

# Results of Ventriculoperitoneal Shunt Surgery among Patients with Normal Pressure Hydrocephalus

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## ABSTRACT

**Objective:** An evaluation of the outcomes and risk factors for idiopathic normal-pressure hydrocephalus patients treated with Ventriculoperitoneal (VP) shunt

**Methods:** The retrospective analysis of 72 patients who were hospitalized to our institution and diagnosed with suspected idiopathic normal-pressure hydrocephalus (iNPH) were included. All of the patients in this research had VP-shunt surgery with a programmable valve, and their results were evaluated six months and two years following surgery, respectively, by means of the modified Rankin scale (mRS) and the Krauss index. Both multivariate and univariate regression analysis were used to recognize the factors of prognosis.

**Results:** 54 men and 18 women were among the 72 patients with probable iNPH, with an average age of  $70.4 \pm 7.2$  years. Symptoms lasted an average of  $22.5 \pm 17.9$  months. In the majority of patients, gait imbalance was the most prevalent presenting symptom. 90.3 percent of patients reported gait imbalance, urinary incontinence in 66.6%, and 52.7 percent had cognitive impairment.  $126.8 \pm 37.2$  mm H<sub>2</sub>O was the average lumbar opening pressure. During shunt implantation, the initial pressure of the valve was determined depending on the surgeon's preference and lumbar opening pressure. The average starting valve pressure was  $94.80 \pm 21.88$  mm H<sub>2</sub>O. Six months following surgery, 58 percent of the 72 patients improved their mRS scores, with 60 percent improving one step and 15.7 percent improving two steps. At 6 months after surgery, the proportion of subjects who were able to live independently (mRS score 1–2) augmented from 55.5 to 86.1 percent. The Krauss index after two years was  $0.55 \pm 0.29$ ; 21 (65.2%) subjects had an index  $>0.5$  and 68.1% of 38 patients were living independently (mRS 0–2). Particularly, at 6-month and 2-year results later to VP-shunt surgery did not vary substantially ( $p > 0.05$ ).

**Conclusion:** Patients with iNPH who underwent VP-shunts reported that their surgical therapy was well tolerated. The majority of patients reported a reduction in the severity of their preoperative symptoms. Patients with iNPH should be evaluated for the presence of several parallel co-morbidities, which must be regarded as unfavourable factor of prognosis.

**Keywords:** comorbidities, prognostic factors, normal pressure hydrocephalus, outcomes, ventriculoperitoneal shunt.

## INTRODUCTION

Idiopathic normal-pressure hydrocephalus is a chronic illness categorized by instability of gait, urinary incontinence and cognitive impairment. It is produced by a buildup of pressure in the normal pressure chamber of the brain<sup>1,2</sup>. It is one of the neuroradiological characteristics of normal CSF opening pressure to have dilated lateral ventricles (Evans index  $> 0.3$ ) or ventriculomegaly that is not clarified by only cerebral atrophy or by any other reason. iNPH is predicted to be present in 1.4–2.9 percent of older persons, depending on the source<sup>3,4</sup>. The typical age at which the disease first manifests itself is between 60 and 70 years<sup>5</sup>. In spite of the fact that the pathophysiological mechanism of iNPH is yet unknown, the symptoms of the condition are possibly reversible with CSF shunting surgery if caught early enough. Current therapy for iNPH involves surgically diverting the CSF from a dilated ventricle to either the peritoneum or another anatomical area in order to reduce the clinical symptoms produced by the dilated ventricles<sup>6,7</sup>. Presently, the ventriculoperitoneal shunt is the most often utilized shunt arrangement, with a success rate of up to 80 percent reported in certain studies. The use of adjustable valves makes it possible to make non-invasive adjustments to the pressure. Better results from shunt surgery are dependent on the cautious assortment of subjects and the screening of patients prior to surgical procedure<sup>8</sup>. As patients' diagnoses are made simply grounded on their neuroimaging and clinical history without the use of supplementary tests, there is a 50–60 percent chance that they will improve following shunt surgery<sup>9–10</sup>. Additional testing (such as external lumbar drainage, CSF resistance tests and spinal tap) has substantial benefits, and various analysis have recorded rate of improvement up to 91% in specific individuals who underwent these operations. In spite of the development of several predictive indicators for favorable shunt surgery results, the surgical outcome is still thought to be worsening with time<sup>11</sup>. Data on outcomes and clinical improvement following shunt surgery, however, are inconclusive due to the diverse approaches used to measure them, the alterations in analytical methods, fluctuating with times,

