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Article

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Vascular hemorrhagic conditions drive secondary CSF outflow disorders in cranial neurosurgery

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Short title: Vascular hemorrhage drives secondary CSFOD

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Abbreviations: aSAH= aneurysmal subarachnoid hemorrhage; AVM= arteriovenous malformation; CSF= cerebrospinal fluid; CSFOD= cerebrospinal fluid outflow disorder; EVD= external ventricular drain; ICB= intracerebral bleeding; iNPH= idiopathic normal pressure hydrocephalus; IVH= intraventricular hemorrhage; IQR= interquartile range; LP= lumbar puncture; NPH= normal pressure hydrocephalus; OR= odds ratio; PTH= posttraumatic hydrocephalus; SAH= subarachnoid hemorrhage; SD= standard deviation; VH= vascular hemorrhagic; VNH= vascular non-hemorrhagic; VA shunt= ventriculoatrial shunt; VP shunt= ventriculoperitoneal Shunt; 95% CI= 95% confidence interval.

Highlights

- We included 6888 patients in 2013 – 2023 from a prospective patient registry.
- 814 patients (12%) were operated for secondary cerebrospinal fluid outflow disorder.
- Vascular hemorrhagic disorders were associated with this surgery (odds ratio 31).

Abstract

Introduction: Cerebrospinal fluid disorders like hydrocephalus may occur as a sequel to intracranial disease. Surgery for hydrocephalus exposes patients to a relatively high rate of adverse events and causes high costs for healthcare systems.
Research Question: Which factors may lead to secondary cerebrospinal fluid outflow disorders (CSFOD) requiring surgery?
Material and Methods: In a monocentric cohort study, we extracted data from our prospective patient registry from patients who were treated in 2013-2023 with a diagnosis of cranial tumor, vascular disorder or trauma. We assessed the proportion of surgical treatment for secondary CSFOD. We created a logistic regression model to investigate predictors for CSFOD treatment.
Results: We included N = 6888 patients (mean age 59±17 y, 54% male), in which 814 (12%) underwent surgery for secondary CSFOD. Patients with a vascular hemorrhagic diagnosis (1083) stood out in that 582 (54%) of them underwent surgery for secondary CSFOD. This was confirmed in multivariable analysis, where vascular hemorrhagic diagnosis was strongly associated with surgery for secondary CSFOD (OR = 31, 95%CI [25 38], $p = 2 \times 10^{-226}$).
Discussion and Conclusion: Patients for cranial neurosurgery with a hemorrhagic diagnosis are more likely to receive surgery for secondary CSFOD, partly because of the routine use of CSF diversion in hemorrhage. In the majority of these patients, the outcome of neurosurgery is not defined by the most complex step of the procedure alone. Technically excellent neurosurgical treatment provides no benefit if a secondary CSFOD occurs and the management of the secondary CSFOD is not performed with equal quality.

Keywords

cerebrospinal fluid; hydrocephalus; subarachnoid hemorrhage; brain tumor; external ventricular drain; hemorrhage; trauma;

1 Introduction

1.1 Background

A neurosurgical patient with a vascular or oncological pathology may suffer from secondary consequences such as cerebrospinal fluid outflow disorders (CSFOD) (Hochstetler et al., 2022). Even if initially not planned, this patient may

require CSFOD treatment. CSFOD is a highly complex clinical entity that is only partially understood. A common form of CSFOD is hydrocephalus, which is characterized by an accumulation of cerebrospinal fluid, resulting in the enlargement of the ventricular spaces (Isaacs et al., 2018; Rekate, 2009). Hydrocephalus can be treated with non-surgical or surgical interventions. Surgical interventions include temporary measures, such as lumbar punctures (LP, intermittent) or external ventricular drain (EVD, continuous), and permanent measures such as ventriculopleural or ventriculoperitoneal shunt (VP shunt) (Hochstetler et al., 2022). In patients with intracranial hemorrhage, CSF diversion is not only a treatment of manifest hydrocephalus. It is also a part of the acute management. Current guidelines recommend early ventricular drainage in aneurysmal subarachnoid hemorrhage and in intracerebral hemorrhage with intraventricular extension (Greenberg et al., 2022; Hoh et al., 2023; Treggiari et al., 2023). A second group of CSFOD are postoperative CSF leaks and fistulas. They occur after about 5% to 7% of intradural cranial operations and they increase the risk of wound infection and meningitis (Coucke et al., 2022; Kinaci et al., 2023). The VP shunt is the most widely used procedure for treating hydrocephalus even in the absence of uniform diagnostic criteria and treatment indications (Mansoor et al., 2023). Shunt treatment is now well established, and shunt placement is considered technically simple so that the procedure is performed by neurosurgeons early during their training. However, adverse events like complications or revisions associated with the VP shunt occur frequently (Mansoor et al., 2021; Schenker et al., 2018). Admissions related to hydrocephalus also cause high and repeated costs for healthcare systems (Koschnitzky et al., 2023). In this case, the success of a technically demanding neurosurgery of the primary vascular or oncological pathology may be masked by treatment of the secondary CSF pathology that becomes prominent in determining the patient's quality of life.

