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## Original Article

# Use of Frameless Stereotactically-Navigated Ventricular Catheter in Medically Refractory Idiopathic Intracranial Hypertension: Short Term Outcome

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**BACKGROUND:** Cerebrospinal fluid (CSF) shunting is a common surgical technique t in treating medically refractory cases of idiopathic intracranial hypertension (IIH). Lumboperitoneal shunting (LPS) is effective, but with a high revision rate. Frameless navigated ventriculoperitoneal shunt (VPS) is as effective as lumboperitoneal shunt but with less complication and revision rates. In this study we aimed to assess efficacy and safety of frameless navigated ventriculoperitoneal shunt compared to lumboperitoneal shunt treating IIH. Predictors of shunting failure were evaluated.

**MATERIALS AND METHODS:** Retrospective analysis of 62 patients with IIH treated by CSF shunting between January 2018 and March 2022. Thirty-two patients had LPS, and 30 patients had frameless navigated VPS. Demographics, clinical, ophthalmological, and radiological assessment were assessed. Clinical outcome, complications, shunt revision and predictors of shunt failure were evaluated.

**RESULTS:** Sixty-two patients underwent CSF shunting for IIH, thirty-two patients had LPS, and 30 patients had VPS with female predominance (22 patients in LPS group and 26 patients in VPS group). Most cases were in the child-bearing period. Mean body mass index (BMI) was 32.6 and 31.8 in LPS and VPS groups respectively. Headache and visual affection were the most prevalent presentations in both groups. No statistical difference appeared as regards clinical outcome, but statistical difference favored VPS as regards complications and revision rates. BMI >35 and LPS were positive predictors of shunt failure on univariate analysis but BMI >35 was significant on multivariate analysis.

**CONCLUSION:** Frameless navigated VPS and LPS achieve favorable clinical outcome in management of IIH. Frameless navigated VPS has less complications and revision rates. On univariate analysis, BMI>35 and LPS were significant on univariate analysis and only BMI>35 was significant on multivariate analysis predicting shunt failure.

**KEYWORDS:** Idiopathic intracranial hypertension, Lumboperitoneal shunt, Ventriculoperitoneal shunt.

## INTRODUCTION

Idiopathic intracranial hypertension (IIH) is a syndrome characterized by manifestations of increased intracranial pressure in absence of structural brain lesions and normal cerebrospinal fluid (CSF) composition. The annual incidence of IIH is 1-3 cases per 100,000 of general populations. It is more common in females in childbearing period and commonly associated with increased body mass index (BMI). Children are rarely affected with IIH with equal distribution between males and females, and no correlation with obesity like adult-onset IIH.[1-3]

Idiopathic intracranial hypertension is usually presented with gradual onset and insidious course; however, it can be of fulminant course with rapid progressive visual loss. Headache is a common presentation of IIH, and sometimes it can be intractable. Progressive visual loss is another presentation due to papilledema. If left untreated it may progress to optic atrophy. Other presentations include squint due to abducent nerve palsy, pulsatile tinnitus, and/or neck and back pain.[4,5]

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Many theories have been proposed to play a role in the pathophysiology of IIH. One of the proposed theories is cerebral venous congestion due to venous sinus stenosis. Other theories incriminate the use of certain antibiotics like tetracycline, minocycline, nitrofurantoin and nalidixic acid, hormonal factors like thyroxine, and growth hormone, excess vitamin A intake, and other drugs like steroids, lithium or ciclosporin, as proved by improvement of manifestations of IIH correcting these incriminated factors.[1,3,5]

Modified Dandy criteria have been proposed for diagnosis of IIH including presence of signs and symptoms of increased intracranial pressure, absence of focal neurological signs except sixth nerve palsy, CSF opening pressure more than 25 cm of water but without cytological or chemical abnormalities, and normal neuroimaging to exclude cerebral venous thrombosis.[5,6]

Treatment of IIH is mostly medical using acetazolamide; a carbonic anhydrase inhibitor, with dose titration depending on symptoms severity, tolerance, and clinical response of the patients. Topiramate may play a role with its weak carbonic anhydrase effect, its ability to prevent migraine, as well as its adverse effect of suppressing appetite. Also, weight loss may play a role in conservative management of IIH. In IIH, papilledema and headache are considerably reduced with a 15% weight decrease.

