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Clinical Analysis of Risk Factors for Recurrence in Patients with Chronic Subdural Hematoma Undergoing Burr Hole Trephination

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Objective: Chronic subdural hematoma (CSDH) is one of the most common types of intra-cranial hemorrhages usually associated with trauma. Surgical treatment is the treatment of choice and burr hole trephination (BHT) is widely performed. The recurrence rate in the patients with CSDH is 3.7−30%. This study investigated the risk factors associated with the recurrence of patients with CSDH who underwent BHT.
Methods: One hundred twenty-five patients with CSDH underwent BHT. Eight of 125 patients (6.4%) underwent reoperation for recurrent CSDH. We retrospectively analyzed demographic, clinical and radiological findings, catheter tip location and drainage duration as the risk factors for the recurrence of CSDH.
Results: Recurrence of CSDH in the high- or mixed-density groups was significantly higher than those in the low- or iso-density groups ($p<0.001$). Placement of catheter tip at the temporoparietal area was associated with a significantly higher recurrence rate of CSDH than placement at the frontal area ($p=0.006$) and the brain re-expansion rate (BRR) was much lower than placement at the frontal area ($p<0.001$).
Conclusion: The operation may be delayed in high- and mixed-density groups, unless severe symptoms or signs are present. In addition, placing the catheter tip at the frontal area helps to reduce the incidence of postoperative recurrence of CSDH and to increase the BRR. (Korean J Neurotrauma 2014;10(1):15-21)

KEY WORDS: Chronic subdural hematoma · Recurrence · Catheter tip location · Computed tomography.

Introduction

Chronic subdural hematoma (CSDH) is one of the most frequent types of intra-cranial hemorrhage usually associated with trauma. It is a common disease of the elderly, with the highest incidence is observed in people over 70.[10,29,30,37] The pathogenic mechanism is the trauma to the bridging veins, which typically results in hemorrhage into the subdural space and liquefaction of the hematoma with micro-hemorrhages that induces expansion.[1,7,32] Surgical treatment is the treatment of choice, which includes twist-drill drainage, burr hole trephination (BHT), craniotomy and capsulectomy, and subduro-peritoneal shunt. Among them, BHT is widely used because of its relative simplicity and effectiveness.[11,26,35]

While most patients fully recover, 3.7−30% experience post-operative recurrence due to the hematoma reformation.[8,18,25,26] A number of factors may be associated with the recurrence of CSDH. However, the crucial risk factors are debatable.[6,8,24,30,35] This study analyzed clinical data acquired over the prior 5 years to clarify the risk factors for recurrence in patients with CSDH who underwent BHT.

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Materials and Methods

The records of patients with CSDH who underwent BHT from January 2008 to December 2012 were retrospectively reviewed. Single BHT was used for the treatment of all the subjects with ipsilateral CSDH. In case of bilateral CSDH, single BHT was recommended for both; however, when the thickness of the one side was less than 5−10 mm, BHT was not performed. The patients with CSDH who underwent other surgical treatments, such as twist-drill drainage, cra-

niotomy, and capsulectomy, were excluded; likewise, double BHT on one side was also excluded. In addition, to block an additional influence on the recurrence of CSDH, we excluded the patients who received anti-coagulant agents, hemodialysis or cerebrospinal fluid shunt surgery. Consequently, the data of the total of 125 patients were used.

Burr holes were trephined at the region of maximal hematoma thickness on brain computed tomography (CT). CSDHs were evacuated and washed out by irrigation with a warm physiological saline solution in all patients. After the surgery, the drainage system was fixed at the level of tragus to prevent rapid drainage of CSDH and the height was changed according to the amount of drainage. Bed rest was recommended until the drainage catheter was removed. Prophylactic antibiotics were used regularly up to 3 days, unless postoperative wound infection occurred. Follow-up brain CT was performed in all patients. If the midline shift did not exist anymore, or thickness of subdural space was less than 5 mm, we concluded that brain expansion occurred and that resolution of hematoma was complete.[21] The recurrence of CSDH was defined as re-accumulation of the hematoma on brain CT obtained within 3 months postoperatively along with the reappearance of neurological symptoms including cognitive dysfunction, hemiparesis or headache.[2,11,15]

