Transition of a Clinical Practice to Use of Subdural Drains after Burr Hole Evacuation of Chronic Subdural Hematoma: The Helsinki Experience

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BACKGROUND: **A number of randomized controlled trials have shown the benefit of drain placement in the operative treatment of chronic subdural hematoma (CSDH); however, few reports have described real-life results after adoption of drain placement into clinical practice. We report the results following a change in practice at Helsinki University Hospital from no drain to subdural drain (SD) placement after burr hole craniostomy for CSDH.**

METHODS: **We conducted a retrospective observational study of consecutive patients undergoing burr hole craniostomy for CSDH. We compared outcomes between a 6-month period when SD placement was arbitrary (July–December 2015) and a period when SD placement for 48 hours was routine (July–December 2017). Our primary outcome of interest was recurrence of CSDH necessitating reoperation within 6 months. Patient outcomes, infections, and other complications were assessed as well.**

RESULTS: **A total of 161 patients were included, comprising 71 (44%) in the drain group and 90 (56%) in the non-drain group. There were no significant differences in age, comorbidities, history of trauma, or use of antithrombotic agents between the 2 groups ($P > 0.05$ for all). Recurrence within 6 months occurred in 18% of patients in the non-drain group, compared with 6% in the drain group (odds ratio, 0.28; 95% confidence interval, 0.09–0.87; $P = 0.028$). There were no differences in neurologic outcomes ($P = 0.72$), mortality ($P = 0.55$), infection rate ($P = 0.96$), or other complications ($P = 0.20$).**

CONCLUSIONS: **The change in practice from no drain to use of an SD after burr hole craniostomy for CSDH effectively reduced the 6-month recurrence rate with no effect on patient outcomes, infections, or other complications.**

INTRODUCTION

The incidence of chronic subdural hematoma (CSDH) ranges from 1.7 to 18 per 100,000 population. In patients age >65 years, this rate increases to 58 per 100,000, making CSDH one of the most common neurosurgical conditions.[1,2] Most physicians would agree that nonsurgical treatment is recommended for asymptomatic patients with a small CSDH.[3] For symptomatic CSDH, burr hole evacuation has become the most preferred treatment method,[4,5] producing rapid resolution of symptoms with a short duration of hospitalization. Other surgical options, such as the use of 2 burr holes, twist drill craniostomy, and even craniotomy in selected patient populations, are also available to treat CSDH.[2,3]

To date, there is a lack of consensus regarding the optimal surgical technique.[6] Even among Scandinavian centers, surgical techniques differ.[7] Reported recurrence rates vary from 3% to 33% and may depend on both treatment- and patient-related factors.[8-11] Numerous studies have indicated that the recurrence rate is most effectively reduced by placement of either a subdural drain (SD) or a subgaleal drain.[12-16] In a randomized controlled trial (RCT) reported by Santarius et al,[16] the placement of an SD after burr hole evacuation reduced the rate of CSDH recurrence from 24% to 9%.

Key words
- Burr hole
- Chronic subdural hematoma
- Drain
- Neurosurgery
- Recurrence
- Subdural drain
- Surgery

Abbreviations and Acronyms
CI: Confidence interval
CSDH: Chronic subdural hematoma
CT: Computed tomography
EHR: Electronic health record
MRI: Magnetic resonance imaging
mRS: Modified Rankin Scale
OR: Odds ratio
RCT: Randomized controlled trial
SD: Subdural drain

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Citation: World Neurosurg. (2019) 129:e614-e626. https://doi.org/10.1016/j.wneu.2019.05.230

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

Although the use of an SD has been reported to reduce recurrence rates, some studies still dispute this conclusion.[11,17] The analysis of numerous questionnaire surveys points to an evidence–practice gap in the use of drains, because not all neurosurgeons place them regularly.[4,18-22] Despite reported evidence supporting the benefits of drain placement, drain use in routine practice at the Department of Neurosurgery of Helsinki University Hospital was arbitrary until April 1, 2017, when consistent management of CSDH with an SD was established in our clinic.

Owing to the stricter inclusion and exclusion criteria of RCTs, the benefits of drain use as shown by such trials might not necessarily reflect the realities of the clinical setting.[23] Nonetheless, there remains a need for real-life observational studies to confirm the data from RCTs.[24] Thus, in the present study, we aimed to assess whether the change in clinical practice to incorporate the routine use of SDs has resulted in a lower recurrence rate. Specifically, our primary goal was to confirm whether patients treated with postoperative drains experienced lower recurrence rates compared with those who did not receive drains. The secondary aim was to compare the changes in hematoma size, complications, and patient outcomes between the 2 groups.

MATERIALS AND METHODS

Ethical Considerations

The Ethics Committee of Helsinki University Hospital approved this study and waived the requirement for informed consent (HUS 1799/2018).

Study Setting and Data Collection

On April 1, 2017, the use of an SD after burr hole craniostomy for CSDH evacuation became routine practice at our clinic. Thus, to assess the effect of SD use on 6-month recurrence risk, we chose time periods to represent the pre-drain era (July–December 2015) and the drain era (July–December 2017). During these periods, we assessed all patients who underwent surgery for CSDH at the Department of Neurosurgery of Helsinki University Hospital. The non-drain group included patients from the pre-drain era, and from this group, we excluded all patients treated with a drain. The SD group included patients from the drain era, and from this group, we excluded those not treated with an SD and also those treated with a type of drain other than an SD. We also excluded patients who had undergone previous intracranial surgery for any reason, as well as those with shunts for cerebrospinal fluid

