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Effects of Newly Designed Drainage Catheter in Treating Chronic Subdural Hematoma

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Objective: Chronic subdural hematoma (cSDH) is a common disorder that is readily surgically treated but has high recurrence rate. This is a preliminary report to evaluate the effectiveness of a newly designed catheter compared with the conventional one in treating cSDH.
Methods: We conducted a retrospective study of 111 patients with unilateral chronic subdural hematoma treated by burr hole craniostomy with closed-system drainage from November 2009 to September 2012. Group A was defined as patients treated with an external ventricular drainage (EVD) catheter and B as patients treated with the new catheter. We measured changes of thickness of hematoma and midline shifting in brain computed tomography (CT), amount of drainage and recurrence rate in both groups.
Results: Group A consisted of 54 and B of 57 cases. The mean duration for total removal of hematoma was 42.6±13.9 hours in group A and 30.3±11.9 hours in group B ($p<0.05$). The mean amount of drainage counted per six hours cumulatively differed significantly between groups. The result ($p<0.05$) showed that the newly designed catheter effectively removed the hematoma. The total recurrence rate in group A was 11% and 3.5% in group B.
Conclusion: The study showed that the newly designed catheter effectively removed the hematoma in less time than the conventional one. This helps re-expand the brain block CSF from flowing into the subdural space and decrease the recurrence rate.
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KEY WORDS: Chronic subdural hematoma · Recurrence · Catheter.

Introduction

Chronic subdural hematoma (cSDH) is a common neurosurgical disorder that often requires surgical intervention. cSDH has become an increasingly prevalent neurological disease encountered by a wide variety of both general and specialized health-care practitioners.[10,16] The increasing incidence of this disease underscores the need for an improved understanding of both the pathophysiology of cSDH as well as available treatment options. Although the treatment goals for cSDH are well-established, several important aspects of clinical management remain controversial.[2] cSDH is widely treated with burr hole craniostomy (BHC) with closed-system drainage.[4,8,14,15,21,22] The use of closed-system drainage after BHC is thought to decrease the recurrence rate promoting brain re-expansion.[11] The recurrence rate of cSDH is 2.7–37%.[1-3,6,8,10,13,15,19,20] Alternative techniques have been proposed to address the problem of recurrence. For example, middle meningeal artery embolization has been found efficacious for refractory chronic subdural hematoma.[17] An adjunct technique for recurrent cSDH treatment is implantation of an ommaya reservoir permitting repeated punctures and aspiration of subdural fluid.[23] The effect of elimination of the hematoma and its capsule through craniotomy and that of evacuation of hematoma and irrigation through burr hole craniostomy are under evaluation.[2,5,9,18-20] Despite these efforts to cure the disease, there isn't a single catheter made to evacuate the hematoma specifically for cSDH. The most widely used catheter for draining out hematoma is made for external

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ventricular drainage (EVD). The EVD catheter we used has eight holes within two centimeters from the tip. It is designed to have openings placed just inside the ventricle to remove CSF. However, removing a hematoma is a different matter. Hematoma, even in its chronic form, has a solid portion of crust that can influence the outflow obstructing holes and disrupting the treatment process. Therefore, it is less suitable to use EVD catheter in treating cSDH. We thought the catheter for cSDH should have more holes that are more widely spread on the body of the catheter. Based on these demands, we designed a new catheter in treating cSDH. This is a preliminary report to compare the effect of the new catheter we built in treating cSDH with the conventional one.

Materials and Methods

The new catheter (CEM tech., Hwaseong, Korea) we designed has multiple bores on silicone shaft. It has eighteen openings laterally side hole of 2 mm diameter. The holes are 7 mm apart from each other and distributed within 50 mm from the tip. Although the outer diameter of the new catheter is the same as the conventional one, 4 mm, the inner diameter is slightly larger than that of the conventional one (2.3 mm vs. 2.2 mm)(Figure 1). The catheter passed the tension test. The EVD catheter is also made of silicone but has eight holes within 15 mm from the tip. We assessed the effects on cSDH drainage and recurrence rates.

