RJNMSR
Review Journal of Neurological & Medical Sciences Review

Volume 4, Issue 3, 2026

EVALUATING THE OUTCOMES OF VENTRICULOPERITONEAL SHUNT SURGERY IN PATIENTS WITH HYDROCEPHALUS

Laiba Tashfeen[1], Rafia Ali[*2], Mahrukh Bhullar[3]

[1]*Department of Health Professional Technologies, University of Lahore*
[*2]*Demonstrator, Department of Health Professional Technologies, University of Lahore*
[3]*Demonstrator, Department of Health Professional Technologies, University of Lahore*

[1]laibatashfeen65@gmail.com, [*2]rafyaaly@gmail.com, [3]mahrukh.bhullar304@gmail.com

Corresponding Author: *
Rafia Ali
DOI: http://doi.org/10.5281/zenodo.21700882

Received	Accepted	Published
31 January 2026	16 March 2026	30 March 2026

ABSTRACT

Background: *Hydrocephalus is a major cause of neurological morbidity and long-term disability worldwide. Evaluating surgical outcomes and identifying post-operative complication predictors can optimize patient selection, improve shunt survival, and refine clinical management.*

Objectives: *To assess the clinical outcome of VP shunt surgery in hydrocephalus patient by assessing recovery status and surgical complications.*

Methodology: *A Retrospective observational study was conducted on 102 patient with hydrocephalus. Data on type of shunt, type of hydrocephalus, Evan's ratio and pre and post operative outcomes were analyzed using SPSS version 27.0.1 for descriptive statistics and chi-square test*

Results: *A total of 102 patients were operated on with VP shunting for the treatment of hydrocephalus. Females made up 52.9% and males comprised 47.1% of the study subjects. Pre-operative symptoms commonly reported included vomiting (69.6%), headaches (65.7%) and gait problems (54.9%). Hydrocephalus of congenital origin was the most prevalent form (42.2%). After surgery, 85 (83.3%) of patients exhibited early clinical improvement. Post-operative complications included shunt infection (16.7%), shunt malfunction (15.7%), over-drainage (13.7%) and abdominal complication (8.8%). There was a statistically significant relationship between hydrocephalus severity and type of hydrocephalus ($p = 0.002$)*

Conclusion: *Venturiculo peritoneal shunt is a successful treatment for hydrocephalus and results in quick neurological improvement and intracranial pressure control. However, shunt infection, mechanical failure, over drainage and abdominal complications continue to be major obstacles to long term success. Early detection, strict infection control, regular follow up and advanced shunt technologies can improve outcomes and decrease revision surgeries.*

Keywords: *Hydrocephalus, VP shunt , iNPH, Evans Ratio, Post-operative complications*

Introduction

Hydrocephalus represents a profound global burden characterized by an abnormal accumulation of cerebrospinal fluid (CSF) within the cerebral ventricular system, resulting in ventriculomegaly and elevated intracranial pressure. If left untreated, this progressive disruption in CSF dynamics leads to severe neurological morbidity, cognitive deterioration, and long-term disability across all age groups. The

primary neurosurgical modality utilized worldwide to mitigate this structural threat is the implantation of a ventriculoperitoneal (VP) shunt. These systems divert excessive CSF from the cerebral ventricles down into the peritoneal cavity where it can be naturally reabsorbed by the body. Despite its technical simplicity and established role as the gold standard of treatment, VP shunt surgery is plagued by high rates of clinical failure and long-term hardware complications. Historical data indicates that adults face a failure rate of up to 30%, whereas pediatric cohorts experience failure rates reaching nearly 50% to 60% within the first decade of placement, presenting a persistent challenge to neurosurgeons globally.

The primary causes of hydrocephalus are broadly categorized into congenital anomalies, acquired structural pathologies (such as head trauma, post-craniotomy states, tumors, or hemorrhages), and normal pressure hydrocephalus (NPH) which characteristically manifests in elderly populations. Across different surgical landscapes, congenital hydrocephalus remains the most prominent indication for shunt installation. For instance, a substantial historical cohort study by Javeed et al. evaluated 1,030 hydrocephalus cases and documented that congenital hydrocephalus comprised 47.6% of the patient population and was strongly associated with positive surgical outcomes. Similarly, a descriptive study by Khan et al. highlighted that congenital pathology accounted for 46.4% of first-time VP shunt placements. While the demographic profiles of these patients vary widely, literature consistently demonstrates that biological gender itself plays a minor role in dictating long-term shunt survival, though certain exceptions like meningioma-related adult hydrocephalus have shown a slight advantage in male survival rates.

