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A Comparison of Subgaleal Active Drainage and Subdural Passive Drainage and an Analysis of Factors Affecting Chronic Subdural Hematoma Outcomes

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ABSTRACT

AIM: To analyze and to compare the factors that influence the recurrence of chronic subdural hematoma (CSDH) among patients treated with subdural non-suction-assisted passive drainage, subgaleal suction-assisted active drainage, and without drainage.

MATERIAL and METHODS: We retrospectively evaluated 87 surgical patients with a diagnosis of CSDH treated between 2007 and 2018 using patient records from the neurosurgery archive of our faculty. The patients were divided into three groups: drain-free group (group A), subdural passive drainage group (group B), and subgaleal active drainage group (group C). Recurrence was defined as an increase in hematoma volume on imaging and persistence of the patient's symptoms.

RESULTS: Patients with double-membrane CSDH exhibited higher recurrence rates (p=0.043) and those with low-density CSDH exhibited lower recurrence rates (p=0.015) compared to the other patients. No relationship was found between the number of burr holes made and CSDH recurrence (p=0.177). Group C showed the lowest recurrence rate (13.3%), but the differences between groups were not statistically significant.

CONCLUSION: Hematoma density, membrane type, postoperative Glasgow Outcome Scale scores, and postoperative drainage time were found to be statistically significant predictors of recurrence. Burr-hole craniotomy with subgaleal active drainage is a safe and effective method for preventing CSDH recurrence and carries a reduced risk of parenchymal injury.

KEYWORDS: Recurrence, Hematoma density, Subdural drain, Subgaleal drain

ABBREVIATIONS: APTT: Activated partial thromboplastin time, **ASDH:** Acute subdural hematoma, **BHC:** Burr-hole craniostomy, **CSDH:** Chronic subdural hematoma, **CT:** Computedtomography, **TDC:** Twist-drill craniostomy, **GOS:** Glasgow Outcome Scale, **INR:** International normalized ratio

INTRODUCTION

Chronic subdural hematoma (CSDH) is a form of intracranial bleeding frequently encountered in neurosurgery (5,37). In Finland, the incidence of CSDH is 17.6 per 100,000 and this rate has increased to 129.5 per 100,000 in those aged >80 years (33). CSDH is predicted to become the most frequently encountered adult cranial pathology in clinical practice by 2030 (4). CSDH is often the consequence of

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a head trauma that causes rupture of the bridging veins (14). However, with the widespread use of anticoagulant and antiaggregant drugs, CSDH can also be detected in patients without a history of trauma (41). Advanced age, excessive alcohol consumption, epilepsy, hemodialysis, and bleeding diathesis are among the other important risk factors (44). The exact mechanism of CSDH has not yet been clarified. However, two possibilities have been proposed in the literature. The first of these is the maturation of a prior asymptomatic trauma-induced acute subdural hematoma due to tearing of the neocapillaries formed after the primary hematoma. The second is the transformation of a previous subdural hygroma due to repeated microhemorrhaging of fragile neovessels (23,24).

Surgery is the widely accepted treatment for patients with symptomatic CSDH (6). Patients diagnosed with CSDH undergo various surgical treatments, such as percutaneous twist-drill and burr-hole craniostomy (BHC) as well as craniotomy of various sizes (1). BHC is the most frequently used technique in the treatment of CSDH (11). Craniotomies are reserved for calcified subdural hematoma or CSDH with multiple membranes due to their higher mortality and recurrence rates than burr-hole and twist-drill craniotomies (TDC) (26,34). Recurrence is a major problem in patients with CSDH, and recurrence rates of up to 33% have been reported (7). In the last 20 years, postoperative drain insertion in the cavity after BHC has becomea widely used method owing to its reduction of the risk of recurrence (8,40,42,45). Several studies have investigated the factors that contribute to the recurrence of CSDH. The recurrence rates and morbidities of different surgical techniques with the use of subgaleal and subdural drains have also been studied (12,45). Recently, BHC followed by passive (without suction) subdural drainage has become the most commonly selected surgical approach and is accepted as a safe and useful technique (2,12). Burr-hole trepanation followed by active subgaleal drainage (suction-assisted) is also used for evacuation of CSDH and is similarly regarded as an effective treatment modality (36).

In this study, we analyzed the factors that influence the recurrence of CSDH and compared these among patients treated with subdural non-suction-assisted passive drainage, subgaleal suction-assisted active drainage, and without drainage.