We retrospectively analyzed the data to establish whether the clinical and radiologic factors, as well as catheter tip location and drainage duration were associated with the recurrence of CSDH. We examined clinical factors of age, sex, history of head trauma, preoperative Glasgow Coma Scale, medication history, laboratory characteristics and underlying diseases including cerebrovascular disease and diabetes (Table 1 and 2). The examined radiographic factors were preoperative hematoma density in brain CT, hematoma volume, location, midline shift (less than or more than 10 mm), postoperative air in the subdural space and the *brain re-expansion rate (BRR)(Table 3).

*Brain re-expansion rate (BRR)=1-[(the postoperative volume of the residual hematoma)/(the preoperative volume of the hematoma)]

The density of hematoma was divided into four categories: high-density (more than 24 Hounsfield units, HU), isodensity (14−24 HU), low-density (4−14 HU) and mixed-

TABLE 1. Characteristics of 125 patients with chronic subdural hematoma undergoing burr-hole trephination

	RG (n=8)	NRG (n=117)	Total (n=125)	*p*-value
Age (mean±SD, year)	66.50±10.65	69.56±12.39	69.37±12.27	0.50
<70 (%)	5 (62.5)	50 (42.7)	55 (44.0)	0.30
≥70 (%)	3 (37.5)	67 (57.3)	70 (56.0)	
Sex (n, %)				
Male	6 (75.0)	86 (73.5)	92 (73.6)	1.00
Female	2 (25.0)	31 (26.5)	33 (26.4)	
Period from head trauma to surgery (mean±SD, weeks)*	6.00±2.31 (n=4)	6.04±3.36 (n=77)	6.04±3.30 (n=81)	0.98
GCS (mean±SD)	14.750±0.463	14.641±1.029	14.648±1.002	0.77

*period from head trauma to surgery was analyzed by using eighty-one patients having trauma history. RG: recurrence group, NRG: non-recurrence group, GCS: Glasgow Coma Scale

TABLE 2. The relationship between the clinical factors and the recurrence of CSDH in 125 patients

	RG (n=8)	NRG (n=117)	Total (n=125)	*p*-value
HTN (%)	6 (75.0)	61 (52.1)	67 (53.6)	0.29
DM (%)	3 (37.5)	28 (23.9)	31 (24.8)	0.40
CVD (%)	0 (0)	5 (4.3)	5 (4.0)	1.00
ACS (%)	0 (0)	7 (6.0)	7 (5.6)	1.00
ACE inhibitors (%)	2 (25.0)	26 (22.2)	28 (22.4)	1.00
Anti-platelet agents (%)	4 (50.0)	31 (26.5)	35 (28.0)	0.22
Corticosteroid (%)	5 (62.5)	60 (51.3)	65 (52.0)	0.72
Platelet (mean±SD, $\times 10^3/mm^3$)	291.1±49.1	253.2±84.6	255.3±83.4	0.24
PT (mean±SD, INR)	0.99±0.05	1.01±0.11	1.01±0.11	0.73
aPTT (mean±SD, sec)	29.66±1.27	29.90±4.01	29.88±3.90	0.70

RG: recurrence group, NRG: non-recurrence group, HTN: hypertension, DM: diabetes mellitus, CVD: cerebrovascular disease, ACS: acute coronary syndrome, ACE inhibitors: angiotensin-converting enzyme inhibitors, PT (INR): prothrombin time (international normalized ratio), aPTT: activated partial thromboplastin time, CSDH: chronic subdural hematoma

TABLE 3. The relationship between the radiologic factors and the recurrence of CSDH in 125 patients

