

Original Article

Comparative study of lumboperitoneal shunt and ventriculoperitoneal shunt in the treatment of idiopathic normal pressure hydrocephalus

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Abstract: Objective: This study aimed to compare lumboperitoneal shunt (LPS) and ventriculoperitoneal shunt (VPS) in the treatment of idiopathic normal pressure hydrocephalus (iNPH). Methods: From September 2016 to November 2019, 76 iNPH patients who underwent shunt operation were recruited and assigned to a lumboperitoneal shunt group (LPS group, n=40) and a ventriculoperitoneal shunt (VPS group, n=36) according to different treatment methods. The right first time (RFT) and improvement in triad of the two groups were observed. Keifer's hydrocephalus score (KHS) was used to evaluate the improvement of clinical symptoms, Mini-Mental State Examination (MMSE) and National Institutes of Health Stroke Scale (NIHSS) were used to evaluate the improvement of cognitive function, and the Functional Independence Measure (FIM) to evaluate the postoperative living status of patients. The two groups of patients were followed up for 6 months to observe the postoperative curative effect and incidence of complications. Results: The RFT of LPS group was markedly higher than that of VPS group. There was no remarkable difference in the improvement of triad, KHS score, MMSE score, NIHSS score, and FIM score between the two groups after treatment, as well as overall response rate (ORR) after six months. The total incidence of complications in LPS group was considerably lower than that in VPS group. Conclusion: LPS and VPS have similar curative effect in the treatment of iNPH, but LPS can avoid intraparenchymal hemorrhage (IPH) caused by ventricular puncture, and it increases the RFT.

Keywords: Lumboperitoneal shunt, ventriculoperitoneal shunt, idiopathic normal pressure hydrocephalus, comparative study

Introduction

Idiopathic normal pressure hydrocephalus (iNPH) refers to a group of hydrocephalus syndromes that occur without a clear etiology of ventriculomegaly but with normal cerebrospinal fluid (CSF) pressure [1]. Patients with this disease are mainly characterized by unexplained unsteady gait, urinary incontinence and cognitive decline [2]. Clinical evidence suggests that iNPH occurs most often in elderly patients, with an insidious onset, and that once patients undergo disease progression, their health may deteriorate over several months, seriously affecting the quality of life (QOL) [3]. With the aging of the population, iNPH brings great challenges to clinical diagnosis and treatment.

At present, shunt operation is still the main therapy [4]. Among them, lumboperitoneal shunt (LPS) and ventriculoperitoneal shunt (VPS) are the most commonly used shunt methods in the clinic [5]. LPS relieves hydrocephalus by draining CSF from the subarachnoid space in the lumbar segment through a shunt into the abdominal cavity [6]. It is simple, safe, and causes no damage to brain tissue and avoids complications such as intracranial hemorrhage [7]. According to the team of Sun, LPS is an effective method for patients with communicating hydrocephalus, and it can alleviate their clinical symptoms with relatively low incidence of postoperative complications and leaves patients with a good QOL [8]. Ventriculoperitoneal shunt (VPS) is the most commonly used and it

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is a classic surgical method in treating hydrocephalus [9]. However, ventricular puncture is required first, which is a technically demanding method and it is prone to brain tissue damage and postoperative complications such as intracranial hemorrhage, tube blockage and epilepsy [10]. Benveniste RJ and Sur S showed that the symptoms of most patients with normal pressure hydrocephalus (NPH) were alleviated after VPS treatment [11]. In this study, patients with iNPH were treated with LPS and VPS, and the impacts of the two different methods on clinical symptoms, curative effect and postoperative complications were observed, thus providing reference for the treatment of patients with iNPH.

Materials and methods

General data

From September 2016 to November 2019, 76 iNPH patients who underwent shunt operation were recruited and assigned to a LPS group (n=40) and a VPS group (n=36) according to different treatment methods. Inclusion criteria: patients in both groups were confirmed with iNPH after diagnosis [12]; patients volunteered to participate in this study; before operation, the patients had at least one typical iNPH triad (unsteady gait, cognitive dysfunction, urinary incontinence). Imaging showed that the patient's Evan's index was over 0.3, and CSF pressure was lower than 200 mmHg. This study was conducted with the approval of the ethics committee of the Aviation General Hospital of China Medical University, and a fully informed consent form was obtained from all the subjects and their families. Exclusion criteria: patients who participated in other clinical trials within six months; patients who had other diseases of ventriculomegaly; patients that did not cooperate with medical staff to complete treatment; patients who suffered from mental diseases or consciousness disorders; patients who quit the experiment halfway; patients who were lost to follow up.

