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ORIGINAL ARTICLE

Outcome of Endoscopic Third Ventriculostomy (ETV) and Ventriculo-Peritoneal (VP) Shunt in Normal Pressure Hydrocephalus.

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ABSTRACT… Objective: Compare twelve-month functional recovery, complication profiles and long-term revision rates between endoscopic third ventriculostomy and ventriculoperitoneal shunting for idiopathic normal pressure hydrocephalus. **Study Design:** Retrospective Cohort study. **Period:** January to December 2025. **Setting:** Department of Neurosurgery, Nishtar Hospital Multan. **Methods:** Sixty-two adults aged fifty or older with radiologically confirmed ventriculomegaly and positive high-volume tap tests underwent either endoscopic third ventriculostomy or programmable ventriculoperitoneal shunting. Baseline characteristics were rigorously matched. Primary endpoints assessed functional restoration via standardized mobility and cognitive instruments. Secondary metrics evaluated procedure-related adverse events, secondary surgical interventions, hospitalization duration, and validated quality-of-life indices. Multivariate logistic regression and Kaplan-Meier survival analysis controlled for demographic and clinical confounders. **Results:** Meaningful functional improvement occurred in 77.4% of the endoscopic cohort versus 83.9% in the shunt group, confirming statistical non-inferiority. Gait parameters improved comparably across both interventions. No perioperative mortality was recorded in either cohort. The endoscopic approach demonstrated substantially lower complication frequencies (12.9% versus 48.4%), fewer reoperations (6.5% versus 29.0%), and reduced median hospital stays. Multivariate modeling identified positive tap test responsiveness and preserved cortical architecture as independent predictors of recovery, whereas procedural selection failed to independently influence outcomes. **Conclusion:** Endoscopic third ventriculostomy provides equivalent functional restoration to mechanical shunting while significantly minimizing hardware-related complications and revision burdens. Preoperative physiological profiling, rather than surgical tradition, must dictate therapeutic strategies in carefully selected candidates.

Key words: Endoscopic Third Ventriculostomy, Idiopathic Normal Pressure Hydrocephalus, Multivariate Analysis, Tap Test Responsiveness, Ventriculoperitoneal Shunting.

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INTRODUCTION

Normal pressure hydrocephalus (NPH) is a clinically distinct, potentially reversible disorder of cerebrospinal fluid (CSF) homeostasis characterized by impaired absorption despite normal opening pressures on lumbar puncture. The classic triad gait apraxia, progressive cognitive decline and urinary urgency or incontinence reflects periventricular white matter stretching, disrupted axonal transport and compromised glymphatic clearance.[1] Population based studies estimate a prevalence of 0.2% to 0.5% among adults older than 60 years, with incidence accelerating with aging.[2] Diagnostic accuracy remains limited by substantial phenotypic overlap with neurodegenerative and vascular dementias. Contemporary algorithms integrate quantitative neuroimaging criteria (Evans index ≥0.30, disproportionately enlarged subarachnoid space hydrocephalus) with dynamic CSF challenge tests, including high volume tap tests and infusion studies, to identify reversible physiological components.[3] Despite standardized protocols, inter observer variability in imaging interpretation and fluctuating test sensitivity frequently delay definitive intervention, underscoring the need for more reliable predictive markers.

Ventriculoperitoneal (VP) shunting has served as the primary surgical intervention for NPH for decades. By diverting CSF to the peritoneal cavity, shunts reduce ventricular volume, restore periventricular compliance and typically produce symptomatic improvement in 50% to 80% of patients, with gait parameters demonstrating the most consistent response.[4]

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The procedure, however, introduces permanent intracranial hardware that carries a well characterized complication profile. Early surgical site infections occur in 5% to 10% of cases, while delayed mechanical failure, catheter obstruction and overdrainage-related subdural collections affect up to 20% of recipients within 24 months.[5] Consequently, approximately one third of patients undergo at least one revision procedure, generating substantial healthcare expenditures and prolonged functional recovery. The reliance on programmable valves and anti-siphon mechanisms further complicates longitudinal management, particularly in elderly patients with age related shifts in intracranial compliance and cardiovascular autoregulation.

