Drain type after burr-hole drainage of chronic subdural hematoma in geriatric patients: a subanalysis of the cSDH-Drain randomized controlled trial

Ladina Greuter, MD,¹ Katharina Lutz, MD,³ Javier Fandino, MD,⁴ Luigi Mariani, MD,^{1,2} Raphael Guzman, MD,^{1,2} and Jehuda Soleman, MD^{1,2}

¹Department of Neurosurgery, University Hospital Basel; ²Medical Faculty, University of Basel; ³Department of Neurosurgery, University Hospital Bern; and ⁴Department of Neurosurgery, Kantonsspital Aarau, Switzerland

OBJECTIVE Chronic subdural hematoma (cSDH) occurs more frequently in elderly patients, while older patient age is associated with worse postoperative outcome following burr-hole drainage (BHD) of cSDH. The cSDH-Drain trial showed comparable recurrence rates after BHD and placement of either a subperiosteal drain (SPD) or subdural drain (SDD). Additionally, an SPD showed a significantly lower rate of infections as well as iatrogenic parenchymal injuries through drain misplacement. This post hoc analysis aims to compare recurrence rates and clinical outcomes following BHD of cSDH and the placement of SPDs or SDDs in elderly patients.

METHODS The study included 104 patients (47.3%) 80 years of age and older from the 220 patients recruited in the preceding cSDH-Drain trial. SPDs and SDDs were compared with regard to recurrence rate, morbidity, mortality, and clinical outcome. A post hoc analysis using logistic regression, comparing the outcome measurements for patients < 80 and ≥ 80 years old in a univariate analysis and stratified for drain type, was further completed.

RESULTS Patients ≥ 80 years of age treated with an SDD showed higher recurrence rates (12.8%) compared with those treated with an SPD (8.2%), without a significant difference ($p = 0.46$). Significantly higher drain misplacement rates were observed for patients older than 80 years and treated with an SDD compared with an SPD (0% vs 20%, $p = 0.01$). Comparing patients older than 80 years to younger patients, significantly higher overall mortality (15.4% vs 5.2%, $p = 0.012$), 30-day mortality (3.8% vs 0%, $p = 0.033$), and surgical mortality (2.9% vs 1.7%, $p = 0.034$) rates were observed. Clinical outcome at the 12-month follow-up was significantly worse for patients ≥ 80 years old, and logistic regression showed a significant association of age with outcome, while drain type had no association with outcome.

CONCLUSIONS The initial findings of the cSDH-Drain trial and the findings of this subanalysis suggest that SPD may be warranted in elderly patients. As opposed to drain type, patient age (> 80 years) was significantly associated with worse outcome, as well as higher morbidity and mortality rates.

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KEYWORDS chronic subdural hematoma; octogenarian; geriatric; recurrence; subperiosteal drain; subdural drain; burr-hole drainage; elderly patients

CHRONIC subdural hematoma (cSDH) is one of the most common neurosurgical diseases, and its incidence increases with patient age.^{1,18} The incidence rate of cSDH in patients 65–74 years of age is approximately 19 per 100,000, whereas it increases to 47–153 per 100,000 in patients older than 75 years.² Older age carries

a higher perioperative risk and is associated with worse outcomes in cSDH.^{3,4}

The gold standard of treatment remains surgical evacuation of the hematoma through burr-hole drainage (BHD) and insertion of a drain.⁵ Drain insertion after BHD was shown to significantly lower recurrence rates and improve

ABBREVIATIONS BHD = burr-hole drainage; CAD = coronary artery disease; CCI = Charlson Comorbidity Index; cSDH = chronic subdural hematoma; GCS = Glasgow Coma Scale; GOS = Glasgow Outcome Scale; LOS = length of stay; MLS = midline shift; mRS = modified Rankin Scale; MWS = Markwalder score; RCT = randomized controlled trial; SDD = subdural drain; SPD = subperiosteal drain.