1.2 Objective

To quantify the relevance of secondary CSFOD for patients and healthcare systems (Koschnitzky et al., 2023), we counted the number of treatments for secondary CSFOD in a large prospective neurosurgical patient registry. Given that the rate of surgery for CSFOD secondary to intracranial tumors or vascular disorders varies widely between centers (Isaacs et al., 2018), we further aimed to identify the factors predisposing patients to requiring surgical treatment for secondary CSFOD.

2 Materials and Methods

2.1 Study design

In a retrospective analysis of prospectively collected monocentric registry data, we analyzed patients with a cranial neurosurgical diagnosis in our center and evaluated predictors of a surgical treatment for secondary CSFOD. We follow the STROBE checklist for cohort studies (von Elm et al., 2007).

2.2 Setting

Surgeries were performed by neurosurgeons of the department of neurosurgery, Universitätsspital Zürich, the largest tertiary neurosurgery center in Switzerland. Surgeries took place in the operating rooms of the neurosurgery department or in the operating rooms of the trauma department. Data was collected prospectively in the department's patient registry (Sarnthein et al., 2022).

2.3 Patients

We included all patients that underwent cranial neurosurgery (2013-2023) indicated for tumor, trauma, or vascular disorder. Patients who underwent surgery for secondary CSF disorder but were not classified under the primary disorder indication group in the registry were identified through electronic patient records. These patients either were not operated on for the primary disorder or had surgery for the primary disorder in other centers and were included only if the diagnosis or the surgery, respectively, were made between 2013 and 2023. We excluded patients without intracranial operations and patients with unknown hemorrhagic/non-hemorrhagic distinction. We excluded patients with primary cerebrospinal fluid disorders and other indications and patients < 18 y or unknown age. We excluded patients with multiple diagnoses among tumor, trauma, vascular and primary CSF disorders due to difficulties in establishing a clear classification of the patient's diagnosis.

2.4 Variables

For the primary diagnosis we defined the following groups: tumor, vascular hemorrhagic, vascular non-hemorrhagic and trauma. Surgery for secondary CSFOD included patients treated with EVD, VP/VA shunt or other procedures related to CSF disorders, with indication hydrocephalus, CSF leak, CSF rhinorrhea, shunt dysfunction or revisions and other unspecified CSF disorders.

Patients with vascular diagnoses who underwent EVD or shunt VP/VA procedures – without documentation of a CSF disorder in the registry – were also considered in the group of patients operated on for secondary CSF disorders. Conversely, patients labeled as indication group “tumor” and “trauma” undergoing EVD procedures but without documentation of CSF disorders in the registry were not included in the outcome group “surgery for secondary CSF disorders”. We chose this rule because in vascular hemorrhagic disease an EVD is placed almost only for CSF related reasons. After tumor and trauma surgery, an EVD is often placed only to monitor intracranial pressure. The rule is not symmetric and it may therefore favor the vascular hemorrhagic group.

2.5 Data sources

Our prospective institutional patient registry (Sarnthein et al., 2022) covers clinical information on all patients that underwent neurosurgery with the neurosurgeons of our center. Variables relevant to this study include age, sex, diagnosis, indication for surgery, type and date of surgery. Missing data was available in electronic patient records.

2.6 Bias

The study uses prospectively collected data from the patient registry (Sarnthein et al., 2022). Completeness and accuracy of the registry depend on motivation and training of the healthcare providers. Missing data was completed retrospectively from electronic patient records.

2.7 Study size

The study size was determined by the number of patients undergoing surgery during the inclusion period.

2.8 Quantitative variables

Age was treated as a quantitative variable, described in the tables of demographic characteristics as mean and standard deviation, in the graph as median and interquartile range, and entered the logistic regression model in steps of 10-year increase in age.

2.9 Statistical methods

Statistical analyses and the creation of graphs and figures were performed using R (R Foundation for Statistical Computing, Vienna, Austria, version 4.4.0) with the software R Studio (version 2025.09.0+387, https://www.R-project.org/).

