Original Article

Proposal of Treatment Strategies for Bilateral Chronic Subdural Hematoma Based on Laterality of Treated Hematoma

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Abstract

Background: Chronic subdural hematoma (CSDH) is a disorder that is commonly seen in routine neurosurgery. Although risk factors for recurrence have been studied, the findings are inconsistent. Furthermore, bilateral CSDHs are operated unilaterally or bilaterally depending on symptoms or hematoma volume. Although there are cases in which hematomas on nonoperated side in unilaterally operated bilateral CSDHs requiring for additional operation, little have been studied on the effect of the surgical selection. The purpose of this study is to identify risk factors for recurrence in operated hematomas and additional operation in nonoperated hematomas and improve surgical strategy. **Materials and Methods:** We retrospectively reviewed patients who underwent surgery in our facility for bilateral CSDHs between January 2011 and December 2016. Univariate and multivariate analyses were performed to examine the relationship between recurrence or requirement for additional operation and clinical and radiological variables. **Results:** Recurrence was observed significantly more frequent for operated hematomas when hematoma type was separated type as reported previously. In unilaterally operated bilateral CSDHs, there were 22 hematomas on nonoperated side, and five hematomas required an additional operation after the first hospitalization. Increased volume of hematoma on the nonoperated side was the risk factors for additional operation (P = 0.022). Receiver operating characteristic (ROC) curve revealed that requirement for additional operation significantly increased when hematoma volume enlarged to approximately 44 cm^3 or greater 1 day after operation. **Conclusions:** In unilaterally operated bilateral CSDHs, when hematoma volume on nonoperated side increased 1 day after the last operation, additional operation in the early stage is considerable to prevent re-hospitalization and deterioration of activities of daily living.

Keywords: *Additional operation, bilateral, chronic subdural hematoma, recurrence, risk factor*

Introduction

Chronic subdural hematoma (CSDH) is a disorder that is commonly seen in routine neurosurgery. Over numerous studies, the recurrence rate of this disorder is reported to be 9%–33%[1-23] and these studies also analyzed the risk factors for postoperative recurrence. The reported risk factors are laterality of hematomas being bilateral,[1,5,16,17,21,22] preoperative hematoma width and midline shift being greater,[5,10,11,16,18,19,23] volume of postoperative residual air and subdural space being greater,[2,4,8,13,14,18-20] preoperative hematoma densities,[2,4,6,7,11,13,17-19] medical history including diabetes mellitus, hypertension, leukemia, liver disease, chronic renal failure and seizure,[5,7,17,23] and intake of anticoagulant or thrombolytic drugs.[7,15] However, the findings were not consistent between the studies. In addition, bilateral CSDHs are operated unilaterally or bilaterally depending on symptoms or hematoma volume. Although there are cases in which hematomas on nonoperated side in unilaterally operated bilateral CSDHs requiring for additional operation, little have been studied on the effect of the surgical selection. As primary treatment of CSDHs is surgical treatment, and continuous surgery leads to multiple hospitalization and deterioration of activities of daily living, it is necessary to consider surgical strategy that prevents rehospitalization. The purpose of this study is to identify risk factors for recurrence in operated hematomas and requirement for additional operation in nonoperated hematomas and improve surgical strategy.

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Materials and Methods

Patients and definition of application for surgical treatment

We retrospectively reviewed patients who underwent surgery in our facility for bilateral CSDHs between January 2011 and December 2016. Patients with a history of brain surgery were excluded from the study, as were patients without pre- and post-operative computerized tomography (CT) scanning. Fifty-seven patients who underwent surgery for bilateral CSDH were included in the study. Surgical treatment was performed for a hematoma with neurological deficits or related symptoms such as headache, nausea, or dizziness that lowered the quality of activities of daily living. Recurrence was defined as a hematoma which is surgically excised and recurred with neurological deficits or related symptoms and was then treated with a burr-hole craniostomy and irrigation with isotonic saline solution within 6 months from the last surgical treatment. The additional operation was defined as an operation performed to nonoperated hematoma within 6 months from the last operation. The study was approved by the Institutional Review Board of Soka Municipal Hospital.