MATERIAL and METHODS

Patients

Eighty-seven patients treated surgically for a diagnosis of CSDH between 2007 and 2018 at the Faculty of Medicine of Istanbul University were evaluated retrospectively using patient records from the neurosurgery archive of our faculty. The Ethics Committee approval for this study was obtained from Istanbul University Istanbul Medical Faculty, Istanbul, Turkey (Approval no/Date: 911-28/06/2019). Patient data collected included sex, age, trauma history, comorbidities, anticoagulant or antiaggregant use, postoperative Glasgow Outcome Scale (GOS) scores, and GOS scores at the last follow-up, computed tomography (CT) findings regarding hematoma density (low-density, isodensity, or mixed-density), whether the hematoma was unilateral or bilateral, the type of membrane (single, double, or multiple layers), the preoperative and postoperative midline shift, the number of burr holes made during surgery, whether a drain was inserted, and, if so, the type of drain used. The patients were divided into a drain-free group (group A), a subdural passive drainage group (group B), and a subgaleal active drainage group (group C). In the Radiology Unit, control CT scans were performed on each patient to locate the drain and assess possible complications. Immediately after the operation, a control cranial CT was performed to check the drain position and rule out any postoperative hemorrhage. Three- and six-month control CT scans were also performed. Recurrence was defined as an increase in hematoma volume on control imaging and persistence of the patient's symptoms.

Surgical Procedure

Surgery was postponed for patients using antiplatelet or anticoagulant medication or when the results of coagulation studies were abnormal. These patients underwent immediate surgery if there were signs of neurological deterioration and they were treated with fresh frozen plasma, apheresis thrombocyte, or vitamin K. In patients without neurological deficits, surgery was performed after the values of coagulation parameters were restored to normal.

Informed consent to the procedure was obtained from all patients. All patients underwent BHC under local anesthesia induced with 10 mL lidocaine HCl 10% (Aritmal, Osel Ilac Sanayi ve Ticaret A.S. Istanbul, Turkey) injected subperiosteally and subcutaneously. Intravenous sedation with 15 mg/^{3} mL midazolam (Dormicum; Deva Holding A.S, Istanbul, Turkey) was used only in nervous patients.

After a scalp incision, periosteal cutting by cautery was performed and a single- or double-burr-hole trepanation with a 1.5 cm diameter was made according to the CT hematoma findings. After dural coagulation with a bipolar coagulator, a durotomy was performed in a cruciate fashion using a no. 11 scalpel, and a dural flap was sealed to the edges of the burr-hole with the bipolar coagulator. Drainage of the subdural space with irrigation was performed with warm saline. For patients in the subgaleal drain group, a 7 mm Jackson Pratt flat drain was introduced into the subgaleal space (Figure 1). Mild suction was applied and active drainage was maintained for 24–48 hours postoperatively, depending on the amount of fluid. In the subdural drain group, an external ventricular drainage catheter (Medtronic, Minneapolis, Minnesota, USA) was inserted into the subdural space, and passive drainage without suction was maintained for 24–48 hours (Figure 2). Particular caution was taken not to injure the inner membrane of the hematoma or brain. After hemostasis and wound closure, each patient was transferred to the intensive care unit or inpatient service, depending on their general condition.

Radiological Evaluation

Based on CT findings, hematomas were classified as comprising single, double, or multiple layers. CSDH was classified by the number of layers covering the cortex and by

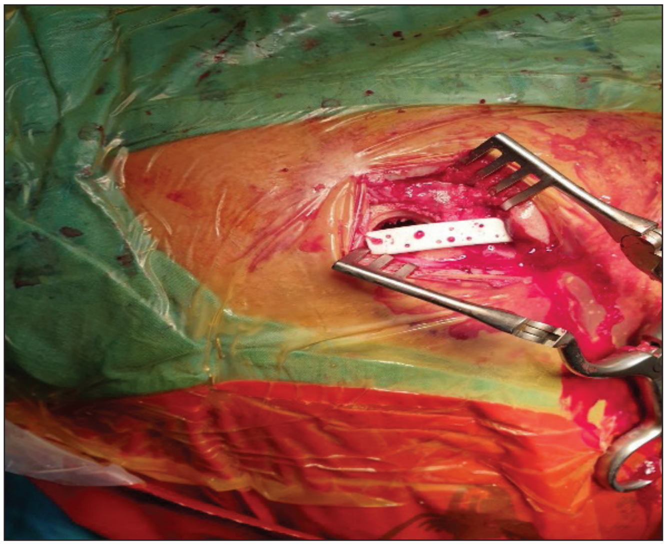

Figure 1: Immediate postoperative view of a subgaleal drain in a patient with chronic subdural hematoma.

