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Research Article

Outcome of Programmable Lumboperitoneal Shunt in the Surgical Management of Idiopathic Normal Pressure Hydrocephalus

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Abstract

Background: Normal pressure hydrocephalus (NPH) is a complex neurological disorder characterized by enlarged ventricles in the brain. While the ventriculoperitoneal shunt is the preferred procedure, lumbar-peritoneal shunts also serve as an alternative. Lumbo-peritoneal shunts are an alternative for diverting cerebrospinal fluid without intracranial surgery. ***Objectives***: To assess the efficacy of programmable LP shunts in managing idiopathic normal-pressure hydrocephalus (iNPH), focusing on postoperative outcomes and complications. ***Methods***: This is a multicenter cohort study, including retrospective and prospective data. It involves 20 iNPH hospitalized patients from January 1st, 2019, to January 1st, 2022. The patients underwent programmable lumboperitoneal shunt surgery and had a six-month follow-up period. Patients with confirmed diagnosis of iNPH were included in this study. Other possible causes of symptoms were ruled out, and there were no reasons why the LP shunt should not be placed. ***Results***: This cohort study involved 20 iNPH patients treated with programmable LP shunts; 19 patients (95%) experienced gait improvement, 16(80%) showed improvement in urinary symptoms, and 16 patients (80%) showed improvement in dementia. The most common post-operative complications included over-shunting (15%), subdural hygroma, CSF collection, and infection (10%). Most patients presented between 2–4 months. When evaluating predictors of operative time, the regression analysis revealed no significant factor that could predict operative time accurately. ***Conclusions***: Lumbar-peritoneal shunts showed significant effectiveness rates with a moderate complication rate. It is minimally invasive without life-threatening complications and can be recommended for iNPH treatment.

Keywords: Lumboperitoneal shunt, Normal pressure hydrocephalus, Programmable LP shunt.

نتيجة التحويلة القطنية الصفيحية القابلة للبرمجة في التداخل الجراحي لاستسقاء الرأس بالضغط الطبيعي مجهول السبب

الخلاصة

الخلفية: استسقاء الرأس بالضغط الطبيعي (NPH) هو اضطراب عصبي معقد يتميز بتضخم البطينين في الدماغ. في حين أن التحويلة البطينية الخفية هي الإجراء المفضل، فإن التحويلات القطنية البريتونية تعمل أيضا كبديل. تعتبر التحويلات القطنية البريتونية بديلا لتحويل السائل الدماغي النخاعي دون جراحة داخل الجمجمة. **الهدف**: تقييم فعالية تحويلات LP القابلة للبرمجة في معالجة استسقاء الرأس بالضغط الطبيعي مجهول السبب (iNPH)، مع التركيز على نتائج ومضاعفات ما بعد الجراحة.**الطرق**: هذه دراسة مستقبلية جماعية متعددة المراكز، بما في ذلك جمع البيانات بأثر رجعي، شملت 20 مريضا في المستشفى iNPH من 1 يناير 2019 إلى 1 يناير 2022. خضع المرضى لجراحة تحويلة قطنية صفاق قابلة للبرمجة ولديهم فترة متابعة مدتها ستة أشهر. تم تضمين المرضى الذين تم تشخيصهم اصابتهم المؤكدة ب NPH في هذه الدراسة. تم استبعاد الأسباب المحتملة الأخرى للأعراض، ولم تكن هناك أسباب لعدم وضع تحويلة LP. **النتائج**: تضمنت هذه الدراسة الجماعية 20 مريضا iNPH عولجوا بتحويلات LP قابلة للبرمجة ؛ 19 مريضا (95٪) شهدوا تحسنا في المشي، وأظهر 16 (80٪) تحسنا في أعراض المسالك البولية، و 16 مريضا (80٪) تحسنا في الخرف. تضمنت المضاعفات الأكثر شيوعا بعد الجراحة الإفراط في التحويل (15٪)، والورم تحت الجافية، وتجمع السائل الدماغي النخاعي، والعدوى (10٪). تمت متابعة معظم المرضى خلال2-4 أشهر. عند لتقييم تنبؤات وقت الجراحة، لم يكشف تحليل الانحدار عن أي عامل مهم يمكنه التنبؤ بوقت العملية بدقة. ***الاستنتاجات***: أظهرت التحويلات القطنية البريتونية معدلات فعالية كبيرة مع معدل مضاعفات معتدل وهي طفيف التوغل دون مضاعفات تهدد الحياة ويمكن التوصية به لعلاج iNPH.

