

## Surgical Management of Huge Pediatric Brain Tumors in Egypt: A Model from Developing Countries

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**BACKGROUND:** Central nervous system tumors (tumors of the brain and spine) are the most common solid tumor in children. The majority of pediatric brain tumors are infratentorial (60 percent). The most common tumor is medulloblastoma. The other 40 percent of pediatric brain tumors are in the cerebral hemispheres (supratentorial).

**OBJECTIVE:** To present the demographic and histopathologic profile of huge supratentorial brain tumors in pediatric patients managed by Neurosurgery Department, Alexandria University during the period starting from May 2016 until February 2020, as well as to gain a better understanding of the best surgical management and effective treatment strategies.

**PATIENTS AND METHODS:** A total of 12 cases of huge supratentorial pediatric brain tumors who presented to Neurosurgery Department, Alexandria University between May 2016 and February 2020 and underwent initial surgical resection, were studied retrospectively, considering the clinical characteristics of these patients, surgical management, clinical outcome, and other needed adjuvant treatment.

**RESULTS:** Among 8 boys and 4 girls, gross total resection of huge brain tumors was achieved for the majority of cases (9 cases). Partial resection and biopsy were performed in 2 cases, while only 1 case underwent subtotal resection. Either transcortical or pterional approach was used for surgical management of these huge supratentorial tumors, and there was no major difference between the two approaches in terms of efficiency and complications. Tumors with calcification or adhesion had a significant lower gross total resection rate. Four patients died, three died within two years postoperatively, and one patient aged 3 months passed away due to severe edema 7 days postoperatively. During follow-up, 9 patients underwent postoperative adjuvant chemotherapy.

**CONCLUSION:** Huge supratentorial pediatric brain tumors are surgically challenging. Total resection is the best treatment. Calcifications or adhesions can influence the tumors' gross total resection and postoperative functional result. Prognosis of pediatric supratentorial brain tumors depends on the age at presentation, size of the tumor, histological type, and extent of resection. In our study, we studied the large-sized brain tumors and how it affects the clinical outcome. Despite the prominent advances in therapy, the outcome remains poor.

**KEYWORDS:** Atypical teratoid/rhabdoid tumors (ATRT), embryonal tumors with multilayered rosettes (ETMR), huge pediatric brain tumors.

### INTRODUCTION

Brain tumors are the most common solid tumors in children. They are the second most common childhood cancer after leukemia, representing about 20% of all childhood cancers, and they are the most common cause of cancer deaths.<sup>1</sup>

Pediatric brain tumors can be classified according to tumor location into supratentorial and infratentorial, with different predilection according to age. Supratentorial brain tumors are more common in children under 3 years of age, meanwhile, infratentorial tumors are more common in older children till 10 years of age. After puberty, supratentorial and infratentorial tumors have similar incidence.<sup>2</sup>

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Considering the age at diagnosis, pediatric brain tumors can be classified into congenital when diagnosis is reached either antenatally or postnatally till 2 months of age; infant pediatric tumors are diagnosed between 2-12 months of age, and older pediatric tumors from (1-18 years). Age at diagnosis is one of the determinant factors of prognosis of pediatric brain tumors. Congenital brain tumors are quite different from other pediatric tumors regarding histological types and prognosis.<sup>2</sup>

Pediatric brain tumors have distinct biological characteristics that differ from brain tumors in adults. They differ in site of origin, histopathological types, clinical presentation, huge size at the presentation, biological behavior, and prognosis.<sup>2</sup>

The common pediatric infratentorial tumors are medulloblastoma, pilocytic astrocytoma, ependymoma, diffuse intrinsic pontine glioma, and atypical teratoid rhabdoid tumor (ATRT). Supratentorial pediatric

tumors can be astrocytoma, gangliogliomas, embryonal tumors with multilayered rosettes (ETMR), germ cell tumors, craniopharyngioma, and oligodendroglioma. Teratoma is the commonest congenital brain tumor, followed by astrocytoma, then choroid plexus papilloma which commonly arises within the lateral ventricles. Craniopharyngioma, ependymoma, and embryonal tumors are less common than congenital brain tumors. Medulloblastoma is the commonest posterior fossa pediatric tumor which arises from vermis and may have leptomeningeal seeding along the spinal cord.<sup>3</sup>

