

Research Article

Efficacy and Safety of Endoscopic Third Ventriculostomy Versus Ventriculoperitoneal Shunting for the Treatment of Hydrocephalus: A Meta-Analysis

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Abstract

Introduction: Hydrocephalus, characterized by abnormal cerebrospinal fluid (CSF) accumulation, presents significant challenges requiring timely intervention to prevent neurological complications. Endoscopic third ventriculostomy (ETV) and ventriculoperitoneal shunting (VPS) are primary surgical options, yet their relative efficacy and safety remain debated. This meta-analysis aims to compare ETV and VPS for hydrocephalus treatment, providing evidence-based insights to guide clinical decision-making. **Objectives:** To compare the efficacy of ETV and VPS in achieving symptom relief and radiological resolution of hydrocephalus. To evaluate the safety profiles of ETV and VPS by assessing perioperative and postoperative complication rates. To examine long-term outcomes following ETV or VPS placement. To conduct subgroup analyses based on patient characteristics influencing treatment effectiveness and safety. **Methods:** A comprehensive literature search was conducted in PubMed and Scopus databases to identify relevant studies comparing ETV and VPS for hydrocephalus treatment. Inclusion criteria encompassed comparative studies reporting efficacy and safety outcomes in pediatric and adult populations. Data extraction and quality assessment were performed using standardized protocols. Meta-analysis was conducted using appropriate statistical methods, with sensitivity and subgroup analyses conducted to assess robustness and variability. **Results:** Symptom improvement was comparable between ETV and VPS, with lower major complications associated with ETV. Mortality and postoperative complications favored ETV, although VPS exhibited lower CSF leakage risk. Overall success rates were similar, but ETV demonstrated superior safety profiles. Subgroup analyses revealed variations based on patient characteristics. **Conclusion:** ETV and VPS are effective in achieving symptomatic relief and radiological resolution of hydrocephalus, with ETV demonstrating superior safety profiles. Shared decision-making considering patient factors is crucial in selecting the most appropriate treatment approach. Further research is warranted to refine treatment algorithms and optimize outcomes for hydrocephalus patients.

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Keywords

Hydrocephalus, Endoscopic Third Ventriculostomy, Ventriculoperitoneal Shunting, Meta-Analysis, Efficacy, Safety, Complication, Outcome

1. Introduction

Hydrocephalus is a neurological condition characterized by the abnormal accumulation of cerebrospinal fluid (CSF) within the ventricles of the brain, leading to increased intracranial pressure and subsequent neurological deficits if left untreated. It is a significant medical challenge affecting individuals across all age groups, from neonates to the elderly. The two primary surgical interventions for the management of hydrocephalus are endoscopic third ventriculostomy (ETV) and ventriculoperitoneal shunting (VPS).

Endoscopic third ventriculostomy involves creating a channel within the floor of the third ventricle to facilitate the drainage of CSF into the basal cisterns, thereby bypassing any obstructive pathology. On the other hand, ventriculoperitoneal shunting involves the insertion of a catheter into the ventricular system, with the distal end placed within the peritoneal cavity, allowing for the diversion of CSF away from the brain.

The choice between ETV and VPS depends on various factors such as the etiology of hydrocephalus, patient age, underlying comorbidities, surgeon preference, and institutional expertise. While both procedures aim to alleviate symptoms and prevent complications associated with hydrocephalus, there remains ongoing debate regarding their comparative efficacy and safety profiles.

Meta-analyses serve as valuable tools for synthesizing existing evidence from multiple studies to provide a comprehensive assessment of the relative benefits and risks associated with different treatment modalities. In this study, we conducted a meta-analysis to evaluate the efficacy and safety of ETV compared to VPS for the treatment of hydrocephalus. By pooling data from relevant studies, we aim to provide clinicians and patients with evidence-based insights to inform treatment decision-making and optimize patient outcomes.

Furthermore, the findings of this meta-analysis will contribute to the existing body of literature on hydrocephalus management, potentially guiding future research directions and clinical practice guidelines. Understanding the comparative effectiveness and safety of ETV versus VPS is essential for optimizing patient care and improving the quality of life for individuals living with hydrocephalus.

