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Original Article

Endoscopic third ventriculostomy for the management of hydrocephalus secondary to posterior fossa tumors: A retrospective study

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ABSTRACT

Background: Endoscopic third ventriculostomy (ETV) is an effective alternative to ventriculoperitoneal shunting as well as external ventricular drainage for the urgent management of acute hydrocephalus. We performed this study to investigate the efficacy and safety of ETV before tumor resection in managing hydrocephalus in patients with posterior fossa brain tumors (PFBT) in our neurosurgery department.

Methods: We conducted this retrospective observational study between February 2018 and February 2020 on all cases diagnosed with PFBT associated with triventricular obstructive hydrocephalus. We retrospectively reviewed the demographic characteristics, operative procedures, and radiological investigations of all cases. During the follow-up period, clinical, as well as radiological success were evaluated.

Results: Twenty-two ETV procedures were performed in 22 cases of PFBT (mean age = 22.1 years, SD = 11.4). Of the 22 cases, 8 cases (36.4%) had ependymoma, 7 cases (31.8%) had cerebellar astrocytoma, and 5 cases (22.7%) had medulloblastoma, while 2 cases (9.1%) had diffuse pontine gliomas. The median follow-up duration was 9 months (range 3–13 months). The most commonly reported clinical presentation was the significant intracranial pressure increase. All operations were performed successfully in all cases. Only two ETV post-tumor resection failures were documented during the follow-up period.

Conclusion: Preoperative ETV has shown to be an effective long-term cerebrospinal fluid diversion procedure to manage PFBT-associated hydrocephalus, with a relatively low rate of complications. Further prospective studies are required to assess the regular use of ETV before complete tumor resection.

Keywords: Brain, Endoscopic third ventriculostomy, Posterior fossa, Resection, Tumors

INTRODUCTION

One of the most prevalent neurosurgical pathologies requiring neurosurgical intervention is hydrocephalus. Managing hydrocephalus secondary to central nervous system tumors is a complicated, challenging neurosurgical issue.[31] Postresection hydrocephalus affects about 10–40% of patients with posterior fossa brain tumors (PFBT), with a more frequent incidence among the pediatric population than adults.[20]

Endoscopic third ventriculostomy (ETV) was first identified as a treatment option for hydrocephalus by William Mixter in 1923.[1] Internal cerebrospinal fluid (CSF) diversion

through ETV has become an appealing treatment choice to manage obstructive hydrocephalus cases secondary to PFBT.[26] ETV has been shown to be an effective alternative to ventriculoperitoneal (VP) shunting as well as external ventricular drainage (EVD) for the urgent management of acute hydrocephalus in such cases because it can easily eliminate the associated symptoms and reduce procedural recurrent hydrocephalus.[6,15,17,25,28]

There is a paucity of data regarding the incidence of perioperative complications as well as permanent hydrocephalus in patients who underwent ETV procedures before PFBT surgeries. We performed this study to investigate the efficacy and safety of ETV before tumor resection in managing hydrocephalus in patients with PFBT.

MATERIALS AND METHODS

The "Strengthening the Reporting of Observational Studies in Epidemiology" statement guidelines were followed while reporting this study.[29] Between February 2018 and February 2020, we conducted this retrospective observational study of PFBT patients with associated triventricular obstructive hydrocephalus, presented to the neurosurgery department of our institution. We retrospectively reviewed the demographic characteristics, operative procedures, and radiological investigations of all cases.

Eligibility criteria

We included all cases diagnosed to have PFBT with associated triventricular obstructive hydrocephalus. Cases experiencing active stage either of ventriculitis or meningitis, intraventricular hemorrhage, or patients who did not accept the ETV treatment were excluded from our study.

Case definition

Patients were diagnosed to have symptomatic hydrocephalus if they had a clinical presentation of increased intracranial pressure (ICP) (i.e., headache, impaired consciousness, nausea, or vomiting) and the magnetic resonance imaging showed enlarged ventricles as well as the obstruction of the fourth ventricle [Figure 1].

