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Effect of Inner Membrane Tearing in the Treatment of Adult Chronic Subdural Hematoma: A Comparative Study

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Abstract

The postoperative results of chronic subdural hematoma (CSDH) procedures using catheterization and tearing of inner membrane (CTIM) technique have not previously been discussed in the literature. This article compares the effects of CTIM technique on brain re-expansion and re-accumulation with cases operated on with a burr-hole craniotomy and outer membrane incision (BCOMI) technique. The study involved operations on 144 patients (Group 1) using the CTIM technique and 108 patients (Group 2) using the BCOMI technique. In the operations using the CTIM technique in Group 1, the mean effusion measured in the subdural space (SDS) was 10.0 ± 0.2 mm, and for Group 2, 14.3 ± 0.6 mm in the postoperative period on the first and third days and this difference was found to be significant ($p < 0.05$). The means were 6.6 ± 0.2 mm for Group 1 and 10.3 ± 0.5 mm for Group 2 on the seventh day ($p < 0.05$). Recurrence rate was 8.3% in Group 2 and 0 in Group 1. This difference was statistically significant (p = 0001). The length of hospital stay was 7.0 ± 0.1 days for the Group 1 and 8.8 ± 0.2 days for Group 2 and this difference was significant ($p < 0.05$). These results indicate that the CTIM technique is preferable because it results in earlier re-expansion, lower recurrence, less subdural effusion and pneumocephalus, and shorter hospital stays.

Key words: chronic subdural hematoma (CSDH), inner membrane, pneumocephalus, recurrence

Introduction

Chronic subdural hematoma (CSDH) is one of the most common types of intracranial hemorrhage and carries significant morbidity.[1–4] There is no unanimity as to its optimal treatment. The annual incidence is 0.001–0.002%.[5] Re-accumulation and pneumocephalus are frequently-encountered situations that can cause problems in patients with CSDH. Many surgical variations for minimizing the risk have been tried and reported.[6–11] There is no conclusive evidence to support any specific surgical technique. Furthermore, following operations on CSDH, subdural tension pneumocephalus may develop and the patient's condition can deteriorate postoperatively.[12,13] According to the literature, various surgical techniques used in the treatment of CSDH hematomas have been compared and their effects on clinical results were discussed.[14] However, the subject of this study, clinical and radiological outcomes of the catheterization and tearing of inner membrane (CTIM) and burr-hole craniotomy and outer membrane incision (BCOMI) techniques, have not previously been compared. The purpose of this study is to compare brain re-expansion and effusions in the subdural space (SDS) during the early postoperative period of patients operated using the CTIM and BCOMI techniques.

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Materials and Methods

This was a retrospective descriptive study conducted in our hospital. The record files of 252 patients operated on for CSDH between July 2004 and August 2011 were included in the study. The surgical files and operation results of four surgeons who were using two different surgical techniques in the treatment of patients with CSDH were compared. While one surgeon from four who attended this study was performing CTIM technique (144 patients), the other three performed BCOMI technique (108 patients). The technique with which the patients were going to be operated was not determined before. This team of surgeons started work in the same hospital after completing career education with different schools of medicine. The surgeon using the CTIM method had learned the method in the course of career education and applied it routinely. The other three surgeons had learned the BCOMI technique.

Preoperative diagnosis and treatment duration were similar in both groups. Clinical laboratory tests before surgery such as full blood count, blood urea and serum electrolytes, random blood sugar, chest X-ray, and electrocardiogram were routinely carried out. All the patients with CSDH were evaluated for pre-existing medical conditions such as ischemic heart disease, hypertension, and diabetes mellitus.

Analysis was carried out on clinical data in all the 252 patients concerning personal factors, pre-and postoperative symptoms and signs, maximum thickness of hematoma, and maximum midline shift on computed tomography (CT) preoperatively. The width of effusion in the SDS and midline shift was measured on the first and third day postoperatively (on the first and the third day both measurements were averaged). These values were measured on the seventh day postoperatively again. Pneumocephalus was followed on the first, third, and seventh day postoperatively. Their hospital stay and complications of surgical treatment were recorded. For statistical analysis, the ages of patients were grouped into those who were 60 years old or younger and those older than 60 years.[14] Hygroma, infantile CSDH, and calcified or ossified CSDH were removed from the study groups because they are different clinical entities.

The pre-and postoperative Glasgow Coma Scale (GCS) for each patient were also evaluated in this study.[15] Each patient was assessed according to the neurological grading system recommended by Markwalder in the pre-and postoperative period.[7] For statistical analysis, grades 0 and 1 were classified together as "good," whereas neurological evidence of corticospinal tract involvement ("paresis" to coma), which involved grades 2 to 4, were classified as "bad."[16] Meantime, for GCS score, GCS of 12 and below were considered as bad, and GCS of more than 12 were considered as good.

