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TEMPORARY VS. DEFINITIVE SURGICAL INTERVENTIONS IN THE MANAGEMENT OF PERI- INTRAVENTRICULAR HEMORRHAGE: A SYSTEMATIC REVIEW ON EFFICACY AND RISKS

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Abstract: Preterm infants, defined as those born before the 37th week of gestation, are at an increased risk for various health complications, including intraventricular hemorrhage (IVH) and its associated condition, post-hemorrhagic hydrocephalus (HPIV). HPIV often leads to ventricular dilation, requiring surgical intervention. This systematic review aims to compare and evaluate the effectiveness and risks of different surgical treatments for HPIV, including ventriculoperitoneal shunting (VPS), drainage, irrigation, and fibrinolysis therapy (DRIFT), ventriculosubgaleal shunting, and neuroendoscopic lavage (NEL). A thorough search of PubMed, BVS, and SciELO databases identified 53 relevant articles, from which 7 key studies were included for analysis. The review underscores the importance of early intervention and careful selection of surgical techniques to improve patient outcomes. Minimally invasive procedures, such as NEL and Subgaleal Ventricular Derivation, show lower complication rates, reduced healthcare costs, and better long-term neurological recovery. Additionally, integrating laboratory biomarkers with imaging can provide a more comprehensive understanding of disease progression and guide treatment decisions. Overall, the study highlights the need for standardized protocols and continued research to optimize the management of HPIV in preterm infants.

Keywords: Post-hemorrhagic hydrocephalus, preterm infants, ventriculoperitoneal shunt, neuroendoscopic lavage, drainage-irrigation-fibrinolysis, surgical treatment, early intervention, biomarkers.

INTRODUCTION

According to the World Health Organization, preterm infants are those born before the 37th week of gestation. In Brazil, preterm births account for approximately 11% of all births, making it the leading cause of infant mortality under five years of age. This is also noted by the Ministry of Health and corroborated by the World Health Organization¹.

Preterm infants are at heightened risk for a variety of comorbidities, with the most prevalent including respiratory distress syndrome, subependymal and intraventricular hemorrhage (IVH), periventricular leukomalacia, patent ductus arteriosus, necrotizing enterocolitis, and retinopathy of prematurity. Subependymal hemorrhage, occurring within the first 72 hours of life, is particularly common in preterm infants with a gestational age below 34 weeks and a birth weight under 1,500 g. Literature indicates that the prevalence of this condition ranges from 10% to 20%, and can rise to 50% among those with extremely low birth weight^{1,3}.

While antenatal interventions, such as corticosteroid administration, have reduced the incidence of subependymal hemorrhage, its prevalence remains high, along with associated morbidity and mortality. A major complication of subependymal hemorrhage is post-hemorrhagic hydrocephalus (HPIV), which often requires surgical intervention. Various surgical approaches, including ventriculoperitoneal derivation, subgaleal ventricular derivation, and external drainage, are used to manage HPIV. This study aims to compare these approaches, evaluating their efficacy and risks to provide a comprehensive overview of current treatment strategies.

METHODOLOGY

Based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, this systematic review was conducted in 2023. Data collection was performed through searches in the Virtual Health Library (BVS), PubMed, and Scientific Electronic Library Online (SciELO) databases, using the following descriptors: “hydrocephalus,” “premature,” and “neurosurgery.” Article selection focused on studies addressing the efficacy and risks of major surgical techniques for managing post-hemorrhagic hydrocephalus in preterm neonates. No restrictions were applied regarding sex, race, or socioeconomic status.

The inclusion criteria encompassed scientific studies such as clinical trials (including randomized ones), systematic reviews, meta-analyses, and cohort studies, provided they were fully available in Portuguese or English, published within the last five years, and presented current and innovative approaches. Exclusion criteria comprised studies of other types not listed, articles in languages other than Portuguese or English, integrative or narrative reviews, and publications prior to 2018.

After applying the filters “from 2018 to 2023,” “Meta-Analysis,” “Clinical Trial,” and “Randomized Controlled Trial” in the mentioned databases, a total of 19 articles were selected (PubMed: 10; BVS: 9; SciELO: 0). A subsequent search in the same databases was conducted to identify additional references using the descriptors: “hydrocephalus,” “neonates,” and “neurosurgery.” This resulted in 2,336 new articles (PubMed: 2,289; BVS: 47), of which 34 remained after applying the aforementioned filters (PubMed: 25; BVS: 9). Ten duplicate texts were excluded, leaving 53 articles for evaluation.