Figure 2: Immediate postoperative view of a subdural drain in a patient with chronic subdural hematoma.

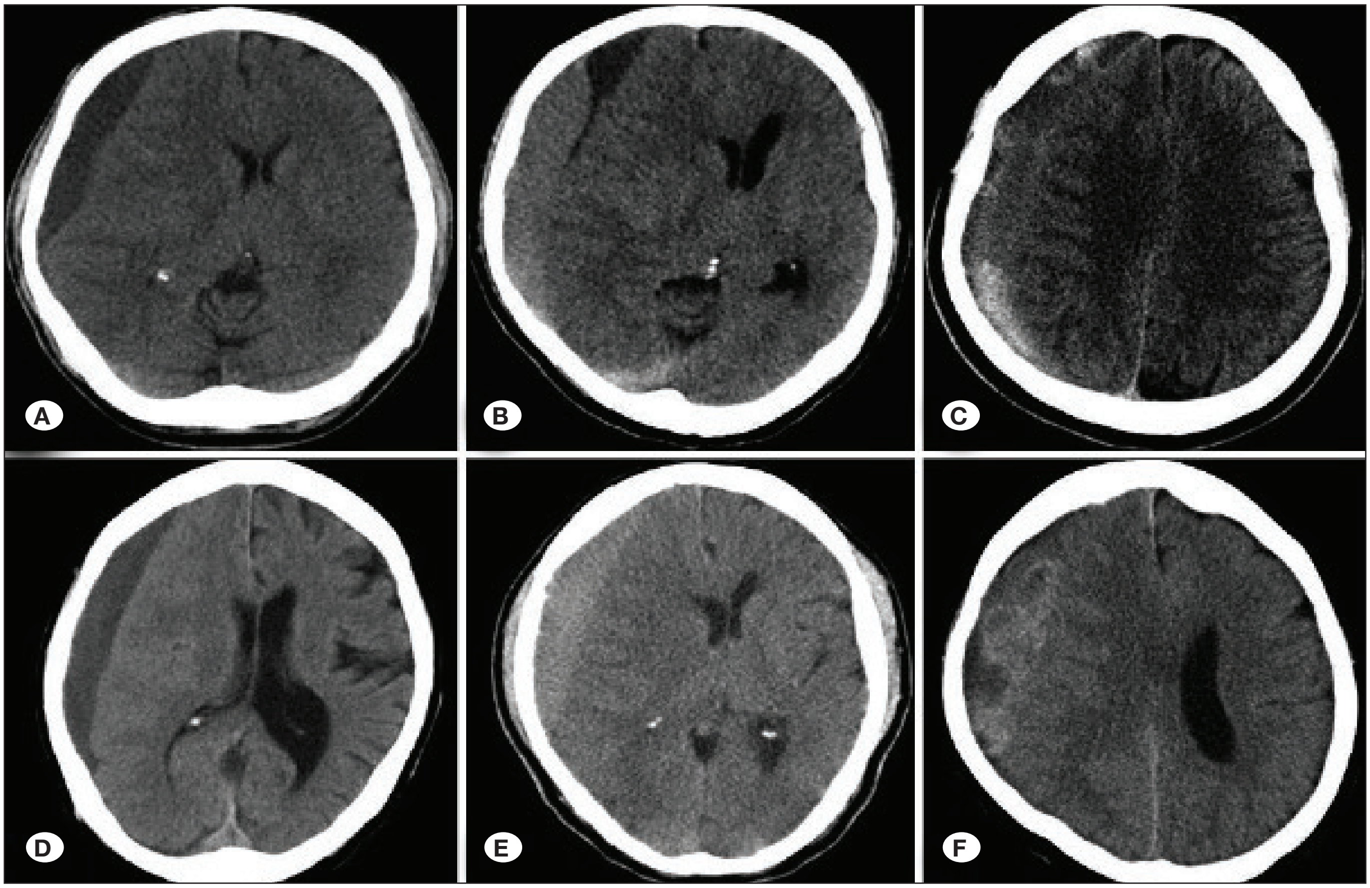

Figure 3: Characteristic CT images of hematomas. **A)** single-membrane hematoma; **B)** double-membrane hematoma; **C)** multiple-membrane hematoma; **D)** low-density hematoma; **E)** isodensity hematoma; **F)** mixed-density hematoma.

the density of the hematomas (isodensity, low-density, and mixed-density) (Figure 3A-F) (20,21).

