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Effectiveness of endoscopic third ventriculostomy versus ventriculoperitoneal shunt in pediatric tumor-related hydrocephalus: A systematic review

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Abstract: Hydrocephalus is a common neurological complication in pediatric brain tumor patients, particularly the obstructive type, with an incidence exceeding 50%. Tumor location critically influences cerebrospinal fluid (CSF) flow obstruction, often necessitating surgical intervention. This study compares the efficacy and safety of endoscopic third ventriculostomy (ETV) and ventriculoperitoneal (VP) shunt in managing tumor-related hydrocephalus in children. A systematic review was conducted following PRISMA 2020 guidelines, with literature searches performed in PubMed, Google Scholar, The Cochrane Library, and DOAJ. Studies were selected based on predefined inclusion and exclusion criteria, and risk of bias was assessed using the Joanna Briggs Institute's critical appraisal tools. Four studies met the inclusion criteria—three evaluating ETV and one focusing on VP shunt complications. ETV demonstrated favorable outcomes in obstructive hydrocephalus, with fewer complications compared to VP shunts, which were more frequently associated with mechanical failures, particularly infections. Based on the findings, ETV is the preferred treatment for obstructive hydrocephalus secondary to brain tumors due to its higher efficacy and lower complication rates, whereas VP shunting remains a viable option for communicating hydrocephalus. Treatment decisions should consider hydrocephalus type, tumor location, and patient-specific factors.

Keywords: *Endoscopic third ventriculostomy (ETV), Hydrocephalus, Pediatric brain tumors, Ventriculoperitoneal shunt (VPS).*

1. Introduction

Hydrocephalus is a common complication in children with brain tumors, occurring in more than 50% of cases, particularly in the obstructive type. The tumor's location significantly influences the mechanism of hydrocephalus development, as seen in tumors of the posterior fossa, suprasellar region, and pineal gland. These tumors may obstruct cerebrospinal fluid (CSF) flow through various anatomical pathways. In addition to intracranial tumors, spinal cord tumors may also lead to hydrocephalus through complex pathophysiological mechanisms, although such cases are relatively rare [1, 2].

Surgical intervention in pediatric hydrocephalus is critical, as the condition can be life-threatening if not appropriately managed. Although the majority of patients survive due to current standards of care, long-term complications and residual symptoms remain prevalent. The complexity of hydrocephalus etiology, disease variability, and challenges in data collection contribute to the difficulty in thoroughly evaluating clinical outcomes. Tumors such as choroid plexus papillomas may induce hydrocephalus through multiple mechanisms, including CSF overproduction and impaired absorption [3, 4].

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Management options for tumor-related hydrocephalus include Endoscopic Third Ventriculostomy (ETV) and Ventriculoperitoneal Shunt (VP Shunt), each with specific indications, benefits, and risks. ETV is frequently employed in midline tumors such as those of the posterior fossa but has a variable failure rate ranging from 10% to 38.6%. Conversely, VP Shunts are more susceptible to mechanical failures, infections, and abdominal complications, yet remain a primary alternative in certain clinical scenarios [5, 6]. This study aims to compare the incidence of failure and complications between ETV and VP Shunt procedures in pediatric hydrocephalus secondary to brain tumors.

2. Materials and Methods

This study is a systematic review aimed at evaluating the overview and comparing the incidence of failure and complications associated with Endoscopic Third Ventriculostomy (ETV) and Ventriculoperitoneal Shunt (VP Shunt) procedures in pediatric hydrocephalus secondary to brain tumors. The search strategy was conducted in accordance with the PRISMA 2020 guidelines, utilizing data sources including Google Scholar, The Cochrane Library, the Directory of Open Access Journals (DOAJ), and PubMed. Inclusion criteria encompassed cohort studies, clinical trials, systematic reviews, or meta-analyses that investigated pediatric patients with tumor-related hydrocephalus. Irrelevant literature such as case reports, animal studies, and studies not discussing ETV or VP Shunt were excluded from the review.