The CT was taken from all the patients on admission and some of the patients also had the magnetic resonance imaging (MRI) scans. The thickness of the hematoma in the SDS was measured in the preoperative and postoperative periods (on the first, third, and seventh days). The maximum thickness of the hematoma was measured on a representative slice. The width of the hematoma was measured from the inner table of the skull perpendicular to the length of the hematoma. For bilateral hematomas, the mean thickness of the hematoma was used as the representative thickness. The midline shift was determined by measuring the distance from the midline on the axial CT scan to the midline structures such as the falx or the third ventricle (Fig. 1A, B).[17]

The density of the hematoma was evaluated according to the classification system developed by Lanksch et al.[18] for hypodense hematomas, varying density hematomas, and isodense or slightly hyperdense hematomas.

In the postoperative period the volume of drainage in the subdural area and the neurological path were noted daily. The patients in both groups remained in hospital until findings such as motor dysphasia,

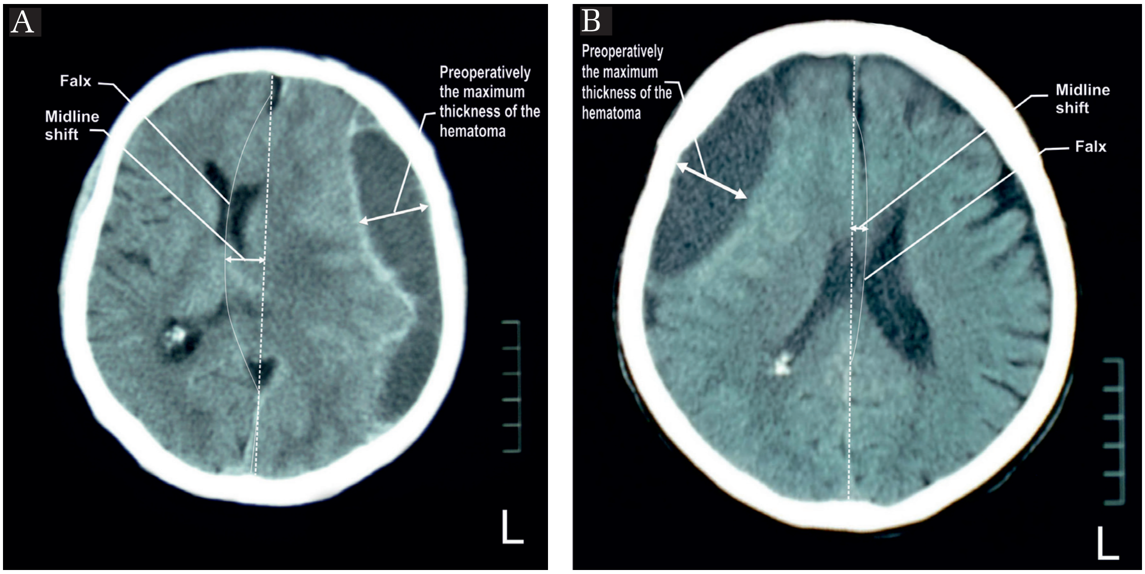

Fig. 1 A: The preoperative computed tomography (CT) scan shows left frontoparietal chronic subdural hematoma (CSDH) with prominent midline shift (Group 1). B: The preoperative CT scan shows right frontal CSDH with prominent midline shift (Group 2).

hemiparesis due to CSDH, and complaints such as headache diminished or disappeared and until effusion and pneumocephalus diminished considerably, brain re-expansion was sufficient and shift disappeared (followed by means of CT). Except for headache, the others were considered as objective criteria. While pnemocephalus developing in the postoperative period was an objective criteria, it could not be calculated by a safe method.

All of the patients in the study group were followed up at least three times within 12 months. A postoperative CT was repeated on all patients in the second month. During these follow-ups, the patients were evaluated for symptoms and signs of hematoma recurrence and any delayed postoperative complications. Any suspicion of hematoma recurrence mandated an urgent CT scan for confirmation.