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clinical outcome.⁶ Drains can be inserted either in the subdural space (subdural drains [SDDs]) or subperiosteally (subperiosteal drains [SPDs]); the recent cSDH-Drain randomized controlled trial (RCT) showed no significant difference in recurrence rate between the two drain types, but found significantly lower drain misplacement and infection rates in the SPD group.⁷

This post hoc analysis aims to compare recurrence rates and clinical outcomes following BHD and the placement of SPDs or SDDs in elderly patients.

Methods

This is a subanalysis of the preceding cSDH-Drain trial.⁷ The original trial was registered with the ClinicalTrials.gov database (<http://clinicaltrials.gov>), and its registration no. is NCT01869855. The detailed methods of the cSDH-Drain trial can be found in two previous reports.^{7,8} In summary, the cSDH-Drain trial was a two-center RCT comparing SPDs to SDDs with regard to recurrence. Two hundred twenty patients were enrolled and randomized to either SPD or SDD placement following BHD of cSDH. Secondary outcome measures were clinical and radiological outcome measurements, drain misplacement rates, and morbidity and mortality. The follow-up time for all patients was 12 months. Recurrence was defined as radiological evidence of cSDH on the ipsilateral side with clinical symptoms requiring surgery within 12 months. Demographic data concerning preoperative clinical condition (age, sex, comorbidities, Glasgow Coma Scale [GCS] score, modified Rankin Scale [mRS] score, and Glasgow Outcome Scale [GOS] score), as well as radiological parameters (Markwalder score [MWS], midline shift [MLS], and diameter of hemorrhage), were assessed. Postoperatively, clinical follow-ups were obtained at 24 hours, 6 weeks, and 12 months, while clinical outcome was assessed through the GCS, mRS, GOS, and MWS. Radiological outcomes at 24 hours and 6 weeks included residual hematoma diameter and residual MLS.

From the patients initially recruited for the cSDH-Drain trial (220 patients: 120 treated with SDD, 100 treated with SPD), all patients ≥ 80 years of age ($n = 104$) were included in this subanalysis. We compared the primary and secondary outcome measures from the cSDH-Drain trial between the different drain types. A post hoc analysis using logistic regression, comparing the outcome measurements for patients < 80 and ≥ 80 years old in a univariate analysis and stratified for drain type, was further completed. For this subanalysis, the outcome scores were dichotomized (GCS: good = 14–15, fair = 9–13, bad = 3–8; mRS: good = 1–3, bad = 4–5; GOS: good = 4–5, bad = 1–3; and MWS: no/mild symptoms = 0–1, significant symptoms = 2, severe symptoms = 3–4). MLS and hemorrhage diameter were measured on the pre- and postoperative CT or MR images. Overall, 5 patients (4.8%) were lost to follow-up, while for patients where recurrence and/or mortality occurred, follow-up from that point on was not undertaken. Therefore, at 6 weeks and 12 months, 93 and 78 patients, respectively, were followed. The initial trial was approved by the local ethics committee (EKNZ) and allows subanalysis of already registered data. Informed consent was

obtained from all participants or their next of kin prior to randomization in the original RCT.

Statistical Analysis

Continuous variables were analyzed using the Mann-Whitney U-test and presented as median and interquartile range (IQR). The chi-square test or Fisher exact test, depending on the number of variables, was used for categorical data and presented as number of patients (percent). Logistic regression (categorical variables) or Poisson regression (continuous variables) analysis was conducted for significant variables in the univariate analysis to compare the association of different drainage types and age with the outcome parameters. Time to recurrence, overall mortality, and 30-day time to mortality of the drain types, stratified by the age groups, were compared using the log-rank test and presented as Kaplan-Meier curves. A p value < 0.05 was considered significant. The reference for odds ratio (OR) presented was the SDD group, unless otherwise stated. All analyses were performed using SPSS software (version 26, IBM Corp.) and R statistical software (version 3.6.2, The R Foundation). The analyses were performed on the per protocol analysis set as defined for the main trial analysis.