Descriptive statistic of the baseline characteristics such as distribution of age, sex, primary diagnosis group and specific diagnoses were summarized in tables. Continuous variables were expressed as mean and standard deviation (SD), and categorical variables as counts and percentage. Proportions were reported with 95% confidence interval (95% CI) calculated through the Wilson score interval method with continuity correction. The relationship between age, sex, diagnosis group and the outcome “surgery for CSFOD” was modeled using a logistic regression. Statistical significance was set at a p-value < .05.

3 Results

3.1 Patients

We scanned 14644 cranial neurosurgical operations that were performed in the inclusion period and obtained 9753 patients who we assessed for eligibility (**Figure 1**). The final study population was 6888 patients (mean age 59 ± 17 years, 54% male, 46% female).

3.2 Descriptive data

Among the patients, 3738 (54%) had a cranial tumor, 1083 (16%) a vascular hemorrhagic disorder, 533 (7.7%) a vascular non-hemorrhagic disorder and 1534 (22%) a trauma (**Table 1, Figure 2).** When looking at the primary diagnosis that resulted in secondary CSFOD surgery, ruptured aneurysms (40%) were the most frequent, followed by non-traumatic parenchymal bleedings (26%) and neoplasms (12%).

3.3 Outcome data

Among the included patients, 814 (12% [11% 13%]) were operated on for a CSFOD secondary to the primary tumoral, vascular or traumatic disorder. The unadjusted relationship between diagnosis group and surgery for secondary CSFOD shows a higher proportion of CSF related surgery in patients with vascular hemorrhagic disorders (**Figure 3**).

The different diagnosis groups showed differences in the treatment received for CSF disorders (**Table 2**). Patients with tumor received EVD and/or other surgeries and shunt in similar proportion. In the vascular hemorrhagic group, 497 of 1083 patients (46%) received an EVD and/or another operation. Of these, 324 patients

(30%) received only an EVD and/or another operation, and 173 patients (16%) received first an EVD and/or another procedure and then a shunt.

3.4 Main results

The proportion of patients treated for secondary CSFOD was highest in the vascular hemorrhagic diagnosis group (**Table 2**). Patients with a vascular hemorrhagic diagnosis were far more likely to undergo surgery for a secondary CSFOD compared to patients with tumor (OR = 31 [25 38], Wald test $p = 2 \times 10^{-226}$, **Table 3**).

4 Discussion

4.1 Key results

In our study population of patients with a cranial neurosurgical diagnosis, 12% experienced a sequel that necessitated surgery for secondary CSFOD. Patients diagnosed with a vascular hemorrhagic diagnosis stood out in that 54% of them underwent surgery for secondary CSFOD.

4.2 Limitations

This study is monocentric and relies on the accuracy of a large prospective institutional registry (Sarnthein et al., 2022), which may introduce documentation-related inconsistencies. We do not quantify patients' outcome or quality of life in scales. We rely on the judgement of the treating neurosurgeon together with the care team. For each patient treated, this team has expected that the patient's outcome and quality of life will improve significantly with CSFOD treatment and that these positive effects outweigh the risks of the procedure. We therefore assume that an untreated CSFOD will have worse outcome.

Heterogeneous diagnostic categories and procedural indications may limit direct comparability with existing literature and may constrain generalizability to other centers. Our analysis was conducted on several more general primary diagnosis groups, and our population included different diagnostic entities. The outcome parameters differ from other studies and included patients who underwent different surgical procedures for various forms of CSF-related disorders. No distinction was made if the CSF related disorder was treated before or after the primary diagnosis, or if the surgical treatment for CSFOD was the only surgical treatment that the patients received. Therefore, the exposition of previous research findings serves primarily to

contextualize our study with part of the existing literature and does not aim at a direct comparison of results.

A further limitation concerns the interpretation of the effect size. In patients with intracranial hemorrhage, ventricular drainage is placed as a part of the recommended acute treatment (Greenberg et al., 2022; Hoh et al., 2023). Exposure and outcome are therefore not fully independent. A part of the association that we report follows from our outcome definition and not from biology. The odds ratio should therefore be read as a measure of how often these patients need CSF related surgery, and not as a measure of biological risk.