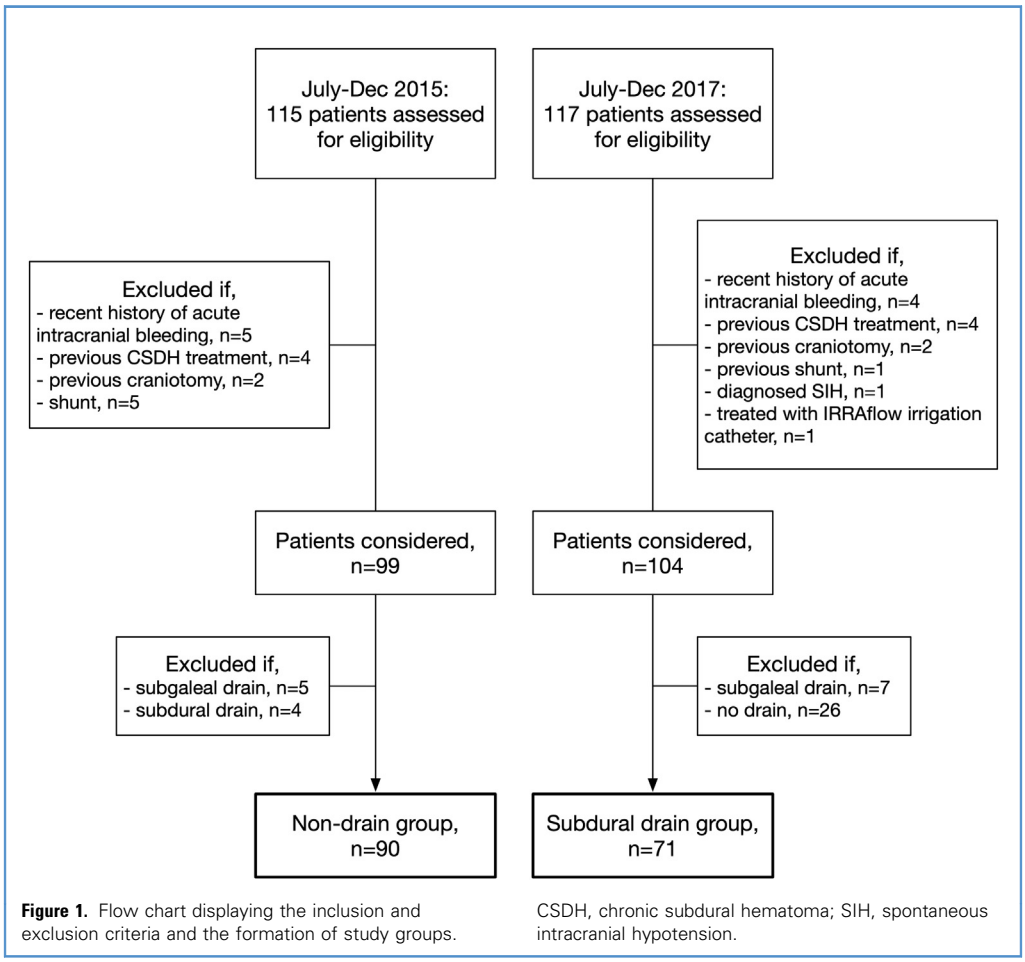

Figure 1. Flow chart displaying the inclusion and exclusion criteria and the formation of study groups. CSDH, chronic subdural hematoma; SIH, spontaneous intracranial hypotension.

Table 1. Baseline Patient Characteristics

Variable	All Patients (N = 161)	Drain (N = 71)	Non-Drain (N = 90)	*P* Value
Age (years), median (range)	77 (46–95)	78 (57–93)	77 (46–95)	0.77
Women, n (%)	51 (32)	21 (30)	30 (33)	0.61
History of trauma, n (%)	131 (81)	62 (87)	69 (77)	0.08
Premorbid mobility, n (%)				0.40
Independent	119 (75)	51 (74)	68 (76)	
Stick	6 (4)	3 (4)	3 (3)	
Zimmer frame	24 (15)	12 (17)	12 (13)	
Wheelchair	5 (3)	3 (4)	2 (2)	
Bed-bound	4 (3)	0	4 (4)	
Premorbid residence, n (%)				0.52
Independent	119 (74)	50 (70)	69 (78)	
Carer	23 (14)	13 (18)	10 (11)	
Residential	15 (9)	6 (8)	9 (10)	
Nursing	3 (2)	2 (3)	1 (1)	
Medical history, n (%)				
Dementia	35 (22)	16 (23)	19 (21)	0.83
Arrhythmia	57 (35)	23 (32)	34 (38)	0.48
Cerebrovascular accident	40 (25)	19 (27)	21 (23)	0.62
Hypertension	110 (68)	45 (63)	65 (72)	0.23
Ischaemic heart disease	40 (25)	18 (25)	22 (24)	0.89
DVT or PE*	3 (2)	0	3 (3)	0.26
COPD	7 (4)	5 (7)	2 (2)	0.24
Diabetes	38 (24)	16 (23)	22 (24)	0.78
Heart valve prosthesis	4 (2)	1 (1)	3 (3)	0.63
Antithrombotic drug history, n (%)†	107 (66)	48 (68)	59 (66)	0.78
Anticoagulants†	56 (35)	26 (37)	30 (33)	0.66
Warfarin	35 (22)	14 (20)	21 (23)	0.58
LMWH	12 (7)	4 (6)	8 (9)	0.43
DOAC	12 (7)	9 (13)	3 (3)	0.025
Antiplatelets†	58 (36)	25 (35)	33 (37)	0.85
Acetylsalicylic acid, dipyridamole	52 (32)	21 (30)	31 (34)	0.51
Clopidogrel, ticagrelor	12 (7)	6 (8)	6 (7)	0.67
Admission mRS score, median (IQR)	3 (2–4)	3 (2–4)	3 (2–4)	0.61
Admission mRS score, n (%)				0.98
0	2 (1)	1 (1)	1 (1)	
1	7 (4)	3 (4)	4 (4)	
2	39 (24)	15 (21)	24 (27)	
3	39 (24)	18 (25)	21 (23)	
4	47 (29)	22 (31)	25 (28)	
5	27 (17)	12 (17)	15 (17)	
Preoperative hemiparesis, n (%)	78 (48)	34 (48)	44 (49)	0.90
Preoperative dysphasia, n (%)	52 (33)	26 (37)	26 (29)	0.32