	RG (n=8)	NRG (n=117)	Total (n=125)	*p*-value
Hematoma location (%)				
Right	2 (25.0)	30 (25.6)	32 (25.6)	
Left	3 (37.5)	61 (52.1)	64 (51.2)	
Ipsilateral	5 (62.5)	91 (77.8)	96 (76.8)	0.386
Bilateral	3 (37.5)	26 (22.2)	29 (23.2)	
Midline shift (mean±SD, mm)*	10.48±3.52	9.39±4.43	9.45±4.38	0.592
<10 mm (%)	1 (20.0)	54 (59.3)	55 (57.3)	0.160
≥10 mm (%)	4 (80.0)	37 (40.7)	41 (42.7)	
Hematoma density (%)				<0.001
Low	0 (0)	37 (31.6)	37 (29.6)	
Iso	0 (0)	55 (47.0)	55 (44.0)	
High	5 (62.5)	17 (14.5)	22 (17.6)	
Mixed	3 (37.5)	8 (6.8)	11 (8.8)	
Air collection in subdural space (%)				1.000
<10 cc	6 (75.0)	86 (73.5)	92 (73.6)	
10−50 cc	2 (25.0)	25 (21.4)	27 (21.6)	
≥50 cc	0 (0)	6 (5.1)	6 (4.8)	
BRR (mean±SD)	0.59±0.19	0.69±0.18	0.68±0.18	0.116

*midline shift was surveyed in the group of patients with ipsilateral hematoma (n=96). RG: recurrence group, NRG: non-recurrence group, BRR: brain re-expansion rate, CSDH: chronic subdural hematoma

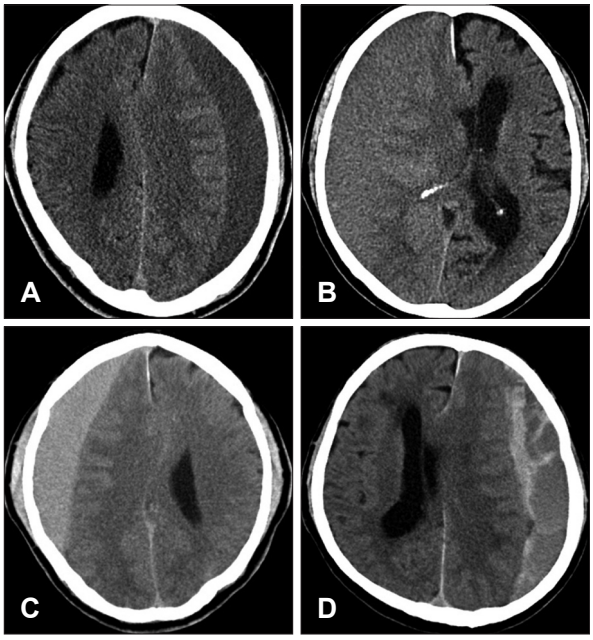

FIGURE 1. Brain CT showing classification of hematoma density. A: Low-density (4-14 HU). B: Iso-density (14-24 HU). C: High-density (≥24 HU). D: Mixed-density. HU: Hounsfield unit.

density (Figure 1). Hematoma volume and thickness were examined, and were classified according to the criteria of volume of 120 cc and thickness of 20 mm. In this study, the brilliance workspace program of BR64 CT (Philips Medical Systems, Amsterdam, the Netherlands) was used to investigate hematoma volume. The amount of the air in the subdural space after surgery was classified into three categories: <10 cc, 10−50 cc and >50 cc.

We investigated whether catheter tip location or drainage duration influenced recurrence of CSDH (Table 4). The location of the drainage catheter tip was classified into two subgroups: frontal area and temporoparietal area (Figure 2). Postoperative brain CT scans were obtained in all patients on the second day after the surgery. When there was no deviation in the midline and the thickness of subdural space was <5 mm, we concluded that the brain was fully expanded and then removed the drainage catheter. In case when thickness of subdural space was >5 mm, the drainage catheter was kept an additional 2−3 days and then removed. The period of drainage was based on the removal time and classified into two subgroups: <2 days and ≥2 days.

Statistical analyses included independent t-test and Fisher exact test to assess the relationship between each parameter and the risk factors on the recurrence of CSDH. For all analyses, $p<0.05$ was considered to be statistically significant.