significant variations in post hospital care, and the use of different types of shunts and systems<sup>12</sup>. After shunt surgery, many studies have indicated prospective and persistent improvement in people with iNPH, with 27–91% of subjects viewing sustained and promising enhancement after 1–10 years<sup>13</sup>. This single-center study examined patient outcomes and prognostic factors after VP-shunt surgery in iNPH patients after six-months and two-years.

## MATERIAL AND METHODS

72 individuals with iNPH were included in the study. Age, gender, initial symptoms, symptom duration, Evans's index, pressure of CSF on lumbar puncture, intensity of symptoms, and shunt system starting pressure were all recorded for each patient. The hospital's institutional ethics committee has given its approval to this research.

All subjects were clinically evaluated by a multidisciplinary team (including a neurosurgeon and neurologist) and identified using standardized and unified algorithms in line with known iNPH principles, which were thereafter followed. We utilized the presence of standard triad, the neuroimaging and the tap test, to identify possible iNPH. Suspected iNPH symptoms were subjected to MRI in order to evaluate ventricular dilatation. It was decided to utilize a spinal tap test on individuals who exhibited ventriculomegaly ( $>0.3$  of Evans index) and minimum one of the three fundamental symptoms. Prior to the diagnostic spinal tap, the patient's gait was evaluated using the ten-meter walk test, and the subsequent data were documented: the time needed in seconds to walk 10 metres, the length of each step, the speed at which the patient walked, and the time necessary to turn 180 degrees (all measured in seconds). The mini-mental state test was used to measure cognitive abilities. Patient subjective sensations were used to assess urine incontinence, which ranged from normal to severe depending on the severity of the condition. By collection of 30–50 ml CSF, 24–72 hours following a spinal tap, a similar examination was repeated. Spinal tap response was definite as a 20% improvement in one of the assessed parameters or a 10%

improvement in 2 measured parameters in the patients' gait. Comorbidities were gathered from the patients' medical records. The comorbidity index score for each disease was determined with the use of a prediction tool for the success of the shunt procedure.<sup>16</sup>

Patients who had a favourable reaction to the spinal tap had a ventriculoperitoneal shunt operation done by a neurosurgeon utilizing a gravitational unit and an adjustable valve, according to routine surgical protocols (Miethke proGAV 2.0).

The clinical outcome was evaluated using the modified Rankin scale (mRS)<sup>26</sup> and the Krauss index<sup>27</sup> at each follow-up. We examined the impact of the shunt on the symptoms one by one using the Krauss index: 0 means no or little progress, 1 means moderate or excellent improvement, and 2 means a lot of improvement. The total Krauss improvement index was generated for each patient to assess their overall symptomatic improvement. When comparing patient outcomes, a fraction was employed, with the numerator reflecting the definite improvement grades for all cardinal symptoms and the denominator representing the maximum potential sum of improvement grades for the cardinal symptoms existing formerly the surgical procedure. This made it possible to make more precise comparisons between patients. This process yielded a number between 0 and 1 as a result. (0 indicates no change; 1 indicates that all three cardinal symptoms have improved). Researchers in prior study<sup>17,27</sup> calculated the improvement score for those who experienced all three cardinal symptoms as follows:

$$\text{Krauss Index} = 0.2(\text{gait}) + 0.2(\text{cognitive}) + 0.2(\text{urinary}) \text{ divided by } 6$$

OR, if the patients had two of the cardinal symptoms as:

$$\text{Krauss Index} = 0.2(\text{symptom1}) + 0.2(\text{symptom2}) \text{ divided by } 4$$

4 Clinical follow-up was done in the outpatient department at six months and two years following surgery. Continuous data was evaluated using T-tests, whereas categorical data was investigated using chi-square tests. Covariate effects were assessed using multivariate regression analysis. All data analysis was done using IBM SPSS version 23.