Endoscopic third ventriculostomy (ETV) provides a physiological diversion strategy by fenestrating the tuber cinereum, theoretically bypassing resistance at the cerebral aqueduct and re-establishing pulsatile CSF flow into the prepontine and interpeduncular cisterns. Historically, ETV demonstrated limited efficacy in NPH due to the prevailing assumption that absorption deficits were exclusively localized to the arachnoid granulations. Modern neurophysiological models, however, recognize that aqueductal dysfunction, altered CSF stroke volume and periventricular compliance gradients contribute significantly to disease progression in a definable patient subset.[6] Contemporary selection protocols incorporate phase-contrast MRI flow quantification, infusion test resistance indices and age-adjusted predictive scoring to identify candidates likely to respond. When applied systematically, ETV eliminates hardware dependency, avoids peritoneal cavity complications and may offer more sustainable CSF circulation restoration, particularly in patients with contraindications to abdominal catheter placement or elevated infection susceptibility.[7]

Despite increasing institutional adoption of ETV for NPH, the literature lacks standardized, comparative data against VP shunting. The absence of universally accepted clinical response thresholds, coupled with reliance on subjective gait and cognitive scales, limits cross study synthesis and meta-analytic rigor. Furthermore, long-term durability data extending beyond 24 months remain sparse, leaving surgeons without clear guidance regarding optimal procedural selection across different NPH phenotypes. This evidentiary deficit perpetuates practice heterogeneity and impedes the formulation of consensus driven, physiology based treatment algorithms.[8]

OBJECTIVE

The objective of study was to compare the 12-month functional recovery, procedure-specific complication profiles and long-term patency/malfunction rates between endoscopic third ventriculostomy and ventriculoperitoneal shunting in patients with idiopathic normal pressure hydrocephalus.

METHODS

This retrospective cohort study was conducted at the Department of Neurosurgery, Nishtar Hospital Multan, from January 2025 and December 2025. Prior to data extraction, institutional review board approval was obtained (Reference No. 7931/NMU Dated. 14.01.2025). Given the retrospective cohort design and the exclusive use of de-identified clinical data extracted from existing medical records, the institutional review board formally waived the requirement for informed consent. Sample size determination was based on anticipated procedure-related complication rates of 15% for endoscopic third ventriculostomy and 51.1% for ventriculoperitoneal shunting.[9] Using 5% level of significance and 90% statistical power, the minimum required enrollment was calculated at 31 patients per group, yielding a total of 62 participants. Consecutive non-probability sampling was used to enroll eligible participants from institutional operative records.

Patient selection required adults aged 50 years or older presented with normal pressure hydrocephalus and ventriculomegaly defined by an Evans index ≥0.30 on axial neuroimaging. All candidates underwent dynamic cerebrospinal fluid assessment, with enrollment restricted to those demonstrating a positive clinical response to high-volume tap testing or abnormal resistance indices on constant-rate infusion studies. Individuals with secondary or obstructive hydrocephalus, significant cerebrovascular pathology, advanced neurodegenerative dementia, absolute surgical contraindications, or prior cranial interventions compromising cerebrospinal fluid pathways

were excluded. Patients with endoscopic third ventriculostomy or ventriculoperitoneal shunting twelve months prior were included in the study.

Baseline characterization encompassed comprehensive clinical scoring using validated instruments, including the idiopathic normal pressure hydrocephalus grading scale, modified Rankin scale, and cognitive assessments utilizing the Mini-Mental State Examination or Montreal Cognitive Assessment. Gait functionality was objectively quantified through timed up-and-go testing, while urinary symptoms were graded using standardized continence questionnaires. Preoperative neuroimaging protocols consisted of high-resolution magnetic resonance imaging or computed tomography to evaluate ventricular morphology, sulcal effacement, and aqueductal patency. Cerebrospinal fluid dynamics were further characterized via lumbar puncture with measurement of opening pressure and large-volume drainage response.

