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Effects of shunt types used in idiopathic normal pressure hydrocephalus on patients' clinical outcomes

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Abstract

Aim: Idiopathic normal pressure hydrocephalus (iNPH) is a surgically reversible neurological disease in adults. It is a neurological condition characterized by ventricular enlargement detected on cranial imaging as well as gait defect, cognitive reduction, and urinary incontinence, with no other reason to explain the clinical findings. Ventricular shunting, predominantly ventriculoperitoneal (VP) shunting, has been shown to be successful in relieving symptoms in patients. In this study, we aimed to investigate the effects of two VP shunts used in the iNPH patients treated in our clinic.

Materials and Methods: Clinical and laboratory records of 28 patients who underwent VP shunting due to iNPH were reviewed retrospectively via the Enlyl system. A programmable shunt was inserted in 9 (32.1%) and a medium-pressure shunt was inserted in 19 (67.9%) patients.

Results: There was no significant difference between the two shunt types with regard to patient age, gender, and preoperative tests ($p>0.05$). However, the prevalence of ataxic gait was significantly higher in the Programmable Shunt group compared to the Medium-Pressure Shunt group ($p<0.05$). Conversely, no significant difference was found between the shunt types with regard to postoperative examination findings and additional neurological disorders ($p>0.05$ for both).

Conclusion: In the present study, no significant difference was observed between the shunt types with regard to clinical outcomes and thus both types of shunts were revealed as viable options.

Introduction

Idiopathic normal pressure hydrocephalus (iNPH), initially defined in 1965, is a reversible disease in adults [1]. It is a neurological condition characterized by ventricular enlargement detected on cranial imaging as well as gait defect, cognitive reduction, and urinary incontinence, with no other reason to explain the clinical findings [2]. Its prevalence is estimated to be 10-22 per 100,000 populations, with 1.30% in individuals aged 65 years, and 5.9% in those aged 80 years [3]. Most important feature of iNPH is that the cerebrospinal fluid (CSF) pressure of an the patients is within normal ranges. Cranial imaging typically shows ventriculomegaly, periventricular hyperintensities, broad Sylvian fissures, a narrowed subarachnoid cavity, and cortical sulci at the high convexity [4].

Unlike the secondary normal pressure hydrocephalus, this has a known etiology, the exact etiology of iNPH remains unknown. Moreover, different mechanisms have been proposed to cause the development of iNPH, whereas its specific pathogenesis remains unclear [5]. The initial accurate diagnosis of iNPH is becoming more and more important due to the high prevalence of iNPH in the elderly population and the demonstration that CSF can be cured with ventriculoperitoneal (VP) shunt surgery [6].

Ventricular shunting, predominantly VP shunting, has been proven to be successful in relieving symptoms in approximately 60-80% patients [7]. In addition, some other strategies such as recurring large-volume lumbar puncture represent alternative therapies that are seldom used for the treatment of iNPH. VP, or less frequently ventriculoatrial (VA), and lumboperitoneal (LP) shunts are the preferred methods for rerouting of CSF. Of these, VP shunt surgery, in which cerebrospinal fluid is diverted from the lateral ventricle to the abdominal space, is the most widely used treatment approach for iNPH in North America and Europe, whereas lumboperitoneal shunt surgery, in which CSF is diverted from the lumbar spinal subarachnoid space

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Table 1. Demographic and clinical data of patients.

		Min-Max	Median	Mean±SD/ n/%
Age (years)		23.0 - 80.0	51.0	52.5 ± 18.0
Gender	Female		13	46.4%
	Male		15	53.6%
Preoperative tests				
External lumbar drainage			8	28.6%
None			20	71.4%
Preoperative examination findings				
Ataxia			3	10.7%
Ataxic gait			10	35.7%
Vertigo			1	3.6%
Diplopia			2	7.1%
Urinary incontinence			13	46.4%
Hearing loss			1	3.6%
Memory loss			6	21.4%
Headache			19	67.9%
Amnesia			5	17.9%
Loss of consciousness			4	14.3%
Upper right extremity paresis			1	3.6%
Postoperative Examination	(-)		8	28.6%
	(+)		20	71.4%
Ataxic gait			4	14.3%
Urinary incontinence			4	14.3%
Amnesia			3	10.7%
Memory loss			2	7.1%
Ataxia			1	3.6%
Hearing loss			1	3.6%
Headache			1	3.6%
Vertigo			1	3.6%
Upper right extremity paresis			1	3.6%
Loss of consciousness			1	3.6%
Additional neurological disorders	No		25	89.3%
	Yes		3	10.7%
	Epilepsy		1	3.6%
	Cerebrovascular disease		2	7.1%
	Parkinson's Disease		1	3.6%
Shunt site				
Right parieto-occipital			24	85.7%
Left parieto-occipital			4	14.3%

SD: Standard deviation.

to the abdominal cavity, is more and more widely used in Japan [8].

A study by Giordan et al. observed no significant changes among patients undergoing VP, VA, and LP shunting with regard to the cure of iNPH and the authors detected neurological improvement in 75% of the patients, which was higher than the predicted ratio [9]. In this study, we aimed to investigate the effects of two VP shunts used in the iNPH patients treated in our clinic.

