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Treatment of post-thalamic hemorrhage hydrocephalus: ventriculoperitoneal shunt or endoscopic third ventriculostomy? A retrospective observational study

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Abstract

Background The aim of this study was to compare the efficacy of ventriculoperitoneal shunt (VPS) and endoscopic third ventriculostomy (ETV) for the treatment of hydrocephalus after thalamic hemorrhage (TH) where external ventricular drainage (EVD) could not be removed after hematoma absorption, and to provide a theoretical basis for the clinical treatment of hydrocephalus after TH.

Methods The clinical data of patients with hydrocephalus after TH whose EVD could not be removed after hematoma absorption were retrospectively analyzed. According to the patients' surgical methods, the patients were divided into the VPS group and ETV group. The operative time, length of hospital stay, complications, and reoperation rates of the two groups were compared.

Results There was no statistically significant difference in intraoperative bleeding, length of hospital stay between the two groups. The EVD tubes were successfully removed in all patients after surgery. There were 4 (9.5%) complications in the ETV group and 3 (6.7%) complications in the VPS group, with no statistically significant difference in postoperative complications between the two groups. During the 1-year follow-up, 7 patients (16.7%) in the ETV group and 3 patients (6.7%) in the VPS group required reoperation. In the subgroup analysis of TH combined with fourth ventricular hemorrhage, 6 patients (14.3%) in the ETV group and 1 patient (2.2%) in the VPS group required reoperation, and the difference between the two groups was statistically significant.

Conclusions ETV had good efficacy in treating hydrocephalus caused by TH and TH that broke into the lateral ventricle and the third ventricle. However, if hydrocephalus was caused by TH with the fourth ventricular hematoma, VPS was a better surgical method because the recurrence rate of hydrocephalus in ETV was higher than that in VPS. Therefore, the choice of surgical method should be based on the patient's clinical features and hematoma location.

Keywords Thalamic hemorrhage, Hydrocephalus, Ventriculoperitoneal shunt, Endoscopic third ventriculostomy, External ventricular drains

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Introduction

Thalamic hemorrhage (TH) was a common type of hypertensive intracerebral hemorrhage (HICH), accounting for 8.3–15.0% of HICH [1, 2], and had a high mortality and disability rate. Because of the specific anatomical location of the thalamus, TH often obstructed the circulation of cerebrospinal fluid (CSF) and caused acute hydrocephalus due to mass effect and hematoma breakthrough into the ventricles [3].

External ventricular drainage (EVD) could quickly alleviate acute hydrocephalus and provide treatment opportunities to save patients' lives. EVD combined with urokinase treatment could make intraventricular hematoma disappear in a short period of time, reduce mortality rate, and improve patient prognosis [4]. However, in some patients with TH, the posterior third ventricle and conduit were permanently impaired in cerebrospinal fluid circulation due to local adhesions caused by hematoma metabolite reaction and hematoma compression. Therefore, the EVD tube could not be removed and CSF shunt surgery was required.

There were few studies on hydrocephalus after TH in which the EVD tube could not be removed. Ventriculoperitoneal shunt (VPS) was a routine treatment for post-hemorrhagic hydrocephalus. However, with the placement of VPS devices, potential complications would accompany patients for life. Endoscopic third ventriculostomy (ETV) had also been recommended in some studies [5], but its effectiveness in hydrocephalus after hemorrhage was controversial [6–8]. Due to the special location of TH, it was often accompanied by different ventricular hematomas, which resulted in some patients having EVDs that could not be removed in time. In order to remove the EVD in time and reduce the disadvantages of surgical methods, surgical methods had to be carefully selected. Our aim was to discuss the value of different surgical approaches in the treatment of post-TH hydrocephalus with failed EVD tube removal and to provide selective recommendations for clinical management.

