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Etiology, Treatment, and Early Postoperative Outcomes of Neonatal Hydrocephalus

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ABSTRACT

Neonatal hydrocephalus is a neurological condition characterized by abnormal accumulation of cerebrospinal fluid (CSF) in the ventricular system of the brain, leading to increased intracranial pressure. **Objective:** To determine the etiology and early postoperative outcomes in neonatal hydrocephalus. **Methods:** This prospective observational study was conducted at the Pediatric Neurosurgery Department of the Children's Hospital and the Institute of Child Health, Multan, Pakistan, from September 2023 to March 2025. A total of 120 newborns aged 0-28 days, who were diagnosed with hydrocephalus on clinical and radiological grounds and subsequently underwent surgical intervention, were analyzed. Postoperative complications and their association with demographic and clinical characteristics were assessed up to 30 days. Data were analyzed using IBM-SPSS Statistics, version 26.0. P<0.05 was taken as significant. **Results:** Among 120 neonates, the mean age at presentation was 14.28 ± 7.53 days, gestational age 36.61 ± 1.93 weeks, and birth weight 2508.89 ± 375.78 grams. Preterm birth and low birth weight were seen in 64.2% and 52.5% neonates, respectively. Common etiologies included congenital (30.0%) and intraventricular hemorrhage (28.3%). Early postoperative complications occurred in 15.8%, with significantly longer hospital stays (9.21 ± 3.44 vs. 6.54 ± 1.78 days, p<0.001). Prematurity (p=0.022), low birth weight (p=0.044), maternal infection (p=0.009), congenital anomalies (p=0.033), intraventricular hemorrhage (p=0.045), and post-infectious hydrocephalus (p=0.033) were significantly associated with complications. **Conclusions:** In neonates with hydrocephalus undergoing surgical management, intraventricular hemorrhage, post-infectious etiologies, prematurity, low birth weight, and abnormal antenatal history were significantly associated with early postoperative complications.

INTRODUCTION

Neonatal hydrocephalus is a neurological condition characterized by abnormal accumulation of cerebrospinal fluid (CSF) in the ventricular system of the brain, leading to increased intracranial pressure [1]. It may be congenital or acquired and poses significant risks to neurodevelopmental outcomes in infants [2]. The incidence of congenital hydrocephalus ranges between 0.5 and 1 per 1,000 live births worldwide [3]. Neonatal hydrocephalus contributes significantly to neurodevelopmental impairment and mortality, particularly in settings with limited access to neurosurgical services. In low- and middle-income countries, post-infectious hydrocephalus accounts for a substantial proportion of cases [4]. The causes are diverse, including intraventricular hemorrhage (particularly in preterm infants), congenital anomalies such as aqueductal stenosis, infections like meningitis, and neoplasms [5, 6]. Early diagnosis and an appropriate surgical intervention are crucial in neonatal hydrocephalus for optimizing outcomes and minimizing long-term disabilities. The standard treatment involves CSF diversion techniques, most commonly ventriculoperitoneal (VP) shunting [7].

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While shunt placement can alleviate symptoms and prevent further damage, complications such as infection, obstruction, or the need for revision are not uncommon [8]. Early postoperative outcomes are variable and influenced by factors including etiology, timing of intervention, and perioperative care [9]. Shunt-related complications can occur in 30-50% of cases within the first year of surgery [10].

Despite advancements in neuroimaging and surgical techniques, neonatal hydrocephalus remains a challenging condition with variable outcomes. There is a pressing need to understand the local etiological profile better, preferred surgical interventions, and early postoperative results to improve clinical protocols. By analyzing the causes, treatment approaches, and short-term surgical outcomes in neonates diagnosed with hydrocephalus, the findings would not only fill the knowledge gap but also help clinicians develop early intervention strategies, anticipate complications, and tailor postoperative care plans to achieve better patient outcomes. Therefore, the study aimed to determine the etiology and early postoperative outcomes in neonates diagnosed with hydrocephalus at a tertiary care center.

