

COMPREHENSIVE ANALYSIS OF PEDIATRIC POSTERIOR FOSSA TUMORS: PATIENT CHARACTERISTICS, TREATMENT EXPERIENCE, AND SURVIVAL OUTCOMES

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ABSTRACT

Background: Pediatric posterior fossa tumors (PFTs) are among the most common childhood brain tumors and a major cause of neurological morbidity and mortality. Their deep location often leads to rapid neurological deterioration and delayed diagnosis.

Aim: To analyze patient characteristics, clinical presentation, treatment experience, and survival outcomes of pediatric posterior fossa tumors.

Methodology: A retrospective observational cohort study was conducted on 77 patients (≤ 18 years) treated surgically between May 2019 and May 2025 at Department of Neurosurgery, Indira Gandhi Institute of Medical Sciences (I.G.I.M.S.), Patna, Bihar, India. Demographic data, symptoms, histopathology, extent of resection, adjuvant therapy, and survival were evaluated using descriptive statistics and survival analysis.

Results: The most affected age group was 4–7 years (32.47%) with male predominance (58.44%). High-grade tumors constituted 59.74%. Intracranial hypertension (89.61%) and cerebellar deficits (81.82%) were the most common presentations. Pilocytic astrocytoma (29.87%) was the most frequent histology. Gross total resection was higher in low-grade tumors (77.42%) than high-grade tumors (56.52%). One-year survival was significantly better in low-grade tumors (96.77%) compared to high-grade tumors (73.91%).

Conclusion: Tumor grade and extent of resection strongly influence outcomes. Early diagnosis and maximal safe resection with tailored adjuvant therapy improve survival in pediatric PFTs.

KEYWORDS: Pediatric brain tumors, posterior fossa tumors, medulloblastoma, pilocytic astrocytoma, hydrocephalus, survival outcome.

1. INTRODUCTION

Pediatric posterior fossa tumors (PFT) constitute one of the most critical oncological issues in childhood with a significant percentage of central nervous system (CNS)-neoplasms and with an enormous number of morbidity and mortality in children and adolescents of less than 14 years. According to epidemiological reports, CNS tumors are among the most frequent in the solid malignancies among the children in the pediatric population, with this tumor still being a major cause of cancer-related death among the children in this age bracket [1]. The accessibility of the brainstem and cerebellum to tumors is life-threatening due to the unique anatomical limitations of the posterior cranial fossa, where relatively small lesions can cause life threatening neurological impairment.

Pilocytic astrocytoma is the most widespread histological subtype of pediatric PFT, with the second in the list being medulloblastoma, ependymoma, and brainstem glioma [2]. Pilocytic astrocytomas are the leading causes of all childhood gliomas (33.2 percent), which is due to their clinical significance in pediatric neuro-oncology. The age structure is also a major factor of tumor incidence. Gliomas (37.2) and embryonic tumors (24.9) are the most common types of tumors diagnosed in infants below the age of 1 year [3,4]. In embryonic PFT, medulloblastomas are the most common (61.9%), then atypical teratoid / rhabdoid tumors (ATRT) (15.0%), and lastly primitive neuroectodermal tumors (PNEO) (14.9%). Although the high-grade gliomas are less frequent than the low-grade tumors, they cause the most deaths (43.8%), highlighting the aggressive and poor prognosis of the malignant histologies.

Both histopathological characteristics and limited space of the anatomical effects in the posterior cranial fossa to a large extent dictate the clinical behavior of PFT. The accelerated growth of tumor in this small compartment may soon result into obstructive hydrocephalus, high intracranial pressure, and compression of the brain stem [5]. As a result, the symptoms usually emerge suddenly and accelerate. Headache (31%), vomiting (31%), convulsions (21%), and changes of behavior (11%), are common presenting symptoms. Headache (51%) and vomiting (51%) are still top complaints at the time of diagnosis, with visual impairment (37%) and seizures (24%) coming next [6]. The early symptoms are relatively nonspecific and this tends to lead to late identification which may imply that tumors are already of a significant size before they are detected. Hence, more awareness of caregivers and clinicians is required to facilitate early assessment and intervention.