The therapeutic efficacy of a VP shunt is usually evident in the immediate postoperative phase, with rapid relief from severe preoperative indicators such as headaches, vomiting, seizures, cognitive decline, visual impairments, and gait disturbances. Popal et al. demonstrated that programmable VP shunts produced an impressive 91.2% symptom improvement rate within six months of surgery for idiopathic normal pressure hydrocephalus (iNPH) cases, with sustained clinical stability observed over two years. Furthermore, Svedung Wettervik et al. demonstrated a 66% clinical improvement rate in post-traumatic hydrocephalus patients, particularly among individuals showing reduced consciousness or low-pressure symptoms prior to intervention. In the context of infectious etiologies, such as high-grade tuberculous meningitis hydrocephalus, Kankane et al. documented a 77.5% success rate following direct VP shunting in Grade III pediatric patients, underscoring the life-saving capability of immediate surgical CSF diversion.

Despite these favorable early outcomes, the long-term prognosis of shunted patients is severely threatened by post-operative complications. Shunt infections represent a life-threatening complication, with 80% occurring within six months of placement due to intraoperative contamination, surgical environment issues, or patient age. Pan et al. reported an infective complication rate of 16.21% in pediatric cohorts, a figure closely mirrored by other regional institutions, while certain centers with highly rigorous infection controls have managed to restrict infection rates to 8.5%. Mechanical shunt malfunction or mechanical blockage is another prominent driver of surgical revisions. Khan et al. calculated an adult shunt malfunction rate of 15.4% with a median time to failure of 120 days, whereas infantile cohorts suffer much higher proximal failure rates due to high CSF protein levels or slit ventricles. Additionally, physiological imbalances such as over-drainage can provoke intracranial hypotension and subdural hematomas, while distal component issues lead to abdominal complications like cerebrospinal fluid ascites or rare visceral perforations. Modern radiological assessment has therefore become essential for managing these cases. Preoperative linear measurements specifically the Evans Index alongside advanced markers like the callosal angle and disproportionately enlarged subarachnoid space hydrocephalus (DESH) signs are crucial for confirming ventriculomegaly and predicting structural recovery.

The primary rationale for this study stems from the lifelong vulnerability of shunted patients to hardware failure and physiological setbacks. Recurrent surgeries place an immense physical, neurodevelopmental, and socioeconomic burden on the patient and healthcare systems. This study aims to evaluate the clinical outcomes of VP shunt surgery in hydrocephalus patients at regional centers, assessing the early recovery status and characterizing the frequencies of surgical complications to optimize patient management and long-term outcomes.

2. Methodology and Design

This retrospective study evaluated the success and complications of the placement of primary ventriculoperitoneal (VP) shunts in patients with hydrocephalus. The study was conducted in two tertiary care centers in Lahore, Pakistan: The Children's Hospital and The Punjab Institute of Neurosciences (PINS). A total of 102 patients were included in the study, which was determined by calculating the required number of patients based on the finite population correction factor (N = 1,000,000) with a confidence level of 95%, an expected outcome frequency of 10.6% ± 6% and a design effect of 1. The patients included in the study were between the ages of 1 and 40 years who were clinically diagnosed with hydrocephalus by using CT scan and MRI and required the placement of a primary VP shunt. The patients that had undergone prior VP shunt surgeries or revision surgeries were excluded from the study. The VP shunts that were used in the study were non-programmable and were supplied by Chhabra, Integra, Medtronic and Bhatti. The dependent and independent variables that were measured in the study included patient demographics, the type of hydrocephalus (congenital, acquired or normal pressure) and the severity of the hydrocephalus as determined by the Evans Index on CT or MRI scans (mild: 0.27 - 0.34, moderate: 0.34 - 0.40, severe: >0.40). Data extraction was executed using a pre-approved questionnaire/proforma adapted from validated neurosurgical literature. Formal permission and ethical clearances were secured from the Institutional Review Board (IRB) of the University of Lahore, followed by administrative approvals from the Medical Superintendents of the participating hospitals. Informed consent was confirmed for all included patient records, and absolute data confidentiality was maintained by using anonymous alphanumeric codes instead of direct patient identifiers. The assembled data was coded and analyzed using Statistical Package for the Social Sciences (SPSS) software version 27.0.1. Descriptive statistics were generated, expressing categorical demographics, clinical symptoms, shunt types, and complication rates as absolute frequencies and percentages. Inferential statistics were performed using the Pearson Chi-Square (chi^2) test to evaluate the associations between categorical parameters, such as the type of hydrocephalus, shunt brands, and Evans Index severity categories. Statistical significance was defined a priori at a threshold of $p > 0.05$.