Surgical procedure and general management

All patients underwent hematoma evacuation by a single burr-hole craniostomy and irrigation with isotonic saline solution, followed by a 1-day of external continuous drainage. Unilateral surgery was performed when the laterality of neurological symptoms could only be attributed to the thicker hematoma. Any antiplatelet and anticoagulant therapy was continued as the influence of the intake over recurrence was not consistent between reported studies and increased the possibility of ischemia might impair the activity of daily living greater and symptoms followed by the ischemia could be persistent.

Classification of hematomas

All hematomas were classified into four types according to their internal architecture: Homogeneous, laminar, separated, and trabecular types as defined by Nakaguchi *et al*.[11] The homogeneous type was defined as a hematoma with a homogeneous density. The laminar type was defined as a hematoma with a thin high-density layer along the inner membrane. The separated type was defined as a hematoma containing a lower density component and a higher density component. The trabecular type was defined as a hematoma with a high-density septum running between the inner and outer membrane in a homogeneous density.

Radiological variables

CSDH was diagnosed in all patients by high-resolution CT scanning within 2 days before the operation. All CT scans of 57 patients were assessed by four neurosurgeons in our facility and a radiologist who was blinded to patient condition. Postoperative CT scanning was performed 1 day after surgery. The same CT scan parameters were employed for postoperative imaging. Factors analyzed through CT scans included the internal architecture of the hematoma, volume of pre- and post-operative hematoma, preoperative midline shift, volume of postoperative subdural space, and the residual high density in the postoperative subdural space (postoperative residual high density). The CT scan performed 1 day after surgery was analyzed for postoperative radiological variables. The internal architecture of hematoma was assessed using the classification of hematomas. Preoperative volume of hematoma and postoperative volume of subdural space or hematoma were calculated using the XYZ/2 method.[24]

Statistical analysis

Reported risk factors from the previous studies on CSDH recurrence were analyzed in the 57 patients (114 hematomas); sex, age, use of antiplatelet or anticoagulant, and pre- and post-operative CT scans were assessed. Alcohol intake and history of smoking were included in the risk factors in consideration of patients' basic characteristics.

The statistical analyses were performed using SigmaStat 3.5 (Systat Software Inc., San Jose, California) and EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan). Data are presented as the mean ± standard deviation (SD) Unpaired *t*-tests or Mann–Whitney U-tests were performed to compare variables. Multivariate analyses were performed using multiple linear regressions to examine the independent factors for the recurrence of CSDH. The variables for the multivariate analysis were selected based on the statistical findings and reported risk factors. The variables with $P < 0.1$ were considered for inclusion in the multivariate analysis. Differences were considered statistically significant if the $P < 0.05$. ROC curve analysis was performed to determine threshold for predicting requirement for additional operation.

Results

Thirteen patients (23%) developed recurrence or requirement for additional operation in the group of 57 patients with bilateral CSDH. Results of the relationship between patients' clinical and radiological variables and recurrence or requirement for additional operation in bilateral CSDH are summarized in Table 1. As for the clinical variables of hematomas, no correlation was observed between variables and recurrence or requirement for additional operation. As for the radiological variables, even sum of hematoma volume of bilateral hematomas and sum of the volume of bilateral postoperative subdural space were compared; however, no correlation between recurrences was observed.

Regarding the influence of surgical selection, all hematomas were classified as hematomas of bilaterally

operated bilateral CSDHs, hematomas of operated side in unilaterally operated bilateral CSDHs, and hematomas of nonoperated side in unilaterally operated bilateral CSDHs.

Results of the relationship between recurrence in operated hematomas and radiological variables are summarized in Tables 2 and 3. Separated type of hematoma recurred significantly more frequent for hematoma of bilaterally operated bilateral CSDH and hematoma on operated side of unilaterally operated bilateral CSDH (P = 0.002 and P = 0.04, respectively).

