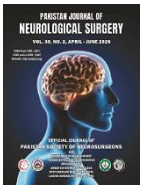

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Original Research

Preoperative Cerebrospinal Fluid Diversion in Pediatric Posterior Fossa Tumor–Associated Hydrocephalus: Ventriculoperitoneal Shunt vs. External Ventricular Drainage

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ABSTRACT

Objective: Assess the effectiveness of preoperative strategies of cerebrospinal fluid (CSF) diversion in children with posterior fossa tumors and related hydrocephalus.

Materials & Methods: The sample size of seventy pediatric patients (1-14 years) with hydrocephalus due to the presence of the posterior fossa tumors was taken. Ventriculoperitoneal (VP) shunting or external ventricular drainage (EVD) was used to treat patients. The complications that were recorded after the operations, and patients were monitored after three.

Results: The mean age was 5.76 ± 3.589 years, and 58.6% were male. In 57.1 and 42.9 percent of patients, VP shunt and EVD were done, respectively. The number of cases of CSF leak was much lower in the VP shunt group (12.5% vs EVD 33.3, P < 0.05). Other complications were also found more common in the EVD group but insignificant: Post-operative meningitis was found 2 times (5.820%) in EVD compared to non-EVD, with pseudomeningocele, which was found 3 times out of seven patients, and which is an infection rate of 42 percent with no significant difference in both groups (p=0.584).

Conclusion: Pediatric patients having hydrocephalus due to posterior fossa tumors will have fewer postoperative complications when the VP shunts are preoperative in comparison to EVD.

Keywords: Pediatric Neurosurgery, Complications, Hydrocephalus, Posterior Fossa Tumors, VP shunt, EVD.

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INTRODUCTION

The lesions may be encountered by medical professionals working in different specialties, and they are found in the posterior fossa. Every physician who is involved in the treatment of patients with this medical condition needs to have a good understanding of the clinical presentation, diagnosis, and work-up, along with the treatment

of these lesions. Patients diagnosed with posterior fossa lesions should be referred to appropriate specialists for further management. The clivus, the temporal bones, the mastoid part of the temporal bones, and the occipital bone are the features that define the posterior fossa. The structure includes the cerebellum, parts of the brainstem like the pons and medulla, and the fourth ventricle.[1] The lesions found in the posterior fossa may be classified based on their etiology, which may include infectious, vascular, traumatic, and neoplastic etiologies. Lesions may be classified as intra-axial or extra-axial, which implies their location in relation to the pia mater in the brain parenchyma. Intra-axial tumors have their origin in the cerebellum and in the fourth ventricle. Two Tumors in the adult as well as pediatric population are found in the posterior fossa, with 65% of all brain tumors among children being realized in this area.[2,3]

Hydrocephalus is associated with symptomatic accumulation of cerebral ventricles with cerebrospinal fluid (CSF).[4-6] The accumulation could be due to a blockage in the normal flow of CSF or a problem with the absorption of the fluid into the venous system via Pacchionian arachnoid granulations or even excessive production of the cerebral fluid. Dandy was the first to subdivide hydrocephalus into two types: communicating and non-communicating. Since then, there have been several other classifications that have been suggested. Four different types also occur in adults.[7,8] Congenital and developmental hydrocephalus often present at birth and are often associated with a genetic syndrome and spinal dysraphism. The former therapy has currently been replaced by surgical therapy, which entails using a ventricular shunt. Endoscopic third ventriculostomy and choroid plexus cauterization are some of the possible ways of intervention for appropriate cases of hydrocephalus. Unless acute hydrocephalus is managed in time, it can also cause herniation of the brain and even death. The mortality rate of hydrocephalus in children is up to 3 per cent, depending on the duration of follow-ups.[8-12]

Hydrocephalus is a rather frequent and even life-threatening complication associated with the presence of a tumor of the posterior fossa caused by obstruction of the CSF in the fourth ventricle or aqueduct. Moreover, certain patients might have the hydrocephalus resolved following tumor resection surgery alone, and it makes the question of whether preoperative CSF diversion is necessary in all cases a controversial matter. Against this background of uncertainty, it is necessary to evaluate management strategies' efficacy to put in place evidence-based management guidelines, to reduce perioperative morbidity, as well as enhance long-term prognoses in patients with posterior fossa tumours and complicated by hydrocephalus.

MATERIALS & METHODS

Study Design and Setting

It was a prospective comparative study, which was a single-center study that was conducted by the Department of Neurosurgery, Hayatabad Medical Complex, Peshawar, during the period of two years, January 2023 to January 2025. The case study was to determine the efficacy of preoperative cerebrospinal fluid (CSF) diversion procedures, i.e., ventriculoperitoneal (VP) shunting and external ventricular drainage (EVD), in the treatment of the case of hydrocephalus associated with the tumor of the posterior fossa. The consent of the Institutional Review Board of Hayatabad Medical Complex (Approval No: 2528) was obtained to enroll the patients.