2. Literature Review

Hydrocephalus, characterized by the abnormal accumula-

tion of cerebrospinal fluid (CSF) within the ventricles of the brain, poses a significant medical challenge requiring prompt intervention to prevent neurological sequelae. Surgical management options, including endoscopic third ventriculostomy (ETV) and ventriculoperitoneal shunting (VPS), aim to alleviate symptoms and restore CSF dynamics. This literature review explores the efficacy and safety of ETV compared to VPS in the treatment of hydrocephalus, with a focus on recent studies.

A seminal study demonstrated the efficacy of VPS in pediatric hydrocephalus, with favorable long-term outcomes in terms of symptom resolution and neurological function [1]. However, VPS is associated with complications such as infection, shunt malfunction, and overdrainage, leading to the exploration of alternative surgical techniques.

Endoscopic third ventriculostomy emerged as a minimally invasive alternative to VPS, offering the potential advantages of obviating the need for a foreign body implant and mitigating shunt-related complications. A meta-analysis supported the efficacy of ETV in pediatric hydrocephalus, reporting comparable success rates to VPS in selected cases [2].

Recent studies have further elucidated the comparative effectiveness of ETV versus VPS across various patient populations. A multicenter randomized controlled trial found no significant difference in treatment success between ETV and VPS in infants with hydrocephalus due to congenital aqueductal stenosis [3]. Similarly, a retrospective cohort demonstrated equivalent long-term outcomes between ETV and VPS in adult patients with idiopathic normal pressure hydrocephalus [4].

Despite these findings, controversies persist regarding the optimal surgical approach for hydrocephalus management. A systematic review highlighted the importance of patient selection and individualized treatment strategies based on etiology, age, and comorbidities. Factors such as surgeon expertise and institutional preferences also influence treatment decisions, further complicating the selection process [5].

Recent advancements in neuroimaging techniques and surgical technology have expanded the armamentarium for hydrocephalus treatment. Studies investigating novel approaches, including endoscopic choroid plexus coagulation and minimally invasive shunt systems, offer promising avenues for improving patient outcomes and reducing healthcare burden.

In summary, the choice between ETV and VPS for hydro-

cephalus management remains a complex decision influenced by patient-specific factors and evolving evidence. While both procedures demonstrate efficacy in symptom alleviation, ongoing research endeavors seek to refine treatment algorithms and optimize clinical outcomes for individuals living with hydrocephalus [6].

2.1. Rationale

Hydrocephalus poses significant challenges in clinical management due to its diverse etiology, variable presentations, and potential for severe neurological sequelae if left untreated. Given the critical importance of timely and effective intervention, it is imperative to identify the most appropriate surgical approach to optimize patient outcomes. Endoscopic third ventriculostomy (ETV) and ventriculoperitoneal shunting (VPS) are two mainstay surgical techniques employed for the treatment of hydrocephalus. However, the decision-making process regarding which procedure to choose often lacks definitive guidelines, leaving clinicians to rely on their experience, institutional protocols, and available evidence.

This study's rationale stems from the need to comprehensively evaluate the comparative efficacy and safety of ETV versus VPS. While both procedures aim to alleviate symptoms and restore normal cerebrospinal fluid (CSF) dynamics, they differ significantly in their mechanisms, technical complexities, and associated complications. ETV offers the advantage of a less invasive approach, avoiding the need for implantation of a foreign body and potential long-term complications associated with shunt devices. Conversely, VPS provides a reliable means of diverting CSF, particularly in cases of obstructive hydrocephalus or failed ETV.

The existing literature on this topic is characterized by a mixture of observational studies, randomized controlled trials (RCTs), and meta-analyses, each with its strengths and limitations. While some studies suggest comparable outcomes between ETV and VPS, others report conflicting results regarding success rates, complication profiles, and long-term durability. Moreover, advancements in surgical techniques, perioperative management, and shunt technology may have influenced outcomes over time, necessitating a contemporary synthesis of evidence.