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INTRODUCTION

Normal pressure hydrocephalus (NPH) is a complicated neurological disorder marked by enlarged ventricles in the brain. It can happen for no clear reason or because of conditions such as post-traumatic, post-meningitis, or tumors, including carcinomatous meningitis [1]. Typically, gait disturbance, cognitive decline, and urinary incontinence go with this enlargement [2,3]. The incidence of the idiopathic form can reach 1.58 per 100,000 per year, with the idiopathic form typically occurring at an older age than the secondary form. NPH stays challenging to diagnose due to its nonspecific symptoms that often overlap with other neurodegenerative conditions [4]. Ventriculoperitoneal (VP) and lumbar-peritoneal shunts lower intracranial pressure. Complications of

shunting procedures include anesthesia-related issues, obstruction, catheter migration, infections, abdominal complications, spinal issues, tonsillar herniation, ophthalmological problems, bleeding, allergic reactions, arachnoiditis, and malfunctions leading to increased intracranial pressure. Over-drainage may cause subdural hematoma or hygroma [5]. A programmable valve in the lumboperitoneal shunt system regulates the flow of cerebrospinal fluid (CSF) in a non-invasive manner. This programmable valve effectively manages the outflow of lumbar CSF to relieve symptoms associated with conditions like pseudotumor cerebri (PTC). It allows for adjustments in CSF drainage based on the patient's clinical status and facilitates indirect intracranial pressure (ICP) assessment [6]. One of the advantages of a programmable LP shunt is its ability to decrease the risk of subdural hematoma by initially setting it at high pressure and gradually lowering the pressure setting over time [7]. This study evaluates the programmable L-P shunt's effectiveness in idiopathic normal pressure hydrocephalus patients.

METHODS

Study design and setting

This retrospective and prospective cohort study was conducted at the hospital from January 1, 2019, to January 1, 2022, and evaluated 20 patients with normal pressure hydrocephalus (NPH). The study protocol was approved by the ethical committee, and all patients provided informed consent regarding the intervention's nature and any potential complications. The neurosurgery unit referred the patients to the neurosurgery unit for participation in the study.

Patient selection

The cohort consisted of individuals diagnosed with idiopathic NPH who underwent treatment with a programmable LP (lumboperitoneal) shunt. Diagnosis was established based on clinical, radiological, and supplemental tests, with all patients presenting the clinical trial of NPH and undergoing neurological assessment and examination for papilledema. Brain CT scans and MRIs were utilized to rule out alternative pathologies. Intracranial pressure (ICP) measurement was performed via lumbar puncture, with cerebrospinal fluid (CSF) obtained for laboratory analysis, including evaluation of appearance, glucose, protein, white blood cell count, and differentiation. Patients meeting clinical and radiological criteria underwent CSF withdrawal through lumbar puncture, followed by analysis.

Inclusion and exclusion criteria

The inclusion criteria for this study encompassed patients with a confirmed diagnosis of idiopathic NPH, excluding other potential causes of symptoms and ensuring no contraindications for LP shunt placement. Specifically, patients must exhibit symptoms consistent with NPH, undergo evaluations ruling out alternative causes, and have no spinal deformities or infections contraindicating shunt placement. The study excluded patients who refused shunting surgery or confirmatory tests or who refused to participate in the study or follow-up visits.