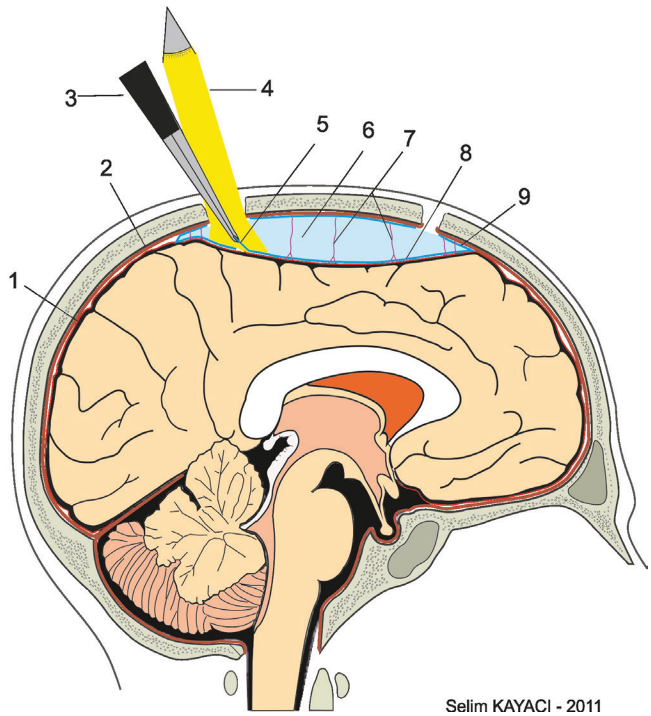

Fig. 2 Drawing shows catheterization and tearing of the inner membrane technique in adult chronic subdural hematoma (CSDH): 1-arachnoidmater, 2-duramater, 3-bipolar cautery, 4-microscope, 5-tearing of the inner membrane, 6-subdural space, 7-bridge veins, 8-inner membrane, and 9-outer membrane. (Figure drawn by Selim Kayaci, 2011)

I. Operative technique

One hundred and thirty-five patients in the Group 1 were operated under intratracheal general anesthetic (ITGA). Nine patients were operated using local anesthesia because of systemic problems that would not tolerate ITGA. The patients were operated in the supine position, in cases where the hematoma was on the right side, the head was turned to the left at a 45 degree angle, in cases the hematoma was on the left side, the head was turned to the right at a 45 degree angle. Two burr-holes were opened when the patient had a one-sided hematoma and three or four burr-holes were opened when the patient had a bilateral hematoma. The burr-hole in the posterior parietal was enlarged with a kerrison rongeur (Ferris-smith-kerrison, P 430.02, 3 mm Bahadir, Samsun, Turkey). The durameter was burnt using a bipolar cautery, it was incised and opened, entering through the burr-hole in the frontal and posterior parietal. The edges of the durameter were coagulated on the edges of the burr-hole. The outer membrane of the SDH was opened and emptied using a number 15 scalpel. A nelaton rubber catheter No. 14 (size CH 14) (Bicakcilar, Istanbul, Turkey) was inserted and the subdural cavity was irrigated using normal saline. Irrigation continued until the color of the fluid became clear. The surgical microscope was pulled into the field and the cortex was seen through the back parietal burr-hole. Entry was made through the burr-hole in the posterior parietal and by using the bipolar cautery the inner membrane was catheterized. The inner membrane was lifted by using a handle and 3 to 5 cm were torn (Fig. 2). After SDS irrigation was completed, the tip of nelaton catheter was inserted at the posterior parietal burrhole in both groups, and the proximal tip catheter was directed towards front and down (fronto-temporal) 5–7 cm and left in SDS. SDS was filled with physiological saline (PS) and it was taken into a closed drainage system. Ninety patients in Group 2 were operated under ITGA in the same way. In this group, 18 patients were operated using local anesthesia because of systemic problems that would not tolerate ITGA. Burr-holes were opened in the frontal and parietal and the durameter was passed in the same way. The outer membrane was opened and the hematoma was drained. The cavity was irrigated, filled with normal saline, and was taken into a closed drainage system. In both groups, the catheter of closed drainage system was externed from posterior parietal burr-hole, and fixed at the level approximately 10 cm below the head of the patient. The drain was removed on the first and third day of the postoperative period in Group 1 and on the second and fifth days in Group 2.

II. Statistical analysis

Data entry and analysis were done using SPSS 18.0 for Windows software (Current name: PASW 18 statistics; IBM, New York, USA). The results were presented as frequencies and means. To compare two surgical groups the means of GCS, the hematoma thickness (mm), the midline shift (mm) and the hospital stay, Mann-Whitney U test, and independent samples *t*-test were used. Wilcoxon matched-pairs signed-rank test was used to compare the means of hematoma thickness within each group. Personal or medical differences between the patients operated with CTIM and BCOMI techniques in Group 1 or Group 2 were analyzed by univariate analysis (Chi square and McNemar tests). Pre-and postoperative grade changes were compared with the McNemar test. We compared the recurrence rates between the groups with Yates corrected chi-square test. Differences were considered as significant when the probability value was less than 0.05. All values were expressed as mean ± standard deviation (SD).

Results

The personal, medical, and radiologic characteristics of the patients in the two different operation technique groups were similarly distributed as seen in Table 1. The CTIM technique was applied to 144 patients in Group 1, consisting of 117 males and 27 females aged between 44 years and 93 years (mean: 68.8 ± 1.5). The BCOMI technique was applied on 108 patients in Group 2, 78 male, 30 female ages varying between 48 years and 85 years (mean: 67.6 ± 1.4). The male-to-female ratio was 4.3/1 in Group 1 and 3.5/1 in Group 2.

In Group 1 a history of moderate or mild head trauma was found in 102 (70.9%) patients. No cause was found in 42 patients (29.2%). In Group 2 there was a history of moderate or mild head trauma in 84 patients (77.7%) and no cause was found in 24 patients (22.3%) (Table 1). In the Group 1 the interval from trauma to appearance of clinical symptoms was 18–180 (mean: 26.7 days) and in Group 2 the interval was 14–160 (mean 27.2 days). For Group 1 the interval was less than 20 days for 45.8% of the patients, 21–30 days for 43.8%, and more than 30 days for 10.4%. The interval for Group 2 was less than 20 days for 44.4% of the patients, 21–30 days for 38.9%, and more than 30 days for 16.7% (Table 1).