Results

Out of the 220 study participants, recruited between April 2013 and December 2015, 41 (18.6%) were < 70 years, 75 (34.1%) were 70–79 years, and 104 (47.3%) were ≥ 80 years of age. For patients ≥ 80 years of age, the distribution of SPDs and SDDs was well matched ($n = 49$ and $n = 55$), while patients < 70 years and 70–79 years old received more SPDs (< 70 years, $n = 28$ and 13; 70–79 years, $n = 43$ and $n = 32$); however, the difference was not significant ($p = 0.06$).

The baseline characteristics of patients < 80 and ≥ 80 years old are presented in Table 1. Both groups were heterogeneous, with significant differences concerning preexisting comorbidities, namely diabetes, coronary artery disease (CAD), atrial fibrillation, and dementia, resulting in a significantly higher Charlson Comorbidity Index (CCI) and more frequent blood thinner intake for patients ≥ 80 years old when compared with patients < 80 years of age. Furthermore, preoperative clinical outcome parameters were significantly worse in patients ≥ 80 years old.

Patients ≥ 80 Versus < 80 Years Old

Patients older than 80 years showed a recurrence rate of 10.6% compared with 9.5% for patients younger than 80 years ($p = 0.79$). Time to recurrence was similar for both drain types regardless of age (Fig. 1).

When comparing patients under the age of 80 years to patients above the age of 80 years, overall mortality (15.4% vs 5.2%, $p = 0.012$), 30-day mortality (3.8% vs 0%, $p = 0.033$), and surgical mortality (2.9% vs 1.7%, $p = 0.034$) rates were significantly higher in patients ≥ 80 years old. After logistic regression analysis, drain type had no association with mortality rate, while age significantly affected overall mortality (Table 2).

Additionally, patients older than 80 years showed sta-

TABLE 1. Baseline characteristics for patients < 80 and ≥ 80 years old

Variable	<80 Yrs	≥80 Yrs	p Value
No. of patients	116	104	
Mean age (SD), yrs	70.21 (8.67)	85.10 (3.67)	<0.001
Females	38 (32.8)	33 (31.7)	0.99
GCS admission score			0.007
Good (14–15)	102 (87.9)	77 (74.0)	
Fair (9–13)	10 (8.6)	25 (24.0)	
Bad (3–8)	4 (3.4)	2 (1.9)	
mRS admission score			0.001
Good (0–3)	100 (86.2)	69 (66.3)	
Bad (4–5)	16 (13.8)	35 (33.7)	
MWS admission			0.009
No/mild symptoms (0–1)	53 (45.7)	28 (26.9)	
Significant symptoms (2)	60 (51.7)	69 (66.3)	
Severe symptoms (3–4)	3 (2.6)	7 (6.7)	
GOS admission score			0.002
Good (4–5)	97 (83.6)	67 (64.4)	
Bad (1–3)	19 (16.4)	37 (35.6)	
Aphasia	22 (19.0)	25 (24.0)	0.452
Coma	3 (2.6)	3 (2.9)	1.000
Motor deficit	51 (44.0)	57 (54.8)	0.141
Incontinence	4 (3.4)	2 (1.9)	0.780
Headache	44 (37.9)	23 (22.1)	0.016
Sensory deficit	10 (8.6)	4 (3.8)	0.241
Confusion	40 (34.5)	63 (60.6)	<0.001
Ataxia	36 (31.0)	39 (37.5)	0.386
Seizures	6 (5.2)	6 (5.8)	1.000
Diabetes	10 (8.6)	20 (19.2)	0.036
Hypertension	59 (50.9)	57 (54.8)	0.653
CAD	25 (21.6)	38 (36.5)	0.021
COPD	4 (3.4)	1 (1.0)	0.434
Kidney failure	11 (9.5)	18 (17.3)	0.130
Dementia	8 (6.9)	18 (17.3)	0.029
Liver failure/cirrhosis	3 (2.6)	0 (0)	0.285
Obesity	4 (3.4)	3 (2.9)	1.000
Atrial fibrillation	14 (12.1)	32 (30.8)	0.001
Smoker	7 (6.0)	1 (1.0)	0.100
Alcohol abuse	10 (8.6)	3 (2.9)	0.130
Valvular disease	3 (2.6)	9 (8.7)	0.093
Stroke	14 (12.1)	13 (12.5)	1.000
Pulmonary embolism	3 (2.6)	5 (4.8)	0.604
DVT	5 (4.3)	3 (2.9)	0.839
Other comorbidities	57 (49.1)	41 (39.4)	0.190
Mean CCI (SD)	4.34 (1.40)	5.10 (0.98)	<0.001
Blood thinner intake	62 (53.4)	71 (68.3)	0.035
Hematoma side			0.747
Rt	47 (40.5)	37 (35.6)	
Lt	46 (39.7)	44 (42.3)	
Bilat	23 (19.8)	23 (22.1)	