Pathologically, pediatric brain tumors can be of glial cell origin (astrocytomas and ependymomas), mixed neuronal-glial origin (ganglioglioma, subependymal giant cell tumors, and pleomorphic xantho-astrocytoma), embryonal origin (ETMR and ATRT), choroid plexus tumors (papilloma, and carcinoma), as well as non-neuroepithelial origin (craniopharyngioma, and pineal region tumors). However meningioma is a very rare pediatric tumor.<sup>3</sup>

Clinical presentations of pediatric brain tumors vary according to the size of the tumor at presentation, location, and age. Congenital brain tumors may present antenatally with increased head circumference, and polyhydramnios. Postnatally, hydrocephalus, macrocrania, and focal neurological deficits are also common presentations. Infants and older pediatric age groups presentations depend on tumor location; supratentorial tumors may present with convulsions, focal deficit, or disturbed level of consciousness, while infratentorial tumors can present with hydrocephalus or focal cerebellar signs like ataxia, hypotonia or imbalance.<sup>4</sup>

Prenatal diagnosis for congenital brain tumors can be accomplished by ultrasound, where tumors appear with variable echogenicity or cystic intracranial lesions. Magnetic resonance imaging (MRI) brain with contrast is the investigation of choice postnatally. Advanced neuro-imaging may be needed for further assessment as perfusion-MRI and magnetic resonance spectroscopy (MRS). Magnetic resonance tractography may be used when lesions are adjacent to eloquent areas.<sup>5</sup>

Whole spine axis scan is mandatory to look for spinal seeding in complementary management of some pediatric brain tumors like medulloblastomas, ependymomas, ETMR (Embryonal Tumors with Multilayered Rosettes), and ATRT (Atypical Teratoid/Rhabdoid Tumors).<sup>6</sup>

Therapeutic options for pediatric brain tumors include surgery, chemotherapy, and radiation therapy. Surgery is the most effective treatment option, aiming at achieving the gross total resection of the lesions, while at the same time preserving the functional capacity of the patients. The extent of gross total resection, size of the tumor, and the general condition of the patient are all important determinants of surgical outcome. Adjuvant therapies are rarely used in congenital brain tumors.

Adjuvant radiotherapy can be used after 3 years of age if

needed, while complementary chemotherapy can be used instead before the age of 3 years. Whole craniospinal axis irradiation is needed if spinal seeding is suspected.<sup>7</sup>

Huge pediatric brain tumors represent the greatest challenge for pediatric neurosurgeons to achieve gross total or subtotal resection of the whole lesion yet avoiding the high morbidity and mortality related to aggressiveness of the surgery.

This study represents our experience of surgical management of huge supratentorial pediatric tumors at Alexandria University Hospital analyzing the biological behavior and clinical characteristics, as well as gaining a better understanding of the surgical management and treatment strategies of these tumors.

## PATIENTS AND METHODS

Data was obtained by reviewing the records of 12 cases of huge supratentorial pediatric brain tumors who presented between May 2016 and February 2020 at Alexandria University Hospital and underwent initial surgical resection. This data were studied retrospectively. The data analyzed included gender, age at the initial diagnosis, location of tumors, surgical treatment data including degree of radicality, surgical approach, amount of intraoperative blood loss, histopathology, presence of calcification, postoperative hospitalization stay, need for adjuvant cerebrospinal fluid (CSF) diversion, further management strategies including chemotherapy and/or radiotherapy, treatment outcome including mortality and morbidity rates, and finally, functional outcome.

### Inclusion criteria

Children aged from one day to two years with confirmed large supratentorial brain tumor were included.

Tumor volume was calculated from the MRI brain images obtained before surgery using the ABC/2 formula, where A, B and C are the maximal diameters of the tumor in the axial, coronal and sagittal images respectively.

Pediatric brain tumors in our study were considered as huge sized when the volume reached at least 90 cc supratentorial, or 40 cc intraventricular on the MRI brain images done before surgery.

### Exclusion criteria

Children with infratentorial brain tumors, head and neck malignancy, and benign cystic lesions (arachnoid cysts, epidermoid cysts, and dermoid cysts) were excluded.

### Clinical and radiological follow up

All patients had an immediate postoperative computerized tomography (CT) and clinical assessment. Follow up MRI brain with contrast was done after 2 months. All patients were clinically followed postoperatively for at least 14 months to detect any regression in the clinical outcome (including orientational status, motor power, visual acuity, and fundus examination). Radiological

follow-up by MRI was performed every 6 months to detect any recurrence.

