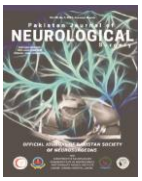

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Original Article

Endoscopic Third Ventriculostomy: A Comparable Alternative to Ventriculoperitoneal Shunt for Obstructive Hydrocephalus Secondary to Infratentorial Tumors

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ABSTRACT

Objective: To establish ETV as a comparable alternative to ventriculoperitoneal shunt for obstructive hydrocephalus secondary to infratentorial tumors.

Materials and Methods: 40 Patients with infratentorial tumors presenting with hydrocephalus were enrolled in a prospective descriptive case series. Symptoms, neurological examinations, CT scans, and intra-operative findings were used to detect the complications at 03 months.

Results: Mean age = 31.98 ± 15.24 years, female to male ratio of 1:1.2. The KPS score of the participants was ≥ 70% and ETVSS ≥80. The average operative meantime was 21 ± 2.82 minutes. Within first week, the improvement in symptoms was recorded: headache – 87.5% ($p < 0.001$), nausea vomiting - 84% ($p < 0.001$), gait disturbance – 59.3% ($p = 0.442$) seizures improvement -100% ($p = 0.016$) and urinary incontinence – 66.7% ($p = 0.687$). Radiological improvement in hydrocephalus on CT scan was seen in one patient within 24 hours – 2.5% ($p = < 0.001$), 12.5% ($p < 0.001$) after two weeks and 87.5% ($p = < 0.001$) after three months post-operatively. The most common of these wasa decrease in the size of the third ventricle and a decrease in the size of the frontal horns of lateral ventricles. However, complete resolution of radiologic features was observed in two patients only 5% ($p<0.001$). However, complete resolution of radiologic features was not observed in any patient. No intra-operative or post-operative complication of ETV was recorded.

Conclusion: ETV is a quick and safe method for CSF diversion in obstructive hydrocephalus alleviating the need for the placement of VP shunt hardware, thus eliminating foreign body-related cranio-abdominal complications.

Keywords: Obstructive Hydrocephalus, Ventriculoperitoneal Shunt (VPS), Endoscopic Third Ventriculostomy (ETV).

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INTRODUCTION

Hydrocephalus may be present at the time of the first diagnosis of infratentorial tumors in up to 80% of pediatric patients and 21.4% of adults, although it resolves after tumor removal in 70 – 90% and 96%, respectively.[1] However, about 79 – 90% of hydrocephalus are shunted before tumor excision,[2] whereas only 20 – 30% of patients need a permanent cerebrospinal fluid (CSF)diversion after tumor excision.[3] For practical purposes, hydrocephalus secondary to the tumor may be considered a distinct entity[2] and traditionally, Ventriculoperitoneal (VP) shunt has been extensively employed for the management of all types of hydrocephalus. About 57.2% of total VP shunt surgeries are being performed for infratentorial tumors.[4] The frequency of VP shunt hardware failure requiring a revision surgery is 27.8%[5] to 32.5%.[6]

Endoscopic third ventriculostomy (ETV) has replaced VP shunt as the first-line treatment for obstructive hydrocephalus with the cumulative complication rate: 05 – 15%,[7] mortalities: 0.22%, permanent morbidity: 2.1%, and an overall success rate: 50 – 90%.[8] Scores of studies have been conducted to compare ETV and VP shunt but most of these studies, however, are centered on pediatric populations.

The objective of this study was to establish the role of ETV as a comparable alternative to VP shunt for the management of obstructive hydrocephalus secondary to infratentorial tumors. The rationale of this study was that the expected practical benefit of ETV in patients with infratentorial lesions is to reduce the frequency of unnecessary but permanent foreign body placement in form of VP shunts and the ensuing complications.

MATERIALS and METHODS

Study Design and Setting

Following approval from the ethical review committee of the Punjab Institute of Neurosciences (PINS), Lahore, Pakistan, a quasi-experimental study was conducted in the Department of Neurosurgery, Punjab Institute of Neurosciences, Lahore, Pakistan, between October 2020 and March 2021. The patients were recruited for the first three months only.

