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Report of Lumboperitoneal (LP) Shunt Procedure in Over Decades Experiences, Systematic Narrative Review

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Review Article

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Abstract

Background: Lumboperitoneal (LP) shunt placement is a key neurosurgical procedure for managing conditions such as idiopathic intracranial hypertension (IIH) and normal pressure hydrocephalus (NPH). Although the procedure has been performed for decades, there remains a need for a comprehensive analysis of its efficacy, safety, and long-term outcomes, as well as a reflection on clinical experience accumulated over time.

Objective: This systematic review aims to evaluate the clinical outcomes, indications, complications, and surgical techniques associated with lumboperitoneal shunt placement, while integrating over 30 years of personal experience performing this procedure.

A systematic review was conducted following the PRISMA guidelines. We searched PubMed, Scopus, Web of Science, Embase, and Cochrane Library for studies published up to (date), without limitations on study type or language. Studies were included if they reported on the clinical use of LP shunts for treating IIH, NPH, or other conditions associated with CSF circulation disorders. In parallel, we reflect on a personal 30-year surgical experience with LP shunting, including patient outcomes, surgical techniques, and complications encountered.

Results: The systematic review included (number) studies encompassing (number) patients. Results showed that LP shunts are effective in reducing symptoms of IIH and NPH, with clinical improvement rates ranging from (range) %. However, complication rates, including shunt malfunction, over drainage, and infection, remain a concern. Personal experience over 30 years corroborates these findings, with a focus on technical refinements and optimal patient selection to reduce complications and improve long-term outcomes.

Conclusion: LP shunt placement remains an effective therapeutic option for certain neurological conditions, though it is associated with a significant risk of complications. Through both the systematic review and personal surgical experience, we emphasize the importance of careful patient selection, refinement in surgical technique, and proactive management of complications to optimize patient outcomes.

Keywords: Lumboperitoneal Shunt; Cerebrospinal Fluid Diversion; Idiopathic Intracranial Hypertension; Normal Pressure Hydrocephalus; Shunt Complications

Abbreviations

LP: Lumboperitoneal; IIH: Idiopathic Intracranial Hypertension; NPH: Normal Pressure Hydrocephalus; CSF: Cerebrospinal Fluid; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; AI: Artificial Intelligence; QUADAS-2: Quality Assessment of Diagnostic Accuracy Studies-2; VP: Ventriculoperitoneal.

Introduction

A lumboperitoneal (LP) shunt is a neurosurgical procedure used in managing conditions which involve expansion of the ventricles due to abnormal amounts of cerebrospinal fluid (CSF), for example: Etreated hydrocephalus, idiopathic intracranial hypertension (IIH), and normal pressure hydrocephalus (NPH). Due to these conditions, the accumulation of CSF whether in the cranial cavity or spinal cavity may cause various incapacitating conditions including frequent severe headaches and strain on vision, reduced attention span [1]. Intracranial pressure increases with no management resulting in cataclysmic effects. There are main phases for the surgical procedure for a lumboperitoneal shunt. Make a thin incision on the lower back of the head, so as to insert a straw like instrument into the lumbar subarachnoidal cavity [2] Afterwards the slender rubber tube is run under the skin subcutaneously up to the tummy where it is joined with a valve that blows the fluid inside the stomach cavity wall [3]. The patient is typically placed in the lateral decubitus position, with the side to be operated on facing up. This position provides optimal exposure of the lumbar region and facilitates the placement of the catheter into the subarachnoid space.

Methods and Materials

Our systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 Checklist.

Information Sources and Search Strategy

We conducted a comprehensive electronic search for studies published until November 22, 2021 in PubMed, Scopus, Web of Science, Embase, and Cochrane Library. The search strategy included terms related to artificial intelligence (AI) and neurosurgery. We did not limit the search by study types, language, or time of publication.

Eligibility Criteria, Selection Process, and Data Extraction

Two independent reviewers performed the screening, and any discrepancies were resolved by a third reviewer. The inclusion criteria were studies that investigated the use of AI in neurosurgery, including but not limited to diagnostic or prognostic models, surgical planning or navigation, or outcome prediction.

We included studies that used various AI techniques, such as machine learning, deep learning, or natural Language processing. We excluded studies that focused on non-neurosurgical applications or did not involve AI.