## RESULTS

Table 1: Baseline features of 72 patients with idiopathic normal-pressure hydrocephalus.

Features	Value
Total	72
Sex	
Male	54
Female	18
Age in years	70.4 ± 7.2
Preoperative symptoms	
Disturbance of Gait	65
Urinary incontinence	48
Cognitive impairment	38
Symptom duration (months)	22.5±17.9
Evans index	
≤0.4	60
>0.4	12
Lumbar puncture pressure (mm H <sub>2</sub> O)	
<130	43
≥130	29
Comorbidity index	
0	13
1	17
2	12
3	10
4	12
≥5	8
Preoperative mRS score	2.31 ± 1.11

54 men and 18 women were among the 72 patients with probable iNPH, with an average age of 70.4 ± 7.2 years.

Symptoms lasted an average of 22.5±17.9 months. In the majority of patients, gait imbalance was the most prevalent presenting symptom.

90.3 percent of patients reported gait imbalance, urinary incontinence in 66.6%, and 52.7 percent had cognitive impairment. 126.8± 37.2 mm H<sub>2</sub>O was the average lumbar opening pressure. During shunt implantation, the initial pressure of the valve was determined depending on the surgeon's preference and lumbar opening pressure. The average starting valve pressure was 94.80± 21.88 mm H<sub>2</sub>O. The baseline clinical features of the patients are shown in Table 1.

At 6 months and 2 years later to surgical procedure, the results of VP-shunt implantation were significant statistically (P 0.05). Following VP surgery for shunt, all 72 patients were follow-up after six months (mean 6.4 ± 1.5 months). According to the Krauss improvement index, 91.7 percent of patients with 0.5± 0.28 mean Krauss index had reduction of their preoperative symptoms, and 50 patients (69.4 percent) had a Krauss score of 0.5 or higher. At 6 months, the postoperative mRS score (mean, 1.68± 1.30) was considerably lower than the preoperative value. Six months following surgery, 58 percent of the 72 patients improved their mRS scores, with 60 percent improving one step and 15.7 percent improving two steps. At 6 months after surgery, the proportion of subjects who were able to live independently (mRS score 1–2) augmented from 55.5 to 86.1 percent. 38 of the 72 patients were available for the 2-year follow-up, and 92.1 percent of these patients showed durable improvement.

Table 2: Patient's predictors and characteristics of VP-shunt surgery outcome.

Variables	Krauss ≥0.5	Krauss <0.5	P-value
Sex			
Male	38	16	
Female	14	4	0.53
Age	70.02 ± 10.09	72.80 ± 7.69	0.19
Primary symptom			
Disturbance of Gait	37	15	
Cognitive impairment	10	4	0.948
Incontinence	4	2	
Duration of symptom (months)	24.70 ± 21.25	20.85 ± 12.21	0.86
Evans index			
<0.4	44	16	
≥0.4	8	4	0.486
LP pressure			
<130 mm H <sub>2</sub> O	30	13	
≥130 mm H <sub>2</sub> O	20	9	0.79
Comorbidity index			0.016*
0	12	1	
1	15	2	
2	10	2	
3	9	1	
4	4	8	
≥5	3	5	

Table 3: Comorbidity, as the solitary factor that negatively impacting outcome of VP-shunt surgery

Variables	P-value	HR CI 95%
Age	0.18	
Symptom length in months	0.120	
Comorbidity index		
≤3		1
>3	0.001*	8.79 (2.629–30.101)

The Krauss index after two years was 0.55 ± 0.29; 21 (65.2%) subjects had an index >0.5 and 68.1% of 38 patients were living independently (mRS 0–2). Particularly, at 6-month and 2-year results later to VP-shunt surgery did not vary substantially (p > 0.05), indicating that the six-month results altered very little in the next 2-years. At both 6 months and 2 years, segmentation of the

Krauss index for three each cardinal symptoms revealed the largest progress in disturbance of gait. Our findings revealed that comorbidity had a greater negative impact on patients' outcomes than age or previous illness (Tables 2, 3).

