Journal of Neurological Disorders ISSN: 2329-6895

Neurological Disorders

Cheng et al., J Neurol Disord 2014, 2:2
DOI: 10.4172/2329-6895.1000148

Research Article | Open Access

Radiological Features and Post-Operative Drainage Amount Independently Predict Recurrence of Chronic Subdural Hematoma after Burr-hole Craniostomy

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Abstract

Background: Chronic subdural hematoma (CSDH) is a common neurologic disease in elderly. It is not always a benign condition because high recurrence rate had been reported. Independent risk factors for CSDH recurrence, especially the surgical and post-operative factors, had not been sufficiently investigated.

Methods: We retrospectively collected and analyzed data for 125 CSDH patients treated by burr-hole craniostomy in a regional hospital in Taiwan.

Results: Of these CSDH patients, the mean age was 70.2 ± 13.2 years and 96 (76.8%) were males. The CSDH recurrence rate after burr-hole craniostomy was 8.8% in our hospital. The recurrence group had thicker hematoma (24 mm vs. 18.5mm, P=0.024) and more often had laminar type CSDH (27.3% vs. 6.1%, P=0.044) than the non-recurrence group. Multivariate analysis found that thicker hematoma (P=0.033; OR=1.121; 95% CI 1.01-1.25), laminar type CSDH (P=0.010; OR=13.461; 95% CI 1.87-97.14) and larger total post-operative drainage amount (P=0.021; OR=1.002; 95% CI 1.000−1.004) were independently associated with recurrence of CSDH after burr-hole craniostomy. We didn't find an association between burr hole numbers and recurrence rate.

Conclusion: We found thicker hematoma,laminar type CSDH and larger post-operative drainage amounts independently predict recurrence of CSDH after burr-hole craniostomy. The patients with these risk factors may need closer surveillance post-operatively. Further studies are needed for surgical method modification to achieve lower recurrence rate.

Keywords: Chronic Subdural Hematoma; Recurrence, Burr-hole craniostomy, Post-operative drainage amount

Introduction

Chronic subdural hematoma (CSDH) is characterized by dark reddish blood accumulated in subdural space and surrounded by a thin outer membrane, which persisted more than 3 weeks after a head trauma history. It is a common type of intracranial hemorrhage in elderly patients [1], and its incidence rate increases with age [2,3]. The standard treatment of symptomatic CSDH is surgical evacuation. The principle techniques presently are twist drill craniostomy, burr-hole craniostomy and craniotomy [4]. From previous literature review, burr-hole craniostomy with drainage appears to be the most effective treatments when considering morbidity, mortality and recurrence rate [5-7].

Surgical evacuation of the CSDH often leads to significant neurological recovery [8]. However, CSDH is not always a benign disease in the elderly because high mortality rate and recurrence rate had been reported. In different studies, the perioperative mortality rate of CSDH ranged from 3-13% and the recurrence rate from 5-30% [4,7,9,10]. The recurrence rate has been showed to be influenced by multiple factors, such as the pre-operative patients' demographics, radiological type, pre-operative CSDH width, the density by brain image and different surgical approach [4,11-13]. Although numerous studies have investigated the risk factors for CSDH recurrence, the results have not been always consistent [11-17]. Most of these studies focused on the pre-operative factors, but few concerned the surgical or post-operative factors, such as burr-hole numbers, use of drainage, duration and volume of drainage. This subject has not been studied sufficiently yet.

In this study, we retrospectively enrolled the patients with CSDH receiving burr-hole craniostomy from a regional hospital in Taiwan. The aim of the study was to evaluate the outcome of CSDH after burr-hole craniostomy, and to analyze the potential risk factors, emphasizing surgical and post-operative ones, for CSDH recurrence.

