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Original Investigation

A Prospective Comparative Study of Twist Drill Craniostomy Versus Burr Hole Craniostomy in Patients with Chronic Subdural Hematoma

Ke WANG*, Dongjiang CHEN*, Xiangyuan CAO, Liang GAO

Tongji University, Shanghai Tenth People's Hospital, Department of Neurosurgery, China

*Ke WANG and Dongjiang CHEN contributed equally to this work and should be considered jointly as first authors.

ABSTRACT

AIM: This study aims to compare clinical outcomes in patients with chronic subdural hematoma (CSDH) following twist drill craniostomy (TDC) or burr hole craniostomy (BHC).

MATERIAL and METHODS: A prospective cohort study was conducted in the patients who suffered from symptomatic CSDH and received surgical treatment in our department from Jan 2011 to Dec 2013. Each patient was followed 3 months after the surgery.

RESULTS: Thirty-eight and 45 patients received TDC and BHC treatment, respectively. There was no significant difference in age, gender, head trauma, diabetes mellitus, hypertension, antiplatelet usage, clinical manifestation, the Glasgow Coma Scale score and preoperative radiographic characteristics between the two groups. Patients in TDC had a significantly shorter operating time, but a longer draining time than those in BHC (16.9 ± 6.3 min vs. 44.4 ± 7.1 min, $p < 0.001$; 3.1 ± 1.0 d vs. 2.5 ± 0.9 d, $p = 0.003$; respectively). A smaller degree of midline shift reversal was observed in patients after TDC than those after BHC (2.6 ± 2.5 mm vs. 3.9 ± 2.8 , $p = 0.030$). Seven patients (18.4%) in TDC and 5 patients (11.1%) in BHC experienced CSDH recurrence. There was no significant difference in the recurrence rate, in-hospital complications, and neurological outcomes between the two groups.

CONCLUSION: This study indicates that TDC and BHC have similar clinical outcomes in the treatment of patients with CSDH. A shorter operating time, but a smaller midline shift reversal and a longer draining time may be expected in patients after TDC than after BHC.

KEYWORDS: Subdural hematoma, Chronic subdural hematoma, Twist drill craniostomy, Burr hole craniostomy, Recurrence

INTRODUCTION

Chronic subdural hematoma (CSDH) is a neurological disorder that predominantly affects elderly people and causes serious morbidity and mortality (1,2). Surgical treatment plays an important role in the treatment of patients with symptomatic CSDH. Twist drill craniostomy (TDC), burr hole craniostomy (BHC), and craniotomy are three commonly used procedures in current clinical practice. Among them, TDC and BHC are recognized as first-tier surgical treatment

while craniotomy is used as a second-tier treatment (16). Both TDC and BHC can be performed in setting of local anesthesia, and TDC can even be performed at bedside (7). Most neurosurgeons tend to use BHC as the procedure of choice to treat patients with initial CSDH (3). With a smaller diameter of skin incision and skull opening, TDC is less invasive than BHC, which theoretically favors its use in elderly patients who usually have comorbidities. Previous studies comparing therapeutic effects of TDC and BHC concluded controversial results (6-8,17). Here, we conducted a prospective cohort



Corresponding author: Liang GAO

E-mail: 071105344@fudan.edu.cn

study to compare clinical outcomes of the two surgical techniques in a selected group of patients with symptomatic CSDH.

■ MATERIAL and METHODS

Inclusion and Exclusion Criteria

A prospective cohort study was undertaken in the patients who suffered from symptomatic CSDH and admitted to the Neurosurgical Department, Shanghai Tenth People's Hospital between January 2011 and December 2013. Inclusion criteria of patients in the study were as follows: (a) patient age \geq 18 years old; (b) initial unilateral CSDH without loculation confirmed by computed tomography (CT); (c) patients who received either TDC or BHC treatment; (d) patients with written consent from their next of kin. Patients with recurrent or bilateral CSDH were excluded from this study. Patients with severe systemic diseases, such as chronic heart failure, coagulation disorders, thrombocytopenia, respiratory insufficiency, liver or renal dysfunction, were excluded. Patients dependent on anticoagulants or alcohol were also excluded. The Institutional Review Board approved this study.