Procedures

The previous literature has extensively described the ETV procedures' technique.[11,13] Before definitive resection of the brain tumor, all patients underwent ETV within 48 h up to 5 days. Regardless of the doubtful radiological diagnosis of the brain tumor's pathology, the decision to conduct ETV procedures was according to the clinical evidence of significantly elevated ICP as well as the radiological evidence of an active process of triventricular hydrocephalus. We performed all ETV procedures under general anesthesia. The patients were in the supine posture, the head is bent to 15°, and the remainder of the body was in a neutral position on a horseshoe headrest. We performed a vertical skin incision with the Kocher's point in the middle. During all procedures, we used a rigid endoscope with a 6° lens. The 3 F or 4 F Fogarty balloon catheters were used to open the floor of the third ventricle [Figure 2]. We steered the endoscope through the foramen of Monro after passing the lateral ventricle, defining the anatomical characteristics of the third ventricle floor. Then, a puncture point was selected halfway between the mammillary bodies and the infundibular recess using the Fogarty catheter's tip. Then, we slowly inflated the balloon inside the third ventricular floor hole using a syringe filled with saline until a stoma large enough to support the endoscope's outer diameter was achieved, and vibrating edges, as well as the whirl sign, became visible. We advanced the endoscope through the stoma and punctured (if present) the Liliequest's membrane to ensure the ventriculostomy patency as well as the prepontine cistern. After ensuring that the ventricular cavities remained blood free, we removed the endoscope and closed the scalp incision in layers. The findings of the clinical assessment as well as MR scans were used to assess the study's follow-up data. All patients underwent preoperatively and postoperatively MR imaging and yearly subsequently.

Clinical and radiological assessment

During the follow-up period, clinical success was characterized as the absence of hydrocephalus clinical presentations during the study's follow-up duration. The continuation or deterioration of hydrocephalus-related clinical manifestations necessitating shunt insertion and the postoperative complications were the characterizations of ETV failure. We assessed the radiological success 72 h after surgery, with the absence of the leakage of CSF; it was considered when the preoperative imaging features of hydrocephalus were improved as well as the features of elevated ICP.

Data analysis

The dichotomous data were expressed as frequencies and percentages, while the continuous data were presented as mean and standard deviation or the median and range in case of normally and non-normally distributed data, respectively. All analyses were carried out using the Microsoft® Excel software version 2019.

RESULTS

We performed 22 ETV procedures in 22 cases (12 males and 10 females). The patients' age ranged between 5 and

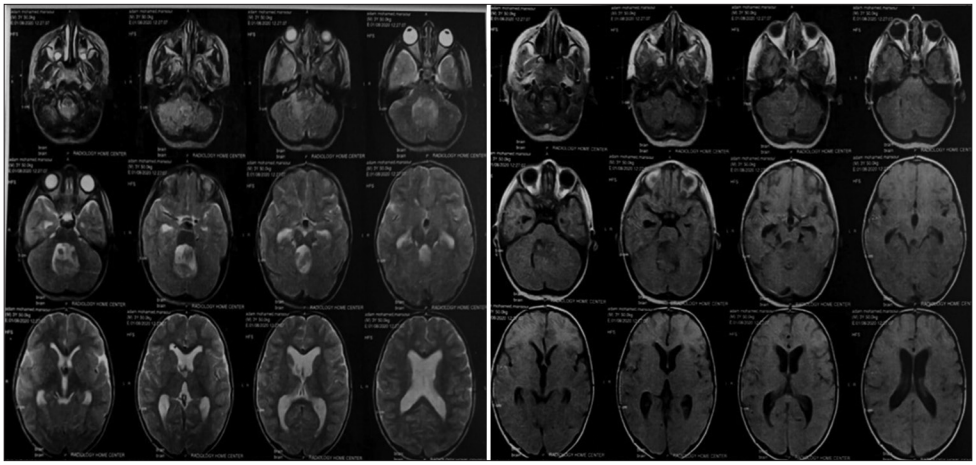

Figure 1: Magnetic resonance imaging of the brain (T1 and T2 images) showing PFBT with supratentorial hydrocephalus.

