *p* value < 0.05.

## Results

### Baseline characteristics

A total of 226 patients with CSDH were included in our study. The baseline demographic characteristics and radiographic findings of the study population are summarized in Table 1. There were 184 (81.4%) males and 42 (18.6%) females, and the mean age was  $65.1 \pm 13.5$  years. One hundred sixty-one (71.2%) patients reported history of head trauma. The hematoma was on the left side in 93 (41.2%) patients, on the right side in 67 (29.6%) patients, and bilateral in 66 (29.2%) patients. With regard to hematoma density, homogenous hypo-dense type was observed in 47 patients (20.8%), homogenous iso-dense type in 55 patients (24.3%), homogenous hyper-dense type in 19 patients (8.4%), laminar type in 9 patients (4.0%), separated type in 33 subjects (14.6%), and trabecular type in 63 subjects (27.9%). Surgery was successful in all patients, and the mean duration of drainage after the initial operation was  $1.4 \pm 1.0$  days.

**Table 1** Clinical characteristics of patients

Characteristic	Value
Number of patients	226
Sex, <i>n</i> (%)	
Male	184 (81.4)
Female	42 (18.6)
Age, mean $\pm$ SD (years)	$65.1 \pm 13.4$
BMI	$22.6 \pm 3.2$
GCS at admission, mean $\pm$ SD	$14.8 \pm 0.9$
Location of hematoma, <i>n</i> (%)	
Left side	93 (41.2)
Right side	67 (29.6)
Bilateral	66 (29.2)
Midline shift, <i>n</i> (%)	
$\geq 1$ cm	122 (50.8)
< 1 cm	104 (25.4)
Hematoma density on CT scan, <i>n</i> (%)	
Homogenous hypo-dense	47 (20.8)
Homogeneous iso-dense	55 (24.3)
Homogeneous hyper-dense	19 (8.4)
Laminar	9 (4.0)
Separated	33 (14.6)
Trabecular	63 (27.9)
History of head trauma	161 (71.2)
Administration of antiplatelet or anticoagulant drugs	14 (6.2)
Pre-existing diseases	
Hypertension	66 (29.2)
Diabetes mellitus	10 (4.4)
Cardiovascular disease	7 (3.1)
Duration of subdural drainage	$1.4 \pm 1.0$

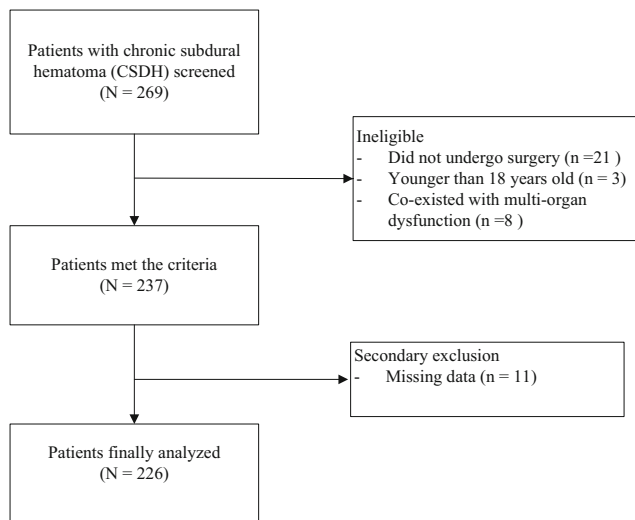
*SD*, standard deviation; *BMI*, body mass index; *GCS*, Glasgow Coma Scale

### Recurrence rate of CSDH

Thirty-four (15.0%) patients experienced a recurrence of CSDH that required reoperation. The average interval between the initial operation and the recurrence was 59.9 days. All the patients with recurrence of CSDH underwent burr-hole and drainage as second operation and achieved good treatment outcome; no additional third operation was needed for the subjects with recurrence (Fig. 2).

### Risk factors for recurrence of CSDH

Univariate analysis of the possible risk factors showed that patients in the recurrence group had shorter duration of post-operative subdural drainage than those in non-recurrence group ( $1.2 \pm 1.4$  vs  $1.5 \pm 0.9$ ,  $p = 0.022$ ). And, types of hematoma were associated with postoperative recurrence ( $p = 0.035$ ) (Table 2). Multiple comparisons of recurrence rate



**Fig. 2** Flowchart showing the recruitment of patients

between hematoma types showed that the homogeneous iso-dense type had the lowest recurrence rate (7.3%), while the homogeneous hyper-dense hematoma had the highest recurrence rate (36.8%), and there were no significant differences between the recurrence rate of homogenous hypo-dense (21.3%), laminar (11.1%), separated (15.2%), and trabecular (11.1%) types (Table 3). Subjects with bilateral hematoma ( $p = 0.192$ ), using antiplatelet or anticoagulant drugs ( $p = 0.144$ ), or pre-existing heart disease ( $p = 0.120$ ) tended to have higher rate of recurrence, although they were not statistically significant. There were no differences in age, gender, BMI, and history of hypertension and diabetes mellitus between recurrence group and non-recurrence group (Table 2).