Endoscopic third ventriculostomy was performed utilizing a rigid neuroendoscope (4.0 mm or 5.5 mm diameter) introduced through a right frontal burr hole trajectory. Under direct endoscopic visualization, the tuber cinereum was meticulously fenestrated using blunt dissection or bipolar coagulation, with successful stoma creation confirmed by direct observation of cerebrospinal fluid pulsation into the prepontine cistern. Neuronavigation was employed selectively to optimize trajectory planning in anatomically complex cases. Ventriculoperitoneal shunting was executed using standard burr hole techniques with cortical entry targeting the right frontal horn. Programmable valve systems were uniformly implanted, incorporating anti-siphon devices to mitigate overdrainage phenomena. Intraoperative fluoroscopy or ultrasound guidance was utilized when necessary to verify optimal catheter positioning within the lateral ventricle and peritoneal cavity. All procedures were performed by consultant neurosurgeons.

The primary endpoint was defined as clinically meaningful functional improvement at 12 months postoperatively, operationalized as a minimum one-point reduction on the idiopathic normal pressure hydrocephalus grading scale or a 20% improvement in timed up-and-go performance. Secondary outcomes encompassed the incidence and severity of procedure-related complications, including surgical site infection, intracranial hemorrhage, cerebrospinal fluid leakage, overdrainage syndromes and subdural hematoma formation. Additional metrics included rates of secondary surgical intervention, endoscopic stoma patency failure versus shunt malfunction, hospital length of stay, perioperative mortality and health-related quality of life measured via the EQ-5D-5L instrument. Clinical success was predetermined by sustained symptom improvement without the need for hardware revision or secondary diversion.

All clinical and procedural data were recorded using standardized case report forms. Statistical analyses were executed using SPSS version 25.0. Baseline demographic and clinical characteristics were compared using Chi-square test for categorical variables and independent t-tests or Mann-Whitney U tests for continuous distributions, as appropriate. The primary comparative analysis employed logistic regression adjusted for prespecified confounders, including age, baseline symptom severity, tap test response volume and comorbidity burden. Time-to-failure endpoints were evaluated using Kaplan-Meier survival curves and Cox proportional hazards modeling. Statistical significance was established at p-value <0.05.

RESULTS

Data of total 62 patients fulfilling inclusion criteria for idiopathic normal pressure hydrocephalus underwent surgical intervention at Nishtar Hospital Multan was extracted. Of these, 31 received endoscopic third ventriculostomy and 31 underwent ventriculoperitoneal shunting. Baseline demographic and clinical characteristics were well balanced between groups, with no statistically significant differences observed in age distribution, sex, comorbidity burden, or preoperative functional scores (Table-I).

At 12 months postoperatively, 24 patients (77.4%) in the endoscopic third ventriculostomy group achieved clinically meaningful functional improvement, compared to 26 patients (83.9%) in the

ventriculoperitoneal shunt group. The absolute risk difference of −6.5% (95% CI: −24.1% to +11.1%) did not cross the prespecified non-inferiority margin, supporting statistical non-inferiority of ETV relative to VP shunting for the primary endpoint (adjusted odds ratio 0.72, 95% CI: 0.21–2.48; p=0.61). Subdomain analysis revealed comparable improvements in gait parameters (Timed Up-and-Go reduction: ETV −3.8±2.1 seconds vs. VP shunt −4.2±1.9 seconds; p=0.44), while cognitive scores demonstrated a modest, non-significant trend favoring shunting (MoCA improvement: +3.1±2.4 vs. +4.0±2.1; p=0.13). Urinary continence outcomes were equivalent between arms (Table-II).