Methods

Study design and participants

In this retrospective cohort study, we will evaluate the efficacy of VPS and ETV in the treatment of post-TH hydrocephalus in which the EVD cannot be removed after hematoma absorption. The aim of this study was to provide a reference for the clinical treatment of post-TH hydrocephalus. We analyzed the clinical records of patients with a diagnosis of HICH who were treated between January 2010 and September 2020 at the People's Hospital of Ningxia Hui Autonomous Region. Applying strict inclusion and exclusion criteria, we identified 87 eligible patients. These participants were divided into two groups according to their surgical intervention: the ETV group and the VPS group. All patients were followed up at 1, 3, 6 months, and 1 year after surgery by outpatient or telephone. The primary outcome was a comparative analysis of the complication rate and reoperation rate of patients in the 12 months after surgery.

Inclusion criteria: (1) The patient met the spontaneous HICH diagnostic criteria; (2) CT: hematoma in the thalamic, with (or without) Intraventricular hematoma; (3) EVD surgery after admission; (4) Age > 18 years; (5) Clinical and imaging data were complete.

Exclusion criteria: (1) Patients with brain herniation at admission and in a near-death state; (2) Patients who had successfully removed EVD tubes after hematoma absorption; (3) Patients with bleeding caused by organic pathology (arteriovenous malformations, moyamoya disease, cerebral aneurysms, or traumatic); (4) Patients with preoperative coagulation disorders or hematologic disorders; (5) Patients with severe mental illness.

Criteria for failure to clamp the EVD tube: (1) CT shows progressive dilation of the lateral ventricle; (2) Increased intracranial pressure or hydrocephalus symptoms, such as: decreased state of consciousness, headache, nausea, and vomit.

TH treatment

All patients underwent CT evaluation by a neurosurgeon on admission. When the TH exceeded 30 ml and the patient's neurological status deteriorated, a puncture and aspiration of the hematoma were performed under slight negative pressure, followed by placement of an external drainage tube. If TH broke into the ventricle and acute obstructive hydrocephalus was seen on CT, EVD was initiated. A follow-up CT scan was conducted within 24 h postoperatively. The residual hematomas were liquefied and drained using EVD combined with urokinase.

After the intraventricular hematoma disappeared or 2 weeks after EVD, the EVD tube should be removed. Before removing the EVD tube, we routinely clamped the EVD tube for 24 h and performed a CT scan to assess any changes in the ventricles and to confirm unimpeded CSF circulation. If the patient exhibited lateral ventricular enlargement, signs of elevated intracranial pressure, a decline in consciousness, the inability to remove the EVD tube was confirmed. To alleviate symptoms of hydrocephalus, EVD was re-established on the contralateral side, with the drainage tube being intermittently clamped daily. This observation period lasted for 10 to 15 days. If EVD still could not be removed, surgical treatment was considered.

Operative procedure

All surgeries were performed by the same surgical team, and patients and their caregivers were informed of the advantages and disadvantages of both surgical options. The choice of surgical option was based on the clinical experience of the surgeon and the choice of the caregivers.

ETV group

All patients underwent endotracheal intubation and general anesthesia. Through the right frontal horn, lateral ventricle, interventricular foramen, and third ventricle, the lateral ventricle was punctured with an endoscopic puncture sheath. An endoscope was placed into the sheath to explore the ventricle, and ETV was performed. The site of the fistula was the weakest in the triangular area in front of both papillae. First, a small hole was formed by bipolar electrocoagulation, then the dilated balloon catheter was placed into the hole. The fistula was expanded to 4–5 mm, and the fistula was flushed with 37 °C balanced liquid. Water flow was observed, and it was confirmed that the fistula was unobstructed and fully communicated with the interpeduncular pool.

VPS group

All patients underwent endotracheal intubation and general anesthesia. A Medtronic adjustable pressure-drainage kit (Medtronic, USA) was used. The triangular area of the right lateral ventricle was punctured, the ventricular end of the shunt tube was placed, a pressure-regulating valve was connected, and the pressure-regulating valve was placed slightly above the back of the ear through the subcutaneous tunnel. Above the right side of the navel, the abdominal cavity was opened through a paramedian incision, and the abdominal end of the shunt tube was led to the abdomen through the subcutaneous tunnel. After confirming that the drainage tube was unobstructed, the end of the shunt tube was placed in the abdominal cavity and fixed.