Serial lumbar punctures aid in estimating opening CSF pressure, temporarily relieving increased intracranial tension and monitoring response to medical treatment.[5-9]

Surgery is indicated in refractory cases to medical treatment with either intractable headache or progressive visual loss or patients with initial fulminant course and rapid visual deterioration. Treatment options include CSF shunting procedures, optic nerve fenestration, endovascular sinus stenting, or even bariatric surgery especially with BMI higher than thirty-five.[10-12]

The choice of the appropriate surgical option is variable with a selection bias based on surgeon's experience, as there is no consensus about the gold standard surgical option. CSF shunting usually alleviates headache and ameliorates vision, meanwhile, optic nerve fenestration positively impacts visual symptoms with minimal effect on headache. Venous sinus stenting may have a therapeutic role in cases presenting with focal stenosis with a pressure gradient across the stenosis higher than 8 mm mercury.[10,12,13]

The most adopted CSF diversion procedure is lumboperitoneal shunt (LPS). It is usually effectively improving headache, and preserving vision, still with non-negligible failure rate, mandating multiple revisions of either proximal or distal ends due to slippage, malposition, obstruction, infection, low pressure headache or even acquired cerebellar tonsils herniation. Also, it may be complicated with lumbar radiculopathy or even abdominal hernia.[12-16]

Ventricular shunting initially was considered ineffective and hazardous due to commonly associated slit or narrow ventricles with IIH. Nowadays, with the advancement in neuroimaging and stereotactic navigation using either frame-based or frameless stereotactic techniques, ventricular catheterization can be achieved effectively and safely, affording significant clinical improvement, yet avoiding the high failure rate and complications of lumboperitoneal shunts.[17-22]

The aim of study is to assess safety and efficacy of frameless stereotactically-navigated ventriculoperitoneal shunt (VPS) compared to LPS, analyzing clinical outcome, complications, and shunt revision related to VPS and LPS in IIH. Also, predictors of shunt failure had been evaluated assessing different risk factors for probable shunt revision.

## PATIENTS AND METHODS

In the current retrospective study we analyzed records of sixty-two patients suffering from IIH treated with CSF shunting between January 2018 and March 2022. Thirty-two patients had LPS using valveless lumboperitoneal shunt, and thirty patients had frameless stereotactically navigated VPS using Curve- image guided Brain lab 2.0 with Varioguide arm. The used VPS shunts were medium pressure ventriculoperitoneal shunts.

All patients underwent clinical, ophthalmological, and radiological assessments. Evaluation of patients' presentation included headache, visual impairment, and sixth nerve palsy. None of the patients had pulsatile tinnitus or axial pain. Headache was evaluated using visual analogue scale (VAS). BMI was calculated for all patients, and they were stratified whether they had a body mass index above or less than 35.

Ophthalmological evaluation included assessment of visual acuity, fundus examination, and visual field using automated Humphrey perimetry. All patients had preoperative brain magnetic resonance imaging (MRI) to exclude any structural brain lesions and assess common radiological findings in IIH. Brain magnetic resonance venography (MRV) to diagnose possible venous sinus stenosis was done.

Lumbar puncture (LP) was done in lateral decubitus position to measure opening CSF pressure, temporarily relieve manifestations of increased intracranial tension by withdrawal of amount of CSF and to do CSF analysis. Patients were classified according to measured opening pressure into mildly elevated (25-30 cm H2O), moderately elevated (30-40 cm H2O), severely elevated (40-50 cm H2O), or fulminant with opening pressure more than 50 cm H2O. Response of measurement of opening CSF pressure to serial lumbar punctures was classified into fluctuant, stationary, or progressive response.

Patients included in the current study had either intractable headache or persistent severe papilledema or had initial fulminant visual deterioration that was not responsive to medical treatment or serial lumbar punctures. None of the selected cases had any previous interventions for IIH. VPS that were inserted without frameless neuronavigation, and patients who lost their follow up for at least 1 year were excluded from this study. The selection of shunt modality was based on the availability of frameless neuronavigation at time of presentation and patients' preference.

All patients received initial medical treatment using Acetazolamide with an initial dose of 0.5-1 gram/day up to 2-4 grams/day as a maximum dose. Potassium and vitamin B12 supplements were also used to guard against fatigue and peripheral paresthesia.

### Surgical technique

For lumboperitoneal shunt group, valveless lumbar peritoneal shunts (Medtronic, Inc., Minneapolis, USA) were used. The patient was placed in the left lateral decubitus position. A three cm incision was made at the back between the spinous processes of 4th and 5th or 3rd and 4th lumbar. A 14-gauge Tuohy needle was introduced into the subarachnoid space with the bevel pointed upwards. The proximal end was advanced into the thecal sac for 8 cm. As soon as CSF egressed from the distal end, the Tuohy needle was withdrawn. One suture was used to prevent migration of the shunt from the thecal sac. A one cm incision was made into the right flank, and a malleable passer was introduced to deliver

the distal end of the shunt. A four cm incision was made in the lower right quadrant of the abdomen, and the same passer delivered the tube, followed by opening the abdominal wall in layers till reaching peritoneal cavity to deliver the distal end. A purse string was used to keep the tube in position. Finally, the abdominal wall was closed in layers.

