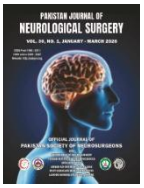

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Original Research

Outcomes of Neuronavigation-Guided Ventriculoperitoneal Shunt Placement in Idiopathic Intracranial Hypertension: A Retrospective Study

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ABSTRACT

Objectives: Idiopathic Intracranial Hypertension (IIH) is the buildup of pressure inside the skull that presents mostly as a headache. Ventriculoperitoneal (VP) shunts are the treatment of choice. Given the challenge of canulating slit ventricles, this study evaluates the outcomes of neuronavigation-guided VP shunt placement.

Materials & Methods: Patients undergoing neuronavigation-guided VP shunt placement were included from January 2021 to June 2024. Patient demographics, clinical signs and symptoms, Body Mass Index (BMI), operative details, and outcomes were recorded. Primary outcomes assessed were predisposing factors, symptom improvement, complication rates, and revision surgery. SPSS v.27 was used for data analysis.

Results: A total of 21 patients were included in this study who reported a statistically significant improvement in symptoms following VP shunt placement ($p<0.05$). Headache relief and visual improvement were the most notable outcomes, with 94% of patients experiencing substantial benefit. One patient had suboptimal placement, and one patient developed a superficial SSI. Both patients were discharged without any complications after treatment. None of the patients included in the study developed low-pressure headaches.

Conclusion: This study reports improved outcomes with Neuronavigation-guided VP shunt placement, resulting in improved surgeon confidence and reduced risk of shunt malposition. Further multicenter, large sample size studies are needed to validate these outcomes.

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INTRODUCTION

Adult idiopathic Intracranial Hypertension (IIH) is a type of elevated intracranial pressure (ICP) that occurs in the absence of any such diseases like space-occupying lesions or hydrocephalus.[1] The recent increase in the IIH in the past few decades can be attributed to multiple factors, causing an economic burden not only on the affected ones but also on society's healthcare systems.[2] These factors include adult females, especially in childbearing age, obesity, systemic diseases (e.g., polycystic ovary disease, chronic kidney disease, SLE), drugs ll (tetracyclines, steroids), and cerebral venous sinus thrombosis, etc.[3]

The usual symptoms of idiopathic intracranial hypertension are headache, progressive visual disturbances, and pulsatile tinnitus, patients may or may not have CSF rhinorrhoea. Papilledema is the main finding on clinical assessment that can lead to suspicion of idiopathic intracranial hypertension.[4] Neuroimaging is usually done to rule out any mass lesion that is leading to the signs of raised intracranial pressure; high-definition imaging modalities may reveal subtle signs that can be related to IIH. These include empty Sella, tortuous optic nerves, tonsillar herniation, slit ventricles, and increased optic nerve sheath diameter.[5] The diagnosis of idiopathic intracranial hypertension is confirmed using modified Dandy criteria.[6]

While non-surgical therapy, including weight management and medications like carbonic anhydrase inhibitors and topiramate, remains the first-line treatment, a subset of patients requires surgical intervention due to refractory symptoms or progressive visual loss.[7,8] LP shunt has been the cornerstone in the treatment of Idiopathic intracranial hypertension, as VP shunt insertion becomes demanding in the presence of slit ventricles. Though it helps to alleviate the symptoms and preserve the vision but at the same time it carries multiple risks that can jeopardise the normal functioning of an otherwise healthy individual. These include low-pressure headaches, frequent blockades, and nerve root irritation.[9]

In the era of modern neurosurgery, Ventriculoperitoneal (VP) shunt placement is considered the gold standard treatment option for idiopathic intracranial hypertension. These shunts are usually placed blindly, which results in various complications, common ones being catheter misplacement, which results in suboptimal drainage and increased revision rates. So here comes the role of Neuronavigational systems that offer a solution, by enabling precise catheter placement with perfect accuracy, thus reducing the likelihood of complications.[10]

Our study aims to assess the effectiveness of neuronavigation-guided VP shunt insertion in reducing the risk of complications regarding catheter placements and its effect on the probable surgical outcomes in idiopathic intracranial hypertension patients.