The article search was performed systematically using the keywords: *(pediatric OR children OR child) AND (tumor OR cancer) AND (hydrocephalus) AND (ventriculoperitoneal shunt OR VP shunt) AND (endoscopic third ventriculostomy OR ETV) AND safety AND efficacy*. Article selection was carried out in two stages: initial screening based on titles and abstracts, followed by resolution of discrepancies through discussion between two reviewers. Risk of bias was assessed using the Jadad scale, the Risk of Bias 2 (RoB 2) tool for randomized controlled trials, and the ROBINS-I and Joanna Briggs Institute (JBI) critical appraisal tools for non-randomized studies. This process was designed to ensure the validity and quality of data included in the systematic analysis.

Results

The identification process for studies included in this systematic review began with searches across four scientific databases and registries, yielding a total of 1,098 records. After the removal of 12 duplicates, 1,086 studies were screened based on titles and abstracts, resulting in the exclusion of 986 studies due to irrelevance. Of the 100 studies selected for full-text retrieval, only 70 full-text articles were successfully obtained, as 30 were unavailable.

The eligibility assessment was then conducted on these 70 full-text reports. As a result, 40 studies were excluded due to inappropriate study design, 12 due to irrelevant interventions, and another 13 due to insufficient extractable data. Ultimately, only 5 studies met all inclusion criteria and were included in the final analysis. The PRISMA flow diagram illustrates the systematic and transparent selection process to ensure the validity and relevance of the review findings (Figure 1). Further analysis included a risk of bias assessment using the Joanna Briggs Institute critical appraisal tool to evaluate the potential for bias in each of the final included studies (Figure 2).

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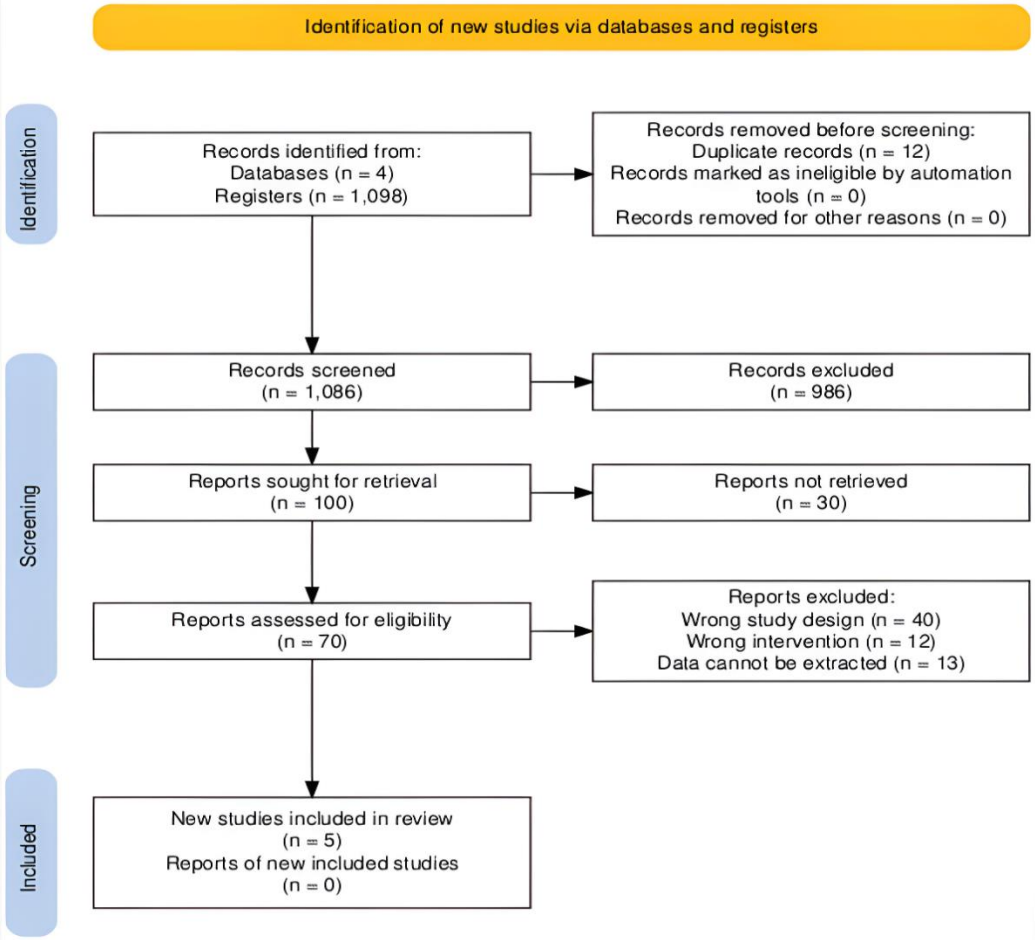