### Statistical Analysis

Using a specially constructed sheet on Microsoft Excel, data was entered, thoroughly revised, and transferred to IBM Statistical Packages for the Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA). For descriptive statistics, the mean and standard deviation were calculated. As for comparative statistics, comparison in all variables using Fisher exact test and Odd's ratio (with 95% confidence interval), when applicable, was performed. A 5% alpha error was adopted (p significance was measured at <0.05).

### Ethical Approval

The study was approved by the Ethics Committee of the Faculty of Medicine of Alexandria University (Institutional Review Board (IRB) No.: 00012098, FWA No.: 00018699). Additionally, the study was performed according to the Strengthening the Reporting of Observational Studies in Epidemiology (SROBE)

statement.

### RESULTS

The study included 12 children. Pediatric brain tumors were more common in males (67%) compared to females (33%). The patients' ages ranged from 2 months up to 2 years at the time of initial diagnosis. None of the treated cases had an antenatal diagnosis. Around 17% of cases were under 6 months, and 83% of cases were between 6 months- 2 years at initial diagnosis. Mean age of presentation was  $13.83 \pm 7.86$  months.

In this study, 12 large lesions underwent surgical resection; 1 Anaplastic ependymomas, 1 ATRT, 3 immature teratomas, 2 craniopharyngiomas, 4 ETMR, and 1 choroid plexus carcinoma (Fig. 1).

In the present study, macrocephalus, inability to thrive, difficulty in suckling and seizures were the most common manifestations prior to the closing of fontanelles. After 1 year, focal neurological deficits, seizures and increased intracranial pressure emerged. (Table 1) shows all patients' clinical presentations.

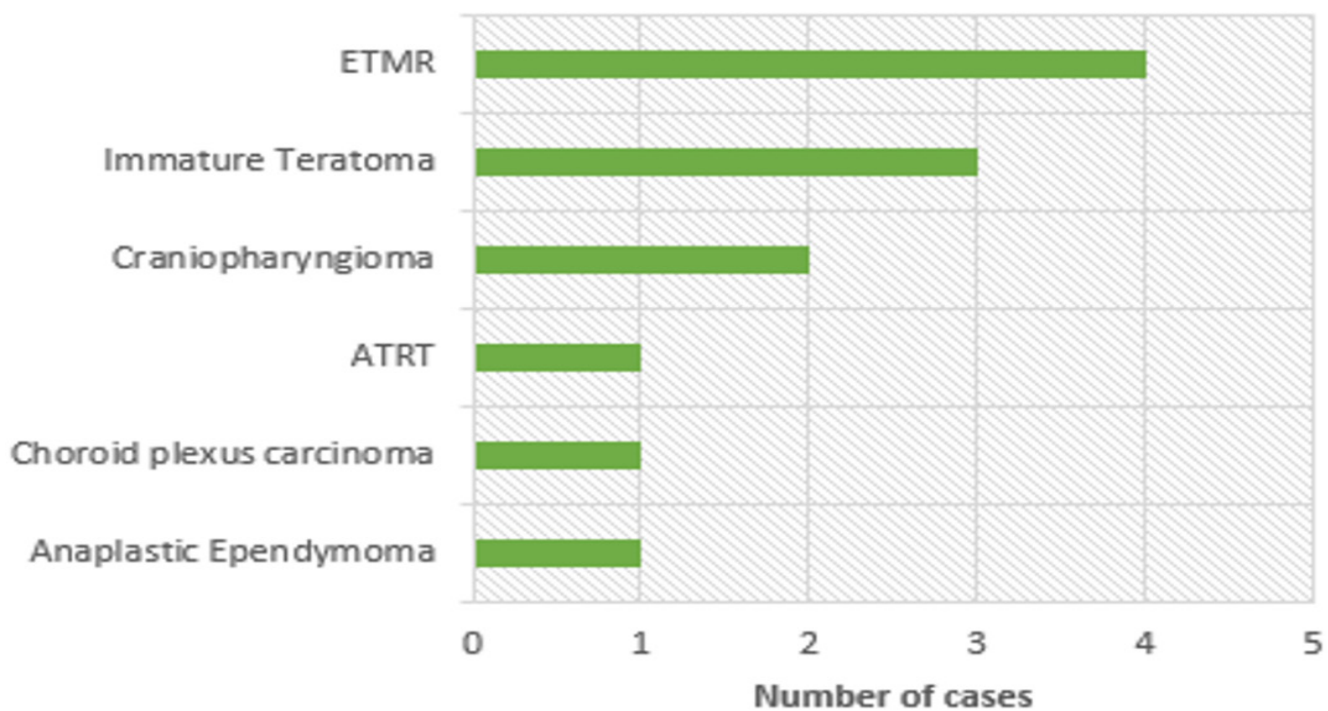


Fig 1: Distribution of treated huge pediatric tumors according to histopathology.