Multivariate logistic regression analysis demonstrated that preoperative homogenous hyper-dense hematoma ( $p = 0.012$ , OR = 4.94, trabecular as reference) and duration of postoperative subdural drainage ( $p = 0.050$ , OR = 0.66) were independent risk

**Table 2** Univariate analysis of factors associated with CSDH recurrence

Characteristic	Non-recurrence group	Recurrence group	<i>p</i> value
Number of patients	192	34	
Sex, <i>n</i> (%)			0.528
Male	155 (80.7)	29 (85.3)	
Female	37 (19.3)	5 (14.7)	
Age, mean $\pm$ SD (years)	65.6 $\pm$ 13.3	62.7 $\pm$ 14.1	0.513
BMI	22.5 $\pm$ 3.2	23.0 $\pm$ 3.5	0.709
GCS at admission, median (IQR)	15 (15–15)	15 (15–15)	0.064
Location of hematoma, <i>n</i> (%)			0.192
Left side	83 (43.2)	10 (29.4)	
Right side	7 (29.7)	10 (29.4)	
Bilateral	52 (27.1)	14 (41.2)	
Midline shift, <i>n</i> (%)			0.380
$\geq 10$ mm	86 (44.8)	18 (52.9)	
$< 10$ mm	106 (55.2)	16 (47.1)	
Hematoma density on pre-operation CT scan, <i>n</i> (%)			0.035*
Homogenous hypo-dense	37 (19.3)	10 (29.4)	
Homogeneous iso-dense	51 (26.6)	4 (11.8)	
Homogeneous hyper-dense	12 (6.3)	7 (20.6)	
Laminar	8 (4.2)	1 (2.9)	
Separated	28 (14.6)	5 (14.7)	
Trabecular	56 (29.2)	7 (20.6)	
History of head trauma	134 (69.8)	27 (79.4)	0.253
Administration of antiplatelet or anticoagulant drugs	10 (5.2)	4 (11.8)	0.144
Pre-existing diseases			
Hypertension	59 (30.7)	7 (20.6)	0.231
Diabetes mellitus	9 (4.7)	1 (2.9)	0.997
Heart disease	4 (2.1)	3 (8.8)	0.120
Duration of subdural drainage	1.5 $\pm$ 0.9	1.2 $\pm$ 1.4	0.022*

SD, standard deviation; BMI, body mass index; GCS, Glasgow Coma Scale

\* $p < 0.05$

**Table 3** Comparisons of recurrence rate of different hematoma types

Hematoma density on pre-operation CT scan, <i>n</i> (%)	Non-recurrence group	Recurrence group	Recurrence rate (%)
Homogenous hypo-dense	37	10	21.3 <sup>a</sup>
Homogeneous iso-dense	51	4	7.3 <sup>b</sup>
Homogeneous hyper-dense	12	7	36.8 <sup>c</sup>
Laminar	8	1	11.1 <sup>a</sup>
Separated	28	5	15.2 <sup>a</sup>
Trabecular	56	7	11.1 <sup>a</sup>

<sup>a</sup> No significant differences between the recurrence rate of hematoma types

<sup>b</sup> The lowest recurrence rate of hematoma type

<sup>c</sup> The highest recurrence rate of hematoma type

factors for recurrence of CSDH, and longer duration of drainage was associated with lower risk of recurrence (Table 4).

## Discussion

In the present study, we identified preoperative homogenous hyper-dense hematoma and duration of postoperative subdural drainage was associated with recurrence of hematoma, and the risk of recurrence decreased with longer duration of drainage.

As a common neurosurgical disease usually occurs in older adults, CSDH showed favorable treatment outcomes in most patients. Nevertheless, some patients experienced recurrence after surgical treatment. Although various risk factors for recurrence of CSDH have been proposed in literature [4], a definitive conclusion is still difficult to be drawn. In the present study, we included 226 cases with CSDH. Thirty-four patients experienced recurrence of hematoma with a recurrence rate of 15.0%, which was comparable to that of previous studies reporting the prevalence of CSDH recurrence from 2.5 to 33%.