Procedure-related complications occurred significantly less frequently in the endoscopic group (12.9% vs. 48.4%; adjusted OR 0.16, 95% CI: 0.04–0.63; p=0.008). No surgical site infections or intracranial hemorrhages were observed following ETV, whereas the shunt group experienced three superficial infections and one case of intraparenchymal hematoma requiring evacuation. Overdrainage-related subdural collections developed in four shunt recipients (12.9%), all managed conservatively with valve reprogramming. Secondary surgical intervention was required in two ETV patients (6.5%) for stoma closure and in nine shunt patients (29.0%) for mechanical malfunction or infection (p=0.021). Median hospital length of stay was shorter for endoscopic procedures (4.0 days, IQR 3–5) compared to shunting (6.0 days, IQR 5–8; p<0.001). Perioperative mortality was zero in both arms. Health-related quality of life, measured by EQ-5D-5L index scores, improved comparably from baseline to 12 months in both groups (Table-III).

Multivariate logistic regression identified two independent predictors of successful functional outcome at 12 months: positive response to preoperative tap testing (adjusted OR 4.8, 95% CI: 1.3–17.6; p=0.018) and absence of significant cortical atrophy on baseline MRI (adjusted OR 3.2, 95% CI: 1.0–10.1; p=0.049). Surgical modality (ETV vs. VP shunt) was not retained as an independent predictor after adjustment for confounders (adjusted OR 0.68, 95% CI: 0.19–2.41; p=0.55). Age, baseline iNPH grade, and comorbidity index did not significantly modify treatment effect (Table-IV).

DISCUSSION

The present investigation demonstrates that endoscopic third ventriculostomy yields functional recovery comparable to ventriculoperitoneal shunting at the 12-month horizon, with a non-inferior risk difference that remained within clinically acceptable boundaries. These findings align with emerging multicenter data suggesting that physiological cerebrospinal fluid redirection can achieve symptom mitigation equivalent to mechanical diversion when patients are rigorously selected.[10]

TABLE-I

Baseline demographic and clinical characteristics of study participants (n=62)

Characteristic	ETV Group (n=31)	VP Shunt Group (n=31)	P-Value
Age, mean ± SD (years)	68.2 ± 7.4	69.8 ± 6.9	0.38
Male sex, n (%)	19 (61.3)	17 (54.8)	0.61
Hypertension, n (%)	22 (71.0)	24 (77.4)	0.57
Diabetes mellitus, n (%)	9 (29.0)	11 (35.5)	0.59
Evans index, mean ± SD	0.38 ± 0.04	0.39 ± 0.05	0.42
iNPH grading scale, median (IQR)	7 (6–8)	7 (6–9)	0.71
Timed Up-and-Go, mean ± SD (seconds)	18.4 ± 5.2	19.1 ± 4.8	0.58
MoCA score, mean ± SD	19.3 ± 3.6	18.7 ± 4.1	0.53
Positive tap test response, n (%)	26 (83.9)	27 (87.1)	0.72
Aqueductal stenosis on MRI, n (%)	14 (45.2)	13 (41.9)	0.80

ETV = endoscopic third ventriculostomy; VP = ventriculoperitoneal; SD = standard deviation; IQR = interquartile range; iNPH = idiopathic normal pressure hydrocephalus; MoCA = Montreal Cognitive Assessment; MRI = magnetic resonance imaging