Treatment methods

LPS group: the patient was asked to rest in lateral position, with knees, hips and neck flexed. Then the intervertebral space of L4-5 or L3-4 was determined as the puncture point for this operation. The doctor made a local skin inci-

sion about 0.5 cm, and then inserted the beveled needle into the upper head and pulled out the needle core after a breakthrough sensation. When CSF flowed out, the shunt tube was inserted into the lumbar cistern along the puncture needle guard (with a depth of 4-5 cm). Then, a 3 cm incision was made at the upper end of the iliac crest, and the shunt tube was guided into the incision. The doctor selected the anti-McBurney point or the McBurney point for the abdominal incision of the patient, and led the abdominal section of the shunt tube to the incision on the upper iliac crest through the subcutaneous tunnel. The distal and proximal shunts and the extracorporeal adjustable pressure shunt valve were connected in the prescribed direction, and the skin incision was closed with a fixed ligature using silk thread.

VPS group: an incision of approximately 3 cm was made at 6-7 cm above the patient's external occipital protuberance, with a midline point opened 3 cm beside the midline, and the patient's skull was drilled. The dura was incised and then punctured in a direction parallel to the sagittal plane. The puncture was aligned with the superciliary ridge and a subcutaneous tunnel was made along the patient's neck and behind the ear to a depth of 4-5 cm. An incision was made right next to the subxiphoid process and a shunt was introduced and connected in the same way. The skin was then sutured and the operation was completed.

Outcome measures

(1) Right first time (RFT): the RFT of the two groups was observed.

(2) Improvement of triad: patients in both groups presented with one or more of the triad signs before treatment, and the improvement of the triad signs after treatment was observed in the two groups.

(3) Clinical symptoms: Keifer's hydrocephalus score (KHS) [13] was applied to evaluate the improvement in clinical symptoms of the two groups before and after treatment. The total score of the scale was 25. The higher score after evaluation indicates more serious symptoms.

(4) Cognitive function: the Mini-Mental State Examination (MMSE) score [14] and National

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Table 1. Comparison of general data between the two groups [n (%)]/(mean ± SD)

Classification	LPS group (n=40)	VPS group (n=36)	t/ χ^2 value	P value
Gender			0.037	0.846
Male	22 (55.00)	19 (52.78)		
Female	18 (45.00)	17 (47.22)		
Average age (years)	72.12±7.06	72.94±7.03	0.506	0.613
BMI (kg/m ²)	22.79±2.13	23.08±2.12	0.594	0.554
Course of disease (month)	1.24±0.35	1.31±0.37	0.847	0.399
Duration of symptoms (d)	22.54±2.14	22.72±2.19	0.362	0.718
Food preference			0.071	0.789
Light	21 (52.50)	20 (55.56)		
Spicy	19 (47.50)	16 (44.44)		
Place of residence			1.145	0.264
City	24 (60.00)	17 (47.22)		
Countryside	16 (40.00)	19 (52.78)		
Ethnicity			1.126	0.288
Han	28 (70.00)	21 (58.33)		
Minority	12 (30.00)	15 (41.67)		
Education background			1.839	0.175
≥ high school	16 (40.00)	20 (55.56)		
< high school	24 (60.00)	16 (44.44)		
Smoking history			0.337	0.561
Present	27 (67.50)	22 (61.11)		
Absent	13 (32.50)	14 (38.89)		
Drinking history			0.015	0.900
Present	25 (62.50)	23 (63.89)		
Absent	15 (37.50)	13 (36.11)		

Table 2. Comparison of RFT between the two groups

Group	n	Success rate (%)	
		RFT (%)	Non-RFT (%)
LPS group	40	38 (95.00)	2 (5.00)
VPS group	36	28 (77.78)	8 (22.22)
χ^2	-	4.918	4.918
P	-	0.026	0.026

Institutes of Health Stroke Scale (NIHSS) score [15] were utilized to assess the cognitive dysfunction of the two groups of patients before and after treatment. The total score of MMSE was 30, with 26-30 as normal, 21-25 as mild dementia, 10-20 as moderate dementia, and 0-9 as severe dementia. The total score of NIHSS was 42, and the higher score indicates a more serious neurological deficit.

