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Comparative Analysis of Surgical Techniques in the Management of Chronic Subdural Hematomas and Risk Factors for Poor Outcomes.

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Abstract

Background. Chronic subdural hematomas (CSDH) are increasingly prevalent, especially among the elderly. Surgical intervention is essential in most cases. However, the choice of surgical technique, either craniotomy or burr-hole opening, remains a subject of debate. Additionally, the risk factors for poor long-term outcomes following surgical treatment remain poorly described.

Methods. This article presents a 10-year retrospective cohort study conducted at a single center that aimed to compare the outcomes of two common surgical techniques for CSDH evacuation: burr hole opening and craniotomy. The study also identified risk factors associated with poor long-term outcome, which was defined as an mRS score ≥ 3 at 6 months.

Results. This study included 582 adult patients who were surgically treated for unilateral CSDH. Burr-hole opening was performed in 43% of the patients, while craniotomy was performed in 57%. Recurrence was observed in 10% of the cases and postoperative complications in 13%. The rates of recurrence, postoperative complications, death and poor long-term outcome did not differ significantly between the two surgical approaches. Multivariate analysis identified postoperative general complications, recurrence, and preoperative mRS score ≥ 3 as independent risk factors for poor outcomes at 6 months.

Conclusion. Burr-hole opening is as effective and less invasive than craniotomy and should be preferred. Although chronic subdural hematoma is often considered benign, general complication and recurrence are significant long-term prognostic factors that should not be overlooked. Our results highlight the importance of preventing postoperative complications through early mobilization and avoiding the prescription of corticosteroids in this elderly population.

1. INTRODUCTION

Chronic subdural hematoma (CSDH) evacuation is one of the most frequent neurosurgical procedures owing to its increasing prevalence, particularly among the elderly population [23]. Its occurrence is often associated with predisposing factors such as anticoagulant therapy, or coagulopathies [3, 4]. The pathophysiology of CSDH is characterized by the gradual accumulation of blood between the dura mater and the arachnoid membrane. This insidious process, driven by bleeding from bridging veins or minor head injuries, can result in increased intracranial pressure, neurologic deficits, and potentially life-threatening complications [7, 8]. Therefore, timely intervention is essential for CSDH management.

When asymptomatic, initial management of CSDH can involve conservative approaches, such as observation or medical management with corticosteroids or anticoagulant reversal agents [12]. However, surgical intervention is necessary in many cases, particularly when hematoma causes a significant mass effect or neurological deterioration [11, 22]. Neurosurgeons are faced with the choice of surgical techniques, craniotomy [1], or burr hole opening [16], to evacuate the hematoma. The selection of the optimal surgical technique for CSDH management remains a subject of ongoing debate in the neurosurgical community. Most systematic reviews and meta-analyses report heterogeneous data from

centers with different perioperative practices, underlining the scarcity of robust evidence in the literature [2, 11, 15]. In addition, the risk factors for poor long-term outcome after surgical treatment are poorly described in the literature.

This article focuses on a 10-year retrospective cohort study conducted at a single center aimed at comparing the outcomes of two commonly employed surgical techniques for CSDH evacuation: burr hole opening and craniotomy. Through an analysis of patient records and follow-up data, we aimed to shed light on the postoperative complications associated with each approach, evaluate the recurrence rates following surgery in a large homogeneous series of patients with comparable perioperative practices, and identify the risk factors for long-term poor outcome.

2. METHODS

2.1 Study design and setting

This was a single-center, retrospective cohort study. We screened patients surgically treated for unilateral CSDH at our tertiary neurosurgical center between January 2012 and December 2022.

2.2 Participants

All adult patients with CSDH who underwent surgery with a burr hole or craniotomy were included in this study. The exclusion criteria were as follows: 1) bilateral CSDH hematoma, 2) previous surgery for CSDH within the last 6 months, and 3) insufficient data (no preoperative CT scan or operative report available).