For frameless navigated VPS patients, Brainlab Varioguide alignment system was used. The used shunts were Medtronic medium pressure VPS (Medtronic, Inc., Minneapolis, USA). After the induction of general anesthesia, the patient was fixed in rigid three points fixator. This was followed by the use of T adapter connected to head fixator which attached patient's reference arm and Varioguide. This was followed by registering of preoperative computed tomography (CT) to Brainlab platform and determination of the track and end point (Right foramen of Monro). After a U-shaped skin incision, a small burr hole was done over the predetermined entry point followed by dural opening. Then, through the Varioguide opening, a pre-registered stylet coupled with the proximal catheter was used to cannulate the right frontal horn. After the egress of CSF from the proximal tube, the pre-registered stylet was withdrawn, and the valve was connected and attached to the peritoneal tube which was ended in a 4 cm incision in the upper right quadrant and was introduced into the peritoneal cavity. Figure 1 **(Fig. 1)** illustrates successful ventricular catheterization in a patient with slit ventricle targeting right foramen of Monro.

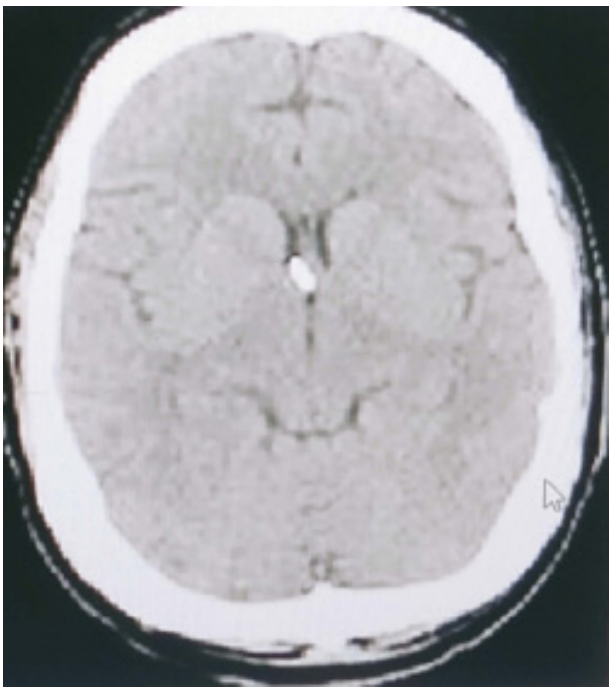

**Fig 1: Postoperative computed tomography (CT) brain illustrating a successful ventricular catheterization in a 32 year old male patient suffering from idiopathic intracranial hypertension with slit ventricle targeting right foramen of Monro.**

Follow up was conducted immediately postoperatively, and on 6 months interval for at least one year. Patients were evaluated postoperatively as regards clinical response assessing headache improvement (improved, stationary, or worsen), visual acuity (improved, stationary, or worsened) and fundus changes whether completely resolved or improved.

Postoperative complications were assessed, and compared in both LPS and VPS groups, including low pressure headache, wound infection, radiculopathy, and shunt obstruction.

Shunt revision rate was assessed as regards the rate, cause of revision, timing in both techniques and predictive factors for shunt failure and need for revision.

**Statistical analysis**

Using a specially constructed sheet on Microsoft Excel, data was entered, thoroughly revised, and transferred to IBM statistical package for the social sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA). For descriptive statistics, the mean and range were calculated. For comparative statistics, comparison in all variables using Fisher exact test and Odd's ratio (with 95% confidence interval), when applicable, was performed. A 5% alpha error was adopted (P significance was measured at <0.05). Revising predictors of need for shunt revision, variables with $p < 0.05$ in the univariate analysis only were entered into a multivariate model to identify independent predictors of shunt failure.

**Ethical Approval:** The study was approved by the Ethics Committee of the Faculty of Medicine of Alexandria University. Patients had signed informed consent to be included in the study.