The age distribution showed the highest peak of incidence at the sixth followed by the seventh decade. In Group 1, 138 (94.4%) of the patients were over 60 years old. In Group 2, 84 (77.7%) patients were over 60 years old. Six patients (5.6%) in the Group 1 and 24 patients (22.3%) in the Group 2 were 60 years old or younger. Although the number of patients below 60 years old was more in Group 2 than Group 1, this was not statistically significant (Table 1). Age distribution in both groups were already similar. In Group 1 there were 51 patients (35.4%) with pre-existing medical conditions and in Group 2 there were 39 patients (36.1%) (Table 1). Hypertension, diabetes mellitus, and ischemic heart disease comprised most cases in both groups with 60 (23.8%), 54 (21.4%), and 42 (16.6%), respectively. Some of the patients had more than one pre-existing medical condition. Predisposing factors included alcohol abuse (18 patients) and the administration of anticoagulant or antiagregant therapy (12 patients). The patients in both groups presented with similar complaints: changes in behavior, headaches, weakness in one side, faltering while walking, confused consciousness, speech disorders, and urinary incontinence. The most common symptoms discovered during neurological examination were cognitive deficiencies (64%), hemiparesis (46%), and motor dysphasia (24%).

Table 1 Medical and personal characteristics of patients in the two groups

Variable	CTIM (n [%])	BCOMI (n [%])	Chi-square (p)
Gender			
Male	117 (81.3)	78 (72.2)	0.328
Female	27 (18.7)	30 (27.8)	
Age			
< 60 years	6 (5.6)	24 (22.3)	0.72
≥ 60 years	138 (94.4)	84 (77.7)	
Etiology			
Head injury	102 (70.8)	84 (77.7)	0.824
Unknown	42 (29.2)	24 (22.3)	
Medical illness			
Absent	93 (64.6)	69 (63.9)	0.948
Present	51 (35.4)	39 (36.1)	
Site of hematoma			
Unilateral	126 (87.5)	96 (88.9)	0.846
Bilateral	18 (12.5)	12 (11.1)	
Types of CSDH			
Hypodens	84 (58.3)	69 (63.9)	0.829
Isodens	48 (33.3)	33 (30.6)	
Slightly hyperdens	12 (8.3)	6 (5.6)	
Interval (days)			
≤ 20	22 (45.8)	16 (44.4)	0.691
21–30	21 (43.8)	14 (38.9)	
> 30	5 (10.4)	6 (16.7)	

BCOMI: burr-hole craniotomy and outer membrane incision, CTIM: catheterization and tearing of inner membrane, CSDH: chronic subdural hematoma.

In the study, 222 patients (88%) had unilateral CSDH, whereas only 30 (12%) had bilateral CSDHs, making a total of 267 hematomas treated with subdural drainage (Table 1). Of the 222 patients, 126 had right-sided lesions (56.7%) and 96 patients (43.3%) had left-sided lesions. In Group 1, the CT scan revealed that the hematoma were hypodense in 84 patients (58%), isodense in 48 patients (33.3%), and slightly hyperdense in 12 patients (8.3%). In Group 2 the hematoma were hypodense in 69 patients (63.9%), isodense in 33 patients (30.6%), and slightly hyperdense in six patients (5.6%) (Table 1).

Mean pre- and postoperative surgical characteristics of patients according to the surgical techniques used are shown in Table 2. The width of effusion in SDS in Group 1 on the first and third day of the postoperative period was 10.0 ± 0.2 mm (range: 8–14 mm) and the width of effusion in SDS in Group 2 on the first and third day of the postoperative period was 14.3 ± 0.6 mm (range: 11–20 mm) (Fig. 3A, B). The width of effusion was remeasured after the seventh day of the postoperative period for Group 1 and Group 2. The results were 6.6 ± 0.2 mm (range: 4–11 mm) for Group 1 and 10.3 ± 0.5 mm (range: 7–14 mm) for Group 2 as shown in Table 2. This difference was statistically significant ($p < 0.05$). However, by the end of the 60th day there was no difference between the two groups.

Associated midline shift was present in 222 patients. The midline shift present for 126 patients in Group 1 ranged from 4 to 22 mm with a mean of 15.4 ± 1.0 mm, and for 96 patients in the Group 2 ranged from 6 to 22 mm with a mean of 15.7 ± 1.2 mm (Table 2).