All patients were routinely monitored for vital signs, and a bed head elevation of 30°, rehydration, infection prevention, and other treatments were administered after surgery.

Table 1 Comparison of general clinical data between the two groups

	ETV($n=42$)	VPS($n=45$)	*P* value
Gender			1.000
Male	28	30	
Female	14	15	
Age (y)	52.4 ± 6.5	54.1 ± 2.5	0.107
Previous disease:			0.983
Hypertension (%)	34(80.9%)	40(88.9%)	
Heart disease (%)	18(42.9%)	20(44.4%)	
Diabetes (%)	19(45.2%)	21(46.7%)	
TH (%)	16	15	0.612
TH break into the ventricles (%)			0.690
Lateral ventricle and third ventricle	16	20	
Fourth ventricles	10	10	
Operation times (min)	35.2 ± 5.1	82.4 ± 3.8	0.001
Intraoperative blood loss (ml)	57.1 ± 6.6	60.4 ± 4.3	0.007
Hospital stay (d)	14.3 ± 4.4	13.6 ± 3.1	0.391

VPS: ventriculoperitoneal shunt; ETV: endoscopic third ventriculostomy; TH: thalamic hemorrhage

Postoperative evaluation

All patients underwent CT examination within 24 h after surgery to assess postoperative intracranial conditions. Postoperative observation indicators included the operative time, length of hospital stay, and postoperative complications. Clinical success of surgery was assumed when the patient was followed up while alive and without subsequent hydrocephalus procedures, such as shunting.

Statistical analysis

SPSS 22.0 software (SPSS Inc., Chicago, IL, USA) was used for data analysis. Continuous variables were expressed as mean ± standard deviation. Differences between variables were evaluated using the independent sample t-test. Categorical variables were expressed as ratio (%), and differences between these variables were compared using the chi-square test. A $p<0.05$ was considered statistically significant. This study is reported according to STROBE guidelines [9].

Results

Patient data

According to the inclusion and exclusion criteria, we obtained clinical data on 103 patients with TH. Ten patients with TH combined with basal ganglia hemorrhage and six patients with automatic discharge were excluded. Ultimately, 87 patients were included in our study. Among them, 58 cases were male and 29 were female. Their ages ranged from 34 to 71 years, with a mean age of 53.2 ± 4.6 years. Thirty-one cases had TH only, and 56 had hematoma that broke into the ventricles, including the lateral and third ventricles in 36 cases and the fourth ventricle in 20 cases. (Table 1)

Comparison of general conditions of patients between the ETV and VPS groups

No patient deaths occurred during the entire treatment. There were no significant differences in age, previous diseases, type of bleeding, intraoperative blood loss, or length of hospital stay between the two groups (Table 1). The operative time in the VPS group was longer than that in the ETV group, and the difference between the two groups was statistically significant ($p=0.001$). The EVD tube was successfully removed from all patients.

Comparison of postoperative complications between the groups.

The ETV group included 13 cases (30.9%) of complications: 1 case of bleeding at the operative site, 2 cases of fever, and 10 cases of pneumocephalus. The VPS group had 12 cases (26.7%) of complications: 1 case of bleeding at the operative site, 1 case of fever, 8 cases of pneumocephalus, and 2 cases of intracranial hypotension. All patients recovered after treatment, and there were no significant differences in postoperative complications between the two groups (Table 2).

Table 2 Comparison of postoperative complications between the two groups

	ETV(*n*,%)	VPS(*n*,%)
Bleeding at the operation site	1(2.4)	1(2.2)
Fever	2(4.8)	1(2.2)
Pneumocephalus	10(23.8)	8(17.8)
Intracranial hypotension	0(0)	2(4.4)

VPS: ventriculoperitoneal shunt; ETV: endoscopic third ventriculostomy

Table 3 Comparison of the reoperation rate between the two groups after 1 year of follow-up

	ETV(*n*,%)	VPS(*n*,%)	*P* value
TH	1(2.4)	1(2.2)	0.961
TH break into the ventricles (%)			
Lateral ventricle and third ventricle	0(0)	1(2.2)	0.331
Fourth ventricle	6(14.3)	1(2.2)	0.039