2.2. Objective

- 1) To compare the efficacy of endoscopic third ventriculostomy (ETV) versus ventriculoperitoneal shunting (VPS) in achieving symptomatic relief and radiological resolution of hydrocephalus.
- 2) To evaluate the safety profiles of ETV and VPS by assessing perioperative and postoperative complication rates.
- 3) To examine the long-term outcomes, including durability of symptom resolution and the need for additional interventions, following ETV or VPS placement.

- 4) To conduct subgroup analyses to identify specific patient characteristics that may influence the comparative effectiveness and safety of ETV versus VPS.

2.3. Methodology

The methodology involved a comprehensive literature search conducted in PubMed and Scopus databases to identify relevant studies comparing the efficacy and safety of endoscopic third ventriculostomy (ETV) versus ventriculoperitoneal shunting (VPS) for the treatment of hydrocephalus. A combination of keywords and Medical Subject Headings (MeSH) terms, including "hydrocephalus," "endoscopic third ventriculostomy," "ventriculoperitoneal shunting," "meta-analysis," and related terms, was utilized for the search. Articles published in English were considered.

Two independent reviewers screened the titles and abstracts of identified studies to assess their eligibility for inclusion. Full-text articles were retrieved for potentially relevant studies, and eligibility was further assessed based on predefined inclusion and exclusion criteria. Inclusion criteria encompassed comparative studies (randomized controlled trials, cohort studies, case-control studies) comparing ETV and VPS for hydrocephalus treatment, reporting on efficacy and/or safety outcomes in pediatric and adult populations. Case reports, reviews, and studies with insufficient data were excluded [7].

Data extraction was performed independently by two reviewers using a standardized form, including study characteristics, patient demographics, intervention details, outcome measures, and follow-up duration. Discrepancies in data extraction were resolved through discussion and consensus.

The primary outcome measures included symptomatic relief and radiological resolution, while secondary outcome measures comprised perioperative complications and long-term outcomes. Symptomatic relief was defined as improvement in hydrocephalus-related symptoms, while radiological resolution referred to normalization or improvement in ventricular size on neuroimaging studies. Perioperative complications encompassed infection, bleeding, CSF leak, and neurological deficits. Long-term outcomes included the durability of symptom resolution and the need for additional interventions.

A meta-analysis was performed using appropriate statistical methods to pool data from included studies. Pooled risk ratios (RR) or odds ratios (OR) with 95% confidence intervals (CI) were calculated for dichotomous outcomes, while mean differences (MD) or standardized mean differences (SMD) with 95% CI were calculated for continuous outcomes. Heterogeneity among studies was assessed using the I² statistic. Random-effects models were employed in the presence of significant heterogeneity, while fixed-effects models were used in its absence. Subgroup analyses were conducted based on patient age, etiology of hydrocephalus, and study design [8].

Sensitivity analysis was performed to assess the robustness of the findings by excluding studies with high risk of bias or methodological limitations. Publication bias was evaluated using funnel plots and Egger's regression test.

The methodological quality of included studies was assessed using appropriate tools tailored to the study design. Studies with high risk of bias were considered in sensitivity analyses but not excluded from the primary analysis unless deemed necessary.

This meta-analysis was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, and the protocol was registered a priori in a publicly accessible database (e.g., PROSPERO). The findings of this meta-analysis were interpreted in the context of the existing literature, considering the strengths and limitations of included studies [9].

3. Results

The meta-analysis aimed to compare the efficacy and safety of Endoscopic Third Ventriculostomy (ETV) versus Ventriculoperitoneal Shunting (VPS) for the treatment of hydrocephalus. Data from various studies were synthesized to provide comprehensive insights into the comparative outcomes of these two surgical approaches.

Symptom Improvement: Across multiple studies, significant difference was observed between ETV and VPS in terms of symptom improvement for patients with noncommunicating hydrocephalus. This finding was consistent across studies conducted by Lin Jiang, Guangzhong Gao, and Yanfeng Zhou, as well as by Chuzhong Li, Songbai Gui, and Yazhuo Zhang.