2.3 Variables and data sources

The following clinical and radiological data were retrospectively collected by two investigators (SH et MS). Clinical data included age, sex, medical history and treatment (anticoagulant or antiplatelet therapy), modified Rankin Scale (mRS), and clinical symptoms at diagnosis. Radiological data included the maximal thickness of the hematoma (mm) and maximum midline shift (mm), defined as the distance from the point of the septum pellucidum between the anterior horns of the lateral ventricles to a perpendicular line connecting the anterior and posterior insertions of the falx cerebri. Surgical data included the choice of the surgical approach (burr hole or craniotomy). Follow-up data included the occurrence of postoperative complications, hematoma recurrence (defined by radiological recurrence with clinical symptoms requiring surgery), mRS at 6 months, and institutionalization. This study was conducted in compliance with the STROBE guidelines. Poor outcome was defined as an mRS score of ≥ 3 (i.e., disability requiring some help).

2.4 Perioperative management

In our center, all patients have similar perioperative management; all patients benefit from subdural drain placement, except in rare cases where drain insertion is impossible. Reverticalization was performed early, within 6 hours of surgery. The drain was removed 2 days after surgery. Anticoagulant or antiplatelet

therapy was stopped 5 days preoperatively, according to the guidelines of the French National Health Agency, except in life-threatening situations.

2.5 Statistical analysis

Univariate analyses were carried out using Fisher's exact or chi-square tests to compare categorical variables, and the Mann–Whitney rank sum test or unpaired t-test for continuous variables, as appropriate. Variables associated with mRS ≥ 3 at 6 months in the univariate analysis were entered into the multivariate logistic regression model. The candidate variates were included in a Least Absolute Shrinkage and Selection Operation (LASSO) penalized regression model. The penalty coefficient (λ) was chosen so as to provide an estimation error lower than one standard deviation of the minimum error obtained by 10-fold cross-validation, while being as parsimonious as possible. No variable had a coefficient different from 0 with this λ coefficient. Statistical significance was set at $P < 0.05$. All statistical analyses were performed using R software, version 4.1 (R Foundation for Statistical Computing, Vienna, Austria).

2.6 Standard protocol approvals, registrations, and patient consents

This study received the required authorization (CLERS 3339) from the institutional review board of our hospital. According to French legislation, the requirement for informed consent was waived for this observational retrospective study.

3. RESULTS

3.1 Study population

During the inclusion period, 630 patients underwent surgery for evacuation of CSDH. Thirty-eight patients had bilateral CSDH, and 20 had undergone previous surgery for CSDH within the last 6 months. Preoperative CT-scan and/or operative reports were unavailable for 10 patients. In total, 582 patients were included in this study. A flowchart of the inclusion and exclusion of patients is shown in Fig. 1. The mean age at diagnosis was 74.6 ± 13.1 years (range 18–96). Men accounted for 74% of all the patients ($n = 430$).

3.2 Clinical and radiological findings

The clinico-radiological findings and group comparability are shown in Table 1. The median preoperative mRS score was 4 (IQ 3–4) and the median preoperative Glasgow score was 15 (IQ 14–15). The most frequent symptom was a motor deficit ($n = 236$, 41%), followed by headache ($n = 117$, 20%), neuropsychological disorder ($n = 77$, 13%), other (including sensitive disorder, disturbance and visual disorder, $n = 76$, 13%), aphasia ($n = 52$, 9%) and epileptic seizures ($n = 24$, 4%). Antiplatelet or anticoagulant therapy was administered to 27% ($n = 155$) and 22% ($n = 130$) of patients, respectively.

Radiological findings on CT scans were hypodense in 38% of cases (n = 219), followed by mixed (25%, n = 143), isodense (24%, n = 152), and septated (11%, n = 65). The mean maximal thickness of the hematoma was 20.5 ± 7.9 mm (range 4.2–40) and the mean maximal midline shift was 9.6 ± 5.6 mm (range 0–37). Clinical and radiological findings did not significantly differ between the two groups, except for the maximal midline shift that was more important in patients with burr hole opening (10.2 mm) than in patients who underwent craniotomy (9.2 mm, $p = 0.02$).

