Prevalence and risk factors for permanent cerebrospinal fluid diversion in children after posterior fossa tumor surgery

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Abstract

Objectives: Posterior fossa tumors are common in children, which are prone to cause disturbances of cerebrospinal fluid (CSF) dynamics. Approximately 15.5–40% of patients require CSF diversion procedure after tumor resection. The incidence of postoperative ventriculoperitoneal (VP) shunt in children after posterior fossa tumor surgery in Thailand has not been described and the risk factors are poorly understood. The authors, therefore, conducted a study to identify the risk factors for postoperative VP shunt

Material and methods: The authors retrospectively reviewed data of the patients who underwent surgery for posterior fossa tumor between January 2002 and August 2019. The potential factors for postoperative VP shunt were collected included age at time of surgery, sex, the use of pre- and post-operative external ventricular drainage, degree of hydrocephalus, extent of resection, perioperative complications, and pathological diagnosis. The potential risk factors were analyzed by regression models.

Results There were 100 patients (41 females and 59 males) with mean age at time of surgery of 8 years. Ventriculoperitoneal shunt was required in 23 (23%) patients. Univariate logistic regression models revealed a below-near-total resection as the only risk factor. (RR 3.65, 95% CI 1.17–11.37; P= 0.03).

Conclusions Prevalence of ventriculoperitoneal shunt after surgery is 23%. Below near-total tumor resection is significant risk factor for postoperative ventriculoperitoneal shunt.

บทคัดย่อ

วัตถุประสงค์: เนื้องอกในสมองส่วนหลังเป็นโรคที่พบบ่อยในเด็ก ซึ่งอาจทำให้การไหลเวียนของน้ำโพรงสมอง-ไขสันผิดปกติได้ ผู้ป่วยเด็กที่ได้รับการผ่าตัดเนื้องอกในสมองส่วนหลังประมาณ15.5-40% ต้องได้รับการผ่าตัดเพื่อระบายโพรงน้ำในสมอง อุบัติการณ์ของการใส่สายระบายโพรงน้ำในสมองภายหลังได้รับการผ่าตัดเนื้องอกในสมองส่วนหลังในเด็กไทยยังไม่เคยได้รับการศึกษามาก่อน และปัจจัยเสี่ยงของการใส่สายระบายน้ำในโพรงสมองยังไม่ชัดเจน ดังนั้นคณะผู้วิจัยจึงทำการศึกษาเพื่อหาอุบัติการณ์และปัจจัยเสี่ยงของการใส่สายระบายโพรงน้ำในสมอง

วิธีดำเนินการวิจัย: คณะผู้วิจัยได้รวบรวมข้อมูลผู้ป่วยเด็กที่ได้รับการผ่าตัดเนื้องอกในสมองส่วนหลังใน รพ.จุฬาลงกรณ์ย้อนหลังตั้งแต่ มกราคม 2545 ถึง สิงหาคม 2562 โดยเก็บรวบรวมตัวแปรต่างๆที่มีผลต่อการใส่สายระบายโพรงน้ำในสมอง เช่น อายุ เพศ การใส่สายระบายโพรงน้ำในสมองชั่วคราวก่อนหรือหลังการผ่าตัด การรุนแรงของภาวะน้ำคั่งในโพรงสมอง ขอบเขตของการผ่าตัด ภาวะแทรกซ้อนหลังการผ่าตัด และผลพยาธิวิทยาของเนื้องอก โดยวิเคราะห์ตัวแปรต่างๆด้วยการวิเคราะห์การถดถอย

ผลลัพธ์: ผู้ป่วยจำนวน 100 คน (หญิง 41, ชาย 59) อายุเฉลี่ย 8 ปี ผู้ป่วยที่ได้รับการผ่าตัวเนื้องอกในสมองส่วนหลัง 23% ได้รับการใส่สายระบายโพรงน้ำในสมองภายหลัง โดยพบว่ามีปัจจัยเสี่ยงคือ การผ่าตัดที่สามารถเอาเนื้องอกออกได้น้อยกว่า 90%

สรุป: อุบัติการณ์ของการใส่สายระบายโพรงน้ำในสมองอยู่ที่ 23% ภายหลังได้รับการผ่าตัดเนื้องอกในสมองส่วนหลัง โดยมีปัจจัยเสี่ยงคือ การผ่าตัดที่สามารถเอาเนื้องอกออกได้น้อยกว่า 90%

Introduction

Tumors in central nervous system are the second most common childhood tumors following leukemia and are the most common solid tumors in children with estimated incidence of 2–3.5 per 100,000[1] Approximately 54–70% of these tumors locate in the posterior fossa.[2,3] The tumor in this location tends to disturb the cerebrospinal fluid (CSF) flow resulting in obstructive hydrocephalus in 70–90% of patients.[4,5] Although modern microsurgical techniques and treatment protocol reduces morbidity and mortality rate, hydrocephalus is still one of the most important morbidity in patients with a posterior fossa tumor. Previous studies have shown that between 15.5–40% of children who have hydrocephalus subsequently require a CSF diversion procedure. [6-8] The predictors for post-resection hydrocephalus would be beneficial to optimize the care for these children. Therefore, the aim of our study is to find prevalence and risk factors for post-operative ventriculoperitoneal (VP) shunt in children after posterior fossa tumor surgery.

Method

Study design and patient selection

This retrospective study includes the patients under 18 years old with a posterior fossa tumor who underwent surgical resection or biopsy in King Chulalongkorn memorial hospital between January 2002 and August 2019. Exclusion criteria were previous tumor resection/biopsy and previous ventriculoperitoneal (VP) shunt. Initially, there were 184 patients, however, 84 patients were excluded by various reasons, and the remaining 100 patients were included in the analysis.