METHODS

This prospective observational study was conducted at the Department of Pediatric Neurosurgery of the Children's Hospital and the Institute of Child Health, Multan, Pakistan, from September 2023 to March 2025, after obtaining prior approval from the institutional ethical committee (letter number: ERC/78/23; dated 16th August 2023). A sample size of 120 was calculated using the WHO online sample size calculator based on the post-procedure infection rate of 27.6%, with 95% confidence level and 8% margin of error [11]. The inclusion criteria were neonates of any gender, aged 0-28 days, who were diagnosed with hydrocephalus on clinical and radiological grounds and subsequently underwent surgical intervention. Exclusion criteria were neonates with gestational age below 32 weeks, birth weight below 1000 grams, multiple congenital anomalies incompatible with life, previously operated hydrocephalus, or those who expired before surgery. Hydrocephalus was labeled based on clinical assessment, which included an abnormally enlarging head circumference, bulging anterior fontanelle, irritability, vomiting, and downward gaze (sun setting sign), along with confirmatory findings on neuroimaging (cranial ultrasound, CT scan, or MRI) demonstrating dilatation of the cerebral ventricles [12]. A non-probability consecutive sampling technique was used to recruit eligible participants. Data were collected on a structured proforma after obtaining informed written consent from the parents or legal guardians. Detailed demographic data, including age at presentation, gender, mode of delivery, birth weight, gestational age, and antenatal history, were recorded. Etiological classification was done based on clinical history and radiological findings. Congenital aqueductal stenosis, intraventricular hemorrhage (IVH), neural tube defects (e.g., myelomeningocele), and post-infectious causes (e.g., ventriculitis or meningitis) were the main categories, along with other structural anomalies. The treatment plan, type of surgical procedure performed (most commonly ventriculoperitoneal shunting), duration of surgery, and any intraoperative complications were noted. Postoperative follow-up was done for up to 30 days to assess early outcomes. Early postoperative outcomes included shunt malfunction (defined as clinical or radiological evidence of persistent or recurrent hydrocephalus due to obstruction, or displacement of the shunt), shunt infection (defined as fever, signs of meningitis, positive CSF culture, or signs of wound infection), and mortality (death occurring within 30 days of surgery regardless of cause).

The statistical analysis was carried out using "IBM-SPSS Statistics" version 26.0. The normality of the data was checked by applying the Shapiro-Wilk test. The quantitative variables, which included age, gestational age, duration of surgery, and birth weight, were expressed as mean and standard deviation (SD) or median and inter-quartile range (IQR). The qualitative data, comprising gender, mode of delivery, etiological classification, type of surgical procedure performed, intra-operative complications, and early postoperative outcomes (shunt malfunction, shunt infection, and mortality), were presented as frequency and percentage. The chi-square test was applied, considering a p-value of 0.05 for significance.

RESULTS

In a total of 120 neonates with hydrocephalus undergoing surgical interventions, the mean ± SD age at presentation, gestational age, and birth weight were 14.28 ± 7.53 days, 36.61 ± 1.93 weeks, and 2508.89 ± 375.78 grams, respectively. There were 74 (61.7%) males, and 77 (64.2%) were born preterm. Low birth weight (<2500 g) was observed in 63 (52.5%) neonates. The most common presenting features were enlarged head in 19 neonates (15.8%), poor feeding in 18 (15.0%), lethargy in 18 (15.0%), seizures in 16 (13.3%), irritability in 15 (12.5%), sun setting eyes in 12 (10.0%), bulging fontanelle in 11 (9.2%), and vomiting in 11 (9.2%). Etiologically, congenital aqueductal stenosis accounted for 30.0% of cases, followed by intraventricular hemorrhage (28.3%), post-infectious causes (19.2%), Dandy-Walker malformation (10.0%), myelomeningocele (5.8%), and other structural anomalies (6.7%). Table-1 is showing demographical, clinical, and

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diagnostic characteristics of neonates.

