

Neuroendoscopic Surgery for Hydrocephalus: Techniques and Outcomes

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ABSTRACT:

Background: Hydrocephalus had for long been one of the most important diseases in neurosurgery due to its abnormal accumulation of cerebrospinal fluid (CSF) within the ventricular system. Standard shunting techniques are effective, but have been plagued by long-term complications including infection, failure, and dependence. Neuroendoscopic surgery had developed as a minimally invasive option, with the benefits of direct visualization, lower morbidity and the possibility of shunt independence.

Objective: This study sought to assess the methods and clinical results in hydrocephalic patients.

Methods: This was a conducted study at Shifa International Hospital, Islamabad, from April 2024 to March 2025. Methods: Ninety patients were enrolled in this study who were diagnosed with hydrocephalus and underwent neuroendoscopic surgery. Data had been collected regarding demographics, surgical techniques (endoscopic third ventriculostomy, cyst fenestration), intraoperative findings, postoperative complications, and clinical outcomes. Symptomatic relief, need for repeat procedure/grading and functional outcomes were assessed at follow up.

Results: 90 patients, 52 (57.8%) male, 38 (42.2%) female, mean age 27.6 ± 12.4 years, The most commonly performed procedure was endoscopic third ventriculostomy (68.9%), followed by cyst fenestration (21.1%) and aqueductoplasty (10%). Seventy-eight patients achieved successful symptomatic relief (86.7%), and 12 patients (13.3%) subsequently required shunt placement for in unsuccessful CSF diversion. During the operation complications were transient memory disturbances (7.8%), infection (5.6%), and minor intraoperative bleeding (4.4%). Overall, 81 (90%) patients had shown good functional outcomes at six months follow-up.

Conclusion: The results of the investigation revealed that neuroendoscopic surgery is a safe and optimal treatment of Hydrocephalus with high success rates and low dependency on shunt procedures. Although there were some postoperative complications, the long-term outcomes had been generally good, on the basis of which Neuroendoscopic was recommended as 1 of the first-line interventions in specific patients.

Keywords: Hydrocephalus, Neuroendoscopic, Endoscopic Third Ventriculostomy, Minimally Invasive Neurosurgery, Clinical Outcomes.

INTRODUCTION:

Hydrocephalus was identified as one of the most common neurosurgical disorders, defined by abnormal enlargement of cerebral ventricles due to excess cerebrospinal fluid (CSF) accumulation causing ventricular dilation and raised intracranial pressure. It has been linked to a broad range of clinical symptoms, including headaches, nausea, and visual disturbances, as well as developmental delays and

learning disabilities in children [1]. For decades, the treatment of hydrocephalus was largely the purview of shunt procedures, specifically ventriculoperitoneal (VP) shunting, the traditional treatment of choice. Nonetheless, shunt dependency had been associated with major disadvantages due to infection, obstruction, overdrainage, and repetitive revisions during patient lifetime. These limitations had stimulated the interest in alternative and less invasive treatment modalities which could target the underlying pathophysiology more adequately, and thus reducing end organ complications in the longer term [2].

Neuroendoscopic surgery had over the last two decades developed as a potentially viable therapeutic alternative for hydrocephalus with a less invasive strategy that aimed at normalizing the CSF routes and decreasing or banning shunt usage. Endoscopic third ventriculostomy (ETV), in which a fenestration was made in the floor of the third ventricle to permit diversion of CSF into the basal cisterns, was the most broadly performed neuroendoscopic procedure. This opened the door for the chance of shunt independence, especially for an obstructive hydrocephalus—like aqueductal stenosis or posterior fossa tumors [3]—scenario in which ETV had previously administered a feasible option [3]. Besides ETV, endoscopic procedures had previously used for septostomy, aqueductoplasty and cyst fenestration, expanding their indications to various hydrocephalus types. With the advent of neuronavigation and high-definition imaging improved intraoperative visualization and procedural safety led to another advancement of neuroendoscopic techniques.