Neuroimaging is a key issue in pediatric PFT diagnosis and treatment. Computed tomography (CT) and magnetic resonance imaging (MRI) are important to offer valuable information on the location, size, and extension of tumor, involvement of the nearby structure, and the presence of the fluid in the skull, leading to the differentiation of diagnosis and treatment planning [7]. MRI, especially has taken the place of other imaging modalities as the cornerstone imaging modality because of its high soft tissue contrast and ability to produce multiplanar images. Timely and accurate neuroimaging would enable surveillance to refer to surgery, optimum surgical planning, and risk stratification [8]. Early imaging in pediatric patients is particularly essential since neurological degradation can be very fast once the intracranial pressure rises or an impairment of the brainstem functionality takes place.

A multidisciplinary approach to management of pediatric posterior fossa tumors involves neurosurgery, neuropathology, radiology, oncology and supportive pediatric care. The safety of tumor resection has also been enhanced by advances in microsurgical processes which allow the resection of tumors with greater completeness, and with fewer neurological deficits [9]. Adjuvant treatment such as radiotherapy and chemotherapy are provided depending on the tumor histology, molecular features and age of the patient. As an illustration, the low-grade tumours like pilocytic astrocytomas can be treated effectively using surgery alone, but embryonal tumours normally demand combined modality therapy. However, therapeutic choices have to issue a prudent balance between oncologic control and long-term neurocognitive and developmental consequences, especially in very young children whose brain is en route of development.

Although there has been an advancement in the diagnostic imaging, surgical technology, and multimodal therapy, the survival outcomes are still inconsistent and heavily dependent on the tumor subtype. Aggressive embryonal tumors still pose serious therapeutic problems because they grow rapidly, propagate cerebrospinal fluid, and do not respond to treatment. The overall survival rates are 74% in children aged below 14 years who have CNS tumors and 76 percent of patients aged 15 to 19 years [10]. These figures are evidence that a lot is being done in pediatric neuro-oncology, but they equally put into perspective the burden of disease that is still present and the requirement of additional studies as a means of maximizing treatment regimens and enhancing quality of life in the long term.

The other vital factor in the management of pediatric PFT is the long-term sequelae that survivors develop. Children often have neurocognitive impairment, endocrinological dysfunction, motor deficits, and psychosocial challenges even after surviving. These delayed outcomes serve as an indication of the need to not only enrich survival but also functional outcome. As treatment plans are being revised, the use of risk-adjusted treatments and rehabilitation measures is being more and more integrated into the treatment process in order to optimize the benefits associated with the treatment and ensure disease control.

The epidemiological information on pediatric brain tumors differs widely in different regions and extensive population-based studies are still not possible in most areas of the world. Lack of elaborated results on the region limits the possibility of comparing the results, finding prognostic variables, and designing region-specific management plans. The knowledge about the local patient traits, availability of treatment and patient survival patterns would thus be crucial in enhancing the process of healthcare delivery and in setting the evidenced-based management rules.

Our research question in this retrospective study was to examine the pediatric patients who were diagnosed with the anterior fossa tumors and examine the patient characteristics, treatment experience and patient survival outcomes. Evaluating clinical presentation, histopathological distribution, treatment modalities, and outcome on follow-up, this research is aimed at adding useful information that can help to improve the knowledge about disease patterns and assist in the enhancement of the treatment of children with neuro-oncological diseases. Finally, treatment strategies in children with posterior fossa tumours should be optimised by an all-round assessment of these factors, in order to decrease the mortality and enhance the quality of life in the long run.

2. METHODOLOGY

Study Design

This research was conducted as a retrospective observational cohort study aimed at evaluating the clinical characteristics, treatment patterns, and short-term survival outcomes of pediatric patients diagnosed with posterior fossa tumors. Hospital medical records were reviewed to analyze demographic profile, presenting symptoms, surgical management, histopathological findings, and postoperative outcomes.

Study Area

The study was carried out in the Department of Neurosurgery at Indira Gandhi Institute of Medical Sciences (I.G.I.M.S.), Patna, Bihar, India.

Study Duration

The study included patients treated over a six-year period from May 2019 to May 2025. Each patient was followed for a minimum duration of six months from the date of surgery or diagnosis to assess postoperative outcome and survival status.

Sample Size

A total of 77 pediatric patients fulfilling the inclusion criteria were enrolled in the study. All eligible patients within the specified time period were included to avoid sampling bias.

Study Population

The study population consisted of children aged 18 years or younger who were diagnosed with posterior fossa tumors and underwent surgical management at the study center. The cohort included both male and female patients presenting with primary intracranial tumors located in the posterior cranial fossa.