Results

One hundred twenty five patients were recruited. Patient clinical characteristics are summarized in Table 1 and 2. The mean age was 69.37 years; 92 patients (73.6%) were males and 33 (26.4%) females. Recurrence of CSDH oc-

TABLE 4. The relationship between the location of catheter tip and drainage duration and the recurrence of CSDH in 125 patients

	RG (n=8)	NRG (n=117)	Total (n=125)	*p*-value
Drainage duration (mean±SD)	2.88±0.84	2.63±0.93	2.65±0.93	0.476
<2 days (%)	3 (37.5)	65 (55.6)	68 (54.4)	0.467
≥2 days (%)	5 (62.5)	52 (44.4)	57 (45.6)	
Location of catheter tip (%)				0.006
Frontal	2 (25.0)	88 (75.2)	90 (72.0)	
Temporoparietal	6 (75.0)	29 (24.8)	35 (28.0)	

RG: recurrence group, NRG: non-recurrence group, CSDH: chronic subdural hematoma

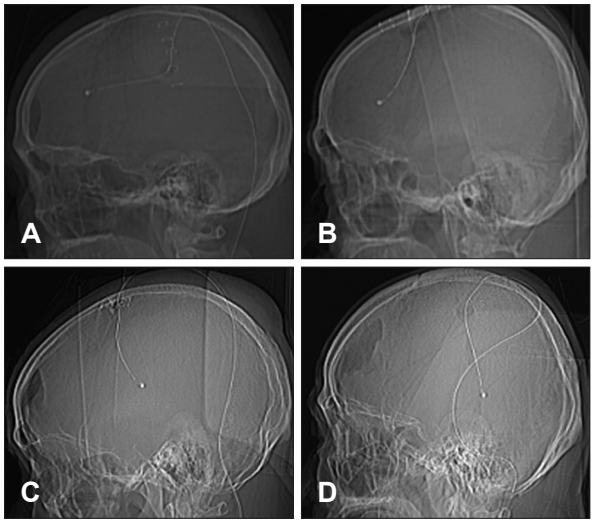

FIGURE 2. Skull radiographs showing catheter tip position after BHT. The location was classified into two areas: frontal area (A, B) and temporoparietal area (C, D). BHT: burr hole trephination.

curred in eight patients (6.4%): six males and two females. Eight patients with recurrent CSDH underwent re-operation and two underwent BHT three times; all recovered fully. The mean age was not different between the recurrence and the non-recurrence group (66.50±10.65 and 69.56±12.39 years, respectively). Eighty-one of 125 patients (64.8%) remembered a previous head trauma, and the interval from the head trauma to surgery ranged from 3 weeks to 4 months. There was no significant difference in the interval between the recurrence and the non-recurrence group (6.00±2.31 and 6.04±1.03 years, respectively; p=0.982).

History of hypertension, diabetes mellitus, cerebrovascular disease and cardiovascular disease were not different between the two groups. Also, use of angiotensin-converting enzyme inhibitors (ACE inhibitors) during the perioperative phase, and anti-platelet agents and corticosteroids after surgery were not different between the two groups. In addition, coagulation status parameters including platelet counts, prothrombin time and activated partial thromboplastin time were not different between the two groups.

CSDH recurred on the right side in two patients (25.0%), on the left side in three patients (37.5%) and on bilateral side

TABLE 5. The relationship between the location of catheter tip and the brain re-expansion in 125 patients

	BRR	*p*-value
Location of catheter tip (mean±SD)		<0.001
Frontal	0.72±0.15	
Temporoparietal	0.57±0.20	

BRR: brain re-expansion rate

in three patients (37.5%). There was no statistically significant difference between the ipsilateral and bilateral recurrence groups (p=0.386). Of 96 ipsilateral CSDH patients, CSDH with midline shift ≥10 mm showed higher recurrence rate than those with midline shift <10 mm, however the difference was not statistically significant (p=0.592). The volume and the thickness of hematoma were not associated with the recurrence of CSDH (p=0.479 and p=0.440, respectively).