In the postoperative period the shift on the first and third day was 6.2 ± 0.4 mm (range: 4.4–10.2 mm) for Group 1 and 9.1 ± 0.7 mm (range: 6.2–14.4 mm) for Group 2. In the postoperative period the shift on the seventh day was 3.5 ± 0.3 mm (range: 2.8–6.2 mm) for Group 1 and 7.0 ± 0.6 mm (range: 4.4–9.6 mm) for Group 2 (Table 2). On the first, third, and seventh day postoperatively, the shift in Group 1 diminished more clearly than in Group 2 (Table 2). This difference was statistically significant ($p < 0.05$). In Group 1, in 12 patients with hyperdense hematoma, subdural effusion on the first and third days were 12.2 ± 0.4 mm (range: 10–16 mm) in postoperative period and on the seventh day it was 6.4 ± 0.3 mm (range: 6–14 mm). In Group 2, these values were 12.4 ± 0.6 mm (range: 9–16 mm) and 8.6 ± 0.2 mm (range: 8–16 mm), respectively.

Patients in Group 1 were discharged between the sixth and eighth day (mean 7.0 ± 0.1 days) of the postoperative period whereas the patients in Group 2 were discharged between the seventh and eleventh day (mean 8.8 ± 0.2 days) of the postoperative period. The hospital stay in Group 1 was shorter than the stay in Group 2 and this difference was statistically significant ($p < 0.05$) as shown in Table 2.

Patients with CSDH were scored using both GCS and Markwalder neurological grading system. The

Table 2 Mean pre- and postoperative surgical characteristics of patients according to the surgical technique used

Variable	Mean ± SEM		Statistical test	p
	CTIM (n = 144)	BCOMI (n = 108)		
Hematoma thickness (mm)*				
Preoperative	27.5 ± 0.5	25.9 ± 0.6	Mann-Whitney U	0.053
Postoperative 1–3 days	10.0 ± 0.2	14.3 ± 0.6	Mann-Whitney U	0.001
Postoperative 7th day	6.6 ± 0.2	10.3 ± 0.5	Mann-Whitney U	0.001
Midline shift (mm)*				
Preoperative	15.4 ± 1.0	15.7 ± 1.2	Independent samples *t*-test	0.673
Postoperative 1–3 days	6.2 ± 0.4	9.1 ± 0.7	Mann-Whitney U	0.001
Postoperative 7th day	3.5 ± 0.3	7.0 ± 0.6	Mann-Whitney U	0.001
Hospital stay (days)*	7.0 ± 0.1	8.8 ± 0.2	Mann-Whitney U	0.001
Recurrence (%)**				
Yes	0 (0.0)	9 (8.3)	Yates corrected Chi-square test	0.001
No	144 (100.0)	99 (91.7)		

*$p < 0.05$, Wilcoxon matched-pairs signed-rank test, **$p = 0.001$, Yates corrected chi-square test. BCOMI: burr-hole craniotomy and outer membrane incision, CTIM: catheterization and tearing of inner membrane, SEM: standard error of mean.

purpose was to evaluate the severity of injury and to provide comparison of outcomes before and after the surgical treatment. In the preoperative period, 114 of the patients (79.2%) in Group 1 scored above 12 on the GCS and 30 (20.8%) scored below 12. In Group 2, 90 patients (83.3%) scored above 12 and 18 patients (16.7%) scored below 12. On the first and third day of the postoperative period, 132 of the patients in Group 1 showed significant improvement on the GCS and 12 patients remained the same. In Group 2, 90 patients showed clear signs of recovery while 18 stayed the same.

When evaluated according to the Markwalder system, in Group 1 there were 84 patients (58.3%) at grade 1, 42 patients (29.1%) at grade 2, 12 patients (8.3%) at grade 3, and 6 patients (4.15%) at grade 4 on admittance. In Group 2, 60 patients (55.5%) were at grade 1, 30 (27.7%) were at grade 2, 12 (11.1%) were at grade 3, and 6 (5.5%) were at grade 4 on admittance. There were no grade 0 patients in this study because all the patients in the sample group were symptomatic, requiring surgical drainage.

The difference in the improvement of patients in Group 1 was statistically significant ($p < 0.05$) pre-and postoperative period. Preoperatively 58.3% of the patients in Group 1 were classified as "good" and 41.7% were classified as "bad." Between the first and third day, 91.7% of the patients became "good" and 8.3% were "bad." On the seventh day all of the patients were "good" (Table 3). For Group 2 the difference was also statistically significant ($p < 0.05$). Preoperatively 52.8% of the patients were classified as "good" and 47.2% were as "bad." Between the first and third day, 83.3% of the patients became "good" and 16.7% were still "bad." On the seventh day, 8.3% of the patients were still in a "bad" condition (Table 3).

Clinical results in the post-operative period according to personal and medical characteristics of patients are summarized in Table 4. No relationship was found between postoperative clinical recovery and gender, age, state of medical illness, whether the hematoma was unilateral or bilateral ($p > 0.05$). All the patients with GCS above 12 preoperatively showed clinical recovery postoperatively, but only 37.5% with GCS below 12 showed clinical recovery ($p < 0.05$). Those whose grading was "good" according to the Markwalder grading system in the preoperative period were all classified as "good" postoperatively. Of those who were "bad" preoperatively 73% were found to be "good" postoperatively ($p < 0.05$).

