Hydrocephalus after aneurysmal subarachnoid hemorrhage

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see also Hydrocephalus after traumatic subarachnoid hemorrhage.

Hydrocephalus after aneurysmal subarachnoid hemorrhage (aSAH) refers to an abnormal accumulation of cerebrospinal fluid (CSF) within the ventricular system of the brain, leading to ventricular enlargement and increased intracranial pressure. One of the aneurysmal subarachnoid hemorrhage complications due to impaired cerebrospinal fluid circulation, cerebrospinal fluid absorption, or excessive cerebrospinal fluid production.

Epidemiology

Hydrocephalus after aneurysmal subarachnoid hemorrhage epidemiology.

Classification

Hydrocephalus after aneurysmal subarachnoid hemorrhage classification.

Etiology

Hydrocephalus after aneurysmal subarachnoid hemorrhage etiology.

Clinical features

see Hydrocephalus clinical features.

Diagnosis

Hydrocephalus after aneurysmal subarachnoid hemorrhage diagnosis.

Treatment

Hydrocephalus after aneurysmal subarachnoid hemorrhage treatment.

Prognosis

Hydrocephalus after aneurysmal subarachnoid hemorrhage prognosis.

Prospective randomized controlled trials

2016

The study is designed to determine the efficacy of lamina terminalis fenestration on the reduction of SDH after aneurysm clipping.

METHODS/DESIGN: A total of 288 patients who meet the inclusion criteria will be randomized into single aneurysm clipping or aneurysm clipping plus FLT in the Department of Neurosurgery, West China Hospital. Follow-up was performed 1, 3, 6, and 12 months after aneurysm clipping. The primary outcome is the incidence of SDH and the secondary outcomes include cerebral vasospasm, functional outcome evaluated by the modified Rankin Scale and Extended Glasgow Outcome Scale, and mortality.

DISCUSSION: The FISH trial is a large randomized, parallel controlled clinical trial to define the therapeutic value of FLT, the results of which will help to guide the surgical procedure and resolve the long-puzzled debate in the neurosurgical community.

CONCLUSIONS: This protocol will determine the efficacy of FLT in the setting of aneurysmal subarachnoid hemorrhage [1)].

Retrospective cohort studies

One-hundred and fifty-two patients who had undergone an operation for SAH were enrolled in this study. Clinical data, radiological data, and procedural data were investigated. Procedural data included the operating technique (clipping vs. EVT) and the use of additional procedures (no procedure, lumbar drainage, or EVD). Delayed hydrocephalus was defined as a condition in which the Evan's index was 0.3 or higher, as assessed using brain computed tomography more than 2 weeks after surgery, requiring shunt placement due to neurological deterioration.

Of the 152 patients, 45 (29.6%) underwent surgical clipping and 107 (70.4%) underwent EVT. Twenty-five (16.4%) patients developed delayed hydrocephalus. Age ($p = 0.019$), procedure duration ($p = 0.004$), and acute hydrocephalus ($p = 0.030$) were significantly correlated with the incidence of delayed hydrocephalus. However, the operation technique ($p = 0.593$) and use of an additional procedure ($p = 0.378$) were not significantly correlated with delayed hydrocephalus incidence.

No significant difference in the incidence of delayed hydrocephalus was associated with operation technique or use of an additional procedure in patients with SAH. However, delayed hydrocephalus was significantly correlated with old age, long procedural duration, and acute hydrocephalus. Therefore, they recommend that additional procedures should be discontinued as soon as possible [2].

2017

Winkler et al. conducted a retrospective review of 663 consecutive patients with aSAH treated from 2005 to 2015 by open microsurgery via a pterional or orbitozygomatic craniotomy by the senior author (M.T.L.). Data collected from review of the electronic medical record included age, Hunt and Hess grade, Fisher grade, need for an external ventricular drain, and opening pressure. Patients were stratified into those undergoing no fenestration and those undergoing tandem fenestration of the LT and MoL at the time of surgical repair. Outcome variables, including VP shunt placement and timing of shunt placement, were recorded and statistically analyzed. RESULTS In total, shunt-dependent hydrocephalus was observed in 15.8% of patients undergoing open surgical repair following aSAH. Tandem microsurgical fenestration of the LT and MoL was associated with a statistically significant reduction in shunt dependency (17.9% vs 3.2%, $p < 0.01$). This effect was confirmed with multivariate analysis of collected variables (multivariate OR 0.09, 95% CI 0.03-0.30). Number-needed-to-treat analysis demonstrated that tandem fenestration was required in approximately 6.8 patients to prevent a single VP shunt placement. A statistically significant prolongation in days to VP shunt surgery was also observed in patients treated with tandem fenestration (26.6 ± 19.4 days vs 54.0 ± 36.5 days, $p < 0.05$). CONCLUSIONS Tandem fenestration of the LT and MoL at the time of open microsurgical clipping and/or bypass to secure ruptured anterior and posterior circulation aneurysms is associated with reductions in shunt-dependent hydrocephalus following aSAH. Future prospective randomized multicenter studies are needed to confirm this result [3].