By univariate analysis, we found that patients with shorter duration of subdural drainage and homogeneous

hyper-dense hematoma were more likely to experience recurrence. Logistic regression analysis further demonstrated that these two factors were independent predictors for CSDH recurrence.

Postoperative subdural drainage has long been a research focus for CSDH recurrence. Several studies had shown that patients with subdural drainage had significantly lower recurrence rate than those without drainage after surgery [17, 22, 23]. However, few studies have investigated the relationships between duration of subdural drainage and recurrence. Although some researchers pointed out that longer duration of drainage might lead to lower rate of recurrence, their reliability was largely affected due to their small sample sizes and lack of rigorous statistic assessment [7, 10]. In our study, both the univariate analysis and multivariate logistic analysis demonstrated that longer duration of drainage was associated with lower recurrence rate of CSDH. Therefore, our study indicated that longer duration of drainage should be used in order to reduce recurrence rate. However, risk of infectious complication may increase with prolonged duration of drainage. Thus, further prospective studies are needed to examine the optimal duration of drainage, which both reduced recurrence of hematoma and do not increase the risk of infection.

A large amount of studies have investigated the relationships between preoperative hematoma density and recurrence of hematoma, yet results were varied [3, 6, 15]. Some research found no associations between them [3], while others reported that trabecular, hyper-dense, and mixed density hematomas had higher rate of recurrence [6, 15]. In the present study, both univariate and multivariate logistic regression analyses revealed that homogenous hyper-dense hematoma was more likely to recur after surgery. This was consistent with previous studies reporting higher recurrence rate in patients with high-density hematoma [6, 8, 11]. High density of hematoma indicated that the CSDH was in the acute phase and was not fully developed, thus a higher recurrence rate was usually observed after surgery in this type of CSDH [8, 19]. Therefore, surgery

**Table 4** Logistic regression analysis of factors related to recurrence of CSDH

Factors	Beta	Standard error	$\chi^2$	<i>p</i> value	OR	95% CI
Duration of subdural drainage	-0.411	0.210	3.825	0.050*	0.663	0.439–1.001
Hematoma density on CT scan						
Homogenous hypo-dense	0.774	0.542	2.035	0.154	2.168	0.749–6.276
Homogeneous iso-dense	-0.432	0.660	0.429	0.513	0.649	0.178–2.368
Homogeneous hyper-dense	1.597	0.633	6.370	0.012*	4.939	1.429–17.071
Laminar	0.008	1.137	0.000	0.994	1.008	0.109–9.365
Separated	0.395	0.636	0.387	0.534	1.485	0.427–5.164
Trabecular	Reference	Reference	Reference	Reference	Reference	Reference

ICU, intensive care unit; OR, odds ratio; CI, confidence interval

\**p* < 0.05

should be delayed in patients displaying high-density hematoma unless severe symptoms were present. Although a lot of studies found separated hematoma was associated with higher recurrence rate, no correlation was observed between them in our study.

The relationships between antiplatelet and anticoagulant administration and CSDH recurrence have been controversial. Some studies concluded that there was no association between them [13, 21], while others revealed that use of antiplatelet or anticoagulant was a risk factor for recurrence [3]. This discrepancy might be explained by the different anticoagulation levels of patients in these studies; high level of anticoagulation was associated with recurrence, while low level of anticoagulation was not correlated with recurrence. In this study, the recurrence group (11.8%) tended to have more patients administrating antiplatelet and anticoagulant drugs than the non-recurrence group (5.2%), even though it was not statistically significant, possibly because only a few patients (14 patients, 6.2%) used these drugs in our study population. In addition, we also investigated patient age, BMI, hypertension, diabetes mellitus, and recurrence of hematoma; no associations were observed.

However, some limitations of our study need to be mentioned. First, this is a retrospective study and thus is potentially subject to selection bias. Second, this study was conducted in a single center, which may affect the generalizability of our study results. Despite these limitations, our relatively large sample size and rigorous statistical analysis supported our conclusions.

## Conclusions

In conclusion, homogeneous hyper-dense hematoma and duration of postoperative subdural drainage were independent predictors for CSDH recurrence, and the risk of recurrence decreased with longer duration of drainage. However, further prospective studies are needed to define the optimal duration of postoperative subdural drainage.

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## Compliance with ethical standards

The study was approved by the ethics committee of the First Affiliated Hospital, College of Medicine, Zhejiang University, and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all individual participants included in the study.

**Conflict of interest** The authors declare that they have no conflict of interest.

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