Data on mobility are missing for 3 patients and data on residence and dysphasia are missing for 1 patient.
DVT, deep venous thrombosis; PE, pulmonary embolism; COPD, chronic obstructive pulmonary disease; LMWH, low molecular weight heparin; DOAC, direct oral anticoagulant; mRS, modified Rankin Scale; IQR, interquartile range.
*Medication used within 12 months.
†Before detection of subdural hematoma.

diversion or subdural hematomas treated with other methods (e.g., subgaleal drain, IRRAflow catheter) (Figure 1).

All data concerning patients' medical history, imaging, and treatment are stored in Helsinki University Hospital's electronic health record (EHR). We retrospectively reviewed and analyzed patients' EHR and preoperative and postoperative head computed tomography (CT) scans or brain magnetic resonance imaging (MRI) images. From the EHR, we obtained patients' baseline and follow-up data concerning mobility and morbidity, history of head trauma in the preceding 12 months, most prominent symptom causing disability, modified Rankin Scale (mRS) score,[25] medical history, and presence of limb weakness or dysphasia. To ensure coherency, a single investigator assessed all clinical data.

Two senior neurosurgeons analyzed all the imaging data from CT and MRI scans. We defined the subdural collection as predominantly hypodense, isodense, or mixed by comparing the density of the collection with the adjacent brain.[26] In addition, we measured the maximum transition of the anatomic midline structures from the midline and determined the midline shift. On bilaterally operated hematomas, we recorded which side caused the midline shift. We also measured the width, length, and height of the collection and calculated the volume of the hematoma using the ABC/2 formula.[27] CSDH volume reduction was analyzed by comparing preoperative and postoperative CT or MRI images. We also recorded the extent of basal cistern effacement, patency of cortical sulci, and presence of contusions.

Burr Hole Craniostomy Procedure

As a routine, all burr hole craniostomies at Helsinki University Hospital are performed under local anesthesia, often combined with intravenous sedation with benzodiazepines and/or opioids during the operation. Here general anesthesia is used only if the neurosurgeon or the anesthesiologist considers it unsafe to perform the procedure under local anesthesia (applicable to only 1 patient in our present cohort).

Typically, the surgeon drills a 14-mm burr hole over the maximum convexity of the hematoma. In the case of an expansive bilateral hematoma, the surgeon operates on both sides. After opening the

Table 2. Preoperative Imaging Characteristics

Variable	All Patients (N = 161)	Drain (N = 71)	Non-Drain (N = 90)	*P* Value
Side, n (%)				0.39
Left	70 (44)	34 (48)	36 (40)	
Right	57 (35)	21 (30)	36 (40)	
Bilateral	34 (21)	15 (22)	18 (20)	
Total hematoma volume, cm^3, median (IQR)	137 (93–175)	149 (99–170)	131 (92–178)	0.54
Unilateral	**(N = 127)**	**(N = 55)**	**(N = 72)**	
Hematoma density, n (%)				0.90
Hypodense	32 (25)	13 (24)	19 (26)	
Isodense	10 (15)	9 (16)	10 (14)	
Mixed	43 (60)	33 (60)	43 (60)	
Midline shift, mm, median (IQR)	7 (4–10)	7 (3–10)	7 (4–10)	0.92
Hematoma thickness, mm, median (IQR)	22 (17–25)	23 (19–27)	20 (15–24)	0.007
Hematoma volume, cm^3, median (IQR)	126 (88–155)	131 (86–157)	116 (88–151)	0.32
Cortical sulci, n (%)				0.07
Open	10 (8)	3 (6)	7 (10)	
Compressed	24 (19)	6 (10)	18 (25)	
Closed	93 (73)	46 (84)	47 (65)	
Bilateral	**(N = 34)**	**(N = 16)***	**(N = 18)**	
Midline shift, mm, median (IQR)	2 (0–4)	0 (0–4)	3 (2–4)	0.08
Side causing midline shift, n (%)				0.13
Left	13 (38)	4 (25)	8 (45)	
Right	9 (27)	3 (19)	6 (33)	
No midline shift	12 (35)	9 (56)	4 (22)	
Total hematoma volume (cm^3), median (IQR)	206 (159–254)	186 (151–241)	239 (184–261)	0.10
Both sides separately	**(N = 68)**	**(N = 27)**	**(N = 41)**	
Hematoma density, n (%)				0.74
Hypodense	12 (18)	5 (19)	7 (17)	
Isodense	22 (32)	10 (37)	12 (29)	
Mixed	34 (50)	12 (44)	22 (54)	
Hematoma thickness, mm, median (IQR)	18 (15–21)	19 (16–22)	17 (14–21)	0.33
Hematoma volume, cm^3, median (IQR)	108 (71–130)	100 (76–123)	108 (67–145)	0.74
Cortical sulci, n (%)				0.91
Open	6 (9)	2 (7)	4 (10)	
Compressed	21 (31)	9 (33)	12 (29)	
Closed	41 (60)	16 (60)	25 (61)	

Neither basal cistern effacement nor contusion was observed in any patient.
IQR, interquartile range.
*Patients treated with a subdural drain unilaterally or bilaterally.

dura, the surgeon washes the subdural collection with warm (body temperature) Ringer's lactate saline until the rinsing appears clear, and decides whether or not to insert an SD. The SD used in this study was a 10 F Spiegelberg Ventricular Catheter (length 270 mm, inner diameter 1.9 mm, outer diameter 3.3 mm; NeoNordic, Odense, Denmark), made of radiopaque polyurethane. The surgeon tunnels the drain under subgaleal skin approximately 5 cm from the incision and links it to a ventricular drainage bag with a connector. The drainage bag is positioned at bed level and is routinely removed after 48 hours. We do not use postoperative prophylactic antibiotics routinely.