Hematoma density on CT scans were high- or mixed-density in 24.4%, iso-density in 44% and low-density in 29.6%. High- or mixed-density groups were significantly more related with the recurrence of CSDH than iso-density or low-density groups (p<0.001). The relationship between the amount of air in the subdural space and the recurrence was not statistically significant (p=1.000)(Table 3). BRR of the recurrence and non-recurrence groups was 0.59±0.19 and 0.69±0.18, respectively. BRR of the non-recurrence group was higher, but the difference did not reach statistical significance (p=0.116)(Table 3).

Finally, we investigated whether the catheter tip location or drainage duration influenced recurrence of CSDH (Table 4). The mean duration of postoperative drainage in the recurrence group was longer than that of the non-recurrence group, but there was no statistically significant difference between the duration of drainage and the recurrence of CSDH (p=0.467). Regarding the location of catheter tip, temporoparietal location showed high recurrence rate compared to frontal location (17.1% versus 2.2%). The relationship between the location of catheter tip and the recurrence of CSDH was statistically significant (p=0.006), as was the relationship between the location of catheter tip and the BRR was

statistically significant ($p<0.001$)(Table 5).

Discussion

As a relatively common brain disease occurring due to a direct or an indirect trauma of brain resulting in the rupture of parasagittal bridging vein, CSDH shows good treatment outcomes. Precipitating factors are intracranial hypotension, brain atrophy, hematologic disorder, deformed skull and cerebrospinal fluid fistula.[21] The hematoma may either resorb spontaneously or gradually increase in size resulting in a CSDH.[1] The volume of CSDH gradually increases because of repeated micro-hemorrhages. This results in the increase of intracranial pressure and leads to the symptoms of CSDH.[1,19,32] In our study, we performed BHT. Of the various surgical treatments, BHT is the simplest and most widely-used treatment for the removal of CSDH.[21] We analyzed risk factors of recurrence according to clinical factors, radiological factors and catheter tip location and drainage duration.

Old age, brain atrophy, poor health status at the time of admission, high bleeding tendency, kidney and liver disease, chronic alcoholism, diabetes mellitus, epilepsy, dementia and intracranial hypotension due to cerebrospinal fluid shunt are reported to be relevant factors of CSDH recurrence.[6,29,37] More recently, anti-angiogenic activity of the ACE inhibitors on blood vessels was reported to reduce the rate of recurrence in CSDH, as well as the levels of vascular endothelial growth factor within the hematoma.[36] Anti-platelet agents have been suggested risk factors for occurrence of CSDH,[20,31] but a number of literature reviews have mentioned that anti-platelet agents are not associated with CSDH recurrence.[20,23,34] In our study, in 35 patients using anti-platelet agents, only four had recurrence. We also established that there was no statistically significant relationship between the use of anti-platelet agents and the recurrence of CSDH.

In line with the theoretical beneficial mechanism of action, namely, the anti-inflammatory and anti-angiogenic effects,[3,4] corticosteroids are often used in CSDH treatment. Accordingly, Berghauser Pont et al.[3] mentioned that the use of corticosteroids lowers the recurrence of CSDH. However, our study revealed no relationship between the use of corticosteroids and the recurrence of CSDH. In addition, we investigated old age (over 70 years), hypertension, diabetes mellitus, as well as cerebrovascular and cardiovascular disease and the recurrence of CSDH, and found no statistically significant relationships. In the examination of the relationship between the use of ACE inhibitors and the recurrence of CSDH, these two factors were not found to be associated.