VPS: ventriculoperitoneal shunt; ETV: endoscopic third ventriculostomy; TH: thalamic hemorrhage

Comparison of reoperation rates between the groups after 1 year of follow-up

During 1-year follow-up, 7 patients (16.7%) in the ETV group and 3 patients (6.7%) in the VPS group required reoperations. Causes in the ETV group included fistula obstruction ($n=2$) and communicating hydrocephalus ($n=5$). Causes in the VPS group included shunt obstruction ($n=2$) and intracranial infection ($n=1$). No significant difference in reoperation rates was found between the groups ($p=0.144$). In the subgroup analysis, TH with fourth ventricular hemorrhage required reoperation in 6 cases (14.3%) in the ETV group and 1 case (2.2%) in the VPS group; the difference between the two groups was statistically significant (Table 3).

Discussion

In this study, our focus was to analyse the efficacy of VPS and ETV in the treatment of hydrocephalus after TH in which EVD could not be removed after haematoma resorption. To our knowledge, this is the first study dedicated to revealing the efficacy of VPS and ETV in hydrocephalus after TH. In addition, we evaluated the surgical efficacy of VPS and ETV in hydrocephalus caused by TH with different ventricular haematomas. Our findings suggested that both VPS and ETV are highly effective in treating hydrocephalus after TH. Notably, VPS was more suitable for the treatment of TH combined with fourth ventricular haematoma, whereas ETV was more suitable for the treatment of hydrocephalus caused by TH and TH with lateral and third ventricles.

TH was very likely to break into the ventricles and compress the three ventricles and aqueduct, interrupting CSF flow. EVD combined with urokinase can rapidly remove intraventricular hematoma [10]. However, the hematoma in the thalamus often did not disappear for a long time, because of its deep location, the dilution of urokinase in CSF, and small interaction surface with the hematoma. In clinical practice, due to the compression of the hematoma, perihematoma edema, the role of local aseptic inflammation, adhesion and obstruction occurred in the rear of the third ventricle and the initial segment of the aqueduct, the hydrocephalus could not be relieved after hematoma absorption, the EVD tube could not be removed [11, 12]. Early evacuation of the hematoma and remission of hydrocephalus could improve the mortality and prognosis of patients [13], thus research efforts had concentrated on managing acute hydrocephalus after hemorrhage. Due to the relatively small number of patients who could not remove EVD after TH, few studies had investigated the treatment of post-TH hydrocephalus.

At present, VPS is widely used for the treatment of hydrocephalus, especially for the treatment of post-hemorrhage hydrocephalus [14]. However, postoperative complications, such as infection and blockage, could easily lead to operative failure, which was difficult to avoid. In the VPS group, 2 patients (4.4%) had shunt obstruction and 1 patient (2.2%) had a fever, 2 patients (4.4%) had intracranial hypotension. In order to reduce the incidence of complications, ETV had emerged as an alternative treatment for hydrocephalus [15]. Over the past few decades, this technique had been refined and had become a frequently used tool in the treatment of hydrocephalus [16–19]. Compared with VPS, ETV was more in line with the physiological process of CSF circulation, it overcames complications such as shunt tube blockage, shunt tube exposure, and the psychological burden caused by internal tube placement on the patient. Because of its high success rate and fewer complications, ETV had been the preferred treatment for obstructive hydrocephalus [20]. However, ETV also had the risk of intracranial infection and fistula obstruction, and the curative effect of communicating hydrocephalus remained controversial [6, 8]. In the ETV group, there was 1 case of bleeding at the operative site, 1 case of fever, and 2 cases of fistula obstruction. The operative time of VPS was longer than that of ETV, and the difference between the groups was statistically significant.