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TABLE 1. Baseline characteristics for patients < 80 and ≥ 80 years old

Variable	<80 Yrs	≥80 Yrs	p Value
Mean MLS preop (SD), mm	7.09 (5.24)	7.51 (5.07)	0.545
Mean hematoma width preop (SD), mm	18.06 (7.16)	19.91 (8.00)	0.071
Hematoma type			0.432
Chronic	52 (44.8)	56 (54.4)	
Acute on chronic	35 (30.2)	27 (26.2)	
Subacute	28 (24.1)	20 (19.4)	
Hygroma	1 (0.9)	0 (0)	

COPD = chronic obstructive pulmonary disease; DVT = deep vein thrombosis. Values are presented as number (%) unless otherwise indicated. Boldface type indicates statistical significance.

tistically significant higher rates of medical complications (20.2% vs 10.3%, $p = 0.04$) and overall complications (37.5% vs 23.3%, $p = 0.022$). After logistic regression analysis, drain type had no association with the medical complication rate, as opposed to age (Table 2).

Clinical outcome (mRS, GOS, and MWS) was significantly worse in patients ≥ 80 years old compared with patients < 80 years old at the 12-month follow-up. Logistic regression analysis showed a significant association for age but not for drain type with outcome (Table 2). Radiological outcome measured as residual cavity at 24 hours postoperatively was significantly higher in patients ≥ 80 years old compared with patients < 80 years old (11 mm [IQR 8–15 mm] vs 10 mm [IQR 7–13 mm], $p = 0.01$), while MLS showed comparable results in both age groups. After logistic regression analysis, drain type had no association with residual cavity at 24 hours, as opposed to age (Table 2).

When comparing patients ≥ 80 to those < 80 years of age, length of stay (LOS) was significantly longer in older patients (7 days [IQR 5–10 days] vs 6 days [IQR 5–7 days], $p = 0.011$). After logistic regression analysis, age showed a significant association with LOS, while drain type had no association (Table 2).

Comparing SDDs and SPDs in Patients ≥ 80 Years Old

The baseline characteristics of the two drain groups in patients ≥ 80 years of age were well matched (Supplementary Table 1). Patients older than 80 years of age treated with an SDD showed recurrence rates of 12.8%, compared with 8.2% when an SPD was inserted, without a significant difference ($p = 0.46$). Time to recurrence was comparable for both drain types as well (Fig. 2).

Overall mortality and 30-day mortality were comparable between the different drain types. Similarly, time to mortality and time to 30-day mortality were comparable for both drain types (Figs. 3 and 4). The SPD group showed a trend toward lower surgical mortality rates compared with the SDD group (0% vs 5.5%, $p = 0.07$).

No drain misplacement was observed in the SPD group, which led to a significant difference between the groups (0% vs 20%, $p = 0.01$).