Inclusion Criteria

Patients were included if they fulfilled all of the following:

- Age $\leq$ 18 years
- Diagnosed with posterior fossa tumor based on radiological imaging
- Histopathological confirmation of tumor after surgery/biopsy
- Underwent primary surgical intervention at IGIMS
- Minimum follow-up of 6 months available

Exclusion Criteria

Patients were excluded if they had:

- Incomplete medical records
- Follow-up less than 6 months
- Metastatic posterior fossa lesions (secondary tumors)
- Cranial nerve tumors
- Tumors located outside posterior fossa
- Patients treated elsewhere before presentation (re-operations)

Ethical Considerations

Approval for the study was obtained from the Institutional Ethics Committee of I.G.I.M.S., Patna prior to data collection. Patient confidentiality was strictly maintained and all personal identifiers were removed during data extraction. As the study was retrospective and record-based, the requirement for individual informed consent was waived by the ethics committee.

Study Procedure

Hospital records were screened to identify eligible cases meeting inclusion criteria. Clinical and radiological details were recorded in a structured data sheet. All patients had undergone surgical intervention and the extent of tumor removal was classified as gross total resection, subtotal resection, partial resection, or biopsy based on postoperative imaging findings. Histopathological diagnosis was confirmed from pathology reports and tumors were grouped into low-grade and high-grade categories. Patients were followed for six months after treatment to assess mortality, recurrence, and clinical outcome. The association between tumor type, extent of resection, and treatment modality with survival was analyzed.

Statistical Analysis

Data were entered into statistical software and analyzed using SPSS version XX or equivalent software. Continuous variables were expressed as mean with standard deviation or median with range, while categorical variables were presented as frequencies and percentages. Associations between categorical variables were assessed using Chi-square or Fisher's exact test, and continuous variables were compared using Student's t-test or Mann-Whitney U test as appropriate. Overall survival was estimated using Kaplan–Meier survival curves and differences between groups were compared using the log-rank test. Cox proportional hazard regression analysis was performed to identify predictors of mortality. A p-value of 0.05 or less was considered statistically significant.

3. RESULT

Table 1 shows that among 77 patients, the largest age group was 4–7 years (32.47%), followed by 8–12 years (27.27%), $\leq$ 3 years (20.78%), and $>$ 13 years (19.48%), with males predominating (58.44%). High-grade tumors were more common, particularly Grade IV (38.96%) and Grade III (20.78%), while Grade I and II accounted for 31.17% and 9.09% respectively. The most frequent tumor location was ventricle with cerebellar vermis involvement (46.75%), followed by cerebellar hemisphere (33.77%), brainstem (12.99%), and cerebellopontine angle (6.49%). Most patients required CSF diversion preoperatively (64.94%), whereas postoperative diversion was needed in 7.79%, intraoperative diversion in 2.60%, and 24.68% required no diversion.

Table 1. Patient Characteristics (N = 77)		
Variable	N	%
Age (years)		
$\leq$ 3	16	20.78%
4–7	25	32.47%
8–12	21	27.27%
$>$ 13	15	19.48%

Sex		
Male	45	58.44%
Female	32	41.56%
Tumor Grade		
Grade I	24	31.17%
Grade II	7	9.09%
Grade III	16	20.78%
Grade IV	30	38.96%
Location		
Brainstem	10	12.99%
Cerebellopontine angle	5	6.49%
Cerebellar hemisphere	26	33.77%
Ventricle + cerebellar vermis	36	46.75%
CSF Diversion		
Preoperative CSF diversion	50	64.94%
Intraoperative CSF diversion	2	2.60%
Postoperative CSF diversion	6	7.79%
Without CSF diversion	19	24.68%

Table 2 demonstrates that the mean duration of symptoms was 3.5 ± 2.4 months. The most common clinical presentation was intracranial hypertension, seen in 89.61% of patients, followed by cerebellar deficits in 81.82%. Cranial nerve palsy occurred in 38.96% of cases, focal weakness in 33.77%, and visual impairment in 24.68%. Seizures were relatively uncommon, reported in only 5.19% of patients. Overall, features related to raised intracranial pressure and posterior fossa involvement predominated.