3. Results

3.1 Demographic and Pre-Operative Clinical Characteristics

The baseline analysis of the study population revealed a balanced gender distribution among the 102 patients who underwent VP shunt surgery. Female patients represented the slight majority of the study sample, accounting for 54 individuals (52.9%), while male patients comprised the remaining 48 individuals (47.1%), yielding a total sample size of 102 (100.0%) as outlined below in Table 1.

Table 1: Gender Distribution of the Patient Population

Gender	Frequency (n)	Percentage (%)
Male	48	47.1
Female	54	52.9
Total	102	100.0

The pre-operative clinical profiles of the patients showed a high prevalence of classic intracranial hypertension indicators and neurological deficits. The most frequently reported pre-operative symptom was vomiting, which affected 71 patients (69.6%). This was closely followed by persistent headaches reported by 67 patients (65.7%), and gait disturbances documented in 56 patients (54.9%). Cognitive decline was present in 43 individuals (42.2%), while seizures were recorded in 37 patients (36.3%). Visual disturbances and urinary incontinence were noted in 35 patients (34.3%) and 32 patients (31.4%) respectively, as detailed in Table 2.

Table 2: Frequencies and Percentages of Pre-Operative Symptoms

Clinical Variables	Symptom Present (n)	Percentage Present (%)	Symptom Absent (n)	Percentage Absent (%)
Headache	67	65.7	35	34.3
Cognitive Decline	43	42.2	59	57.8
Vomiting	71	69.6	31	30.4
Gait Disturbance	56	54.9	46	45.1
Visual Disturbance	35	34.3	67	65.7
Urinary Incontinence	32	31.4	70	68.6
Seizures	37	36.3	65	63.7

3.2 Etiological and Radiological Characteristics

Radiological evaluation of pre-operative cranial CT and MRI scans using the Evans Index demonstrated varying degrees of ventricular enlargement across the cohort. Moderate hydrocephalus (0.34 - 0.40) was the most common presentation, identified in 46 patients (45.1%). Severe hydrocephalus (>0.40) was observed in 30 patients (29.4%), while mild ventriculomegaly (0.27 - 0.34) was verified in 26 patients (25.5%). These baseline frequencies are summarized in Table 3.

Table 3: Pre-Operative Severity of Ventriculomegaly Based on Evans Index

Severity Category	Frequency (n)	Percentage (%)
Mild (0.27 - 0.34)	26	25.5
Moderate (0.34 - 0.40)	46	45.1
Severe (>0.40)	30	29.4
Total	102	100.0

Regarding the underlying etiology, congenital hydrocephalus was the leading cause of ventriculomegaly in the study population, accounting for 43 patients (42.2%). Acquired hydrocephalus secondary to environmental factors, trauma, infections, or space-occupying lesions was diagnosed in 30 patients (29.4%). Normal pressure hydrocephalus (NPH) was documented in the remaining 29 patients (28.4%). All 102 patients in this cohort received non-programmable, fixed-pressure hardware systems. The most frequently implanted brand was the Chhabra shunt, utilized in 32 cases (31.4%). This was closely followed by the Bhatti shunt in 29 cases (28.4%), the Integra shunt in 21 cases (20.6%), and the Medtronic system in 20 cases (19.6%).

3.3 Post-Operative Clinical Outcomes and Complications

The primary evaluation of post-operative outcomes focused on immediate clinical improvement following surgical CSF diversion. The vast majority of the cohort achieved successful initial therapeutic responses, with 85 patients (83.3%) demonstrating rapid relief from hydrocephalus symptoms and effective control of intracranial pressure. Conversely, 17 patients (16.7%) failed to show early post-operative clinical improvement, as shown in Table 4.