4.3 Interpretation

The high rate of CSFOD in patients with vascular hemorrhagic disorders agrees with reports in the literature. The proportion of patients receiving an EVD after intracranial hemorrhage varies across the literature depending on the study and the analyzed population. For example, rates of 54% have been reported in patients with subarachnoid hemorrhage (Lele et al., 2024), whereas rates of 29% and 4% have been reported in patients with intracerebral bleeding with and without intraventricular hemorrhage, respectively (Warren et al., 2022). Recent meta-analyses of shunt dependency after aneurysmal subarachnoid hemorrhage report pooled rates between about 20% and 30%. They identify a high Hunt-Hess grade, a high Fisher grade, intraventricular hemorrhage, acute hydrocephalus and EVD placement as the main predictors (Chen et al., 2024; Siddiqi et al., 2023; Wilson et al., 2017). Older single-center and database studies compared clipping and coiling and reported conflicting results (Hoh et al., 2011; Varelas et al., 2006). The pooled analyses cited above do not find a consistent difference between the two treatment modalities. In our cohort the proportion of EVD/other CSF-related interventions in patients with hemorrhagic disorder was 46% (30% only EVD/other). 7.8% of the patients received a VP/VA shunt directly and 16% received first an EVD/other operation and then a VP/VA shunt.

Trial evidence supports the view that CSF diversion is used in part as a preventive measure. In the EARLYDRAIN randomized controlled trial, early lumbar CSF drainage in addition to standard care after aneurysmal subarachnoid hemorrhage reduced unfavorable neurological outcome after six months (Wolf et al., 2023). An earlier study found a correlation between the extent of ventricular enlargement before CSF diversion and adverse outcome after subarachnoid

bleeding. The authors suggested that CSF diversion should already be considered as a prevention of ventricular enlargement (Dupont & Rabinstein, 2013). Preventive use of EVD in the management of intracranial bleeding could therefore explain a large part of the high proportion of surgery for secondary CSFOD in our vascular hemorrhagic population. In these patients the procedure is a planned part of the treatment and not an adverse sequel.

The proportion of patients receiving a shunt after intracranial tumor surgery varies in the literature. Reported rates range from 1.0% (Hosainey et al., 2018) to more than 20% in selected series. In adults with supratentorial intraventricular tumors, shunt dependency depends strongly on the extent of tumor resection (Teske et al., 2023). A recent meta-analysis of adult patients after decompressive craniectomy found a pooled hydrocephalus incidence of 20.5%. Subarachnoid hemorrhage and intraventricular hemorrhage were among the strongest risk factors (Bagherzadeh et al., 2025). Decompressive craniectomy itself also increases the incidence of post-traumatic hydrocephalus compared to conservative treatment (Mavrovounis et al., 2021). Other cohorts report much lower shunt rates after traumatic brain injury (3.5%) (Svedung Wettervik et al., 2022). Blood in the subarachnoid space and in the ventricles is therefore a risk factor in the trauma group as well as in the vascular group. This supports our main observation that hemorrhage, and not the disease category itself, drives secondary CSFOD.

Postoperative CSF leakage is a separate part of our composite endpoint. In a multicenter cohort of 2310 intradural cranial operations, incisional CSF leakage occurred in 7.1% of the patients. The odds for wound infection or meningitis were about 15 times higher in these patients, and infratentorial surgery was the main risk factor (Kinaci et al., 2023). Pooled estimates after elective cranial surgery are similar (Coucke et al., 2022). Such leaks are treated with external drainage or with revision surgery and they therefore enter our outcome definition. They are a further mechanism by which the quality of CSF management determines the result of an otherwise successful cranial operation.

Several candidate mechanisms have been proposed for the development of hydrocephalus after intraventricular hemorrhage, which involve hemoglobin, iron, and thrombin (Wang et al., 2025). The mechanisms include TGF-beta-induced fibrosis of the subarachnoid spaces, blood clots obstructing the aqueduct of Sylvius and the foramen of Magendie, dysfunction of the arachnoid granulations, inflammatory

response with consequent fibrosis of the arachnoid membrane and ependyma, ependymal damage, and disruption of the blood brain barrier.

4.4 Generalizability

While our prospective patient registry covers a large number of patients over the period 2013-2023, it reflects the surgical strategy and diagnostic approaches of the largest tertiary neurosurgery center in Switzerland. Strategies and approaches may vary in other centers and healthcare systems.

5 Conclusions

Technically excellent neurosurgical treatment provides no benefit if a secondary CSFOD occurs and the management of the secondary CSFOD is not performed with equal quality. In vascular-hemorrhagic conditions, CSFOD management is a part of the treatment pathway in the majority of patients, and it carries its own long-term risk of complication and revision. More broadly speaking, the outcome of neurosurgery is not defined by the most complex step of the procedure alone. While being outside the focus of many neurosurgeons, CSFOD therapy is often essential and deserves further dedicated research.