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181 participants with a mean age of 54.4 years. Higher sodium (hazard ratio, 1.53; 95% confidence interval, 1.13-2.07; $p = 0.005$), lower potassium, and higher glucose levels were associated with higher shunt-dependent hydrocephalus. The receiver operating characteristic curve analysis showed that the areas under the curve of sodium, potassium, and glucose were 0.649 (cutoff value, 142.75 mEq/L), 0.609 (cutoff value, 3.04 mmol/L), and 0.664 (cutoff value, 140.51 mg/dL), respectively.

Despite the exploratory nature of this study, we found that higher sodium, lower potassium, and higher glucose levels were predictive values for shunt-dependent hydrocephalus from postoperative day (POD) 1 to POD 12-16 after subarachnoid hemorrhage. Strict correction of electrolyte imbalance seems necessary to reduce shunt-dependent hydrocephalus. Further large studies are warranted to confirm our findings [4].

2003

Seven hundred eighteen patients with aneurysmal subarachnoid hemorrhage who were treated between 1990 and 1999 were retrospectively studied, to identify factors contributing to shunt-dependent hydrocephalus. With these data, a stepwise logistic regression procedure was used to determine the effect of each variable on the development of hydrocephalus and to create a scoring system.

Overall, 152 of the 718 patients (21.2%) underwent shunting procedures for treatment of hydrocephalus. Four hundred seventy-nine of the patients (66.7%) were female. Of the factors investigated, the following were associated with shunt-dependent hydrocephalus, as determined with a variety of statistical methods: 1) increasing age ($P < 0.001$), 2) female sex ($P = 0.015$), 3) poor admission Hunt and Hess grade ($P < 0.001$), 4) thick subarachnoid hemorrhage on admission computed tomographic scans ($P < 0.001$), 5) intraventricular hemorrhage ($P < 0.001$), 6) radiological hydrocephalus at the time of admission ($P < 0.001$), 7) distal posterior circulation location of the ruptured aneurysm ($P = 0.046$), 8) clinical vasospasm ($P < 0.001$), and 9) endovascular treatment ($P = 0.013$). The presence of intracerebral hematomas, giant aneurysms, or multiple aneurysms did not influence the development of shunt-dependent hydrocephalus.

The results of this study can help identify patients with a high risk of developing shunt-dependent hydrocephalus. This may help neurosurgeons expedite treatment, may decrease the cost and length of hospital stays, and may result in improved outcomes [5].

2000

In 138 patients with ruptured cerebral aneurysms operated on within 48 to 72 hours after subarachnoid hemorrhage, an external ventricular drainage catheter was inserted before craniotomy and was used intermittently during the first week after surgery. In 51 patients, intracranial pressure (ICP) was measured intraoperatively. The majority of patients showed increased ICP intraoperatively irrespective of the preoperative Hunt and Hess grade and the amount of subarachnoid blood accumulation or intraventricular blood clot. Intraoperative drainage of cerebrospinal fluid allowed easy access for aneurysm dissection by making the brain slack in more than 90% of patients. Postoperative ICP measurements revealed that significant brain swelling did not occur in the majority of patients. In 7 patients, persistently elevated ICP (greater than 20 mm Hg) was recorded. Nine patients (8%) developed shunt-dependent hydrocephalus; all of these patients had suffered an intraventricular hemorrhage. Measurements of the volumes of cerebrospinal fluid drained did not allow prediction of shunt-dependent hydrocephalus [6].

1987

The incidence and clinical aspects of acute hydrocephalus were examined in 200 patients with recently ruptured intracranial aneurysms. The following conclusions were reached: Acute hydrocephalus is an important complication of aneurysmal subarachnoid hemorrhage that occurs in approximately 20% of all cases and exhibits an incidence that tends to parallel clinical grade (Grade I, 3%; Grade II, 5%; “Good” Grade III, 21%; “Bad”Grade III, 40%; Grade IV, 42%; Grade V, 26%). Impaired consciousness leading to a general downgrading of clinical status was the predominant clinical finding (93%), but neither this nor other nonspecific signs of increased intracranial pressure were distinguishable from the effects of the precipitating hemorrhage. The computed tomographic signs of acute hydrocephalus are distinctive and consist of selective ballooning of the frontal horns, rostral-caudal enlargement of the cerebral ventricles, and a halo of periventricular hyperdensity (edema) that evolves in sequence with ventricular changes. The treatment of choice is external ventricular drainage, which results in prompt and often dramatic improvement in approximately two-thirds of the patients [7)].