In 2015, drain use was not mandatory in our clinic, and the use of SDs and subgaleal drains was sporadic. At the beginning of 2017, a new administrative guideline was enforced, and drain use became a requirement, except in cases where the surgeon believes that a drain would compromise patient safety. SDs are routinely left in place for 48 hours, and patient mobilization is allowed during this time.

Follow-Up and Outcome Measures

At approximately 4–6 weeks postsurgery, follow-up was completed for all patients in the Helsinki Metropolitan Area at an outpatient clinic. For patients living outside this area, a recommendation for follow-up was made to their local hospital. For the follow-up, a routine head CT was recommended. If residual hematoma or symptoms warranted further assessment, the patient was invited monthly for further follow-ups until the collection or symptoms resolved.

Our primary outcome was CSDH recurrence necessitating reoperation within 6 months. Because no other institution in the catchment area of Helsinki University Hospital performs intracranial operations, all patients requiring reoperation are referred to this hospital. We consider reoperation in patients with a new CT scan–verified CSDH with recurrent neurologic symptoms or with a recurrent hematoma of similar or larger size as the primary CSDH.

Our secondary outcomes included neurologic outcome within 7 days and then at 6 months after the primary operation (as measured by the mRS), 30-day and 6-month mortality, length of stay in the neurosurgical ward, and development of postoperative infections and other complications. A favorable postoperative neurologic outcome was defined as an mRS score of 0–3, and an unfavorable outcome was defined as an mRS score of 4–6. We also recorded all postoperative complications and determined whether they were related to the operation. In addition, we obtained dates of deaths through the Finnish Population Registry (available to all Finnish citizens).

Statistical Analyses

We compared categorical variables using the χ^2 test, adjusting the Bonferroni method and using Fisher's exact test when appropriate. We used the Shapiro–Wilk test to evaluate continuous variables for normality, the Mann–Whitney U test to compare nonparametric data, and the t test to compare normally distributed data. Testing was also performed to identify any differences in baseline characteristics between patients in the SD and non-drain groups. Binary logistic regression analysis was used to identify associations between variables and the risk of recurrence within 6 months, with adjustments made for differences in baseline characteristics between the groups (reported as odds ratios [ORs] and 95% confidence intervals [CIs]). We used Kaplan–Meier curves to show differences in time to recurrence within 6 months between the SD and non-drain groups. We considered a P value <0.05 to

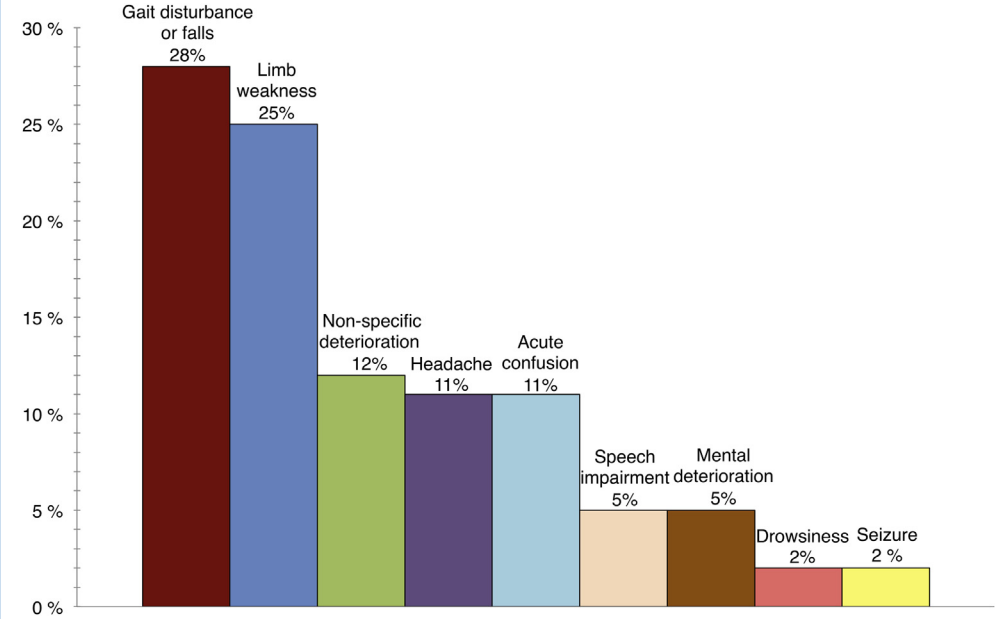

Figure 2. Most prominent symptom causing disability to the patient

Table 3. Univariable Logistic Regression Analysis for Primary and Secondary Outcomes in the Drain and Non-Drain Groups