Interventions and outcome measurement

The Black Grading System for Shunt Assessment [8] and the NPH Recovery Rate (based on the clinical grading for NPH of Kiefer) [9] were employed to express the results of the clinical examinations. The results of all graded examinations were divided into four clinical outcome groups: An NPH recovery rate of approximately 7.5 (75–100% improvement) in the excellent group indicates a restoration of pre-morbid activity levels. Good: A rate of approximately 5 (50–74% improvement) suggests a modest decrease in activity levels. Poor: Transient or no improvement, defined by a rate of < 2 (partial improvement up to 19% or deterioration) and Fair: Partial improvement, defined by a rate of ≥ 2 (20–49% improvement) [6,10,11]. The Japan NPH Grading System, also known as the Japanese Ministry of Health and Welfare (JMHW) scale, is a diagnostic tool for assessing the severity of normal pressure hydrocephalus (NPH). It evaluates symptoms of gait disturbance, cognitive impairment, and urinary incontinence. The scale typically ranges from 0 to 4 for each symptom, with higher scores indicating more severe impairment. This grading system helps clinicians diagnose and monitor the progression of NPH [12]. The valve used in this study was manufacturer-adjusted or adjusted to the proper initial performance level (P/L) setting before implantation. Patients were positioned in the left lateral decubitus position under general anesthesia, with preoperative antibiotics administered. The head was positioned up, with the right hip and knee flexed. A small, low back midline incision (approximately 2.5 cm) was made in the lumbar region between L3-L4, followed by the insertion of a 14-gauge Tuohy needle into the subarachnoid space. Upon observing cerebrospinal fluid (CSF) flow, a stainless-steel guidewire with an adjustable stop facilitated the insertion of the lumbar catheter, pre-flushed with normal saline, through the Tuohy needle into the subarachnoid space. The Tuohy needle was removed, and the lumbar catheter was secured to the fascia using a fixation tab and non-absorbable sutures. A left abdominal paramedian incision (approximately 4 cm) was made to expose the peritoneum, followed by a left flank incision (approximately 3 cm) over a rib at the mid-axillary line for valve placement. A passer was used to pass the peritoneal catheter from the abdominal to the flank incision, after which it was connected to the valve and secured with encircling ligatures. The passer was then used to pull the lumbar catheter from the flank to the lumbar incision. Once CSF flow was confirmed from the peritoneal end, a small opening was made in the peritoneum to insert the peritoneal end into the peritoneal cavity. The peritoneal catheter was then secured to the fascia using a provided fixation tab. All layers were closed using absorbable suture material, followed by closure

of the skin using non-absorbable sutures. This detailed surgical technique ensured the precise placement and secure fixation of the lumboperitoneal shunt components, facilitating optimal CSF diversion and patient outcomes in managing idiopathic NPH. After completion of the surgery and recovery from general anesthesia, patients were monitored in the neurosurgery ward for 24-48 hours to assess for potential complications such as CSF collection or leakage. Patients received intravenous (IV) antibiotics, typically Ceftriaxone or Ceftazidime (1 gm twice daily), unless contraindicated due to allergy, in which case Amikacin (500 mg vial) was administered. IV analgesia, including paracetamol infusion (1 gm three times/day) with Nefopam IV ampule (20 mg as needed), was provided to manage pain. Patients were instructed to remain supine for several hours post-surgery to minimize the risk of headache, followed by encouragement to initiate oral intake once bowel sounds were positive. If no complications arose within 24 hours postoperatively, patients were discharged home on day 1 with a regimen of injectable antibiotics (Ceftriaxone 1 gm once daily), oral analgesia (Paracetamol 500 mg tablets three times daily), and daily wound dressing changes after cleansing with a proper antiseptic such as diluted Betadine. Patients were given a discharge card containing instructions for medication administration, wound care, and recommendations for follow-up visits. A follow-up visit within a week to 10 days was scheduled for stitch removal (if wound healing was satisfactory) and reassessment of the performance level (P/L), with adjustments made if necessary for patients with programmable shunts. A second follow-up visit, typically four weeks postoperatively, was recommended to assess the patient's presenting symptoms, monitor for complications, and reassess the performance level (P/L) as needed. During both follow-up visits, thorough documentation of symptoms, complications, and any adjustments to the P/L was recorded. Patients were educated about potential complications and advised to seek further medical attention if any issues arose during the postoperative period, emphasizing the importance of ongoing monitoring and management.

Statistical analysis

Data was analyzed using descriptive and inferential statistics with a 95% confidence level using SPSS version 26. The continuous data was checked for normality using Shapiro-Wilk and Kolmogorov-Smirnov tests. The Wilcoxon signed-rank test was used for related ordinal data, while the paired sample t-test was used for scale data. Regression analysis was used to evaluate factors affecting operative time.

RESULTS

Six (30%) of patients were female, with a female to male ratio of 2.1:1. The age range of the patients was 62–86 years, with a mean value of 72 years, as shown in Figure 1.

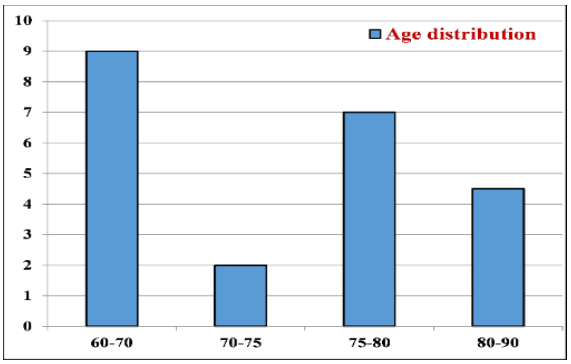

Figure 1: Age distribution of patients

Regarding the symptoms that the patients studied showed, all of them were part of a clinical trial, and papilledema was not present in any of them (100%); all of them were graded using the Japan NPH Grading System (Table 1).

