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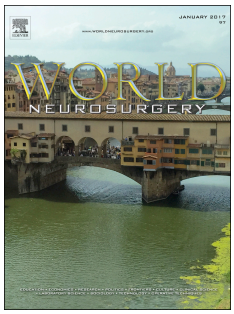

Transition of a clinical practice to use of subdural drains after burr-hole evacuation of chronic subdural haematomas: The Helsinki experience

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Transition of a clinical practice to use of subdural drains after burr-hole evacuation of chronic subdural haematomas: The Helsinki experience

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Keywords burr-hole, chronic subdural haematoma, drain, neurosurgery, subdural drain, surgery

Running title:

Transition to use of SDs after evacuation of CSDHs

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Transition of a clinical practice to use of subdural drains after burr-hole evacuation of chronic subdural haematomas: The Helsinki experience

Abstract

Background A number of randomised controlled trials have shown the benefit of drain in operative treatment of chronic subdural haematomas (CSDHs). However, few reports describe real life result when adopting the 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 craniostomies for CSDHs.

Methods We conducted a retrospective observational study including consecutive patients undergoing burr-hole craniostomies for CSDHs. We compared outcomes between a six-month time period when the SD placement was arbitrary (July to December 2015) and a time period when SD placement for 48 h was routine (July to December 2017). Our primary outcome of interest was recurrences requiring reoperation within six months. Furthermore, patient outcome, infections and other complications were assessed.

Results A total of 161 patients were included, of which 71 (44%) were in the SD group and 90 (56%) in the non-drain group. There were no differences in age, comorbidities, history of trauma or use of antithrombotic medication between the groups ($p>0.05$). Recurrences within six months occurred in 18% of patients in the non-drain group compared to 6% in the SD group ($p=0.028$; OR 0.28; 95% CI 0.09-0.87). There were no differences in neurological outcome ($p=0.72$), mortality rate ($p=0.55$), infection rate ($p=0.96$) or other complications ($p=0.20$).

Conclusions The change in practice from no drain to SD after burr-hole craniostomies for CSDHs effectively reduced the six-month recurrence rate without any effect on patient outcome, infections or other complications.

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Keywords burr-hole, chronic subdural haematoma, drain, neurosurgery, subdural drain, surgery

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Introduction

The incidence of chronic subdural haematomas (CSDHs) ranges from 1.7 to 18 per 100,000 people. In patients older than 65 years, this rate increases to 58 per 100,000 people, making CSDHs one of the most common neurosurgical conditions.[1,2] Most physicians would agree that nonsurgical treatment is recommendable with asymptomatic patients who have small CSDHs.[3] For symptomatic CSDHs, burr-hole evacuation has become the most preferred treatment method,[4,5] as it results in rapid resolution of the symptoms and a short period of hospitalisation. Other surgical options, such as using two burr-holes, twist drill craniostomy or even craniotomy in selected patient population have been used to treat CSDHs.[2,3]

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

Although the use of a drain has been reported to reduce recurrence rates, some studies still dispute this.[11,17] However, numerous questionnaire surveys indicate that there is an evidence-practice gap in the usage of drains, as not all neurosurgeons place them regularly.[4,18–22] Despite reported evidence supporting the benefits of drain placement, drain usage in everyday practice within the neurosurgical department of Helsinki University Hospital was arbitrary until, on April 1, 2017, consistent management of CSDHs with subdural drains was established in our clinic.

Due to the stricter inclusion and exclusion criteria of RCTs, the benefits of drain usage as shown by such trials may not necessarily reflect the real clinical setting.[23] Still, there is a need for real-life observational studies to confirm results from RCTs.[24] Thus, our aim was to assess whether the change of clinical practice to start using subdural drains had translated into a lower recurrence rate. Specifically, our primary goal was to confirm if patients treated with postoperative drains experienced lower recurrence rates compared to patients not receiving

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drains. The secondary aim was to compare the changes in haematoma size, complications and patient outcome.

Material and methods

Ethical considerations

The ethics committee of Helsinki University Hospital approved the study and waived the need for informed consent (HUS 1799/2018).

Study setting and data collection

On April 1, 2017, the use of subdural drain after burr-hole craniostomy for CSDH evacuation became routine at our clinic. Thus, to assess the effect of subdural drain usage on six-month recurrence risk, we chose time periods to represent the pre-drain era (July to December 2015) and the drain era (July to December 2017). During these time periods, we assessed all patients who underwent operations for CSDHs at the Department of Neurosurgery at Helsinki University Hospital. The non-drain group included patients from the pre-drain era and from this group, we excluded all patients that were treated with a drain. The subdural drain group included patients from the drain era and from this group, we excluded those not treated with a subdural drain and those treated with another type of drain than a subdural drain. We excluded patients who had undergone previous intracranial operations for any reason, as well as those with shunts for cerebrospinal fluid diversion or subdural haematomas treated with other methods (subgaleal drain or IRRAflow catheter). (**Figure 1**)