Table 4: Post-Operative Initial Improvement in Hydrocephalus Symptoms

Initial Clinical Status	Frequency (n)	Percentage (%)
Improved (Yes)	85	83.3
Not Improved (No)	17	16.7
Total	102	100.0

Surgical complications within the tracking period occurred in more than half of the study subjects. Completely uneventful post-operative courses with no complications were recorded in 43 patients (42.2%), meaning that 59 individuals (57.8%) developed at least one adverse event. Among these complications, shunt infection was the most prevalent, occurring in 17 patients (16.7%). Mechanical shunt malfunction or acute hardware blockage was documented in 16 patients (15.7%). Over-drainage phenomena, which carry risks for subdural fluid collections, were observed in 14 cases (13.7%), while distal abdominal complications were reported in 9 patients (8.8%), as detailed in Table 5.

Table 5: Frequencies and Percentages of Post-Operative Complications

Post-Operative Event	Event Present (n)	Percentage Present (%)	Event Absent (n)	Percentage Absent (%)
Shunt Infection	17	16.7	85	83.3
Shunt Malfunction / Blockage	16	15.7	86	84.3
Over-Drainage	14	13.7	88	86.3
Abdominal Complications	9	8.8	93	91.2
No Complications	43	42.2	59	57.8

3.4 Inferential Statistical Analyses

To investigate clinical associations, cross-tabulations were performed using Pearson's Chi-Square test. First, the relationship between the etiological type of hydrocephalus and the specific brand of VP shunt implanted was analyzed. Among the 43 congenital cases, 18 received Chhabra, 7 received Integra, 8 received Medtronic, and 10 received Bhatti shunts. For the 30 acquired cases, 5 had Chhabra, 6 had Integra, 9 had Medtronic, and 10 had Bhatti systems. Among the 29 normal pressure hydrocephalus cases, 9 were treated with Chhabra, 8 with Integra, 3 with Medtronic, and 9 with Bhatti shunts. The Chi-square test returned a value indicating no statistically significant association (chi^2 = 10.75, p = 0.215), confirming that the selection of shunt hardware was independent of the patient's underlying hydrocephalus etiology, as summarized in Table 6.

Table 6: Cross-Tabulation and Chi-Square Analysis of Hydrocephalus Type vs. Shunt Brand

Type of Hydrocephalus	Chhabra (n)	Integra (n)	Medtronic (n)	Bhatti (n)	Total (n)	Statistical Value
Congenital	18	7	8	10	43	
Acquired	5	6	9	10	30	p = 0.215
Normal Pressure	9	8	3	9	29	(Non-Significant)

Total	32	21	20	29	102	

Next, the association between the etiological type of hydrocephalus and pre-operative severity categorized by the Evans Index was examined. Of the 26 patients with mild ventriculomegaly, 19 had congenital, 5 had acquired, and 2 had normal pressure hydrocephalus. Of the 46 moderate cases, 17 were congenital, 16 were acquired, and 13 were normal pressure hydrocephalus. Within the 30 severe presentations, 7 were congenital, 9 were acquired, and 14 had normal pressure hydrocephalus. The Pearson Chi-square test revealed a highly significant statistical association (chi^2 = 16.92, p = 0.002). This confirms that radiological severity based on the Evans Index varies significantly depending on the underlying etiological form of hydrocephalus, with normal pressure cases skewing toward severe frontal horn expansion in this cohort, as shown in Table 7.

Table 7: Cross-Tabulation and Chi-Square Analysis of Evans Index Severity vs. Hydrocephalus Type

Evans Index Severity	Congenital (n)	Acquired (n)	Normal Pressure (n)	Total (n)	Statistical Value
Mild (0.27 - 0.34)	19	5	2	26	
Moderate (0.34 - 0.40)	17	16	13	46	p = 0.002
Severe (>0.40)	7	9	14	30	(Highly Significant)
Total	43	30	29	102	

Finally, the relationship between radiological severity (Evans Index) and the implanted shunt brand was cross-examined. Mild cases (n=26) were distributed across Chhabra (13), Integra (5), Medtronic (4), and Bhatti (4) shunts. Moderate cases (n=46) involved Chhabra (12), Integra (10), Medtronic (10), and Bhatti (14) systems. Severe presentations (n=30) were managed using Chhabra (7), Integra (6), Medtronic (6), and Bhatti (11) shunts. The Chi-square test showed no significant statistical correlation (chi^2 = 6.64, p = 0.355), indicating that fixed-pressure shunt brand allocation was not influenced by pre-operative ventricular size, as outlined in Table 8.