The drain in the SDS of 22% patients was removed on postoperative day 1 in Group 1. Very little hemorrhage was seen (30–40 cc/24 hours). In these patients, brain re-expansion was very good in control CT and subdural effusion was very little. Drain was removed from 78% of patients on postoperative day 3. In those patients 300–400 cc/day xanthochromic fluid (blood mixed with CSF) in their drain bag was noted. The color of fluid was quite clear on the postoperative day 3. Hemorrahage from bridging veins stopped and the drain was removed. The drain was removed in 24%

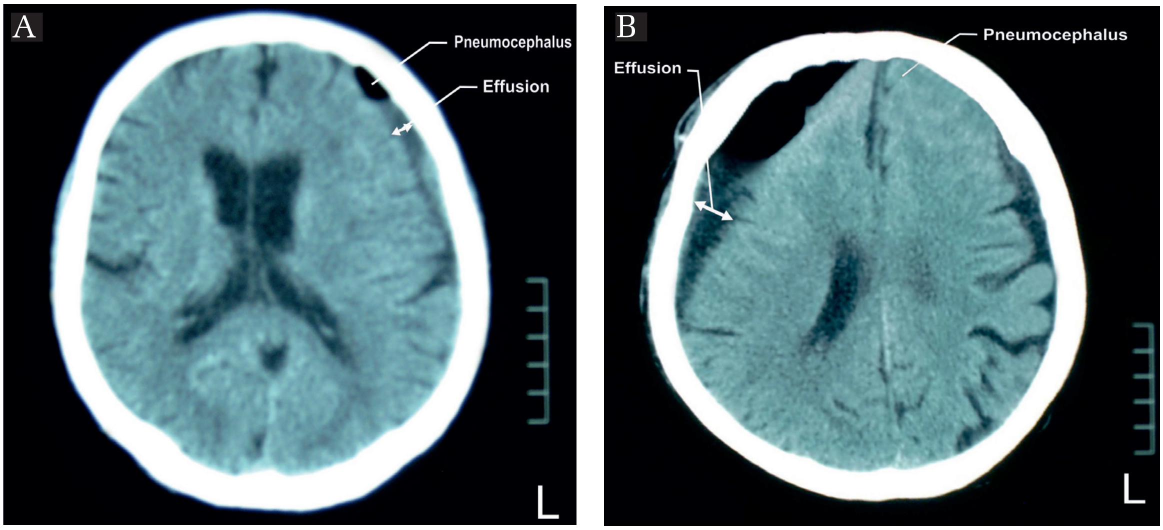

Fig. 3 A: The CT scan obtained two days after surgery shows good re-expansion of the brain (with CTIM technique). B: The CT scan obtained two days after surgery shows insufficient re-expansion of the brain. There is prominent pneumocephalus (with BCOMI technique). CT: computed tomography, CTIM: catheterization and tearing of inner membrane, BCOMI: burr-hole craniotomy and outer membrane incision.

Table 3 Comparison of pre-and postoperative conditions of patients in the two groups according to Markwalder neurological grading system*

		Postoperative 1–3 days			McNemar p
	Preoperative	Good (n[%])	Bad (n[%])	Total (n[%])	
Group I	Good	84 (100.0)	0 (0.0)	84 (58.3)	0.001
	Bad	48 (80.0)	12 (20.0)	60 (41.7)	
	Total	132 (91.7)	12 (8.3)	144 (100.0)	
		Postoperative 1–3 days			
	Preoperative	Good (n[%])	Bad (n[%])	Total (n[%])	
Group II	Good	57 (100.0)	0 (0.0)	57 (52.8)	0 001
	Bad	33 (64.7)	18 (35.3)	51 (47.2)	
	Total	90 (83.3)	18 (16.7)	108 (91.7)	
		Postoperative 7th day			
	Preoperative	Good (n[%])	Bad (n[%])	Total (n[%])	
Group II	Good	57 (100.0)	0 (0.0)	57 (52.8)	0.001
	Bad	42 (82.4)	9 (17.6)	51 (47.2)	
	Total	99 (91.7)	93 (8.3)	108 (91.7)	

*Because all patients in Group 1 were in a good condition on the seventh day postoperatively their data are not presented in the table.

of patients in Group 2 on second postoperative day. In these patients 40–50 cc/day hemorrhage from drain was noted. Because there was sufficient re-expansion and because hemorrhage from bridging veins stopped, drain was removed. In 76% of patients, 350–450 cc/day xanthochromic fluid was collected in the drain bag. The color of fluid gradually cleared at the end of fifth day, and the drain was removed.

A Tapping (Tap) was performed on 12 patients (8.3%) in Group 1 on the third and sixth day of the postoperative period because there was excessive pneumocephalus and subdural effusion. In this group no re-operation was performed. Tap was performed on 24 patients (22.2%) in Group 2 on the third, fifth, and seventh day of the postoperative period because the effusion built up again and there was excessive pneumocephalus. But, persistent subdural effusion and insufficient brain re-expansion was seen in 9 patients (8.3%) in this group and these patients were accepted as recurrence, and craniotomy was performed. There was statistically significant difference ($p = 0.001$).