Table 1: Demographical, clinical, and diagnostic characteristics of neonates (n=120)

Characteristics		Frequency (%)
Gender	Male	74 (61.7%)
	Female	46 (38.3%)
Age at Presentation (Days)	≤7	25 (20.8%)
	8-28	95 (79.2%)
Gestational Age	Preterm	77 (64.2%)
	Term	43 (35.8%)
Low Birth Weight		62 (51.7%)
Maternal Age (Years)	<30	61 (50.8%)
	≥30	59 (49.2%)
Mode of Delivery	Assisted	15 (12.5%)
	Cesarean	48 (40.0%)
	Vaginal	57 (47.5%)
Place of Birth	Hospital	109 (90.8%)
	Home	11 (9.2%)
Antenatal History	Normal	50 (41.7%)
	Maternal Infection	28 (23.3%)
	Congenital Anomaly	23 (19.2%)
	Polyhdramnions	19 (15.8%)
Etiology	Congenital	36 (30.0%)
	Dandy-Walker	12 (10.0%)
	Intraventricular Hemorrhage	34 (28.3%)
	Myelomeningocele	7 (5.8%)
	Post-Infectious	23 (19.2%)
	Other	8 (6.7%)

The mean duration of hospitalization was 6.97±2.33 days, ranging between 2-16 days. Early postoperative complications were observed in 19 neonates (15.8%) (Figure 1).

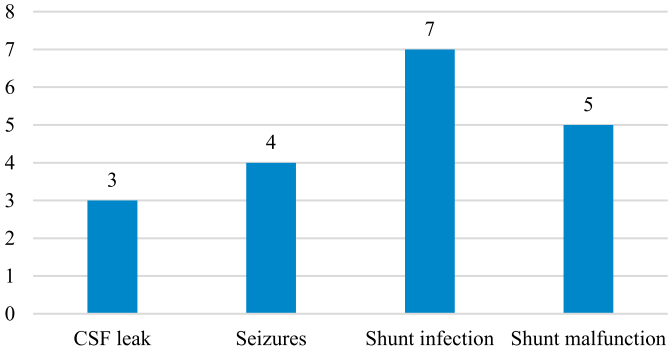

Figure 1: Post-operative complications (n=19)

The mean duration of postoperative hospitalization was significantly longer among neonates with complications than among those without complications (9.21 ± 3.44 vs. 6.54 ± 1.78 days, p<0.001). Readmission due to complications was noted in 6 cases (5.0%). No mortality was reported during the study period (Figure 2).

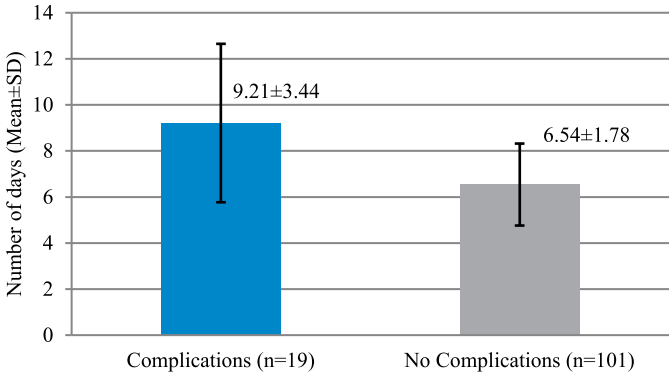

Figure 2: Duration of Hospitalization Among Neonates with and Without Post-Operative Complications (n=120)

Prematurity (78.9% vs. 50.5%; p=0.022) and low birth weight (73.7% vs. 48.5%; p=0.044) were significantly associated with postoperative complications. Abnormal antenatal history, including maternal infection (p=0.009), and presence of congenital anomalies (p=0.033) also showed significant associations. In terms of etiologies, intraventricular hemorrhage (p=0.045) and post-infectious hydrocephalus (p=0.033) were significantly more frequent in neonates with complications (Table 2).