FIG. 1. Kaplan-Meier curve for time to recurrence for the different drain types stratified by age groups.

In general, clinical and radiological outcome measures were similar in both groups, with the exception of a statistically significant higher MWS at the last follow-up in the SDD group ($n = 12$ vs $n = 3$, $p = 0.049$) and a lower residual MLS in the SPD group ($n = 3$ [IQR 0–4] vs $n = 3$ [IQR 1–6], $p = 0.038$) 24 hours after surgery.

Discussion

To date, the cSDH-Drain trial is the largest study randomly comparing recurrence rates of surgically drained cSDH after the insertion of an SPD or SDD.⁷ As the incidence of cSDH increases with age, it is not surprising that 104 of the patients were over 80 years of age, showing the importance of analyzing the outcome after BHD of cSDH stratified by age. To date, no studies exist analyzing different operative techniques for cSDH that might affect outcome depending on the patient's age. It has been shown that older patients have overall worse outcome after surgical treatment of cSDH.³ Our data showed that patients ≥ 80 years old show higher complication and mortality rates. Hence, optimal surgical treatment is of paramount importance in geriatric patients.

The most commonly used method for cSDH treatment is BHD.^{5,9} BHD was shown to have significantly lower complication rates compared with open craniotomy, especially in elderly patients, while a trend toward higher complication rates as opposed to percutaneous twist-drill evacuation was observed.^{9,10} Especially in older patients with high perioperative risks, BHD is preferred to craniotomy as it is less invasive, is associated with shorter operative duration, leads to lower morbidity, and can be performed under local anesthesia. BHD and open craniotomy were shown to be significantly superior to percutaneous

twist-drill evacuation regarding recurrence rates.¹⁰ This is especially important in geriatric patients, since avoiding recurrences, which can potentially lead to reoperations, is paramount for achieving a good outcome in this group of patients. Therefore, it appears that BHD is also the treatment with the best risk-benefit ratio in elderly patients suffering from cSDH.¹¹

Conservative management is, to date, still reserved for patients with high perioperative risk or with mild symptoms. Several options were discussed in the literature, including administration of tranexamic acid, corticosteroids, mannitol, statins, or angiotensin-converting enzyme inhibitors.¹² In a meta-analysis, the use of corticosteroids was shown to lack a significant difference concerning recurrence rate, morbidity, and mortality when compared with surgical treatment.⁹ However, ongoing RCTs are investigating the value of corticosteroids as stand-alone and adjunct treatment to surgery for cSDH.^{13,14} A recent placebo-controlled RCT showed that atorvastatin significantly lowers hematoma volume and neurological symptoms as a stand-alone treatment of cSDH.¹⁵ Hence, atorvastatin could be considered a pharmacological treatment, especially for geriatric patients who are often high-risk surgical candidates. Endovascular middle meningeal artery embolization has recently been described for the treatment of cSDH. This technique was shown to have a high success rate and comparable complication rates to surgical treatment, but results from large studies are still lacking.^{16,17} In the future, minimally invasive methods and pharmacological treatments might play a greater role in the treatment of cSDH in geriatric patients presenting with comorbidities and a high perioperative risk. However, to date, surgery (BHD) remains the gold standard treatment for geriatric patients, while we eagerly anticipate results

TABLE 2. Primary and secondary outcome measures in patients < 80 and ≥ 80 years old

