Neuroendoscopic lavage for periventricular-intraventricular hemorrhage

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Neuroendoscopic lavage for periventricular-intraventricular hemorrhage (PIVH) is an emerging surgical approach aimed at improving the clearance of intraventricular blood clots, reducing hydrocephalus, and improving neurological outcomes in affected patients. Here's an overview of the technique and its implications:

Indications

Neuroendoscopic lavage is typically indicated in cases of:

1. **Severe intraventricular hemorrhage (IVH)** associated with periventricular hemorrhage.

2. **Obstructive hydrocephalus** caused by blood clots in the ventricular system.

3. Cases where conservative management or external ventricular drainage (EVD) alone is insufficient for clot resolution.

Procedure

The procedure involves using a neuroendoscope to directly access the ventricular system. Key steps include:

1. **Ventricular access:** A burr hole is created to access the affected ventricle under neuronavigation guidance.

2. **Neuroendoscopic insertion:** A flexible or rigid endoscope is introduced into the ventricle.

3. **Clot removal:** Blood clots are aspirated or fragmented under direct visualization using specialized instruments or saline irrigation.

4. **Irrigation:** The ventricles are irrigated with warmed saline to ensure clearance of debris and residual clots.

5. **EVD placement:** Often, an external ventricular drain is left in place to monitor intracranial pressure (ICP) and facilitate further drainage of blood or cerebrospinal fluid (CSF).

Advantages

1. **Enhanced clot clearance:** Direct visualization allows for targeted and effective removal of clots, reducing clot burden and the associated risk of persistent hydrocephalus.

2. **Reduced inflammation:** By removing blood and its breakdown products, neuroendoscopic lavage may decrease the inflammatory response that contributes to ventricular scarring and hydrocephalus.

3. **Minimally invasive:** Compared to open surgical approaches, it involves smaller incisions and reduced disruption of brain tissue.

4. **Potential for improved outcomes:** Studies have suggested better neurological recovery and lower rates of shunt dependency in some cases.

Challenges and Limitations

1. **Technical expertise:** The procedure requires advanced neuroendoscopic skills and specialized equipment.

2. **Risks:** Complications include infection, hemorrhage, or damage to ventricular structures.

3. **Not universally applicable:** It is most effective in cases where clot consistency and location are suitable for endoscopic removal.

4. **Limited evidence:** While promising, robust clinical trials are needed to establish its efficacy compared to standard treatments.

Outcomes

- Early studies indicate that neuroendoscopic lavage can reduce mortality and improve functional outcomes in patients with PIVH and hydrocephalus.

- It may decrease the need for permanent CSF shunting and lower rates of complications related to prolonged EVD use.

Future Directions

1. **Standardization:** Developing standardized protocols for patient selection and procedural techniques.

2. **Technological advances:** Innovations in endoscopic tools and navigation systems to enhance safety and efficacy.

3. **Long-term studies:** Further research to evaluate the long-term benefits and cost-effectiveness of neuroendoscopic lavage.

The current neurosurgical procedure for periventricular-intraventricular hemorrhage resulting in posthemorrhagic hydrocephalus (PHH) seeks to reduce intracranial pressure with temporary and then Cerebrospinal fluid shunt. In contrast, neuroendoscopic lavage (NEL) directly addresses the intraventricular blood that is hypothesized to damage the ependyma and parenchyma, leading to ventricular dilation and hydrocephalus.

Systematic reviews

Wassef et al. conducted a systematic review of the literature on neuroendoscopic lavage in IVH of prematurity to examine data on the choice of neuroendoscope and outcomes regarding shunt rate. They then collected manufacturer data on neuroendoscopic devices, including inflow and outflow mechanisms, working channel specifications, and tools compatible with the working channel. We paired this information with the advantages and disadvantages reported in the literature and observations from the experiences of pediatric neurosurgeons from several institutions to provide a pragmatic evaluation of international clinical experience with each neuro endoscope in NEL.

Eight studies were identified; four neuroendoscopes have been used for NEL as reported in the literature. These include the Karl Storz Flexible Neuroendoscope, LOTTA® system, GAAB system, and Aesculap MINOP® system. The LOTTA® and MINOP® systems were similar in setup and instrument options. Positive neuroendoscope features for NEL include increased degrees of visualization, better visualization with the evolution of light and camera sources, the ability to sterilize with autoclave processes, balanced inflow and outflow mechanisms via separate channels, and a working channel. Neuroendoscope disadvantages for NEL may include special sterilization requirements, large outer diameter, and limitations in working channels.