TDC and BHC Procedures

Each patient received head CT scan before surgery. Based on individual preference, the neurosurgeons performed either TDC with drainage or BHC with drainage for each patient in the operating room. All the operations were performed under local anesthesia with 2% lidocaine, and adjunctive intravenous anesthesia with propofol and fentanyl was added if the patient was uncooperative. A single-shot antibiotic prophylaxis with first generation cephalosporin was intravenously administered 30 min before skin incision. The single-use YL-1 puncture needle for treatment of encephalic hematomas (Beijing Wantefu Medical Apparatus Corporation, China) was used for the patients who received TDC treatment. With a 3-mm external and 2.5-mm internal diameter, the needle has an available length ranging from 20 mm to 70 mm with an increment of 5 mm. The preoperative CT image was used to measure the distance from the skin surface to the outer membrane of the hematoma in order to determine the appropriate length of the needle. Under sterile conditions and local anesthesia, a 4-5 mm skin incision was made over the maximum width of the hematoma and a craniostomy was made using an electronic drill with the needle attached on it. After the needle penetrated the outer membrane of the hematoma, the neurosurgeon felt resistance loss and removed the stylet inside the needle to allow for outflow of liquefied hematoma. A closed external ventricular drainage system was attached to the trocar port on the needle.

In the patients who underwent BHC, a 3-4 cm skin incision was made over the area of maximal hematoma thickness. A single burr hole was made using a 13-mm Cushing drill. After coagulation with bipolar diathermy, the dura and outer membrane was incised in cruciate fashion. The hematoma cavity was irrigated by warm saline solution at body temperature. After that, an external ventricular draining tube was inserted into the hematoma cavity and tunneled subcutaneously to prevent infection. The same closed external ventricular drainage system was used in these patients.

Postoperative Care

After surgery, all patients were kept at the supine position, with the chamber of the closed drainage system at 40-50 cm below the head level. Patients were encouraged to do active lower limb movement in bed and to cough out sputum. The drainage system was removed when draining volume per 8 hours was less than 5 mL. Antibiotic prophylaxis was used during the draining period. Each patient routinely received head CT scan within 24 hours after surgery, on the day of draining system removal, at discharge, and at 3-month follow-up. Additional CT would be obtained if patients had deteriorated neurological conditions during this period. Antiplatelet agent was restarted at the day of discharge for the patients who had used it preoperatively.

Recurrence referred to clinical and radiographic worsening due to enlargement or reappearance of a previously treated CSDH within 3 months after the initial surgery. The recurrence rate was defined as the rate of reoperation to treat a recurrent CSDH during the time period. Functional outcome was measured by the Glasgow Outcome Scale (GOS) and modified Rankin Scale (mRS) at 3-month follow-ups. A GOS score \leq 3 and a mRS score \geq 4 were regarded as an unfavorable outcome.

Statistical Analysis

Data collected included patients' demographics, radiographic characteristics, and medical histories. The internal structure of the hematoma was classified into four types as previously described: homogenous, laminar, separate or trabecular (4,9,11). Continuous data were expressed in the mean \pm standard deviation (SD) while categorical data was described as the percentage. All statistical analyses were performed using the SPSS 16.0 for windows. The two-tailed student's *t* test, the Mann-Whitney U test, the Pearson Chi-square test, or the Fisher's exact test was used to evaluate the differences of variables, which were considered significant at $p < 0.05$.

■ RESULTS

A total of 83 patients were enrolled, with a mean age of 66 years. As shown in Table I, sixty-six male and 17 female patients were included. Among them, forty-two patients suffered from left CSDH while 41 patients had right CSDH. Thirty-eight patients received TDC and 45 patients underwent BHC treatment. There was no significant difference in age, gender, head trauma, diabetes mellitus, hypertension, antiplatelet usage, clinical manifestation, the Glasgow Coma Scale (GCS) score, and preoperative CT characteristics between the two groups of patients.