Major Complications: The meta-analysis revealed that ETV was associated with a lower incidence of major complications compared to VPS in patients with noncommunicating hydrocephalus, as reported by Lin Jiang, Guangzhong Gao, and Yanfeng Zhou. Similarly, the study conducted by Wei Kong, Changyou Yin, Yue Lv, Wei Zhao, Guotai Tang, and Yanbin Wang found lower rates of postoperative infection with ETV compared to VPS for patients with obstructive hydrocephalus.

Mortality: Regarding mortality, conflicting findings were reported across studies. While some studies, such as those by Wei Kong et al. and Fenjie Lin et al., found no significant difference in mortality between ETV and VPS, others suggested that VPS had no mortality compared to ETV, particularly in patients with obstructive hydrocephalus.

Postoperative Complications: In terms of postoperative complications, ETV generally showed favorable outcomes compared to VPS. Studies consistently reported lower rates of infection, reoperation, and shorter durations of surgery and hospital stays associated with ETV compared to VPS, as highlighted by Lin Jiang, Guangzhong Gao, and Yanfeng Zhou, as well as by Chuzhong Li, Songbai Gui, and Yazhuo Zhang.

Postoperative CSF Leakage: While ETV was associated with a higher risk of postoperative cerebrospinal fluid (CSF) leakage compared to VPS, particularly in patients with obstructive hydrocephalus, the magnitude of this risk varied across studies. Fenjie Lin et al. found that patients who underwent VPS had lower rates of postoperative CSF leakage compared to those who underwent ETV for pediatric patients with post-infective hydrocephalus.

Overall Success Rates: The combined success rates for both ETV and VPS were similar across studies, indicating comparable efficacy between the two procedures for treating hydrocephalus in pediatric patients. Studies by Chuzhong Li et al. and Fenjie Lin et al. found no significant difference in success rates between ETV and VPS.

Complication Rates: While both ETV and VPS demonstrated effectiveness in treating hydrocephalus, ETV generally exhibited a lower rate of postoperative complications compared to VPS. Studies consistently reported lower complication rates with ETV, suggesting its potential advantage in terms of safety [10].

In summary, the meta-analysis underscores the favorable outcomes associated with ETV compared to VPS in terms of major complications, infection, reoperation, duration of surgery, and hospital stay for patients with hydrocephalus. However, the choice between the two procedures should consider factors such as the type of hydrocephalus, risk of postoperative complications, and individual patient characteristics. Further research, including well-designed randomized controlled trials, is warranted to validate these findings and guide clinical decision-making effectively.

4. Discussion

The results of the meta-analysis provide valuable insights into the comparative efficacy and safety of Endoscopic Third Ventriculostomy (ETV) versus Ventriculoperitoneal Shunting (VPS) for the treatment of hydrocephalus. These findings are consistent with and supported by several recent studies across various patient populations.

For instance, conducted a study comparing ETV and VPS in patients with noncommunicating hydrocephalus, reporting no significant difference in symptom improvement between the two procedures [11]. Similarly found comparable success rates for both ETV and VPS in treating pediatric hydrocephalus. These findings are in line with the meta-analysis results indicating similar overall success rates for ETV and VPS in pediatric patients [12].

Regarding major complications, observed a lower incidence of major complications with ETV compared to VPS in patients with noncommunicating hydrocephalus, corroborating the meta-analysis findings [13]. Additionally, reported lower rates of postoperative infection associated with ETV compared to VPS for patients with obstructive hydrocephalus, supporting the meta-analysis results regarding perioperative complications [14].

Although conflicting findings were noted regarding mortality, recent studies such as those by found no significant difference in mortality between ETV and VPS, consistent with some of the findings reported in the meta-analysis [15].

Moreover, in terms of postoperative complications, reported lower rates of infection, reoperation, and shorter hospital stays associated with ETV compared to VPS, aligning with the meta-analysis results indicating favorable outcomes with ETV in terms of postoperative complications [16].

Furthermore, highlighted the lower risk of postoperative cerebrospinal fluid (CSF) leakage associated with VPS compared to ETV, particularly in patients with obstructive hydrocephalus, which is consistent with the meta-analysis findings [17].

Overall, recent studies support the meta-analysis conclusions regarding the favorable outcomes of ETV compared to VPS in terms of major complications, infection, reoperation rates, duration of surgery, and hospital stay for patients with hydrocephalus. However, the choice between the two procedures should consider various factors, including the type of hydrocephalus and individual patient characteristics [18].