Table 2. Clinical Features of Patients		
Clinical Feature	N	%
Average symptom duration (months)	3.5 ± 2.4	—
Intracranial hypertension symptoms	69	89.61%
Seizures	4	5.19%
Visual impairment	19	24.68%
Cranial nerve palsy	30	38.96%
Focal weakness	26	33.77%
Cerebellar deficit	63	81.82%

Table 3 shows the distribution of histological tumor types, with pilocytic astrocytoma being the most common (29.87%), followed by desmoplastic/nodular medulloblastoma (19.48%) and ependymoma (15.58%). Classic medulloblastoma accounted for 7.79% of cases, while diffuse midline glioma and ATRT each represented 5.19%. Less frequent tumors included pilomyxoid astrocytoma (3.90%), diffuse astrocytoma (2.60%), anaplastic astrocytoma (2.60%), large cell/anaplastic medulloblastoma (2.60%), PNET (2.60%), and other rare tumors

(2.60%). Overall, low-grade astrocytic tumors formed the largest proportion, whereas high-grade and embryonal tumors were comparatively less common.

Table 3. Histological Types of Tumors		
Histologic Type	N	%
Pilocytic astrocytoma	23	29.87%
Pilomyxoid astrocytoma	3	3.90%
Diffuse astrocytoma	2	2.60%
Anaplastic astrocytoma	2	2.60%
Diffuse midline glioma	4	5.19%
Ependymoma	12	15.58%
Desmoplastic/Nodular medulloblastoma	15	19.48%
Classic medulloblastoma	6	7.79%
Large cell/anaplastic medulloblastoma	2	2.60%
ATRT	4	5.19%
PNET	2	2.60%
Other rare tumors	2	2.60%

Table 4 compares clinical characteristics and outcomes between low-grade (I–II) and high-grade (III–IV) tumors. Patients with high-grade tumors were slightly younger (6.7 ± 3.8 vs 8.1 ± 4.0 years) and had a markedly higher incidence of hydrocephalus (89.13% vs 64.52%). Gross total resection was achieved more frequently in low-grade tumors (77.42%) compared to high-grade tumors (56.52%), whereas subtotal resection was more common in the high-grade group (43.48% vs 22.58%). Post-operative radiotherapy was required in a majority of high-grade cases (84.78%) but only in 25.81% of low-grade cases. One-year survival was substantially better in the low-grade group (96.77%) than in the high-grade group (73.91%), indicating poorer prognosis with increasing tumor grade.

Table 4. Tumor Grade Group Comparison		
Parameter	Low Grade (I–II) n=31	High Grade (III–IV) n=46
Mean age (years)	8.1 ± 4.0	6.7 ± 3.8
Hydrocephalus	20 (64.52%)	41 (89.13%)
Gross total resection	24 (77.42%)	26 (56.52%)
Subtotal resection	7 (22.58%)	20 (43.48%)
Post-operative radiotherapy	8 (25.81%)	39 (84.78%)
1-year survival	30 (96.77%)	34 (73.91%)

4. DISCUSSION

The present series of 77 pediatric posterior fossa tumor (PFT) patients demonstrated a peak incidence in early school-age children (4–7 years, 32.47%) with a mean age lower in high-grade tumors (6.7 years) compared with low-grade tumors (8.1 years). This age trend aligns with international epidemiological data showing that malignant embryonal tumors tend to occur at younger ages, whereas low-grade astrocytomas predominate in slightly older children (Ostrom et al., 2015) [1]. Similar age clustering around 6–8 years has also been reported in retrospective European and Asian cohorts (Stensvold et al., 2017) [3]. However, our cohort still contained a substantial proportion of infants ≤ 3 years (20.78%), higher than some Western reports where infants constitute a smaller fraction, possibly reflecting referral patterns and delayed diagnosis in developing settings (Picariello et al., 2022) [11].

A male predominance (58.44%) was observed, consistent with multiple pediatric neuro-oncology studies showing higher incidence of medulloblastoma and ependymoma in males (Ostrom et al., 2015) [1]. Nevertheless, some literature reports balanced gender distribution or even slight female predominance depending on subtype and region (Picariello et al., 2022) [11]. Therefore, our findings support the concept that gender distribution varies primarily by histology rather than geographic population.

High-grade tumors comprised the majority of our cases (Grade III–IV: 59.74%), contrasting with some population-based datasets where low-grade tumors slightly outnumber malignant lesions in posterior fossa cohorts (Udaka & Packer, 2018) [12]. The relatively higher proportion of aggressive tumors in our study may reflect referral bias to tertiary neurosurgical centers. Tumor location was most commonly vermian/ventricular (46.75%), followed by cerebellar hemisphere (33.77%), which mirrors imaging-based classification studies demonstrating midline dominance in pediatric PFT, especially medulloblastoma (D'Arco et al., 2018) [2].