Discussion

The treatment of CSDH is a debated topic. Putnam and Cushing,[19] suggest craniotomy and removal of the outer membrane. For many years craniotomy has been accepted as the optimal technique in the treatment of CSDH despite a high surgical mortality rate of 30%. Nowadays, however, it is rarely used except in the cases of recurrent hematomas and solid hematomas. In 1981, Markwalder[7] identified indications for craniotomies as: (a) re-accumulation of subdural collection; (b) the existence of a solid hematoma; or (c) the closing of the SDS and insufficient brain expansion. Nowadays closed drainage with burr-hole trepanation is frequently used procedure in the treatment of CSDH.[2]

CSDH have a tendency to occur in the elderly population and medical problems are common in this group. Death and recurrence are more commonly caused by accompanying condition complications or the poor clinical state of the patient pre-operatively than by surgical incompetence complications. In our study 35.4% of the patients in Group 1 and 36.1% of the patients in Group 2 had medical problems such as hypertension, diabetes mellitus, and ischemic heart disease. In Group 1, 94.4% of the patients were over 60 years old. Ten patients (6.9%) over 75 had more than one medical problem. In Group 2, 77.7% of the patients were over 60 and 8 patients (7.4%) over 75 had more than one medical problem. Postoperative recovery was worse in patients over 75 and with more than one medical problem. Thus

Table 4 Clinical results in the postoperative period according to personal and medical characteristics of patients

Variable	Outcome		Chi-square (p)
	Good (n [%])	Bad or no change (n[%])	
Sex			
Male	174 (89.2)	21 (10.8)	0.552
Female	48 (84.2)	9 (15.8)	
Age			
< 60 years	33 (91.7)	3 (8.3)	0.680
≥ 60 years	189 (87.5)	27 (12.5)	
Preoperative GCS			
> 12	204 (100.0)	0 (0.0)	0.001
≤ 12	18 (37.5)	30 (62.5)	
Medical illness			
Absent	144 (88.9)	18 (11.1)	0.763
Present	78 (86.7)	12 (13.3)	
Site of hematoma			
Unilateral	195 (87.8)	27 (12.2)	0.843
Bilateral	27 (90.9)	3 (10.0)	
Types of CSDH			
Hypodens	132 (86.3)	21 (13.7)	0.610
Isodens	72 (88.9)	9 (11.1)	
Slightly hyperdens	18 (100.0)	0 (0.0)	
Types of procedure			
CTIM	114 (79.2)	30 (20.8)	0.243
BCOMI	90 (83.3)	18 (16.7)	
Preoperative Markwalder grade*			
Good	141 (100.0)	0 (0.0)	0.001
Bad	81 (73.0)	30 (27.0)	

*McNemar test. BCOMI: burr-hole craniotomy and outer membrane incision, CSDH: chronic subdural hematoma, CTIM: catheterization and tearing of inner membrane.

18 patients with multiple medical problems between the ages of 75 and 93 did not expand sufficiently in the postoperative period. A Tap was carried out due to shift and extensive pneumocephalus. The same was done for 24 patients in the same condition in Group 2. Because persistent subdural effusion, pneumocephalus and shift continued in nine of these, a craniotomy was performed and inner membrane resection was conducted.

The recurrence and pathogenesis of CSDH are still a topic for debate and some uncertainty continues. The theory that is most widely accepted is that the hematoma is a result of repeated bleeding in the outer membrane of the hematoma.[20] It has been reported that five major risk factors are influencing recurrence CSDH after surgery: (1) hematoma density, (2) the location of the catheter tip, (3) presence of postoperative intracranial air, (4) intracranial hematoma extension, and (5) hematoma width.[2] In another study, it has been suggested that the main reason for the development of recurrence is poor brain re-expansion abilities.[1]

Because brain re-expansion ability was insufficient, after the hematoma was removed the buffer effect of the brain was also removed, so potential space for the hematoma to re-accumulate formed.[21] In addition this space is a potential area for air to accumulate. Many writers have maintained that SDS should be pre-emptively filled with liquid after emptying of hematoma.[15,20] In this study, the subdural cavity of the patients in Groups 1 and 2 was irrigated thoroughly, filled with PS and taken into a closed system drainage following the draining of hematoma.

In the postoperative period, in the case of Group 2, CSF drainage with subdural effusion occurred as in the case in Group 1. How did it happen? It is understood that, from the study of Haines et al.[22] performed at the electron microscopic level, there is passage between subdural and subarachnoid space in patients with CSDH and hygromas. In order to exist, there must be a microscopic level rupture in arachnoid membrane. Drainage of CSF to SDS in patients operated by BCOMI technique may be explained by this rupture of arachnoid membrane. This passage may increase with nelatone drain's tearing of arachnoid membrane during irrigation of SDS. In our study, no extra or more outflow of CSF from the drain was observed in the cases of Group 1.