Other variables included in our analyses were the degree of midline shift, hematoma thickness, and the site of the hematoma. Midline shift was measured as the distance from the septum pellucidum point between the anterior horns of the lateral ventricles to a perpendicular line connecting the anterior and posterior insertions of the falx cerebri (38). Hematoma thickness was defined as the maximal thickness of the hematoma on the upper level of the lateral ventricle.

Statistical Analysis

Data distribution was determined using a z-test of kurtosis and skewness. Normally distributed quantitative data were presented as mean ± standard deviation and non-normally distributed quantitative data as median and range. Qualitative data were presented as the number and percentage of cases. The Mann–Whitney *U* test was applied tonon-normally distributed data and the student's *t*-test to normally distributed data. Multivariate binary logistic regression analyses were performed to determine the strength of the variables to predict the recurrence of CSDH. All statistical analyses were conducted using the SPSS (Statistical Package for the Social Sciences) software for Windows v.15.0 (SPSS Inc; Chicago, IL, USA).

RESULTS

Patient Population and Demographics

Our study sample comprised 58 men (66.7%) and 29 women (33.3%), and the mean age was 72.16 ± 13.48 years (Table I). In group A, there were 52 patients, of whom, 33 (63.4%) were male and 19 (36.6%) female. In group B, there were 20 patients, 13 (65%) male and 7 (35%) female. In group C, there were 15 patients, 12 (80%) male and 3 (20%) female. The mean follow-up time was 14.87 ± 3.65 months.

Comorbidities

Of the 87 patients, 49 (56.32%) suffered from hypertension, 48 (55.17%) from diabetes mellitus, and 17 (19.54%) from hyperlipidemia. Ten (11.49%) patients had a history of chronic renal disease, and 23 (26.44%) patients had cardiac diseases. Statistical analysis found no relationship between any of these comorbidities and the recurrence of CSDH.

Complications

In group A, two (3.85%) patients were diagnosed with meningitis and one patient (1.92%) who had a cardiovascular comorbidity was found to have had a stroke. In group B, meningitis was detected in one patient (5%) and subdural empyema in another (5%). Appropriate antibiotic treatments were started and patients were later discharged from the hospital uneventfully. In group C, two patients (13.33%) were diagnosed with pneumocephalus. Both these patients showed neurological deterioration, but one underwent simple aspiration of air using a syringe, while in the other, an intravenous catheter was introduced into the air cavity through a burr-hole and connected to an underwater-seal drainage system. On control CT imaging, pneumocephalus was found to be resorbed.The patient was later discharged uneventfully.

Distribution of Patients According to Pre- and Postoperative Glasgow Outcome Scale Scores

The mean preoperative GOS score of group A patients was 4.34 and their mean score at the last follow-up was 4.73. The mean preoperative GOS score of group B patients was 3.95 and their mean at the last follow-up was 4.95. In group C, the mean preoperative GOS score was 4.06, and that at the last follow-up was 4.8. The mean preoperative GOS score for the entire patient sample was 3.80 and 4.35 at the last follow-up. The relationship between recurrence and pre- and postoperative GOS scores was investigated. A postoperative GOS score of ≤3 was significantly correlated with an increased likelihood of recurrence, which was 2.5 times greater for those with GOS ≤3 than those with GOS >3 (p=0.001; odds ratio: 2.5, 95% confidence interval: 1.5–9.4).

Distribution of Patients According to Hematoma and Membrane Types

The patients were evaluated according to their CT characteristics. In group A, 37 (71.15%) patients had a single-membrane, 11 (21.15%) had a double-membrane, and 4 (7.7%) had multiple-membranes. In group B, 10 (50%) and 10 (50%) patients had a single and a double-membrane, respectively. In group C, eight (53.3%) and seven (46.7%) patients had a single and a double-membrane, respectively.