Table 2: Association of Post-Operative Complications with Demographic and Clinical Characteristics of Neonates (n=120)

Characteristics		Post-Operative Complications		p-value
		Yes (n=19)	No (n=101)	
Gender	Male	9 (47.4%)	65 (64.4%)	0.162
	Female	10 (52.6%)	36 (35.6%)	
Age at Presentation (Days)	≤7	6 (31.6%)	19 (18.8%)	0.209
	8-28	13 (68.4%)	82 (81.2%)	
Gestational Age	Preterm	15 (78.9%)	51 (50.5%)	0.022
	Term	4 (21.1%)	50 (49.5%)	
Low Birth Weight		14 (73.7%)	49 (48.5%)	0.044
Maternal Age (Years)	<30	11 (57.9%)	50 (49.5%)	0.502
	≥30	8 (42.1%)	51 (50.5%)	
Mode of Delivery	Assisted	3 (15.8%)	12 (11.9%)	0.836
	Cesarean	8 (42.1%)	40 (39.6%)	
	Vaginal	8 (42.1%)	49 (48.5%)	
Place of Birth	Hospital	17 (89.5%)	92 (91.1%)	0.823
	Home	2 (10.5%)	9 (8.9%)	
Abnormal Antenatal History	Maternal Infection	8	16	0.009
	Congenital Anomaly	7	16	0.033
	Polyhdramnions	4	15	0.497
Etiology	Congenital	2	34	0.070
	Dandy-Walker	–	12	0.113
	Intraventricular Hemorrhage	9	25	0.045
	Myelomeningocele	1	6	0.908
	Post-Infectious	7	16	0.033
	Other	–	8	0.204

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Surgical Procedure	Endoscopic Third Ventriculostomy	1 (5.3%)	5 (5.0%)	0.716
	External Ventricular Drain	4 (21.1%)	14 (13.9%)	
	Ventriculoperitoneal Shunt	14 (73.7%)	82 (81.2%)	

DISCUSSION

In the present neonatal hydrocephalus cohort, the predominance of preterm births (64.2%) and low birth weight (52.5%) corresponds closely with Mandzukovska *et al.* who found 60.8% of hydrocephalic neonates to be preterm, and a birth weight of 2120 grams [13]. The higher frequency of IVH underscores the pathophysiological vulnerability of preterm infants to germinal matrix hemorrhage, a known precursor of post-hemorrhagic hydrocephalus. In this study, IVH was significantly associated with postoperative complications (p=0.045), a finding echoed in the cost-analysis study by Mancha *et al.* where 40% of infants undergoing neurosurgical procedures had IVH, and infection rates reached 11% within 30 days of surgery [14]. Congenital aqueductal stenosis, representing 30.0% of cases in the current analysis, remains one of the most commonly encountered causes of obstructive hydrocephalus in neonates. This is consistent with the descriptive study conducted by Deshmukh and Yadav who identified aqueductal stenosis as the leading congenital cause [15]. Congenital hydrocephalus was not significantly associated with early postoperative complications (p=0.070), possibly due to the absence of inflammatory debris and better anatomical delineation, facilitating more effective shunt function. Post-infectious hydrocephalus was significantly associated with early complications (p=0.033), including shunt infection and malfunction. This aligns with findings from a local study by Bakhsh who documented a 14% shunt infection rate and a 10% failure rate in infants with post-meningitic hydrocephalus [16]. The higher risk in this subgroup is biologically plausible given the altered CSF characteristics, inflammation-mediated adhesions, and higher rates of colonization during shunt placement. Mottolese *et al.* observed a 90.9% complication rate in children with abnormal CSF findings at the time of shunt insertion, reinforcing the idea that infected or proteinaceous CSF predisposes to mechanical and infective shunt failure [17]. Early and appropriate preoperative management of infection may be pivotal in mitigating adverse outcomes in this high-risk population. The overall postoperative complication rate of 15.8% in this study is relatively lower than rates observed in several retrospective and prospective studies. Kumar *et al.* reported a 32.0% overall complication rate, with shunt malfunction (29.2%) and infection (4.4%) being the most common [18]. The comparatively lower complication rate in the current study may be attributed to strict exclusion criteria, which omitted neonates with birth weight below 1000 g and those with multiple anomalies incompatible with life. Rigorous aseptic surgical protocols and specialized pediatric neurosurgical care may have contributed to improved short-term outcomes. No early mortality was recorded during the 30-day follow-up period in the present study. This contrasts with the findings of Lodha *et al.* who reported a 17.5% mortality rate, predominantly in infants younger than 3 months following endoscopic third ventriculostomy (ETV) [19]. The zero mortality in this study reflects both the inclusion of only hemodynamically stable neonates and the efficacy of perioperative management. The possibility of delayed complications beyond 30 days, such as shunt dependency or neurodevelopmental deficits, remains a concern and was not captured in the current follow-up window. In terms of procedure type, ventriculoperitoneal shunting was performed in 80.0% of cases, consistent with its continued designation as the standard of care for neonatal hydrocephalus. Although not significantly associated with early complications in this study (p=0.716), VP shunts inherently carry a long-term risk of mechanical failure and infection. Ji *et al.* have shown that both ETV and VPS can result in cognitive improvement, although VPS yielded more significant gains in infants [20]. Sharafat *et al.* found a 57.1% success rate of ETV in infants under one year, with low rates of complications [21]. The present study reaffirms that ETV remains underutilized in neonates, largely due to anatomical and physiological limitations, and its effectiveness remains lower in children under 3–6 months of age, as supported by Kim *et al.* and Lodha et al [19, 22]. This study also found that the mean duration of hospitalization was significantly prolonged among neonates with complications (9.21 ± 3.44 days vs. 6.54 ± 1.78 days, p<0.001). This observation corroborates the findings of Mancha *et al.* who reported that postoperative infections extended NICU stay by approximately 10.6%, thereby increasing overall healthcare costs [14]. This reinforces the clinical and economic imperative to prevent shunt-related complications in the neonatal population. The importance of antenatal history, particularly maternal infection and polyhydramnios, is underscored in the current data, where maternal infection demonstrated a statistically significant association with complications (p=0.009). This parallels findings from Abebe *et al.* who emphasized antenatal infections as a key risk factor for congenital hydrocephalus [2]. While polyhydramnios was not significantly associated with complications in this study (p=0.497), it remains an important antenatal marker and has been linked to neural tube defects such as myelomeningocele in previous literature, like Venkataramana and Mukundan who found that even children with spina bifida can achieve favorable