Table 1: Presenting features (Japan NPH Grading System)

Symptom/sign	Grade	n (%)
Gait Apraxia	0	0(0.0)
	1	1(5)
	2	2(10%)
	3	9(45)
	4	8(40)
Urinary Incontinence	0	0(0.0)
	1	1(5)
	2	5(25)
	3	10(50)
	4	4(20)
Dementia	0	0(0.0)
	1	1(5)
	2	5(25)
	3	10(50)
	4	4(20)
Japan NPH Grading System score	0-3	0(0.0)
	3-6	1(5)
	6-9	7(35)
	9-12	12(60)

Opening intracranial pressure for all patients was within the normal range. The CSF appearance was clear in all patients, and the analysis results of the obtained CSF showed a glucose range of 33–75 mg/dl (mean value of 50.67 mg/dl) and a protein range of 21–55 (mean value = 33.93). All patients had an initial performance level of 2.5, with 85% of them changing to level 1.5 on the last visit, as shown in Table 2.

Table 2: The number and percentage of patients based on their performance level

Performance level	Pressure range (mmH_2O)	Initial PL	Final PL	*p*-value
0.5	0-30	0(0.0)	0(0.0)	
1.0	10-60	0(0.0)	0(0.0)	
1.5	55-115	0(0.0)	17(85)	0.001
2.0	105-170	0(0.0)	0(0.0)	
2.5	155-255	20(100)	2(5)	

Only one patient needs shunt removal due to the development of complications. The Wilcoxon Signed Rank Test showed significant changes in performance level between the initial and final performance levels. Table 3 shows that the post-op JNPHGS was statistically higher than the preoperative score after

the insertion of an adjustable LP shunt, with a *p*-value less than 0.001.

Table 3: Japan NPH Grading System (JNPHGS) score mean, and standard deviation categorized by gender

		Pre-operative JNPHGS	Post-operative JNPHGS	Mean difference	*p*-value
Gender	Female	7.50±2.74	4.67±4.18	2.83	0.016
	Male	9.50±1.45	4.36±3.05	5.14	0.001
Total		8.9±2.07	4.45±3.32	4.45	0.001

The rate of improvement showed that 35% of them had an excellent recovery rate, as shown in Figure 2.

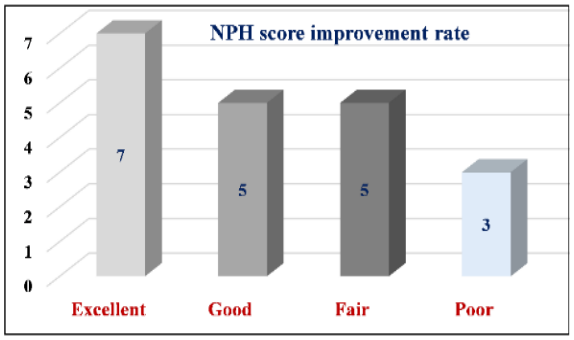

Figure 2: The NPH score improvement rate.

Table 4 provides further details on the most common post-op complications encountered, which included over-shunting (15%), subdural hygroma, CSF collection, and infection (10%).

Table 4: Post-operative complications

Complication	n (%)
Over shunting	3(15)
Subdural hygroma	2(10)
CSF collection	2(10)
Infection	2(10)
Slipping upper end	1 (5)
Slipping lower end	1(5)
Affected by magnetic	0(0.0)
Revision	2(10)
Subdural hematoma	1(5)
Removal	1(5)
Weakness and radiculopathy	1(5)

In this study, we observed improvement rates of 90% for gait, 80% for urinary symptoms, and 80% for dementia. Most patients underwent an uneventful post-op period with a mean average hospital stay of 1.75 days, as shown in Figure 3.

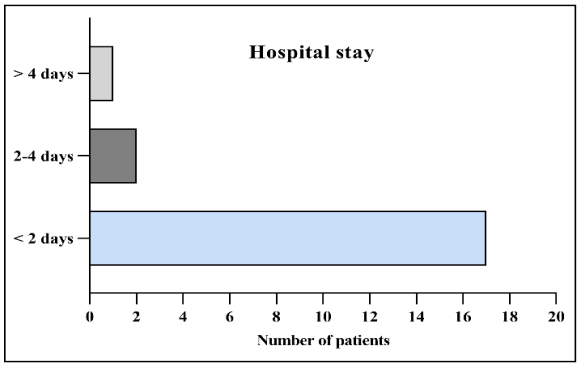

Figure 3: Postoperative hospital stays.