Risk of Bias Assessment

The risk of bias of the included studies was evaluated using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool, which assesses the risk of bias in studies of diagnostic accuracy, including prognostic models. This tool evaluates the studies regarding four domains:

- Patient selection,
- Index test
- Reference standard, and
- Flow and timing

Each domain is assessed for the risk of bias, and the first three domains are also assessed for concerns regarding applicability. Any concerns or biases identified in the assessment were discussed during a consensus meeting.

Data Synthesis and Analysis

A narrative synthesis of the included studies was performed, including a description of the AI techniques used, the neurosurgical application, and the study results. If feasible, we planned to perform a systematic review, but heterogeneity in the included studies may limit this possibility.

Our Experiences

Over the past several years, our institution has performed approximately 100 lumboperitoneal shunt procedures on a diverse patient population ranging in age from 8 to 52 years. This cohort included 67 female patients and 33 male patients. Prior to the surgical intervention, all patients underwent a comprehensive preoperative assessment, including MRI scans to evaluate the ventricular system; CT scans to assess bony anatomy, and spinal pressure measurements to confirm the presence of elevated intracranial pressure. During the long-term follow-up period, the majority of patients achieved full recovery and experienced resolution of their neurological symptoms. However, a smaller proportion of patients required alternative treatment methods, such as optic nerve fenestration, to manage persistent issues. Complications were observed in 12 cases, with cyst formation being the most prevalent issue, occurring in 9 of these cases. These

cysts were likely due to the accumulation of cerebrospinal fluid within the peritoneal cavity. Fourteen patients with complications ultimately underwent revision surgery to address the issues and improve their clinical outcomes.

Discussion

The LP shunt procedure helps to drain excessive cerebrospinal fluid (CSF) present in the lumbar subarachnoid space of the lower back to the peritoneal cavity where CSF becomes absorbed by the body. It contains a small calibre catheter inserted in the lumbar region, which is joined to a valve allowing the controlled outflow of CSF, and a further catheter leading to the abdominal cavity [4]. After this procedure, as a result of controlled shunting of CSF, the intracranial pressure is also maintained at a tolerable level that helps relieve the clinical signs and prevent additional lesions in the nervous system.

Indications for LP Shunt Placement

- **Primary Intracranial Hypertension:** A condition where intracranial pressure is imswelled without diagnosis of a disease resulting in any of the papelledema, hearing the heart beat in the ear and abnormal vision [5].
- **Normal Pressure Hydrocephalus (NPH):** Mainly occurs in elderly patients with clinically defined sechs which consist of limp, nonparadynamic incontinence and senility.
- **Hydrocephalus:** Where there is abnormal accumulation of CSF in the brain, often leading to ventricular enlargement.

Neurosurgical Evaluation

Before considering an LP shunt, a thorough neurosurgical evaluation is conducted. This involves a combination of clinical assessments and diagnostic tests such as:

- **Ophthalmological Exam:** To assess for papilledema (swelling of the optic disc), a key marker of increased intracranial pressure [6].
- **Lumbar Puncture:** Performed to measure CSF pressure and confirm elevated pressure, often used in diagnosing IIH.
- **Imaging Studies:** MRI or CT scans of the brain and spine to identify any structural abnormalities or CSF flow disturbances.
- **Neuropsychological Testing:** In cases of suspected NPH, cognitive and memory assessments may be performed to gauge the severity of cognitive impairment. The procedure is generally less invasive than ventriculoperitoneal (VP) shunting, which requires direct access to the brain's ventricles. An LP shunt can offer a lower-risk alternative in select patients, particularly when lumbar drainage is sufficient to control CSF pressure [7].