(5) Living status: The Functional Independence Measure (FIM) scale [16] was utilized to evaluate the living status of the two groups of patients before and after treatment, with a total score of 126. The lower score after evaluation indicates a worse self-care ability of the patients.

(6) Overall response rate (ORR): the curative effect of patients was evaluated six months after operation. Cured: after treatment, the patient was conscious, the triad signs basically disappeared, and the patients was able to resume daily work, and the cranial ventricle was normalized by cranial CT examination. Improved: the patient was conscious after treatment, the triad signs were alleviated, and the patient had basic self-care ability and smaller ventricle than before. Invalid: the clinical symptoms of patient were not relieved or were even aggravated, and the ventricles were reduced, unchanged or further enlarged according to CT examination. ORR = (cured number of cases + improved number of cases)/total number of cases ×100%.

(7) Complications: the complications during operation were observed in both groups.

Statistical significance

SPSS 25.0 (Beijing EasyBio Co., Ltd., China) was adopted for statistical analysis, and GraphPad Prism 7 was used for data illustration. The counting data were expressed as [n (%)], and compared using chi-square test. When the theoretical frequency in chi-square test was less than 5, continuity correction Chi-square test was adopted. The measurement data were expressed by mean ± standard deviation (mean ± SD), and compared using independent sample t-test. Paired t-test was utilized for intra-group comparison before and after treatment. When P < 0.05, the difference was statistically significant.

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Table 3. Improvement of triad in the two groups

Group	n	Instability of gait		Cognitive disorder		Urinary incontinence	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
LPS group	40	30 (75.00)	20 (50.00)	25 (62.50)	16 (40.00)	32 (80.00)	11 (27.50)
VPS group	36	31 (86.11)	21 (58.33)	23 (63.89)	17 (47.22)	29 (80.56)	10 (27.78)
χ^2	-	1.477	0.529	0.015	0.402	0.003	0.001
P	-	0.224	0.466	0.900	0.525	0.951	0.978

Table 4. Comparison of KHS scores between the two groups before and after treatment

Group	n	KHS score	
		Before treatment	After treatment
LPS group	40	10.07±1.12	6.07±0.43
VPS group	36	10.11±1.15	6.11±0.11
t	-	0.153	0.542
P	-	0.878	0.589

Results

General data

The general data of patients were collected and shown in **Table 1**.

Comparison of RFT between the two groups

According to our comparison, the RFT of the LPS group was 95.00%, which was markedly higher than that of the VPS group (77.78%) ($P < 0.05$), as shown in **Table 2**.

Improvement of triad in the two groups after treatment

Before treatment, patients in both groups had one or more signs of triad, with no remarkable difference in the incidence of unsteady gait, cognitive dysfunction and urinary incontinence ($P > 0.05$). After treatment, the incidence of the above symptoms was markedly lower than that before treatment ($P > 0.05$), as shown in **Table 3**.

Comparison of KHS scores between the two groups before and after treatment

Our comparison of KHS scores revealed no remarkable difference between the two groups before treatment ($P > 0.05$). The scores were improved after treatment, and lower than those before treatment ($P > 0.05$), as shown in **Table 4**.

Improvement in cognitive function in the two groups before and after treatment

We compared the cognitive function of the two groups, and found no marked difference in MMSE and NIHSS scores before treatment ($P > 0.05$). After treatment, the scores of the two groups were improved, and were lower than those before treatment ($P > 0.05$), as shown in **Figure 1**.

Comparison of FIM scores between the two groups before and after treatment

We witnessed no considerable difference in FIM score between the two groups before treatment ($P > 0.05$). After treatment, the scores of patients in both groups were improved, and were lower than those before treatment ($P > 0.05$), as shown in **Figure 2**.