Following title and abstract screening, 30 articles were excluded for not aligning with the study’s scope, leaving 23 papers. After a

full-text review, 16 articles were further excluded for failing to meet the inclusion criteria (despite the applied filters). Consequently, seven references were included. The flow diagram detailing the search and selection strategy is presented in Figure A.

RESULTS

Through literary analysis, seven articles were identified that individually compared and discussed each currently available surgical treatment in full. The surgical management techniques identified were: Ventriculoperitoneal Shunting (VPS), Drainage, Irrigation, and Fibrinolysis Therapy (DRIFT), Ventriculosubgaleal Shunting, and Neuroendoscopic Lavage (NEL).

In summary, early intervention and the appropriate selection of a shunting technique are crucial for managing post-hemorrhagic ventricular dilation in preterm infants. Minimally invasive techniques and rigorous monitoring can significantly improve long-term outcomes. Table 1 presents the main scientific evidence on the surgical treatments for post-hemorrhagic intraventricular hydrocephalus (PHIV) identified in this study

DISCUSSION

Although the literature on HPIV (post-hemorrhagic hydrocephalus) is extensive, few studies explore in detail the treatments and outcomes of these interventions. The lack of a standardized intervention protocol calls for more in-depth research to establish clear guidelines, particularly for Ventriculoperitoneal Derivation (VPD). The absence of such a protocol is a significant limitation as it may affect the consistency of results and the choice of the most appropriate therapeutic approach for each patient. Establishing clear protocols would help improve outcomes and ensure more reliable data on the effectiveness of treatments³.