Of the entire sample, 50 patients (57.47%) had mixed-density, 23 (26.43%) had low-density, and 14 (16.1%) had isodensity CSDH. In group A, 13 patients (25%) had low-density hematomas, 9 (17.3%) had isodensity hematomas, and 30 (57.7%) had mixed hematomas. In group B, 4 patients (20%) had low-density hematomas, 3 (15%) had isodensity hematomas, and 13 (65%) had mixed-density hematomas. In group C, 7 patients (46.7%) had low-density hematomas, 1 (6.6%) had an isodensity hematoma, and 7 (46.7%) had mixed-density hematomas.

Predictive Values in Remission

In the total sample, 20 (22.9%) of the 87 patients suffered recurrence. In group A, 14 (26.9%) of the 52 patients; in group B, 4 (20%) of the 20 patients; and in group C, 2 (13.3%) of the 15 patients suffered recurrence and underwent reoperation. Group C had the lowest recurrence rate of 13.3%. However, the difference in recurrence rates between groups was not significant (p=0.632).

In the recurrent CSDH group, 8 (40%), 11 (55%), and 1 (5%) patients had single-, double-, and multiple-membrane subdural hematomas. The recurrence rate was significantly higher in patients with a double membrane than those with single or multiple-membrane hematomas (p=0.043) (Figure 4).

In the total sample, 50 patients (57.47%) had mixed-density CSDH, 23 (26.43%) had low-density CSDH, and 14 (16.1%) had isodensity CSDH. In the recurrent group, 2 (10%) of the 20 patients had low-density CSDH, 4 (20%) had isodensity CSDH, and 14 (70%) had mixed-density CSDH (Table II).

The patients with low-density CSDH had significantly lower recurrence rates than the other patients (p=0.015) (Figure 5).

In the recurrent group, 5 patients (83.3%) who underwent BHC followed by drainage had the drain removed in <24 hours, and 1 (16.7%) in >24 hours. Recurrence rates were significantly higher in patients who underwent <24 hours of drainage than in those who underwent >24 hours of drainage (p=0.044). When the entire patient population was evaluated, 11 (12.64%) and 76 (87.36%) patients had midline shifts >10 mm and <10 mm, respectively.

In the recurrent CSDH group, 11 (55%) and 9 (45%) patients had midline shifts of <10 mm and >10 mm, respectively. The direction and quantity of the midline shift were not significantly related to recurrence (p=0.405).

In the whole patient population, 7 (0.08%), 59 (67.81%), and 21 (32.11%) patients underwent 1, 2, and ≥3 BHC,

Table I: Characteristics of Patients

	Group A Non-Drainage	**Group B Subdural Drain**	**Group C Subgaleal Drain**	**p**
Number of patients	52	20	15	
Age +- SD	72 +- 14.08	74 +- 9.5	70 +- 16.2	0.774
Sex, n (%) male/female	33/19 (63/37)	13/7 (65/35)	12/3 (80/20)	0.689
Hypertension, n (%) present/absent	27/25 (52/48)	13/7 (65/35)	9/6 (60/40)	0.576
Diabetus Mellitus, n (%) present/absent	13/39 (25/75)	7/13 (35/65)	6/9 (40/60)	0.455
Hyperlipidemia, n (%) present/absent	10/42 (19/81)	4/16 (20/80)	3/12 (20/80)	0.996
Cardiac disease, n (%) present/absent	16/36 (31/69)	6/14 (30/70)	3/12 (20/80)	0.381
Chronic renal failure, n (%) present/absent	4/48 (8/92)	6/14 (30/70)	0	0.009
Antiaggregant use, n (%) present/absent	12/40 (23/77)	5/15 (25/75)	5/10 (33/67)	0.723
Anticoagulant use, n (%) present/absent	7/45 (13/87)	2/18 (10/90)	0/15	0.320
Hematoma type 1, n (%)				
Single-membrane	37 (71)	10 (50)	8 (53)	0.023
Double-membrane	11 (21)	10 (50)	7 (47)	0.006
Multiple-membrane	4 (8)	0	0	0.616
Hematoma type 2, n (%)				
Low density	13 (25)	4 (20)	7 (47)	0.282
Isodensity	9 (17)	3 (15)	1 (6)	0.290
Mixed density	30 (58)	13 (65)	7 (47)	0.413
Midline shift direction, n (%) right/left/absent	9/11/32 (17/21/62)	4/2/14 (20/10/70)	4/2/9 (27/13/60)	0.750
Midline Shift, n (%) <10 mm/>10 mm	13/39 (25/75)	15/5 (75/25)	14/1 (93/7)	0.575
Trauma, n (%) Present/Absent	41/11 (79/21)	14/6 (70/30)	14/1 (93/7)	0.239
Burr-hole number 1/2/3/4	7 /35/5/5	1/15/1/3	1/9/1/4	0.924