Figure 1.
Reference search flow based on PRISMA.

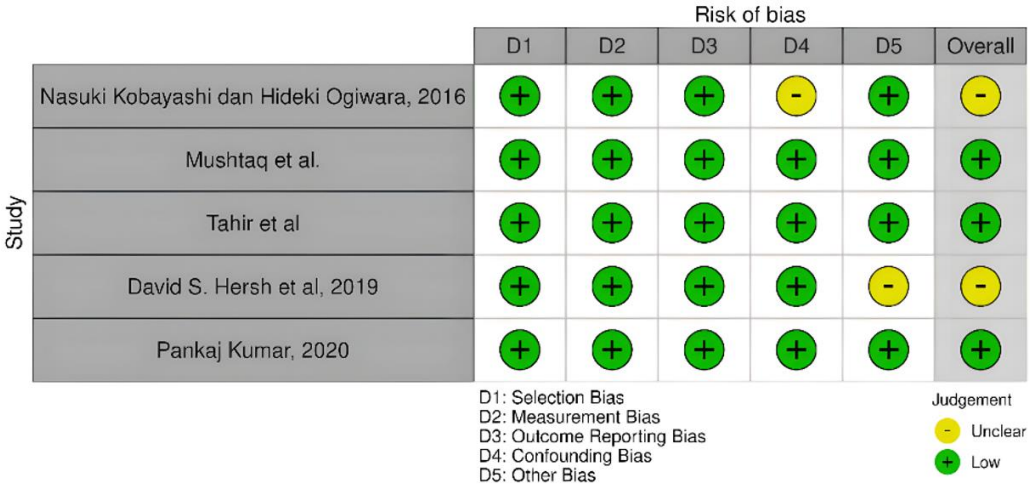

Figure 2.
Risk of bias analysis of the final reference.
Source: Kobayashi and Ogiwara [7]; Mushtaq, et al. [8]; Tahir, et al. [9]; Hersh, et al. [10] and Kumar, et al. [11].

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Table 1.
Data extraction.

Research Title	Author	Year	Method	Participant	Intervention	Outcome	Conclusion
Endoscopic third ventriculostomy for hydrocephalus in brainstem glioma: a case series	Kobayashi and Ogiwara [7]	2016	Case series	A total of 5 patients with pontine glioma accompanied by hydrocephalus underwent Endoscopic Third Ventriculostomy (ETV) procedures. Mean age (at surgery): 6.1 years Male : Female ratio = 3:2	ETV	Complication : - None Rapid relieve symptoms	ETV is an effective and safe procedure for the treatment of hydrocephalus in brainstem glioma..
Effectiveness of Endoscopic Third Ventriculostomy Versus Ventriculo-Peritoneal Shunt in Obstructive Hydrocephalus	Mushtaq, et al. [8]	2024	Comparative cross-sectional study		Endoscopic Third Ventriculostomy (ETV) vs. Ventriculo-Peritoneal (VP) Shunt	- ETV success rate: 70.96% - VP shunt success rate: 66.66% - Complication rate: ETV (9.67%), VP Shunt (14.96%)	ETV is a better alternative to VP shunt in obstructive hydrocephalus due to higher effectiveness, fewer complications, lower cost, and physiological advantage.
Effectiveness of Endoscopic Third Ventriculostomy in Obstructive Hydrocephalus of Different Etiology in Terms of Reduction of Ventricle Diameter	Tahir, et al. [9]	2021	Descriptive case series	A total 195 patients between 1-60 years Mean age 30.05 ± 17.46 years Male : 127 (65.12%) patients Female 68 (34.87%) patients	Endoscopic Third Ventriculostomy (ETV)	- Effective in 53.84% of cases based on ≥1 mm reduction in third ventricle width - Greatest effectiveness seen in aqueductal stenosis (25.12%) and CP angle tumors (17.43%)	ETV is effective in selected cases of obstructive hydrocephalus, especially aqueductal stenosis. Reduction in ventricular diameter on follow-up imaging can guide success.