All data concerning patients' medical history, imaging and treatment is stored in Helsinki University Hospital's electronic health records (EHRs). We retrospectively reviewed and analysed patients' EHRs and their pre- and postoperative head computerised tomography (CT) scans or brain magnetic resonance images (MRIs). From EHRs, we obtained patients' baseline and follow-up data concerning mobility and morbidity, history of head trauma during the preceding 12 months, most prominent symptom causing disability to the patient, modified Rankin scale (mRS) scores,[25] medical history and existence of limb weakness or dysphasia. To ensure coherency, a single investigator assessed all clinical data.

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Two senior neurosurgeons analysed 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 to the adjacent brain.[26] We also measured the maximum transition of the anatomical midline structures from the midline and determined the midline shift. On bilaterally operated haematomas, we recorded which side caused the midline shift. Further, we measured the width, length and height of the collection and, using formula ABC/2,[27] assessed the volume of the haematoma. The CSDH volume reduction was analysed by comparing pre- 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 anaesthesia, often combined with intravenous sedation with benzodiazepines and/or opioids during the operation. Here, general anaesthesia is used only if the neurosurgeon or the anaesthesiologist considers it unsafe to perform the procedure under local anaesthesia (applicable to only one patient in the current cohort). Typically, the surgeon drills one 14-mm burr-hole over the maximum convexity of the haematoma. In the case of an expansive bilateral haematoma, the surgeon operates on both sides. After opening the dura, the surgeon washes the subdural collection with warm (body temperature) Ringer's lactate saline until rinsing appears clear. The operating surgeon decides whether or not to insert a subdural drain. The subdural drain used in this study was Spiegelberg Ventricular Catheter 10F (NeoNordic, Odense, Denmark), made of radiopaque polyurethane (length 270 mm, inner diameter 1.9 mm and outer diameter 3.3 mm). The surgeon tunnels the drain under subgaleal skin approximately 5 cm from the incision, and it is linked to a ventricular drainage bag with a connector. The drainage bag is positioned at bed level and routinely removed after 48 h. We do not use postoperative prophylactic antibiotics routinely.

In 2015, drain usage was not mandatory in our clinic, and the use of subdural and subgaleal drains was sporadic. At the beginning of 2017, a new administrative guideline was enforced, and usage of subdural drains became a requirement except in cases where the surgeon believes drain usage would compromise the patient's safety. Subdural drains are routinely left in place for 48 h. We allow patient mobilisation during drain treatment.

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Follow-up and outcome measures

Approximately four to six weeks postoperatively, follow-ups were completed with all operated patients in the Helsinki Metropolitan Area at an outpatient clinic. For patients living outside of this area, a recommendation for follow-up was made to their local hospitals. For the follow-up, a routine head CT was recommended. If the residual haematoma or the patient's symptoms required further assessment, the patient was invited monthly for further follow-ups until the collection or symptoms resolved.

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

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

Statistical analyses

We compared categorical variables by using a chi-square test, adjusting the Bonferroni method when appropriate and using Fisher's exact test when appropriate. We tested continuous variables for normality with the Shapiro-Wilk test and thereafter used the Mann-Whitney U test to compare nonparametric data and a t-test to compare normally distributed data. Testing was also completed to find any differences in baseline characteristics between patients in the subdural drain and non-drain groups. To identify associations between variables and the risk of recurrence within six months, binary logistic regression analysis was employed, with adjustments made for differences in baseline characteristics between the

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groups (reported as odds ratios [OR] and 95% confidence intervals [CI]). We used Kaplan-Meier curves to show differences in time to recurrence within six months between patients treated with a subdural drain and those treated with no drain. We considered p-values under 0.05 to be statistically significant. We also performed a post-hoc logistic regression analysis assessing the association between drain and recurrence within six months, adjusting for age, sex, preoperative neurological deficit and use of antithrombotic medication. All analyses were done using SPSS 25.0 for macOS (IBM Corp, Armonk, NY, USA).

Results

Baseline characteristics

We included a total of 161 patients in our study (**Figure 1**). There were no significant differences in baseline characteristics between patients treated with subdural drains and those treated with no drain (**Table 1**). Similarly, no substantial differences could be observed between patients treated in 2017 with subdural drains and those treated in 2017 without drains (**Supplementary table 1**). The only significant baseline finding was that patients in the subdural drain group had thicker haematomas (median 23 mm vs. 20 mm; p=0.007) (**Table 2**).

The reasons for not inserting a subdural drain in 2017 were 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 statement that inserting a drain would be unsafe (N=1).