Materials and Methods

The retrospective study reviewed the laboratory and clinical records of 28 patients who underwent VP shunting due to iNPH in Van Yüzüncü Yıl University Dursun Odabaş Hospital Neurosurgery Clinic between 2010 and 2021. A programmable shunt was inserted in 9 (32.1%) and a medium-pressure shunt was inserted in 19 (67.9%) patients. No sampling was selected in the study and thus all patients that underwent shunting due to a diagnosis of iNPH were included in the study. Patients were divided into two groups as those with programmable and medium-pressure shunts. The criteria for determining the patients in both groups are given below. An ethics committee approval was obtained from Van Yüzüncü Yıl University Non-Invasive Research Ethics Committee (Date 14.10.2022, No: 2022/10-26).

Demographic and clinical characteristics including age, gender, pre- and post-operative neurological examinations, initial postoperative neurological findings, additional neurological disorders, type of shunt inserted, shunting site, perioperative complications, postoperative imaging, and preoperative lumbar puncture administration were reviewed for each patient (Table 1 and 2). Patients with incomplete medical records and those who had adult hydrocephalus with a known cause were excluded from the study.

Statistical analysis

Data were analyzed using SPSS 28.0 for Windows (Armonk, NY: IBM Corp.). Descriptives were expressed as

Table 2. Demographic and clinical data of patients.

		n	%
Initially improved symptom after surgery			
Ataxia		2	7.1%
Headache		13	46.4%
Urinary incontinence		6	21.4%
Loss of consciousness		4	14.3%
Diplopia		2	7.1%
Ataxic gait		1	3.6%
Complication	(-)	14	50.0%
	(+)	14	50.0%
Complication type			
Subdural effusion		6	21.4%
Revision		3	10.7%
Slit ventricle syndrome		1	3.6%
Cerebral edema		1	3.6%
Epidural hematoma surgery		1	3.6%
Death		1	3.6%
Intracerebral hemorrhage		1	3.6%
Subdural hematoma		1	3.6%

Table 3. Demographic data of patients with programmable and medium pressure shunts.

		Programmable shunt			Medium-pressure shunt			p
		Mean±SD/n/%		Median	Mean±SD/n/%		Median	
Age (years)		59.0 ± 21.9		63.0	49.4 ± 15.5		41.0	0.209 ^{m}
Gender	Female	4	44.4%		9	47.4%		0.885 $^{X^2}$
	Male	5	55.6%		10	52.6%		
Preoperative tests								
External lumbar drainage		4	44.4%		4	21.1%		0.201 $^{X^2}$
None		5	55.6%		15	78.9%		
Preoperative examination findings								
Ataxia		0	0.0%		3	15.8%		0.530 $^{X^2}$
Ataxic gait		6	66.7%		4	21.1%		0.019 $^{X^2}$
Vertigo		0	0.0%		1	5.3%		1.000$^{X^2}$
Diplopia		0	0.0%		2	10.5%		1.000$^{X^2}$
Urinary incontinence		6	66.7%		7	36.8%		0.139$^{X^2}$
Hearing loss		0	0.0%		1	5.3%		1.000$^{X^2}$
Memory loss		3	33.3%		3	15.8%		0.352 $^{X^2}$
Headache		6	66.7%		13	68.4%		0.926 $^{X^2}$
Amnesia		3	33.3%		2	10.5%		0.290 $^{X^2}$
Loss of consciousness		0	0.0%		4	21.1%		0.273 X^2
Upper right extremity paresis		0	0.0%		1	5.3%		1.000$^{X^2}$
Postoperative	(-)		33.3%		5	26.3%		0.701 $^{X^2}$
Examination	(+)		66.7%		14	73.7%		
Ataxic gait		2	22.2%		2	10.5%		
Urinary incontinence		3	33.3%		1	5.3%		
Amnesia		2	22.2%		1	5.3%		
Memory loss		1	11.1%		1	5.3%		
Ataxia		0	0.0%		1	5.3%		
Hearing loss		0	0.0%		1	5.3%		
Headache		0	0.0%		1	5.3%		
Vertigo		0	0.0%		1	5.3%		
Upper right extremity paresis		0	0.0%		1	5.3%		
Loss of consciousness		0	0.0%		1	5.3%		
Additional neurological disorders	No	8	88.9%		17	89.5%		1.000 $^{X^2}$
	Yes	1	11.1%		2	10.5%		
	Epilepsy	0	0.0%		1	50.0%		
	CVD	1	100%		1	50.0%		
	PD	1	100%		0	0.0%		

CVD: Cerebrovascular disease, SD: Standard deviation m Mann-Whitney U test / X^2 Chi-square test (Fischer's test).

Table 4. Comparison of programmable and medium pressure shunt.