Table 1

Clinicoradiological findings and group comparability. CT: computed tomography; mRS: modified rankin scale; IQ: Interquartile; SD: standard deviation

Parameters	Whole serie (n = 582)	Burr-hole opening (n = 253)	Craniotomy (n = 329)	p-value
Sex	430 (74%)	190 (75%)	240 (73%)	0.56
Male	152 (26%)	63 (25%)	89 (27%)	
Female				
Age, years (mean ± SD)	74.6 ± 13.1	74.5 ± 13.7	74.6 ± 12.8	0.97
mRS score (median, IQ)	4 (3–4)	4 (3–4)	4 (3–5)	0.33
Glasgow score (median, IQ)	15 (14–15)	15 (14–15)	15 (14–15)	0.14
First symptom at diagnosis	52 (9%)	32 (10%)	20 (8%)	0.37
Aphasia	24 (4%)	18 (6%)	6 (2%)	
Epileptic seizure	117 (20%)	62 (19%)	55 (22%)	
Headache	77 (13%)	43 (13%)	34 (13%)	
Neuropsychological disorder	236 (41%)	135 (41%)	101 (40%)	
Motor deficit	76 (13%)	39 (12%)	37 (15%)	
Other				
Antiplatelet therapy	427 (73%)	194 (77%)	233 (71%)	0.11
No	155 (27%)	59 (23%)	96 (29%)	
Yes				
Anticoagulant therapy	452 (78%)	189 (75%)	263 (80%)	0.13
No	130 (22%)	64 (25%)	66 (20%)	
Yes				
Radiological aspect on CT-scan	219 (38%)	86 (34%)	133 (40%)	0.23
Hypodense	152 (24%)	63 (25%)	89 (27%)	
Isodense	143 (25%)	70 (28%)	73 (22%)	
Mixed	65 (11%)	31 (12%)	34 (10%)	
Septated				

Parameters	Whole serie (n = 582)	Burr-hole opening (n = 253)	Craniotomy (n = 329)	p-value
Sex	430 (74%)	190 (75%)	240 (73%)	0.56
Male	152 (26%)	63 (25%)	89 (27%)	
Female				
Maximal thickness of the hematoma (mean ± SD)	20.5 ± 7.9	20.6 ± 7.7	20.3 ± 8.1	0.65
Maximal midline shift (mean ± SD)	9.6 ± 5.6	10.2 ± 6.1	9.2 ± 5.2	0.02

3.3 Intraoperative findings

Burr-hole opening was performed in 43% (n = 253) of the patients and craniotomy in 57% (n = 329). All patients, except 6% (n = 35), underwent subdural drain placement.

3.4 Postoperative outcomes

The postoperative outcomes and comparisons between the techniques are detailed in Table 2. Recurrence occurred in 10% (n = 57) of cases. General complications occurred in 13% (n = 74) of cases, including stroke (1%, n = 8), deep vein thrombosis and/or pulmonary embolism (1%, n = 8), and myocardial ischemia (0.5%, n = 3). Surgical site infection occurred in 2% (n = 11) of the cases. Clinical data 1 month after surgery were available for 549 patients; of these, 7% (n = 34) had neurological deficits, 6% (n = 32) were institutionalized, and 4% (n = 21) died. The mRS score at 6 months was < 3 in 78% (n = 397) of 506 patients. The rate of recurrence did not differ between the two surgical approaches, nor did the rates of general postoperative complications, surgical site infection, death, institutionalization, mRS score at 6 months, or persistence of neurological deficit at 1 month.

Table 2
Postoperative outcomes and comparison between techniques.

Parameters	Whole serie (n = 582)	Burr-hole opening (n = 253)	Craniotomy (n = 329)	p-value
Recurrence	525 (90%)	224 (89%)	301 (91%)	0.23
No	57 (10%)	29 (11%)	28 (9%)	
Yes				
General postoperative complication	508 (87%)	225 (89%)	283 (86%)	0.3
No	74 (13%)	28 (11%)	46 (14%)	
Yes	8 (1%)	4 (2%)	4 (1%)	
Stroke	8 (1%)	3 (1%)	5 (2%)	
Deep vein thrombosis/pulmonary embolism	3 (0.5%)	2 (1%)	1 (0.5%)	
Myocardial ischemia				
Surgical site infection	571 (90%)	248 (98%)	323 (98%)	1
No	11 (2%)	5 (2%)	6 (2%)	
Yes				
Neurological deficit at 1 month (n = 549)	515 (93%)	228 (95%)	281 (92%)	0.2
No	34 (7%)	11 (5%)	23 (8%)	
Yes				
Institutionalization (n = 549)	549 (94%)	240 (95%)	309 (94%)	0.73
No	32 (6%)	13 (5%)	19 (6%)	
Yes				
Death at 1 month (n = 549)	553 (96%)	240 (96%)	313 (96%)	0.96
No	21 (4%)	9 (4%)	12 (4%)	
Yes				
mRS score at 6 months (n = 506)	397 (78%)	145 (76%)	252 (80%)	0.28
< 3	109 (22%)	46 (24%)	63 (20%)	
≥ 3				