MATERIALS AND METHODS

Study Design and Settings

Our study includes the data collected from Pakistan Ordinance Factories (POFs) Hospital, Wah Cantt, Neurosurgery department, comprising those patients who underwent neuronavigational-guided VP shunt placement between January 2021 to June 2024 who were diagnosed as having IIH. The Institutional Review Board (IRB) of POFs Hospital, Wah Cantt, approved this study (No. IRB/ POFH/06-2025/ NEURO-SURG/ 02).

Inclusion Criteria

Patients between the ages of 18 and 80 years, both genders, diagnosed with IIH based on modified Dandy's criteria, who underwent neuronavigation-guided VP shunt and had a minimum of six months post-op follow-up were included in the study.

Exclusion Criteria

Patients with insufficient or missing data, and those who lost six months post-surgical follow-up.

Data Acquisition

All the relevant data was collected on the standardized proforma. The Proformas were only filled by the consultant neurosurgeon.

The parameters included in the proforma were age, gender, BMI, patient's presenting symptoms, diagnostic findings like CT/MRI pre-operative findings, clinical findings like Fundoscopic findings, opening LP pressure, Postop clinical follow-up, fundoscopy, and postop imaging details. Separate columns were there for pre, intra, and post op details.

Though the patients were regularly followed up and they reported symptomatic relief, formal documentation of papilledema was not done.

Surgical Procedure

Neuronavigation Setup

Preoperative imaging data were uploaded to the neuronavigation system using the BrainLab Curve navigation system. The patient's head was fixed on the Mayfield head clamp. The image for patient registration was completed using standard protocols.

Shunt Insertion

Under general anaesthesia, a parietal burr hole was made, and the peritoneum was opened through a transverse incision. A medium-pressure, burr hole 12 mm valve was used. No programmable shunt was used due to the high cost. A navigated disposable stylet (Figure 1) or a navigated dandy cannula (Figure 2) was used to access the ventricles. The trajectory of the VP shunt was followed in three planes on the navigation screen. Free flow was confirmed on ventriculostomy, and the tip of the catheter was positioned in the frontal horn of the lateral ventricle (Figure 3). Operating time was not taken into consideration, as the use of neuronavigation improves the accuracy as compared to the freehand technique. Moreover, the use of neuronavigation adds another 15-20 minutes for setup and registration. No registration error was encountered. The rest of the procedure was completed as a routine VP shunt surgery.

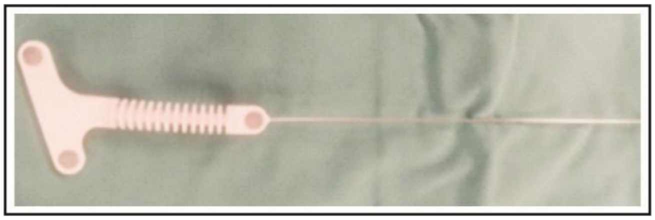

Figure 1: ***Navigated Disposable Stylet.*** *A single-use, sterile stylet designed for integration with Brainlab's Neuro-navigation system.*
Note: Written informed consent was obtained from the patient(s) for the publication of the images included in this manuscript. The patients were informed that these images would be used for scientific and educational purposes, that their identities would remain confidential, and that all images were de-identified to ensure privacy.

Figure 2: ***Navigated Dandy Cannula.*** *A tracking array was attached to the Dandy cannula and calibrated using the Brainlab Instrument Calibration Module (ICM), enabling real-time navigation of Dandy's cannula during ventriculostomy.*
Note: Written informed consent was obtained from the patient(s) for the publication of the images included in this manuscript. The patients were informed that these images would be used for scientific and educational purposes, that their identities would remain confidential, and that all images were de-identified to ensure privacy.

Postoperative Verification

A CT scan brain plain was done on the first postop day to confirm catheter positioning (Figure 4).