Sample Size and Technique

40 patients (n = 40) were included who met the inclusion criteria. Consecutive non-probability sampling was considered.

Inclusion Criteria

Patients of both genders with ages between 3-80 years were included. Patients included who were diagnosed with acute hydrocephalus due to infratentorial lesions having no previous CSF diversion procedures.

Exclusion Criteria

Patients with KPS < 70 were excluded from the study because most of them were managed with VP shunt in the emergency department. Patients excluded who were unfit for general anesthesia. Patients who did not give informed consent were also not included.

Data Collection

The demographic details, diagnosis, symptoms, neurological examination findings, Karnofsky Performance Status Scale (KPS)[9,] and ETV success score (ETVSS)[10] were recorded. CT scan brain for diagnosis of acute hydrocephlus[11] (Table 1) and MRI were used to confirm the diagnosis.

Statistical Analysis

Table 1: CT Scan Brain Criteria for the Diagnosis of Hydrocephalus.[11]

Temporal Horns ≥ 2mm and	and Sylvian & interhemispheric fissures and cerebral sulci not visible
Size of Temporal Horns ≥ 2mm	and Ratio of FH/ID > 0.5
Mickey Mouse Ventricles	Ballooning of frontal horns of lateral ventricles and/or 3rd ventricle
Periventricular lucency	Periventricular low density
FH/ID	>50%
Evans' Ratio (Ratio of FH to maximal biparietal diameter (BPD) measured in the same CT slice)	>0.3

FH is the largest width of the frontal horns and ID is the internal diameter from inner table to inner table at the same level

Data Analysis

Data were entered and analyzed by using SPSS 26 version. Quantitative variables such as age, demographic variables, ETVSS, KPS were described as Mean ± S.D. Qualitative variables such as gender, diagnoses, clinical outcome, and complications were described as frequency and percentage. Comparison of outcome variables was done by using the student t-test according to the nature of outcome variables. P-value of equal or less than 0.05 was considered significant.

Complications

Most common complications[7] of ETV include neurovascular injury, Basilar artery injury, stoma failure, Oculomotor nerve palsy, hemodynamic alterations, endocrinologic abnormalities, diabetes insipidus, electrolyte imbalances, cerebrospinal fluid leakage, fever, infection, wound infection, meningitis, and herniation syndrome, were actively sought for documentation. Intra-operative findings, changes in symptomatology, neurological examination, and CT scan brain were used to document complications and record improvement.

Procedure

All the procedures were performed by the same surgical team. Injection Ceftriaxone 01 gram was given intravenously at the time of induction of anesthesia. The surgical position was supine with 15 degrees' neck flexion. A burr hole was made at the right Kocher's point - 01cm anterior to coronal suture in the mid pupillary line. Dura was opened in a cruciate manner. A rigid endoscope with a 6° angle of view and a sheath diameter of 6.8 mm of the LOTTA® system ventriculoscope (KARL STORZ Endoscopy-America, United States of America) was used. The scope was passed through the burr hole, traversing the lateral ventricle, and then through the foramen of magnum to visualize the floor of the third ventricle. Fenestration was done anterior to mammillary bodies with a 4 FrFogarty catheter to create a 5 – 6 mm stoma. A warm Normal Saline solution was used for irrigation. A thorough visual examination was done at the end of the procedure to observe CSF flow through the stoma and to detect any intra-operative complication. The wound was closed layers. Operative time was measured as the duration between skin incision and end of wound closure.

Post-operative Management and Follow-up

The patients were kept in ICU for 24 hours and CT brain was performed within the first 24 hours after surgery. The wound dressing was changed daily and the stitches were removed on the seventh postoperative day. Intra-operative findings, post-operative CT scan brain, and postoperative change in symptomatology and neurological examinations for new-onset deficit or worsening of previous deficit were used to detect the complications. The second CT scan was

obtained after tumor excision surgery, usually done two weeks after ETV and the third scan was performed three months after ETV. Two weeks after ETV, tumor excision surgery was performed except in one case where ETV and tumor excision with EVD placement were performed as a single surgery. The mean follow-up period was three months.