Declarations and Details

We confirm that manuscript complies with all instructions to authors.

This manuscript has not been published elsewhere and is not under consideration by another journal.

Reporting checklist

We follow the STROBE checklist for cohort studies (von Elm et al., 2007).

Ethics approval

The scientific workup was approved in advance by the local ethics review board (Kantonale Ethikkommission Zürich PB-2017-00093) and this study was conducted in accordance with the Declaration of Helsinki.

Availability of data and materials

The code in R is available as supplementary file. The data can be made available by the corresponding author on reasonable request and after approval by the local ethics committee.

Consent to Participate

Patient informed consent was waived by the local ethics review board (Kantonale Ethikkommission Zürich PB-2017-00093).

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authors' contributions

PZ performed analysis, created figures, wrote the manuscript; LS supervised research, treated patients, wrote the manuscript; JS managed the patient registry, wrote the manuscript, supervised research. All authors reviewed and approved the final manuscript.

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Figures

Figure 1. Patient enrollment flow.

CSF: cerebrospinal fluid.

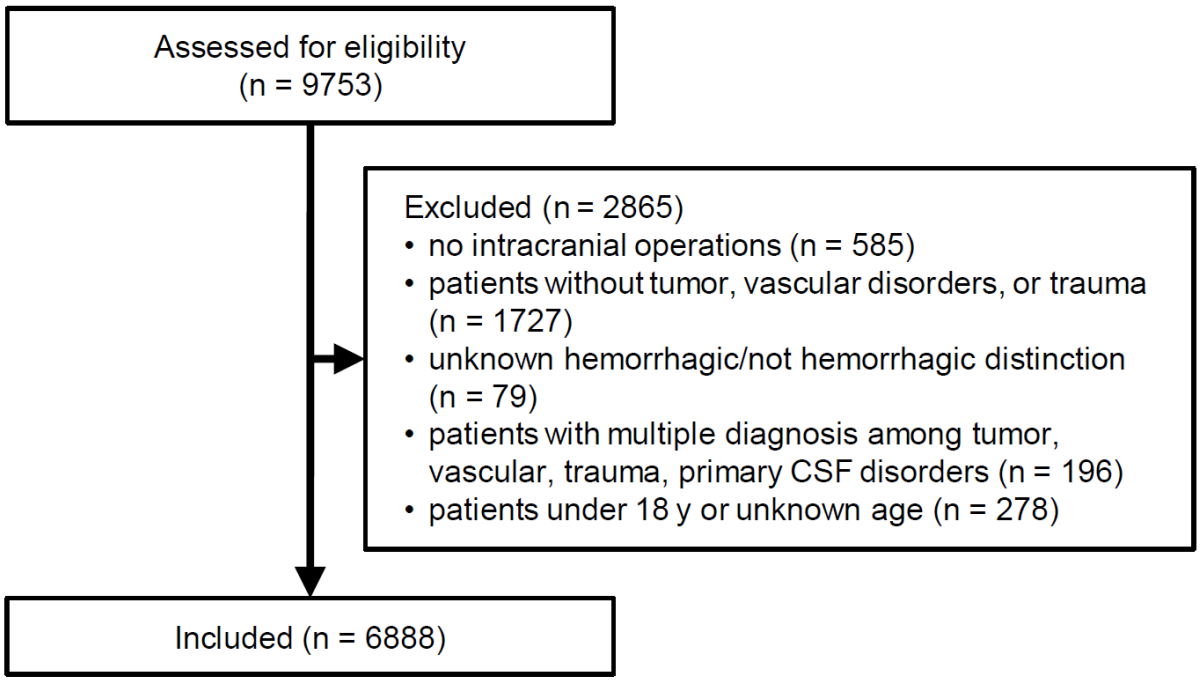
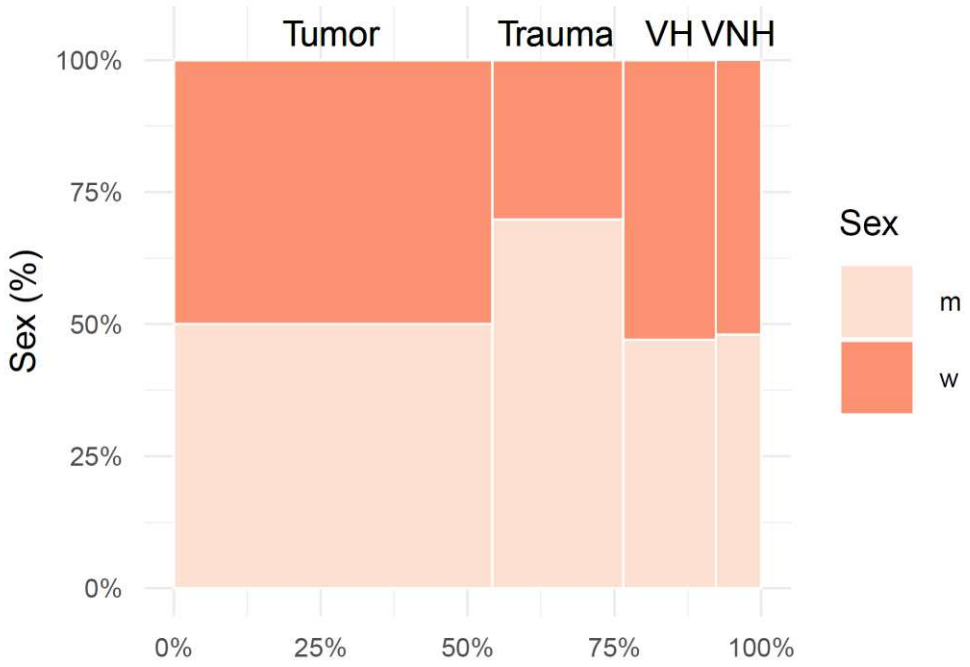