## DISCUSSION

Furthermore, the effectiveness of shunt surgery is still debatable, and many people believe that the benefits of shunts are just transitory<sup>8-10</sup>. According to Junkkari et al., only 43% of patients reported a substantial improvement in their overall life quality one year after undergoing a VP-shunt operation. According to the results, improvement was reduced from 75% to 50% one year after surgery, and after three years, only one patient in three maintained an improvement in gait, one patient had continued improvement in cognitive function, and one patient had improvement in urinary incontinence<sup>11-12</sup>. According to the results of a thorough review of the literature, individuals with iNPH reported development proportion as low as 29 percent three years following surgery<sup>13</sup>. Although there is likely to be some variance in these shunt outcomes, this is most likely owing to differences in diagnostic techniques and criteria, as well as the usage of several outcome variables<sup>14</sup>. A uniform outcome measure for iNPH is necessary to decrease outcomes inconsistency, and a standardised diagnostic process is required to improve accurateness in these outcomes. Among the participants in our analysis, shunt surgery was linked with a high rate of positive outcomes<sup>15</sup>. Increased success rates were achieved through the use of suitable diagnostic procedures in accordance with guidelines of iNPH, stringent principles for choosing appropriate applicants for shunt surgery, consideration of the consequences of additional prognostic predictive tests, and steady follow-ups, the latter of which permitted the identification and correction of malfunctioning shunt components that, if not detected in time, would have resulted in a reduction in the operative shunt life. 115 patients with iNPH had VP-shunt surgery, and the findings were reported in a European multicenter trial<sup>18</sup>. Gait improvement was seen in 78 percent of patients, cognitive improvement in 64 percent, and 68 percent have urinary incontinence improvement. According to a current meta-analysis of shunted individuals with iNPH, there was a 75% overall improvement rate in these patients. As a consequence, while determining whether or not to treat iNPH patients with shunt surgery, the longevity of the therapeutic effect should not be the major concern. Shunt surgery for iNPH has been shown to enhance gait and functional independence for daily living in patients who have improved functional independence and gait for daily living<sup>19-20</sup>. This suggests that improving symptoms while simultaneously normalising mortality may be achieved with shunt surgery for iNPH. It is important to note that patients with iNPH are typically elderly individuals, and even a little development in gait may advance their life quality while also lowering social implications and functional constraints. Comorbidity had a considerable negative impact on the results in this study. Because iNPH is an adult-onset condition, it is typically accompanied with one or more comorbidities. We hypothesize that patients' outcomes are influenced by a pseudo-correlation mediated by comorbidities with older age and longer symptom histories. Our patients had an average of 81.9 percent of concurrent comorbidities, which is greater than the 44 percent observed in patients with iNPH<sup>21-22</sup>.

A recent study found that shunt surgery had a 38% overall complication rate and a 22% shunt revision rate. A more recent literature review indicated a 10% pooled complication rate and a 16% shunt revision rate<sup>23</sup>. Another study found that shunt malfunction accounted for more than half of all shunt revisions, with 50% happening during the first year of use. Because we employed precise surgical techniques, no patients in our series needed shunt revision surgery within two years after the initial shunt operation. As a consequence, we believe that precision shunt surgery and the use of adjustable valves with the gravitational unit may assist reduce catheter displacement<sup>24</sup>. A

programmable valve had a lower shunt revision rate (12%) than a fixed valve (32%) in a meta-analysis, and an antigravity component reduced the revision rate even more<sup>25</sup>. Our patients' neurosurgeons selected the beginning shunt pressure (20–30 mm H<sub>2</sub>O less the lumbar opening pressure).

## CONCLUSION

Surgical therapy with a VP-shunt has better results in individuals with iNPH, and the majority of these subjects report a decrease in their preoperative symptoms over time. 6 months to 2 years following VP-shunt surgery for iNPH, the outcome was steady, suggesting that the results at 6-months was stable for up to 24 months. Concerning the risk-benefit ratio of surgery, patients' comorbidities should be considered. The VP-shunt procedure has a low complication risk and a high success rate. Regular shunt system monitoring and modification may help prolong the shunt treatment's effectiveness.

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