Outcome	Drain (N = 71)	Non-Drain (N = 90)	OR (95% CI)	*P* Value
Recurrence within 6 months, n/N (%)				
All	4/71 (6)	16/90 (18)	0.28 (0.09–0.87)	0.028
Unilateral CSDHs	3/55 (5)	12/72 (17)	0.29 (0.08–1.08)	0.07
Bilateral CSDHs	1/16 (6)	4/18 (22)	0.23 (0.02–2.35)	0.22
Postoperative mRS 0–3, n/N (%)				
At 7 days	40/71 (56)	52/90 (58)	0.94 (0.50–1.77)	0.85
At 6 months	35/55 (64)	48/72 (67)	0.88 (0.42–1.83)	0.72
Mortality, n/N (%)				
At 30 days	1/71 (1)	6/90 (7)	0.20 (0.02–1.70)	0.14
At 6 months	8/71 (11)	13/90 (14)	0.75 (0.29–1.93)	0.55
Hospital stay in neurosurgical unit, days, median (IQR)	3 (2–5)	2 (1–4)	NA	0.17‖
Further care needed, n/N (%)	45/71 (63)	53/90 (59)	1.21 (0.64–2.29)	0.56
Postoperative complications within 7 days, n/N (%)*	8/71 (11)	5/90 (6)	2.16 (0.67–6.91)	0.20
Postoperative infections, n/N (%)†				
Within 30 days	8/71 (11)	11/90 (12)	0.91 (0.35–2.40)	0.85
Within 6 months	16/56 (29)	20/71 (28)	1.02 (0.47–2.22)	0.96
Worse mobility at 6 months, n/N (%)‡	10/48 (21)	14/59 (24)	0.85 (0.34–2.12)	0.72
Hematoma volume reduction (cm^3), mean (SD)§	103 (56)	72 (60)	NA	0.005‖
Percent volume reduction, mean (SD)§	70 (31)	50 (39)	NA	0.005‖

ORs are calculated for binary outcomes using logistic regression. An OR <1 indicates that a subdural drain is associated with a lower probability for the specific outcome and an OR >1 indicates association with a greater probability.
OR, odds ratio; CI, confidence interval; CSDH, chronic subdural hematoma; mRS, modified Rankin Scale; IQR, interquartile range; NA, not applicable; SD, standard deviation.
*Postoperative complications included cerebral infarction, intracerebral hemorrhage, wound bleeding, epileptic seizure, unintended drain removal, cardiac failure, pulmonary embolism, and epidural hematoma.
†Postoperative infections included urinary tract infection, pneumonia, soft tissue infection, shingles, upper respiratory infection, erysipelas, gastroenteritis, and nonspecific infection.
‡Excluding patients dying before 6 months.
§Missing for 44 of 161 patients (27%).
‖Calculated using the nonparametric Mann–Whitney *U* test.

indicate statistical significance. We also performed a post hoc logistic regression analysis assessing the association between drain use and recurrence within 6 months, adjusting for age, sex, preoperative neurologic deficit, and use of antithrombotic medication. All analyses were done using SPSS 25.0 for macOS (IBM, Armonk, New York, USA).

RESULTS

Baseline Characteristics

Our study cohort comprised 161 patients, including 71 (44%) in the SD group and 90 (56%) in the non-drain group (Figure 1). There were no significant differences in baseline characteristics between the 2 groups (Table 1). Similarly, no substantial differences were seen between patients treated in 2017 with SDs and those treated in 2017 without drains (Supplementary Table 1). The only significant baseline finding was thicker hematomas in the SD group (median, 23 mm vs. 20 mm; P = 0.007) (Table 2).

Reasons cited for not placing an SD in 2017 included immediate brain expansion (n = 11), membrane loculations (n = 3), antithrombotic treatment (n = 2), infection (n = 1), head wound operation (n = 1), and a surgeon's belief that inserting a drain would be unsafe (n = 1).

The main presenting symptoms are shown in Figure 2. Altogether, 53% of the patients had a motor deficit, presenting as gait disturbance or limb weakness.

Rate of CSDH Recurrence

The 6-month CSDH recurrence rate was 6% (n/N = 4/71) in the SD group and 18% (n/N = 16/90) in the non-drain group (P = 0.028). Because there were no differences in patient baseline characteristics between the 2 groups, we assessed the association between SD use and risk of recurrence within 6 months using univariable logistic regression analyses. SD use was associated with an OR of 0.28 (95% CI, 0.09–0.87) for recurrence within 6 months compared with no drain use. In patients with unilateral CSDH, the 6-month recurrence rate was reduced from 17% (n/N = 12/72) in

Table 4. Factors Associated with Recurrence of Chronic Subdural Hematomas Requiring Reoperation within 6 Months

Variable	No Recurrence (N = 141)	Recurrence (N = 20)	OR (95% CI)	*P* Value
Age (years), median (range)	78 (46–95)	77 (56–90)	0.98 (0.94–1.02)	0.33
Neurologic deficit (hemiparesis or dysphasia), %	60	45	0.54 (0.21–1.38)	0.20
History of trauma, %	84	65	0.36 (0.13–1.01)	0.051
Antithrombotic drug history, %*	65	75	1.60 (0.55–4.66)	0.39
Anticoagulants, %*	33	50	2.07 (0.80–5.31)	0.13
Antiplatelets, %*	38	25	0.55 (0.19–1.61)	0.28
Preoperative mRS 0–3, %	53	60	1.32 (0.51–3.43)	0.57
Preoperative mRS 4–5, %	47	40	0.76 (0.29–1.97)	0.57
Unilateral hematoma, %	79	75	0.78 (0.26–2.31)	0.65
Bilateral hematoma, %	21	25	1.29 (0.43–3.83)	0.65
Midline shift, mm, median (IQR)†	7 (3–10)	9 (4–11)	1.06 (0.95–1.19)	0.30
Mixed-density clot, %	61	42	0.47 (0.18–1.25)	0.13
Subdural drain, %	48	20	0.28 (0.09–0.87)	0.028

