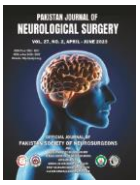

PAKISTAN JOURNAL OF NEUROLOGICAL SURGERY (QUARTERLY) – OFFICIAL JOURNAL OF PAKISTAN SOCIETY OF NEUROSURGEONS

Original Article

The Comparison of Outcome of Ventriculoperitoneal Shunts vs. Endoscopic Third Ventriculostomy in Patients with Idiopathic Normal Pressure Hydrocephalus

Syed Hammad Naqvi[1], Muhammad Motsim Shah[1], Yasir Shahzad[2], Soban Sarwar[1] Fraz Mehmood[3], Nadeem Akhtar[1]

Department of Neurosurgeries, [1]DHQ Hospital, [2]Rawal Institute of Health Sciences, and [3]Holy Family Hospital Rawalpindi, Pakistan

ABSTRACT

Introduction:

Objective: To compare functional outcomes in terms of INPGHS score and overall improvement in patients of iNPH treated with ETV vs. VP shunting.

Materials & Methods: A Randomized control trial was conducted for 6 months at the Department of Neurosurgery, Rawalpindi Medical University and Allied Hospitals, Rawalpindi. 62 patients (31 in each group) were enrolled & allocated into two groups. In group A patients ETV was done and in group B VP shunting. Post-operatively, Patients were followed up for 1 month.

Results: The mean age of the patients in the ETV & VP shunting groups was 63.19 ± 6.95 & 63 ± 6.82 years respectively. Males were 64.5% (n = 20) in both groups. Improvement was noted in 9 (29%) patients in the ETV group & 15 (48.4%) patients in the latter group (p-value = 0.118).

Conclusion: Ventriculoperitoneal shunts are superior to endoscopic third ventriculostomy in terms of functional neurological outcomes and improvement in symptoms.

Keywords: Endoscopic Third Ventriculostomy, Ventriculoperitoneal Shunt, Idiopathic Normal Pressure Hydrocephalus Grading Scale (iNPHGS), Aqueductal CSF Stroke Volume (ACSV).

Corresponding Author: Yasir Shahzad
Department of Neurosurgery, Rawal Institute of Health Sciences, Islamabad – Pakistan
Email: dryasirs@yahoo.com

Date of Submission: 14-04-2023
Date of Revision: 05-06-2023
Date of Acceptance: 09-06-2023
Date of Online Publishing: 30-06-2023
Date of Print: 30-06-2023

DOI: 10.36552/pjns.v27i2.854

INTRODUCTION

Normal-pressure-hydrocephalus (iNPH) is a prevalent neurological disorder affecting the older age groups which are mostly underdiagnosed but are surgically curable. Ventriculoperitoneal shunts (VP), which redirect

cerebrospinal fluid (CSF) have been their mode of treatment. However, given the minimally invasive basis, endoscopic techniques i.e. Endoscopic third ventriculostomy (ETV) are quickly becoming popular. Literature reports mixed outcome results of the two & a gold standard is yet to be established. This study explores this research question. Idiopathic.[1, 2] Prevalence of congenital and acquired hydrocephalus is 0.5 – 1 and 3 – 5 respectively, per 1000 live-born infants, in developed countries.[3, 4] The occurrence of idiopathic NPH has been stated to be 200 per 100000 people.[5]

Characteristics of iNPH are, gradual gait ataxia, urinary incontinence, and cognitive impairment, also known as Hakim-Adams syndrome and approximately 50% of cases show this clinical trial. [6, 7]INPH is related to communicating hydrocephalus, as exhibited by various diagnostic modalities such as CT or MRI of the brain and a normal cerebrospinal fluid (CSF) pressure. (7 – 24 cm H_2O).

VP-shunt with programmable valve placement is the most commonly acknowledged and performed procedure. Overall, the highly accepted treatment of choice for iNPH is surgery, as it has been associated with a better outcome of the disease.[8, 9] Sharma et al. compared the outcomes of VP-shunt with ETV for the management of iNPH and concluded that VP-shunt is better than ETV for the treatment of iNPH, they reported significant improvement in 73% patients in VP-shunt group versus only 37% patients in ETV group.[10]

While a study by Uche et al. did not report any noteworthy difference between VP-shunt and ETV. They reported motor function improvement in 49% of patients who have undergone the VP-shunt procedure compared to only 36% of patients who had undergone the ETV procedure with an insignificant statistical difference.[11]

This study aims to collate the outcome of ETV vs VP-shunt for the treatment of iNPH. As literature has reported mixed results regarding the outcomes of these two procedures and still no gold standard technique has been recommended for the management of iNPH.[6] The present study will help us to determine the better modality &will help to adopt a better technique for the management of iNPH.