Hydrocephalus requiring preoperative cerebrospinal fluid diversion was noted in 64.94% of patients and was significantly more common in high-grade tumors (89.13%). Comparable rates of hydrocephalus (60–90%) have been documented in posterior fossa lesions due to fourth ventricular obstruction (Stocco et al., 2017) [5]. The strong association between malignant tumors and obstructive hydrocephalus in our cohort supports the concept that rapidly growing embryonal tumors present earlier due to raised intracranial pressure rather than focal deficits. Clinically, intracranial hypertension (89.61%) and cerebellar dysfunction (81.82%) were the dominant symptoms, with seizures rare (5.19%). This presentation closely parallels classic pediatric posterior fossa symptomatology described in clinical neurology reviews (Udaka & Packer, 2018) [12]. Cranial nerve palsy and focal weakness were less frequent and generally indicate advanced or brainstem-adjacent disease, again consistent with previously published observations (Stocco et al., 2017) [5]. The mean symptom duration of 3.5 months in our patients is comparable to the 2–4-month interval described in other developing-country cohorts but longer than the short diagnostic interval reported in high-resource healthcare systems, suggesting delayed neuroimaging access as a persistent challenge (Picariello et al., 2022) [11].

Histologically, pilocytic astrocytoma was the most common tumor (29.87%), followed by desmoplastic/nodular medulloblastoma (19.48%) and ependymoma (15.58%). This distribution matches global epidemiologic trends identifying these three entities as the principal pediatric posterior fossa tumors (Ostrom et al., 2015) [1]. The predominance of pilocytic astrocytoma in our cohort also parallels multiple institutional surgical series (Bornhorst et al., 2016) [13]. However, the proportion of ATRT and diffuse midline glioma (each 5.19%) appears slightly higher than in many Western registries, possibly due to improved pathological classification and referral of aggressive tumors to specialized centers (Baliga et al., 2021) [14].

Extent of resection differed significantly between tumor grades; gross total resection was achieved in 77.42% of low-grade tumors compared with 56.52% of high-grade tumors. Similar findings have been consistently reported, emphasizing that tumor biology and infiltration limit resectability in malignant lesions (Lopez-Rivera et al., 2020) [15]. Importantly, our survival analysis demonstrated a 1-year survival of 96.77% for low-grade tumors versus 73.91% for high-grade tumors, reinforcing the established prognostic role of histology and completeness of resection (Millard & De Braganca, 2016) [16].

Pilocytic astrocytoma outcomes in our cohort were favorable, consistent with long-term survival rates exceeding 90% in most studies (Bornhorst et al., 2016) [13]. Conversely, ependymoma and medulloblastoma showed comparatively poorer early survival, paralleling reports that these tumors require multimodal therapy and still carry significant mortality risk (Toescu & Aquilina, 2019) [17]. Notably, postoperative radiotherapy was required in 84.78% of high-grade tumors in our study, reflecting current treatment protocols where adjuvant radiation significantly improves survival in medulloblastoma and ependymoma (Millard & De Braganca, 2016) [16].

Overall, our findings demonstrate patterns broadly comparable to international literature regarding age distribution, symptom profile, histological prevalence, and prognostic significance of tumor grade. However, we observed a relatively higher proportion of high-grade tumors and hydrocephalus at presentation, suggesting delayed diagnosis and referral bias typical of tertiary care centers. The survival difference between low-grade and high-grade tumors in our study emphasizes the continuing importance of early detection, maximal safe resection, and timely adjuvant therapy in improving pediatric posterior fossa tumor outcomes.

CONCLUSION

This comprehensive analysis highlights the diverse clinical, radiological, and pathological spectrum of pediatric posterior fossa tumors and underscores the strong influence of tumor biology on management strategies and outcomes. Most patients presented with features of raised intracranial pressure and cerebellar dysfunction, reflecting delayed diagnosis and frequent hydrocephalus, often necessitating cerebrospinal fluid diversion. Tumors were predominantly located in the midline posterior fossa, with a wide range of histological subtypes spanning low- and high-grade lesions. Surgical resection remained the cornerstone of treatment, with a greater likelihood of complete resection in low-grade tumors, while high-grade tumors more often required adjuvant radiotherapy. Survival outcomes were closely linked to tumor grade, extent of resection, and need for multimodal therapy, with more favorable outcomes observed in low-grade tumors. Overall, the study emphasizes the importance of early recognition, maximal safe resection, and tailored adjuvant treatment to improve survival and functional outcomes in children with posterior fossa tumors.

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