Most hydrocephalus caused by TH was obstructive hydrocephalus, therefore, ETV seemed to be more suitable for post-TH hydrocephalus than VPS. Hussein et al. performed ETV on eight TH patients who could not remove their EVD tubes due to hydrocephalus. Those patients were followed up for 3 months, and the authors concluded that ETV was a safe and effective treatment for post-TH hydrocephalus [21]. However, TH often broke into the ventricles, and clinical outcomes varied depending on the location of the hematoma. If the hematoma was located in the thalamus or only broke into the lateral ventricle and third ventricle, the patient had obstructive hydrocephalus after EVD+urokinase drainage. When TH was associated with fourth ventricle hematoma, the effectiveness of urokinase was diminished due to midbrain aqueduct obstruction. The fourth ventricle hematoma was absorbed through the subarachnoid space after catabolism, and communicating hydrocephalus occurred easily in the later stage. Regarding communicating hydrocephalus, ETV had a high failure rate because its pathogenesis was a disorder of cerebrospinal fluid subarachnoid reabsorption [22, 23]. Multiple studies had shown that the failure rate of ETV was significantly increased in hydrocephalus caused by intraventricular hemorrhage [22–25]. Our study's results supported this viewpoint. Among patients with TH and hemorrhage breaking into the lateral and third ventricles, the reoperation rate of ETV was 2.2%, however, in cases of TH with fourth ventricle hemorrhage, the reoperation rate of ETV was 14.3%, and that of VPS was 2.2%.

To achieve optimal surgical outcomes and reduce the reoperation rate, the location of hematomas must be analyzed individually: (1) TH combined with ventricular hemorrhage in the lateral and(or) third ventricles, because hydrocephalus was an obstructive hydrocephalus caused by the compression of hematoma and adhesion, which made it more suitable for ETV. (2) TH combined with hematoma in the fourth ventricle was more likely to develop into communicating hydrocephalus in the later stage, even if they showed obstructive hydrocephalus in the early stage, the long-term effect of ETV was poor and the reoperation rate was high in such cases. Therefore, this type of patient was suitable for VPS.

Limitations

The present study has some limitations. First, this is a retrospective analysis, and some of the indicators derived are not comprehensive and may be biased. In addition, more comprehensive data collection and analysis are needed. Second, there is a lack of prospective analysis, the sample size was small (TH is common, but cases whose EVD cannot be removed after TH are relatively rare). A priori sample size calculation was not performed, however, according to the previous literature [26], we were sufficiently powered to see an effect. Third, the ETV and VPS cases were evaluated retrospectively on the basis of clinical records, and the postoperative follow-up is only 1 year. This study lacks long-term follow-up.

Conclusions

ETV had effectiveness in treating hydrocephalus caused by TH and TH with lateral and third ventricular hemorrhage. However, when hydrocephalus caused by TH with fourth ventricular hematoma, VPS was a better surgical method because the recurrence rate of hydrocephalus after VPS was lower than that of ETV. Therefore, the choice between ETV and VPS should be based on a careful assessment of the patient's clinical presentation and the location of the hematoma. This tailored approach ensured that the chosen surgical approach was best suited to the patient's condition, thereby reducing complications and improving postoperative efficacy.

Abbreviations

VPS	ventriculoperitoneal shunt
ETV	endoscopic third ventriculostomy
TH	thalamic hemorrhage
EVD	external ventricular drainage
HICH	hypertensive intracerebral hemorrhage
CSF	cerebrospinal fluid
CT	computed tomography

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12883-024-03880-0.

Supplementary Material 1

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Author contributions

WC. L.: Data collection and statistical analysis, wrote the main manuscript. AD. D.: Data collection and revision of the manuscript. XM. Z. :Design of the study; confirmed the results of the statistical analysis. All authors reviewed the manuscript.

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Data availability

As the raw data contains clinical information of the patients. Due to the protection of patient privacy, the raw data cannot be shared publicly. However, reasonable research needs can be addressed to the corresponding author by email.

Declarations

Ethical approval

This study was approved by People's Hospital of Ningxia Hui Autonomous Region Hospital Institutional Review Board, and this research conforms with the Declaration of Helsinki. Informed consent was waived by People's Hospital of Ningxia Hui Autonomous Region Hospital Institutional Review Board because of the retrospective nature of our study.

Consent for publication

Not Applicable.

Competing interests
The authors declare no competing interests.

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