**RESULTS**

The records revealed sixty-two patients who underwent CSF diversion for surgical treatment of idiopathic intracranial hypertension; thirty-two patients had lumboperitoneal shunt surgery and thirty patients had frameless-stereotactically navigated ventriculoperitoneal shunt surgery between January 2018 and March 2022 at Alexandria University Hospital with a minimum follow up period of 12 months.

**A. Lumboperitoneal shunt group**

Of thirty-two patients had lumboperitoneal shunt, there were 22 (69%) females, their age ranged between 18-42 years with a mean of 31 years. The mean BMI in this group was 32.6 as 13 (41%) patients had BMI <35, and 19 (59%) patients had BMI >35.

Headache was present in 30 (94%) patients, deteriorating visual acuity was present in all patients, meanwhile squint was present in 2 (6%) patients. Fundus examination revealed papilledema in 31 (97%) patients while 1 (3%) patient had optic atrophy. Revising visual field changes, 6 (19%) patients had enlarged blind spots, 4 (12.5%) patients had peripheral field constriction, while 10 (31%) patients had scotomas.

Radiologically, revising MRI brain findings, ventricular size in 13 (41%) patients was normal, 10 (31%) patients had narrow ventricles, meanwhile, 9 (28%) patients had slit ventricles. Empty Sella turcica was present in 17 (53%) patients, while optic nerve hydrops was present in 21 (66%) patients, and optic nerve tortuosity was evident in 13 (41%) patients. MRV finding illustrated transverse sinus stenosis in 17 (53%) patients. Demographic, clinical, and radiological findings are illustrated in **(Table 1)**.

On initial lumbar puncture preoperatively in lumboperitoneal shunt group, CSF opening pressure was mildly elevated in 9 (28%) patients, moderately elevated in 20 (62.5%) patients, severely elevated in 2 (6%) patients, and 1 (3%) patient had fulminant increase in CSF opening pressure. On serial lumbar punctures, 22 (69%) patients had progressive opening pressure measurements, 8 (25%) patients had stationary high CSF opening pressure, and 2 (6%) patients had fluctuant high CSF opening pressure. Initial CSF opening pressure measurements and response to serial lumbar punctures are illustrated in **(Table 2).**

Considering clinical outcome after lumboperitoneal shunt, headache improved immediately in 31 (97%) patients, and only one (3%) patient had persistent headache but of milder intensity and improved with medical treatment. Visual acuity improved in 31 (97%) patients, and one (3%) patient did not improve due to previous optic atrophy. Fundus examination showed complete resolution of papilledema in 28 (87.5%) patients, 3 (9%) patients had improvement in papilledema grade, and only one (3%) patient had optic atrophy.

As regards complications following lumboperitoneal shunt insertion for IIH, two (6%) patients suffered from postoperative shunt infection which mandated shunt extraction and medical treatment. Three (9%) patients suffered from postoperative low-tension headache which was managed conservatively. Two (6%) patients suffered from postoperative radiculopathy which was treated conservatively. One (3%) patient suffered from shunt obstruction mandating shunt revision.

Nine (28%) patients had shunt revision; five (16%) patients had their shunt revision due to distal end migration, 1 (3%) patient had revision for both proximal and distal ends due to migration of both ends. Two (6%) patients had shunt revision due to shunt infection. Only one (3%) patient had shunt obstruction which was revised. The mean time for shunt revision was 13 months. The clinical response, complications and shunt revision causes are illustrated in **(Table 3).**

**B. Frameless-navigated ventriculoperitoneal shunt**

Of thirty patients had frameless-navigated ventriculoperitoneal shunt, there were 26 (87%) females, their age ranged between 16-38 years with a mean of 27 years. The mean BMI in this group was 31.8 as 12 (40%) patients had BMI <35, meanwhile 18 (60%) patients had BMI >35.

Headache was present in 29 (97%) patients, deteriorating visual acuity was present in all patients, meanwhile squint was present in 1 (3%) patient. Fundus examination revealed papilledema in 29 (97%) patients while 1 (3%) patient had optic atrophy. Revising visual field changes, 8 (27%) patients had enlarged blind spots, 4 (13%) patients had peripheral field constriction, while 15 (50%) patients had scotomas.

Radiologically, revising ventricular size, 16 (53%) patients had normal ventricular size, 10 (33%) patients had narrow ventricles, meanwhile, 4 (13%) patients had slit ventricles. Empty Sella turcica was present in 24 (80%) patients, while optic nerve hydrops was present in 17 (57%) patients, and optic nerve tortuosity was evident in 16 (53%) patients. MRV finding illustrated transverse sinus stenosis in 13 (43%) patients. Demographic, clinical, and radiological findings are illustrated in **(Table 1)**.