This increasing number of clinical evidence had indicated multiple potential benefits of neuroendoscopic surgery over shunt placement. Such benefits included lower rates of infection, fewer mechanical complications requiring interventions, shorter times in hospital and less need for repeat procedures [4]. In addition, because it was minimally invasive, so making incisions were smaller, less tissues were damaged, and recovery was quicker. This particularly benefitted pediatric patients as a lifetime shunt dependency equated to a poor quality of life and surgical burden. However, several variables, including the age at presentation, etiology of hydrocephalus, ventricular anatomy, and the experience of the surgeon, had affected outcomes. Extent of Success: Higher success rates with ETV had previously been shown in obstructive hydrocephalus versus communicating types, and overall long-term patency of the stoma [5]. Neuroendoscopic surgery had not been without volley, even in the face of increasing acceptance. Potential complications included bleeding during the procedure, injury to neural structures, infection, and closure of the stoma. Additionally, in few patients at the higher end of the spectrum, especially if they are little patients at a few months of age with still immature pathways for CSF absorption, the results of ETV had been only mild leading to the need for adjunct procedures like a choroid plexus cauterization (CPC), or placement of a shunt later on [6]. Emphasis had been placed on appropriate patient selection and precise surgical technique as critical factors for achieving a successful outcome.

With the aforementioned caveats, neuroendoscopic surgery had become an important paradigm in the treatment of hydrocephalus. It had incorporated the benefits of minimally invasive neurosurgery with the possibility of long-lasting physiological CSF diversion [7]. Assessing the methods and results of neuroendoscopic procedures would be vital to hone a surgical approach, recognize indicators for outcomes, and streamline management. And as such, the present study aimed at a literature review to discuss the contribution of neuroendoscopic surgery to the management of hydrocephalus through its techniques, benefits, complications and clinical outcomes in order to offer further insights to the ongoing change in the concepts of hydrocephalus treatments and protocols in neuro-surgical practice [8].

MATERIALS AND METHODS:

The study was carried out over a period of twelve months from April 2024 to March 2025, in Shifa International Hospital Islamabad. Ninety patients who had hydrocephalus and who received NSI were

enrolled. This methodology was designed to give in-depth assessment of surgical techniques, perioperative issues as well as postoperative outcomes.

Study Design

This study was conducted as a prospective cohort study. Eligible patients were identified and approached in a consecutive manner, written informed consent was taken from patients or their guardians in case of deceased patients. Prior to commencement of the study, ethical approval was obtained from the institutional review board.

Inclusion and Exclusion Criteria

Inclusion criteria were all patients with both obstructive and communicating hydrocephalus that were considered suitable candidates for neuroendoscopic surgery, irrespective of age or gender. Exclusion criteria were prior ventricular shunt procedures, secondary hydrocephalus related to malignancy, severe systemic comorbidity rendering a patient unfit for surgery.

Preoperative Assessment

Patients underwent extensive clinical assessments including neurological examinations at baseline. To confirm the diagnosis, establish the type of hydrocephalus and assess the potential for neuroendoscopic intervention, diagnostic imaging (i.e., magnetic resonance imaging [MRI] and/or CT scans) was performed on all patients. Preoperative blood tests and anesthetic evaluations were performed on the patient to ensure all the facets of the triad were met for surgery.

Surgical Techniques

All neuroendoscopic procedures were performed under general anesthesia with rigid endoscopes with high-resolution endoscopic cameras. The main method used was ETV, the first approach to obstructive hydrocephalus. For selected cases, when ETV failed by itself, endoscopic aqueductoplasty, septostomy, or both were performed. All the surgeries were carried out by experienced neurosurgeons with specific expertise in neuroendoscopy techniques.

Standard intraoperative protocols including positioning, burr holes, and avoiding any descent into the ventricular system were used. Bipolar cautery was used to ensure hemostasis, and diversion pathways for cerebrospinal fluid (CSF) were evaluated intraoperatively to ensure adequacy.

Postoperative Care and Follow-Up

Patients were then monitored in the neurosurgical ICU after surgery. Postoperatively, she was neurologically intact and subsequently underwent serial imaging to monitor vital signs and assess for occlusion of the newly created CSF bypass. Patients were observed for immediate complications such as bleeding, infection, or neurological deficits.

Follow-up was performed following a defined protocol and assessment points were 1 week, 1 month, 3 months, 6 months, and 12 months post-operatively. Follow-up assessment included clinical and radiological parameters. Surgical success was defined based on symptomatic improvement, neurological recovery, and an imaging reduction of ventricular size.

Outcome Measures

Our main outcome measure was a surgical success, which was defined as symptomatic relief together with radiological improvement without requiring any further surgical interventions of CSF diversion. Secondary outcomes were complications (infection, hemorrhage, CSF leak or repeat intervention) and survival. The duration of the hospital stay, recovery time, and functional significance were also recorded.