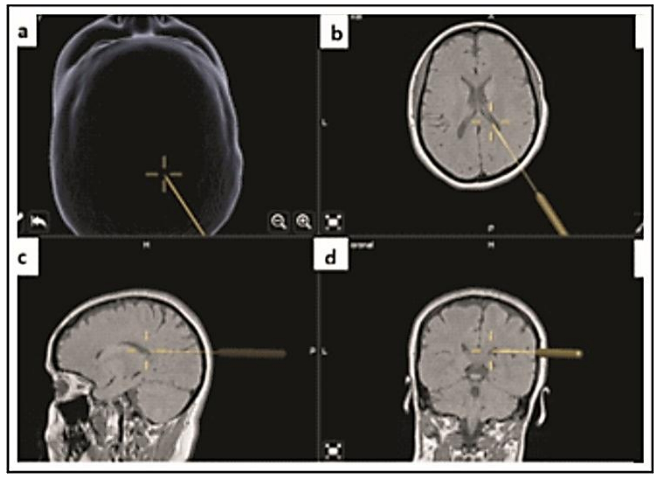

Figure 3: ***Per-operative Trajectory of VP Shunt****. (a) 3D skull rendering with a planned trajectory.* ***(b)*** *CT scan axial section showing the target point within the lateral ventricle, aligned with the planned trajectory.* ***(c)*** *CT scan sagittal section showing the depth and angle of the planned cannula insertion.* ***(d)*** *CT scan coronal section confirming lateral ventricular placement*
Note: Written informed consent was obtained from the patient(s) for the publication of the perioperative images included in this manuscript. The patients were informed that these images would be used for scientific and educational purposes, that their identities would remain confidential, and that all images were de-identified to ensure privacy.

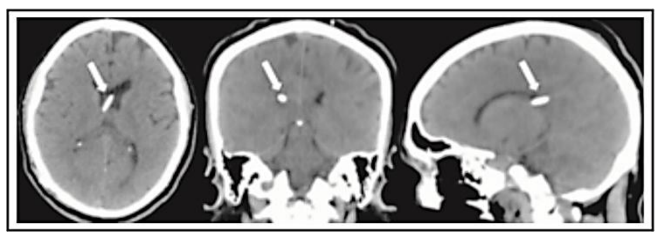

Figure 4: *Postoperative CT scan. The bold white arrows show the VP shunt position in axial (left), coronal (middle), and sagittal (right) planes.*
Note: Written informed consent was obtained from the patient(s) for the publication of the postoperative images included in this manuscript. The patients were informed that these images would be used for scientific and educational purposes, that their identities would remain confidential, and that all images were de-identified to ensure privacy.

Follow-Up

Patients were followed for six months with periodic clinical evaluations and imaging studies.

Statistical Analysis

SPSS version 27 was used to analyze the data. Chi-square test was used to analyze Categorical data like gender, symptoms, and papilledema grade. Student t-test was used to analyze Nominal data like age, BMI, and opening LP pressure. Post-stratification Chi-square test for parametric data and Fisher's exact test for non-parametric data were applied to account for the small sample size. A $p < 0.05$ was considered significant.

RESULTS

Demographics and Clinical Characteristics

A total of 21 patients were included in this study, with a female predominance (95.2%). The mean age of the patients was 35.2 years, with a mean BMI of 30.1 kg/m². Common presenting complaints reported were headaches (100%), visual disturbances (90.5%), nausea, vomiting (66.7%), and tinnitus (38.1%). 95.2% of the patients had papilledema on fundoscopic examination at the time of presentation. Imaging findings showed slit ventricles in 85.7% of patients, while 9.5% exhibited empty Sella. Mean opening lumbar puncture pressure of 38.5 mmHg.

Post-Operative Assessment

Postoperatively, there was a significant improvement in all measured parameters. Follow-up assessments at two weeks, six weeks, and six months were carried out, which demonstrated resolution of papilledema in most patients. Statistical analysis showed significant improvements across symptoms and papilledema reduction, indicating the efficacy of neuronavigation-guided VP shunt insertion in enhancing clinical outcomes for BIH patients (Table 1).