Many studies have discussed the importance of the outer and inner membranes in recurrence. Putnam and Cushing propose craniotomy and excision of these membranes to prevent recurrence.[19] However, the excision of the membrane still carries high mortality and morbidity. There is a risk for local brain herniation through inner membranectomy even in adult patients.[23] In this study, in no case who were operated with CTIM technique, local brain herniation was developed. We believe that in order to prevent recurrence, CTIM technique can be an alternative to membranectomy.

In this study no recurrence occurred in Group 1 and this differs from the findings of other authors.[24–27] Markwalder found that, among the patients on whom they performed burr-hole craniotomies and closed system drainage, 78% of the cases presented with persistent subdural collection.[7] Nakaguchi et al. stated that residual air volume would decrease in the frontal position with drainage and in this way it could be protected from CSDH recurrence.[28] Mori suggested that recurrence in the SDS could be decreased by the cavity being filled with PS after the hematoma had been drained to stop air entry to the SDS.[29] In this study, in both groups the subdural cavity was filled with PS following the emptying and irrigation of the subdural cavity. All the patients were monitored in the frontal position in the post-operative period.

The rate of pneumocephalus in postoperative period in Zakaraia et al. study was 40%.[14] In this study the rate of pneumocephalus in the postoperative period was 28.6% in Group 1 and 38.8% in Group 2. Because brain re-expansion in the postoperative period was better in Group 1, only 12 patients (8.3%) developed excessive pneumocephalus and after Tap they had sufficiently improved by the seventh day. Because of excessive pneumocephalus Tap was performed on 24 (22%) patients in Group 2.

CSDHs have different visual aspects that make them easy to define in cranial CTs. The image may be of low, slight, or high density according to brain parenchyma.[17,23] Many studies was found that the incidence of CSDH recurrence in the high-density and mixed-density groups was significantly higher than that in the low-density and iso-density groups.[17,23,30,31] In our study, in the cases with high-density hematoma, subdural effusion was found more than cases with the low-density and iso-density in postoperative period.

We believe this result is also connected with the fact that by manipulating the inner membrane the integrity of the arachnoid mater was also compromised and so the impact of these membranes that act as barriers to brain re-expansion was also removed. The manipulation of the inner membrane may be considered risky or invasive. During the procedure, cortical vessels may be damaged and intracerebral hemorrhage may be formed. However, the probability of such a serious complication can be minimized if the procedure is performed carefully under a surgical microscope, in a 2–3 mm area where there are no cortical vessels. Hence, in this study, no complication was seen pertaining to the procedure.

In the removal of catheter in the SDS, the decolourization of fluid (xanthochromy: blood mixed with CSF) coming from catheter is an indicator. Because this means that the leakage coming from bridging veins was lessened or stopped. However, this is not sole indicator. At the same time, control CTs were obtained from every patient, the degree of re-expansion, effusion, shift, and pneumocephalus were noted. There was insufficient re-expansion, but in the cases where xanthochromic fluid comes from the drain, we removed the catheter again. Because, in these cases, hemorrhage from bridging veins lessened or stopped. The insufficient brain re-expansion was related to poor brain compliance. Because brain re-expansion was earlier and subdural effusion was less in the postoperative period in Group 1, catheter in SDS was removed earlier. Therefore, hospital stay in this group was shorter.

In the treatment of CSDH determining the thickness of the inner and outer membrane before surgery with the MRI is instructive for a membranectomy.[32] In our batch the inner membrane could not be resected completely and was ripped 3 to 5 cm and so it lost its integrity. Consequently it was not deemed necessary to measure the thickness of the inner membrane during preoperative MRI.

The CTIM technique is not new. However, the CTIM and BCOMI techniques used in the treatment of CSDH have not previously been compared in relation to differences in postoperative clinical and radiological results (neurological status, postoperative effusion, time spent in hospital due to recurrence, shift, and pneumocephalus). The CTIM technique can be physiologically accepted when the tightness of the extracerebral space and the development of CSDH in the older people are taken into account. Because the barrier in the brain is lifted after the arachnoid mater is ripped alongside the inner membrane of the hematoma in this technique, it is thought that re-expansion is easier.

At the end of 2 months, there were no differences between groups in terms of subdural effusion, pneumocephalus, and midline shift. However, the main subject that was wanted to be stressed was that by providing faster brain re-expansion with CTIM technique, less pneumocephalus, and effusion in the early postoperative period occurred. In these patients, it was possible to remove the drain in the SDS earlier. Thus, earlier mobilization of older patients and those who had multi medical problems were possible to be observed and also it was possible to shorten their duration of hospital stay. Furthermore, this is significant in terms of preventing new problems that might occur in longer hospital stay.

Conclusion

The CTIM technique is a preferable method in the treatment of CSDH because the brain re-expands earlier in the postoperative period, and in relation to this there is lower recurrence rate, less subdural effusion and pneumocephalus, and shorter hospital stay.

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Conflicts of Interest Disclosure

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