Outcome Measure	<80 Yrs (n = 116)	≥80 Yrs (n = 104)	p Value	Regression Analysis (OR [95% CI], p value)*
Recurrence	11 (9.5)	11 (10.6)	0.79	
Mortalities				
Overall	6 (5.2)	16 (15.4)	0.012	Age: 1.08 (1.02–1.16), 0.01 SPD: 0.84 (0.34–2.10), 0.70
30-day	0 (0)	4 (3.8)	0.033	Age: 1.12 (0.96–1.30), 0.15 SPD: 1.0 (0.14–7.32), 1.0
Surgical	2 (1.7)	3 (2.9)	0.034	Age: 1.00 (0.91–1.10), 0.99 SPD: 4.95 (5.33–49.52), 0.16
Postop bleeding†	13 (11.2)	7 (6.7)	0.25	
Postop bleeding group			0.30	
None	103 (88.8)	97 (93.3)		
aSDH	7 (6)	5 (4.8)		
IPH	3 (2.6)	1 (1)		
SAH	3 (2.6)	0 (0)		
EDH	0 (0)	1 (1)		
Misplaced drain				
Total	7 (6)	11 (10.6)	0.22	
Causing bleeding	2 (1.7)	3 (2.9)	0.56	
Causing neurologic sequel	1 (0.9)	1 (1)	0.94	
Surgical infection	11 (9.5)	7 (6.7)	0.27	
Postop seizure	4 (3.4)	7 (6.7)	0.46	
Complications				
Surgical	13 (11.2)	11 (10.6)	0.88	
Medical	12 (10.3)	21 (20.2)	0.04	Age: 1.04 (1.00–1.09), 0.07 SPD: 0.90 (0.42–1.91), 0.78
Total	27 (23.3)	39 (37.5)	0.022	Age: 1.01 (0.98–1.04), 0.57 SPD: 0.75 (0.41–1.35), 0.34
Revision surgery†	6 (5.2)	7 (6.7)	0.63	
GCS score at 6 wks‡			0.45	
Good (14–15)	105 (90.5)	92 (88.5)		
Fair (9–13)	3 (2.6)	1 (1)		
Bad (3–8)	1 (0.9)	0 (0)		
mRS score at 6 wks			0.07	
Good (0–3)	103 (88.8)	81 (77.9)		
Bad (4–5)	6 (5.2)	12 (11.5)		
MWS at 6 wks			0.20	
No, mild symptoms (0–1)	100 (86.2)	80 (76.9)		
Significant symptoms (2)	9 (7.8)	11 (10.6)		
Severe symptoms (3–4)	0 (0)	2 (1.9)		
GOS score at 6 wks			0.14	
Good (4–5)	99 (85.3)	78 (75)		
Bad (1–3)	10 (8.6)	15 (14.4)		
GCS score at 12 mos§			0.44	
Good (14–15)	95 (81.9)	76 (73.1)		
Fair (9–13)	1 (0.9)	2 (1.9)		
Bad (3–8)	0 (0)	0 (0)		
mRS score at 12 mos			0.008	
Good (0–3)	93 (80.2)	67 (64.4)		Age: 1.20 (1.07–1.33), 0.001 SPD: 0.62 (0.19–2.02), 0.43
Bad (4–5)	3 (2.6)	11 (10.6)		

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TABLE 2. Primary and secondary outcome measures in patients < 80 and ≥ 80 years old

Outcome Measure	<80 Yrs (n = 116)	≥80 Yrs (n = 104)	p Value	Regression Analysis (OR [95% CI], p value)*
MWS at 12 mos			0.006	
No, mild symptoms (0–1)	91 (78.4)	62 (59.6)		Age: 1.17 (1.07–1.28), 0.001
Significant symptoms (2)	4 (3.4)	15 (14.4)		SPD: 2.35 (0.80–6.90), 0.12
Severe symptoms (3–4)	1 (0.9)	1 (1.0)		
GOS score at 12 mos			<0.001	
Good (4–5)	90 (77.6)	58 (55.8)		Age: 1.16 (1.08–1.25), <0.001
Bad (1–3)	6 (5.2)	20 (19.2)		SPD: 0.94 (0.38–2.3), 0.88
Postop new neurological sequel	8 (6.9)	8 (7.7)	0.82	
Residual subdural cavity at 24 hrs (IQR), mm	10 (7–13)	11 (8–15)	0.01	Age: 1.01 (1.00–1.02), <0.001
Residual MLS at 24 hrs (IQR), mm	4 (2–6)	3 (0–5)	0.10	SPD: 1.03 (0.94–1.12), 0.56
LOS (IQR), days	6 (5–7)	7 (5–10)	0.011	Age: 1.01 (1.00–1.01), 0.001
				SPD: 0.98 (0.89–1.08), 0.98
Residual subdural cavity at 6 wks (IQR), mm	4 (0–9)	5 (0–11)	0.41	
Residual MLS at 6 wks (IQR), mm	0 (0–0)	0 (0–1)	0.38	