Odds ratios calculated using univariable logistic regression. An odds ratio over 1 indicates that the specific variable is associated with a higher probability for recurrence and vice versa.
OR, odds ratio; CI, confidence interval; mRS, modified Rankin scale; IQR, interquartile range.
*Before detection of subdural hematoma.
†Excluding bilateral hematomas.

the non-drain group to 5% (n/N = 3/55) in the drain group (P = 0.06). In patients with bilateral CSDH, the 6-month recurrence rates were 22% in the non-drain group (n/N = 4/18) and 6% in the drain group (n/N = 1/16) (P = 0.22). All recurrences were treated by burr hole craniostomy (Table 3).

The results of our analysis of factors possibly associated with 6-month recurrence of CSDH are presented in Table 4. Apart from SD use, no other risk factors were significantly associated with recurrence. In the post hoc logistic regression analysis, adjusting for age, sex, preoperative neurologic deficit, and use of antithrombotic medication, SD use remained independently associated with a reduced risk of 6-month recurrence (OR, 0.27; 95% CI, 0.08–0.85; P = 0.025).

Before being diagnosed with CSDH, 66% of the patients (n/N = 107/161) were receiving some type of antithrombotic medication. Preoperative use of antithrombotic medication was not associated with CSDH recurrence. Postoperatively, antithrombotic medication was resumed before the first control (4–6 weeks after the operation) in 28% of the patients (n/N = 29/102), 17% (n = 5) of whom had a recurrent CSDH. One of these 5 patients was treated with an SD and the other 4 were treated without drain in the primary operation.

Figure 3 presents a Kaplan–Meier curve of differences between the SD and non-drain groups in the time to 6-month recurrence and the risk of 6-month recurrence. Notably, the risk of recurrence was greatest in the first 30 days after the procedure, after which it remained low throughout the follow-up period.

Secondary Outcomes

There were no significant between-group differences in immediate postoperative mRS score (P = 0.85), 6-month mRS score (P = 0.72), 30-day mortality (P = 0.14), 6-month mortality (P = 0.55), hospital length of stay (P = 0.17), need for further care (P = 0.56), infection within 30 days (P = 0.85) or within 6 months (P = 0.96), or other complications (P = 0.20) (Table 3). Among the secondary outcomes, only volume reduction differed significantly between the SD and non-drain groups (mean volume reduction, 70% vs. 50%; P = 0.005). Postoperative infections and other complications are presented in Supplementary Table 2. All complications were diagnosed within 7 days postoperatively. Of note, no patient developed wound infection, meningitis, or intracranial empyema.

DISCUSSION

In this study, we have shown that the transition to consistent use of an SD after burr hole craniostomy for CSDH in a real-world clinical setting (Helsinki University Hospital) reduced the 6-month recurrence rate from 18% to 6% with no increase in the rates of infections or complications. SD use did not affect patient outcome but corresponded to a notable decrease in CSDH volume. Furthermore, we showed that CSDH recurrence is greatest within the first 30 days after treatment and decreases thereafter. Our findings are in line with recurrence rate reductions reported in numerous RCTs.[16,28-30]

Our findings indicating a predominance of elderly patients and those with a recent history of head trauma (81%), as well as a sex ratio in favor of males (68%), are also in line with previous reports.[31-34] CSDH is common in elderly patients and has a major impact on their independence. Numerous studies have reported a high rate of functional dependency, even in patients who have undergone surgery.[31,33,35] In a study reported by Leroy et al.,[33] the

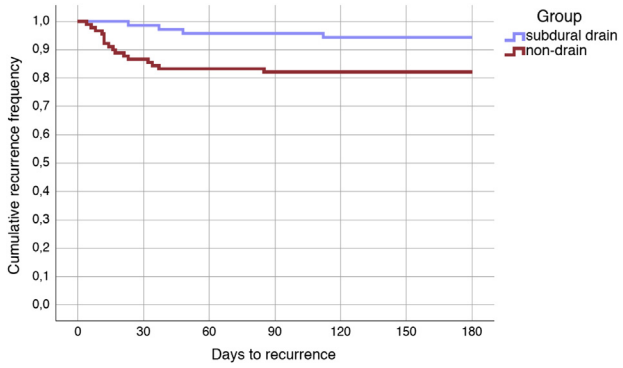

Figure 3. Kaplan-Meier curve showing differences in time to 6-month recurrence and risk of 6-month recurrence between patients in the subdural drain and non-drain groups. Of patients in the non-drain group, 18% had a recurrence, most often occurring within the first 30 days following treatment. Of patients in the subdural drain group, 6% had a recurrence.

age threshold of 75 years was associated with an unfavorable functional outcome. In our study, the median patient age was 78 years in the drain group and 77 years in the non-drain group. Before diagnosis, 75% of our patients had been walking independently, and 70% of the drain group and 78% of the non-drain group were living independently. At 6 months after treatment, only 80% had recovered to walk independently. In this study, we were unable to reproduce the reduction of mortality rate by drain usage reported by Santarius et al.[16] Furthermore, only 64% of patients recovered to a good mRS score, compared with 84% reported by Santarius et al.[16] These differences may be due to the slightly older age of our patients, with the attendant higher morbidity and greater need for assistance.