MATERIALS & METHODS

Study Design & Settings

A randomized controlled trial was conducted at the Department of Neurosurgery, District Head Quarters Hospital Rawalpindi over 6 months from 30-9-2021 to 30-3-2022.

Sample Size & Sampling Technique

62 patients were included with 31 in each group. Non-probability consecutive sampling with random allocation into two equal groups using draw randomization.

Inclusion Criteria

Those patients (aged 50-75 years) were included who were diagnosed with iNPH as per-operational definition and those.

Exclusion Criteria

The patients having Brain tumors, Alzheimer's Disease, Parkinson's Disease, Stroke related memory impairment & Patients unwilling to be a part of the study, were excluded.

Procedure Details

In group A patients endoscopic third ventriculostomy (ETV) was done and in group B Ventriculoperitoneal shunt (VP-shunt) was done. After the procedure, patients were followed up for 1 month. Variables noted the were patient's age, gender, duration of symptoms & INPHGS score.

Both VP shunting & ETV were performed by consultant neurosurgeons in elective settings.

- ETV – in this procedure, with the help of a rigid neuroendoscope and a Fogarty catheter a perforation was made in the floor of the third ventricle establishing a corridor between ventricles and cisterns resulting in a decrease in subsequent CSF pressure. The fenestration made was more than 5mm in size.
- VP shunt – we used medium-pressure ventriculoperitoneal shunts, a burrhole was created at the KEEN's point and the shunt was passed into the lateral ventricle of the brain, the other end of the shunt was tunneled into the peritoneal cavity through subcutaneous tissue via an abdominal incision.

Idiopathic Normal-Pressure Hydrocephalus Grading Scale (INPHGS)

A grading scale was used to classify the severity of the components of iNPH i.e. gait disturbance, cognitive disturbance & urinary disturbance. The score ranges from 0 – 12, with scores in the lower range showing better outcomes and higher depicting poor outcomes.

Data Analysis

The level of significance was taken as 5% the and power of the study was 80%.

Data were analyzed via SPSS v25.0. Quantitative variables were analyzed via mean and standard deviations. Categorical variables such as gender and improvement in clinical outcome were calculated as percentages and frequency. Comparison of the iNPH grading scale between two groups at the 1st-month follow-up was done via independent t-test. The chi-square test was used for the comparison of improvement in clinical outcomes between the groups. P-value ≤ 0.05 was taken as significant.

Ethical Considerations

This study was approved by the Ethics Review Committee of District Headquarters Hospital Rawalpindi.

RESULTS

Distribution by Gender

The total number of patients in the study was 62 with Male to female ratio of 1.8:1, while 64.5% (n = 40) were male & 35.4% (n = 22) were female. Males were 64.5% (n = 20) in both groups.

Distribution by Age

The mean age of patients in the study was 63.09 ± 6.83 years and the range was 53-74 years. In the ETV group, the mean age of the subjects was 63.19 ± 6.95 years & in the VPS group, it was 63 ± 6.82 years.

Distribution by the Duration of Disease

Patients included in the study showed a mean period of 6.59 ± 4.83 years with symptoms showing a minimum duration of 1 year and a maximum duration of 20 years respectively. In the ETV group, it was 6.61 ± 5.13 years while in the VPS group, it was 6.58 ± 4.59 years.

Comparison of INPHGS Score

Before surgery, the mean INPHGS score was 7.31 ± 1.44 and after 1st month of surgery, the mean INPHGS score was 6.32 ± 1.39. Before surgery: In the ETV group the mean INPHGS score was 7.16 ± 1.39 and in the VPS group it was 7.45 ± 1.50 (p-value = 0.433). After surgery: In the ETV group the mean INPHGS score of the patients was 6.35 ± 1.43 and in the VPS group it was 6.29 ± 1.37. (p-value = 0.857). After surgery improvement

Table 1: Comparison of Pre and post-surgery INPHGS scores of the patients between study groups

INPHGS	Study Groups	Mean	SD	p-value

Before Surgery	ETV	7.16	1.39	0.433
	VPS	7.45	1.50	
After 1st month	ETV	6.35	1.43	0.857
	VPS	6.29	1.37	

was noted in 38.71% (n = 24) of patients (Table 1).