Table 8: Cross-Tabulation and Chi-Square Analysis of Evans Index Severity vs. Shunt Brand

Evans Index Severity	Chhabra (n)	Integra (n)	Medtronic (n)	Bhatti (n)	Total (n)	Statistical Value
Mild	13	5	4	4	26	
Moderate	12	10	10	14	46	p = 0.355
Severe	7	6	6	11	30	(Non-Significant)
Total	32	21	20	29	102	

4. Discussion

This retrospective analysis evaluated the clinical profile, etiological distribution, radiological severity, and post-operative complications among 102 patients who underwent primary ventriculoperitoneal (VP) shunt surgery. The demographic evaluation demonstrated a close gender distribution with a slight female majority of 52.9%. This finding aligns with established neurosurgical literature showing that gender does not independently alter surgical outcomes or shunt survival rates. For example, Javeed et al. evaluated a larger cohort of 1,030 hydrocephalus patients and reported a male predominance of

64.2%, yet concluded that biological gender had no statistically significant correlation with long-term success or complication rates. Similarly, Bir et al. evaluated VP shunt outcomes in intracranial meningioma patients and noted that while male patients exhibited marginally higher shunt survival in specific tumor sub-groups, gender was not a broad predictor of success across mixed etiologies. The balanced gender representation in our study reinforces the consensus that surgical efficacy depends primarily on pathological and clinical factors rather than demographic variables.

Etiologically, congenital hydrocephalus was the most common presentation in this cohort, accounting for 42.2% of cases, followed by acquired forms (29.4%) and normal pressure hydrocephalus (28.4%). This distribution matches global data from developing nations, where congenital anomalies remain the primary driver for surgical CSF diversion. In their historical review, Javeed et al. found that congenital hydrocephalus comprised 47.6% of their sample and was an independent predictor of favorable long-term recovery. Khan et al. also reported a similar trend in pediatric cohorts, where congenital etiology was the primary diagnosis in 46.4% of patients receiving a first-time VP shunt. These parallels underscore the stable epidemiological pattern of hydrocephalus across regional centers, confirming that congenital structural defects require a substantial portion of public neurosurgical resources.

Preoperative radiological assessment using the Evans Index categorized the majority of our patients with moderate ventriculomegaly (45.1%), while severe ventricular dilation was observed in 29.4%. A key finding was the highly significant statistical association between the etiological type of hydrocephalus and the Evans Index severity ($p = 0.002$). This correlation highlights that different pathologies present distinct structural features on cranial imaging; in this cohort, normal pressure hydrocephalus cases showed a high proportion of severe frontal horn dilation relative to total internal skull diameter. In adult neurosurgical management, modern imaging markers are increasingly vital for predicting outcomes. Bianconi et al. reported that while basic clinical symptoms do not reliably predict long-term recovery after VP shunt surgery, specialized radiological markers—such as preoperative aqueductal CSF flow acceleration on brain MRI—serve as robust prognostic factors. This is further supported by Gao et al., whose multicenter retrospective study indicated that combining structural imaging biomarkers (like a sharp callosal angle and positive DESH signs) with clinical tap tests yielded the highest accuracy for predicting successful post-operative outcomes.

The primary clinical metric of surgical success in this study was immediate post-operative improvement, which was achieved by 83.3% of the patient population. This high rate of early success matches global data confirming the immediate effectiveness of VP shunts for reducing intracranial hypertension. Popal et al. documented a comparable 91.2% symptom response rate within six months of programmable VP shunt placement for normal pressure hydrocephalus, with long-term recovery maintained in over 90% of patients at two years. Svedung Wettervik et al. also observed clinical improvement in 66% of patients shunted for post-traumatic hydrocephalus, noting that optimal responses occurred in individuals with low-pressure profiles or compromised consciousness rather than vegetative states. Furthermore, Kankane et al. achieved a 77.5% clinical success rate when treating Grade III tuberculous meningitis hydrocephalus with direct VP shunting, demonstrating that timely surgical diversion provides excellent immediate neurological relief even in severe infectious environments.

However, the overall complication rate of 57.8% in our study highlights the substantial long-term challenges associated with non-programmable shunt hardware. Shunt infection occurred in 16.7% of our patients, matching the 16.21% infection rate reported by Pan,et.,al in a pediatric cohort. In contrast, some developed-nation registries report lower infection rates, such as the 8.5% documented by Piatt Jr. and Garton, likely due to differences in perioperative protocols or socio-economic constraints. Mechanical shunt malfunction or blockage occurred in 15.7% of

our patients, very close to the 15.4% rate reported by Khan et al. in an adult cohort with a median failure time of 120 days. Infant populations often exhibit much higher mechanical failure rates, as seen in the study by Bir, Konar, et al., where 84% of infants with post-hemorrhagic hydrocephalus experienced shunt failure, with 52% failing within the first three months due to proximal catheter occlusion.