The use of antithrombotic medication is a pressing issue in patients with CSDHs. In a recent meta-analysis,[36] both anticoagulation and antiplatelet therapy were associated with a greater risk of recurrence. In our study, two-thirds of patients were on some sort of antithrombotic medication. We did not find any association between preoperative use of antithrombotic medication and recurrence risk. Furthermore, antithrombotic medication was resumed before the first follow-up (4–6 weeks postoperatively) in 28% of the users, only 17% of whom had a recurrent CSDH necessitating reoperation. The number of recurrences in the antithrombotic users was too low to allow for any more detailed statistical analysis. Regardless, these low numbers suggest that excessive caution regarding restarting of antithrombotic medication after CSDH evacuation might not be as important as previously thought. More studies on this topic are needed, however.

Our results were derived from a retrospective analysis, which is prone to well-known limitations, and thus caution in interpretation is advised. As mentioned earlier, in the Helsinki catchment area, all patients requiring reoperation are sent to Helsinki University Hospital, the only institution in the region that performs such operations. This allowed us to obtain complete data in terms of 6-month recurrence and mortality rates. Furthermore, we obtained 6 months of follow-up data on mRS scores for 79% of patients, on mobility for 76%, and on infection rate for 75%.

In the operative management of CSDH, numerous unsettled intraoperative and postoperative factors contribute to outcomes. At Helsinki University Hospital, we routinely perform the procedures under local anesthesia, whereas some institutions favor general anesthesia.[16] We typically use 1 burr hole, whereas some centers prefer 2 burr holes.[37] We use SDs rather than other drainage methods, such as active SDs, drains with continuous irrigation and drainage, or subgaleal drains. None of these methods has been shown to be superior to the others.[7,9,15] We provide intraoperative irrigation until fluid is clear. Some studies have reported that irrigation results in better outcomes,[9] whereas others have shown no disadvantage to placing a drain without irrigation.[5,38,39] We keep the drain in place for 48 h, although 12–18 hours of drainage has been reported.[7] We allow patient mobilization during drain treatment, whereas some centers opt for bed rest.[11,40]

Although we observed a reduced rate of 6-month recurrence after the initiation of SD use, we note that several factors related to perioperative treatment may affect the risk of recurrence. Evidence in favour of drain use is increasingly convincing; however, the need for further research in the treatment of CSDH remains.

CONCLUSION

SD use after burr hole craniostomy for CSDH has been shown to significantly reduce the risk of recurrence without affecting patient outcome, infections or complications. More research is needed to identify other treatment-related factors that might further reduce this risk.

ACKNOWLEDGMENTS

We thank Volkert Dirk Siersma (statistician at University of Copenhagen, Department of Public Health) for statistical assistance.

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Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Received 21 April 2019; accepted 27 May 2019

Citation: World Neurosurg. (2019) 129:e614-e626. https://doi.org/10.1016/j.wneu.2019.05.230

Journal homepage: ***www.journals.elsevier.com/world-neurosurgery***

Available online: ***www.sciencedirect.com***

APPENDIX

Supplementary Table 1. Baseline Characteristics of the Drain and Non-Drain Groups in 2017

Variable	Drain (N = 71)	Non-Drain (N = 26)	*P* Value
Age (years), median (range)	78 (57—93)	78 (42—102)	0.67
Women, n/N (%)	21/71 (30)	9/26 (35)	0.63
History of trauma, n/N (%)	62/71 (87)	18/26 (69)	0.07
Premorbid mobility, n/N (%)			0.58
Independent	51/69 (74)	17/26 (65)	
Stick	3/69 (4)	1/26 (4)	
Zimmer frame	12/69 (17)	5/26 (19)	
Wheelchair	3/69 (4)	3/26 (12)	
Premorbid residence, n/N (%)			0.92
Independent	50/71 (70)	20/26 (77)	
Carer	13/71 (18)	5/26 (19)	
Residential	6/71 (8)	1/26 (4)	
Nursing	2/71 (3)	0/26	
Medical history, n/N (%)			
Dementia	16/71 (23)	2/26 (8)	0.14
Arrhythmia	23/71 (32)	7/26 (27)	0.61
Cerebrovascular accident	19/71 (27)	9/26 (35)	0.45
Hypertension	45/71 (63)	18/26 (69)	0.59
Ischemic heart disease	18/71 (25)	7/26 (27)	0.88
DVT or PE*	0/71	1/26 (4)	0.27
COPD	5/71 (7)	1/26 (4)	0.99
Diabetes	16/71 (23)	8/26 (31)	0.41
Heart valve prosthesis	1/71 (1)	1/26 (4)	0.47
Antithrombotic drug history, n/N (%)†	48/71 (68)	15/26 (58)	0.36
Anticoagulants†	26/71 (37)	7/26 (27)	0.37
Warfarin	14/71 (20)	6/26 (23)	0.72
LMWH	4/71 (6)	1/26 (4)	0.99
DOAC	9/71 (13)	0/26	0.11
Antiplatelets†	25/71 (35)	9/26 (35)	0.96
Acetylsalicylic acid, dipyridamole	21/71 (30)	9/26 (35)	0.63
Clopidogrel, ticagrelor	6/71 (8)	2/26 (8)	0.99
Admission mRS score, median (IQR)	3 (2—4)	4 (2—4)	0.99
Admission mRS score, n/N (%)			0.94
0	1/71 (1)	0/26	
1	3/71 (4)	2/26 (8)	
2	15/71 (21)	6/26 (23)	

DVT, deep venous thrombosis; PE, pulmonary embolism; COPD, chronic obstructive pulmonary disease; LMWH, low molecular weight heparin; DOAC, direct oral anticoagulant; mRS, modified Rankin Scale; IQR, interquartile range; NA not applicable.
*Medication used within 12 months.
†Before detection of subdural hematoma.
‡Patients treated with subdural drain unilaterally or bilaterally.