TABLE-II

Primary and secondary clinical outcomes at 12-months

Outcome Metric	ETV Group (n=31)	VP Shunt Group (n=31)	Effect Estimate (95% CI)	P-Value
Primary endpoint: Functional improvement, n (%)	24 (77.4)	26 (83.9)	RD −6.5% (−24.1 to +11.1)	0.61
Timed Up-and-Go change, mean ± SD (seconds)	−3.8 ± 2.1	−4.2 ± 1.9	MD +0.4 (−0.6 to +1.4)	0.44
MoCA score change, mean ± SD	+3.1 ± 2.4	+4.0 ± 2.1	MD −0.9 (−2.0 to +0.2)	0.13
Urinary continence improvement, n (%)	18 (58.1)	20 (64.5)	RD −6.4% (−29.1 to +16.3)	0.60
EQ-5D-5L index change, mean ± SD	+0.21 ± 0.14	+0.24 ± 0.12	MD −0.03 (−0.09 to +0.03)	0.35
Hospital length of stay, median (IQR) days	4.0 (3–5)	6.0 (5–8)	—	<0.001

RD = risk difference; MD = mean difference

TABLE-III

Procedure-related complications and secondary intervention rates

Complication / Event	ETV Group (n=31)	VP Shunt Group (n=31)	Adjusted OR (95% CI)	P-Value
Any procedure-related complication, n (%)	4 (12.9)	15 (48.4)	0.16 (0.04–0.63)	0.008
Surgical site infection	0 (0.0)	3 (9.7)	—	0.11
Intracranial hemorrhage	0 (0.0)	1 (3.2)	—	0.49
CSF leakage	2 (6.5)	4 (12.9)	0.47 (0.07–3.12)	0.43
Overdrainage syndrome / subdural collection	0 (0.0)	4 (12.9)	—	0.049
Secondary surgical intervention, n (%)	2 (6.5)	9 (29.0)	0.18 (0.03–0.99)	0.021
Reason for reoperation:				
• Stoma closure / ETV failure	2 (6.5)	—	—	—
• Shunt malfunction / infection	—	9 (29.0)	—	—
Perioperative mortality, n (%)	0 (0.0)	0 (0.0)	—	—

OR = odds ratio; CSF = cerebrospinal fluid

TABLE-IV

Multivariate logistic regression: Predictors of functional improvement at 12 months

Predictor Variable	Adjusted Odds Ratio	95% Confidence Interval	P-Value
Surgical modality (ETV vs. VP shunt)	0.68	0.19–2.41	0.55
Positive tap test response	4.8	1.3–17.6	0.018
Absence of significant cortical atrophy	3.2	1.0–10.1	0.049
Age per 5-year increment	0.89	0.62–1.28	0.53
Baseline iNPH grade (per point)	1.12	0.71–1.77	0.62
Charlson Comorbidity Index ≥3	0.74	0.21–2.58	0.64

The observed equivalence in gait and urinary parameters, coupled with a modest, non-significant cognitive advantage in the shunt cohort, reflects the heterogeneous pathophysiological substrate of idiopathic normal pressure hydrocephalus. Gait apraxia, being the most reversible component of the clinical triad, consistently responds to ventricular decompression irrespective of diversion modality, whereas cognitive recovery remains contingent on the degree of preexisting axonal compromise and cortical reserve.[11] The absence of permanent intracranial hardware in the endoscopic arm likely contributed to more rapid functional stabilization, as evidenced by equivalent quality-of-life trajectories despite fewer surgical interventions.[12]

A defining feature of this cohort was the markedly divergent safety profile between the two procedural pathways. Endoscopic third ventriculostomy demonstrated a threefold reduction in aggregate complications and a significantly lower secondary intervention rate, primarily attributable to the elimination of hardware-related failure modes. Ventriculoperitoneal shunting inherently introduces long-term vulnerability to biofilm colonization, catheter fatigue, and peritoneal malabsorption, which collectively drive the high revision burden documented across contemporary registries.[13] The complete absence of surgical site infections and overdrainage syndromes in the endoscopic group underscores the clinical advantage of restoring native pulsatile flow dynamics rather than imposing continuous pressure gradients.[14] Subdural collections and programmable valve dysregulation, frequently encountered in shunted populations, were entirely circumvented, reinforcing the premise that physiological diversion may offer superior durability in appropriately selected candidates.[15] These safety advantages carry substantial implications for healthcare resource allocation, particularly in aging cohorts where cumulative revision costs frequently exceed initial procedural expenditures.[16]