Table 4 shows results from univariate and multivariate analyses of the association between the requirement for additional operation in nonoperated hematoma of unilaterally operated bilateral CSDH and variables. There were 22 hematomas for which surgery was not performed, and five hematomas (23%) were additionally operated after the first hospitalization. Hematomas of nonoperated side being the separated type did not show a significant difference (P = 0.95). Even hematomas of operated side being the separated type did not show significant difference (P = 0.15). Hematoma volume 1 day after surgery being greater was the risk factor for additional operation (P = 0.022).

A ROC curve analysis was performed to determine threshold for predicting requirement for additional operation in consideration of hematoma volume 1 day after surgery [Figure 1]. The curve had a threshold of approximately 44 cm^3, as determined by the Youden index with 80% sensitivity, 76.5% specificity, and the area under the curve was 0.835.

Table 1: Summary and analyses of characteristics in 57 patients (13 patients of recurrence or requirement for additional operation) with bilateral chronic subdural hematoma

Variables	Nonrecurrence or nonadditional operation (n=44), n (%)	Recurrence or additional operation (n=13), n (%)	P*
Age	74.9±13.7 (30-90)	77.2±8.3 (63-88)	0.94
Sex (male)	34 (77)	10 (77)	0.99
Antiplatelet	7 (16)	0 (0)	0.13
Anticoagulant	5 (11)	1 (8)	0.72
Alcohol	11 (25)	6 (46)	0.15
Smoking	7 (16)	1 (8)	0.47
Preoperative midline shift (mm)	4.4±2.8	2.8±1.1	0.14
Total volume of preoperative hematoma (cm^3)	154.3±48.8	161.7±44.1	0.63
Total volume of postoperative subdural space (cm^3)	92.1±36.5	104.2±46.3	0.34

*P value for univariate analysis

Table 2: Hematoma analyses of bilaterally operated bilateral chronic subdural hematomas

Variables	Nonrecurrence (n=57), n (%)	Recurrence (n=13), n (%)	P*	$P^{\dagger}$
Volume of preoperative hematoma (cm^3)	77.5±39.9	97.6±27.3	0.012	0.21
Volume of postoperative subdural space (cm^3)	46.4±25.1	60.5±30.0	0.15	
Internal architecture of hematoma				
Homogeneous type	15 (26)	2 (15)	0.42	0.002
Laminar type	14 (25)	2 (15)	0.49	
Separated type	13 (23)	9 (69)	0.001	
Trabecular type	15 (26)	0 (0)	0.039	
Postoperative residual high density	21 (37)	1 (8)	0.043	

*P value for univariate analysis, $^{\dagger}P$ value for multivariate analysis

Table 3: Hematoma analyses of operated side in unilaterally operated bilateral chronic subdural hematomas

Variables	Nonrecurrence (n=20)	Recurrence (n=2)	P*	$P^{\dagger}$
Volume of preoperative hematoma (cm^3)	110.9±44.4	114.1±38.4	0.92	
Volume of postoperative subdural space (cm^3)	51.0±29.3	49.6±30.5	0.95	
Internal architecture of hematoma				
Homogeneous type	4 (20)	0 (0)	0.55	0.04
Laminar type	6 (30)	0 (0)	0.42	
Separated type	5 (25)	2 (100)	0.04	
Trabecular type	5 (25)	0 (0)	0.48	
Postoperative residual high density	14 (70)	1 (50)	0.62	0.81

*P value for univariate analysis, $^{\dagger}P$ value for multivariate analysis

Table 4: Hematoma analyses of nonoperated side in unilaterally operated bilateral chronic subdural hematomas

Variables	No additional operation (*n*=17), *n* (%)	Additional operation (*n*=5), *n* (%)	*P**	P†
Volume of preoperative hematoma (cm^3)	32.3±18.5	35.3±13.6	0.21	
Volume of postoperative hematoma (cm^3)	34.7±13.4	56.1±17.8	0.012	0.022
Internal architecture of hematoma				
Homogeneous type	5 (29)	3 (60)	0.24	
Laminar type	5 (29)	1 (20)	0.72	
Separated type	3 (18)	1 (20)	0.95	
Trabecular type	4 (24)	0 (0)	0.27	
Postoperative residual high density	13 (76)	2 (40)	0.15	
Existence of separated type on operated side	4 (24)	3 (60)	0.15	0.25