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developmental outcomes post-shunting if managed early [23]. The presence of seizures (21.1%) and CSF leaks (15.8%) among those with postoperative complications corresponds to the complication spectrum reported in similar populations. The present study contributes valuable data from a low-to-middle-income country (LMIC) context, where resource limitations, late presentation, and inconsistent antenatal care frequently influence surgical outcomes. This setting makes the relatively low complication and mortality rates particularly noteworthy and offers a benchmark for similar tertiary centers in the region. The findings in this study carry important clinical implications. The identification of prematurity, low birth weight, and specific etiologies (post-infectious and IVH) as predictors of early complications underscores the need for risk-stratified perioperative planning. Antenatal screening for infections and structural anomalies should be reinforced, particularly in settings with limited resources. The study also reaffirms that while VP shunting remains the primary intervention, attention to patient selection, early diagnosis, and meticulous surgical technique can substantially reduce complication rates. Incorporating protocols for preoperative CSF drainage in high-risk neonates may further reduce morbidity [17, 24].

Several limitations of this study must also be acknowledged as well. The follow-up period was limited to 30 days, precluding assessment of long-term complications, such as shunt dependency, neurodevelopmental delay, or cognitive impairment. The exclusion of neonates with birth weight <1000 grams or gestational age <32 weeks may have introduced selection bias, limiting the generalizability of the findings to extremely low birth weight and extremely premature infants. While this study relied on structured clinical and radiologic criteria for hydrocephalus classification, volumetric imaging tools such as FOHR or Evan's Index were not routinely employed, which could enhance risk stratification and guide intervention decisions.

CONCLUSIONS

In neonates with hydrocephalus undergoing surgical management, intraventricular hemorrhage, post-infectious etiologies, prematurity, low birth weight, and abnormal antenatal history were significantly associated with early postoperative complications. The use of ventriculoperitoneal shunts remained the predominant surgical modality, with a relatively lower complication rate and no reported mortality within 30 days. These findings highlight the prognostic relevance of birth and etiological characteristics in predicting early outcomes and underscore the need for targeted perioperative strategies to improve the care and outcomes of neonates with hydrocephalus, particularly in resource-constrained settings.