Table II: Predictive Factors of the Recurrence

Factors	p
Low density hematoma	0.015*
Double-membrane	0.043*
Postoperative drainage time	0.044*
Midline shift	0.405
Burr-hole number	0.177
Postoperative GOS	0.001*
History of anticoagulant use	0.640
History of antiplatelet use	0.581

***Statistical Method:** Multivariate Logistic Regression Analysis.*
**Statistically significant.*

respectively. No significant relationship was found between the number of burr holes made and CSDH recurrence. The result was statistically significant (p=0.177).

DISCUSSION

CSDH is relatively common in older patients and is one of the most frequently encountered pathologies in the field of neurosurgery (3,5). At present, surgical management is the primary treatment for symptomatic CSDH, with satisfactory outcomes in most patients (10). Cure, complication, and recurrence rates vary between the three main surgical modalities: TDC, BHC, and craniotomy. BHC is frequently performed as a safer and more effective alternative to craniotomy for the management

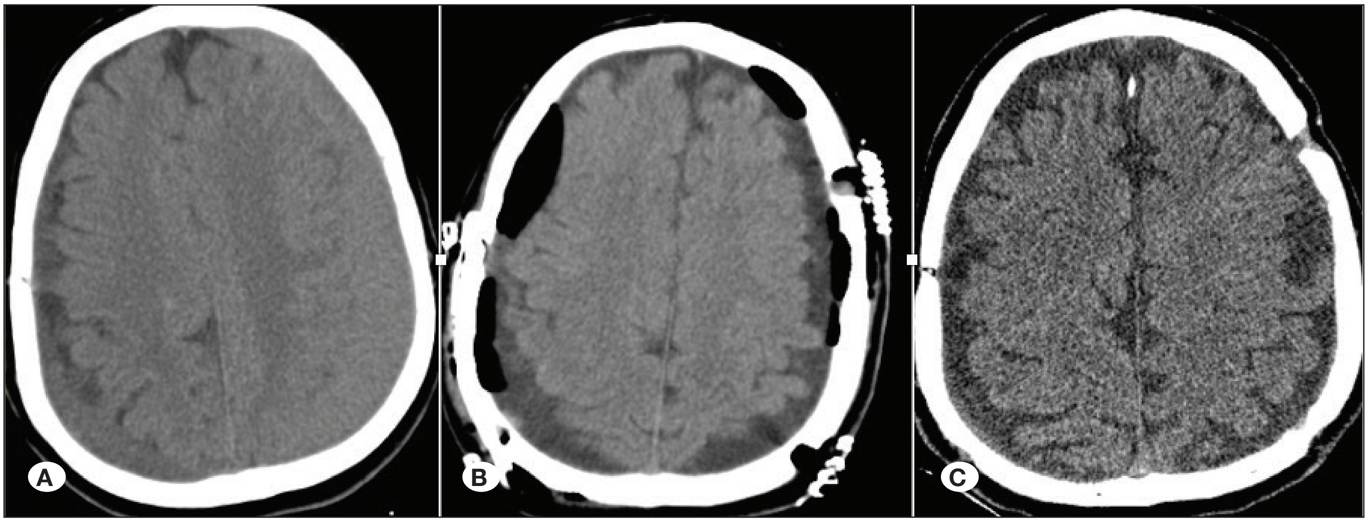

Figure 4: A 70-year-old patient with bilateral frontoparietal CSDH and a history of trauma and anticoagulant use underwent BHC followed by subgaleal active drainage. **A)** Preoperative CT image showing single-membrane isodensity CSDH. **B)** Immediate postoperative CT image. **C)** Six-month postoperative CT image. **BHC:** Burr-hole craniostomy; **CSDH:** Chronic subdural hematoma; **CT:** Computed tomography.