Study Population

This study involved 70 pediatric patients aged between 1 and 14 years with the diagnosis of hydrocephalus as a result of having a posterior fossa tumor. Computed tomography (CT) and magnetic resonance imaging (MRI) were used to confirm the diagnosis. Written informed consent

was taken before the parents or guardians of all patients were included in the study.

Inclusion Criteria

The inclusion criteria used in the study were as follows: the patients had to be of pediatric age (1-14 years), had to have hydrocephalus secondary to the presence of posterior fossa tumors, which were to be confirmed by CT and/or MRI, and the patients needed to have undergone preoperative cerebrospinal fluid (CSF) diversion either in the form of ventriculoperitoneal (VP).

Exclusion Criteria

Patients were not included in case they had hydrocephalus not caused by the tumor of the posterior fossa, had a prior CSF diversion procedure, had incomplete clinical records, or were lost to follow-up within the study period.

Intervention Protocol

All these were conducted by consultant neurosurgeons who had not less than five years of post-training experience. A non-randomized allocation was done where patients received either preoperative VP shunting or EVD, depending upon the severity of hydrocephalus and the preference of the surgeon (non-randomized allocation). This approach introduces potential selection bias, as patients with more severe hydrocephalus were more likely to receive VP shunting, which may influence outcome comparisons between groups.

Preoperative VP shunting was done by inserting a catheter system to divert CSF through the ventricles into the peritoneal cavity under general anesthesia before tumor resection. External ventricular drainage (EVD) was a temporary intervention that involved the use of a ventricular catheter, which is linked to an external diversion system to have a gradual weaning effect after the tumor is removed.

Outcome Measures

The most important findings of the research were postoperative complication rates, such as cerebrospinal fluid (CSF) leak, meningitis, persistent hydrocephalus, and pseudomeningocele. Constant hydrocephalus was defined as the need for additional diversion of CSF in the form of CSF tumor resection, which was clinically and radiologically determined.

Comparison of complication rates in the VP shunt and EVD groups were qualifying as secondary outcome.

Data Collection Procedure

All patients were noted in terms of demographic information such as age and gender. Preoperative imaging (CT/MRI) and histopathological reports were used to identify the characteristics of the tumor (type and location). The monitoring of patients was done in the course of the hospital stay, after which the patient was followed over a period of three months after the procedure to evaluate the complications. The results were verified by clinical examination, laboratory tests (including the analysis of the CSF in suspected meningitis), and radiological tests.

Data Analysis

The data were entered and analyzed using the Statistical Package of Social Sciences (SPSS version 25). Such variables as age were continuous and presented as mean SD. Frequencies and percentages were used to state categorical variables such as gender, tumor type, tumor location, management strategy, and complications. The chi-square test has been used to compare the rate of complications in the two groups. The statistical significance level was determined as 0.05 or lower.

RESULTS

Demographic Characteristics

This research included 70 pediatric patients who met the inclusion criteria. The average age of the patients was 5.76 years, and the standard deviation was 3.589 years. The population of the study was dominated by males (41 (58.6) and 29 (41.4) respectively).

Tumor Characteristics

The nature of the tumors was examined, and pilocytic astrocytoma was determined to be the most prevalent, as 30 (42.9) of the patients were found to have it. Ependymoma was observed in 23 (32.9) patients, and medulloblastoma was observed in 17 (24.3) patients.

In terms of the location of the tumor, most of the tumors were in the midline, with 52 (74.3) cases. In 8 (11.4) patients, there was involvement of the cerebellar hemisphere, in 7 (10.0) patients, the brainstem tumors, and in 3 (4.3) patients, the cerebellopontine angle tumors were observed (Table 1).

Management Strategy

Cerebrospinal fluid diversion before surgery was done in every patient. Ventriculoperitoneal (VP) shunting was done in 40 (57.1) patients, and external ventricular drainage (EVD) was performed on 30 (42.9) patients (Table 1).

Secondary Outcome Findings

The effectiveness of the management strategies was evaluated by measuring the postoperative complications. It was noted that EVD patients were relatively more prone to complications compared to patients who were treated with VP shunting.

The leakage of CSF was more frequent in EVD patients. In the same manner, the infectious complications like meningitis were also more prevalent in the EVD group.

Even though statistical significance was not obtained in all complications, a definite tendency for higher rates of complications in the EVD group was observed.