Continues

Supplementary Table 1. Continued

Variable	Drain (N = 71)	Non-Drain (N = 26)	*P* Value
3	18/71 (25)	5/26 (19)	
4	22/71 (31)	8/26 (31)	
5	12/71 (17)	5/26 (19)	
Preoperative hemiparesis, n/N (%)	34/71 (48)	5/25 (20)	0.015
Preoperative dysphasia, n/N (%)	26/71 (37)	6/26 (23)	0.21
Imaging characteristics			
Side, n/N (%)			0.038
Left	21/71 (30)	15/26 (58)	
Right	34/71 (48)	8/26 (31)	
Bilateral	16/71 (23)	3/26 (12)	
Total hematoma volume, cm^3, median (IQR)	149 (99–170)	84 (62–120)	<0.001
Basal cisterns open, n/N (%)	71/71 (100)	26/26 (100)	NA
Unilateral	**N = 55**	**N = 23**	
Imaging characteristics			
Hematoma density, n/N (%)			0.09
Hypodense	13/55 (24)	11/23 (48)	
Isodense	9/55 (16)	1/23 (4)	
Mixed	33/55 (60)	11/23 (48)	
Midline shift, mm, median (IQR)	7 (3–10)	5 (2–7)	0.11
Hematoma thickness, mm, median (IQR)	23 (19–27)	15 (12–17)	<0.001
Hematoma volume, cm^3, median (IQR)	131 (86–157)	75 (62–116)	<0.001
Cortical sulci, n/N (%)			0.038
Open	3/55 (5)	3/23 (13)	
Compressed	6/55 (11)	7/23 (30)	
Closed	46/55 (84)	13/23 (57)	
Brain contusion, n/N (%)	0/55	1/23 (4)	0.29
Operation			
Subdural fluid, n/N (%)			0.59
Clear	0/37	1/20 (5)	
Straw	6/37 (16)	5/20 (25)	
Engine oil	13/37 (35)	7/20 (35)	
Fresh blood	8/37 (22)	4/20 (20)	
Mixture	10/37 (27)	3/20 (15)	
Subdural fluid pressure, n/N (%)			0.022
Low	6/53 (11)	9/23 (39)	
Medium	31/53 (58)	8/23 (35)	
High	16/53 (30)	6/23 (26)	
Bilateral	**N = 16‡**	**N = 3**	
Imaging characteristics			
Midline shift, mm, median (IQR)	0 (0–4)	3 (NA)	0.63

Continues

Supplementary Table 1. Continued

Bilateral	**N = 16‡**	**N = 3**	
Side causing midline shift, n/N (%)			0.54
Left	4/16 (25)	2/3 (67)	
Right	3/16 (19)	0/3	
No midline shift	9/16 (56)	1/3 (33)	
Total hematoma volume, cm^3, median (IQR)	186 (151—241)	178 (NA)	0.71
Both sides separately	**N = 27**	**N = 11**	
Hematoma density, n/N (%)			0.59
Hypodense	5/27 (19)	3/11 (27)	
Isodense	10/27 (37)	2/11 (18)	
Mixed	12/27 (44)	6/11 (55)	
Hematoma thickness, mm, median (IQR)	19 (16—22)	15 (11—18)	0.049
Hematoma volume, cm^3, median (IQR)	100 (76—123)	65 (51—84)	0.010
Cortical sulci, n/N (%)			0.41
Open	2/27 (7)	1/11 (9)	
Compressed	9/27 (33)	6/11 (55)	
Closed	16/27 (59)	4/11 (36)	
Brain contusion, n/N	0/27	0/11	NA
Operation			
Subdural fluid, n/N (%)			0.002
Clear	0/21	1/6 (17)	
Straw	0/21	3/6 (50)	
Engine oil	12/21 (57)	2/6 (33)	
Fresh blood	2/21 (10)	0/6	
Mixture	7/21 (33)	0/6	
Subdural fluid pressure, n/N (%)			0.90
Low	6/25 (24)	3/11 (27)	
Medium	12/25 (48)	6/11 (55)	
High	7/25 (28)	2/11 (18)	

DVT, deep venous thrombosis; PE, pulmonary embolism; COPD, chronic obstructive pulmonary disease; LMWH, low molecular weight heparin; DOAC, direct oral anticoagulant; mRS, modified Rankin Scale; IQR, interquartile range; NA not applicable.
*Medication used within 12 months.
†Before detection of subdural hematoma.
‡Patients treated with subdural drain unilaterally or bilaterally.

Supplementary Table 2. Postoperative Infections and Complications

Parameter	Drain (N = 71)	Non-Drain (N = 90)	All Patients (N = 161)
Infections within 1 month, n			
Urinary tract infection	4	2	6
Pneumonia	1	5	6
Nonspecific infection	1	2	3
Pyelonephritis	1	1	2
Shingles	1		1
Soft tissue infection		1	1
All	8	11	19
Infections within 6 months, n*			
Urinary tract infection	6	6	12
Pneumonia	3	7	10
Nonspecific infection	2	4	6
Upper respiratory infection	1	4	5
Pyelonephritis	2	2	4
Soft tissue infection	1	2	3
Erysipelas	2		2
Shingles	1		1
Gastroenteritis		1	1
All	18	26	44
Complications within 7 days, n			
Cerebral infarction		2	2
Wound bleeding	2		2
Unintended drain removal	2		2
Intracerebral haemorrhage	1	1	2
Epileptic seizure	1	1	2
Pulmonary embolism	1		1
Epidural haematoma	1		1
Cardiac failure		1	1
All	8	5	13

*Missing for 34 of 161 patients (21%).