Case Discussion

One of the included cases deserves a special mention where we further pushed the limits of the role of ETV by performing ETV and tumor excision simultaneously, so that the usual waiting time of two weeks for tumor excision may be eliminated. A 14 – year old female presented with a history of headache, vertigo, ataxia, and fits for 03 months. On examination, she was conscious and oriented with a grade II Left facial nerve palsy. GCS was recorded to be 15/15; KPS score 90% while ETVSS was 80%. CT brain and MRI brain plain and post-contrast revealed a left cerebellar tumor with the features of obstructive hydrocephalus. (Figure 1 & 2).

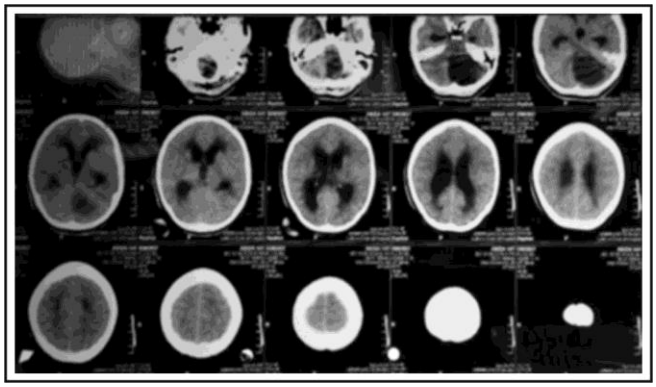

Figure 1: CT Scan Brain Plain – Left Cerebellar Tumor and Hydrocephalus. (Scans used with patient's permission)

Surgery was performed including a right-sided ETV, a craniectomy and excision of the left cerebellar tumor, and right-sided EVD placement. EVD was titrated for seven days. The symptoms were resolved and no new neurological deficit was noted. Moreover, no procedure-related complication was observed. Histopathology confirmed the diagnosis of Pilocytic Astrocytoma. Post-operative CT scans brain showed no radiologic complications. (Figures 3 & 4)

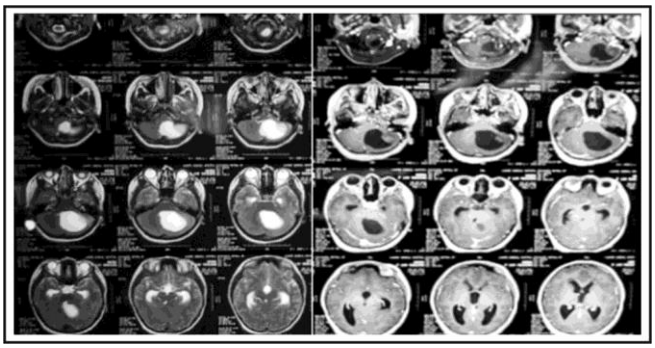

Figure 2: MRI Brain T2W and T1 – Postcontrast Showing Features of Left Cerebellar Pilocytic Astrocytoma and Hydrocephalus.

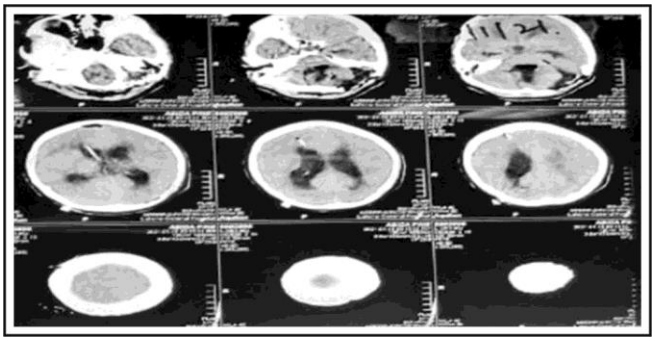

Figure 3: Post-ETV CT Brain Plain – Showing Craniectomy, Tumor Excision External Ventricular Drain (EVD) in Situ.