Comparison of Improvement

Improvement was noted in 29% (n=9) patients in the ETV group &48.4% (n=15) patients in the VPS group.

Comparison of Improvement by Gender

By gender, in male patients of the ETV group, improvement was noted in 25% (n = 5) patients, and in the VPS group, it was 40% (n = 8). In females in the ETV group improvement was noted in 36.4% (n = 4) and the latter it was noted in 63.6% (n = 7) patients (Table 2).

Table 2: Comparison of improvement based on Study groups

		Study Groups		Total	p-value
		ETV	VPS		
Improvement	Yes	9	15	24	0.118
		29.0%	48.4%	38.7%	
	No	22	16	38	
		71.0%	51.6%	61.3%	

Comparison of Improvement by Age – Group

In the 50 – 60 years age group: In the ETV group improvement was noted in 4 (28.6%) patients and in the latter group it was 53.3% (n = 8). In patients aged > 60 years: In the former group, the improvement was 29.4% (n = 5) & in the latter group it was 43.8% (n = 7).

Table 3: Improvement between study groups stratified by age group.

Improvement			Study Groups		Total	p-value
			ETV	VPS		
Age Groups	50 – 60	Yes	4	8	12	0.176
			28.6%	53.3%	41.4%	
		No	10	7	17	
			71.4%	46.7%	58.6%	
	> 60	Yes	5	7	12	0.392
			29.4%	43.8%	36.4%	
		No	12	9	21	
			70.6%	56.2%	63.6%	

Table 4: Stratification by the duration of symptoms.

Improvement			Group		Total	p-value
			ETV	VPS		
Duration of symptoms (Years)	≤ 7	Yes	5	11	16	0.121
			26.3%	50.0%	39.0%	
		No	14	11	25	
			73.7%	50.0%	61.0%	
	> 7	Yes	4	4	8	0.604
			33.3%	44.4%	38.1%	
		No	8	5	13	
			66.7%	55.6%	61.9%	

Comparison of Improvement by Disease Duration

In patients having a duration of symptoms ≤7 years: In the ETV group the improvement was noted in 26.3% (n = 5) patients and latter group it was noted in 50% (n = 11). In patients having duration of symptoms > 7 years: In the ETV group improvement was noted in 33.3% (n = 4) patients and latter group it was noted in 44.4% (n = 4) patients.

DISCUSSION

Idiopathic normal pressure hydrocephalus (INPH) is constituted by a triad of gait apraxia, cognitive dysfunction & urinary incontinence (Hakim-Adams syndrome) which is found nearly in half of these cases, however, only 1 or 2 features are sufficient for diagnosis alone. It is associated with communicating hydrocephalus and a normal cerebrospinal fluid (CSF) (7 – 24 cm H2O).[12,13] It is classified into two types primary and secondary. The former type also labeled idiopathic differentiates from the latter based on etiology with respective etiologic causes such as meningitis, trauma, or subarachnoid hemorrhage. The primary type forms the bulk.

The prevalence of NPH ranges from 0.3%- 3% in patients over the age of 65. This number is thought to be under-representation with greater cases unreported. The dilemma can be explained by a similar spectrum of symptoms between iNPH and other neurodegenerative diseases posing a diagnostic challenge. Moreover, a prevalence as high as 14% in extended care facilities has been suggested.[14]

The pathophysiological mechanisms underlying iNPH are poorly understood to date. Various theories are present, the most popular being disturbances in CSF dynamics, brain parenchyma, and vascular differences. CSF bulk flow theory & CSF pulsatile flow theory have both been scrutinized for possible causation.[15,16] Hakim and Adam's hypothesis attributes iNPH to decreased CSF absorption resulting in increased intracranial pressure causing compensatory ventricular enlargement. Using PET scans, Owler et al, demonstrated a significant decrease in cerebral blood flow within the cerebrum, cerebellum & deep gray matter in iNPH patients, moreover, a reduction of up to 50% in venous compliance has also been reported.[17,18]

Shunt surgery is the current standard of care for effective treatment but ETV is also an option.[12,19] The prognosis of shunt surgery is determined by timely & accurate diagnosis & presence of co-morbidities. In our study of patients with symptoms less than 7 years, 11 patients showed clinical improvement after VPS compared to the ETV procedure where only 5 patients showed improvement (p = 0.121). The presence of severe dementia may lead to unfavorable results while in contrast, a gait ataxia is a good prognostic feature.[20] Other studies have studied CSF flow distribution, which indicates that Aqueductal CSF stroke volume (ACSV) increases with the progression of the disease i.e. from the onset of symptoms to 24 months and favors a positive response to shunting, While after that there is a gradual decline till 12 months with decreased (ACSV) stroke volume over time which can predict irreversible damage due to iNPH and hence shunt unresponsiveness ensues.[21,22] CSF tap test can also be employed as a prognostic marker with the betterment of symptoms after 30-60 ml of fluid drainage generally a positive sign. However, the contrary does not mark a negative shunt response.[23]