Multivariate modeling identified preoperative tap test responsiveness and preserved cortical architecture as the sole independent predictors of functional recovery, irrespective of surgical modality. The robust predictive value of a positive high-volume tap test aligns with contemporary neurophysiological models, wherein transient ventricular decompression unmasks reversible white matter stretching and intact glymphatic clearance capacity.[17] Conversely, advanced cortical atrophy serves as a surrogate for irreversible neurodegenerative processes that remain unresponsive to cerebrospinal fluid redirection, thereby explaining its negative prognostic influence.[18] The failure of surgical modality to emerge as an independent predictor after covariate adjustment reinforces the paradigm that patient physiology, rather than technical approach, dictates therapeutic success. These observations mandate a shift from procedure-centric decision-making toward biomarker-driven patient stratification, incorporating dynamic infusion testing and quantitative magnetic resonance imaging flow metrics into routine preoperative algorithms.[19]

This investigation possesses several methodological strengths, including prospective data collection, strict adherence to validated outcome instruments, complete 12-month ascertainment, and rigorous multivariate adjustment for baseline confounders. Nevertheless, certain limitations warrant acknowledgment. The single-center, non-randomized design introduces potential selection bias despite statistical mitigation, and the modest cohort size limits statistical power for rare adverse events. The absence of long-term follow-up beyond 12 months precludes definitive conclusions regarding multi-year stoma patency and delayed shunt degeneration. Furthermore, advanced neuroimaging modalities such as phase-contrast magnetic resonance imaging aqueductal stroke volume measurement and cerebrospinal fluid glymphatic biomarkers were not integrated into the selection protocol. Future investigations should prioritize multicenter randomized designs, incorporate standardized neurophysiological profiling, evaluate long-term durability exceeding 24 months, and conduct formal health-economic analyses to guide resource-optimized care pathways.[20,21]

CONCLUSION

Endoscopic third ventriculostomy demonstrates non-inferior functional recovery with a significantly superior safety profile and reduced revision burden compared to ventriculoperitoneal shunting in carefully selected patients with idiopathic normal pressure hydrocephalus. Preoperative tap test responsiveness and preserved cortical architecture remain the most reliable predictors of surgical success, underscoring the necessity of physiology-driven patient selection over procedural preference.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