This retrospective study included 111 unilateral cSDH patients who were treated with burr hole craniostomy and closed system drainage in our institution, from November 2009 to September 2012, consecutively. Patients with organized cSDH, bilateral lesion, subacute form hematoma, mixed or septated hematoma were excluded. Burr hole craniostomies were performed at the parietal eminence with a diameter of about 2 cm. A catheters were inserted 8 cm deep from the dura aiming at glabella. No other measures such as irrigation were taken. Catheters were randomly selected when treating cSDH. Fifty four cases were grouped as A treated with the conventional EVD catheter and remaining 57 were grouped as B, which were treated with the newly designed catheter. Brain CT scans were taken one day and one week after surgery. The preoperative and postoperative thickness of hematoma and midline shifting were measured and hematoma drained from the catheter was gathered and measured every six hours and the rate of the extraction was analyzed. The rate of improvement was calculated by subtracting the initial value by the value after a day or a week and dividing it by the initial value. When there was no further drainage of hematoma through the catheter, catheter was removed. Recurrence rate was evaluated at 6 months after discharge.

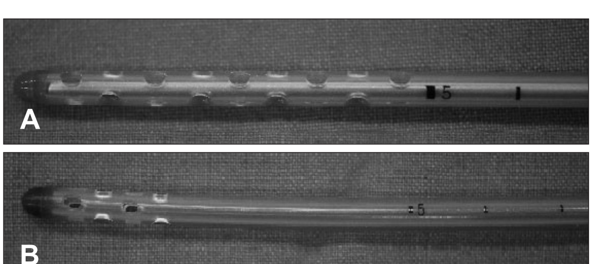

FIGURE 1. The newly designed catheter with 18 holes within 5 centimeters from the tip (A), and external ventricular drainage (EVD) catheter used to treat chronic subdural hematoma conventionally (B).

The data from these studies were statistically analyzed using analysis of covariance, *t*-test and chi-square through SPSS version 20.0 (SPSS Inc., Chicago, IL). Null hypotheses of no difference were rejected if *p*-value were less than 0.05. Analysis of covariance (ANCOVA) evaluates whether population means of a dependent variable (DV) are equal across levels of a categorical independent variable (IV), while statistically controlling for the effects of other continuous variables that are not of primary interest, known as covariates (CV). Therefore, when performing ANCOVA, we are adjusting the DV means to what they would be if all groups were equal on the CV.

Results

We retrospectively analyzed clinical and imaging data of 111 patients who were randomly assigned to one of two treatments. The mean age was 65.08 (range 6−93). There were 83 (74.7%) men with 28 (25.2%) women, and left convexity hematoma outnumbered the right side by 62 to 49. Variables such as age, sex, initial hematoma thickness and initial midline shifting in both groups were similar (Table 1). The mean amount of total drainage postoperatively in group A was 212.2 mL and in group B 174.2 mL. The total time consumed to evacuate hematoma and to remove the catheter was longer in group A 42.6±13.9 (range, 24−80) hours versus 30.3±11.9 (range, 24−60) hours in group B ($p<0.05$).

The mean preoperative maximum thickness of hematoma according to the brain CT taken was 20.59±6.37 mm in group A and 20.83±4.87 mm in group B, without significant difference. The thickness a day and a week after the operation were 9.57±3.91 mm and 9.07±4.69 mm in group A and in group B 10±4.10 mm and 8.16±3.70 mm. The improvement of the thickness over a day and a week

Table 1. Summary of the patients characteristics between two groups

Group	A	B
Number of patients	54	57
Age (y)	64	67.3
Sex (M : F)	42 : 12	41 : 6
Location (Rt : Lt)	30 : 24	19 : 38
Initial mean thickness (range)(mm)	20.59 (8–35)	20.83 (11–30)
Initial midline shift (range)(mm)	10.74 (3–20)	9.71 (0–19)
Recurrence rate (%)	11	3.5

Group A: treatment with conventional EVD catheter, group B: treatment with newly designed catheter