As shown in Table II, patients who received TDC treatment had a significantly shorter operating time than those who received BHC plus drainage (16.9 ± 6.3 min vs. 44.4 ± 7.1 min, $p < 0.001$). However, the draining time in TDC was longer than that in BHC (3.1 ± 1.0 d vs. 2.5 ± 0.9 d, $p = 0.003$). Head CT scans showed that both TDC and BHC significantly reduced the midline shift after surgery (6.4 ± 4.1 mm vs. 3.8 ± 2.3 mm, $p = 0.003$; 7.9 ± 4.5 mm vs. 4.1 ± 2.6 mm, $p < 0.001$ respectively). However, the degree of midline shift reversal was significantly

smaller in TDC than that in BHC (2.6 ± 2.5 mm vs. 3.9 ± 2.8 mm, $p=0.030$) although there was no significant difference in postoperative midline shift between the two groups. Moreover, BHC significantly reduced the percentage of patients with the midline shift ≥ 5 mm from 71.1% to 40.0% ($p=0.003$) while TDC reduced the percentage from 63.2% to 44.7%, showing no significant difference ($p=0.107$).

Seven patients in TDC and 5 patients in BHC had their CSDH reoccurred during the observation period, demonstrating not significant difference (18.4% vs. 11.1%, $p=0.345$). All the twelve patients received reoperation using the same technique as the initial treatment. There was no significant difference in in-hospital complications between the two groups of patients. Neither the GOS score nor the mRS score at 3-month follow-up demonstrated significant difference between them. One patient in TDC died of uncontrolled pneumonia during hospitalization.

Illustrative Case

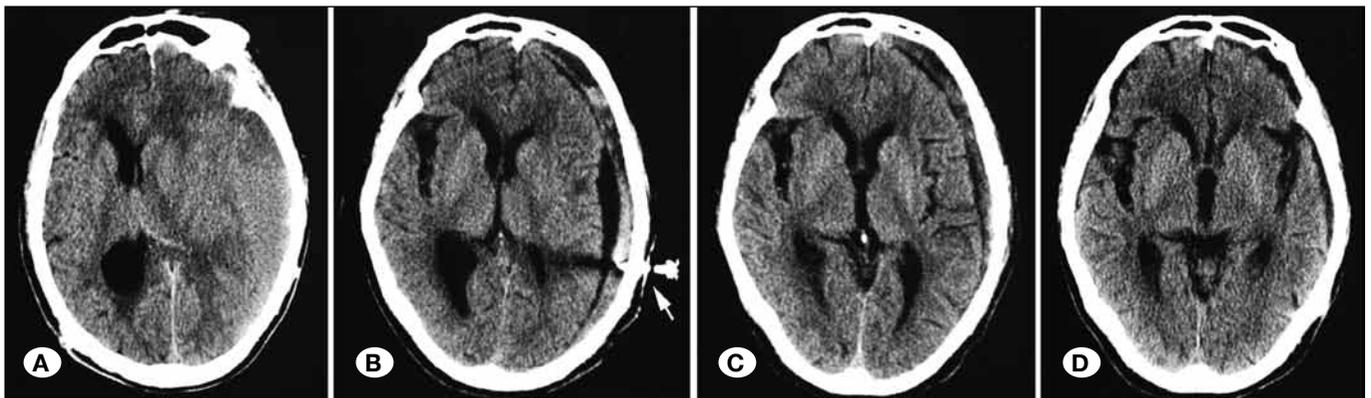
An 80-year-old male patient suffered from headache for two days and came to the emergency department. The history review showed that he had mild head trauma due to falling two weeks ago. At admission, he was stuporous, aphasic, and incontinent. His right-sided muscle strength decreased to grade 2 using the Medical Research Council Scale. The head CT displayed a large left CSDH with significant midline shift towards the opposite side (Figure 1A). He underwent an emergent surgery of TDC with drainage, and the postoperative CT scan showed remarkable reduction of the hematoma volume and subtotal reversal of the midline shift (Figure 1B). The draining volume was 300 mL in the first day and 100 mL in the second day after surgery. The draining system was removed in the third day, and the patient was discharged on the fourth day after surgery. He was alert, continent, and showed total recovery of right-sided muscle strength to grade 5. The pre-discharge CT showed the total reversal of