On first lumbar puncture preoperatively in ventriculoperitoneal shunt group, CSF opening pressure was mildly elevated in 12 (40%) patients, moderately elevated in 16 (53%) patients, severely elevated in 2 (7%) patients, and none of the patients had fulminant increase in CSF opening pressure. On serial lumbar punctures, 24 (80%) patients had progressive opening pressure measurements, 6 (20%) patients had stationary high CSF opening pressure. Initial CSF opening pressure measurements and response to serial lumbar punctures are illustrated in **(Table 2)**.

Ventricular catheterization was achieved effectively from the first pass in all patients. Considering clinical outcome after ventriculoperitoneal shunt, headache improved immediately in all patients. Visual acuity improved in 29 (97%) patients, and one (3%) patient did not improve due to previous optic atrophy. The Fundus examination showed complete resolution of papilledema in 27 (90%) patients,two (7%) patients had improvement in papilledema grade, and only one (3%) patient had optic atrophy.

As regards complications following VPS insertion for IIH, none of the patients suffered from postoperative shunt infection, low-tension headache, or obstruction. Two (7%) patients had shunt revision due to distal end migration. Mean time for shunt revision was 12 months from time of shunt insertion.

There was no statistically significant difference between both groups as regards demographic data, BMI, preoperative clinical and radiological characteristics, preoperative ophthalmological assessment, initial CSF opening pressure, response to serial lumbar punctures and clinical outcome considering postoperative improvement of headache and visual acuity.

There was statistically significant difference as regards the rate of postoperative complications between LPS

group and VPS group in favor of the latter group as 8 (25%) patients had complications in LPS group compared to VPS group including shunt infection, low tension headache, lumbar radiculopathy, and shunt obstruction. None of the patients in VPS group suffered from postoperative cranial hemorrhage.

Similarly, there was a statistically significant difference regarding the rate of shunt revision between both groups as 9 (28%) patients had revision in lumboperitoneal group compared to 2 (7%) patients in VPS group. The most incriminated factor for shunt revision in both groups was distal end migration from peritoneal cavity as was documented in 6 patients in LPS group and in 2 patients in VPS group. None of the treated cases in VPS group needed revision for the ventricular catheter. There was no statistically significant difference as regards the mean interval for shunt revision in both groups. The clinical response, complications and shunt revision causes are illustrated in **(Table 3).**

Age, sex, fulminant initial clinical presentation, ventricular size, and severely elevated or fulminant CSF opening pressure were not statistically significant factors to predict shunt failure and need for revision. On univariate analysis, high BMI above 35, lumboperitoneal shunting were statistically significant predictors of shunt failure but only BMI above 35 was statistically significant on multivariate analysis. **(Table 4)** illustrates evaluation of predisposing factors to shunt failure.

**Table 1: Demographic, clinical and radiological differences between lumboperitoneal shunt group and frameless stereotactically navigated ventriculoperitoneal shunt**

| Variables | LPS (no=32) | VPS (no=30) | P-value |
|---|---|---|---|
| Female, no., (%) | 22, (69%) | 26, (87%) | 1.023 |
| Age, range, mean | 18-42, 31 | 16-38, 27 | 0.089 |
| BMI (mean) | 32.6 | 31.8 | 0.073 |
| <35, no., (%) | 13, (41%) | 12, (40%) | |
| >35, no., (%) | 19, (59%) | 18, (60%) | |
| **Clinical presentation , no., (%)** | | | |
| Headache | 30, (94%) | 29, (97%) | |
| Decreasing visual acuity | 32, (100) | 30 (100%) | 0.072 |
| Squint | 2,(6%) | 1, (3%) | |
| **Fundus, no., (%)** | | | |
| Papilledema | 31,(97%) | 29, (97%) | 0.74 |
| Optic atrophy | 1, (3%) | 1, (3%) | |
| **Visual field changes, no., (%)** | | | |
| Enlarged blind spot | 6, (19%) | 8, (27%) | |
| Peripheral field constriction | 4, (12.5%) | 4, (13%) | 0.367 |
| Scotomas | 10, (31%) | 15, (50%) | |
| **Radiological finding, no., (%)** | | | |
| Ventricular size | | | |
| Normal | 13, (41%) | 16, (53%) | |
| Narrow | 10, (31%) | 10, (33%) | |
| Slit | 9, (28%) | 4, (13%) | |
| Empty sella turcica | 17, (53%) | 24, (80%) | 0.076 |
| Optic nerve hydrops | 21, (66%) | 17, (57%) | |
| Optic nerve tortuosity | 13, (41%) | 16, (53%) | |
| MRV(Venous sinus stenosis) | 17, (53%) | 13, (43%) | |

*Statistically significant at p <0.05.