	Programmable shunt		Medium-pressure shunt		p
	n	%	n	%	
Initially improved symptom					
Ataxia	1	11.1%	1	5.3%	1.000 $^{X^2}$
Headache	5	55.6%	8	42.1%	0.505 $^{X^2}$
Urinary incontinence	2	22.2%	4	21.1%	1.000$^{X^2}$
Loss of consciousness	0	0.0%	4	21.1%	0.273 $^{X^2}$
Diplopia	0	0.0%	2	10.5%	1.000 $^{X^2}$

mean, standard deviation (SD), median, minimum, maximum, frequencies (n), and percentages (%). Normal distribution of data was assessed using Kolmogorov-Smirnov test. Continuous variables were compared using Mann-

Whitney U test. A p value of 0.05 was considered significant.

Results

There was no significant difference between the shunt types with regard to patient age, gender, and preoperative tests ($p>0.05$). Similarly, no significant difference was detected between the shunt types with regard to comorbidities including preoperative ataxia, dizziness, diplopia, urinary incontinence, hearing loss, memory loss, headache, amnesia, loss of consciousness, and right upper extremity paresis ($p>0.05$). However, the prevalence of ataxic gait was significantly higher in the Programmable Shunt group compared to the Medium-Pressure Shunt group ($p<0.05$). On the other hand, no significant difference was found between the shunt types with regard to postoperative examination findings and additional neurological disorders ($p>0.05$ for both) (Table 3).

No significant difference was observed between the two shunt types with regard to initially improved symptom, shunting site, and complication rate ($p>0.05$ for all) (Table 4).

Discussion

A study by Andrén et al. showed that the symptoms of iNPH progressed over time and that unshunted iNPH patients had a significant deterioration in gait, balance, and cognitive performance as well as worsened scoring abilities during a mean follow-up of 13 months [10]. Additionally, such conditions have been reported in patients refusing shunt surgery due to the presence of additional diseases and the risk of surgery [11].

Patients awaiting treatment are likely to experience a wide range of clinical changes varying from a slight improvement in symptom progression to a marked decline in neurological functions during the waiting period. Theoretically, it can be assumed that such changes are a result of differences in progression rates due to diurnal waving, analysis error, differences in waiting times, characteristics of the iNPH itself, and the presence of comorbidities [12].

Hypertension is one of the most known risk factors for iNPH. Additionally, other vascular risk factors such as diabetes mellitus and hyperlipidemia have additionally been shown to be associated with iNPH [12]. Although the true pathophysiology of iNPH remains indefinite, studies suggest that the pathogenesis of iNPH may be associated with a change in CSF dynamics because of vascular dysfunction. On the other hand, there are studies arguing whether vascular risk factors are associated with clinical outcomes after shunt surgery [13].

A review by Toma et al. found that despite patient age, associated comorbidities, and poor mobility, the recovery rate following shunt placement in this patient population has increased in recent years and there has been a significant decrease in mortality and morbidity in this patient population [14].

Studies performing cortical biopsies for patients with iNPH have reported that 25–67.6% of the patients with iNPH had Alzheimer's disease and that this finding was associated with worse baseline cognitive performance and reduced postoperative outcomes in patients with iNPH [15].

A review by Thavarajasingam et al. found that CSF levels of phosphorylated tau and total tau increased significantly more in shunt-responsive iNPH patients in proportion to shunt-non-responsive iNPH patients [16].

In the primary stages of iNPH, cognitive defects are observed primarily in executive functions and working memory, which are cantilevered by frontostriatal circuits. Moreover, as the disease advances, cognition continuously declines, and cognitive deficits occur in many areas, leading to difficulties and immense financial burdens in daily life [17].

Despite much study, reliable predictors of positive outcomes after shunt surgery are still controversial [18]. In addition, surgery is associated with a 16% shunt revision ratio, a 3% infection rate, a 6% subdural hematoma, a 1% mortality rate, and an overall complication rate of almost 20% [14]. In our study, although similar rates of complications were obtained, no significant difference was found between the shunt types (Table 4).

A study conducted by Messerer et al. showed that the evaluation of iNPH patients by preoperative external lumbar drainage is highly important for postoperative outcomes and also for optimizing the selection of surgical candidates [19]. In our study, there was no significant difference between the shunt types with regard to the effect of the external lumbar drainage test on clinical outcomes (Table 3).

Nakajima et al. both administered and recommended programmable shunt placement in iNPH patients [20]. In our study, no major difference was detected between programmable shunt and normal-pressure shunt with regard to clinical outcomes and complication rate.

Our study was limited due to the small number of patients. Further studies with larger patient series are needed to confirm our findings.

Conclusion

Additional studies are under development to determine the etiology, diagnosis, and surgical treatment of iNPH. Additionally, there are ongoing discussions about medium-pressure shunt and programmable shunt, which are the most commonly preferred shunt types. In the present study, no significant difference was observed between the shunt types with regard to clinical outcomes and thus both types of shunts were revealed as viable options.

Ethics approval

Ethics Committee approval was obtained from Van Yüzüncü Yil University Faculty of Medicine Non-Invasive Research Ethics Committee (Date 14.10.2022, No: 2022/10-27).

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Author contributions

Concept (MEA, EC), Design (MEA), Data Collection and/or Processing (MEA, EC), Analysis and/or Interpretation (MEA, EC).

Conflict of interest statement

The authors have no conflict of interest for this study.

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