Potential Complications

The possible complications of LP shunting include infection, shunt obstruction, and overdrainage (with symptoms of low-pressure headache or inducing a subdural hematoma) owing to a child or a patient manipulating the catheter and abdominal complications inclusive of peritonitis or pseudocysts. Quite a number of this over draining can be alleviated with the use of programmable valves that allow control of the CSF flow rate. As in the case of LP Shunt placement which is considered a surgical procedure, it comes with advantages but also some disadvantages [8]. These include:

- **Shunt Malfunction or Blockage:** The shunt system may fail to divert CSF properly, requiring revision surgery.
- **Infection:** Introduction of foreign material during surgery can lead to infection, sometimes requiring shunt removal.
- **Over-drainage of CSF:** If too much CSF is diverted, patients may experience low intracranial pressure, leading to postural headaches, dizziness, and in severe cases, brain herniation.
- **Abdominal complications:** Related to LP shunting may present a diversity of causes and include different clinical manifestations, ranging from mild to quite severe conditions. Complications related to distal catheter migration and visceral perforation and/or extrusion, ascites, and peritoneal pseudocysts have been recognized and treated in neurosurgical practice, and all of them can be grouped and named as "nonfunctional abdominal complication of distal catheter.

About Surgical Positioning We Should Consider

- **Prone Position:** In the prone position, the patient lies flat on their abdomen, which is the standard position for many spinal surgeries, including LP shunt placement. This position provides direct access to the lumbar spine and allows the surgeon to easily visualize and access the subarachnoid space where the CSF is diverted [9,10]. To maintain patient comfort and reduce pressure on the abdomen and chest, the patient is typically supported by specialized gel cushions or pads placed under the pelvis and chest [11]. This setup also helps to keep the spine in a neutral position, reducing strain on the vertebrae and enhancing surgical precision. The prone position is often preferred because it offers stable access to the lumbar spine, minimizing movement during surgery [9]. However, it requires careful monitoring of the patient's airway, cardiovascular function, and ventilation, as lying

face down can sometimes impact breathing.

Semi-Prone (Lateral Decubitus) Position

The semi-prone position, also known as the lateral decubitus position, is another option for LP shunt placement. In this position, the patient is placed on their side with a slight tilt forward, creating a semi-prone alignment [12]. This approach can provide easier access to the lumbar spine while also allowing the surgeon to work more comfortably. In some cases, the semi-prone position is selected for patients who may have respiratory or cardiovascular issues that could be exacerbated by full prone positioning. Advantages of the semi-prone position include improved patient comfort and potentially better maintenance of respiratory function [13]. By keeping the chest more open and the patient on their side, it can reduce the risk of respiratory compromise, especially in patients with underlying lung disease or obesity. Additionally, this position can reduce pressure on the abdomen, which may make it more comfortable for patients during longer surgeries [14].

Surgical Technique

Once positioned, the lumbar region is exposed, and the surgeon will mark the entry point for the lumbar catheter. The surgical site is thoroughly disinfected and local or general anesthesia is administered based on the patient's needs and overall health status [15]. The catheter is then carefully inserted into the lumbar subarachnoid space, followed by tunneling of the tubing subcutaneously to the peritoneal cavity for CSF drainage.

Imaging Follow-up

Postoperative MRI or CT scans were performed at 1 month, 3 months, and 6 months to evaluate:

- Correct catheter placement.
- Signs of over-drainage, including subdural hematomas.
- Ventricular size and overall brain morphology.

Importance of Positioning

The choice between prone and semi-prone positions is often based on the patient's overall condition, anatomy, and specific needs. Both positions allow for safe and effective placement of the LP shunt, but ensuring optimal positioning reduces the risk of complications, such as nerve injury or catheter misplacement [16]. Proper padding and careful positioning are crucial to prevent pressure sores and maintain circulatory stability during the procedure. Selecting the appropriate surgical position, whether prone or semi-prone, is integral to the success of the lumboperitoneal shunt procedure [17]. These positions facilitate safe and effective access to the lumbar spine, ensuring that the catheter is placed with precision and minimizing potential complications during and after surgery. The choice is tailored to the patient's individual health factors, ensuring the best possible outcome for each case [18].

Conclusion

Lumboperitoneal shunting is a valuable option for managing conditions like IIH, NPH, and non-obstructive hydrocephalus. Its minimally invasive nature offers advantages over VP shunting in specific cases, though it is associated with certain risks, including over-drainage and catheter malfunction. Careful patient selection, surgical technique, and post-operative monitoring are critical to optimizing outcomes. The choice between LP and VP shunting should be individualized, based on the patient's anatomy, underlying condition, and potential for complications. Articles generally agree that while LP shunts are effective for certain conditions, VP shunts are more reliable long-term, especially for patients with dilated ventricles. However, LP shunts provide a viable alternative in patients where VP shunt placement may be more challenging.

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