**Table 2: Comparison between LPS versus VPS groups as regards initial CSF opening pressure and response to serial lumbar punctures**

| Variables | LPS | VPS | P-value |
|---|---|---|---|
| **Initial CSF opening pressure** | | | |
| Mild increase (25-30 cm $H_2O$) | 9, (28%) | 12, (40%) | 0.89 |
| Moderate increase (30-40 cm $H_2O$) | 20, (62.5%) | 16,(53%) | |
| Severe increase (40-50 cm $H_2O$ ) | 2, (6%) | 2, (7%) | |
| Fulminant increase (> 50 cm $H_2O$) | 1, (3%) | 0 | |
| **Response to serial lumbar puncture** | | | |
| Progressive pressure | 22 (69%) | 24, (80%) | 1.043 |
| Stationary pressure | 8 (25%) | 6, (20%) | |
| Fluctuant pressure | 2 (6%) | 0 | |

*Statistically significant at p <0.05.

**Table 3 : Comparison of clinical response, complications, and need for shunt revision between LPS group and VPS group**

| Variables | LPS | VPS | p-value |
|---|---|---|---|
| **Clinical outcome** | | | 0.062 |
| Headache improvement | 32 (100%) | 30, (100%) | |
| Vision improvement | 31 (97%) | 29, (97%) | |
| **Papilledema, no., (%)** | | | |
| Complete resolution | 28, (87.5%) | 27, (90%) | |
| Improvement | 3, (9%) | 2, (7%) | 0.382 |
| Optic atrophy | 1, (3%) | 1, (3%) | |
| **Complications** | 8, (25%) | 0 | 0.029* |
| Postoperative infection | 2, (6%) | 0 | |
| Postoperative low-tension headache | 3, (9%) | 0 | |
| Postoperative radiculopathy | 2, (6%) | 0 | |
| Shunt obstruction | 1, (3%) | 0 | |
| **Shunt revision no., (%)** | 9, (28%) | 2 (7%) | 0.041* |
| Distal end revision | 5, (16%) | 2, (7%) | |
| Proximal and distal revision | 1, (3%) | 0 | |
| Shunt obstruction | 1, (3%) | 0 | |
| Postoperative wound infection | 2, (6%) | 0 | |
| Mean time for revision (m.) | 13 | 12 | 0.349 |

*Statistically significant at p <0.05.

**Table 4: Evaluation of predictors of shunt failure and need for revision**

| Variables | Univariate | | | Multivariate | | |
|---|---|---|---|---|---|---|
| | HR | 95% CI | p-value | HR | 95% CI | p-value |
| Age | 0.17 | 0.988-1.068 | 1.027 | | | |
| Sex | 0.304 | 0.083-2.170 | 0.425 | | | |
| BMI >35 | 8.6 | 2.124-34.0815 | **0.003*** | 11.934 | 1.685-37.548 | **0.013*** |
| Fulminant clinical presentation | 0.544 | 0.131-2.264 | 0.403 | | | |
| LPS shunting | 5.333 | 1.778-30.250 | **0.042*** | 0.739 | 0.950-1.516 | 0.636 |
| Ventricular size | 0.964 | 0.938-1.033 | 0.541 | | | |
| Initial fulminant or severely elevated CSF opening pressure | 0.889 | 1.752-1.110 | 0.649 | | | |

Abbreviations: CI, confidence interval; HR, hazard ratio, BMI, body mass index. Only variables with p < 0.05 in univariate analysis were included in the multivariate analysis. *Statistically significant at p <0.05.

## DISCUSSION

This study represents a single tertiary center experience revising safety and efficacy of frameless-stereotactically guided VPS in refractory cases of IIH compared to traditional LPS. Also, it aims at assessing the predictors of failure of CSF shunting in treatment of IIH.