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

Recurrence rate of CSDHs

The six-month recurrence rate of CSDHs was 6% (N=4/71) in the subdural drain group and 18% (N=16/90) in the non-drain group (p=0.028). As there were no differences in patient baseline characteristics between the groups, we assessed the association between use of drain and risk of recurrence within six months using univariable logistic regression analyses.

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Subdural drain usage was associated with an OR of 0.28 (95% CI 0.09-0.87) for recurrence within six months compared to no drain. Among unilateral CSDHs, the six-month recurrence rate was reduced from 17% (N=12/72) in the non-drain group to 5% (N=3/55) in the drain group (p=0.06). Among bilateral CSDHs, the six-month recurrence rates were 22% in the non-drain group (N=4/18) and 6% in the drain group (N=1/16) (p=0.22). All recurrences were treated by burr-hole craniostomy. (**Table 3**)

The results of our analysis of factors possible associated with six-month recurrence of CSDHs are displayed in **Table 4**. Apart from subdural drain usage, there were no other risk factors significantly associated with recurrence. In the post-hoc logistic regression analysis, adjusting for age, sex, preoperative neurological deficit and use of antithrombotic medication, the use of subdural drain still independently associated with a reduced risk of six-month recurrence (OR 0.27; 95% CI 0.08-0.85; p=0.025).

Prior to the diagnosis of a CSDH, 66% of patients (N=107/161) were on some type of antithrombotic medication. Preoperative use of antithrombotic medication did not associate with recurrent CSDHs. Postoperatively, antithrombotic medication was restarted prior to the first control (four to six weeks after operation) in 28% of patients (N=29/102), 17% (N=5) of which had a recurrent CSDH. Of the five patients, one was treated with a subdural drain and four were treated without one in the primary operation.

Figure 3 shows a Kaplan-Meier curve of differences in time to six-month recurrence and risk of six-month recurrence between patients in each group. Notably, the risk of recurrence was highest in the first 30 days following the procedure, after which it remained low throughout the follow-up period.

Secondary outcomes

There were no significant differences between the groups regarding immediate postoperative mRS (p=0.85), six-month mRS (p=0.72), 30-day mortality (p=0.14), six-month mortality (p=0.55), hospital length of stay (p=0.17), need for further care (p=0.56), infections within 30 days (p=0.85) or within six months (p=0.96) or other complications (p=0.20). (**Table 3**) Of all secondary outcomes, only volume reduction differed significantly between the subdural

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and non-drain groups (mean volume reduction 70% vs. 50%; p=0.005). Postoperative infections and other complications are shown in detail in **Supplementary table 2**. All complications were diagnosed within seven days postoperatively. Noticeably, there were no wound infections, meningitides or intracranial empyemas.

Discussion

In our study, we showed that the transition to consistent use of subdural drains after burr-hole craniostomies for CSDHs in a real-life clinical setting (Helsinki University Hospital) reduced the six-month recurrence rate from 18% to 6% without any increase in infections or complications. Subdural drain usage did not affect patient outcome, but did correspond with a notable decrease in CSDH volume. Furthermore, we showed that CSDH recurrence often happens within the first 30 days after treatment, following which the risk of recurrence is low. Our findings are well in line with recurrence rate reductions reported in numerous RCTs.[16,28–30]

Our findings indicating the predominance of aged patients and those with a recent history of head trauma (81%), as well as a sex ratio in favour of male (68%), are in line with previous reports.[31–34] CSDHs are common in elderly patients and have a major impact on their independence. Many authors have reported a high rate of functional dependency, even in operated patients.[31,33,35] In a report by Leroy et al., the age threshold of 75 years was associated with an unfavourable functional outcome.[33] In our study, the patients' median age was 78 years in the subdural drain group and 77 years in the non-drain group. Prior to 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. Six months after treatment, only 80% had recovered to walk independently. In our study, we were unable to reproduce the reduction of mortality rate by drain usage reported by Santarius et al.[16] Furthermore, in our study only 64% of patients recovered to good mRS, as compared to 84% reported by Santarius et al. These differences may be due to the fact that the patients in our study were slightly older than in the report by Santarius et al. therefore having more morbidity and a higher need for assistance.

The use of antithrombotic medication is a pressing issue in patients with CSDHs. In recent meta-analysis,[36] both anticoagulation and antiplatelet therapy had higher risks of recurrence.

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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. Further, antithrombotic medication was restarted prior to the first follow-up (four to six weeks postoperatively) in 28% of the users, only 17% of which had a recurrent CSDH requiring reoperation. The number of recurrences in the antithrombotic users was too low to allow for any more detailed statistical analysis. Still, these low numbers suggest that excessive caution regarding restarting of antithrombotic medication after CSDH evacuation may not be as warranted as previously thought. However, more studies are needed on this topic.