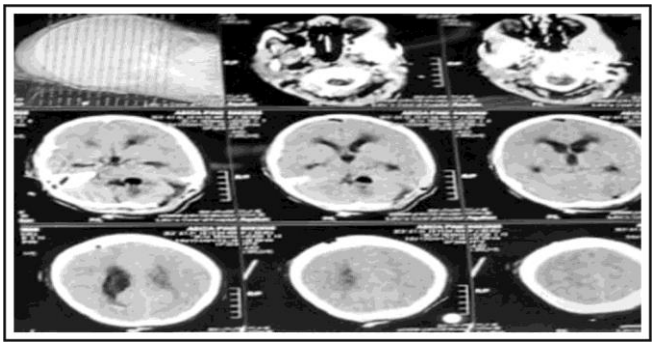

Figure 4: Post-ETV CT Brain plain – Showing Craniectomy, Tumor Excision, and EVD Removed.

RESULTS

Age and Gender Distribution

A total of 40 patients were enrolled during three months with the age range of 11 to 65 years (mean age = 31.98 ± 15.24 years) and a female to male ratio of 1:1.2.

Pre-operative Assessment and Diagnoses

The KPS score of the participants was ≥ 70% and ETVSS ≥80. Stratification according to the diagnoses: Pilocytic Astrocytoma – 10%, Schwannoma – 20%, Medulloblastoma – 10%, Meningioma – 15%, Brain Stem Glioma – 7.5%, Ependymoma – 10%, Hemangioblastoma – 5%, Ganglioglioma – 2.5% Metastatic – 10%, Arachnoid Cyst – 2.5%, Dermoid Cyst – 2.5% and Epidermoid Cyst 5% (Table 2).

Table 2: Distribution of Patients According to Diagnoses.

Diagnoses	Incidence (%)
Arachnoid Cyst	2.5%
Brainstem Glioma	7.5%
Dermoid Cyst	2.5%
Ependymoma	10%
Epidermoid Cyst	5%
Ganglioglioma	2.5%
Hemangioblastoma	5%
Medulloblastoma	10%
Meningioma	1%
Metastatic	10%
Pilocytic Astrocytoma	10%

Presenting complaints attributed to hydrocephalus were headache in all patients (p < 0.001), nausea and vomiting – 62.5% (p = 0.154), gait disturbance – 67.5% (p = 0.038), seizures – 17.5% (p < 0.001) and urinary incontinence – 15% (p < 0.001).

Operative Time

The average operative time was 15 to 25 minutes (mean time = 21 ± 2.82 minutes).

Post-operative Assessment and Outcome

Within first week, the improvement in symptoms was recorded (CI=95%): headache – 87.5% (p < 0.001), nausea vomiting - 84% (p < 0.001), gait disturbance – 59.3% (p = 0.442) seizures improvement – 100% (p = 0.016) and urinary incontinence – 66.7% (p = 0.687). Radiological improvement in hydrocephalus on CT scan was seen in one patient within 24 hours – 2.5% (p = < 0.001), 12.5% (p < 0.001) after two weeks and 87.5% (p = < 0.001) after three months post-operatively (CI 95%). Most common of these were decrease in the size of third ventricle and decrease in the size of frontal horns of lateral ventricles. However, complete resolution of radiologic features was observed in two patients only 5% (p < 0.001) (Tables 3 and 4).

COMPLICATIONS

However, no case was reported of intraoperative complications including hemorrhage, injury to neural structures, or failure to complete the procedure. Postoperative complications including contusion around the point of entry, injury to deeper neural structures, hematoma formation,

Table 3: Incidence of Symptoms at Presentation and Improvement in Symptoms and Radiologic Features after ETV.