Out of all 21 patients, just two developed complications like surgical site infection and a misplaced VP shunt. The one with a surgical site infection was treated with IV antibiotics and wound care while the malpositioned VP shunt was readjusted. Both patients remained symptom-free on the follow-up visits.

Table 1: *Association between VP shunt Surgery and Improvement in Major Symptoms and Papilledema (n = 21).*

Parameter	Pre-operative (Present)	Post-operative (Present)	χ^2 value	df	p-value
Headache	21 (100%)	3 (14.3%)	18.2	1	<0.001
Visual disturbance	19 (90.5%)	2 (9.5%)	16.4	1	<0.001
Nausea / Vomiting	14 (66.7%)	2 (9.5%)	11.9	1	<0.001
Tinnitus	8 (38.1%)	1 (4.8%)	6.7	1	0.009
Papilledema	20 (95.2%)	1 (4.8%)	19.6	1	<0.001

DISCUSSION

In the past few decades, the incidence reports of idiopathic intracranial hypertension have been on the rise due to multiple factors demonstrated above.[11] As a result, shunt placement procedures are becoming common in all the neurosurgery centers. Since the neuro navigation system is not readily available at most of the centers in LMIC hospitals, usually these shunts are placed blindly depending upon the surface markings and anatomical landmarks, which obviously have high failure or complication rates, or lumbo-peritoneal shunts are placed, which are associated with higher rates of complications.[12] The repositioning of misplaced and displaced VP shunts is one of the common procedures. It not only raised the question of the surgeon's expertise but also added to the suffering of the patients. There is no doubt that repeated redo shunt surgery procedures are a burden on the patients as well as the hospital economy; ultimately, the whole health care system has to bear the financial consequences.

The advent of neuro-navigation is a blessing, saving both the surgeons and the patients from the misery of redo surgeries. In the IIH, where the ventricle system is already slit-like, collapsed, or distorted, to put these shunts in the ventricles with accuracy with traditional methods is not only very difficult but has a high failure rate.

Our results suggested that neuronavigation offers superior precision, minimizing revision rates and enhancing patient outcomes. Our cohort showed that just one patient required the re-do surgery for shunt placement; this low complication rate further supports the safety of neuronavigation-guided procedures. At the same time, neuronavigation-guided VP shunt offers several benefits over traditional lumbar-peritoneal (LP) shunt placement, including reduced risks of complications commonly associated with LP shunts.

Strengths and Limitations

This study is limited by its small sample size and single-centre design, which results in an impaired generalizability of the results in the general population. However, the results of this investigation report favorable outcomes in patients undergoing neuronavigation-guided VP shunt placement for IIH, providing a strong foundation for future studies to investigate our results.

CONCLUSION

Our study concludes that Neuronavigation-guidance during VP shunt placement in IIH patients remains the gold standard for VP shunt insertion in IIH patients, which has enhanced the cannulation of ventricles with enhanced accuracy, decreased complications like displacements and misplacements, and increased the surgeon’s confidence, thereby reducing the post-procedure complications rates and better patients’ recovery outcomes. Further studies are needed to validate the findings in this investigation.

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Additional information

Disclosures: Authors report no conflict of interest.
Ethical Review Board Approval: The Institutional Review Board (IRB) of POFs Hospital Wah Cantt, approved of this study (No. IRB/ POFH/06-2025/ NEURO-SURG/ 02).
Human Subjects: Consent was obtained by all patients/participants in this study.
Conflict of Interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
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AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Muhammad Mehboob Alam	Study design and methodology.
2.	Sohail Ahmed	Paper writing.
3.	Haris Ali	Data collection and calculations.
4.	Rashada Farooqi	Analysis of data and interpretation of results.
5.	Syed Asim Ali Shah	Literature review and referencing.
6.	Mohammad Aadil Qamar	Editing and quality insurer.