Materials and Methods

Patient selection and data collection

We retrospectively collected data on consecutive patients with symptomatic CSDH confirmed by a brain computed topography (CT) and underwent burr-hole craniostomy at the neurosurgical department at Chang Gung Memorial Hospital, Chia-yi Center, in Taiwan from March, 2002 to November, 2009. We excluded patients with a ventriculo-peritoneal shunt for cerebrospinal fluid diversion,

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Received February 15, 2014; **Accepted** February 26, 2014; **Published** February 28, 2014

Citation: Cheng CY, Cheng YK, Hsu CY, Wang TC, Lin HC, et al. (2014) Radiological Features and Post-Operative Drainage Amount Independently Predict Recurrence of Chronic Subdural Hematoma after Burr-hole Craniostomy. J Neurol Disord 2: 148. doi:10.4172/2329-6895.1000148

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taking anticoagulant or antithrombotic medication, or receiving corticosteroid therapy. Clinical information such as patient age, sex, Glasgow Coma Scale (GCS) at admission and the length of hospital stay were collected by chart reviews. Recurrence of CSDH was defined as the occurrence of symptoms or signs attributable to a re-accumulation of subdural hematoma proved by brain CT within 3 months after the initial surgical evacuation.

Radiological evaluation

Brain CT at admission of all patients was reviewed by one neuroradiologist. Hematoma thicknesses, presence of midline shift or uncal herniation were evaluated. For patients with bilateral symptomatic CSDH, hematoma thickness was calculated at the more severe side. All CSDH were classified into four types according to Nakaguchi's classification: homogenous, laminar, separated, and trabecular type [18].

Surgical procedure and post-operative drainage

All patients received burr-hole craniostomy under general anesthesia with one or more burr holes over the area of maximal hematoma width. The selection of the number of burr hole was made by the attending neurosurgeon's preference. Much room temperature normal saline irrigation was performed via each burr holes until the irrigation return became clear. During the operation, the inner membrane and the arachnoid membrane were not disturbed. When the subdural space allowed, a closed subdural drainage system was placed and tunneled subcutaneously. The subdural drain was connected to a soft collection bag (an External Ventricular Drainage bag) and maintained with the drip nozzle below the level of the head. The patient was kept recumbent with the lesion side down for at least 24 hours, if possible. For those with bilateral lesions, their head on neutral position were suggested and the post-operative drainage amount was recorded daily. The drain was removed according to the change of the drainage volume, clinical performance and radiological findings. Most drains were removed within 5 days to avoid the complications associated with drainage catheter such as infection. Data about burr hole numbers, drain placement, total drainage amount, mean drain amount (defined as total drainage amount divided by drainage days) and drainage days were collected for all patients by chart review.

Statistical analysis

Descriptive summaries were reported as mean ± standard deviation for continuous variables with normal distribution, median (interquartile range) for continuous variables with non-normal distribution and counts (frequencies) for categorical variables. Population characteristics were compared using the chi-square test and Fisher's exact test for categorical variables. Continuous variables were analyzed using independent-samples t-test (when the data distribution was normal) and the Mann–Whitney U-tests (when the distribution was non- normal). We used univariate logistic regression analyses to assess the potential risk factors for recurrence of CSDH after Burr hole craniotomy, including age, sex, admission GCS, hematoma thickness, presence of midline shift, presence of uncal herniation, Nakaguchi's radiological types, burr hole numbers, drain placement, total post-operative drainage volume and drainage days. The predictor variables with $P<0.1$ were further analyzed using multivariate logistic regression. Odds ratios (OR) and 95% confidence intervals (CI) were calculated for each variable. Statistical analysis was performed using Stata version 12.0 statistical software (StataCorp. 2011. Stata Statistical Software: Release 12.0. College Station, TX: StataCorp LP.). All tests were 2-sided, and $P<0.05$ was considered statistically significant.