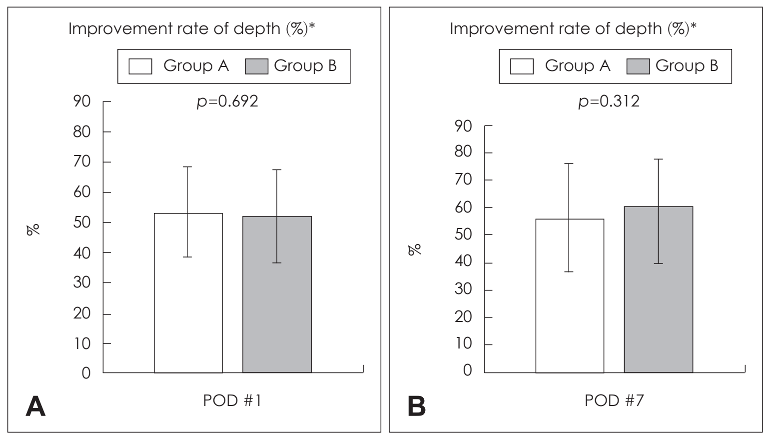

FIGURE 2. Improvement rate of maximum thickness one day (A) and one week (B) after the surgery. There is no difference between groups. *improvement rate: (1-value of 24 h after surgery/pre-operative value)×100.

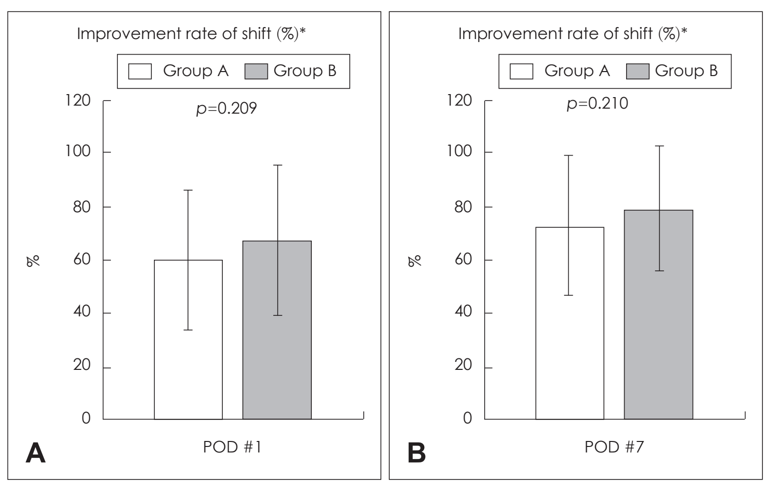

FIGURE 3. Improvement rate of midline shift one day (A) and one week (B) after the surgery. There is no difference between groups. *improvement rate: (1-value of 24 h after surgery/pre-operative value)×100.

after surgery was 53.3±15.17%, 56.13±19.79% in group A, and 52.2±15.42%, 59.78±18.14% in group B (Figure 2). The difference between two groups was not statistically significant.

The average midline shifting checked initially was 10.74 ±4.49 mm in group A and 9.71±5.18 mm in group B, without significant difference. The shifting a day and a week after the operation were 4.37±3.21 mm and 3.09±3.11 mm in group A and in group B 3.74±3.48 mm and 2.42±2.56 mm. The improvement of the shift over a day and a week after surgery was 60.8±26.51%, 72.66±26.32% in group A and 67.4±28.60%, 78.65±23.74% in group B (Figure 3). The difference between two groups was not statistically significant.

The mean cumulative amount of drainage for 6, 12 and 24 hours were 55.06±27.6 mL, 92.01±37.29 mL, 147.3±63.21 mL in group A, and 83.9±37.8 mL, 106.35±51.69 mL, 148.95±51.42 mL in group B, respectively. In addition, the ratio of accumulative amount of hematoma checked in 6, 12, 24 hours to total drainage volume were 31.1±19.17%, 49.8±20.76%, 74.6±18.51% in group A and 44.2±24.10%, 67.2%±13.65 and 88.5±2.97% in group B respectively (Fig-