**P* value for univariate analysis, †*P* value for multivariate analysis

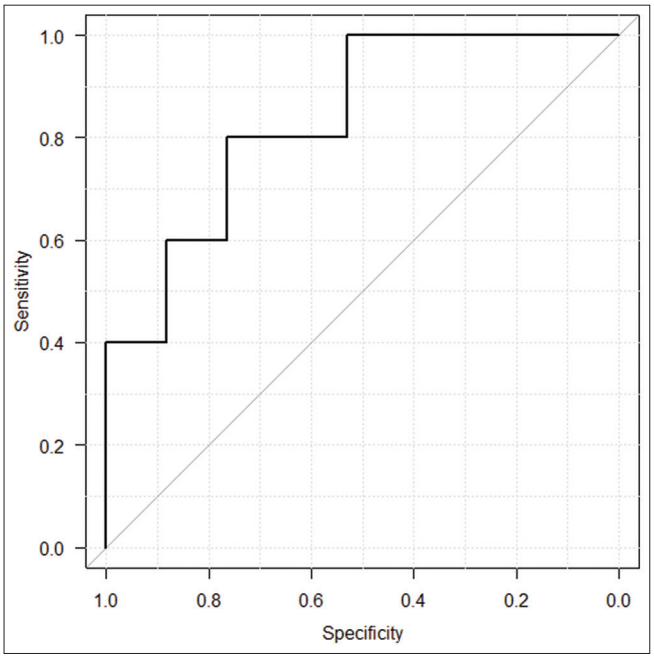

Figure 1: Receiver operating characteristic curve analysis performed to determine threshold for predicting requirement for additional operation in consideration of hematoma volume one day after surgery

Discussion

Separated type of hematomas recurred significantly more frequent for operated hematomas, and enlargement of hematoma volume on nonoperated side 1 day after surgery was the postoperative factor for additional operation for nonoperated hematomas in unilaterally operated bilateral CSDHs.

In our study, 23% of hematomas on nonoperated side needed additional operation in unilaterally operated bilateral CSDH. The surgical selection was performed based on patient's neurological deficit, and the result showed that hematoma volume of nonoperated side was significantly smaller than operated side ($P < 0.001$, mean ± SD: 34.2 ± 17.6 cm^3 for nonoperated side and 111.2 ± 42.1 cm^3 for operated side). Although hematoma volume of nonoperated side was smaller than hematoma volume of operated side even 1 day after operation with no neurological deficit, 23% of hematomas of nonoperated side required additional operation which was even greater compared with recurrence rate of operated hematomas (16%). Patients treated with additional operation were discharged from hospital after the last operation with no neurological deficit, and additional operation was performed after certain period (mean ± SD: 38.4 ± 34 1 days). Andersen-Ranberg *et al*. reported that bilateral surgery decreases the recurrence rate in bilateral CSDHs[1] and several other studies also recommended bilateral surgery. However, in hematomas with small amount, the distance to the cortex is small and the risk of damaging the brain increases. In our study, the additional operation was needed significantly more in hematomas of nonoperated side when hematoma volume 1 day after surgery enlarged in unilaterally operated bilateral CSDHs. Andersen-Ranberg *et al*. mentioned the same phenomenon[1] and this phenomenon may be effective to be used as a postoperative predictor for the requirement of additional operation in nonoperated hematomas in bilateral CSDHs. This enlargement of nonoperated hematoma may be due to high pressure in hematoma cavity of nonoperated side. With hematoma of higher pressure on other side, hematoma of lower pressure may be pressed leading to smaller appearance of hematoma volume in CT scans. However, hematoma volume of operated side did not show significant difference (mean ± SD: 115.5 ± 46.5 cm^3 vs 96.5 ± 26.6 cm^3, $P = 0.40$) for 22 hematomas of nonoperated side in unilaterally operated bilateral CSDHs. Multiple factors such as preoperative brain atrophy or elasticity of the brain may contribute to change in the appearance of hematoma volume of nonoperated side even with the same hematoma volume of operated side.