1985

Hydrocephalus, defined as a bicaudate index above the 95th percentile for age, was found in 34 (20%) of 174 prospectively studied patients with subarachnoid hemorrhage (SAH) who survived the first 24 hours and who underwent computerized tomography (CT) scanning within 72 hours. The occurrence of acute hydrocephalus was related to the presence of intraventricular blood, and not to the extent of cisternal hemorrhage. The level of consciousness was depressed in 30 of the 34 patients. Characteristic clinical features were present in 19 patients, including a gradual obtundation after the initial hemorrhage in 16 patients and small nonreactive pupils in nine patients (all with a Glasgow Coma Scale score of 7 or less). In the remaining 15 patients (44%), the diagnosis could be made only by CT scanning. After 1 month, 20 of the 34 patients had died: six from rebleeding (four after shunting), 11 from cerebral infarction (eight after an initial improvement), and three from other or mixed causes. Only one of nine patients in whom a shunt was placed survived, despite rapid improvement in all immediately after shunting. The mortality rate among patients with acute hydrocephalus was significantly higher than in those without, with the higher incidence caused by cerebral infarction (11 of 34 versus 12 of 140 cases, respectively; p less than 0.001). Death from infarction could not be attributed to the extent of cisternal hemorrhage, the use of antifibrinolytic drugs, or failure to apply surgical drainage, but could often be explained by the development of hyponatremia, probably accompanied by hypovolemia [8)].

1984

Seventeen patients suffering from SAH and/or intraventricular hemorrhage were studied; all were admitted in Grades II to V according to Hunt and Hess. Eleven patients had a proven aneurysm. The ICP, monitored via an intraventricular catheter, was above 15 mm Hg (2 kPa) during part of the monitoring period in all patients. B-waves at 1/min were noted in all patients. Resistance to outflow of CSF was determined by the following techniques: 1) bolus injection; 2) constant-rate steady-state infusion; or 3) controlled withdrawal (“inverse infusion”). Resistance to outflow of CSF was increased in all patients, ranging from 11.5 to 85 mm Hg/ml/min. The ICP was linearly correlated with outflow resistance. Four (50%) of the eight survivors required a shunt. Neither the presence of hydrocephalus on admission, nor the level of ICP, nor the magnitude of resistance to outflow of CSF was clearly related to the requirement of a permanent CSF diversion [9)].

Case reports

The formation of a liver pseudocyst is a rare occurrence, and its mechanisms are still largely unknown.

Mallereau et al. reported the case of a 69-year-old woman with a ventriculoperitoneal shunt, inserted for the management of hydrocephalus after aneurysmal subarachnoid hemorrhage, presenting to the Accident and Emergency for acute cholecystitis. Besides confirming the diagnosis, an ultrasound investigation revealed the presence of a hepatic cyst. Conservative treatment with antibiotics and non-steroidal anti-inflammatory drugs was performed with favorable outcomes and resorption of the cyst. Interestingly the patient kept on presenting several similar episodes managed well by non-steroidal anti-inflammatory drugs alone, each of them associated with transient symptoms and signs of ventriculoperitoneal shunt malfunction. Computerized Tomography brain and lumbar puncture were normal, whereas the CT abdomen showed the ventriculoperitoneal shunt distal catheter passing through the hepatic cyst. Given the ventriculoperitoneal shunt malfunction, in the context of an infective/inflammatory process, a conversion of the ventriculoperitoneal shunt into a ventriculoatrial shunt was carried out with a successful clinical outcome.

Based on current literature they propose a clinical and radiological classification of such pseudocysts related to ventriculoperitoneal shunt. Clinical presentation, diagnostic findings, and management options are proposed for each type: purely infective, spurious (infective/inflammatory), and purely inflammatory. In the absence of system infection, a simple replacement of the distal catheter seems to be the best solution [10)].

Preclinical experimental studies

A model that can stably mimic the histopathological and neuroethological features of hydrocephalus is critical for animal experiments. There have been fewer animal studies on hydrocephalus after SAH than on other stroke subtypes. The development of a reproducible and effective model of hydrocephalus after SAH is essential. In this study, we establish a mouse model of SAH that stably mimics brain injury and hydrocephalus after SAH through injections of autologous blood into the cisterna magna via different methods and characterize the model in terms of neurological behavior, histology, imaging, neuronal damage, and white matter damage [11)]

Case reports from the HGUA

Title: Post-Hemorrhagic Hydrocephalus Following Endovascular Aneurysm Treatment: A Case Report

Abstract

Background: Post-hemorrhagic hydrocephalus (PHH) is a well-recognized complication of aneurysmal subarachnoid hemorrhage (aSAH), often requiring cerebrospinal fluid (CSF) diversion. This report presents a case of chronic PHH following endovascular embolization, emphasizing the diagnostic and surgical challenges in an elderly patient.