3.5 Risk factors of poor outcome

The risk factors for poor outcome (i.e., mRS score ≥ 3) are detailed in Table 3. In univariate analysis, age ($p = 0.016$), preoperative mRS score ≥ 3 ($p < 0.01$), maximal hematoma thickness ($p = 0.03$), recurrence ($p < 0.001$), and postoperative general complications ($p < 0.001$) were associated with poor outcome. Sex, first symptom at diagnostic, anticoagulant therapy, antiplatelet therapy, preoperative Glasgow score, radiological aspect on CT-scan, maximal midline shift, and surgical site infection were not significant risk factors for poor outcome. In the multivariate analysis, age (OR, 1.02 [95%CI:1.00-1.05], $p = 0.033$), postoperative general complications (OR, 15.0 [95%CI:8.20–28.3], $p < 0.001$), recurrence (OR, 2.59 [95%CI:1.26–5.20], $p < 0.01$), and preoperative mRS score ≥ 3 (OR, 3.62 [95%CI:1.28–13.3], $p < 0.01$) were independent risk factors for poor outcome at 6 months. A forest plot of this multivariate analysis is shown in Fig. 2.

Table 3

Univariate analysis of factors associated with poor outcome (i.e. mRS score at 6 months ≥ 3 , n = 506).

Parameters	mRS at 6 months < 3 (n = 397)	mRS at 6 months ≥ 3 (n = 109)	p-value
Sex	296 (75%)	79 (72%)	0.66
Male	101 (25%)	30 (28%)	
Female			
Age, years (mean \pm SD)	74 \pm 13.1	77.4 \pm 12.8	0.016
Preoperative mRS score ≥ 3	336 (85%)	105 (96%)	< 0.01
Glasgow score (median, IQ)	15 (14–15)	15 (13–15)	0.63
First symptom at diagnosis	33 (8%)	11 (10%)	0.74
Aphasia	19 (5%)	2 (2%)	
Epileptic seizure	82 (21%)	26 (24%)	
Headache	55 (14%)	13 (12%)	
Neuropsychological disorder	152 (38%)	43 (39%)	
Motor deficit	56 (14%)	14 (13%)	
Other			
Antiplatelet therapy	109 (27%)	32 (29%)	0.69
Anticoagulant therapy	81 (20%)	27 (25%)	0.32
Radiological aspect on CT-scan	162 (41%)	38 (35%)	0.088
Hypodense	112 (28%)	23 (21%)	
Isodense	79 (20%)	35 (32%)	
Mixed	43 (11%)	13 (12%)	
Septated			
Maximal thickness of the hematoma (mean \pm SD)	19.7 \pm 7.9	21.8 \pm 8.6	0.03
Maximal midline shift (mean \pm SD)	9.7 \pm 5.8	9.2 \pm 5.7	0.41
Recurrence	29 (7%)	26 (24%)	< 0.001
Postoperative general complication	21 (5%)	50 (46%)	< 0.001

Parameters	mRS at 6 months < 3 (n = 397)	mRS at 6 months ≥ 3 (n = 109)	p-value
Sex	296 (75%)	79 (72%)	0.66
Male	101 (25%)	30 (28%)	
Female			
Surgical site infection	6 (2%)	5 (5%)	0.07

4 DISCUSSION

4.1 Key results

In this retrospective monocentric study, which included 582 cases, we assessed the differences between surgical approaches for the treatment of CSDH and the risk factors associated with poor long-term outcomes following this surgery. Our findings indicate that

1) Burr-hole opening and craniectomy had similar rates of postoperative complications, including general postoperative complications, surgical site infections, death within 1 month, and institutionalization; 2) burr hole opening and craniectomy showed similar rates of recurrence; and 3) age, postoperative general complications, recurrence, and preoperative mRS score ≥ 3 were identified as independent risk factors for poor long-term outcomes.