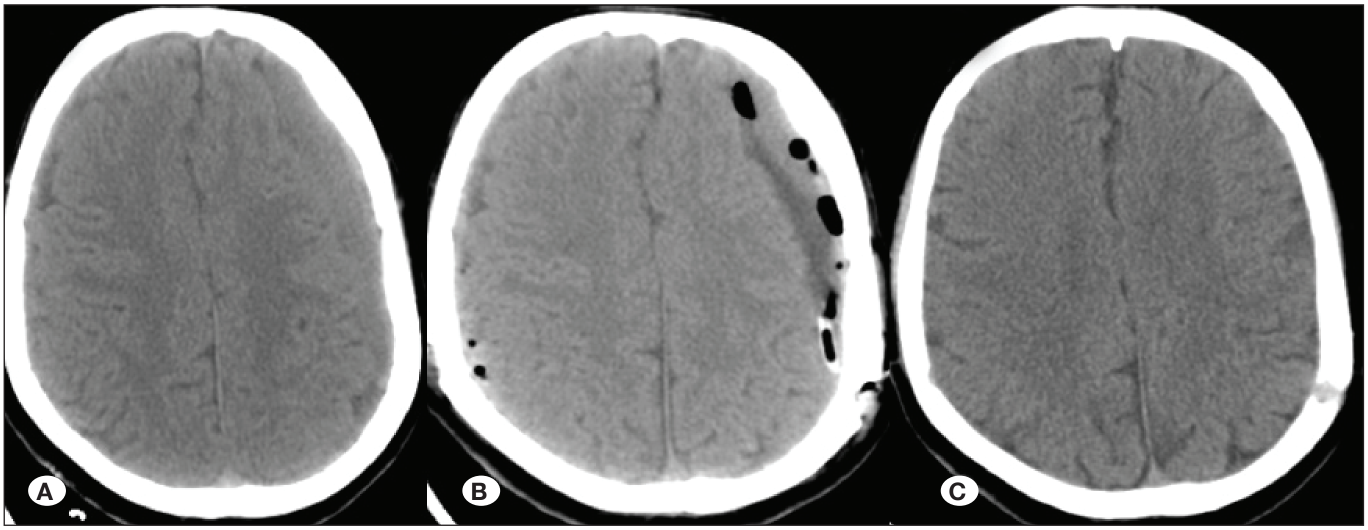

Figure 5: A 74-year-old patient with left CHSD withahistory of trauma and hypertension underwent BHC followed by subdural passive drainage. **A)** Preoperative CT image showing single-membrane isodensity CSDH **B)** Immediate postoperative CT image. **C)** Six-month postoperative CT image. **BHC:** Burr-hole craniostomy; **CSDH:** Chronic subdural hematoma; **CT:** Computed tomography.

of CSDH (29) and is the favored surgical option (7). However, some studies recommend TDC over BHC, particularly for older patients with comorbidities (19,22,39).

BHC followed by drainage is a widely accepted treatment for CSDH owing to the lower risk of recurrence (25,27,28). There have been various studies on the use of subgaleal and subdural drains with different surgical techniques. Gazzeri et al. conducted a retrospective study of 234 patients with CSDH who underwent BHC and received a subgaleal suction drainage into the cavity after the evacuation of the hematoma. The results revealed that 17 patients (7.6%) required reoperation for CSDH recurrence, and 3 developed postoperative complications (12). Soleman et al. conducted a randomized clinical trial of 220 patients and found that the mean recurrence rate in patients given a subperiosteal drain was lower than that in patients given a subdural drain (37). Sjåvik reported recurrence rates in 1,260 patients with CSDH who underwent BHC in three centers. The recurrence rates in patients who received continuous postoperative drainage and irrigation, suction-assisted active subgaleal drainage, and non-suction-assisted passive subdural drainage cohorts were compared and the subgaleal active drainage group showed the lowest recurrence rate (36). In addition, a meta-analysis that included 3,149 patients from 10 studies also concluded that subgaleal drainage is an effective surgical option owing to it resulting in lower recurrence rates (43). Further, a study of 86 patients with CHSD reported that single burr-hole irrigation and aspiration with continuous closed subdural drainage resulted in a lower recurrence rate than single burr-hole irrigation with subdural drainage (31).