Table 1: The clinical presentation of the studied cases

Clinical picture	Number of cases
Macrocephalus	12
Inability to thrive	10
Difficult in suckling	8
Seizures	7
Neurological deficits	4
Vomiting	6

Each patient may have more than one clinical presentation.

In our study, we observed a large interval of time between the onset of symptoms and the time of surgery, it was extended from 1 week to 5 months (mean 1.6 months, and standard deviation 1.4 months). This is because of the lack of awareness and delayed detection of the tumor. The time interval tended to decrease as the children got older, because closure of the fontanelle led to aggravation of the symptoms as the intracranial pressure increases. Only a total of 7 patients (58%) were operated upon 2 weeks after the onset of symptoms.

Transcortical approach was performed in 10 cases (83%), and pterional approach in 2 cases (17%). Amount of intraoperative blood loss was estimated in all cases, and blood transfusion was ensured to avoid massive blood loss. Blood loss ranged between 40cc and 150cc, with a mean blood loss of 55 cc  $\pm$  25 cc. Postoperative hospital admission days ranged between 3 days and 14 days with a mean of 4 days, and standard deviation 3.2 days.

Considering the need for further interventions, one patient needed a subdural subgaleal shunt. Two cases (17%) of craniopharyngiomas needed insertion of Ommaya reservoir. Ten cases showed hydrocephalus before surgery, but none needed a postoperative insertion of ventriculoperitoneal shunt.

As the present protocol, immediate follow up CT brain was done postoperatively and MRI brain with Gadolinium (GAD) after 2 months of surgery. Five cases (42%) needed re-operation for residual or recurrent lesions, but only four of them underwent complementary surgery. First case, 1.6-years-old girl showed a residual tumor in the follow-up MRI images at two months post-operatively. She then went through a second operation for gross total resection (GTR) of the residual tumor. The second case was a 2-month-old girl, who had partial resection of the tumor, which was very vascular and later diagnosed as immature teratoma and re-operation was done. Unfortunately, the girl died after 4 months. The third case was a 10-month-old boy who was operated for GTR for ATRT but a recurrence appeared during the follow-up period after 1.6 years of the first surgery. He entered for a second surgery for another gross total resection. After that his whole spine and brain MRI follow-up images showed a CSF seeding associated with intracranial dissemination, and he passed away 5 months later. The fourth case, a girl aged 10 months, showed recurrent immature teratoma during the follow-up period and entered a second surgery for removal of tumor recurrence, but unfortunately she passed away within 3 months. The fifth patient, aged 3 months, the surgical team was sure that there was a residual lesion left behind since the operation was terminated due to large bleeding loss. At the end, this child also passed away a few days after the first surgery due to massive brain edema.

We emphasize that reoperation should be approached with caution in high Grade IV patients because of their poor prognosis.

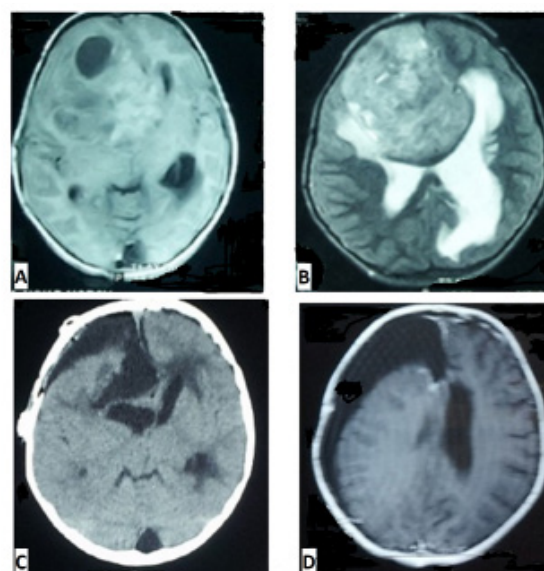
All cases were demonstrated in (Table 2) showing the

patients' age, sex, location, radicality, surgical approach, histopathology, and the follow up period after surgery.

Considering degree of radicality, gross total resection was accomplished in 9 (75%) cases, subtotal resection in 1 (8%) cases and partial resection in 2 (17%) cases. Ommaya reservoir was inserted in 2 cases of craniopharyngiomas.