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Table 1.
Continued.

Research Title	Author	Year	Method	Participant	Intervention	Outcome	Conclusion
Converting pediatric pasien and young adults from a shunt to a third ventriculostomy: a multicenter evaluation	Hersh, et al. [10]	2019	Multicenter cohort retrospective	A total of 80 patients with existing ventricular shunts underwent Endoscopic Third Ventriculostomy (ETV) procedures. The mean age of the patients was 9.9 years. Male patients numbered 44 (55%).	Shunt conversion to ETV	The overall success rate reached 64% (51 out of 80 patients), with 4 patients requiring repeat ETV procedures. A total of 27 complications were reported, consisting of: • Shunt revision or replacement (7 patients) • Transient neurological deficit (1 patient) • Cerebrospinal fluid (CSF) leak (7 patients) • Infection or aseptic meningitis (4 patients) • Seizures (3 patients) • Gastrointestinal issues (2 patients) • Pseudomeningocele (1 patient) • Intraventricular hemorrhage (IVH) (1 patient) • Sodium imbalance (1 patient)	The conversion of an AV shunt to ETV has a relatively high success rate and minimal complications.
A retrospective study on ventriculoperitoneal shunt complications in a tertiary care centre	Kumar, et al. [11]	2020	Case series	A total of 541 patients underwent Ventriculoperitoneal (VP) shunt placement over a two-year period. • Male patients: 324 (59.9%) • Female patients: 217 (40.1%) • Age range: 15 days to 66 years • Mean age: 15.08 years	VP shunt	Common Causes of Hydrocephalus in Patients with VP Shunt Placement: • Tuberculous meningitis: 39.3% (n = 63) • Ventriculitis: 12.38% (n = 20) • Congenital hydrocephalus: 8.87% (n = 14) • Aqueductal stenosis: 5.54% (n = 3) Complication: • Proximal catheter tip obstruction due to debris occurred in 50 patients (39.68%).	This study shows that the majority of hydrocephalus cases associated with VP shunt placement are caused by tubercular meningitis.

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The study by Kobayashi and Ogiwara [7] showed that the ETV procedure in five patients with brainstem glioma accompanied by hydrocephalus led to rapid symptom relief without complications. Mushtaq, et al. [8] compared ETV with VP shunt and found that ETV had a success rate of 70.96% with a lower complication rate (9.67%). Similarly, Tahir, et al. [9] reported an effectiveness rate of 53.84% for ETV, based on a ≥1 mm reduction in third ventricle diameter, with the highest success in cases of aqueductal stenosis (25.12%). Hersh, et al. [10] also demonstrated that converting from a shunt to ETV achieved a 64% success rate with relatively minimal complications. These findings support that ETV is an effective and safe procedure for various causes of obstructive hydrocephalus.