Figure 2. Sex and age distribution across diagnosis groups.

(**A**) The X-axis shows the distribution of diagnosis groups across the total study population. The Y-axis shows the percentage of men and women within each diagnosis group.

(**B**) Age distribution across the diagnosis groups, with median age (central line), interquartile range (box), minimum and maximum age (whiskers extension). VH: vascular hemorrhagic. VNH: vascular non-hemorrhagic. m: male. f: female.



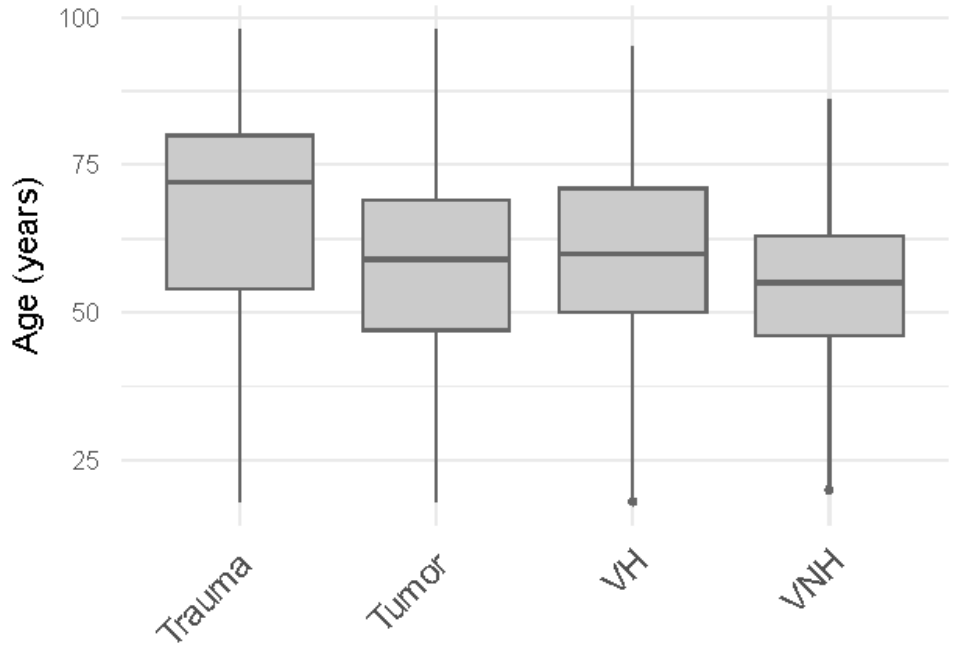
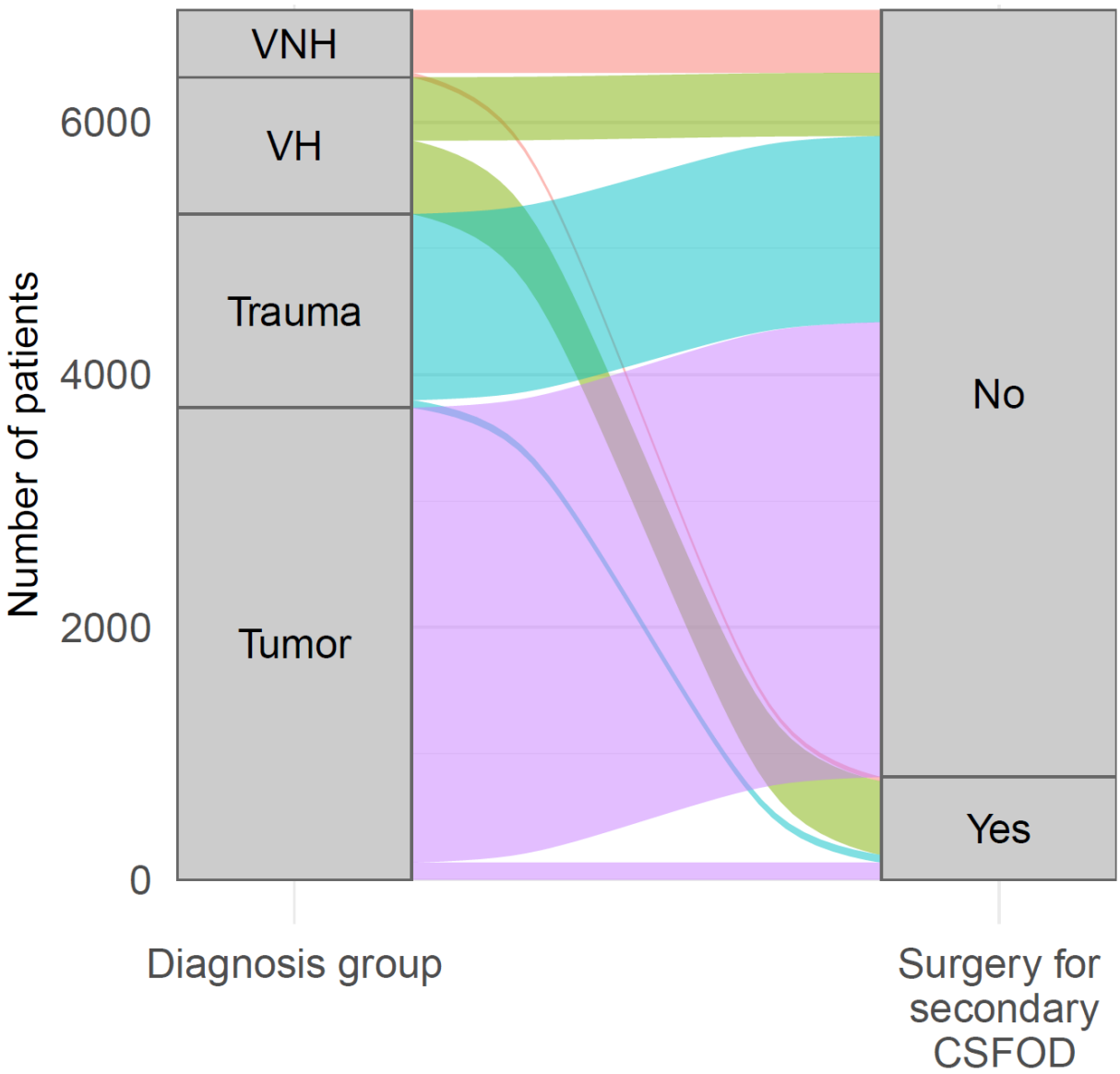


Figure 3. Patient flow from diagnosis group to surgery for cerebrospinal fluid outflow disorders.

The majority of patients with vascular hemorrhagic disorders (54%) underwent surgery for secondary CSFOD, but not patients from other diagnosis groups. VH: vascular hemorrhagic. VNH: vascular non-hemorrhagic. CSFOD: cerebrospinal fluid outflow disorders.



Tables

Table 1. Baseline characteristics of the study population. Group rows show % within the group, while subrows show % of the column total. n: number of patients. SD: standard deviation. CSFOD: cerebrospinal fluid outflow disorders. ICB: intracerebral bleeding.