A neuroendoscope integrating continuous irrigation, characterized by measured inflow and outflow via separate channels and multiple associated instruments, appears to be the most commonly used technology in the literature. As neuro endoscopes evolve, maximizing clear visualization, adequate inflow, measured outflow, and large enough working channels for paired instrumentation while minimizing the footprint of the outer diameter will be most advantageous when applied for NEL in premature infants [1)].

Wassef et al.'s review provides an essential contribution to the understanding of neuroendoscopic technology in the context of NEL for IVH in premature infants. While the study outlines critical device features and evolving trends, its conclusions are constrained by limited data and a lack of quantitative analysis. Nevertheless, the work highlights key priorities for technological and clinical advancement, serving as a foundation for future research and innovation in this challenging yet promising area of pediatric neurosurgery.

Retrospective cohort studies

The records of patients with a diagnosis of grade III or IV IVH were reviewed between September 2022 and February 2024. The Papile-Burstein classification grade was determined on cranial

ultrasonography. Demographic information collected included gestational age, birth weight, weight at the time of surgical intervention, infection confirmed with CSF, and hemorrhage. Standard local guidelines for temporary (CSF reservoir) and permanent (shunt or endoscopic third ventriculostomy (ETV) CSF diversion was implemented. Warmed Lactated Ringer's was utilized for NEL. The primary outcome was the need for permanent CSF diversion (shunt or ETV).

Twenty consecutive patients with grade III or IV IVH complicated by PHH were identified. Twelve patients underwent CSF reservoir placement and NEL, 4 underwent CSF reservoir placement only, 1 underwent shunt placement only, and 3 did not require neurosurgical intervention. Of the 12 patients who underwent reservoir placement and NEL, 8 (67%) ultimately met the criteria for permanent CSF diversion compared with 2 of 4 (50%) who underwent CSF reservoir placement only. The mean gestational age at birth, birth weights, and age/weight at the time of temporary CSF diversion were similar across groups. The average time interval between temporary and permanent CSF diversion was longer in patients who underwent NEL (2.5 months for shunt and 6.5 months for ETV) compared with CSF reservoir placement only (1.1 months).

NEL is an innovative alternative for the treatment of PHH of prematurity. Flanders et al. from the New York University Grossman School of Medicine, Department of Pediatrics, Children's Hospital of Philadelphia, Pennsylvania established an endoscopic lavage program at their institution and herein report the first published account in the United States of the feasibility of NEL for PHH [2].

Flanders et al. provide an intriguing glimpse into the potential of neuroendoscopic lavage for managing PHH of prematurity. While the approach is innovative and technically feasible, the study's small sample size, lack of randomization, and limited long-term outcome data temper the enthusiasm for immediate adoption. Further research is essential to confirm the efficacy, safety, and cost-effectiveness of NEL, ensuring its role as a viable alternative or adjunct to existing treatment paradigms for PHH.

Comparative retrospective studies

Between August 2010 and December 2012 (29 months), 19 neonates with posthemorrhagic hydrocephalus underwent neuroendoscopic lavage for removal of intraventricular blood remnants. During a similar length of time (29 months) from March 2008 to July 2010, 10 neonates were treated conventionally, initially using temporary CSF diversion via lumbar punctures, a ventricular access device, or an external ventricular drain. Complications and shunt dependency rates were evaluated retrospectively. Results The patient groups did not differ regarding gestational age and birth weight. In the endoscopy group, no relevant procedure-related complications were observed. After the endoscopic lavage, 11 (58%) of 19 patients required a later shunt insertion, as compared with 100% of infants treated conventionally ($p < 0.05$). Endoscopic lavage was associated with fewer numbers of overall necessary procedures (median 2 vs 3.5 per patient, respectively; $p = 0.08$), significantly fewer infections (2 vs 5 patients, respectively; $p < 0.05$), and supratentorial multiloculated hydrocephalus (0 vs 4 patients, respectively; $p < 0.01$) [corrected]. Conclusions Within the presented setup the authors could demonstrate the feasibility and safety of neuro-endoscopic lavage for the treatment of posthemorrhagic hydrocephalus in neonates with IVH. The nominally improved results warrant further verification in a multicenter, prospective study [3].

The study provides a compelling case for the feasibility and safety of neuroendoscopic lavage in neonates with posthemorrhagic hydrocephalus. The lower rates of shunt dependency, infections, and multiloculated hydrocephalus are encouraging and suggest a potential benefit of NEL over conventional management.

However, the study's limitations, particularly its retrospective design, small sample size, and lack of long-term outcomes, necessitate further investigation. A multicenter, prospective study is critical to validate these findings, optimize patient selection, and determine the technique's broader applicability and impact on long-term neurodevelopment.

This study represents a promising step forward, but cautious interpretation is essential until more robust evidence emerges.

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