Variable	Level	Count	Total	Proportion	p-value	95% CI for Proportion	
						Lower	Upper
Headache	Present	40	40	1.000	< 0.001*	0.912	1.000
Headache	Improved	35	40	0.875	< 0.001*	0.732	0.958

Improvement	Not Improved	5	40	0.125	< 0.001*	0.042	0.268
Nausea Vomiting	Present	25	40	0.625	0.154	0.458	0.773
	Absent	15	40	0.375	0.154	0.227	0.542
Nausea Vomiting Improvement	Improved	21	25	0.840	< 0.001*	0.639	0.955
	Not Improved	4	25	0.160	< 0.001*	0.045	0.361
Gait Disturbance	Present	27	40	0.675	0.038*	0.509	0.814
	Absent	13	40	0.325	0.038*	0.186	0.491
Gait Disturbance Improvement	Improved	16	27	0.593	0.442	0.388	0.776
	Not Improved	11	27	0.407	0.442	0.224	0.612
Seizures	Present	7	40	0.175	< 0.001*	0.073	0.328
	Absent	33	40	0.825	< 0.001*	0.672	0.927
Seizures Control	Controlled	7	7	1.000	0.016	0.590	1.000
Urinary Incontinence	Present	6	40	0.150	< 0.001*	0.057	0.298
	Absent	34	40	0.850	< 0.001*	0.702	0.943
Urinary Incontinence Improvement	Improved	4	6	0.667	0.687	0.223	0.957
	Not Improved	2	6	0.333	0.687	0.043	0.777
Radiology within 24 hours	Improved	1	40	0.025	< 0.001*	6.327e-4	0.132
	Not Improved	39	40	0.975	< 0.001*	0.868	0.999
Radiology – 2 weeks	Not Improved	5	40	0.125	< 0.001*	0.042	0.268
Radiology – 3 months	Complete Resolution	3	40	0.075	< 0.001*	0.016	0.204
	Improved	35	40	0.875	< 0.001*	0.732	0.958
	Not Improved	2	40	0.050	< 0.001*	0.006	0.169

Proportions tested against a value: 0.5 p value <0.05*= Significant

Table 4: Comparison Between Means of Incidence of Symptoms at Presentation and Post-ETV Improvement, and Between Improvement of Radiologic Features within 24 Hours, after 2 Weeks, and after Three Months after ETV.

Measure 1	Measure 2	T	Df	P	Mean Difference	SE Difference	Cohen's d
Headache	Headache Improvement	NaN					
Nausea Vomiting	Nausea Vomiting Improvement	-2.138	24	0.043*	-0.160	0.075	-0.428
Gait Disturbance	Gait Disturbance Improvement	-4.228	26	< 0.001*	-0.47	0.096	-0.814
Urinary Incontinence	Urinary Incontinence Improvement	-1.581	5	0.175	-0.333	0.211	-0.645
Radiology within 24 hours	Radiology – 2 weeks	2.2082	39	0.044*	0.100	0.048	0.329
Radiology within 24 hours	Radiology – 3 months	8.327	39	< 0.001*	0.800	0.096	1.317

Note: Student's t-test
df (Degree of Freedom), SE Difference (Standard Error of Difference between means)
NaN: The Variance in headache is equal to 0
The Variance between Seizures at presentation and Seizures controlled is equal to 0
p-value <0.05* = Significant

electrolyte imbalance, diabetes insipidus, infection were assessed by neurological Oculomotor nerve palsy, CSF leakage, and examination, laboratory tests, and CT scans.

Failure of the procedure was documented in terms of the need for revision of ETV or other CSF diversion procedures (VP shunt or EVD). None of these mentioned complications was documented in any patient.

DISCUSSION

Infratentorial tumors is an umbrella term used to denote intracranial tumors originating within the region of the brain inferior to the tentorium cerebelli containing the cerebellum, fourth ventricle, cerebellopontine angle, brain stem, and related structures. These most commonly occurring tumors in this region include schwannoma, meningioma, hemangiopericytoma, epidermoid, cerebellar astrocytoma, ependymoma, medulloblastoma, haemangioblastoma, and metastasis.[2,12,13] According to the anatomical and age-wise distribution of brain tumors, 15 – 20% in adults while 54 – 70% in children occur in the posterior fossa.[12]

Hydrocephalus is a dreadful yet common complication. Regrettably, 70 – 90%[3] of infratentorial tumors present with obstructive hydrocephalus which requires at least an urgent, if not an emergent cerebrospinal fluid (CSF) diversion procedure. Unfortunately, its optimal management algorithm remains debatable. ETV has successfully replaced the VP shunt procedure as the first – line treatment of obstructive hydrocephalus, mainly because of being less invasive and still produces comparable efficacy. Three irrefutable benefits of ETV are freedom from foreign body implant, no abdominal complications, and an opportunity to perform a simultaneous biopsy in certain cases. But most of the studies are based on pediatric populations. In our study, the patient population had a broader age range with mostly adult patients.