Patients and Diagnosis	Total n (%)	No surgery for secondary CSFOD	Surgery for secondary CSFOD
Patients	6888 (100%)	6074 (88%)	814 (12%)
Age, mean (SD)	59 (±17) y	59 (±17) y	59 (±15) y
Male	3708 (54%)	3309	399
Female	3180 (46%)	2765	415
Tumor total	3738 (100%)	3602 (96%)	136 (3.6%)
Abscess	449 (6.5)	441 (7.3)	8 (.98)
Metastasis	324 (4.7)	308 (5.1)	16 (2)
Neoplasm	2638 (38)	2544 (42)	94 (12)
Tumor other	327 (4.8)	309 (5.1)	18 (2.2)
Vascular hemorrhagic total	1083 (100%)	501 (46%)	582 (54%)
Aneurysm ruptured	526 (7.6)	197 (3.2)	329 (40)
Arteriovenous malformation ruptured	67 (.97)	45 (.74)	22 (2.7)
Cavernoma VH	14 (.20)	13 (.21)	1 (.12)
Dural fistula VH	6 (.09)	4 (.07)	2 (.25)
Parenchymal bleeding (ICB, not traumatic)	441 (6.4)	226 (3.7)	215 (26)
Vascular hemorrhagic other	29 (.42)	16 (.26)	13 (1.6)
Vascular non-hemorrhagic	533 (100%)	497 (93%)	36 (6.8%)
Aneurysm not ruptured	282 (4.1)	277 (4.6)	5 (.61)
Arteriovenous malformation not ruptured	32 (.46)	31 (.51)	1 (.12)
Cavernoma VNH	4 (.06)	4 (.07)	0 (.00)
Ischemia	195 (2.8)	166 (2.7)	29 (3.6)
Vascular non-hemorrhagic other	20 (.29)	19 (.31)	1 (.12)
Trauma	1534 (100%)	1474 (96%)	60 (3.9%)
Hematoma epidural	48 (.70)	45 (.74)	3 (.37)
Hematoma parenchymal	338 (4.9)	331 (5.5)	7 (.86)
Hematoma subdural acute	225 (3.3)	213 (3.5)	12 (1.5)
Hematoma subdural chronic	726 (11)	713 (12)	13 (1.6)
Trauma other	197 (2.9)	172 (2.8)	25 (3.1)

Table 2. Surgical treatment for secondary CSFOD. The category "EVD/Other" includes patients that received EVD and/or other operations without shunt. The category "shunt" includes patients that received only a shunt, patients that received first a shunt and after that EVD or another CSF related procedure. EVD: external ventricular drain. CSFOD: cerebrospinal fluid outflow disorder. 95% CI: 95% confidence interval.

Diagnosis group	Procedure	Number of patients	% [95% CI]
Tumor	EVD/Other	54	1.4% [1.1% 1.9%]
	Shunt	61	1.6% [1.3% 2.1%]
	EVD/Other, then shunt	21	.56% [.36% .87%]
	No CSFOD operations	3602	96% [96% 97%]
Vascular hemorrhagic	EVD/Other	324	30% [27% 33%]
	Shunt	85	7.8% [6.4% 9.7%]
	EVD/Other, then shunt	173	16% [14% 18%]
	No CSFOD operations	501	46% [43% 49%]
Vascular non-hemorrhagic	EVD/Other	22	4.1% [2.7% 6.3%]
	Shunt	8	1.5% [.70% 3.1%]
	EVD/Other, then shunt	6	1.1% [.46% 2.6%]
	No CSFOD operations	497	93% [91% 95%]
Trauma	EVD/Other	13	.85% [.47% 1.5%]
	Shunt	37	2.4% [1.7% 3.3%]
	EVD/Other, then shunt	10	.65% [.33% 1.2%]
	No CSFOD operations	1474	96% [95% 97%]
Statistical population	EVD/Other	413	6.0% [5.5% 6.6%]
	Shunt	191	2.8% [2.4% 3.2%]
	EVD/Other, then shunt	210	3.0% [2.7% 3.5%]
	No CSFOD operations	6074	88% [87% 89%]

Table 3. Logistic regression model. For the variable age, the odds ratio indicates the change in odds for a 10-year increase in age. For the categorical variables (sex and diagnosis), the odds ratio indicates the change in odds from the baseline level (male or tumor) to the level of interest (female, trauma, vascular hemorrhagic, vascular non-hemorrhagic). CSFOD: cerebrospinal fluid outflow disorders. 95% CI: 95% confidence interval.

Compared categories		Odds ratio for surgery for secondary CSFOD	95% CI	Z value	P value
Age		.98	[.93 1.0]	-.559	.576
Sex	Female vs. male	1.0	[.85 1.2]	.195	.845
Diagnosis	Trauma vs. tumor	1.1	[.79 1.5]	.572	.567
Diagnosis	Vascular hemorrhagic vs. tumor	31	[25 38]	32	**2×10^{-226}**
Diagnosis	Vascular non-hemorrhagic vs. tumor	1.9	[1.3 2.8]	3.34	**8×10^{-4}**

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- 260708CodeStatisticalAnalysis.r