aSDH = acute subdural hematoma; EDH = epidural hematoma; IPH = intraparenchymal hematoma; SAH = subarachnoid hemorrhage.

Values are presented as number (%) unless otherwise indicated. Boldface type indicates statistical significance.

* Logistic regression or Poisson regression analysis for significant variables in univariate analysis, analyzing for association of drain type and age with the variable.

† Postoperative bleeding and revision surgeries for recurrence not included.

‡ At the 6-week follow-up, cohort = 202.

§ At the 12-week follow-up, cohort = 174.

FIG. 2. Kaplan-Meier curve for time to recurrence in patients ≥ 80 years old stratified by different drain types.

FIG. 3. Kaplan-Meier curve for time to overall mortality in patients ≥ 80 years old stratified by different drain types.

from various prospective studies on pharmacological and other interventional treatment options.¹⁴

In general, recurrence rates for surgically evacuated cSDH are estimated to be around 10%.²¹ The main study and many other publications comparing SPD to SDD in regard to recurrence did not detect a statistically significant difference, except for a trend for a lower recurrence rate in the SPD group. A recent meta-analysis showed a

significantly lower recurrence rate for SPD compared with SDD.^{19–22} Based on our subgroup analysis, lower recurrence rates were also noted for patients treated with SPD who were ≥ 80 years old, without statistically significant differences. It seems, therefore, that SPD insertion in the geriatric population is comparable to SDD insertion, while the risk of drain misplacement can be avoided. Time to recurrence was comparable for both drain types in patients

FIG. 4. Kaplan-Meier curve for time to 30-day mortality in patients ≥ 80 years old stratified by different drain types.

≥ 80 years old; no difference was seen when also comparing patients ≥ 80 and < 80 years of age (Figs. 1 and 2). This finding is congruent with the recent subanalysis of the cSDH-Drain trial analyzing time to recurrence for the entire study population.²³ Based on a recently published survey, many surgeons tend to insert an SPD only when intraoperative brain expansion after BHD occurs.^{5,24} Otherwise, an SDD is generally preferred because it is considered to be safe by some surgeons. However, based on the available literature, this practice is not justified.^{7,23,25,26} Studies have shown that even when a large residual subdural cavity is apparent, the risk for drain misplacement, potentially leading to bleeding and neurological deficits, is present.^{7,27} Elderly patients often show brain atrophy, which explains the significant difference in preoperative MLS and hematoma diameter between patients < 80 and ≥ 80 years old in our cohort (results not shown). Similarly, postoperative residual subdural cavity diameter (representing the amount of intraoperative brain expansion) and MLS were significantly higher in the geriatric population, indicating less intraoperative brain expansion (Table 2). Therefore, the tendency of most surgeons would probably be to place an SDD. However, the risk for drain misplacement in geriatric patients is also significantly higher in the SDD group (Table 2). The results of this subanalysis suggest that an SPD may be warranted for geriatric patients usually showing minimal intraoperative brain expansion, because recurrence rates are comparable to SDD and drain misplacement is avoided. In addition, approximately 65% of these patients are receiving blood thinner treatment, and therefore manipulation within the subdural space should be avoided whenever possible.^{23,25}

Older age predisposes patients to more complications, consequently resulting in higher mortality rates. Mortality rates for cSDH in geriatric patients can occur in as many as 20% of the cases.⁴ Our cohort showed a total complication rate of 37.5% and 30-day mortality rate of approximately 4% in patients ≥ 80 years of age.