Our results were derived from retrospective analysis, which is prone to well-known limitations. Therefore, caution is advised in interpreting them. As mentioned, in the Helsinki catchment area, all patients in need of reoperation are sent to Helsinki University Hospital, since it is the only institution in the region that performs such operations. Therefore, we were able to obtain complete data in terms of six-month recurrence and mortality rates. Furthermore, six months of follow-up data was obtained for 79% of patients in terms of mRS, 76% in terms of mobility and 75% in terms of infection rates.

In the operative management of CSDHs, there are still numerous unsettled intra- and postoperative factors that contribute to the outcome. At Helsinki University Hospital, we routinely perform the procedures under local anaesthesia, while some institutions favour general anaesthesia.[16] We typically use one burr-hole, while some centres prefer two.[37] We use subdural drains rather than other drainage methods, i.e. active subdural drains, drains with continuous irrigation and drainage or subgaleal drains. No one method has been shown to be superior to another.[7,9,15] We use intraoperative irrigation until fluid is clear. Some studies indicate that irrigation results in a better outcome,[9] while others show that there is no disadvantage to placing a drain without irrigation.[5,38,39] We keep the drain in place for 48 h, although elsewhere, the use of 12- to 18-h drainage has been reported.[7] We allow patient mobilisation during drain treatment, while some opt for bed rest.[11,40]

Although we observed a reduction in recurrences within six months after beginning to use subdural drains, it is important to note that there are several factors related to perioperative treatment that may affect the risk of recurrence. Evidence in favour of drain usage is ever

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more convincing; however, there is still a need for further research in the field of treatment of CSDHs.

Conclusions

Subdural drain usage after burr-hole craniostomies for CSDHs has been shown to significantly reduce the risk of recurrence without affecting patient outcome, infections or complications. More research is required to identify other treatment-related factors that might further reduce this risk.

Compliance with ethical standards

Funding This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Declarations of interest None.

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.

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Figure captions

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

Figure 2. Most prominent symptom causing disability to the patient

Figure 3. Kaplan-Meier curve showing differences in time to six-month recurrence and risk of six-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.

Legends for supplementary material

Supplementary table 1
Baseline characteristics drain vs. non-drain in 2017

Supplementary table 2
Postoperative infections and complications

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Table 1 Baseline 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	51 (32%)	21 (30%)	30 (33%)	0.61
History of trauma	131 (81%)	62 (87%)	69 (77%)	0.08
Pre-morbid mobility				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%)	
Pre-morbid residence				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				
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†	107 (66%)	48 (68%)	59 (66%)	0.78
Anticoagulant†	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
Antiplatelet†	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	3 (2-4)	3 (2-4)	3 (2-4)	0.61
0	2 (1%)	1 (1%)	1 (1%)	0.98
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%)	

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Preoperative hemiparesis	78 (48%)	34 (48%)	44 (49%)	0.90
Preoperative dysphasia	52 (33%)	26 (37%)	26 (29%)	0.32

Categorical data as n (%) and continuous as median (IQR), unless otherwise stated. Data regarding mobility is missing for three patients and regarding residence and dysphasia missing for one patient. *Medication used within 12 months. †Before detection of subdural haematoma.
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

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Table 2 Preoperative imaging characteristics

Variable	All patients N = 161	Drain N = 71	Non-drain N = 90	p-value
Side				0.39
Left	70 (44%)	34 (48%)	36 (40%)	
Right	57 (35%)	21 (30%)	36 (40%)	
Bilateral	34 (21%)	15 (22%)	18 (20%)	
Total haematoma volume, cm^3	137 (93-175)	149 (99-170)	131 (92-178)	0.54
Unilateral	**N = 127**	**N = 55**	**N = 72**	
Haematoma density				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	7 (4-10)	7 (3-10)	7 (4-10)	0.92
Haematoma thickness, mm	22 (17-25)	23 (19-27)	20 (15-24)	0.007
Haematoma volume, cm^3	126 (88-155)	131 (86-157)	116 (88-151)	0.32
Cortical sulci				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	2 (0-4)	0 (0-4)	3 (2-4)	0.08
Side causing midline shift				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 haematoma volume, cm^3	206 (159-254)	186 (151-241)	239 (184-261)	0.10
Both sides separately	**N = 68**	**N = 27**	**N = 41**	
Haematoma density				0.74
Hypodense	12 (18%)	5 (19%)	7 (17%)	
Isodense	22 (32%)	10 (37%)	12 (29%)	
Mixed	34 (50%)	12 (44%)	22 (54%)	
Haematoma thickness, mm	18 (15-21)	19 (16-22)	17 (14-21)	0.33
Haematoma volume, cm^3	108 (71-130)	100 (76-123)	108 (67-145)	0.74
Cortical sulci				0.91
Open	6 (9%)	2 (7%)	4 (10%)	
Compressed	21 (31%)	9 (33%)	12 (29%)	
Closed	41 (60%)	16 (60%)	25 (61%)	

Data are n (%) or median (IQR). Neither basal cistern effacement nor contusion were observed in any of the patients.
*Patients treated with subdural drain unilaterally or bilaterally.