Authors' Contribution

Conceptualization: SA, SZHS, ZK
Methodology: SA, SSK, MAW
Formal analysis: SA, SSK, SZHS, MAW, ZK
Writing and Drafting: SSK, UU
Review and Editing: SA, SSK, SZHS, MAW, UU, ZK

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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REFERENCES

[1] Hochstetler A, Raskin J, Blazer-Yost BL. Hydrocephalus: Historical Analysis and Considerations for Treatment. European Journal of Medical Research. 2022 Sep; 27(1): 168. doi: 10.1186/s40001-022-00798-6.

[2] Abebe MS, Seyoum G, Emamu B, Teshome D. Congenital Hydrocephalus and Associated Risk Factors: An Institution-Based Case–Control Study, Dessie Town, North East Ethiopia. Pediatric Health, Medicine, and Therapeutics. 2022 May: 175-182. doi: 10.2147/PHMT.S364447.

[3] Chi JH, Fullerton HJ, Gupta N. Time Trends and Demographics of Deaths from Congenital Hydrocephalus in Children in the United States: National Center for Health Statistics Data, 1979 to 1998. Journal of Neurosurgery: Pediatrics. 2005 Aug; 103(2): 113-118. doi: 10.3171/ped.2005.103.2.0113.

[4] de Macêdo Filho LJ, Mansouri A, Otamendi-Lopez A, Sarigul B, Diógenes AV, Carate CK *et al.* Congenital Pediatric Hydrocephalus in the Brazilian Public Health System: The Reality of a Middle-Income Country in the past 13 years. World neurosurgery. 2024 Jan; 181: 801-808. doi: 10.1016/j.wneu.2023.10.137.

[5] Tully HM and Dobyns WB. Infantile Hydrocephalus: A Review of Epidemiology, Classification and Causes. European Journal of Medical Genetics. 2014 Aug; 57(8): 359-368. doi: 10.1016/j.ejmg.2014.06.002.

[6] Garne E, Loane M, Addor MC, Boyd PA, Barisic I, Dolk H. Congenital Hydrocephalus–Prevalence, Prenatal Diagnosis and Outcome of Pregnancy in Four European Regions. European Journal of Paediatric Neurology. 2010 Mar; 14(2): 150-155. doi: 10.1016/j.ejpn.2009.03.005.

[7] Williams MA and Malm J. Diagnosis and Treatment of Idiopathic Normal Pressure Hydrocephalus.

DOI: https://doi.org/10.54393/pjhs.v7i7.3174

Continuum: Lifelong Learning in Neurology. 2016 Apr; 22(2): 579-599. doi: 10.1212/CON.0000000000000305.

[8] Kim M, Choi JH, Park JC, Ahn JS, Kwun BD, Park W. Ventriculoperitoneal Shunt Infection and Malfunction in Adult Patients: Incidence, Risk Factors, And Long-Term Follow-Up of Single Institution Experience. Neurosurgical Review. 2024 Jun; 47(1): 269. doi: 10.1007/s10143-024-02505-x.

[9] Paudel P, Bista P, Pahari D, Sharma G. Ventriculoperitoneal Shunt Complication in Pediatric Hydrocephalus: Risk Factor Analysis from a Single Institution in Nepal. Asian Journal of Neurosurgery. 2020 Mar; 15(1): 83-87. doi: 10.4103/ajns.AJNS_216_19.

[10] Hanak BW, Bonow RH, Harris CA, Browd SR. Cerebrospinal Fluid Shunting Complications in Children. Pediatric Neurosurgery. 2017 Mar; 52(6): 381-400. doi: 10.1159/000452840.

[11] Bloch K and Hasbun R. Central Nervous System Infections Associated with Neurologic Devices. Current Opinion in Infectious Diseases. 2021 Jun; 34(3): 238-244. doi: 10.1097/QCO.0000000000000723.