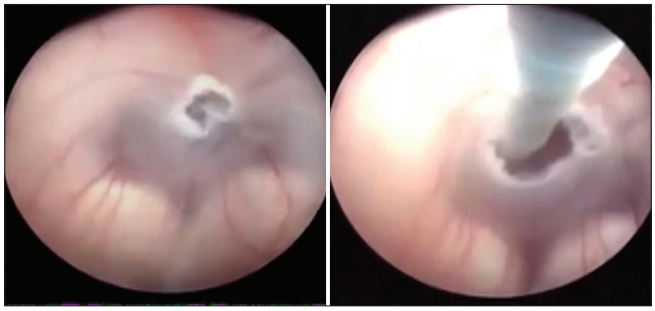

Figure 2: Intraoperative endoscopic image showing ostium in the floor of the third ventricle with Fogarty catheter insertion for dilation.

42 years old (mean age = 22.1 years, SD = 11.4). The most common types of PFBT were ependymoma noted in 8 cases (36.4%) followed by cerebellar astrocytoma in 7 cases (31.8%) and medulloblastoma noted in 5 cases (22.7%). Diffuse pontine glioma was reported in only 2 cases (9.1%). The follow-up duration ranged between 3 and 13 months (median follow-up = 9 months, IQR = 6.50). In the studied cases, the most commonly reported clinical presentation was the significant ICP increase in the form of headaches and vomiting followed by gait unsteadiness and papilledema [Figure 3].

There were no mechanical difficulties reported during the fenestration of the third ventricle's floor; all operations were performed successfully in all cases. ETV was effective in relieving hydrocephalus. No ETV failures were observed before surgical excision of the PFBT; all patients exhibited significant clinical improvement as well as the radiological absence of ventriculomegaly. During the follow-up phase, two ETV post-tumor resection failures were documented. The ETV outcome, as well as the follow-up periods of the included patients, is detailed in [Table 1].

DISCUSSION

There is no agreement about how to manage adult patients with PFBT-associated obstructive hydrocephalus surgically. The previous literature stated that, at the time of presentation, most patients with PFBT experience hydrocephalus; the management of such cases is still debatable. Previously, the VP shunt placement was an effective preoperative management in cases with PFBT-related hydrocephalus. However, as neurosurgeons became more conscious of the frequent ventricular shunting-associated complications, as well as the less frequent complications such as upward herniation, tumor bleeding, and intracranial tumor seedling inside the peritoneum, they began to inquire about the routine ventricular shunting.[4,18,24] We performed this study to investigate the efficacy of preresection ETV in the management of hydrocephalus in patients who underwent ETV procedures before PFBT surgeries and assess the incidence of perioperative complications as well as persistent hydrocephalus.

Summary of the main findings

In our study, 22 ETV procedures were performed in 22 cases. The age ranged between 5 and 42 years old, with a mean age of 22.1 years, and the follow-up duration ranged between 3 and 13 months, with a median of 9 months. Regarding the distribution of PFBT among the studied population, 36.4% had ependymoma, 31.8% had cerebellar astrocytoma, 22.7% had medulloblastoma, and 9.1% had diffuse pontine glioma.

All operations were performed successfully in all cases, with no serious intraoperative complications. In our study, ETV relieved hydrocephalus effectively before the surgical excision of the PFBT. All cases showed considerable clinical and radiological improvements. During the follow-up period, only two ETV post-tumor resection failures were detected.