In the present study, we found a lower recurrence rate in the active subgaleal drain group than in the subdural passive drainage and non-drainage groups, consistent with previous studies. However, while the subgaleal active drainage group had the lowest recurrence rate, the result was not statistically significant. The smaller number of patients in the subgaleal and subdural drainage cohorts than in the non-drainage cohort was a limitation of this study. We believe that statistical significance would be achieved with a larger subgaleal or subdural drainage patient cohort in future studies.

In the active subgaleal drainage group, two patients developed pneumocephalus. One of these showed neurological deterioration and tension pneumocephalus on a control CT scan. Simple aspiration of air using a syringe was performed. In the other patient, neurological examination showed no deterioration and the pneumocephalus was found to have resorbed on control CT imaging.

We posit that, if the subgaleal Jackson Pratt drain is not sutured tightly enough to the skin and the perforated part of the drain is close to the skin surface, airmayenter the intracranial compartment. This may also occur when negative pressure is applied by squeezing the subgaleal drain after the operation to create suction.

Various studies favor the use of subdural drains for CSDH. Aprospective cohort study demonstrated that subdural drains decrease recurrence rates and the need for reoperation (13). Another study found that subdural drainage of CSDH decreases the risk of recurrence without significantly increasing the risk of complications (32). Although subdural drainage decreases the risk of recurrence, the use of a subdural drain also carries risks and can be related to complications such as acute hemorrhage, tension pneumocephalus, parenchymal injury, and subdural empyema (9,15,16,17,30,37). Postoperative CT findings in a case of CSDH using a subdural external ventricular drainage catheter with irrigation for the first time demonstrated a decrease in subdural fluid volume and midline shift (40).

In our subdural drainage group of 20 patients, we used a Medtronic external ventricular subdural drainage catheter without irrigation. We used ventricular drainage catheters because they are made of silicone, so are soft and pliable. This minimizes the risk of trauma to cerebral tissue, and the incidence of parenchymal injury and hemorrhage. No parenchymal injury or hemorrhage occurred in our subdural drain patient group.

The optimum postoperative drainage time has been debated in the literature. A randomized clinical trial of 420 patients investigated the relationship between postoperative drainage time and CSDH recurrence and found no significant difference in the recurrence rate between patients that received passive subdural drainage of CSDH for 24 hours and those that received it for 48 hours (18). In contrast, Sindouet al. reported higher complication rates in patients that received drainage for 96 hours than those that received it for 48 hours (35). In the present study, patients with postoperative drainage times <24 hours showed significantly higher recurrence rates than those with postoperative drainage times >24 hours ($p=0.044$).

Two studies have found significantly higher recurrence rates in CSDH patients with isodense and single-membrane CSDH (20,38). A side from these, however, there has been little research on the effect of membrane type on CSDH recurrence rates. In the present study, we also compared recurrence in patients according to the membrane type and density of CSDH. Contrary to the findings of the previous two studies, patients with double-membrane CSDH had significantly higher recurrence rates than the other patients ($p=0.043$). In addition, the patients with low-density CSDH had significantly lower recurrence rates than those with iso- and mixed-density CSDH ($p=0.015$).

CONCLUSION

Postoperative drainage in patients with CSDH reduces recurrence rates, and drain placement in the subgaleal area is preferred because of its low mortality and recurrence rates. The results of our study indicate that membrane types and hematoma density data from preoperative radiological images can be used to predict the likelihood of CSDH recurrence. Unlike other studies, we found that patients with double-membrane hematomas had higher recurrence rates than those with single-membrane hematomas.

We found that hematoma density, membrane type, postoperative GOS score, and postoperative drainage time are significant predictors of CSDH recurrence. BHC with subgaleal active drainage can be recommended as a safe and effective treatment for patients with CSDH owing to its lower recurrence rate. Subdural drainage after BHC with an external ventricular drain may be used to lower the risk of parenchymal injury as the drain is soft and pliable silicone. More studies with larger patient groups are warranted to support these findings.

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■ AUTHORSHIP CONTRIBUTION

Study conception and design: UO, KTH, AA

Data collection: UO, KTH, PAS

Analysis and interpretation of results: UO, AA, TCU, YA

Draft manuscript preparation: UO, EK, ID

Critical revision of the article: KTH, PAS

Other (study supervision, fundings, materials, etc...): ID, EK

All authors (UO, ID, TCU, PAS, AA, YA, AA, EK, KTH) reviewed the results and approved the final version of the manuscript.

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