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Table 3 Univariable logistic regression analysis for primary and secondary outcomes in drain and non-drain groups

Outcome	**Drain (N = 71)**	**Non-drain (N = 90)**	**OR (95% CI)**	**p-value**
Recurrence within six months				
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				
At seven days	40/71 (56%)	52/90 (58%)	0.94 (0.50-1.77)	0.85
At six months	35/55 (64%)	48/72 (67%)	0.88 (0.42-1.83)	0.72
Mortality				
At 30 days	1/71 (1%)	6/90 (7%)	0.20 (0.02-1.70)	0.14
At six months	8/71 (11%)	13/90 (14%)	0.75 (0.29-1.93)	0.55
Hospital stay in neurosurgical unit, days	3 (2-5)	2 (1-4)	NA	0.17¶
Further care needed	45/71 (63%)	53/90 (59%)	1.21 (0.64-2.29)	0.56
Postoperative complications* within seven days	8/71 (11%)	5/90 (6%)	2.16 (0.67-6.91)	0.20
Postoperative infections†				
Within 30 days	8/71 (11%)	11/90 (12%)	0.91 (0.35-2.40)	0.85
Within six months	16/56 (29%)	20/71 (28%)	1.02 (0.47-2.22)	0.96
Worse mobility at six months‡	10/48 (21%)	14/59 (24%)	0.85 (0.34-2.12)	0.72
Haematoma volume reduction, cm^3§	103 (56)	72 (60)	NA	0.005¶
Percentual volume reduction (%)§	70 (31)	50 (39)	NA	0.005¶

Data are n/N (%), median (IQR) or mean (SD). Odds ratios are calculated for binary outcomes using logistic regression. An odds ratio under one indicates that subdural drain is associated with a lower probability for the specific outcome and vice versa. *Postoperative complications included cerebral infarction, intracerebral haemorrhage, wound bleeding, epileptic seizure, unintended drain removal, cardiac failure, pulmonary embolism and epidural haematoma. †Postoperative infections included urinary tract infection, pneumonia, soft tissue infection, shingles, upper respiratory infection, erysipelas, gastroenteritis and non-specific infection. ‡Excluding patients dying before six months. §Missing for 44/161 (27%) patients. ¶Calculated using a non-parametric Mann-Whitney U test.

OR odds ratio, *CI* confidence interval, *CSDH* chronic subdural haematoma, *mRS* modified Rankin scale, *NA* not applicable

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Table 4 Factors associated with recurrence of chronic subdural haematomas requiring reoperation within six 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
Neurological 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
Anticoagulant*	33%	50%	2.07 (0.80-5.31)	0.13
Antiplatelet*	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 haematoma	79%	75%	0.78 (0.26-2.31)	0.65
Bilateral haematoma	21%	25%	1.29 (0.43-3.83)	0.65
Midline shift, mm†	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

Data are percentage of patients in the subgroup or median (IQR), unless otherwise stated. Odds ratios calculated using univariable logistic regression. An odds ratio over one indicates that the specific variable is associated with a higher probability for recurrence and vice versa. *Before detection of subdural haematoma. †Excluding bilateral haematomas. *OR* odds ratio, *CI* confidence interval, *mRS* modified Rankin scale