Table I: General Characteristics of Enrolled Patients

	All patients (n = 83)	TDC (n = 38)	BHC (n = 45)	p value
Gender, Male	66 (79.5%)	28 (73.7%)	38 (84.4%)	0.226
Age, Mean \pm SD (years)	67.7 \pm 15.6	68.2 \pm 18.5	67.3 \pm 12.9	0.803
Medical history				
Head trauma	49 (59.0%)	23 (60.5%)	26 (57.8%)	0.800
Diabetes Mellitus	9 (10.8%)	4 (10.5%)	5 (11.1%)	1.000
Hypertension	33 (39.8%)	18 (47.4%)	15 (33.3%)	0.193
Antiplatelets	12 (14.5%)	6 (15.8%)	6 (13.3%)	0.751
Preoperative GCS score				
Mean \pm SD	14.4 \pm 1.6	14.5 \pm 1.3	14.5 \pm 1.8	0.891
14-15	75 (90.4%)	34 (89.5%)	41 (91.1%)	1.000
9-13	4 (4.8%)	2 (5.3%)	2 (4.4%)	
≤ 8	4 (4.8%)	2 (5.3%)	2 (4.4%)	
Clinical manifestation				
Decreased consciousness	18 (21.7%)	9 (23.7%)	9 (20.0%)	0.685
Headache	39 (47.0%)	18 (47.4%)	21 (46.7%)	0.949
Focal neurological deficit	44 (53.0%)	23 (60.5%)	21 (46.7%)	0.208
Preoperative radiographic features				
Laterality, Left	42 (50.6%)	18 (47.4%)	24 (53.3%)	0.588
Homogenous type	39 (47.0%)	20 (52.6%)	19 (42.2%)	0.344
Laminar type	26 (31.3%)	16 (42.1%)	20 (44.4%)	0.830
Separate type	18 (21.7%)	9 (23.7%)	9 (20.0%)	0.685
Trabecular type	0	0	0	
Preoperative midline shift, (mm)				
Mean \pm SD	7.2 \pm 4.3	6.4 \pm 4.1	7.9 \pm 4.5	0.110
< 5	27 (32.5%)	14 (36.8%)	13 (28.9%)	0.441
5 - 10	33 (39.8%)	16 (42.1%)	17 (37.8%)	0.688
> 10	23 (27.7%)	8 (21.1%)	15 (33.3%)	0.213

Table II: Outcome and Complications

	TDC (n = 38)	BHC (n = 45)	p value
Operating time, (min)			
Mean ± SD	16.9 ± 6.3	44.4 ± 7.1	<0.001
Postoperative midline shift, (mm)			
Mean ± SD	3.8 ± 2.3	4.1 ± 2.6	0.666
< 5	21 (55.3%)	27 (60.0%)	0.189
5 - 10	17 (44.7%)	17 (37.8%)	0.521
> 10	0	1 (2.2%)	
Change of the midline shift, (mm)			
Mean ± SD	2.6 ± 2.5	3.9 ± 2.8	0.030
Postoperative GCS score			
Mean ± SD	14.3 ± 2.2	14.9 ± 0.3	0.106
14-15	35 (92.1%)	44 (97.8%)	0.328
9-13	2 (5.3%)	1 (2.2%)	0.591
≤ 8	1 (2.6%)	0	
Draining time, (days)			
Mean ± SD	3.1 ± 1.0	2.5 ± 0.9	0.003
In-hospital complications			
Wound infection	1 (2.6%)	0	1.000
Intracranial infection	0	1 (2.2%)	
Epilepsy	0	1 (2.2%)	
Pneumonia	1 (2.6%)	1 (2.2%)	
Mortality	1 (2.6%)	0	
Recurrence within 3 month after surgery	7 (18.4%)	5 (11.1%)	0.345
mRS score at 3-month follow-up			
Mean ± SD	1.4 ± 1.4	1.3 ± 1.1	0.633
≥ 4	2 (5.3)	1 (2.2%)	0.591
GOS score at 3-month follow-up			
Mean ± SD	4.6 ± 0.8	4.8 ± 0.4	0.197
≤ 3	2 (5.3%)	0	