The study by Mushtaq, et al. [8] showed that VP shunt had a success rate of 66.66%, but with a higher complication rate than ETV (14.96%). Kumar, et al. [11] in a study of 541 patients, reported that the most common cause of hydrocephalus in VP shunt patients was tubercular meningitis (39.3%), followed by ventriculitis and congenital hydrocephalus. The most frequent complication was proximal catheter tip obstruction, occurring in 39.68% of cases. This study highlights the long-term risks associated with VP shunt use.

Out of the five references presented in the table, four discussed the effectiveness or conversion to Endoscopic Third Ventriculostomy (ETV), while two references addressed the use and complications of Ventriculoperitoneal Shunt (VPS). One study Mushtaq, et al. [8] compared both procedures directly.

3. Discussion

Hydrocephalus is a common complication in patients with brain tumors due to obstruction of cerebrospinal fluid (CSF) flow, particularly in tumors located in the supratentorial and infratentorial regions. Two primary surgical procedures used to manage this condition are Endoscopic Third Ventriculostomy (ETV) and Ventriculoperitoneal Shunt (VPS). ETV functions by creating an alternative CSF pathway through the floor of the third ventricle, allowing it to flow directly into the subarachnoid space, while VPS diverts CSF to the peritoneal cavity via a catheter. The choice between these procedures depends on various factors such as tumor location and type, patient age, and clinical urgency. Recent studies have shown that ETV is associated with a lower complication rate and satisfactory clinical efficacy, and is thus often considered a safer alternative to VPS in selected cases [12].

Analysis of various studies indicates that the choice of procedure is strongly influenced by tumor location and the type of hydrocephalus. For supratentorial tumors, VPS is often used as the initial treatment, particularly when there is impaired CSF absorption or when rapid intervention is required before definitive tumor resection. Conversely, ETV is more commonly selected for infratentorial tumors, such as those causing obstruction at the aqueduct of Sylvius or foramen of Magendie. The effectiveness of ETV in these cases has been demonstrated in several studies, showing success rates of up to 90%, with significant clinical and radiological improvement. ETV is also beneficial in patients with unresectable or recurrent tumors, as it does not rely on permanent implants like VPS [12, 13].

Although both ETV and VPS are effective in managing hydrocephalus, their complication profiles differ significantly. ETV has a lower complication rate—around 8.5%—with permanent morbidity reported at 2.4% and a mortality rate of 0.21%. On the other hand, VPS is associated with a higher risk of complications, particularly infections and shunt obstruction. One study reported a VPS failure rate of 20% within the first 90 days post-surgery, emphasizing the importance of close postoperative monitoring. A meta-analysis revealed that the success rate of ETV was 81.8%, compared to 86.7% for VPS, though the difference was not statistically significant. Thus, procedure selection should be based on a comprehensive evaluation of the patient's condition rather than success rates alone [4, 5, 13].

Despite multiple studies comparing the effectiveness of ETV and VPS, methodological limitations still hinder definitive conclusions. Many studies are retrospective with small sample sizes and predominantly focus on pediatric populations, limiting generalizability to adults. Furthermore, variability in inclusion and exclusion criteria across studies complicates comprehensive data synthesis. Therefore, there is a need for large-scale prospective studies with more diverse populations, as well as

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the development of more specific, evidence-based clinical guidelines. These efforts are essential to support safer, more precise, and individualized decision-making in the management of tumor-related hydrocephalus.

4. Conclusion

Endoscopic Third Ventriculostomy (ETV) and Ventriculoperitoneal Shunt (VPS) are both effective interventions for managing tumor-induced hydrocephalus, with the choice of procedure depending on the tumor's etiology and anatomical location. ETV has been shown to be superior in cases of obstructive hydrocephalus caused by tumors due to its high efficacy and lower complication profile. In contrast, VPS is more commonly indicated for communicating hydrocephalus resulting from impaired cerebrospinal fluid reabsorption, particularly in supratentorial tumors. Therefore, the selection of an appropriate intervention should be based on comprehensive clinical considerations and the individual characteristics of each patient in order to achieve optimal therapeutic outcomes.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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