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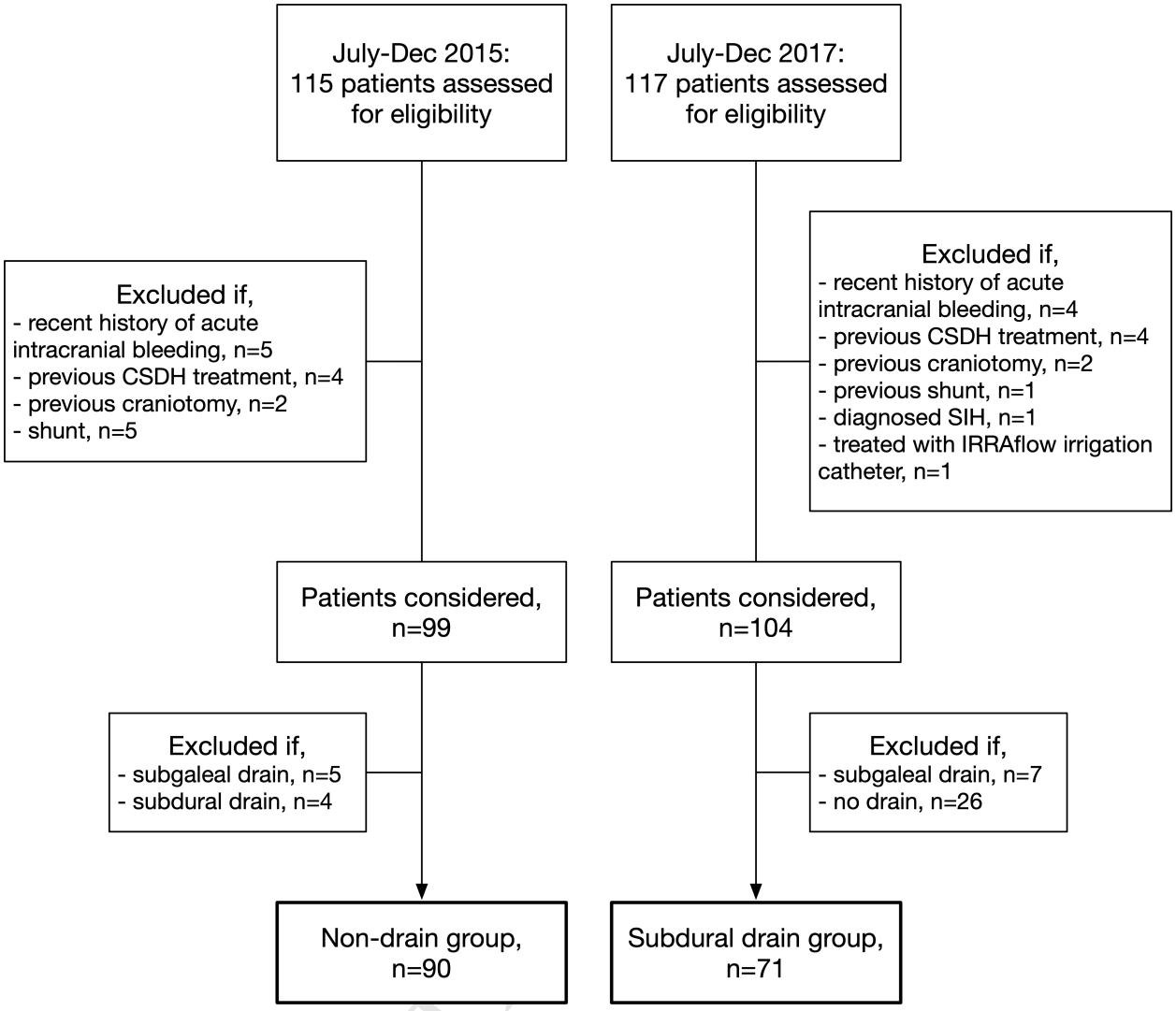

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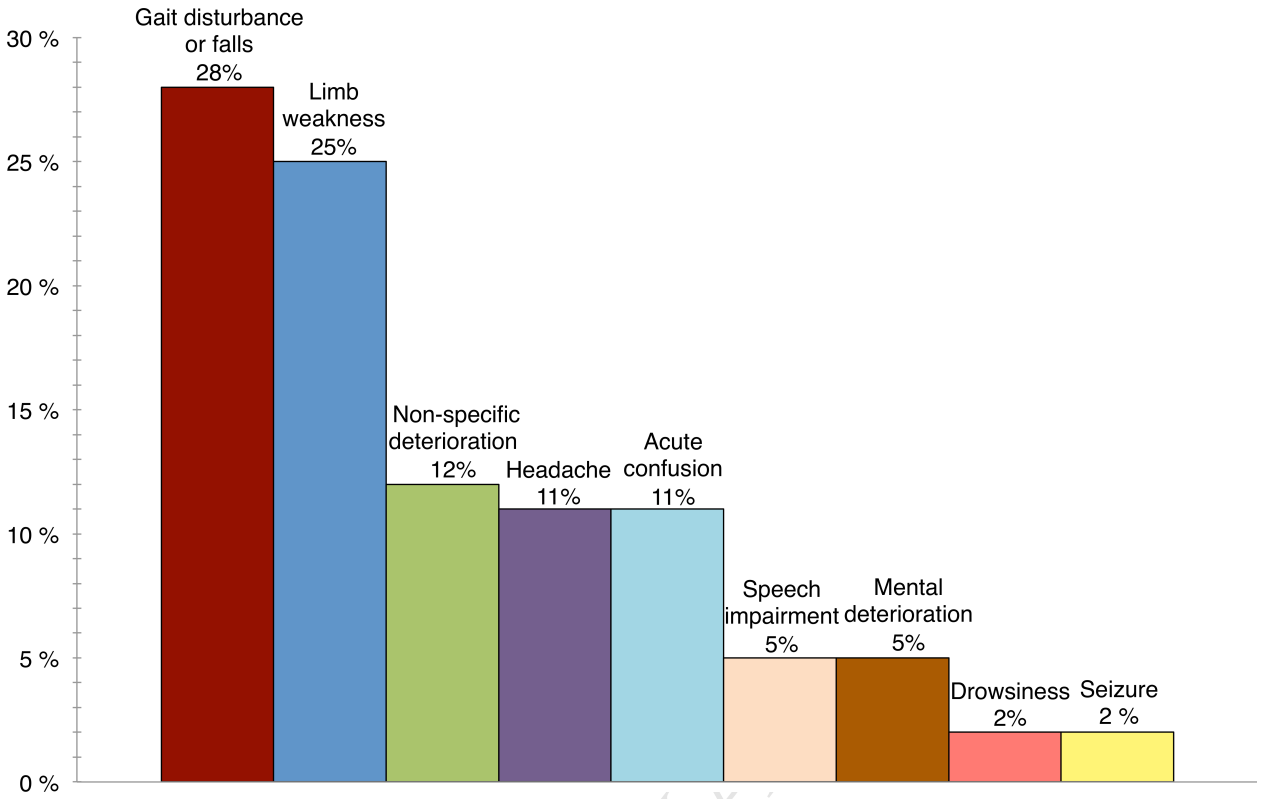