Radiological factors that have been reported to be associated with the recurrence of CSDH include a large number of hematomas, bilateral hematoma, hematoma formation within the outer membrane, the amount of air in the postoperative subdural space and high and mixed density of hematomas in brain CT.[5,8,16,23-25,37] CSDH is classified according to the density of hematomas.[11,14] The density of CSDH reflects the proportion of fresh blood clots in the hematoma cavity, and a high proportion of fresh blood clots means the active growth of blood vessels into the membrane of CSDH.[14,29] Therefore, high density of hematoma indicates that the neocapillary network actively forms into the membrane of hematoma and indicates the likelihood of hematoma re-bleeding at the same time.[14] Higher density of hematoma has been related to a higher rate of CSDH recurrence.[2,14,15] However, contradictory results have been presented, which could be due to the subjectivity of the density of hematoma classification. The incidence of re-bleeding was reportedly lower in the mixed and the layered density.[27] However, Ohba et al.[28] reported no relationship between the density of hematoma and its recurrence.

In our study, more patients displayed high- or mixed-density in the CSDH recurrence group than in the non-recurrence group, with statistical significance. This result is consistent with the previous conclusions that high density is indicative of the progress of CSDH in the acute phase and is associated with a high CSDH recurrence rate.[14] Surgery of hematomas that were not fully developed resulted in a high recurrence of CSDH. Consequently, in cases of acute phase patients with CSDH showing high and mixed density on brain CT, surgery should be delayed, unless severe symptoms are present, and undertaken at a later stage when CSDH appears as iso- or low-density on brain CT. Doing so would reduce the recurrence of CSDH.[2,14]

We investigated the relationship between postoperative BRR and the recurrence of CSDH. Based on several studies,[9,33] CSDH is expected to be more likely to recur due to the reformation of subdural hematoma when subdural space continuously existed or the re-expansion of brain was delayed after BHT. Presently, BRR was higher in the non-recurrence group than in the recurrence group, but this relationship was not statistically significant.

Several studies have shown that the existence of residual air in the postoperative subdural space is associated with the recurrence of hematoma or brain re-expansion. In addition, air influx into subdural space during surgery prohibits brain re-expansion and then raises the recurrence of CSDH.[5,23]

Our study found no relationship between the amount of postoperative subdural air and the recurrence of CSDH. In addition, the relationship between the recurrence of CSDH and the degree of midline shift was analyzed; no statistically significant meaning was evident.

Regarding treatment for the recurrence of CSDH, inadequate drainage and early surgery before the full liquefaction of hematoma have been reported.[30] In addition, a longer drainage period corresponds to less frequent recurrence of CSDH.[13,17] For duration drainage <48 hours, the recurrence rate of CSDH exceeds 10%.[22,25,26] According to Yu et al.,[38] while the recurrence rate of CSDH in postoperative patient group having more than 3 days of drainage duration was only 1.3%, the recurrence rate of CSDH in the postoperative patient group having less than 3 days of drainage duration was 16.3%. Thus, this study insisted on at least 3 days of drainage duration. However, there was no significant difference between the patients group having less than 2 days of drainage duration and the patients group having more than 2 days of drainage duration in our study.

According to Choi et al.,[5] the rate of re-formation in hematoma varies depending on the location of burr hole, and drilling burr hole in the frontal bone produces a better result than in the parietal bone. In addition, Nakaguchi et al.[26] and Kim et al.[12] reported that there was less recurrence of CSDH in cases where the drainage catheter tip was placed in the frontal area. In our study, placement of the catheter tip in the temporoparietal area was associated with higher recurrence of CSDH than placement in the frontal area; this difference was statistically significant. In addition, BRR was higher in cases where the catheter tip was placed in the frontal area compared to temporoparietal area placement, and the difference was also statistically significant.

Although the significant relationship between BRR and recurrence rate of CSDH was not verified in this study, the BRR in the recurrence group was lower than that in the non-recurrence group, and the case of placing the catheter tip into the frontal area showed a significantly higher BRR compared to the temporoparietal area. Based on this study, further research on the relationship between BRR and the recurrence of CSDH is needed.

Conclusion

Surgery should be delayed for patients with CSDH showing high- or mixed-density on brain CT until they reach low-density hematoma unless the symptoms are already severe. In addition, placing the catheter tip to the frontal area may be helpful in reducing postoperative recurrence of CSHD and increasing the BRR.

■ The authors have no financial conflicts of interest.

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