Case Presentation: A 70-year-old female presented with sudden-onset headache and vomiting

while dancing. Imaging confirmed aSAH due to rupture of an anterior communicating artery aneurysm, which was successfully embolized. The postoperative course was complicated by acute hydrocephalus requiring external ventricular drainage (EVD) and severe vasospasm treated with intra-arterial milrinone and nimodipine. Despite initial improvement, the patient experienced progressive cognitive impairment, anosmia, and urinary urgency. MRI at five months post-SAH demonstrated ventricular enlargement, confirming chronic PHH. A ventriculoperitoneal shunt (VPS) with a ProGAV 14/20 adjustable valve was placed, resulting in significant symptomatic improvement.

Conclusions: This case highlights the delayed onset of PHH in elderly SAH patients and the role of shunt valve selection in optimizing patient outcomes. Long-term monitoring is essential in post-aSAH patients to detect evolving hydrocephalus.

Keywords: Post-hemorrhagic hydrocephalus, subarachnoid hemorrhage, aneurysm, ventriculoperitoneal shunt, neurosurgery

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Introduction

Aneurysmal subarachnoid hemorrhage (aSAH) is a leading cause of morbidity and mortality in cerebrovascular disease. Post-hemorrhagic hydrocephalus (PHH) is one of its most common sequelae, occurring in up to 30% of cases. PHH can manifest acutely, subacutely, or chronically, often necessitating CSF diversion. While surgical clipping was historically the preferred aneurysm treatment, endovascular coiling is now the standard of care in many centers. However, evidence suggests that endovascular therapy may increase the risk of hydrocephalus due to inflammatory responses triggered by embolization materials. Here, we report a case of PHH following endovascular treatment, underscoring the importance of long-term follow-up in elderly patients with aSAH.

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Case Presentation

Patient History and Initial Presentation A 70-year-old female with no history of hypertension, diabetes, or dyslipidemia experienced a sudden headache and vomiting on June 16, 2024. She also reported dizziness and instability but did not lose consciousness. She was transported to the emergency department, where a non-contrast CT scan revealed diffuse subarachnoid hemorrhage, predominantly in the anterior communicating artery region (Fisher grade III). CT angiography confirmed an anterior communicating artery aneurysm, leading to emergency endovascular coiling.

Postoperative Course and Complications Two days post-procedure, the patient developed acute hydrocephalus requiring EVD placement. Additionally, severe vasospasm was detected on cerebral angiography, necessitating two intra-arterial treatments with milrinone and nimodipine. Despite initial clinical improvement, the patient later exhibited persistent cognitive slowing, anosmia, short-term memory deficits, and urinary urgency.

Diagnosis of Chronic Hydrocephalus At five months post-SAH, an MRI (November 2024) demonstrated ventricular enlargement with an Evans index increase (0.399 vs. 0.378 in prior CT). Given the worsening clinical picture, a diagnosis of chronic PHH was established.

Surgical Intervention and Outcome A ventriculoperitoneal shunt (VPS) with a ProGAV 14/20 adjustable valve was implanted on the right side. The patient reported improvement in cognitive function and gait disturbances. A postoperative CT scan confirmed correct shunt positioning

and adequate ventricular decompression. The patient was discharged with scheduled follow-up imaging and clinical evaluations.

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Discussion

Post-hemorrhagic hydrocephalus occurs due to impaired CSF resorption following SAH. This case highlights multiple key aspects of PHH management:

1. **Delayed Diagnosis in Elderly Patients:** PHH symptoms (bradypsychia, anosmia, memory deficits) are often misinterpreted as age-related cognitive decline, delaying intervention. 2. **Endovascular Therapy and Hydrocephalus Risk:** Some studies suggest an increased risk of PHH with endovascular coiling due to inflammatory responses. 3. **Valve Selection for VPS Placement:** The ProGAV 14/20 adjustable system was chosen to prevent overdrainage, a common concern in elderly patients.

These findings reinforce the need for proactive hydrocephalus surveillance in aSAH patients, particularly when endovascular therapy is used.

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Conclusion

This case illustrates the challenges in detecting and managing PHH after aSAH, particularly in elderly patients. Neurosurgeons must maintain a high index of suspicion for delayed hydrocephalus and utilize appropriate valve selection to optimize patient outcomes.

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