Comparison of ORR between the two groups after six months of treatment

We followed the patients for the assessment of curative effect after six months and acquired the ORR of 90.00% in LPS group and 88.89% in VPS group, indicating no remarkable difference ($P > 0.05$), as shown in **Table 5**.

Comparison of incidence of complications after treatment in the two groups

After treatment, the total incidence of complications was 7.50% in the LPS group, which was markedly lower than that in the VPS group (25.00%), with statistical significance ($P < 0.05$), as shown in **Table 6**.

Discussion

INPH, a disease mostly seen in the aging population, is also a specific type of hydrocephalus [17]. The ventricular system of patients with INPH is clearly enlarged, and with lumbar punc-

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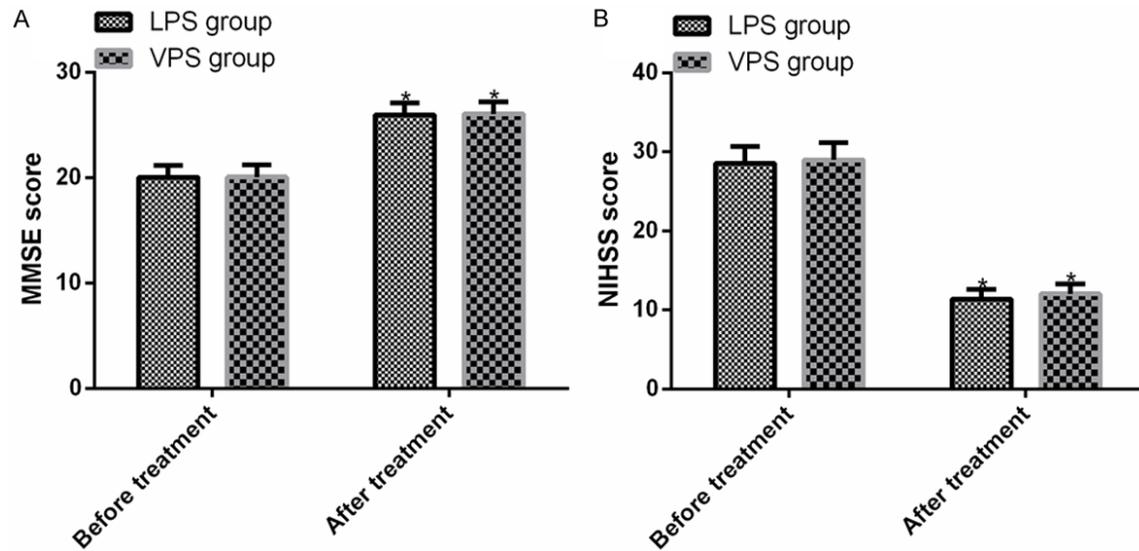


Figure 1. Comparison of cognitive function between the two groups before and after treatment. A. There is no significant difference in MMSE score between the two groups before and after treatment, and the score of the two groups after treatment is lower than that before treatment. B. There is no significant difference in NIHSS score between the two groups before and after treatment, and the score of the two groups after treatment is lower than that before treatment. Note: * $P < 0.05$ vs. before treatment.

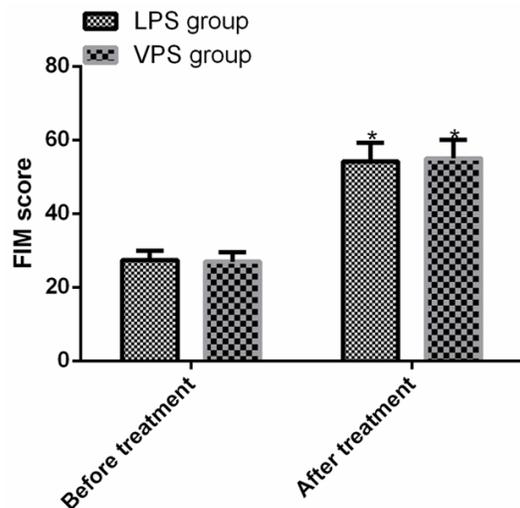


Figure 2. Comparison of FIM scores between the two groups before and after treatment. There is no significant difference in FIM score between the two groups before and after treatment, and the score of the two groups after treatment is lower than that before treatment. Note: * $P < 0.05$ vs. before treatment.

ture patients have normal intracranial pressure [18]. Triad syndrome, as with its classic symptoms, seriously affects the QOL of patients and brings heavy burden to family and society [19], but some patients' symptoms can be soothed after CSF shunt operation [20].