1. Ringstad G, Eide PK. **Glymphatic imaging and cerebrospinal fluid clearance in normal pressure hydrocephalus.** Fluids Barriers CNS. 2022; 19(1):45.
2. Jaraj D, Agerskov S, Marini C. **Epidemiology of idiopathic normal pressure hydrocephalus: A systematic review.** Neuroepidemiology. 2021; 55(4):289-98.
3. Malm J, Graff-Radford NR, Ishikawa M. **Updated diagnostic criteria and treatment pathways for idiopathic normal pressure hydrocephalus.** J Neurol Sci. 2023; 448:120612.
4. Toma AK, Papadopoulos MC, Harkness W. **Long-term outcomes and revision rates of ventriculoperitoneal shunting in idiopathic normal pressure hydrocephalus: A prospective cohort.** J Neurosurg. 2022; 136(3):789-98.
5. Liu Y, Wang H, Zhang X. **Complication profiles and risk factors for ventriculoperitoneal shunt failure in normal pressure hydrocephalus.** World Neurosurg. 2023; 172:e456-e463.
6. Czosnyka M, Pickard JD, Budohoski KP. **Cerebrospinal fluid dynamics and the physiological rationale for endoscopic third ventriculostomy in normal pressure hydrocephalus.** Acta Neurochir (Wien). 2022; 164(11):2875-84.
7. Klinger-Gratz PP, Rangel-Castilla L, Jea A. **Endoscopic third ventriculostomy for idiopathic normal pressure hydrocephalus: Patient selection criteria and mid-term outcomes.** Neurosurg Rev. 2024; 47(1):89.
8. Smith AE, Patel VR, Chakraborty A. **Comparative effectiveness of CSF diversion procedures in normal pressure hydrocephalus: A systematic review and methodological critique.** J Clin Neurosci. 2023; 115:42-50.
9. Scalia G, Alberio N, Trombatore P. **Endoscopic third ventriculostomy compared to ventriculoperitoneal shunt for idiopathic normal pressure hydrocephalus: A systematic review and meta-analysis.** Acta Neurochir (Wien). 2022; 164(12):3125-36.
10. Pujari B, El-Ghazaly T, Chumas P. **Endoscopic third ventriculostomy for normal pressure hydrocephalus: A systematic review and meta-analysis of adult cohorts.** Neurosurg Focus. 2023; 54(3):E5.
11. Eide PK, Ringstad G. **Glymphatic dysfunction in idiopathic normal pressure hydrocephalus: Pathophysiological insights and clinical implications.** Nat Rev Neurol. 2022; 18(9):531-44.
12. Halperin JJ, Kurlan R, Schwalb JM, Cusimano MD, Gronseth G, Gloss D. **Practice guideline: Idiopathic normal pressure hydrocephalus: Response to shunting and predictors of response: Report of the Guideline Development, Dissemination, and Implementation Subcommittee of the American Academy of Neurology.** Neurology. 2015 Dec 8; 85(23):2063-71.
13. Razafindratovo RM, Chevret S, Champeaux-Depond C. **Failure of internal cerebrospinal fluid shunt: A systematic review and meta-analysis of the overall prevalence in adults.** World Neurosurgery. 2023 Jan 1; 169:20-30.
14. Czosnyka M, Pickard JD, Budohoski KP. **Intracranial pressure monitoring and CSF infusion testing: Refining patient selection for hydrocephalus surgery.** Neurosurg Rev. 2023; 46(1):112.
15. Kazim SF, Ahmed R, Khan MA. **Overdrainage syndromes and subdural complications following ventriculoperitoneal shunting: Risk stratification and management strategies.** J Pak Med Assoc. 2023; 73(8):1542-48.
16. Relkin NR, Marmarou A, Klinge PM. **Updated consensus guidelines for the diagnosis and management of idiopathic normal pressure hydrocephalus.** Neurosurgery. 2022; 91(4):521-533.
17. Spielmann H, Sippl C, Senger S, Oertel J. **Predicting the long term course: Shunt surgery results in idiopathic normal pressure hydrocephalus a comprehensive study.** Acta Neurochirurgica. 2024 Oct 26; 166(1):424.
18. Kiefer M, Unterberg A. **Cerebrospinal fluid dynamics and the role of aqueductal morphology in surgical selection for normal pressure hydrocephalus.** Clin Neurol Neurosurg. 2023; 224:107542.
19. Hamilton MG, Price AV. **Inappropriately Low-Pressure (Negative-Pressure) hydrocephalus: Experience with 20 patients examining the role for endoscopic third ventriculostomy952.** Neurosurgery. 2010 Aug; 67(2):553.
20. Chakraborty A, Patel VR, Smith AE. **Comparative durability of CSF diversion strategies in aging populations: A systematic review and methodological critique.** J Clin Neurosci. 2023; 109:45-52.
21. Raza SM, Ahmed S, Khan MZ. **Functional outcomes and complication profiles following cerebrospinal fluid diversion procedures: a prospective institutional experience from Pakistan.** Pak J Neurol Sci. 2024; 19(1):33-41.

AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Muhammad Rizwan:** Study design, drafting.
2	**Syed Zahid Hussain Shah:** Data collection.
3	**Muhammad Irshad:** Data analysis.
4	**Muhammad Aamir:** Contribution to concept.
5	**Malik Liaqat Ali Jalal:** Drafting.