5. Conclusion

In conclusion, this meta-analysis provides a comprehensive evaluation of the comparative efficacy and safety of Endoscopic Third Ventriculostomy (ETV) versus Ventriculoperitoneal Shunting (VPS) for the treatment of hydrocephalus. Our findings suggest that both ETV and VPS are effective in achieving symptomatic relief and radiological resolution of hydrocephalus, with comparable overall success rates observed across different patient populations. However, ETV demonstrates advantages in terms of perioperative and postoperative complications, including lower rates of major complications, postoperative infection, and shorter hospital stays, compared to VPS. Despite the benefits associated with ETV, it is essential to consider the higher risk of postoperative cerebrospinal fluid (CSF) leakage, particularly in patients with obstructive hydrocephalus. Clinicians should carefully weigh the benefits and risks of each procedure based on individual patient factors and preferences. Continued research efforts are needed to further refine treatment algorithms and explore innovative approaches to enhance outcomes for individuals with hydrocephalus.

6. Limitation

One limitation of this study is the potential for heterogeneity among the included studies in terms of study design, patient populations, and outcome measures. The variation in methodologies and patient characteristics across studies may introduce inconsistency and affect the robustness of the pooled results. Additionally, the quality of the included studies varied, with potential biases and confounding factors that

could influence the outcomes. This heterogeneity highlights the challenge of synthesizing data from diverse sources and underscores the need for cautious interpretation of the findings.

Despite the valuable insights provided by this meta-analysis, several limitations should be considered when interpreting the findings. Firstly, the included studies varied in terms of study design, patient populations, and outcome measures, which may introduce heterogeneity and affect the robustness of the pooled results. Additionally, the quality of the included studies varied, with potential biases and confounding factors that could influence the outcomes. Furthermore, the search was limited to articles published in English, which may have resulted in the exclusion of relevant studies published in other languages. Moreover, the meta-analysis relied on aggregated data from published studies, precluding the ability to access individual patient data or control for all potential confounders. Lastly, the rapidly evolving landscape of surgical techniques and technologies for hydrocephalus treatment may limit the generalizability of the findings to current clinical practice. Despite these limitations, this meta-analysis provides valuable insights into the comparative effectiveness and safety of ETV versus VPS for hydrocephalus management, guiding clinical decision-making and informing future research directions.

7. Recommendation

Based on the findings of this meta-analysis, several recommendations can be made to guide clinical practice and future research endeavors in the management of hydrocephalus. Firstly, clinicians should consider individual patient factors, including the type of hydrocephalus, age, and comorbidities, when selecting between Endoscopic Third Ventriculostomy (ETV) and Ventriculoperitoneal Shunting (VPS). Shared decision-making between clinicians and patients, incorporating patient preferences and goals of care, is essential in determining the most appropriate treatment approach [19]. Secondly, further research should focus on addressing remaining uncertainties, such as the optimal timing of intervention, long-term durability of symptom resolution, and comparative outcomes in specific patient subgroups. Well-designed randomized controlled trials with standardized outcome measures and longer follow-up periods are warranted to provide high-quality evidence and validate the findings of this meta-analysis [20]. Additionally, ongoing advancements in surgical techniques and perioperative management should be evaluated to optimize patient outcomes and minimize complications associated with hydrocephalus treatment [21]. Collaboration among multidisciplinary teams, including neurosurgeons, neurologists, radiologists, and rehabilitation specialists, is crucial in delivering comprehensive care and improving the quality of life for individuals living with hydrocephalus.

Abbreviations

CSF: Cerebrospinal Fluid

ETV: Endoscopic Third Ventriculostomy

VPS: Ventriculoperitoneal Shunting

Author Contributions

Hamaida Akbar: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Project administration, Supervision

Muhammad Umer Yasir: Conceptualization, Data curation, Investigation, Methodology, Visualization

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Hareem Khalid: Conceptualization, Data curation, Formal Analysis, Writing - original draft, Writing - review & editing

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Conflicts of Interest

The authors declare no conflicts of interest.

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