Endoscopic third ventriculostomy (ETV) is increasingly being employed & being utilized for hydrocephalus of multiple etiologies[24] but its outcome is poor in cases that are post-hemorrhagic & post-infective. Appropriate selection of cases is vital to the required outcome. Additionally, better surgical expertise and post-operative care aid in improved outcomes.[25]

According to our study, VPS showed better results as compared to ETV. Overall improvement after surgery was noted in 24 (38.71%) patients. In the ETV group this improvement was noted in 9(29%) patients and VPS group improvement was noted in 15 (48.4%) patients. However, despite this difference being statistically insignificant, better results of VP shunt can be attributable to the ETV failure rate which is inherent to the technical constitution of the procedure, the fenestration that is made in ETV is liable to collapse due to the anatomical and mechanical factors, whereas VP shunt provides a relatively robust alternative pathway for continuous drainage of CSF.

Consistent with our findings, ETV in communicating HCP has shown a very low success rate making its use questionable.[26] Although the contrary has been reported as well.[37] Adil Aziz Khan et al,[28] demonstrated that ETV patients with less per-operative duration had decreased hospitalization periods. Additionally, ETV was also cost-effective & had less revision, fewer complications, and less re-hospitalization rates compared to the VPS group.[28]

A study by Sharma et al. compared the outcomes of VP-shunt with ETV for the management of iNPH and reported that VP-shunt is better than ETV for the treatment of iNPH, they reported significant improvement in 73% of patients in the VP-shunt group versus only 37% patients in ETV group.[10]

In 2008, an Italian multicenter study reported the benefits of ETV in the treatment of 110 patients with INPH. They reported a 69.1% improvement in their patients post-surgery after a 24-month follow-up period.[29] In contrast, VPS shunting success rate ranged from 69 – 90%.[30-33] Hence still faring better than the ETV group. However, the significance of its results is limited due to the study design being retrospective & patients not being assessed by commonly used predictive functional tests.[34]

Evidence in favor of VPS as the treatment of choice for patients with communicating HCP is significant in quantity.[34,35,36] In cases of PTH (post-traumatic hydrocephalus), VPS is favored over ETV as the preferred treatment, i.e. in a study reported by Phuenpathom et al,[36] they concluded VPS was the procedure of choice due to PTH caused by decompressive craniectomy.

Similarly, Pinto et al,[26] concluded that the VPS group showed better overall improvement results (ETV = 50%, VPS = 76.9%) and reported VPS to be better in terms of functional outcomes after 1-year follow-ups. Meanwhile, a study by Uche et al. did not report any noteworthy difference between VP-shunt and ETV. They reported motor function improvement in 49% of patients in the VP-shunt group versus 36% of patients in the ETV group with insignificant statistical differences. [11]

Hence our results reflect & stand consistent with the findings of previous studies on the subject consolidating the primacy of VP shunting over ETV in this specific cohort of patients. While ETV remains a viable option for the treatment of iNPH it had no significant improvement in our study in contrast to VPS which has fewer potential complications and better success rates.

CONCLUSION

From the findings of this study, we may conclude that Ventriculoperitoneal Shunt showed better results as compared to Endoscopic Third Ventriculostomy for the neurosurgical treatment of idiopathic Normal Pressure Hydrocephalus in terms of functional outcome and clinical improvement.

RECOMMENDATION

Ventriculoperitoneal shunting should be used as a procedure of choice when treating cases of Idiopathic Normal pressure hydrocephalus.