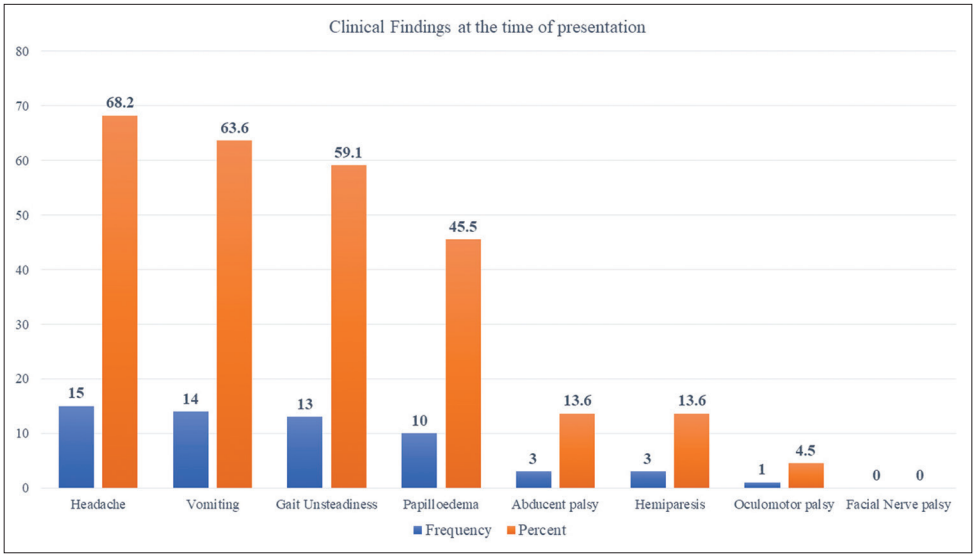

Figure 3: The clinical findings at the time of presentation among the included patients (n = 22).

Table 1: The outcomes of ETV and follow-up periods among the study population.

Case no.	Sex	Age (years)	Type of tumor	Outcome	Follow-up (months)
Patient 1	Male	32	Ependymoma	Successful	3
Patient 2	Male	42	Medulloblastoma	Successful	3
Patient 3	Female	8	Ependymoma	Failed	6
Patient 4	Male	6	Medulloblastoma	Successful	12
Patient 5	Female	7	Cerebellar astrocytoma	Successful	13
Patient 6	Male	22	Ependymoma	Successful	3
Patient 7	Male	18	Cerebellar astrocytoma	Failed	12
Patient 8	Female	20	Medulloblastoma	Successful	4
Patient 9	Male	39	Ependymoma	Successful	5
Patient 10	Female	36	Cerebellar astrocytoma	Successful	6
Patient 11	Male	20	Diffuse pontine glioma	Successful	7
Patient 12	Female	16	Ependymoma	Successful	3
Patient 13	Female	20	Cerebellar astrocytoma	Successful	9
Patient 14	Male	25	Medulloblastoma	Successful	10
Patient 15	Male	30	Ependymoma	Successful	12
Patient 16	Female	12	Ependymoma	Successful	8
Patient 17	Male	41	Cerebellar astrocytoma	Successful	9
Patient 18	Female	31	Diffuse pontine glioma	Successful	10
Patient 19	Male	17	Medulloblastoma	Successful	11
Patient 20	Male	15	Cerebellar astrocytoma	Successful	9
Patient 21	Female	24	Cerebellar astrocytoma	Successful	11
Patient 22	Female	5	Ependymoma	Successful	13

The first case was an 8-year-old girl with ependymoma who presented 6 months after tumor resection with symptoms of high ICP. The CT scan showed that there was obstructive hydrocephalus; despite a patent fourth ventricle. Moreover, we observed a nonenhancing mass in the left frontal lobe, with nearby perifocal edema, causing a considerable mass effect. A second ETV was performed for this patient; it exhibited a patent stoma of the floor of the third ventricle. The other case was an 18-year-old male patient with cerebellar astrocytoma who experienced CSF infection 5 days after tumor excision; this case was treated with EVD as well as antibiotics, then, a VP shunt was inserted.

Agreement and disagreement with the previous studies

In 2019, a retrospective analysis was conducted by Frisoli *et al.* on children with PFBT- associated hydrocephalus who underwent tumor resection. They showed that ETV

before PFBT resection in the pediatric population decreased the postoperative VP shunt placement (16% of patients underwent ETV compared to 31% in the matched control group), with no complications reported during ETV.[9]

In 2018, a retrospective study was conducted on adult patients who underwent ETVs before PFBT surgery; of them, 82.5% had symptomatic hydrocephalous, and all of them reported clinical improvement after EVT, with no reported EVT-related complications.[19] During their 76.5 months follow-up period, no cases required permanent shunting procedures, and only five cases required either redo ETV or external ventricular drain. The authors suggested the safety as well as the feasibility of preresection ETV before PFBT surgeries in patients with symptomatic hydrocephalus, but not for asymptomatic patients as a prophylactic procedure. Similarly, in their article, Roux *et al*. concluded that ETV might be a proper management for patients suffering from symptomatic obstructive hydrocephalus.