Results

A total of 139 consecutive patients with symptomatic CSDH receiving burr hole craniostomy were reviewed. Fourteen patients were excluded because their pre-operative brain images were unavailable for radiological evaluation. In the remaining 125 patients, mean age was 70.2 ± 13.2 years and 96 (76.8%) were males. Median admission GCS was 15 (14-15). Bilateral symptomatic CSDH was present in 23 patients (18.4%). The median hematoma thickness was 19 (13.4-24.5) mm. There were 101 patients (80.8%) having midline shift and 41 (32.8%) having uncal herniation. For the Nakaguchi's radiological type, 38 (30.4%) CSDH was homogenous type, 10 (8%) laminar type, 39 (31.2%) separated type and 38 (30.4%) trabecular type (Table 1).

Among the 102 patients with unilateral CSDH, 25 (24.5%) received craniostomy with one burr hole and 77 (75.5%) with 2 or more burr holes. Among the 23 patients with bilateral CSDH, 8 (34.8%) patients received one burr hole craniotomy on each side, and 15 (65.2%) had 2 or more burr holes on at least one side. There were 108 (86.4%) patients having drain placement after the operation. The median total drainage amount was 37 (12.5-108) ml, median mean drainage amount was 24 (6-57.2) ml/day and median drainage days was 2 (1-3) days (Table 1).

Recurrence of the CSDH happened in 11 patients (8.8%). Ten patients had unilateral recurrence and 1 had bilateral recurrences. All of these patients received the second burr-hole craniostomy at the recurrent side. However, 5 out of the 11 cases had the second recurrence of the CSDH. Among the 5 patients, 4 underwent craniotomy and 1 refused further operation. The median hospital stay was 8 (6-11.5) days. In-hospital mortality happened in 2 patients (1.6%), 1 died of pneumonia, and 1 died of pulmonary edema due to congestive heart failure. There was no surgery-related mortality in these patients.

The patients with recurrence had thicker hematoma (24 mm vs. 18.5 mm, P=0.024) and more often had laminar type CSDH (27.5%

	All patients (N=125)	Patient without recurrence	Patient with recurrence (N=11)	P Value
Age (year)	70.2 ± 13.2	70.0 ± 13.5	71.7 ± 10.1	0.682
Male	96 (76.8%)	86 (75.4%)	10 (90.9%)	0.455
Admission GCS	15 (14-15)	15 (14-15)	15 (11-15)	0.335
Bilateral hematoma	23 (18.4%)	19 (16.7%)	4 (36.4%)	0.118
Hematoma Thickness (mm)	19 (13.4-24.5)	18.5 (13.1-24)	24 (19-28)	0.024
Uncal herniation	41 (32.8%)	36 (31.6%)	5 (45.5%)	0.502
Midline shift	101 (80.8%)	90 (78.9%)	11 (100%)	0.121
Radiological type				
Homogenous	38 (30.4%)	35 (30.7%)	3 (27.3%)	1.000
Laminar	10 (8%)	7 (6.1%)	3 (27.3%)	0.044
Separated	39 (31.2%)	35 (30.7%)	4 (36.3%)	0.738
Trabecular	38 (30.4%)	37 (32.5%)	1 (9.1%)	0.170
≥ 2 burr holes/sides	66 (52.8%)	62 (54.4%)	4 (36.4%)	0.346
Drain placement	108 (86.4%)	99 (86.8%)	9 (81.8%)	0.645
Total drainage amount (ml)	37 (12.5-108)	35.5 (10-104.3)	103 (15-269)	0.152
Mean daily drainage amount (ml/day)	24 (6-57.2)	23.3 (5.3-53.5)	51.5 (7.5-89.7)	0.380
Drainage days	2 (1-3)	2 (1-3)	3 (2-3)	0.090
Hospital stay (day)	8 (6-11.5)	8 (6-11.5)	8 (6-11.5)	0.810

All values are presented as mean ± standard deviation, median (IQR) or N (percentage), as appropriate GCS: Glasgow Coma Scale

Table 1: Clinical and radiological features in patients with chronic subdural hematoma.

vs. 6.1%, P=0.044) than the patients without recurrence. There was no difference in age, sex, admission GCS, bilateral hematoma, presence of midline shift or uncal herniation, burr hole numbers, drain placement, total drainage amount, mean drainage amount, drainage days and length of hospital stay in recurrence and non-recurrence group (Table 1).