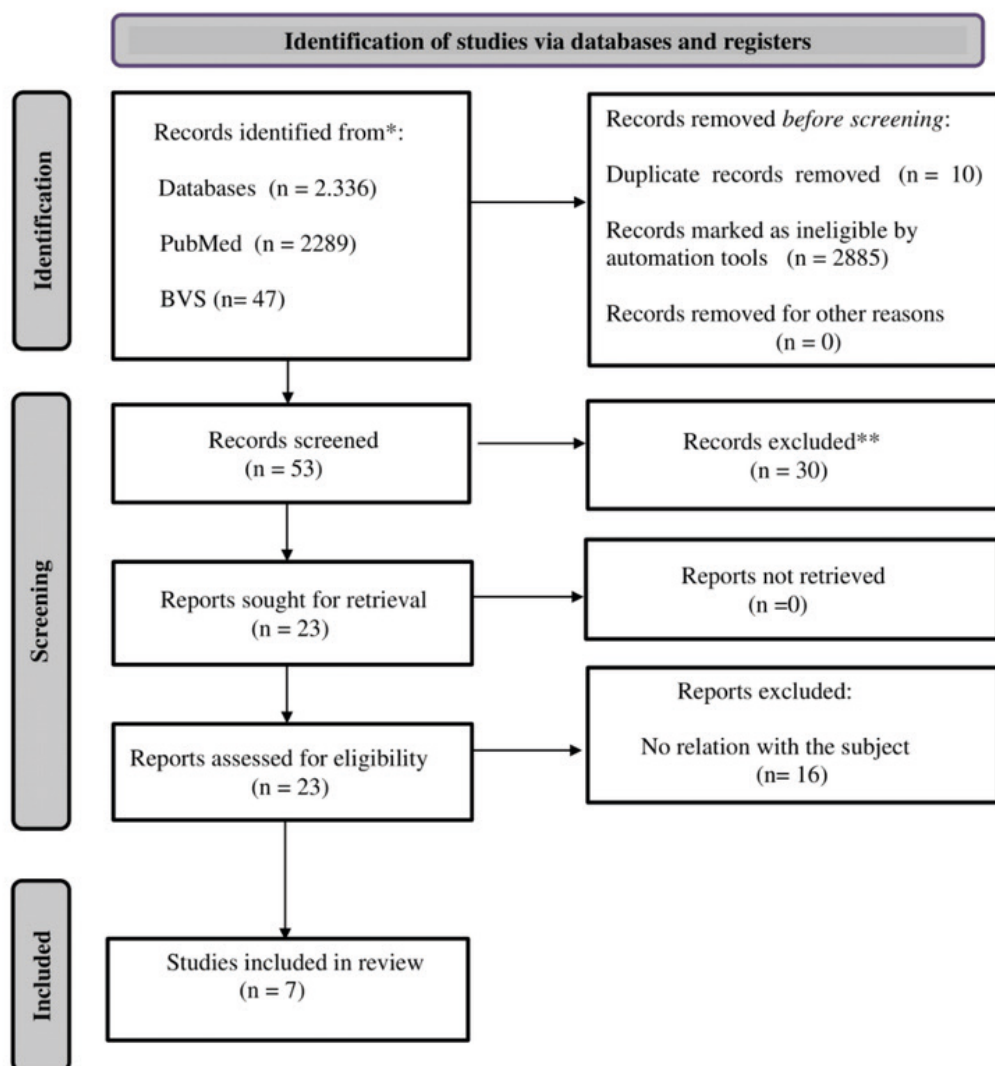


Figure A. PRISMA Flowchart: Strategy and Study Selection

Author	Study	Findings
Cizmeci et al., 2019	Randomized controlled trial	Higher brain injury rates and larger ventricular volumes were observed in the high-threshold group compared to the low-threshold group. These findings support the positive effects of early intervention for post-hemorrhagic ventricular dilation.
Benavente-fernández et al., 2023	Randomized controlled trial	Pre-reservoir VV measurements were associated with the need for VP shunt placement and cognitive outcomes at two years among preterm infants with post-hemorrhagic ventricular dilation.
Lai et al., 2022	Retrospective study	Patients with DVA who underwent ventriculoperitoneal shunt (VP shunt) had an average of 22.2 ± 18.4 aspirations per patient. Comparatively, DVA patients required fewer aspirations, and the cost was significantly lower.
Sandoval et al., 2019	Systematic review	Cranial ultrasound can be used to identify hemorrhage and classify it according to the modified Papile classification system.
Mahaney et al., 2020	Prospective cohort	Newborns with post-hemorrhagic hydrocephalus had significantly higher hemoglobin levels than those with high-grade IVH. Blood degradation products, hemoglobin, ferritin, and bilirubin levels correlated with ventricular size. Thus, post-hemorrhagic hydrocephalus is understood as a disease state occurring when endogenous iron clearance mechanisms are overwhelmed.

Kandula et al., 2022	Meta-analysis	The treatment modality had a significant effect on secondary hemorrhage and mortality; however, mortality was no longer significant after adjusting for the publication year. The re-hemorrhage rate was significantly higher for DRIFT ($p < 0.001$) but did not differ among other modalities. NEL also showed lower mortality compared to EVD ($p < 0.001$) and thrombolytics ($p = 0.013$), though this was no longer significant after adjusting for publication year. Thus, NEL appears safer than DRIFT in terms of hemorrhage risk and is not significantly different from other blood-clearing strategies in terms of mortality. Outcomes related to shunting and cognitive impairment did not differ.
Parenrengi et al., 2023	Meta-analysis	LV reduces shunt dependency in PHH, decreasing shunt-related infection rates. Early ventricular lavage may provide benefits for neurocognitive outcomes.

Figure 1

Cizmeci et al. highlight the differences between early and late intervention, emphasizing the benefits of a quicker approach. Early intervention, which includes monitoring with ultrasound exams, assisted ventilation in the early stages (grade 2), antibiotics, anticonvulsants, and parenteral nutrition, has been shown to reduce the risk of additional brain injuries and lower ventricular volumes. The use of magnetic resonance imaging (MRI) for continuous monitoring plays an important role in evaluating neurological status. The study found that infants who received early intervention (before reaching the 97th percentile + 4 mm of ventricular dilation) showed less progression of ventricular enlargement, reinforcing the importance of early diagnosis and intervention for better clinical outcomes. Early intervention limits neurological damage and improves the prognosis of these infants ⁴.

When examining different surgical therapies, Benavente-Fernández et al. stress the importance of considering factors like maximum ventricular volume, gestational age at birth, and the age at the time of intervention. These factors directly impact the need for a Ventriculo-peritoneal Derivation and affect long-term neurocognitive outcomes. Comparing the different intervention methods is critical, as treatments such as Subgaleal Ventricular Derivation and External Drainage come with varying risks and benefits. A better understanding of these differences is key to tailoring the treatment to each patient's needs ⁵.

LAI et al. (2022) also emphasize the costs and risks associated with liquor aspiration in preterm infants with post-hemorrhagic hydrocephalus. The Subgaleal Ventricular Derivation has proven to be an effective and lower-cost alternative to traditional ventriculo-peritoneal derivation, requiring less aspiration and thus reducing the risk of complications. This approach offers significant advantages, especially when considering long-term healthcare costs and minimizing invasive procedures in fragile, preterm infants. Choosing less invasive techniques not only reduces healthcare expenses but also improves the safety and recovery of these infants, making it an important factor when deciding on the most appropriate treatment ⁶.