#### Case Presentation:

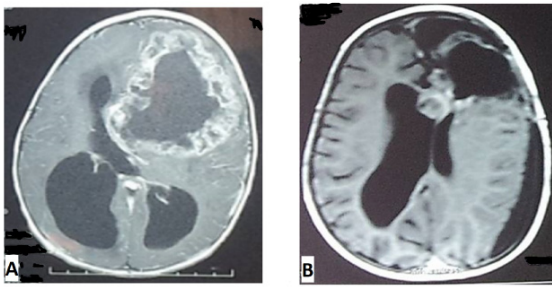
**Case No 8 (Table 2):** A two-year-old girl presented with vomiting, left sided weakness, and disturbed level of consciousness; MRI revealed huge right frontal space occupying lesion exerting severe mass effect with massive midline shift with effacement of ipsilateral lateral ventricle and evolving hydrocephalus. Patient was prepared for surgery, which was done through a transcortical approach for gross total resection of the lesion without any need for further intervention for CSF diversion. (Fig. 2).



**Fig 2:** (a) Contrast enhanced MRI brain T1 film (axial view) and (b) MRI brain T2 film (axial view) showing huge right frontoparietal ETMR of a female patient aged 2 years at presentation, exerting severe mass effect with evolving hydrocephalus. (c) Immediate postoperative CT brain (axial view) showing no postoperative hemorrhage or brain oedema. (d) Follow up contrast enhanced MRI brain T1 film (axial view) after 6 months shows gross total surgical resection was achieved, with neither recurrence nor residual.

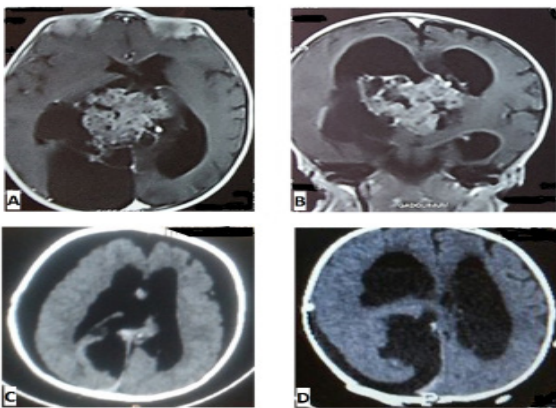
**Case No 2 (Table 2):** A one and half-year-old girl presented with vomiting, large head, right sided weakness and disturbed level of consciousness. MRI revealed huge left fronto-parietal lesion exerting severe mass effect with massive midline shift with effacement of ipsilateral lateral ventricle and evolving hydrocephalus. Patient had preoperative medical dehydrating measures as corticosteroids, and was prepared for surgery. Transcortical approach and resection of the tumor was done without any need for further intervention for CSF diversion. After 2 months, the follow-up contrast

enhanced MRI brain showed subtotal resection with a small residual. So the girl entered for a second surgery for gross total surgical. (Fig. 3).



**Fig 3:** (a) Contrast enhanced MRI brain T1 (axial view) showing huge left frontoparietal anaplastic ependymoma, exerting severe mass effect with evolving hydrocephalus. (b) Follow up contrast enhanced MRI brain T1 (axial view) after 2 months shows subtotal resection with a small residual, the girl received a second surgery and gross total resection was achieved.

**Case No 1 (Table 2):** A nine-month-old boy presented with vomiting, focal convulsions, and large head. MRI revealed huge supratentorial intraventricular space occupying lesion and evolving hydrocephalus. Patient was prepared for immediate surgery. Transcortical approach was done. GTR of the lesion was achieved. Postoperatively the patient developed a bilateral large subdural hygroma more on the right side, a temporary subdural-subgalial tube was inserted for a week to drain the accumulated CSF and decrease the pressurizing subdural collection on the brain. (Fig. 4).



**Fig 4:** (a) Contrast enhanced MRI brain T1 film (axial view) and (b) Contrast enhanced MRI brain T1 film (coronal view) showing huge intraventricular choroid plexus carcinoma with developing hydrocephalus. (c) Postoperative CT brain (axial view) reveals neither postoperative hemorrhage nor cerebral oedema, but shows an emerging bilateral pressurizing subdural hygroma. (d) Postoperative CT brain (axial view) reveals decreasing of the subdural collection bilaterally after insertion of a temporary subdural-subgalial tube for a week.