Multivariate analysis found that thicker hematoma (P=0.033; OR=1.121; 95% CI 1.01-1.25), laminar type CSDH (P=0.010; OR=13.461; 95% CI 1.87-97.14) and more total post-operative drainage amount (P=0.021; OR=1.002; 95% CI 1.000-1.004) were independently associated with recurrence of CSDH after burr-hole craniostomy. On the other hand, age, sex, admission GCS, presence of midline shift or uncal herniation, burr hole numbers, drain placement and drainage days were not associated with recurrence of CSDH (Table 2 and Table 3).

Discussion

This study found that CSDH recurrence rate was 8.8% after burr hole craniostomy, and thicker hematoma, laminar type CSDH and larger post-operative drainage amount were independent risk factors for CSDH recurrence. Otherwise, operating with more than one burr hole had no advantage in reducing CSDH recurrence.

Ducruet et al. had resented a flowchart for decision-making in the surgical management of CSDH [15]. Burr-hole craniostomy with a closed drainage system appears to be the most effective treatment with acceptable recurrence and mortality rates [5,19]. However, there is still a large variation in CSDH recurrence rate after burr-hole craniostomy between different studies and medical centers. Different patient characters, CSDH location or types, and modification of the surgical procedures may contribute to the variation in recurrence rate [17,18,20,21]. Recurrence rate in our study is quite low. It may be explained by some reasons. First, our patients had better baseline CGS (median was 15), which means the CSDH may be less severe when it was treated. Second, in the operation, enough fluid irrigation was done until the hematoma was removed and the fluid became clear. This procedure may result in more complete hematoma removal. Third, a subdural drain was left in most cases. It had been proved in some studies that a drain placement might reduce recurrence rate post-operatively [19,22].

Tentative risk factors	Odd's ratio	95% confidence interval	P Value
Age (year)	1.011	0.96-1.06	0.680
Male	0.307	0.04-2.51	0.270
Admission GCS	0.943	0.76-1.17	0.591
Bilateral hematoma	2.857	0.76-10.73	0.120
Hematoma Thickness	1.106	1.01-1.21	0.032
Uncal herniation	1.806	0.52-6.31	0.355
Radiological type			
Homogenous	1.000	-	0.117
Laminar	5.000	0.83-30.18	0.079
Separated	1.333	0.28-6.40	0.719
Trabecular	0.315	0.31-3.18	0.327
≥ 2 burr holes/sides	0.479	0.13-1.73	0.261
Drain placement	0.682	0.13-3.47	0.644
Total drainage amount	1.002	1.000-1.004	0.044
Drainage days	1.458	0.88-2.42	0.144

GCS: Glasgow Coma Scale

Table 2: Univariate logistic regression to access risk factors for recurrence of chronic subdural hematoma.

Tentative risk factors	Odd's ratio	95% confidence interval	P Value
Age (year)	1.037	0.97-1.11	0.282
Male	0.383	0.04-4.19	0.432
Hematoma Thickness	1.121	1.01-1.25	0.033
Laminar type	13.461	1.87-97.14	0.010
Total drainage amount	1.002	1.000-1.004	0.021

Age, male and the potential risk factors with P<0.1 in univariate analysis were chosen for multivariate analysis

Table 3: Multivariate logistic regression to access risk factors for recurrence of chronic subdural hematoma.