Further studies by Mahaney et al. and Kandula et al. explore the relationship between laboratory biomarkers, such as hemoglobin and bilirubin levels, and the degree of ventricular enlargement. These biomarkers provide valuable insights into the severity of post-hemorrhagic hydrocephalus and can complement clinical monitoring alongside imaging tests. Using both laboratory data and neuroimaging helps give a more complete picture of the patient's condition, allowing clinicians to predict outcomes better and make more informed decisions about therapy. These findings highlight the importance of integrating laboratory tests with imaging for a more thorough approach to patient care ^{7,8}.

Lastly, the drainage-irrigation-fibrinolysis (DRIFT) therapies and neuroendoscopic lavage (NEL) techniques are discussed in the meta-analysis by Parenrengi et al. (2023). When performed early, these minimally invasive therapies can reduce dependency on ventriculoperitoneal derivations and lower the risk of infection. Moreover, these approaches have shown potential in improving long-term neurological function, which is crucial for the prognosis of preterm infants with HPIV. The benefits of DRIFT and NEL include fewer complications, fewer hospital readmissions, and better quality of life for affected infants. Offering a less invasive and more effective alternative to traditional methods could represent a significant advancement in the treatment of post-hemorrhagic hydrocephalus ⁹.

Despite advancements in the treatment of post-hemorrhagic hydrocephalus, continuous research remains essential to refine existing protocols, enhance clinical outcomes, and investigate innovative therapeutic approaches. Early interventions, combined with advanced

monitoring tools such as MRI and biomarkers, are poised to play a critical role in shaping the future management of this complex and challenging condition.

CONCLUSION

The reviewed studies highlight the importance of early interventions and the need to standardize treatment protocols for post-hemorrhagic intraventricular hydrocephalus (HPIV). Early intervention has shown significant benefits in reducing brain injuries and ventricular volume, while approaches such as Subgaleal Ventricular Derivation have proven advantageous in terms of cost reduction and minimizing risks associated with frequent aspirations. The combination of techniques like NEL and DRIFT, with less dependence on derivation and a lower risk of infection, suggests an effective approach that could be integrated into clinical practice. However, it is crucial to implement uniform protocols and continue validating new therapeutic approaches to optimize outcomes in the treatment of HPIV.

REFERÊNCIAS

1. Gustavo Rassier Isolan, Samir Ale Bark, Viviane Aline Buffon, Eberval Gadelha Figueiredo. Neuroanatomia. Thieme Revinter; 2024.
2. Valdez Sandoval P, Hernández Rosales P, Quiñones Hernández DG, Chavana Naranjo EA, García Navarro V. Intraventricular hemorrhage and posthemorrhagic hydrocephalus in preterm infants: diagnosis, classification, and treatment options. *Child's Nervous System*. 2019 Apr 5;35(6):917–27.
3. Cizmeci MN, Khalili N, Claessens NHP, Groenendaal F, Liem KD, Heep A, et al. Assessment of Brain Injury and Brain Volumes after Posthemorrhagic Ventricular Dilatation: A Nested Substudy of the Randomized Controlled ELVIS Trial. *The Journal of Pediatrics*. 2019 May;208:191–197.e2.
4. Benavente-Fernández I, Steggerda SJ, Liem KD, Simón Pedro Lubián-López, Linda. Ultrasonographic Estimation of Ventricular Volume in Infants Born Preterm with Posthemorrhagic Ventricular Dilatation: A Nested Substudy of the Randomized Controlled Early Versus Late Ventricular Intervention Study (ELVIS) Trial. *The Journal of Pediatrics*. 2023 Oct 1;261:113578–8.
5. Lai G, Shlobin NA, Zhang L, Wescott A, Lam S. The cost of serial cerebrospinal fluid aspirations between ventricular access device (VAD) and ventriculosubgaleal shunt (VSGS) for treatment of post-hemorrhagic ventricular dilatation (PHVD) in premature infants. *Pediatric Neurosurgery*. 2022 Jan 1;57(2):93–101.
6. Mahaney KB, Buddhala C, Paturu M, Morales D, Limbrick DD, Strahle JM. Intraventricular Hemorrhage Clearance in Human Neonatal Cerebrospinal Fluid. *Stroke*. 2020 Jun;51(6):1712–9.
7. Viswajit Kandula, Mohammad L, Vineeth Thirunavu, LoPresti MA, Beestrum M, Lai G, et al. The role of blood product removal in intraventricular hemorrhage of prematurity: a meta-analysis of the clinical evidence. *Child's Nervous System*. 2022 Jan 13;38(2):239–52.
8. Muhammad Arifin Parenrengi, IG. M. Aswin R. Ranuh, Wihasto Suryaningtyas. Is ventricular lavage a novel treatment of neonatal posthemorrhagic hydrocephalus? a meta analysis. *Child's Nervous System*. 2023 Jan 9;39(4):929–35.