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MODERN METHODS OF TREATING HYDROCEPHALUS IN CHILDREN. COMPARATIVE ANALYSIS OF SHUNTING AND ENDOSCOPIC METHODS

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Abstract

Modern surgical methods, in particular shunting and neuroendoscopic procedures, are widely used in the treatment of pediatric hydrocephalus. This article presents a comparative analysis of shunting methods (ventriculoperitoneal shunts) and endoscopic treatment methods (Endoscopic Third Ventriculostomy (ETV) and ETV with choroid plexus catheterization (ETV+CPC)). The article evaluates the effectiveness, safety, complications, and results of the methods in different age groups. Based on an analysis of the available scientific literature, the advantages and disadvantages of both methods are highlighted, and the importance of considering factors such as the patient's age, the etiology of hydrocephalus, and the results of previous procedures when choosing a treatment method is emphasized. The article also discusses technological advances and future prospects in pediatric neurosurgery.

Keywords: Hydrocephalus, shunting, Endoscopic third ventriculostomy, ETV+CPC, pediatric neurosurgery, treatment methods

Introduction

Pediatric hydrocephalus is a serious neurosurgical condition characterized by excessive accumulation of cerebrospinal fluid (CSF) in the ventricles of the brain, leading to increased intracranial pressure and neurological deficits. Hydrocephalus is relatively common in children, occurring in 0.5 to 3 per 1000 live births, and is associated with significant morbidity and mortality. Treatment of this condition requires surgical intervention, and treatment options have evolved significantly in recent years. While the traditional treatment has been to place a shunt system to divert the CSF from the brain cavity to another body cavity (often the abdomen), minimally

invasive endoscopic techniques, such as Endoscopic Third Ventriculostomy (ETV) and Endoscopic Third Ventriculostomy with Choroid Plexus Cauterization (ETV+CPC), are increasingly being used. This article is devoted to a comprehensive comparative analysis of modern methods of treating hydrocephalus in children - shunting and endoscopic procedures. The main purpose of the article is to assess the advantages, disadvantages, effectiveness and safety of each method and to establish criteria for choosing a treatment method based on available scientific evidence.

Analysis of literature on the topic

Pathophysiology, diagnosis and classification of hydrocephalus. Hydrocephalus is usually caused by impaired cerebrospinal fluid (CSF) flow, decreased absorption or, rarely, excessive production. Obstructive hydrocephalus in children (due to blockage of the outflow tract) is one of the most common forms. Diagnosis is made by clinical examination, neuroimaging methods (ultrasound, CT, MRI) and, rarely, invasive intracranial pressure monitoring. Hydrocephalus is divided into congenital, acquired (e.g., due to hemorrhage, infection, tumor) and types of impaired absorption or flow. Shunting methods: types, mechanisms and clinical results. Ventriculoperitoneal shunt (VPS) is a long-standing and "gold standard" method of treating pediatric hydrocephalus. In this method, a special catheter and valve system are implanted to divert excess CSF from the ventricles of the brain into the abdominal cavity. Valves regulate the flow of CSF and help maintain normal intracranial pressure. The main advantage of VPS is that it is effective in hydrocephalus of various etiologies. However, there are a number of complications associated with shunting techniques, including infection (shunt sepsis [4]), mechanical dysfunction (catheter occlusion, rupture, malposition [2, 4]), over-drainage, and, rarely, chronic pain. Some studies have shown that shunt sepsis occurs in 10.16% of cases and shunt dysfunction in 6.7% of cases [4]. Endoscopic treatment methods: ETV and ETV+CPC technique and efficacy. In the last two decades, neuroendoscopy has taken an important place in pediatric neurosurgery and has expanded the possibilities of minimally invasive procedures [2]. Endoscopic Third Ventriculostomy (ETV) is a surgical procedure that aims to restore the normal outflow tract of the third ventricle by creating a small opening in the floor of the third ventricle using a neuroendoscope. This procedure is mainly effective in obstructive hydrocephalus. The main advantage of ETV is that it does not leave a foreign body (shunt catheter) in the brain, thus preventing the potential for shunt-related infection and mechanical complications. In order to improve the effectiveness of ETV in infants, choroid plexus cauterization (ETV+CPC) is used. CPC reduces the production of OMS by