Table 1: *Tumor Characteristics and Management Strategy.*

Variable	n	%
Tumor Type		
Medulloblastoma	17	24.3%
Ependymoma	23	32.9%
Pilocytic Astrocytoma	30	42.9%
Tumor Location		
Midline	52	74.3%
Cerebellar Hemisphere	8	11.4%
Brainstem	7	10.0%
Cerebellopontine Angle	3	4.3%
Management Strategy		
Preoperative VP Shunt	40	57.1%
External Ventricular Drainage (EVD)	30	42.9%

Comparison of Complications Between the Management Strategies

The comparison of the VP shunt versus EVD groups revealed that 5 (12.5) patients in the VP shunt group and 10 (33.3) patients in the EVD group had CSF leakage, and the difference was statistically significant ($P < 0.05$).

In the VP shunt group, 4 (10.0) patients were found to have meningitis, and 8 (26.7) patients in the EVD group. The incidences of persistent hydrocephalus were 2 (5.0) patients with VP shunts and 5 (16.7) patients with EVD. Pseudomeningocele was a rare occurrence, with 1 (2.5) patient in the VP shunt group and 2 (6.7) patients in the EVD group.

Nevertheless, the differences did not prove to be statistically significant ($P > 0.05$) (Table 2).

Postoperative Complications

In general, the rate of postoperative complications was rather low. The most prevalent complication that was witnessed in the study population was CSF leak. Other complications like meningitis, persistent hydrocephalus, and pseudomeningocele were less common.

Notably, the majority of complications were treated conservatively, and no death or

neurological disability in the long-term was reported in the follow-up.

DISCUSSION

We studied 70 children aged a mean of 5.76 years old ± 3.589 years, which were relatively younger than the mean age of 7 years old ± 3.421 years reported by Aftab et al,[13] and 9.2 years old, and 3.37 years old reported by Khan et al.[14] The distribution of gender in our study (41 males and 29 females) compares with Aftab et al, as 62 percent expressed in their research resulted in 38 percent of the population being female.[13] Our gender distribution shows a slight male dominance, as compared to Aftab et al, which also showed no significant difference in outcomes according to gender.[14]

Table 2: *Comparison of Complications Between Management Strategies.*

Complication	VP Shunt n (%)	EVD n (%)	Chi-square (χ^2)	P-value
CSF Leak	5 (12.5%)	10 (33.3%)	**4.42**	0.034
Meningitis	4 (10.0%)	8 (26.7%)	**3.36**	0.072
Persistent Hydrocephalus	2 (5.0%)	5 (16.7%)	**2.59**	0.118
Pseudomeningocele	1 (2.5%)	2 (6.7%)	**0.71**	0.576

Tumor type distribution in our cohort showed pilocytic astrocytoma as the most common (42.9%), which was followed by ependymoma (32.9%) and medulloblastoma (24.3%). This aligns with Aftab et al, where pilocytic astrocytoma was the most common tumor type finding, followed by ependymoma and medulloblastoma.[13] Khan et al, reported a higher prevalence of medulloblastoma and astrocytoma, followed by ependymoma.[14] Shah et al, also noted medulloblastoma as the most common tumor type, followed by ependymoma.[15] Pilocytic astrocytoma's prominence in our study and Aftab et al's, study suggests a favorable prognosis, as these tumors are often amenable to resection, potentially reducing hydrocephalus persistence compared to medulloblastoma, which is associated with higher shunt dependency, as reported by Khan et al.[14]

The localization of the tumors in our study was predominantly the midline (74.3%), followed by the cerebellar hemisphere (11.4%), brainstem (10.0%), and cerebellopontine angle (4.3%), which is similar to Shah et al.[15] Midline tumors, since they are close to the fourth ventricle and are most likely to cause obstructive hydrocephalus, which requires CSF diversion. The pattern of localization is similar, which confirms the anatomical difficulty in treating such cases.

Management in our work was in preoperative VP shunting (40 patients or 57.1) and EVD (30 patients or 42.9), which is consistent with the study by Khan et al, in which most of them underwent preoperative VP shunt.[14] Aftab et al, only concentrated on EVD, of which 67 per cent were weaned off and 33 per cent converted to VP shunt.[13]

Complications were important sources of information. There was a significant difference in the number of patients who developed CSF leak in 5 VP shunt patients (12.5) and 10 EVD patients (33.3). The same trends were reported by Khan et al, in 20% of VP shunts and 30% of EVD cases with leak of CSF.[14] Meningitis was found in 4 VP shunt (10.0%) and 8 EVD (26.7%), but not significantly significant ($P > 0.05$) compared to Abdul Aziz Khan et al.[14] Persistent cases of hydrocephalus were less common in VP shunt (5.0%) than in EVD (16.7%), and pseudomeningocele was also insignificant in both treatments (1 VP shunt 2.5; 2 EVD 6.7%).