In this study, we treated iNPH patients with two different shunt interventions and found that the prognosis of the two groups of patients was improved to varying degrees after treatment. According to the team of Tervonen, most patients with hydrocephalus who were treated with VPS received shunt modification after 8 months [21]. In the present study, the RFT in the LPS group was notably higher than that of the VPS group. We speculated the thicker subcutaneous tissues in the abdomen and ilio-lumbar region better protected the CSF shunts, thus leading to notably higher RFT in the LPS group. INPH patients may have triad symptoms such as unsteady gait, urinary incontinence and cognitive decline [22]. Previous studies have shown that VPS can improve the triad of iNPH patients and ameliorate their clinical symptoms [23]. After three months of LPS treatment, almost all triad symptoms were relieved in iNPH patients with and without AD [24]. The above studies are also similar to the results of this one, which showed that both LPS and VPS can improve the clinical triad symptoms of iNPH patients, and that no marked difference was found in the improvement degree between the two groups, indicating that both shunts have the same effects on alleviating the triad symptoms of patients with iNPH. Here, KHS score was applied to compare the improvement

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Table 5. Comparison of ORR of the two groups between the two groups after half a year of treatment

Group	n	Cured	Improved	Invalid	ORR (%)
LPS group	40	23 (57.50)	13 (32.50)	4 (10.00)	36 (90.00)
VPS group	36	20 (55.56)	13 (33.33)	4 (11.11)	32 (88.89)
χ^2	-	-	-	-	0.062
P	-	-	-	-	0.801

Table 6. Comparison of incidence of complications after treatment in the two groups

Group	n	Adjustment of shunt	Tube blockage	Infection	Epilepsy	Intracranial hematoma	Brain parenchyma edema	Total incidence rate (%)
LPS group	40	1 (2.50)	1 (2.50)	0 (0.00)	0 (0.00)	0 (0.00)	1 (2.50)	3 (7.50)
VPS group	36	1 (2.78)	2 (5.56)	0 (0.00)	0 (0.00)	4 (11.11)	2 (5.56)	9 (25.00)
χ^2	-	0.005	0.466	-	-	4.691	0.466	4.364
P	-	0.939	0.494	-	-	0.030	0.494	0.036

of postoperative clinical symptoms between the two groups. No considerable difference was found in the improvement degree of postoperative clinical symptoms between the two groups, indicating that LPS and VPS shunts have similar effects on iNPH patients. INPH can cause cognitive dysfunction in patients, while shunt therapy can improve it [25]. In this study, different shunt operations were given to iNPH patients, and the results showed no marked difference in MMSE score and NIHSS score between the two groups after treatment. Such results as above suggested that LPS and VPS can improve the neurological function of patients on the basis of reducing intracranial pressure, thus reducing the occurrence of cognitive dysfunction.

INPH is a chronic and progressive disease, which affects patients' QOL [26]. After treatment of LPS and VPS, both groups of patients had elevated FIM scores, illuminating that the two different shunt operations can improve the living status and QOL of patients. After that, we followed the patients for 6 months, and observed the curative effects. We found no marked difference in the ORR between the two groups, which proved no remarkable difference in the curative effects of the two shunt operations. At last, we followed up the incidence of complications six months after operation. The total incidence of complications after treatment in the LPS group was notably lower than that in the VPS group, which may be due to the fact that LPS can prevent IPH caused by ven-

tricular puncture, and therefore LPS is safer than VPS.

Although this study confirmed that LPS and VPS treatment of iNPH is feasible, but there is still room for improvement. The factors affecting the prognosis of patients could be observed and analyzed, and the postoperative recurrence rate and factors leading to recurrence should be investigated. In future studies, it is necessary to extend the research time and add postoperative follow-up to further support the results of this study.

To sum up, LPS and VPS have similar curative effects in the treatment of iNPH, but LPS can avoid IPH caused by ventricular puncture and increase the RFT.

Disclosure of conflict of interest

None.

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