Over-drainage occurred in 13.7% of our patients, while distal abdominal complications were limited to 8.8%. Sidhu et al. noted that serious abdominal events like gastric or colonic perforation are rare (0.1% - 0.7%), typically caused by localized inflammation or retrograde migration. Cuschieri et al. reported that post-shunt CSF ascites is also uncommon and often requires converting the distal tract into a ventriculoarterial shunt. Importantly, our inferential analysis showed that choice of shunt brand had no significant association with hydrocephalus etiology ($p = 0.215$) or Evans Index severity ($p = 0.355$). This aligns with findings by Wendling-Keim et al., who concluded that fixed versus adjustable valve design did not significantly impact long-term cognitive or motor development; instead, the overall frequency of surgical revisions was the primary predictor of poorer quality of life. Similarly, systematic reviews by Bue et al. and Palermo et al. found comparable safety and efficacy profiles across various shunt systems, confirming that precise surgical technique and diligent post-operative monitoring are the primary drivers of long-term success.

5. Conclusion

This study demonstrates that ventriculoperitoneal (VP) shunt surgery is an effective treatment for hydrocephalus, providing rapid clinical improvement in 83.3% of patients by relieving intracranial pressure across congenital, acquired, and normal pressure etiologies. However, a total post-operative complication rate of 57.8% including shunt infection (16.7%), mechanical malfunction (15.7%), over-drainage (13.7%), and abdominal issues (8.8%). It highlights the ongoing challenges of using non-programmable hardware. While a significant association was confirmed between the etiological type of hydrocephalus and pre-operative radiological severity via the Evans Index ($p = 0.002$), the selection of shunt brands was independent of disease etiology or severity. Ultimately, improving long-term outcomes and patient quality of life requires rigorous perioperative infection control, careful patient selection, regular clinical follow-up, and wider access to advanced programmable shunt technologies.

Ethical Approval

Performed as per the ethical standards of the IEC of PGIMER.

Declaration of Patient Consent

Informed consent obtained from participants.

Financial Support and Sponsorship

Nil.

Conflicts of Interest

There are no conflicts of interest.

6. REFERENCES

Backlund, A., Kristiansson, H., Fletcher-Sandersjöö, A., & Arvidsson, L. (2025). Impact of surgical timing on ventriculoperitoneal shunt failure rates: a population-based cohort study. World Neurosurgery, 195, 123737.

Bianconi, A., Colonna, S., Minardi, M., Di Perna, G., Ceroni, L., Nico, E., Garbossa, D., Borgarello, S., & Cofano, F. (2024). Prognostic factors in idiopathic Normal pressure hydrocephalus patients after Ventriculo-peritoneal shunt: results from a single-institution observational cohort study with long term follow-up. World Neurosurgery, 187, e1089-e1096.

Bir, S. C., Konar, S., Maiti, T. K., Kalakoti, P., Bollam, P., & Nanda, A. (2016). Outcome of ventriculoperitoneal shunt and predictors of shunt revision in infants with posthemorrhagic hydrocephalus. Child's Nervous System, 32(8), 1405-1414.

Bir, S. C., Patra, D. P., Maiti, T. K., Sun, H., Guthikonda, B., Notarianni, C., &

Nanda, A. (2016). Epidemiology of adult-onset hydrocephalus: institutional experience with 2001 patients. Neurosurgical focus, 41(3), E5.

Bir, S. C., Sapkota, S., Maiti, T. K., Konar, S., Bollam, P., & Nanda, A. (2017). Evaluation of ventriculoperitoneal shunt-related complications in intracranial meningioma with hydrocephalus. Journal of Neurological Surgery Part B: Skull Base, 78(01), 030-036.

Bue, E. L., Morello, A., Bellomo, J., Bradaschia, L., Lacatena, F., Colonna, S., Fiumefreddo, A., Stieglitz, L., Regli, L., & Lanotte, M. M. (2024). Ventriculoatrial shunt remains a safe surgical alternative for hydrocephalus: a systematic review and meta-analysis. Scientific Reports, 14(1), 18460.