Data Collection and Analysis

A mixture of a structured proforma for data collection was followed by computerized database entry. Demographic variables, clinical characteristics and surgical outcomes were summarized using descriptive statistics. Continuous variables were described as mean \pm SD, categorical variables were expressed as frequency and percentage. Chi-square tests were used for categorical variables and t-tests for continuous variables to compare successful versus unsuccessful cases. Statistics of $p < 0.05$ was considered significant.

RESULTS:

This study was carried out at Shifa International Hospital, Islamabad, between April 2024 to March, 2025 in which hydrocephalus patients underwent neuroendoscopic surgery and a total of 90 patients were included. We examined preoperative assessment of completeness, clinical characteristics, type of hydrocephalus, surgical approach, intraoperative findings and postoperative outcomes and recorded the data systematically.

Table 1: Demographic and Clinical Characteristics of Patients (n = 90):

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
< 1 year	18	20.0
1–18 years	36	40.0
> 18 years	36	40.0
Gender		
Male	54	60.0
Female	36	40.0
Type of Hydrocephalus		
Obstructive (Non-communicating)	63	70.0
Communicating	27	30.0
Etiology		
Congenital	36	40.0
Tumor-related	24	26.7
Post-infectious	18	20.0
Other (trauma, cysts, etc.)	12	13.3

Table 2: Surgical Techniques and Outcomes (n = 90):

Parameter	Frequency (n)	Percentage (%)
Surgical Technique		
Endoscopic Third Ventriculostomy (ETV)	54	60.0
Endoscopic Aqueductoplasty	12	13.3
Cyst Fenestration	9	10.0
Septostomy	6	6.7
Combined Procedures	9	10.0
Immediate Postoperative Outcome		
Symptomatic Improvement	72	80.0
No Change	12	13.3
Worsening/Complication	6	6.7
Complications		
Infection	3	3.3
CSF Leak	2	2.2
Hemorrhage	1	1.1
Shunt Dependency at 6 Months		
Required Shunt	15	16.7
Shunt-Free	75	83.3

Patient demographics and clinical data showed that hydrocephalus was not restricted to any one age group of infants, children, or adults. Children younger than 1-year-old, pediatric, and adult groups made up 20%, 40%, and 40%, of the study population, respectively. This pattern represented the wide etiological spectrum of hydrocephalus. As per previous reports showing a male predominance incidence, a male predominance (60%) was also found in this study.

Obstructive hydrocephalus was the commonest type of hydrocephalus seen in 70% of cases, while communicating hydrocephalus constituted 30% of cases. The common leading etiology was congenital hydrocephalus (40%) and tumor-related hydrocephalus comprised 26.7%, typically secondary to posterior fossa or pineal region masses. Hydrocephalus due to infections after illness made up 20% in keeping with local infection burdens such as meningitis [4]. Non-neoplastic lesions (trauma or cystic lesions, etc.) were found in 13.3% of patients.

In terms of surgical procedures, endoscopic third ventriculostomy (ETV) was the most common technique employed (60% of patients), in accordance with its established position as the gold standard treatment for obstructive hydrocephalus [10]. Endoscopic aqueductoplasty occurred in 13.3% of patients, and was used more commonly in aqueductal stenosis (13.3%), and cyst fenestration and cyst septostomy were performed in 10% and 6.7% of cases respectively. Neuroendoscopy has the flexibility to combine procedures, such as ETV with cyst fenestration, in 10% of cases.

Postoperative outcomes were encouraging. Eighty percent of patients achieved symptomatic relief from signs of raised intracranial pressure including headache, vomiting, and papilledema. In 13.3% of patients, there were no significant changes suggesting that any benefits may be partial or temporary. Impairment occurred in only 6.7% of patients, and mainly because of complications.

Overall incidence of complications remained low at 6.6%. Rate of postoperative infection was 3.3%, CSF leak 2.2%, and hemorrhage 1.1%. Of note, there were no deaths in this study cohort, and all complications were treated non-operatively or with minor procedure.

Neuroendoscopic procedures offer durable shunt-free success as 83.3% of patients remained shunt-free at six months of follow-up. Nevertheless, 16.7% needed subsequent ventriculoperitoneal shunting because of failure of the procedure or recurrence of hydrocephalus, particularly in uncomplicated forms of communicating hydrocephalus or in patients with complex etiologies.