REFERENCES

1. Karimy JK, Duran D, Hu JK, Gavankar C, Gaillard JR, Bayri Y, et al. Cerebrospinal fluid hypersecretion in pediatric hydrocephalus. Neurosurgical Focus, 2016; 41 (5): E10.
2. Muir RT, Wang S, Warf BC. Global surgery for pediatric hydrocephalus in the developing world: a review of the history, challenges, and future directions. Neurosurgical Focus, 2016; 41 (5): E11.
3. Nacher M, Lambert V, Favre A, Carles G, Elenga N. High mortality due to congenital malformations in children aged< 1 year in French Guiana. BMC Pediatrics, 2018; 18 (1): 1-5.
4. Tully HM, Dobyns WB. Infantile hydrocephalus: a review of epidemiology, classification, and causes. European Journal of Medical Genetics, 2014; 57 (8): 359-68.
5. Williams MA, Malm J. Diagnosis and treatment of idiopathic normal pressure hydrocephalus. Continuum: Lifelong Learning in Neurology, 2016; 22 (2 Dementia): 579.
6. Mori E, Ishikawa M, Kato T, Kazui H, Miyake H, Miyajima M, et al. Guidelines for management of idiopathic normal pressure hydrocephalus. Neurologia Medico-chirurgica. 2012; 52 (11): 775-809.
7. Nassar BR, Lippa CF. Idiopathic normal pressure hydrocephalus: a review for general practitioners. Gerontology and Geriatric Medicine, 2016; 2: 2333721416643702.
8. Bräutigam K, Vakis A, Tsitsipanis C. Pathogenesis of idiopathic normal pressure hydrocephalus: a review of knowledge. Journal of Clinical Neuroscience, 2019; 61: 10-3.
9. Gholampour S, Bahmani M, Shariati A. Comparing the efficiency of two treatment methods of hydrocephalus: shunt implantation and endoscopic third ventriculostomy. Basic and Clinical Neuroscience, 2019; 10 (3): 185.
10. Sharma R, Sharma R, Tandon V, Phalak M, Garg K, Singh M, et al. Is endoscopic third ventriculostomy a feasible option or is ventriculoperitoneal shunt a safer bet for the treatment of posttraumatic hydrocephalus? A gap time model-based algorithm. Neurology India, 2020; 68 (5): 1125.
11. Uche EO, Okorie C, Iloabachie I, Amuta DS, Uche NJ. Endoscopic third ventriculostomy (ETV) and ventriculoperitoneal shunt (VPS) in non-communicating hydrocephalus (NCH): comparison of outcome profiles in Nigerian children. Child's Nervous System, 2018; 34 (9): 1683-9.
12. Adams R, Fisher C, Hakim S, Ojemann R, Sweet W. Symptomatic occult hydrocephalus with normal cerebrospinal-fluid pressure: a treatable syndrome. New England Journal of Medicine, 1965; 273 (3): 117-26.
13. Hakim CA, Hakim R, Hakim S. Normal-pressure hydrocephalus. Neurosurgery clinics of North America, 2001; 12 (4): 761-73, ix.
14. Marmarou A, Young HF, Aygok GA. Estimated incidence of normal-pressure hydrocephalus and shunt outcome in patients residing in assisted-living and extended-care facilities. Neurosurgical Focus, 2007; 22 (4): 1-8.
15. Greitz D. Cerebrospinal fluid circulation and associated intracranial dynamics. A radiologic investigation using MR imaging and radionuclide cisternography. Acta Radiological Supplementum, 1993; 386: 1-23.
16. Brinker T, Stopa E, Morrison J, Klinge P. A new look