**Figure 1A-D:** Computed tomography scans of the patient in the illustrative case. The arrow denotes the location of the draining needle.

the midline shift, a thin-layer of the residual hematoma, and reappearance of left insular gyri (Figure 1C). He lived independently after discharge and got a mRS score of 0 at 3-month follow-up, when the head CT scan showed total absorption of the residual hematoma (Figure 1D).

■ DISCUSSION

Since the introduction of TDC technique three decades ago (15), several studies have compared this technique with BHC in the management of CSDH, which resulted in controversial conclusions (6,8,14,17). Smely et al. first conducted a prospective study including 33 patients in TDC and 33 patients in BHC treatment, and the result showed that TDC was superior to BHC due to a low recurrence rate (18.1% vs. 33.3%), infection rate (0 vs. 18.1%), and mortality rate (6.0% vs. 9.0%)(14). After that, a retrospective study from Williams et al. found a significantly higher recurrence rate in TDC than in BHC (63.6% vs. 7.1%), hence in favor of TDC when treating the disease (17). This study showed that there was no significant difference in recurrence rate, in-hospital complications, and neurological outcome at 3-month follow-up between the patients who received TDC or BHC treatment.

In contrast to previous studies in which a draining tube was placed in the hematoma cavity when performing TDC (5,7,12,14), here we used a modified technique to do the operation. After its tip penetrated the outer membrane of the hematoma, the hollow needle autonomously fixed on the cranium and served as a tunnel for drainage. This tool waived the time spent on insertion of a draining tube, further shortening the operating time. Free from tube insertion may also minimize the possibility of subdural air collection after surgery, which is recognized as a risk factor for CSDH recurrence (10,11,13). The recurrence rate in the patients treated by this technique was 18.4% in this study, comparable to 18.1% in Smely's study and 18.2% in Horn's study in which a subdural draining tube was placed when performing TDC (7,14). The comparison between this modified TDC technique and conventional technique need to be assessed by future studies.

This study showed that patients in TDC had significantly longer draining time than those in BHC, which was consistent with the result from the study conducted by Muzii et al.(8). A longer draining time usually means a longer bedridden period for the patients, and this may raise the concerns of clinicians about postoperative complications. Elderly patients are more susceptible to complications of immobility than young patients, such as pneumonia and deep vein thrombosis. However, this study showed no significant difference in in-hospital complications between the patients in TDC and those in BHC. Further studies with a larger sample size are warranted to verify these findings.

Another positive finding in this study was that patients in TDC had a smaller degree of midline shift reversal than those in BHC. The procedure of BHC is more effective for midline shift reversal than TDC, especially for the patients with preoperative midline shift ≥ 5 mm. Noteworthy, as for the eight patients with a preoperative GCS score ≤ 13 , one (25.0%) of the four

patients in TDC and three (75.0%) of the four patients in BHC saw their GCS score improved to 14-15 after surgery. These findings may support the usage of BHC for the patients with severe midline shift (≥ 5 mm) or a lower GCS score before surgery.

Some limitations of this study should be acknowledged. This is a prospective study with a limited sample size, and therefore has sources of bias and variation. A prospective randomized controlled trial with a larger number of patients is required to verify the findings in this study. The patients enrolled in this study were also selected, which may limit extrapolation of the results in this study.

■ CONCLUSION

TDC and BHC have similar clinical outcomes in the treatment of patients with CSDH. A shorter operating time, but a smaller midline shift reversal and a longer draining time may be expected in patients after TDC than after BHC.

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