Few studies had investigated the association of post-operative drainage amount and duration with the CSDH recurrence [23]. There is no consensus about an adequate drainage amount and duration of drain keeping. The major finding in our study is that larger drainage amount is independently associated with higher recurrence rate of CSDH. There are some explanations. First, some CSDH with large post-operative drainage amount may be transformed from subdural hygroma. It has been reported that persistent subdural hygroma is an important risk factor in the development of CSDH [24,25]. The subdural hygroma caused by trauma may gradually progress to CSDH by tearing of the arachnoid membrane and the amount of CSF leakage can affect the recurrence of CSDH [26,27]. Second, some elderly patients had severe cerebral atrophy and poor brain re-expansion. After hematoma evacuation, cerebrospinal fluid may pass through into the low-pressure subdural space. If there is large amount of subdural effusion, the bridge veins in the subdural space may tear gradually and bleeding from the inner membrane or more anti-thrombolytic factors produced made the CSDH recurrent [24]. The much post-operative subdural effusion is similar to traumatic subdural hygroma; the potential for recurrence of CSDH should be considered. This result also suggests that the clinical physician should aggressively monitor those patients with much post-operative drainage amount and prolonged drainage may be needed [28].

Nakaguchi et al. described four types of CSDH according to its internal architecture, including homogeneous, laminar, separated and trabecular types [18]. Each type represents a different stage of CSDH. CSDH generates at homogenous stage, develops at the laminar stage, and then matures during the separated stage and finally resolute at the trabecular stage. In our study, laminar type CSDH had highest recurrence rate (30%), in contrast to recurrence rate of 7.9%, 10.3% and 2.6% in homogeneous, separated and trabecular types respectively. Our study also showed that laminar type CSDH was an independent predictor of CSDH recurrence. In the laminar stage, there is much fresh blood on the inner membrane, and it is a hypervascular condition with an active inflammation process. The inner membrane is fragile among elderly with increased permeability. Therefore, fibrinolytic factors or inflammatory cytokines easily aggregates during angiogenesis in the CSDH evolution. Because we didn't remove inner membrane during the CSDH evacuation, the active inflammatory process on the inner membrane may easily cause CSDH recurrence. Although most published studies found that CSDH recurrence rate was higher in separated type [18], a recent study by Chon et al. found both laminar type and separated type CSDH had higher possibility to recur than homogeneous and trabecular types [29]. We suggest that, CSDH should be treated at early stage (homogeneous type) or after it had been totally mature (trabecular stage), if possible. If the CSDH is necessary to be treated when it was still in evolution (laminar or separated types), more complete hematoma removal and closer post-operative monitoring were suggested.

In this study, around 75% of patients received more than one burr hole per side of CSDH. Although the general recurrence rate was low, we could not found an association between burr hole numbers and recurrence rate. Previous studies regarding the burr hole numbers and CSDH recurrence showed conflicting results [30-32]. Some surgeons prefer one burr-hole craniostomy due to shorter operation time and less invasive procedure; others use two burr-holes because it offers more efficient space to evacuate the hematoma. There is still no consensus on the best policy for burr hole numbers. The method of surgical evacuation, the degree of brain re-expansion, and the required duration of drainage may play a more important role than burr hole numbers in the recurrence of CSDH [33].

Our study had limitations. First, because of the limited case numbers and low recurrence rate, there were only 11 cases of CSDH recurrence. The statistic results may be influenced. Second, it is a retrospective study and some selection bias may exist. For example, two burr-hole craniostomy may be preferred in patients with more severe symptoms and thicker hematoma. Therefore, the advantage of two burr-hole craniostomy, if any, may be masked by the initial severity of the CSDH.

Conclusion

The present study found that thicker hematoma, laminar type CSDH and larger post-operative drainage amounts are independently associated with CSDH recurrence. This information might be helpful for clinicians to recognize the high-risk patients and do closer post-operative surveillance. The factors influencing the CSDH recurrence are multi-factorial. A systemic review of published studies and further prospective studies with large number of cases are needed to clarify the risk factors that are really important. Future studies should be conducted to modify the surgical method for these high-risk patients to achieve a lower recurrence rate.

Acknowledgements

No financial or any other conflict of interest exits in the submission of this manuscript.

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