4.2 Comparison between surgical approaches

In this retrospective analysis, we aimed to compare the postoperative outcomes of patients undergoing either surgical approach and to investigate the impact of recurrence on long-term functional outcomes. Our findings indicate that in terms of immediate postoperative outcomes, there were no statistically significant differences between the two surgical techniques. This result is not consistent with previous research in the field; Ducruet et al. showed in a meta-analysis that the complication rate was higher for patients who received a trepan hole than for those who underwent craniotomy, even though the mortality rate was higher in the craniotomy group [5]. In contrast, Weigel et al. showed that morbidity was higher after craniotomy, with a similar recurrence rate between the two techniques [22] and Almenawer et al. showed that craniotomy led to more complications but less recurrence [2]. In addition, a decision analysis model by Lega et al. using Monte Carlo simulation of meta-analysis data revealed that BHC was ultimately superior to craniotomy [14]. Our results underscore the notion that from a short-term perspective, either technique can be employed with a similar expectation of success in terms of complications and recurrence. The strength of our study lies in the homogeneous nature of our postoperative follow-up: all patients were up and about the evening of the operation, which is not always the case, particularly for craniotomy patients who are often referred for postoperative intensive care [1]. In the meta-analyses cited above, intraoperative practices varied, especially between craniotomy and burr

hole, and may explain the differences observed. This underlines the importance, in our opinion, of early reverticalization of patients who are often frail and elderly. This may also explain our mortality rate, which is lower than that in other studies [12]. Indeed, reverticalization has been shown to reduce postoperative complications, without affecting recurrence [13, 18]. The future lies in the twist drill, which has complication rates similar to those of the trepan hole and is less invasive [2, 11], but seems to have a higher recurrence rate [6]. This technique should therefore be used with caution, since as we have shown, recurrence is an independent risk factor for poor clinical outcome.

4.3 Antiplatelet and anticoagulant therapy

French guidelines recommend stopping antiplatelet or anticoagulant therapy five days before surgery, except in cases of life-threatening situations. We showed that thrombotic and embolic events are rare (< 1%). This shows that the benefit/risk balance favors stopping these treatments before surgery. We have also shown that the use of anticoagulants and/or anti-aggregants is not a risk factor for recurrence, in line with the results of other studies [9, 19, 21]. Resumption of these treatments is therefore possible, depending on the thrombotic and/or embolic risk of the initial pathology.

4.4 Risk factors of poor outcome

Our study highlights a crucial factor that has not been extensively explored in the context of SDH management: the role of recurrence and postoperative complications as a predictor of long-term functional outcomes. Regardless of whether patients underwent burr hole trepanation or craniotomy, the presence of recurrent hematomas significantly increased the risk of having an mRS score greater than 3 at a later stage. This finding underscores the importance of considering the impact of recurrence in clinical decision making and the necessity for future research into strategies that minimize recurrence risk, irrespective of the chosen surgical method. These new data are absent from most series and literature reviews [12, 17]. Our study revealed that, beyond the risk of recurrence, the occurrence of postoperative complications constitutes a significant factor contributing to a poor prognosis (OR 15, $p < 0.001$). Corticosteroid treatment may contribute to postoperative complications, and its role in preventing recurrence remains a subject of debate in the literature. A recent meta-analysis indicated that adjuvant corticosteroid therapy appeared effective in reducing the risk of recurrence but significantly elevated the risk of adverse events, particularly in elderly subjects [20]. These findings were further supported by the results of the DEX-CSDH clinical trial [10]. Our study reinforces these conclusions and suggests that corticosteroids should not be prescribed for patients undergoing surgery for chronic subdural hematoma. Implementing early mobilization of these patients should also be considered a standard practice for minimize the risk of general complications.

4.4 Limitations

Although our study provides valuable insights into the outcomes of these surgical techniques, it is not without limitations. The retrospective nature of the analysis and the potential for selection bias in the surgical approach must be acknowledged. Furthermore, patient data at 6 months are only available for

506 patients, the others having been lost to follow-up. Prospective randomized studies would provide more robust evidence to guide clinical practice.