Idiopathic intracranial hypertension has a clinical presentation of headache and visual deterioration due to increased intracranial tension in absence of organic brain lesion. This pathology is usually managed by medical treatment and in some cases, serial lumbar punctures may be sufficient for dealing with this pathology. However, in some cases medical treatment or even serial lumbar punctures may be of little clinical value mandating surgical intervention. Among several surgical options dealing with cases refractory to conservative management, CSF shunting is highly effective with marvelous improvement of clinical symptoms, yet with high revision rate.[5,16,17]

Lumboperitoneal shunting was the most adopted CSF shunting technique dealing with IIH especially that patients with IIH usually have narrow or slit ventricles that makes ventricular cannulation not feasible. This technique is usually effective and safe with rapid amelioration of headache and papilledema. Lumboperitoneal shunt despite being effective, still it may be associated with low tension headache, infection, obstruction, shunt migration or even lumbar radiculopathy. These complications usually end in high incidence of shunt revision.[15,16,20,21]

With advancement in neuronavigation, ventricular catheterization can be done effectively in cases with IIH even with narrow or slit ventricles. Stereotactically navigated VPS affords an alternative option to LPS improving safety, and accuracy with better outcome in patients with IIH.[22-26]

This study aims at comparing LPS and frameless stereotactically navigated VPS as regards safety and efficacy in management of IIH and revising the main predictors of shunting failure with subsequent need of shunt revision.

Regarding demographic data, female predominance in this study was evident in both LPS and VPS groups and this matched with similar studies addressing IIH. Idiopathic intracranial hypertension is common in childbearing periods. This matched with the age at presentation in both LPS and VPS groups as the mean age at presentation was 31 and 27 years, respectively. Bjornson et al. had a similar mean age in his studies. Even though II can affect children, none of the treated cases in the current study was in this age category. There was no statistically significant difference between both groups as regards demographic data.[1,2,6]

Obesity is a common association in patients with IIH. Many studies documented the role of obesity in the pathophysiology of IIH. Bjornson et al. and Markey et al. emphasized the role of high BMI in patients with IIH and this matched with high BMI spotted in both groups of the current study. Increasing incidence of obesity is associated with increasing incidence of IIH. Dhungana et al. concluded that females who are more than 10% over their ideal weight are thirteen times more prone to IIH and increase to nineteen folds if they are above average weight by 20%. No statistical difference between both groups in the current study.[5-7]

Headache and visual affection are the common presentations in patients with IIH. The course is usually protracted but it can be fulminant with rapid progressive loss of vision. Papilledema is a common finding in IIH patients. Also, visual field changes are common findings. Similar studies showed comparable results. No statistical difference as regards fundus or visual field assessment was present comparing both groups in the current study.[1,4,5,8]

Idiopathic intracranial hypertension is commonly associated with characteristic radiological findings; the most common are empty Sella turcica, narrow or slit ventricular size, optic nerve hydrops and tortuosity. Also, transverse sinus stenosis is a common finding in MRV brain. Sultan et al.'s study on clinical and radiological findings in IIH documented similar MRI and MRV findings like the current study. There were no statistically significant differences as regards radiological findings in both studied groups.[4,5]

Similarly, most of the cases of IIH had either mildly or moderately elevated initial CSF opening pressure. Initial CSF opening pressure was severe or fulminant in 9% and 7% in LPS and VPS groups, respectively. There was no statistically significant difference between both groups as regards the degree of elevated initial CSF opening pressure or response to serial lumbar punctures. Despite the beneficial role of lumbar puncture and opening pressure as a diagnostic and therapeutic tool in managing cases of IIH as it may be a temporary vision saving in cases of severely elevated CSF opening pressure, yet it may be hazardous. With lumbar puncture, the rate of post-LP headache is known to range from 17.5% to 32.2% and about 10% of patients undergoing lumbar puncture may need blood patch to manage persistent post-lumbar puncture headache. Yiangou et al recommended that therapeutic LP to treat headache are only considered in those with severe headaches at baseline, and patients should be aware that the improvements are modest over the following week.[9,27,28]

CSF shunting usually has a high success rate as regards clinical outcome. Amelioration of headache and visual affection was achieved in more than 95% of treated patients in both groups. Similarly, cure or improvement of papilledema was achieved in more than 95% of treated patients. There was no statistically significant difference between LPS and VPS groups as regards clinical outcome or fundus examination response to CSF shunting. Most of studies considering CSF shunting for treatment of IIH had comparable results.[22-25]

In the current study, frameless navigated VPS had statistically significant less complications than LPS group. The complications rate was 28% in LPS group compared to VPS group. VPS may also have complications but in the small, treated sample in the current study there was no postoperative complications. De Oliveira et al. Taranis et al. and Sunderland, and in their studies concluded similarly the higher complication rate in LPS compared to VPS. In many studies, the most common complication in LPS treated patients was shunt obstruction. McGirt et al documented a three folds increase of shunt obstruction compared to VPS. Menger et al. documented the superiority of VPS as regards lower complication rate compared to LPS.[16,20,21,25,29-31]