A few common symptoms of hydrocephalus include headache, nausea, vomiting, gait disturbance, diplopia, drowsiness, seizures, and urinary incontinence.[12,13] We compared the changes in symptoms of headache, nausea/ vomiting, gait disturbance, seizures, and urinary incontinence for the assessment of improvement. We concluded in this study that monitoring of symptomatic changes is more reliable for early monitoring as compared to radiology, as controversy exists regarding the expected post-operative features, duration, and frequency of radiologic improvement. In our study, changes in symptomatology were found to be immediately reliable through a subjective criterion for the success of the procedure during the early postoperative period. However, it should be borne in mind that symptoms of hydrocephalus overlap with those of infratentorial tumors. Therefore, a complete resolution of symptoms without tumor excision should not be expected with ETV alone. Regarding symptomatic improvement, we found that seizures control was achieved in all the patients followed by improvement in headache, nausea/vomiting, urinary incontinence, and gait disturbance.

Radiologic improvement is quite delayed and incomplete rendering radiologic improvement criteria less practical during the early postoperative period. Sometimes the ventricular size may not show a remarkable reduction on imaging after ETV as compared to post-shunting. Usually, the extent of ventricular size reduction postoperatively is inversely proportional to the duration of hydrocephalus preoperatively.[10] Our study suggests that radiologic improvement becomes more evident after two weeks. However, complete resolution of radiological changes takes even longer or might never occur. The results of this study also support that ETVSS is a good practical predictor of the success of the procedure and correlates well with the risk of stoma failure, and a better KPS score suggests an overall better prognosis.

Chang H. et al have concluded in a meta-analysis that ETV and VPS have therapeutic equivalence for non-communicating

hydrocephalus, whereas ETV can result in lower surgery time, the incidence of postoperative complication, and reoperation rate of hydrocephalus.[14] (Jiang et al – 2018) concluded that ETV has greater benefits in terms of major complications, infection, reoperation, duration of surgery, and hospital stay than VPS for patients with non-communicating hydrocephalus.[15] Complication rate of ETV also relates to the learning curve of the surgeon. Regarding complications of ETV, no case of any of the common intra-operative or post-operative complications was reported in our study, establishing the safety of ETV. All the results of this study are comparable to previous studies mentioned in references. A well-deserved credit should be given to proper patient selection, optimally equipped neuroendoscopic center, and surgical expertise. On the other hand, this might be, in part, due to the smaller sample size and a shorter follow-up period. Therefore, further studies with a bigger sample size, broader patient selection criterion, and a longer follow-up period should be undertaken to further support the superiority of ETV or VPS in terms of efficacy and complications.

CONCLUSION

In a well-equipped neuroendoscopic center with a skillful team, ETV is a quick and safe method for CSF diversion in obstructive hydrocephalus alleviating the need for VP shunt hardware placement, thus avoiding foreign body-related cranio-abdominal complications. It is strongly endorsed that amid the turmoil of tumor excision surgery and radiotherapy, a successful ETV may offer a chance to cherish a VP shunt-free life to the already stressed patients suffering from infratentorial tumors. Every patient with obstructive hydrocephalus deserves a chance to live a shunt-free life.

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Additional Information

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Human Subjects: Consent was obtained by the patient in this study.
Conflicts of Interest:
In compliance with the ICMJE uniform disclosure form, all authors declare the following:
Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Faiq Sheikh	1. Study Design and Methodology.
2.	Shehzad Safdar	2. Paper Writing and Data Calculations.
3.	Mubashir Malik	3. Data Collection and Calculations.
4.	Muhammad Abuzar Rauf	4. Analysis of Data and Interpretation of Results etc.
5.	Rabia Saleem	5. Literature Review and Referencing.