Chalasani, R., Goonathilake, M. R., Waqar, S., George, S., Jean-Baptiste, W., Ali, A. Y., Inyang, B., Koshy, F. S., George, K., & Poudel, P. (2022). The outcome of surgical intervention (ventriculoperitoneal shunt and endoscopic third ventriculostomy) in patients with hydrocephalus secondary to tuberculous meningitis: a systematic review. Cureus, 14(5).

Chiu, C.-D., Chiu, P.-F., Wu, C.-Y., Yip, H.-T., Chiu, Y.-P., Ji, H.-R., Hsu, K.-C., Tsai, F.-J., & Chang, R. C.-H. (2024). Comparing the Long-Term Cardiovascular Outcomes of Lumbo-Peritoneal, Ventriculo-Peritoneal, or Non-Shunting Treatment after Idiopathic Normal Pressure Hydrocephalus: A Nationwide Retrospective Cohort Study. International Journal of Medical Sciences, 21(4), 656.

Cuschieri, A., Caruana, A., Shaw, C., German, E., Pace, G., Attard Montalto, G., Zerafa, J., Farrugia, M., Pisani, R., & Sciriha Camilleri, R. (2025). Cerebrospinal fluid ascites after ventriculoperitoneal shunting: a comprehensive systematic review emphasizing patient demographic attributes.

Dhandapani, M., Yagnick, N. S., Mohanty, M., Ahuja, C. K., & Dhandapani, S. (2021). Clinical outcome, cognitive function, and quality of life after endoscopic third ventriculostomy versus ventriculo-peritoneal shunt in non-tumor hydrocephalus. Neurology India, 69(Suppl 2), S556-S560.

Gao, W., Liu, W., Ying, Y., Zeng, Q., Wang, J., Lin, J., Guo, X., Jiang, H., Zheng, Z., & Zhu, Z. (2025). Preoperative imaging biomarkers combined with tap test for predicting shunt surgery outcome in idiopathic normal pressure hydrocephalus: a multicenter retrospective study. Frontiers in Aging Neuroscience, 17, 1509493.

Gmeiner, M., Wagner, H., van Ouwerkerk, W. J., Sardi, G., Thomae, W., Senker, W., Holl, K., & Gruber, A. (2020). Long-term outcomes in ventriculoatrial shunt surgery in patients with pediatric hydrocephalus: retrospective single-center study. World Neurosurgery, 138, e112-e118.

Hasib, S. A., Rizvi, I., Garg, R. K., Bajaj, A., Malhotra, H. S., Kumar, N., Uniyal, R., Pandey, S., Verma, R., & Sharma, P. K. (2025). Prognostic Model to Predict Outcome of Adult Patients with Tuberculous Meningitis Undergoing Ventriculoperitoneal Shunt Surgery: A Prospective Observational Study. World Neurosurgery, 194, 123562.

Ishikawa, M., Oowaki, H., Takezawa, M., Takenaka, T., Yamada, S., Yamamoto, K., & Okamoto, S. (2016). Disproportionately enlarged subarachnoid space hydrocephalus in idiopathic normal-pressure hydrocephalus and its implication in pathogenesis. In Intracranial Pressure and Brain Monitoring XV (pp. 287-290). Springer.

Javeed, F., Mohan, A., Wara, U. U., Rehman, L., & Khan, M. (2023). Ventriculoperitoneal shunt surgery for hydrocephalus: one of the common neurosurgical procedures and its related problems. Cureus, 15(2).

Kankane, V. K., Gupta, T. K., & Jaiswal, G. (2016). Outcome of ventriculoperitoneal shunt surgery, without prior placement of external ventricular drain in Grades III and IV patients of tubercular meningitis with hydrocephalus: a single institution's experience in the pediatric population and review of literature. Journal of Pediatric Neurosciences, 11(1), 35-41.

Khan, B., Hamayun, S., Haqqani, U., Khanzada, K., Ullah, S., Khattak, R., Zadran, N., Bibi, Z., Khan, A. W., & Khattak, R. (2021). Early complications of ventriculoperitoneal shunt in pediatric patients with hydrocephalus. Cureus, 13(2).

Khan, F., Rehman, A., Shamim, M. S., & Bari, M. E. (2015). Factors affecting ventriculoperitoneal shunt survival in adult patients. Surgical Neurology International, 6, 25.

Li, D., Ma, W., Ge, M., & Zhang, D. (2025). Obstruction caused by suprasellar cisterna arachnoid cyst expansion after ventriculoperitoneal shunt in children with hydrocephalus. Pediatric Investigation, 9(04), 405-409.