There was a statistically significant difference between both groups in favor of VPS as regards rate of shunt revision. Many studies documented the higher revision rate of LPS whether the revision of proximal or distal ends or both. Distal catheter malfunction was similarly the most common cause of shunt revision as documented by Sweid et al. and Abubaker et al. which was attributed to prevailing overweight and associated increased abdominal fat and pressure with resultant dislodgement of distal catheter. These results matched the results of the current study. According to published data, the incidence of revision surgery due to shunt dysfunction or infection varied from 38% to 85.7%. with a 52% overall rate. Menger et al. documented that 3.9% of VP shunt admissions and 7.0% of LP shunt admissions had revision surgery. Abubaker et al. study showed higher revision rate of LPS (60%) compared to VPS (30%).[11,17,23,29-32]

Cerebrospinal fluid shunting despite being an effective treatment for IIH, yet failure rate is higher in IIH compared to shunting in non IIH patients. Greener et al. concluded that the median shunt survival was more than doubled in non IIH patients compared to IIH patients due to obesity and small ventricles. This increased failure rate mostly occured in the initial 6 -12 months after shunting. In many series, the most common cause of shunt revision was proximal or distal catheter revision, followed by shunt overdrainage, or infection. The frequent need for proximal catheter revision may be attributed to small ventricular size. Despite neuronavigation mostly allowing successful ventricular catheterization even from the first pass, still the small ventricular size may result in easy blockage due to proximity of ependymal lining or choroid plexus. Fortunately, this was not encountered in the current study in the VPS group. Distal catheter revision is common due to either initial malpositioning extraperitoneally due to severe obesity which represents a technical challenge or shunt migration postoperatively after proper initial positioning which can be attributed to increased intraabdominal pressure. Also In morbidly obese patients, their abdominal fat pannus moves whenever they are lying down and turn from side-to-side. When a LPS is tunneled circumferentially to the abdomen, the distal catheter gets pulled every time they turn over at night and must be anchored well at the anterior abdominal fascia with an accessory "strain relief loop" to prevent it ending up in the pre-peritoneal space with a distal malfunction. This pathophysiology is avoided through tunneling vertically from head to abdomen, that's why VPS has fewer distal malfunctions. In the current study, distal end revision was the most common cause for shunt revision which again matched with results of other series. Obesity is a major factor for shunt failure. In the current study, BMI>35 was the only significant factor in both univariate and multivariate analysis associated with shunt failure. Galloway et al. study concluded that the most common cause of shunt revision was migration or misplacement of the peritoneal catheter and this study found that patients with higher BMI were significantly more likely to have shunt revision. The same conclusion about the role of increased BMI in having a high revision rate was documented by Sweid et al. and Greener et al.[17,33,34]

Lumboperitoneal shunting was documented to be associated with a higher failure rate in treating IIH compared to VPS. This matched our results in the current study, as lumboperitoneal shunting was a significant factor in the univariate analysis for factors associated with higher failure rate but it was proven insignificant in multivariate analysis. A higher failure rate of lumboperitoneal shunting in addition to frequent need for distal catheter revision, which is unlike VPS, may be attributed to being valveless, may be complicated with higher risk of low-pressure headache due to overdrainage. The infection rate may be slightly higher in lumboperitoneal shunt compared to ventriculoperitoneal shunt, but this was insignificant.[16,17,21,29,30,32-34]

**Limitations of the study**

Being a retrospective with a relatively short follow-up period were limiting factors in this study. Also, patients' selection in either group were not randomized as it depended on availability of neuronavigation, surgeon expertise and patients' choice.

## CONCLUSION

CSF shunting is highly effective in managing patients with idiopathic intracranial hypertension. Frameless stereotactically navigated ventriculoperitoneal is as effective as lumboperitoneal shunt considering the clinical outcome. It is associated with statistically significant less complications and less revision rates. On univariate analysis, predictors of shunt failure following CSF shunting in IIH were BMI above 35, and lumboperitoneal shunting as a shunting modality, but only BMI above 35 maintains its significance on multivariate analysis suggesting the role of weight loss ,not only in amelioration of clinical presentation, but also to lessen the high failure rate of CSF shunting in management of IIH.

**List of Abbreviations**

BMI: Body mass index.
CSF: Cerebrospinal fluids.
CT: Computed tomography.

IIH: Idiopathic intracranial hypertension.
LPS: Lumboperitoneal shunt.
LP: Lumbar puncture.
MRI: Magnetic resonance imaging.
SPSS: Statistical package for the social sciences.
VAS: Ventriculoperitoneal shunt.

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