Furthermore, in Marx *et al*., the authors performed a 10-year period study between 2005 and 2014. They reported that the incidence rate of hydrocephalus before PFBT surgery in adults is lower than the rate reported in the previous literature in the pediatric population, and it is estimated to be 21.4%. Furthermore, they stated that the persistent hydrocephalus occurrence risk was low (5.7%) while it was 2.1% for the newly formed hydrocephalus following PFBT surgery, and not all adult patients require ETV before PFBT surgeries.[20]

In a previous single-center experience retrospective study conducted by Grand *et al*., the authors reported that the success rate of the total of 243 completed procedures was 72.8%. Of the intended ETV procedures, only nine complications were documented (3.6%); of these complications, only 5 complications (2%) were serious. The authors concluded that in selected patients, the use of ETV in adult hydrocephalus has a broad scope, with a low complication rate and relatively good efficacy.[10] Previously, Lee *et al*. conducted a retrospective study on 42 children suffering from medulloblastoma that had not been shunted before surgery. Permanent shunts were warranted in 17 children (40%) within 1-month postcraniotomy. Compared to those who had VP shunts preoperatively, patients who did not have VP shunts had a much higher risk of morbidity.[16]

Significance of the findings

Before tumor resection, an EVD insertion is a viable CSF diversion management option that can be used in patients with PFBT and subsequent obstructive hydrocephalus. EVD increases the risk of CSF inflammation, hemorrhage, and upward herniation. As a result of these issues, a more conservative care protocol was introduced, which included preoperative steroids accompanied by tumor excision and, if necessary, the insertion of an EVD.[3] Because of the short surgery period, the low rates of morbidity and failure, and minimizing the shunt dependency, many neurosurgeons consider ETV a First Choice Management procedure in cases with hydrocephalus secondary to PFBT;[6] however, its regular use before tumor resection remains controversial.

The success rate of ETV is mainly dependent on the tumor's localization as well as its growth pattern. Compared to benign lesions, progressive tumors are more prone to close ventriculostoma. Furthermore, the symptoms' duration seems to be a predictor.[21] The previous literature reported that the success rates range between 50% and 95%.[5,21,22,25,26,30] In our study, the overall success rate was 90.9%. Preresectional ETV was shown to be a successful and reliable treatment with a high success rate after up to a 7.5-year follow-up period in a study comprising 59 patients.[1] In contrast, a significantly lower success rate of 56% has been reported in the case of tumors.[30] Moreover, the ETV failure rate postoperatively was reported to be similar to the VP shunt implanted in patients suffering from obstructive hydrocephalus secondary to PFBT.[27] Recently, Hong *et al*. documented an association between ETV success score and the long-term success rate, but not with long-term intellectual status; no additional CSF diversion technique was required for all patients at the 15-month follow-up period following initial ETV.[12]

Complete resection of PFBT should restore the normal CSF pathway. However, many children would develop uncontrolled persistent hydrocephalus after tumor resection because of the postoperative adhesions related to either the aqueduct or the outlets of the fourth ventricle.[20] The previous literature had reported that this risk of incidence of postoperative hydrocephalus, and subsequently morbidity and mortality rates, was decreased when preresectional ETV procedures were performed.[8] Therefore, an additional prophylactic role of ETV before tumor resection has been proposed. Normalizing the CSF hydrodynamics preoperatively can decrease the postoperative persistent impairment of the CSF circulation.[23] Waiting for the hydrocephalus to be resolved after PFBT surgeries put patients with PFBT-related ventricular dilatation at a considerable likelihood to develop intracranial hypertension, CSF leakage, pseudomeningocele, and pseudobulbar palsy.[7] The rate of complications in our study (9%) falls within the range of rates of complication documented in the previous studies (6–20%). The previous literature has reported serious and fatal complications that included but was not limited to intraoperative bleeding (either venous or arterial), seizures, leakage of CSF, infection, cerebral aneurysms, and brain hematomas.[2,14,24]

The main limitation of our study is the low number of included patients. Furthermore, being a single-institution

observational study limits the generalization of our findings. We could not include a control group because of the retrospective design; thus, we recommend that further prospective clinical trials should compare different groups to assess the optimal CSF diversion procedure and to assess the long-term follow-up among such cases.

CONCLUSION

Preoperative ETV has been shown to be an effective long-term CSF diversion procedure to manage PFBT-associated hydrocephalus, with a relatively low rate of complications. To support these findings, further prospective studies are required to assess the regular use of ETV before complete tumor resection.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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