Prognosis was considerably affected by presurgical general condition of the patient, size of lesion, and degree of radicality in first surgery. In (Table 3), tumor volume had an effect on both the extent of tumor resection, as

well as the survival by the end of follow-up. Although patients with tumor volume of less than 100 cc achieved more gross total resection (100%) than larger tumors (66.6%), such association did not reach the statistical significance ( $p=0.51$ ) due to small sample size. Also, the survival rate of the patients with tumor volume of less than 100 cc (100%) was higher than those with larger tumors (55.5%); such association did not reach the statistical significance ( $p=0.49$ ) due to small sample size. However, conflicting effect of tumor volume was observed on the patients' survival at the end of follow-up.

The gross total resection depends on tumor size and eloquence of the brain areas. Supratentorial tumors are more amenable to surgical treatment. There was a considerable association between eloquence and gross total resection. Gross total resection was higher in non-eloquent tumors than in eloquent tumors.

In Table 4 our results indicated that GTR was associated with an improvement in the overall survival (77.7%) compared to the survival rate of those with subtotal resection (STR) (66.6%). Yet this association did not reach the statistical significance ( $p$  value=0.49 and Odd's ratio (95% confidence interval (CI) = 0.143 (0.0081-2.517) due to small sample size. In addition, adjuvant therapy for the surgical cavity after GTR has a potential benefit regarding survival.

## DISCUSSION

Pediatric brain tumors are a peculiar entity of central nervous system tumors, attaining certain characteristics, related to location, histopathology, size of lesion at presentation, therapeutic options and prognosis.<sup>8</sup>

Achieving secure gross total resection is the best therapeutic choice for pediatric brain tumors, but not always possible without substantial morbidity and mortality; hence the beneficial use of postoperative adjuvant therapy, while taking into account, the condemned usage of radiation therapy before age of 3 years.<sup>9</sup> Because of its toxicity, chemotherapy must be used cautiously in neonates who are at risk of myelosuppression, anemia and infection.

The best way to treat these large tumors was by combining gross total resection with adjuvant chemotherapy, which prolonged the child's survival, and was found consistent with Malano et al.<sup>10</sup> who reviewed 67 cases.

However, because of children's limited volume of circulating blood, surgical management is to be performed carefully to neonates, where only a minor loss of blood will trigger hemodynamic instability. Treating these types of tumors in this period of life involves very precise work with attention to detail.

Histologically, these supratentorial tumors always represent as huge sized tumors, which tend to be teratomas, craniopharyngiomas, ETMR, ATRT, astrocytomas, or choroid plexus papillomas. They reach this large size due to delayed diagnosis and lack of the medical awareness in developing countries.

**Table 2: Demonstrates the surgical cases concerning age, sex, tumor location, tumor volume, with or without hydrocephalus, the radicality of the surgical procedure, the surgical approach, histopathological diagnosis and the follow up period**

Age/sex	Location	Tumor volume cc	Hydrocephalus/ VP shunt	Radicality	Approach	Histopathology	Postoperative complication	Follow-up
9m/M	Supratentorial intraventricular	41	HC / No VP shunt	GTR	Transcortical	Choroid plexus carcinoma	Scalp CSF bogginess	Subdural hygroma → subdural -subgalial shunt → on follow up
1.6y/F	Left frontoparietal	195	HC / No VP shunt	STR	Transcortical	Anaplastic ependymoma	Nil	Residual → 2 <sup>nd</sup> operation → GTR → on follow up
10m/F	Right frontotemporal	121	HC / No VP shunt	GTR	Transcortical	Immature teratoma	Cephalhematoma and seroma	Recurrence → 2 <sup>nd</sup> operation → died
2y/M	Sellar and suprasellar	91	No HC / No VP shunt	GTR	Pterional	Craniopharyngioma	Nil	Neither residual nor recurrence → on follow up
1.8y/M	Left frontoparietal	172	HC / No VP shunt	GTR	Transcortical	ETMR	Nil	CSF seeding → surgical removal → on follow up
2m/F	Right frontotempoparietal	189	HC / No VP shunt	Partial	Transcortical	Immature teratoma	drain showed 60cc blood postoperatively	2 <sup>nd</sup> operation → STR → died within 4 months
11m/M	Left frontoparietal	139	HC / No VP shunt	GTR	Transcortical	ETMR	Right temporary hemiparesis	Neither residual nor recurrence → on follow up
2y/F	Right frontal	275	HC / No VP shunt	GTR	Transcortical	ETMR	Nil	Neither residual nor recurrence → on follow up
3m/M	Right frontotempoparietal	111	HC / No VP shunt	Partial	Transcortical	Immature teratoma	Repeated seizures then DLC	Residual → died within days after surgery
1y/M	Left frontoparietal	152	HC / No VP shunt	GTR	Transcortical	ETMR	Nil	Subdural hygroma → subdural -peritoneal shunt → on follow up
10m/M	Left frontoparietal	147	HC / No VP shunt	GTR	Transcortical	ATRT	Small cephalhematoma	Recurrence after 1.6 year → 2 <sup>nd</sup> operation → CSF seeding → died after 5 months
2y/M	Sellar and suprasellar	96	No HC / No VP shunt	GTR	Pterional	Craniopharyngioma	Nil	Neither residual nor recurrence → on follow up