Overall complication and mortality rates were comparable for the SPD and SDD groups in patients ≥ 80 years old. Surgical mortality, however, showed a trend toward higher rates within the SDD group (5.5% vs 0%, $p = 0.07$). To evaluate the validity of these results, larger cohorts with adequate power are probably needed. Overall, patients ≥ 80 years old showed higher risk for complications and mortality as opposed to younger patients. The higher frequency of preexisting comorbidities in patients ≥ 80 years old (results not shown) could explain these results.

The existing data concerning postoperative infection in the different drain types vary in the literature; the cSDH-Drain trial has shown statistically significantly fewer infections in the SPD group.^{5,28} Although in the geriatric group the infection rate was slightly higher in the SDD group compared with the SPD group (7.3% vs 6.1%), significance was not observed. Because this subanalysis was probably underpowered, further studies powered for the detection of infection rates within the different drain types are needed to confirm our results.

Currently, only one study has shown a favorable outcome for patients treated with an SPD compared with an SDD after BHD of cSDH.²⁹ In this subanalysis, similar

outcomes were observed at 24 hours, 6 weeks, and 12 months of follow-up for the different drain types in patients ≥ 80 years old, with the exception of higher rates of severe symptoms based on the MWS at 12 months of follow-up in the SDD group. These findings are congruent with the main study.⁷ Additionally, worse outcome measures at presentation as well as at the last follow-up were observed for geriatric patients. Further prospective studies designed to analyze the outcome after insertion of an SPD compared with an SDD in cSDH are required.

Limitations

Because this study is a subanalysis of an RCT, it was not designed or powered to study the outcome measurements of SPD and SDD in geriatric patients. Hence, the results might be underpowered and need to be analyzed with caution. As cSDH is a disease of the elderly, most patients in our cohort were older than 70 years of age and no comparison to a younger subgroup is possible, but this reflects daily neurosurgical practice. However, comparing patients younger and older than 80 years of age led to sufficient patients in both cohorts, while the size of the cohorts and the baseline parameters in both drain groups were evenly matched. The strengths of this study are the prospectively collected subset of data, presented from the largest RCT analyzing recurrence rate and outcome after BHD of cSDH and insertion of an SPD compared with an SDD. The rather low rate of patients lost to follow-up presents an additional strength. To date, this is the first study analyzing which drain type appears to be more suitable for patients undergoing BHD of cSDH at ≥ 80 years old.

Conclusions

Similar recurrence, complication, and mortality rates were observed for SPD compared with SDD in geriatric patients. Like the results of the cSDH-Drain trial, the rate of drain misplacement in the SDD group was significantly higher in geriatric patients, although postoperative brain expansion was significantly lower in patients ≥ 80 years old when compared with younger patients. Of all outcome parameters, only the MWS was significantly worse in the SDD group at the last follow-up (12 months). A trend for higher surgical complication rates was seen in the SDD group. These results suggest that the insertion of an SPD after BHD of cSDH may be warranted in geriatric patients as well. As opposed to the type of drain inserted, patient age (> 80 years) was significantly associated with worse outcome, as well as higher morbidity and mortality rates, resulting in significantly longer hospital stays.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Soleman, Greuter. Acquisition of data: Lutz. Analysis and interpretation of data: Soleman, Greuter. Drafting the article: Greuter. Critically revising the article: Soleman, Greuter, Fandino, Mariani, Guzman. Reviewed submitted version of manuscript: all authors. Statistical analysis: Soleman, Greuter. Study supervision: Soleman.

Supplemental Information

Online-Only Content

Supplemental material is available online.

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Correspondence

Jehuda Soleman: University Hospital Basel, Switzerland.
jehuda.soleman@gmail.com.