5. CONCLUSION

In conclusion, the comparison of burr hole trepanation and craniotomy for the management of CSDH did not reveal significant differences in the postoperative outcomes. Post-operative complication and recurrence has been identified as a critical factor in predicting long-term functional outcomes. This underscores the necessity for a thorough evaluation of patients with chronic subdural hematoma (CSDH) and highlights the importance of preventing postoperative complications through early mobilization and avoiding the prescription of corticosteroids. Future research is necessary to mitigate the risk of recurrence, regardless of the surgical technique employed.

Declarations

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Competing interest

The authors have no relevant financial or non-financial interests to disclose.

Ethical approval

This study received the required authorization (CLERS 3339) from the institutional review board of our hospital. According to French legislation, the requirement for informed consent was waived for this observational retrospective study.

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Author Contribution

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by SH, MS, TG and AL. The first draft of the manuscript was written by SH and

all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Availability of data and materials

We support data sharing within the restrictions of the ethical approval permissions. Reasonable requests can be made to the corresponding author.

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Figures

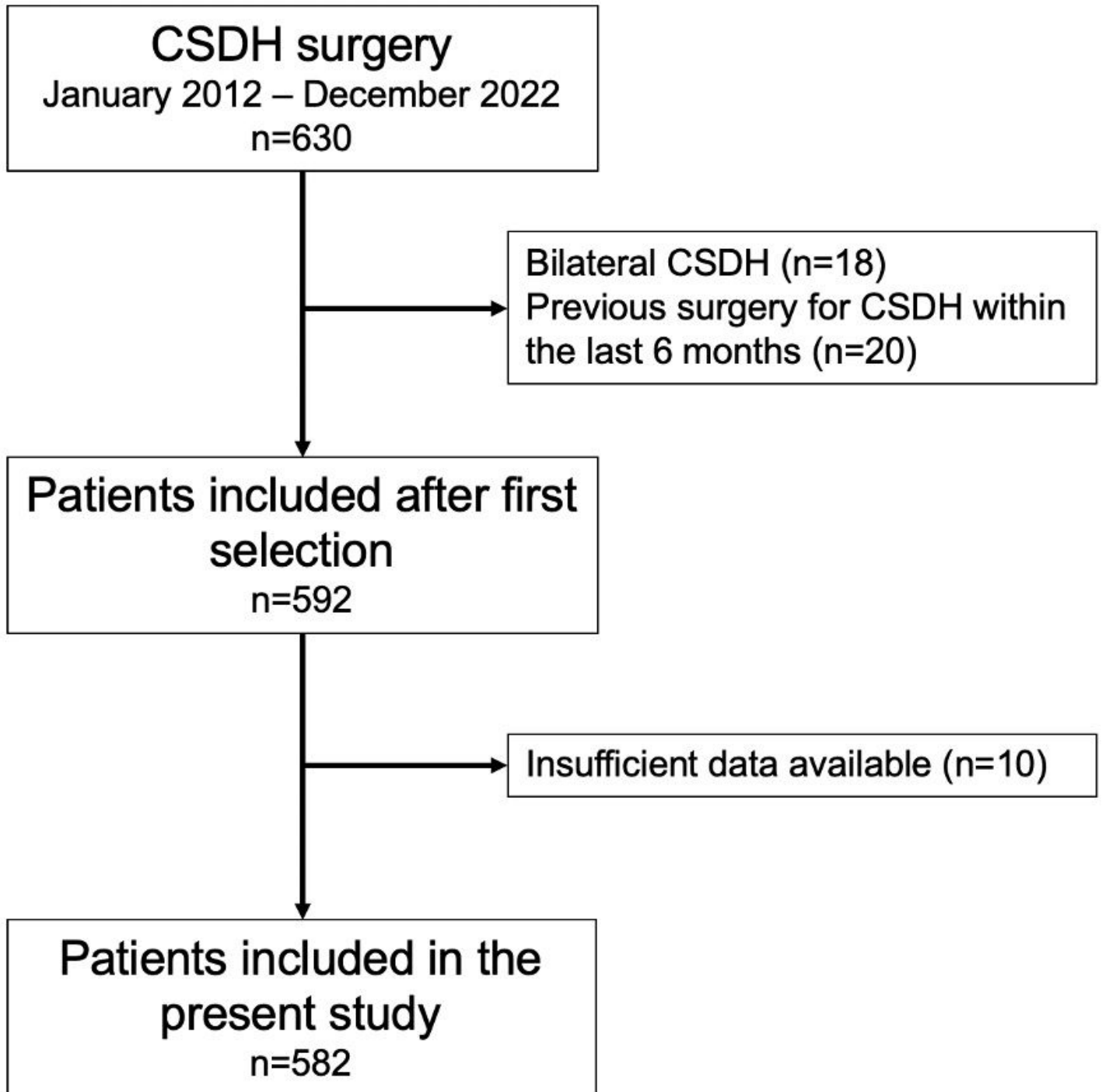


Figure 1

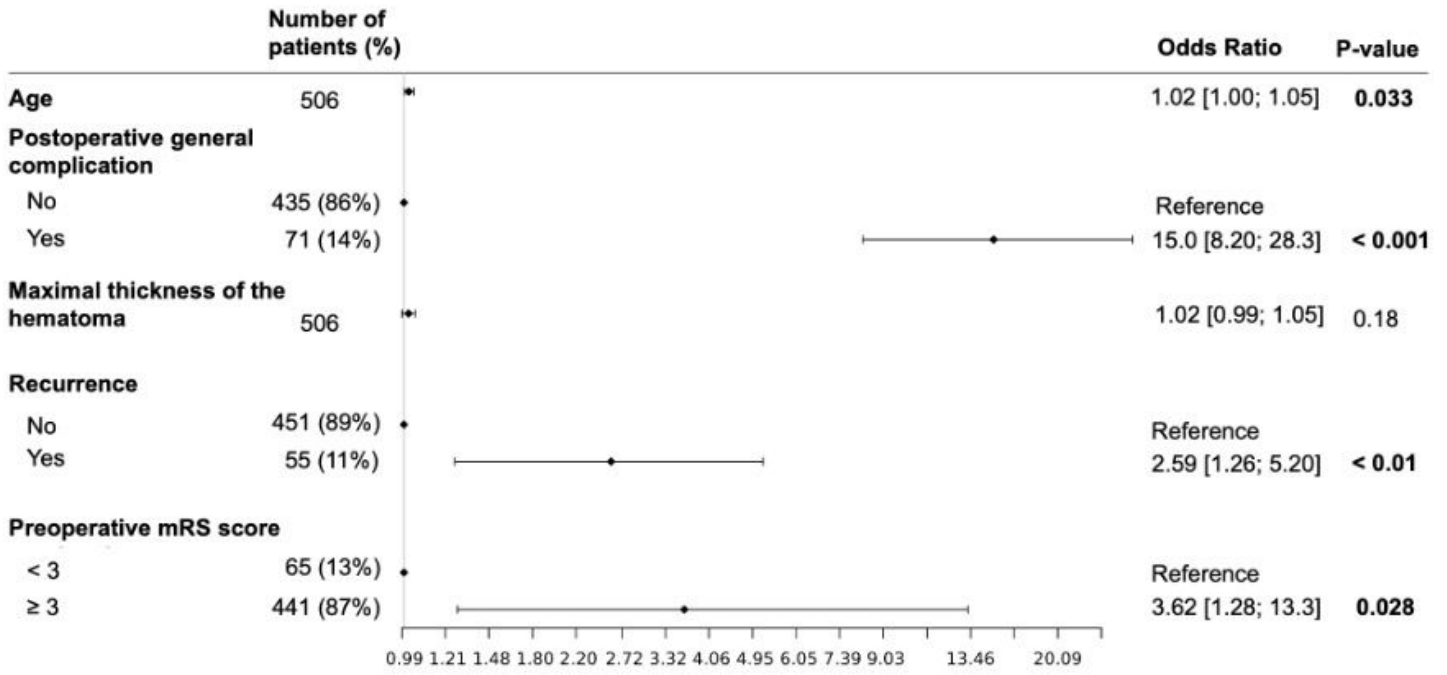


Figure 2

Forest plot of factors associated with poor outcome (i.e. mRS score at 6 months \geq 3)