Our study also revealed that when the volume of nonoperated hematoma enlarged to approximately 44 cm^3 or greater 1 day after the last operation, additional operation was required significantly more frequent within 6 months. As primary treatment of CSDHs is surgical

treatment and additional operation for nonoperated hematomas leads to rehospitalization and deterioration of activities of daily living, additional burr-hole craniostomy, and irrigation in the early stage can be considered when the volume of nonoperated hematoma increases in the CT scan 1 day after surgery. Our proposal for surgical strategy in bilateral CSDHs is to perform burr-hole craniostomy and irrigation to hematomas responsible for neurological deficit, calculate the postoperative hematoma volume in the CT scan 1 day after operation for hematoma of nonoperated side in unilaterally operated bilateral CSDHs, and when the volume was increased by approximately 44 cm^3 or greater, consider additional operation in the same period of hospitalization to avoid re-hospitalization.

In the current study, hematomas of the separated type had a significantly more frequent recurrence in operated hematomas. It has been reported that the recurrence rate is significantly higher in CSDHs of the separated type.[2,4,6,7,13,17-19] Nomura *et al*. analyzed the concentrations of fibrinogen, fibrin monomer, and D-dimer in hematomas of the separated type, and reported that hematomas of this type show hyperfibrinolytic activity which leads to a high tendency to re-bleed. Hyperfibrinolytic activity in hematoma cavity was thought to be responsible for the frequent recurrence of separated type hematomas.[12] Although the internal architecture of preoperative hematoma being the separated type was responsible for recurrence in operated hematoma, no relationship was observed for additional operation in nonoperated hematoma. Even internal architecture of nonoperated hematoma, 1 day after the last operation was assessed and no relationship was observed (data not shown). Nakaguchi, *et al*. reported that internal architecture of CSDH change in order of homogeneous, laminar, separated, and trabecular by time course.[11] In the five hematomas, which required additional operation, change in internal architecture was observed for three hematomas between the first operation and the additional operation. This change in internal architecture might be related to growing volume of hematoma. Further accumulation of cases might be effective to clarify the relationship between internal architecture of hematoma and requirement for additional operation in more detail.

In our study, any antiplatelet and anticoagulant therapy was continued. The influence of the intake over recurrence had been studied; however, the results were not consistent between reported studies. Rust *et al*. reported a higher rate of recurrence in patients taking aspirin.[15] Leroy *et al*. noted that anticoagulant therapy was the independent risk factor for the recurrence of CSDH.[8] However, several previous studies have reported that antiplatelet or anticoagulant therapy had no significant association between CSDH recurrences.[3,9,15] In our study, all patients under anticoagulant therapy had arterial fibrillation. In five patients, under antiplatelet therapy, three patients had a history of cerebral infarction and two patients were postoperation for abdominal aortic aneurysm. For most of the patients with anticoagulant or antiplatelet therapy, the intake of medication was for prevention of ischemia and was necessary to be continued. Moreover, increased possibility of ischemia by discontinuance of medication might impair the activity of daily living greater and symptoms followed by the ischemia could be persistent. Furthermore, our study revealed that anticoagulant or antiplatelet therapy did not increase the recurrence rate and primary cause of recurrence was the internal architecture of hematomas being the separated type. From these aspects, the possibility of ischemia that can cause persistent symptoms should be taken into consideration, and any anticoagulant or antiplatelet therapy should not be routinely discontinued.

The main limitation of our study is the small number of patients available for the analysis and further accumulation of cases is necessary to verify these findings.

Conclusions

In unilaterally operated bilateral CSDHs, when hematoma volume on nonoperated side increased after the last operation, rehospitalization, and additional operation were required significantly more frequent. Rehospitalization can lead to deterioration of activities of daily living. Our proposal for surgical strategy in bilateral CSDHs is to perform burr-hole craniostomy and irrigation to hematomas responsible for neurological deficit, calculate the postoperative hematoma volume in the CT scan 1 day after operation for hematoma of nonoperated side in unilaterally operated bilateral CSDHs, and when the volume was increased by approximately 44 cm^3 or greater, consider additional operation in the same period of hospitalization to avoid rehospitalization.

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Conflicts of interest

There are no conflicts of interest.

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