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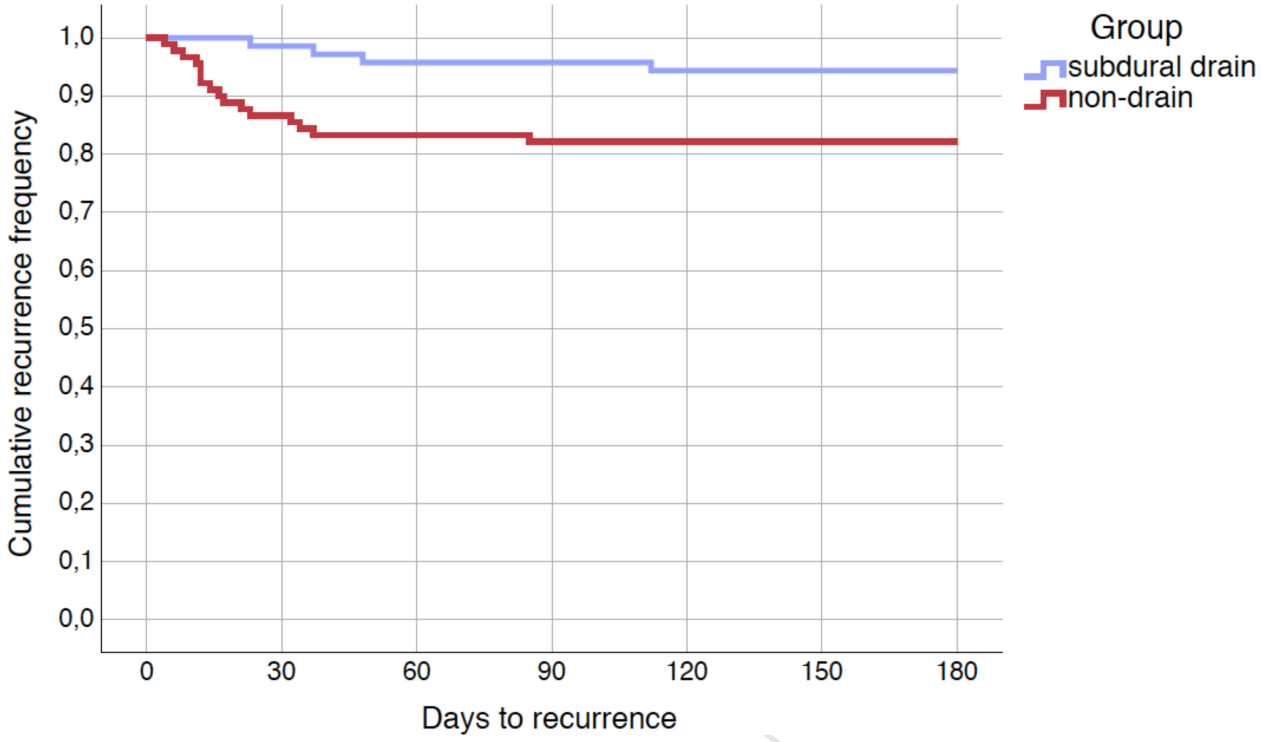

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Supplementary table 1
Baseline characteristics drain vs. non-drain in 2017

Variable	Drain N = 71	Non-drain N = 26	p-value
Age (years), median (range)	78 (57-93)	78 (42-102)	0.67
Women	21/71 (30%)	9/26 (35%)	0.63
History of trauma	62/71 (87%)	18/26 (69%)	0.07
Pre-morbid mobility			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%)	
Pre-morbid residence			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			
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
Ischaemic 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†	48/71 (68%)	15/26 (58%)	0.36
Anticoagulant†	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
Antiplatelet†	25/71 (35%)	9/26 (35%)	0.96
Acetylsalicylic acid, dipyridamole	21/71 (30%)	9/26 (35%)	0.63