cauterizing part of the choroid plexus, thereby increasing the likelihood of ETV success. Studies in sub-Saharan Africa have shown that there is no statistically significant difference in one-year survival between ETV±CPC and VPS (80% vs. 78%) [4]. Comparative analysis of shunting and endoscopic techniques: efficacy, safety, and complications.According to a systematic review and analysis by the Pediatric Hydrocephalus Evidence-Based Guidelines Task Force, OMS shunts and ETV have shown equivalent outcomes across the clinical etiologies studied. Therefore, both modalities are recommended options for the treatment of pediatric hydrocephalus [1]. However, this general conclusion requires consideration of age-related outcomes and the specific complications of each modality. A recent study analyzed 30-day postoperative outcomes after ETV and shunt surgery by age [5]. Results showed that ETV in patients younger than 6 months had significantly higher rates of recurrent seizures (6.3% vs. 0.4%), rehospitalization (15.7% vs. 6.1%), and reoperation (17.4% vs. 4.8%). Similarly, in patients aged 6 months to 2 years, ETV was associated with more seizures (3.3% vs. 1.0%), rehospitalization (14.9% vs. 7.8%), and reintervention (13.0% vs. 5.4%). In contrast, in patients older than 2 years, ETV resulted in shorter hospital stays and lower mortality (0.4% vs. 1.5%). This suggests that ETV in younger children may have more short-term complications, and 30-day outcomes may be misleading as the sole quality measure in the management of childhood hydrocephalus [5]. Secondary therapies are also important in cases where primary ETV fails. A systematic review comparing re-ETV (Re-ETV) and VPS after primary ETV failure showed a failure rate of 74.98% for Re-ETV and 22.26% for VPS [3]. This suggests that VPS placement is generally a more successful option after initial ETV failure. Bleeding during primary ETV also significantly favored VPS over Re-ETV [3]. These findings highlight the need for individualized treatment planning for patients who fail primary ETV. Treatment selection criteria, postoperative management, and future prospects. The choice of treatment modality should be based on several factors, including the etiology of hydrocephalus (obstructive or communicating), patient age, brain anatomy, previous surgeries, and surgeon experience. While ETV is often the first choice in obstructive hydrocephalus, VPS may be more appropriate in communicating or complicated forms of hydrocephalus. The high short-term complication rate of ETV in young children [5] requires caution in its selection, especially in infants younger than 6 months of age. More studies are needed to understand the role and efficacy of ETV+CPC. Postoperative management includes continuous monitoring,includes early detection and treatment of complications. Shunt-related complications, such as infection and dysfunction, require

neurosurgical intervention. After ETV, hydrocephalus may recur, which may necessitate a subsequent shunt operation. Future prospects in pediatric neurosurgery include technological innovations, such as neuronavigation, intraoperative MRI, and augmented reality, which will increase the safety and accuracy of operations [2]. It is also important to ensure patient safety and a humane approach, and to develop a family-centered care model [2]. Shared decision-making in the selection of treatment options and the development of individualized plans for patients can lead to more effective outcomes.

Research methodology

This article was prepared based on a comprehensive review and critical analysis of the available scientific literature to study the current methods of treatment of hydrocephalus in children - shunting and endoscopic methods. The article synthesizes evidence from systematic reviews, retrospective studies, and other relevant publications. The study used articles published in the US National Library of Medicine (PubMed/MEDLINE) and Cochrane databases as the main sources. The main focus was on a comparative assessment of the effectiveness, safety, complications, and age-related outcomes of shunting and endoscopic methods. The article does not include a primary data collection; it presents a qualitative synthesis based on data from secondary sources only.

Conclusion

Shunting and endoscopic techniques are an integral part of modern neurosurgical practice in the treatment of hydrocephalus in children. A review of the available literature suggests that both techniques may be effective in certain cases, and extensive systematic reviews have demonstrated their equivalence in terms of overall outcomes. However, the choice of treatment method must be based on the individual characteristics of each patient, including age, etiology of hydrocephalus, and the results of previous treatments. The high risk of short-term complications after ETV, especially in infants under 2 years of age, suggests the potential for increased efficacy of the ETV+CPC method in this age group, but emphasizes the need for caution in evaluating these cases. In cases where primary ETV has failed, VPS has been shown to be more successful than repeat ETV. Future studies aimed at improving neurosurgical technology, developing more precise treatment protocols tailored to individual patients, and evaluating long-term outcomes will further improve the quality of care provided to children with hydrocephalus. During the treatment process, it is important to adhere to the principles of patient safety, minimal invasiveness, and humaneness.

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