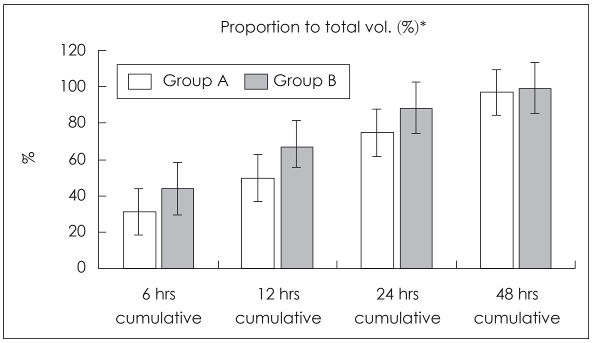

FIGURE 4. Mean cumulative amount of drainage in 6 hours ($p<0.05$), 12 hours ($p<0.05$) and 24 hours ($p<0.05$) proportion to total amount after surgery, significantly larger in group B. *proportion to total vol.: cumulative vol./total vol.×100.

ure 4). We found significant differences in cumulative drainage and in hematoma to drainage ratio at all time points, with results favoring Group B. The recurrence rate was 11% for group A versus 3.5% in group B, with borderline statistical significance.

Discussion

Chronic subdural hematoma is well known a curable disease although its mechanism of progression and recurrence not well described.[12)] The spatial proportion of the brain parenchyma declines as atrophy proceeds.[1,9)] Patients with extensive brain atrophy, such as the elderly or alcoholics, are particularly vulnerable to developing SDH, due to the increased baseline stretch of the bridging vessels. Patients maintained on chronic anticoagulation are also at increased risk for SDH.[1)] Although the mechanism for this increased risk is incompletely understood, it has been suggested that contained, asymptomatic "microbleeds" are common in elderly people and that anticoagulants impair the ability to control these bleeds, allowing progression to symptomatic hemorrhage. cSDH may evolve from a prior traumatic acute SDH, often asymptomatic, through a series of distinct pathologic processes.[6)]

Craniostomy and closed system drainage is less aggressive, takes less operation time and causes less complications than other methods of treatments.[15)] Because of its beneficial effects, it is widely used to treat cSDH. However, this method also has several disadvantages including brain parenchyma injury or neomembrane bleeding. It could also incompletely evacuate the hematoma, causing recollection.[3)] Catheter related infection and pneumocephalus are also potential problems. To address these shortcomings, attempts have been made to reduce the recurrence rate.[6,15,19)]

To the authors' knowledge, there is no report concerning the effects of the drainage catheter. Multiple bores with wider inner diameters and widely spread holes provide a larger drainage area facilitating removal of the hematoma with minimal obstruction. We think it offers significant benefits of rapid drainage of hematoma and early removal of the catheter. Effective evacuation of the hematoma allows the brain to re-expand. The other benefit of new drainage catheter is that partial withdrawal of the catheter is unnecessary.

The primary aim for the new catheter was to change the hemodynamics when draining out the hematoma. It was thought to promote the brain to re-expand better than the conventional one which would fill the vacant space and eventually decrease the recurrence rate. Although our results showed difference in the amount of hematoma drained between the groups, recovery of midline shifting did not. There are several reports published on the relationship between postoperative drainage and brain re-expansion.[11)] Fukuhara et al.,[7)] reported the relationship between brain surface elastance and brain re-expansion after evacuation of chronic subdural hematoma.[11)] Patients with an enlarged subdural space or with high age have higher elastance which delays brain re-expansion. Fibrous capsule, cerebrovascular dysfunction and degenerative brain atrophy could also affect brain re-expansion.

The recurrence rate was lower when treated with the new catheter. Although the difference was not statistically significant, the new catheter took a significantly shorter time to remove a hematoma. The amount of hematoma drained, cumulatively measured every six hours and calculated as a ratio of the amount of hematoma extracted was greater in group B. Therefore, further studies with larger sample size and a longer duration could give statistically significant results on brain re-expansion and the recurrence rate.

Conclusion

This study was conducted to verify the effect of the new catheter we have designed. The basic concept is that more holes that are more widely separated in the catheter to drain out cSDH, facilitate more rapid removal of the hematoma, promote brain re-expansion and eventually lower the recurrence rate. Although the recurrence rate showed no statistically significant difference between the groups, it would be worthwhile to extend the research for a better understanding of the effect of the newly designed catheter.

■ The authors have no financial conflicts of interest.

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