at cerebrospinal fluid circulation. Fluids and Barriers of the CNS. 2014; 11 (1): 1-16.
17. Bateman G. The pathophysiology of idiopathic normal pressure hydrocephalus: cerebral ischemia or altered venous hemodynamics? American Journal of Neuroradiology, 2008; 29 (1): 198-203.
18. Klinge PM, Brooks DJ, Samii A, Weckesser E, van den Hoff J, Fricke H, et al. Correlates of local cerebral blood flow (CBF) in normal pressure hydrocephalus patients before and after shunting—A retrospective analysis of [15O] H2O PET-CBF studies in 65 patients. Clinical neurology and Neurosurgery, 2008; 110 (4): 369-75.
19. Rosell CM, Andersson J, Kockum K, Lilja-Lund O, Söderström L, Laurell K. Prevalence of idiopathic normal pressure hydrocephalus-a pilot study in Jämtland, Sweden. Fluids and Barriers of the CNS. 2015; 12 (1): 1-.
20. Bugalho P, Alves L, Miguel R. Gait dysfunction in Parkinson's disease and normal pressure hydrocephalus: a comparative study. Journal of Neural Transmission, 2013; 120 (8): 1201-7.
21. Toma AK, Holl E, Kitchen ND, Watkins LD. Evans' index revisited: the need for an alternative in normal pressure hydrocephalus. Neurosurgery, 2011; 68 (4): 939-44.
22. Scollato A, Gallina P, Gautam B, Pellicanò G, Cavallini C, Tenenbaum R, et al. Changes in aqueductal CSF stroke volume in shunted patients with idiopathic normal-pressure hydrocephalus. American Journal of Neuroradiology, 2009; 30 (8): 1580-6.
23. Marmarou A, Young HF, Aygok GA, Sawauchi S, Tsuji O, Yamamoto T, et al. Diagnosis and management of idiopathic normal-pressure hydrocephalus: a prospective study in 151 patients. Journal of Neurosurgery, 2005; 102 (6): 987-97.
24. Singh D, Gupta V, Goyal A, Singh H, Sinha S, Singh A, et al. Endoscopic third ventriculostomy in obstructed hydrocephalus. Neurology India, 2003; 51 (1): 39.
25. Yadav YR, Parihar V, Pande S, Namdev H, Agarwal M. Endoscopic third ventriculostomy. J Neurosci Rural Pract. 2012; 3 (2): 163-73.
26. Pinto FCG, Saad F, Oliveira MFd, Pereira RM, Miranda FLd, Tornai JB, et al. Role of endoscopic third ventriculostomy and ventriculoperitoneal shunt in idiopathic normal pressure hydrocephalus: preliminary results of a randomized clinical trial. Neurosurgery, 2013; 72 (5): 845-54.
27. Hailong F, Guangfu H, Haibin T, Hong P, Yong C, Weidong L, et al. Endoscopic third ventriculostomy in the management of communicating hydrocephalus: a preliminary study. Journal of Neurosurgery, 2008; 109 (5): 923-30.
28. Khan AA, Gondal SS, Sharif MM, Yousaf M, Akhtar N. Outcome of Endoscopic Third Ventriculostomy. Journal of Rawalpindi Medical College, 2018; 22 (1): 4-7.
29. Gangemi M, Maiuri F, Buonamassa S, Colella G, de Divitiis E. Endoscopic third ventriculostomy in idiopathic normal pressure hydrocephalus. Neurosurgery, 2004; 55 (1): 1 29-34.
30. Boon AJ, Tans JT, Delwel EJ, Egeler-Peerdeman SM, Hanlo PW, Wurzer HA, et al. Dutch Normal-Pressure Hydrocephalus Study: randomized comparison of low-and medium-pressure shunts. Journal of Neurosurgery, 1998; 88 (3): 490-5.
31. McGirt MJ, Woodworth G, Coon AL, Thomas G, Williams MA, Rigamonti D. Diagnosis, treatment, and analysis of long-term outcomes in idiopathic normal-pressure hydrocephalus. Neurosurgery, 2005; 57 (4): 699-705.
32. Zemack G, Romner B. Adjustable valves in normal-pressure hydrocephalus: a retrospective study of 218 patients. Neurosurgery, 2002; 51 (6): 1392-402.
33. Marmarou A, Bergsneider M, Klinge P, Relkin N, Black PM. The value of supplemental prognostic tests for the preoperative assessment of idiopathic normal-pressure hydrocephalus. Neurosurgery, 2005; 57 (suppl_3): S2-17-S2-28.
34. Gölz L, Ruppert F-H, Meier U, Lemcke J. Outcome of modern shunt therapy in patients with idiopathic normal pressure hydrocephalus 6 years postoperatively. Journal of Neurosurgery, 2014; 121 (4): 771-5.
35. Kim HS, Lee SU, Cha JH, Heo W, Song JS, Kim SJ. Clinical Analysis of Results of Shunt Operation for Hydrocephalus Following Traumatic Brain Injury. Korean J Neurotrauma, 2015; 11 (2): 58-62.
36. Phuenpathom N, Ratanalert S, Saeheng S, Sripairojkul B. Post-traumatic hydrocephalus: experience in 17 consecutive cases. J Med Assoc Thai. 1999; 82 (1): 46-53.

Additional Information

Disclosures: Authors report no conflict of interest.
Ethical Review Board Approval: The study was conformed to the ethical review board requirements.
Human Subjects: Consent was obtained by all patients/participants in this study.
Conflicts 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.
Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.
Financial Relationships: None.

AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Syed Hammad Naqvi & Yasir Shahzad	Study design, literature review, data collection, and methodology.
2.	Syed Hammad Naqvi & Motsim Shah	Analysis of data, interpretation of results, and paper writing.
3.	Nadeem Akhtar & Soban Sarwar	Editing and quality insurer.