[12] Gonț BF, Mitran L, Dima V, Vlădăreanu S. Cranial Ultrasound in the Management of Hydrocephalus in Newborns: A Case Series. Children. 2025 Mar; 12(4): 419. doi: 10.3390/children12040419.

[13] Mandzukovska H, Sofijanova A, Voinovska T, Timovska SN, Hristov MK, Vejseli B *et al.* Hydrocephalus with Ventriculoperitoneal Shunts in Infants: Our Experiences and Clinical Outcomes. Journal of Morphological Sciences. 2022 Dec; 5(3): 64-68. doi: 10.55302/JMS2253064m.

[14] Mancha GT, Kadakia S, Muñoz L, Seske LM. Ten-Year Review of Neonatal Neurosurgical Outcomes and Cost Analysis. Surgical Neurology International. 2023 Jun; 14: 203. doi: 10.25259/SNI_59_2023.

[15] Deshmukh SN and Yadav AT. Clinical Study and Management of Hydrocephalus in Children. International Surgery Journal. 2020; 7(4): 1258-1262. doi: 10.18203/2349-2902.isj20201408.

[16] Bakhsh A. CSF Shunt Complications in Infants-An Experience from Pakistan. Pediatric Neurosurgery. 2011 Aug; 47(2): 93-98. doi: 10.1159/000329628.

[17] Mottolese C, Beuriat PA, Szathmari A, Di Rocco F. Complications Related to the Treatment of Hydrocephalus with Extrathecal Cerebrospinal Fluid Shunts. In-Textbook of Pediatric Neurosurgery. Springer International Publishing. 2020 Jun: 681-704. doi: 10.1007/978-3-319-72168-2_33.

[18] Kumar S, Dutta G, Singh RK, Prakash A, Singh RB, Saran K *et al.* A Study of Surgical Outcomes and Complications in Children Undergoing Ventriculoperitoneal Shunt in a Tertiary Care Hospital of Eastern India. Annals of African Medicine. 2025 Oct; 24(4): 858-863. doi: 10.4103/aam.aam_283_24.

[19] Lodha K, Jaiswal G, Gupta T, Parashar V, Singh Y. Endoscopic Third Ventriculostomy for Hydrocephalus in Infants: A Single-Center Experience. Asian Journal of Neurosurgery. 2020 Jun; 15(2): 302-305. doi: 10.4103/ajns.AJNS_17_20.

[20] Ji WY, Cai N, Tu KB, Wang YX, Fan YD, Geng D. Effects of ETV and VPS on Cognitive Impairment in Infants with Congenital Hydrocephalus: A Retrospective Study. European Journal of Inflammation. 2021 Jan; 19: 1-5. doi: 10.1177/2058739219866095.

[21] Sharafat S, Khan Z, Azam F, Ali M. Frequency of Success and Complications of Primary Endoscopic Third Ventriculostomy in Infants with Obstructive Hydrocephalus. Pakistan Journal of Medical Sciences. 2022 Jan; 38(1): 267. doi: 10.12669/pjms.38.1.4097.

[22] Kim SK, Wang KC, Cho BK. Surgical Outcome of Pediatric Hydrocephalus Treated by Endoscopic III Ventriculostomy: Prognostic Factors and Interpretation of Postoperative Neuroimaging. Child's Nervous System. 2000 Mar; 16(3): 161-168. doi: 10.1007/s003810050485.

[23] Venkataramana NK and Mukundan CR. Evaluation of Functional Outcomes in Congenital Hydrocephalus. Journal of Pediatric Neurosciences. 2011 Jan; 6(1): 4-12. doi: 10.4103/1817-1745.84399.

[24] Chen Z, Zhou M, Wen H, Wang Q, Guan J, Zhang Y, Zhang W. Predictive Factors for Persistent Postoperative Hydrocephalus in Children Undergoing Surgical Resection of Periventricular Tumors. Frontiers in Neurology. 2023 Jul; 14: 1136840. doi: 10.3389/fneur.2023.1136840.