Abbreviations: CSF: Cerebrospinal fluid, HC: hydrocephalus, VP shunt: ventriculoperitoneal shunt, ETMR: embryonal tumors with multilayered rosettes, ATRT: atypical teratoid rhabdoid tumor, GTR: gross total resection, STR: subtotal resection, and DLC: deteriorated level of conscious.

**Table 3: The association between the tumor size and the gross total resection and survival rate at the follow-up**

Tumor volume (cubic centimeter)	Number of patients (number, percentage of total patient number)	Patients achieving gross total resection (number, percentage of total patient number)	Survival of patients at the end of follow-up (number, percentage of total patient number)
< 100 cc	3 (25%)	3/3 (100%)	3/3 (100%)
>100 cc	9 (75%)	6/9 (66.6%)	5/9 (55.5%)

**Table 4: The effect of the radicality of the tumor resection on the survival rate**

	Number of patients (percentage)	Survival of patients at the end of follow-up
Gross total resection	9 (75%)	7/9 (77.7%)
Subtotal and partial resection	3 (25%)	1/3 (66.6%)

Late diagnosis of pediatric brain tumors causes many lesions to attain huge size before detection. This is in accordance with other series of pediatric brain tumors,<sup>4,5</sup> where it was observed that there was difficulty in many cases to achieve gross complete resection. However, advances in neuroimaging, whether antenatally or postnatally, have dramatically improved this problem, enabling early intervention and thus better prognosis.

Due to the substantial blood loss and the risk of hypovolemia, it is important to first devascularize the tumors, by coagulating either the capsule or the main feeders if possible, with immediate and precise blood replacement. Also the arterial line was of a beneficial influence since it detects instant drop in the blood pressure, therefore avoiding potential risk to these patients.

In the current study, 67% of cases are alive and are still followed up periodically. No intraoperative mortalities occurred; however, there were 4 patients (33%) who died postoperatively. One of them died 1 week after surgery. He was conscious postoperatively for 48 hours, unfortunately he had repeated convulsions and developed massive brain oedema, where his conscious level deteriorated. Dehydrating measures (hypertonic saline and corticosteroids) and antiepileptic drugs were given. He was sedated on mechanical ventilation for another 4 days, but he passed away in spite of all of these measures. The other 3 cases passed away during the course of treatment within two years.

Five patients (42%) needed second surgery for residual lesions, but only 4 of them underwent complementary surgery, as the fifth aged 3 months, died from massive edema prior to the chance of reintervention. Nine cases (75%) needed adjuvant therapy after surgery (chemotherapy). It was obvious that the patients who received GTR had significant improvements in the clinical outcome survival.

Postoperative sequela of large supratentorial pediatric brain tumors is the subdural fluid collections which are hard to treat if showed a progressive course. We were challenged by 3 (25%) cases of subdural collections. Only 2 cases showed a pressurizing CSF collection, which led to midline shift and compression on the brain. One case was treated by insertion of subdural-subgalial tube and the other with subdural-peritoneal shunt. Both cases were cured and the collections were decreased gradually and the pressure on the brain was relieved.

Like other series,<sup>11,12</sup> cerebrospinal fluid (CSF) seeding was encountered more frequently in pediatric brain tumor than in adults, and it is frequently observed in ETMR. However, our team developed an imaging protocol with recommendations for timing to evaluate metastatic/leptomeningeal disease, besides the investigation for CSF cytology. We observed two cases in their follow-up period with spinal intradural drop metastasis, one as ETMR, and the other as ATRT. The first patient went for

surgical removal of a solitary drop metastasis followed by adjuvant chemotherapy, while the ATRT case showed tumor cells in the CSF associated with intracranial dissemination and the patient died after 5 months.

In this study, the borders of few tumors were not clearly demarcated and there was infiltration to the surrounding tissues. Tumors with calcification or adhesion had a significant lower gross total resection rate.