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Clopidogrel, ticagrelor	6/71 (8%)	2/26 (8%)	0.99
Admission mRS score, median	3 (2-4)	4 (2-4)	0.99
0	1/71 (1%)	0/26	0.94
1	3/71 (4%)	2/26 (8%)	
2	15/71 (21%)	6/26 (23%)	
3	18/71 (25%)	5/26 (19%)	
4	22/71 (31%)	8/26 (31%)	
5	12/71 (17%)	5/26 (19%)	
Preoperative hemiparesis	34/71 (48%)	5/25 (20%)	0.015
Preoperative dysphasia	26/71 (37%)	6/26 (23%)	0.21
Imaging characteristics			
Side			0.038
Left	21/71 (30%)	15/26 (58%)	
Right	34/71 (48%)	8/26 (31%)	
Bilateral	16/71 (23%)	3/26 (12%)	
Total haematoma volume, cm^3	149 (99-170)	84 (62-120)	<0.001
Basal cisterns open	71/71 (100%)	26/26 (100%)	NA

Unilateral	**N = 55**	**N = 23**	
Haematoma density			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	7 (3-10)	5 (2-7)	0.11
Haematoma thickness, mm	23 (19-27)	15 (12-17)	<0.001
Haematoma volume, cm^3	131 (86-157)	75 (62-116)	<0.001
Cortical sulci			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	0/55	1/23 (4%)	0.29
Operation			
Subdural fluid			0.59
Clear	0/37	1/20 (5%)	

Bilateral	**Drain N = 16‡**	**Non-drain N = 3**	**p-value**
Midline shift, mm	0 (0-4)	3 (NA)	0.63
Side causing midline shift			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 haematoma volume, cm^3	186 (151-241)	178 (NA)	0.71

Both sides separately	**N = 27**	**N = 11**	
Haematoma density			0.59
Hypodense	5/27 (19%)	3/11 (27%)	
Isodense	10/27 (37%)	2/11 (18%)	
Mixed	12/27 (44%)	6/11 (55%)	
Haematoma thickness, mm	19 (16-22)	15 (11-18)	0.049
Haematoma volume, cm^3	100 (76-123)	65 (51-84)	0.010
Cortical sulci			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	0/27	0/11	NA
Operation			
Subdural fluid			0.002
Clear	0/21	1/6 (17%)	

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Straw	6/37 (16%)	5/20 (25%)		Straw	0/21	3/6 (50%)	
Engine oil	13/37 (35%)	7/20 (35%)		Engine oil	12/21 (57%)	2/6 (33%)	
Fresh blood	8/37 (22%)	4/20 (20%)		Fresh blood	2/21 (10%)	0/6	
Mixture	10/37 (27%)	3/20 (15%)		Mixture	7/21 (33%)	0/6	
Subdural fluid pressure			0.022	**Subdural fluid pressure**			0.90
Low	6/53 (11%)	9/23 (39%)		Low	6/25 (24%)	3/11 (27%)	
Medium	31/53 (58%)	8/23 (35%)		Medium	12/25 (48%)	6/11 (55%)	
High	16/53 (30%)	6/23 (26%)		High	7/25 (28%)	2/11 (18%)	

Data are n/N (%) or median (IQR), unless otherwise stated. *Medication used within 12 months. †Before detection of subdural haematoma. ‡Patients treated with subdural drain unilaterally or bilaterally.

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, *NA* not applicable

Article title: Transition of a clinical practice to use of subdural drains after burr-hole evacuation of chronic subdural haematomas: The Helsinki experience
Journal name: World Neurosurgery
Authors: Pihla Tommiska, Kimmo Lönnrot, Rahul Raj, Teemu Luostarinen, Riku Kivisaari
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Supplementary table 2

Postoperative infections and complications

	Drain N = 71	Non-drain N = 90	All patients N = 161
Infections within one month			
Urinary tract infection	4	2	6
Pneumonia	1	5	6
Non-specific infection	1	2	3
Pyelonephritis	1	1	2
Shingles	1		1
Soft tissue infection		1	1
All	8	11	19
Infections within six months*			
Urinary tract infection	6	6	12
Pneumonia	3	7	10
Non-specific 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 seven days			
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 34/161 (21%) patients.

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Abbreviations and acronyms

CI confidence interval

COPD chronic obstructive pulmonary disease

CSDH chronic subdural haematoma

CT computerised tomography

DOAC direct oral anticoagulant

DVT deep venous thrombosis

EHR electronic health record

LMWH low-molecular-weight heparin

MRI magnetic resonance imaging

mRS modified Rankin scale

OR odds ratio

PE pulmonary embolism

RCT randomised controlled trial

SD subdural drain

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