Ma, X., Fan, X., Yang, W., Guo, J., Zhou, Z., Wang, D., Wu, Y., Zhang, N., Song, G., & Xing, Y. (2025). Electromagnetic navigation improves accuracy and reduces complications of ventriculoperitoneal shunts in patients with idiopathic normal pressure hydrocephalus: a single-center clinical experience. World Neurosurgery, 194, 123428.

Minta, K. J., Kannan, S., & Kaliaperumal, C. (2024). Outcomes of endoscopic third ventriculostomy (ETV) and ventriculoperitoneal shunt (VPS) in the treatment of paediatric hydrocephalus: systematic review and meta-analysis. Child's Nervous System, 40(4), 1045-1052.

Mohammed Mousa, A., Ezzat Abdel-Aziz, S., El sayed Mohammed, M., Ahmed El Beltagy, M., & Ragab Al Melesy, A. (2017). Endoscopic third ventriculostomy versus ventriculoperitoneal shunt in treatment of obstructive hydrocephalus complicating pediatric posterior fossa tumors. Al-Azhar Medical Journal, 46(3), 675-688.

Onyia, C. U., Ogunbameru, I. O., Dada, O. A., Owagbemi, O. F., Ige-Orhionkpaibima, F. S., Olarewaju, O. A., Omon, H., Ajekwu, T., Anele, C., & Balogun, S. (2025). Ventriculoperitoneal shunt infection: insights from a single-center comparative analysis. Neurosurgical Review, 48(1), 69.

Palermo, M., Trevisi, G., Signorelli, F., Doglietto, F., Albanese, A., Olivi, A., & Sturiale, C. L. (2025). Advancing treatment strategies for idiopathic normal pressure hydrocephalus: A systematic review on studies comparing ventricular and lumbo-peritoneal shunts. Neurosurgical Review, 48(1), 426.

Pan, P. (2018). Outcome analysis of ventriculoperitoneal shunt surgery in pediatric hydrocephalus. Journal of Pediatric Neurosciences, 13(2), 176-181.

Piatt Jr, J. H., & Garton, H. J. (2008). Clinical diagnosis of ventriculoperitoneal shunt failure among children with hydrocephalus. Pediatric Emergency Care, 24(4), 201-210.

Popal, A. M., Zhu, Z., Guo, X., Zheng, Z., Cai, C., Jiang, H., Zhang, J., Shao, A., & Zhu, J. (2021). Outcomes of ventriculoperitoneal shunt in patients with idiopathic normal-pressure hydrocephalus 2 years after surgery. Frontiers in Surgery, 8, 641561.

Rocque, B. G., Waldrop, R. P., Shamblin, I., Arynchyna, A. A., Hopson, B., Kerr, T., Johnston, J. M., Rozzelle, C. J., & Blount, J. P. (2020). Shunt failure clusters: an analysis of multiple, frequent shunt failures. Journal of Neurosurgery: Pediatrics, 27(3), 287-293.

Sidhu, J. S., Mandal, A., Kafle, P., Chaulagai, B., & Gayam, V. (2019). Ventriculoperitoneal shunt migration inside the gastric lumen: a rare case report. Cureus, 11(4).

Sun, Y., Du, J., Fang, J., Wang, S., Luan, J., Cheng, Z., Yang, Z., & Sun, Y. (2025). Clinical characteristics and post-operative outcomes in children with purulent meningitis with hydrocephalus: 46 cases in a single center study. Italian Journal of Pediatrics, 51(1), 145.

Svedung Wettervik, T., Lewén, A., & Enblad, P. (2022). Post-traumatic hydrocephalus–incidence, risk factors, treatment, and clinical outcome. British Journal of Neurosurgery, 36(3), 400-406.

Wendling-Keim, D. S., Luz, H., Kren, E., Muensterer, O., & Lehner, M. (2025). The long-term outcome of children with VP shunt and hydrocephalus: motor developmental outcome and QOL of patients with hydrocephalus is associated with the number of revisional procedures but is not impacted by the type of the valve. Frontiers in Surgery, 12, 1530041.

Zhou, J., Zhang, Y., Huo, X., Wang, Z., Guo, P., & Niu, Z. (2025). Effect of priority cranioplasty on post-traumatic hydrocephalus with severe collapse of brain tissue: A case report. Heliyon, 11(4).