One patient (8%) developed right temporary hemiparesis postoperatively, which improved along the follow up period. One case (8%) needed a ventilator postoperatively. In our study, we did not observe any cases of infection relating to the surgery itself or to any of the shunts used.

Pediatric brain tumors are different from adult brain tumors considering the location, tumor size at presentation, histopathology, therapeutic options, and prognosis. Presurgical general condition of the patient, size of lesion, and degree of radicality were relevant influencing factors affecting the survival rate. On the other hand, cases with post-resection residual tumor or metastatic/leptomeningeal disease were observed to have much worse survival rate. Thus, early diagnosis may improve the prognosis, since early detection of the tumors, before reaching huge size, will make it easier to be completely resected.

The low socioeconomic status and unawareness of the parents led to delayed detection of these tumors, which directly affects the outcome. Also, the failure to recognize the seriousness of symptoms or misattributing them to other existing conditions or more common causes. These circumstances led the lesions to reach huge sizes, which in turn, becomes a great challenge for the neurosurgeons, thus decreasing the possibility of gross total resection, and increasing the blood loss.

Brain tumors account for less than a quarter of childhood cancers, so a single general practitioner will be extremely unlikely to encounter such a child. The general practitioners do know that some childhood brain tumors have a good prognosis, but only if identified early with the correct diagnosis.

Due to limited financial resources, molecular genetics study and subgrouping of the lesion could not be accomplished, hence the use of targeted therapy was not available and only chemotherapy was used instead.<sup>13</sup>

Jimenez et al. reported good disease outcomes for a small cohort of very young patients with medulloblastoma and supratentorial primitive neuroectodermal tumors (PNET) who were treated with upfront chemotherapy followed by 3-dimensional proton radiation therapy, but stated that longer follow-up and larger numbers of patients are needed to assess long-term outcomes and late toxicity.<sup>14</sup>

Upfront chemotherapy may devascularize the tumors and reduce the size of pediatric brain tumors, but patients may face different problems as the tumor size reduction may be

temporary, or even increase in tumor size, and deleterious intracranial changes during chemotherapy, which were thought to be directly due to the chemotherapy.<sup>15,16</sup>

### Limitations of the study

The main limitations of our study were the relatively small number of patients and the short follow-up period. Since our study only discussed the huge sized supratentorial pediatric brain tumors, and although the number of patients included in our study was 12, this is still a small number when compared to other published studies discussing similar topics. Further studies incorporating a larger number of patients with a longer follow-up period is justified to confirm or refute our findings.

### CONCLUSION

Huge supratentorial pediatric brain tumors represent a major challenge to pediatric neurosurgeons, taking into consideration the major anesthetic and surgical risks, such as hemorrhage, long operative time, need for blood transfusion, the maximal safe resection without derangement of patient's functional capacity, need for second surgery for large tumors and the sensitive postoperative care. Safe gross total resection is the best therapeutic choice for pediatric brain tumors.

Increased awareness of the pediatric brain tumors symptoms, multidisciplinary team, a well-equipped specialized center and proper presurgical planning allow a better chance for fruitful outcomes. Still, early diagnosis will allow early detection and better outcome before reaching a huge size and difficulty of gross total resection.

Bearing in mind that for many countries, brain tumors now represent the greatest challenge in pediatric oncology, it is recommended that more resources and effort should be devoted to obtaining fundamental epidemiological data, either through a cooperative multicenter study or the establishment of a pediatric brain tumor registry, in order to improve the treatment outcomes and the survival of children suffering from brain tumors.

### List of abbreviations

ATRT: Atypical teratoid/rhabdoid tumors.  
 CSF: Cerebrospinal fluid.  
 CT: Computed tomography.  
 DLC: Deteriorated level of consciousness.  
 ETMR: Embryonal tumors with multilayered rosettes.  
 GAD: Gadolinium.  
 GTR: Gross total resection.  
 HC: Hydrocephalus.  
 IRB: Institutional review board.  
 MRI: Magnetic resonance imaging.  
 MRS: Magnetic resonance spectroscopy.  
 PNET: Primitive neuroectodermal tumors.  
 SPSS: Statistical packages for the social sciences.  
 STR: Subtotal resection.  
 STROBE: Strengthening the reporting of observational studies in epidemiology.

VP: Ventriculo-peritoneal shunt.

### Disclosure

The authors report no conflict of interest in the materials or methods used in this study or the findings specified in this paper.

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