An important consideration in interpreting our findings is the non-randomized allocation of patients. Since the choice of CSF diversion was influenced by the severity of hydrocephalus and

surgeon preference, patients with more severe clinical presentation were more likely to undergo VP shunting. This introduces a selection bias that may affect the observed complication rates and limits direct comparison between the two groups. Therefore, the apparent advantage of VP shunting should be interpreted with caution.

We suggest a VP shunt to those with severe hydrocephalus who need urgent treatment and EVD to those who are likely to have their hydrocephalus resolved after surgery. The future research ought to examine the long-term VP shunt results and EVD weaning procedures, which we were not able to encompass in our study. Shunt dependency may be lowered by the incorporation of ETV.[15] The non-randomized design may introduce selection bias, which could influence outcomes.

Our result continues with what was already found in other published literature, which proposes that the preoperative CSF diversion is important to maximize surgical outcomes in the case of the posterior fossa tumors. Research has proven that VP shunting offers a more stable control of intracranial pressure than EVD, which potentially may be the reason behind the decreased rates of complications in our cohort. Moreover, EVD is linked with threats of infection and accidental displacement, which could contribute to the increased trends of complications. The new literature is also in favor of the selective use of CSF diversion instead of regular use because the treatment should be given individually basing on the nature and severity of the tumor and on the severity of the hydrocephalus. Current neurosurgical consensus suggests a stepwise approach in the management of hydrocephalus associated with posterior fossa tumors. Primary tumor resection alone remains the first-line treatment in many cases, as hydrocephalus may resolve after decompression. Endoscopic third ventriculostomy (ETV) is increasingly preferred in selected patients. External ventricular drainage (EVD) serves as a temporary measure, while ventriculoperitoneal (VP) shunting is generally reserved for selected or persistent cases. Therefore, CSF diversion strategies should be individualized rather than routinely applied.

It is also important to note that preoperative VP shunting in posterior fossa tumors carries a risk of upward transtentorial herniation due to rapid pressure gradient changes and, therefore, should be used cautiously in selected cases. Moreover, new procedures, including endoscopic third ventriculostomy (ETV), have recorded encouraging outcomes in terms of decreasing long-term dependency on shunts and could be used in place of other procedures in the selected patients. The results explain individual decision-making in the management of pediatric hydrocephalus in the case of posterior fossa tumors.

LIMITATIONS

This research is limited in a number of ways. To begin with, it was a one-centre study with a rather limited sample size, which could restrict the extrapolation of the results. Second, the non-randomized assignment of the patients could have created a selection bias since the selection of the intervention was based on the preference of the surgeon and the clinical condition. Another important limitation is the absence of objective hydrocephalus severity grading using standardized indices such as Evan's index, frontal–occipital horn ratio (FOHR), ventricular size classification, papilledema grading, or Glasgow Coma Scale (GCS). The lack of these parameters limits accurate stratification of disease severity and may influence the interpretation of treatment outcomes. The follow-up duration was limited to three months, which is sufficient for early postoperative complications but inadequate to assess long-term outcomes such as shunt dependency, delayed hydrocephalus, and recurrence-related hydrocephalus.

Additionally, radiological factors such as fourth ventricle compression, aqueductal obstruction, brainstem distortion, and tonsillar descent were not assessed, which may influence hydrocephalus severity and treatment outcomes. Finally, the other significant variables, like the tumor size, surgical extent, and intraoperative factors, were not examined in detail.

FUTURE DIRECTIONS

To confirm these findings, there is a need to conduct research in massive, multicentric randomized controlled trials. The follow-up should be long-term to evaluate the outcome characteristics like shunt dependency, neurodevelopment status, and recurrence of hydrocephalus. Also, comparative trials that use endoscopic third ventriculostomy (ETV) as a treatment arm could augment the studies to shed more light on the best management techniques. The importance of predictive factors in the choice of the correct technique of CSF diversion should also be investigated.

CONCLUSION

Preoperative VP shunting was associated with lower early postoperative complication rates compared to EVD in this study. However, due to the non-randomized design and potential selection bias, these findings should be interpreted cautiously, and definitive superiority of one modality over the other cannot be established. Furthermore, current evidence supports an individualized approach to CSF diversion, prioritizing tumor resection and considering alternative strategies such as ETV or temporary CSF diversion before permanent shunting.

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Additional Information

Disclosure: The authors report no conflict of interest.
Ethical Review Board Approval: This study was approved by the Institutional Review Board, Hayatabad Medical Complex, Peshawar, **Approval No: 2528.**
Human Subjects: Informed consent was obtained from all participants included in the study.
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AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	***Muhammad Ali Noman***	Study concept, methodology design, literature review, and referencing.
2.	***Imran Khan***	Data collection, statistical analysis, and result interpretation.
3.	***Muhammad Danial***	Final review and referencing support, Manuscript writing, editing, and quality assurance.