60% of the patients had post-op pain scores of 4-6, and 40% scored between 1-3. Most patients experienced a smooth intraoperative course, with an average mean surgery time of 64.5 minutes; only two cases (10%) encountered challenges in passing the Touhy needle, necessitating the use of intraoperative fluoroscopy, and two cases (10%) struggled to pass the upper-end tube due to canal stenosis, a problem resolved with the use of a tube guide wire. Figure 4 presents a polygon that illustrates the duration of symptoms prior to surgical intervention. Most patients presented between 2–4 months. When evaluating predictors of operative time, the regression analysis revealed no significant factor predicting operative time.

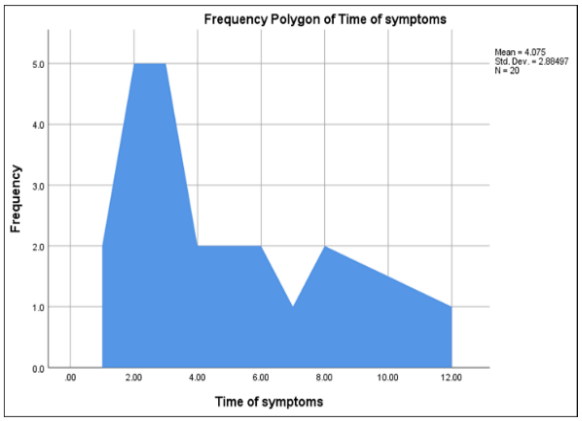

Figure 4: The length of symptoms before surgery.

DISCUSSION

This study evaluated the efficacy of programmable shunts on a sample of 20 Iraqi patients, focusing on postoperative clinical improvement and complication rates. LP shunts are seldom used for iNPH treatment in Iraq. The high complication rate and cost of LP shunts, as reported by other researchers [10,13], are the most significant contributing factors to this low usage. Toma *et al.* [14] conducted a study that implemented LP shunts in 20 patients with an average age of 40.3 years, employing a Strata NSC programmable valve. They found that seven of their patients (35%) required shunt revision. Most of these cases involved patients with idiopathic intracranial hypertension and slit-ventricle syndrome, who were typically young and engaged in daily activities. We hypothesize that elevated CSF pressure and trunk movement may contribute to the displacement of proximal/distal shunt catheters. Despite the limited number of reports on using LP shunts for iNPH treatment, Bloch and McDermott conducted LP shunts in 33 iNPH patients utilizing the Integra H/V valve systems. They found that nine patients (27%) required reoperation during the average follow-up period of 19 months [15], whereas in our study, the reoperation rate was 15%. Although the follow-up period of our cases was short, the rate of complications requiring shunt revision was 2 of 20 cases (10%). Compared to those previously listed, the lower complication rates found in this study may be because older iNPH patients with LP shunts are less active and have lower CSF pressure, which leads to fewer complications. The study by Bayar *et al.* (2016) [16], which involved 65 iNPH patients, had a mean follow-up time of three

months. In contrast, our study included 20 patients with a mean follow-up time of 6 months. Bayar *et al*.'s study comprised 46.2% females. In comparison, this study consisted of 30% females and 70% males. Additionally, the mean age in a study by Bayar *et al*. was 53.7 years, while in this study, it was 70.5 years. Regarding the clinical trial, Bayar *et al*. demonstrated improvement in gait (80%), urinary symptoms (72%), and dementia (87%). In comparison, our study showed improvement rates of 90%, 80%, and 80%, respectively, for gait, urinary symptoms, and dementia. Moreover, three patients (4.6%) experienced postoperative CSF leak or collection in the early postoperative period, according to Bayar *et al*. [16]. In comparison, our study had only one patient (5%) who developed CSF collection in the early postoperative period. Furthermore, we treated two instances (3%) of surgical site infection conservatively. Two patients (10%) in this study experienced surgical site infections, for which they received conservative treatment.

Conclusion

Programmable LP shunts have proven effective in treating iNPH patients despite initial unfamiliarity and a higher complication rate. They offer minimal invasiveness, and a lower risk of lethal complications compared to other shunt procedures. The programmable feature allows for easy valve setting adjustment, helping reverse over-drainage and under-drainage issues without revision surgeries. Additionally, it prevents or reduces complications like distal end obstruction by accommodating different tube widths.

Conflict of interests

No conflict of interest was declared by the authors.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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