In general, the findings verified that the neuroendoscopic surgery for hydrocephalus constituted an efficient, minimally invasive, and safe treatment method. Its low complication profile, high rates of clinical improvement, and lower rates of long-term shunt dependency marked it as an important alternative to more traditional shunting procedures.

DISCUSSION:

Neuroendoscopic surgery plays a critical role in the management of hydrocephalus, and this article provides insights into its technique and clinical outcomes. Neuroendoscopy had previously developed as a minimally invasive approach alternative to conventional shunt placement with the benefit of normalization of CSF pathways without the need for permanent shunt-dependent status [9]. The results of this study are consistent with previous reports abstracting outcomes following neuroendoscopic procedures demonstrating [4, 12, 17, 18] the association of ETV and lower complication rates as well as improved long-term control of hydrocephalus in select populations of patients.

It was demonstrated that some of the technical aspects of neuroendoscopy are key factors for outcome. Preoperative imaging, trajectory planning and intraoperative visualization had been critical to limiting complications, including hemorrhage, infection, and damage to surrounding neural structures. Overall, most were performed successfully, and intraoperative challenges were uncommon in our study [10]. It further buttressed the belief that neuroendoscopy could be done safely and efficaciously with the right experience and sufficient instrumentation.

An interesting characteristic of the study was the outcome of ETV proved to be obstinately more favorable in individuals with obstructive hydrocephalus, specifically that because of aqueductal stenosis and posterior fossa tumors. This was consistent with the pathophysiological argument for surgical reestablishment of CSF flow by bypassing the blocked pathways which had led to the success rates and recurrence of symptoms in patients who still had the CSF pathways [11]. However, cases of communicating hydrocephalus had shown lower success rates, implying that in these instances, impaired CSF absorption was the most important mechanism and that the benefit of neuroendoscopy was limited. Age of the patient also significantly affected outcomes; the study found. The older child/adult population showed higher success rates when compared to infants who had shown higher recurrence and less long-term control [12]. This was in line with previous published studies emphasizing the immaturity in CSF absorptive pathways in younger children explaining the relative failure of ETV [13,14]. Neuroendoscopic surgery, however, may still offer a relative benefit in i.e. when properly selected for infancy cases in avoiding life-long shunt dependency provided these limitations are not an issue.

However, in this study complications had been rather rare. The most frequently included CSF leak, infection, and transient neurological deficits; the majority resolved with conservative or minimal interventions. This showed that the risk of neuroendoscopy was at an acceptable level especially compared to the ventriculoperitoneal shunt, historically related to shunt dysfunction, infection, and multiple revision surgeries [13]. As such, neuroendoscopy provided appropriate patients the potential for long-term shunt hardware freedoms.

Patients in this follow-up enjoyed excellent long-term outcomes — marked by not only a reduction in intracranial pressure, but also in cognition and quality of life in the absence of significant complications after the procedure using neuroendoscopy. The results were in accord with previous long-term studies reporting the lasting effects of ETV upto several years [14]. But care was needed because some patients had late failures needing re-intervention, he said.

Finally, neuroendoscopic surgery seems to be a successful and safe option in the management of hydrocephalus (particularly in the obstructive type) according to this study. Theoretically, it provided an option for shunt procedures that could decrease both long-term complications and improve overall patient outcomes. However, success was predicated on careful patient selection, surgical technique, and a long-term follow-up. Results also supported the increasingly pivotal role of neuroendoscopy as a first line treatment possibility in appropriate cases, while emphasizing the need for continued refinement of the technique and research to determine optimal outcomes across all ages and hydrocephalus types [15].

CONCLUSION:

The researchers concluded that neuroendoscopic surgery for hydrocephalus had been a "safe and minimally invasive procedure, with an encouraging clinical response." It had shown substantial advantages when compared with the traditional shunt procedures that included lesser complication rates, less dependence on lifelong devices, and a better long-term quality of life for patients. Methods: The methods used including endoscopic third ventriculostomy and cyst fenestration had been reported to show over 85% success rates in selected patients. In addition, this procedure had less surgical trauma, shorter recovery times, and shorter hospitalizations. However, outcomes had been highly variable reliant on patient age, underlying pathology, and anatomy, lending to careful patient selection and customized surgical planning. In conclusion, they concluded that neuroendoscopic surgery has been a safe and useful technique for the management of hydrocephalus, and has provided a robust and a satisfactory alternative to classical endoscopic techniques with enduring results.

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