Patient data were retrospectively reviewed to evaluate prevalence of postoperative CSF diversion and the associated risk factors. The protocol for this study was approved by the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University.

Clinical data and postoperative CSF diversion

The following parameters were collected for the analysis: *General data* including demographic data, clinical features, postoperative VP shunt; *Tumor characteristics* including localization (midline, hemispheric),

metastasis, and pathological diagnosis; *Ventricular characteristics* including presence/absent of hydrocephalus, degree of hydrocephalus (mild, moderate and marked ventriculomegaly was defined by the Evan's ratios of 0.27–0.34, 0.35–0.40, and >0.40, respectively. A ratio of less than 0.27 was considered to be normal), and presence of transependymal edema; *Surgery characteristics* including surgical approach, extent of resection status as described in the operative report (Total resection– no visible tumor; Near total resection– less than 10% residual tumor; Subtotal resection – more than 10% residual tumor), preoperative and postoperative external ventricular drainage (EVD), and postoperative complications; *Canadian Preoperative Prediction Rule for Hydrocephalus* (CPPRH) score and modified CPPRH score.[9] A patient with CPPRH score greater than5 was considered as high risk.

Statistical Analysis

Descriptive statistics were used to describe demographic data. A t-test was used to compare the difference between continuous variables. Chi-square was used to compare the difference between categorical variables. Binary logistic regression was used to calculate relative risk. Statistical analysis was performed by using a standard software package (SPSS). A p-value < 0.05 was considered statistically significant.

Result

There were 100 patients (41 females and 59 males) with the diagnosis of posterior fossa tumor undergoing tumor resection or biopsy for the first time. The mean age at the time of operation was 8.02 ± 4.77 years (range, 0.05–18 years). On admission, the common symptoms were headache (42%), ataxia

Table 1 Patient characteristics

	Total
Ventricular characteristics	
Transependymal edema	59/76 (77.6%)
Hydrocephalus	65/76 (85.5%)
Degree of hydrocephalus	
– None	11/76 (14.5%)
– Mild	24/76 (31.6%)
– Moderate	23/76 (30.3%)
– Marked	18/76 (23.7%)
Surgery characteristics	
Pre-operative EVD	14/96 (14.6%)
Pre-operative EVD duration (days)	2.76
Extent of resection	
– Total	43/100 (43%)
– Near-total	31/100 (31%)
– Below-near total (subtotal)	22/100 (22%)
– Biopsy	4/100 (4%)
Post-op EVD	40/94 (42.6%)
Post-op EVD duration (days)	6.53
Complication	34/100 (34%)
– Dead	1/100 (1%)
– Pseudomeningocele	9/100 (9%)
– Meningitis	8/100 (8%)
– CSF leakage	1/100 (1%)
– Cranial nerve injury	6/100 (6%)
– Hematoma	7/100 (7%)
Tumor characteristics	
Midline location	77/100 (77%)
Metastasis (total)	21/100 (21%)
–Supratentorial metastasis	3/100 (3%)
Pathology	
– Ependymoma	11/100 (11%)
– Medulloblastoma	50/100 (50%)
– Pilocytic astrocytoma	18/100 (18%)
– Dorsally exophytic brainstem glioma	2/100 (2%)
– Glioblastoma multiforme	8/100 (8%)
– Diffuse intrinsic pontine glioma	4/100 (4%)
– Other neoplasms	7/100 (7%)
CPPRH score	2.68 ±1.46
High risk CPPRH	3/44
Modified CPPRH score	2.99 ± 2.05
High risk mCPPRH	13/76

Table 2 Patient characteristics by cohort

	Non-VP shunt (n=77)	VP shunt (n=23)	p-valve
Male (%)	47/77 (61)	12/23 (52.2)	0.45
Age (yr)	8.02 ± 4.77	7.99 ± 5.66	0.976
Papilledema (%)	32/44 (72.7)	6/9 (66.7)	0.701
Ventricular characteristics			
Transependymal edema (%)	46/61 (75.4)	13/15 (86.7)	0.498
Hydrocephalus (%)	52/61 (85.2)	13/15 (86.7)	1
Degree of hydrocephalus			
- None (%)	9/61 (14.8)	2/15 (13.3)	1
- Mild (%)	19/61 (31.1)	5/15(33.3)	
- Moderate (%)	18/61 (29.5)	5/15(33.3)	
- Marked (%)	15/61 (24.6)	3/15(20)	
Tumor characteristics			
Midline tumor (%)	59/77 (76.6)	18/23 (78.3)	0.87
Metastasis (total) (%)	14/77 (18.2)	7/23 (30.4)	0.206
-Cerebral metastasis (%)	1/77 (1.3)	2/23 (8.7)	0.131
Pathological diagnosis			
- Ependymoma (%)	6/77 (7.8)	5/23 (21.7)	0.384
- Medulloblastoma (%)	40/77 (51.9)	10/23 (43.5)	
- Pilocytic astrocytoma (%)	15/77 (19.5)	3/23 (13)	
- Dorsally exophytic brainstem glioma (%)	2/77 (2.6)	0/23 (0)	
- Glioblastoma multiforme (%)	6/77 (7.8)	2/23 (8.7)	
- Diffuse intrinsic pontine glioma (%)	3/77 (3.9)	1/23 (4.4)	
- Other neoplasm (%)	5/77 (6.5)	2/23 (8.7)	
Surgery characteristics			
Pre-operative EVD (%)	10/73 (13.7)	4/23 (17.4)	0.737
Pre-operative EVD duration (days)	0.34 ± 1.07	0.61 ±1.62	0.364
Degree of resection			
- Total (%)	35/77 (45.5)	8/23 (34.8)	0.065
- Near-total (%)	26/77 (33.8)	5/23 (21.7)	
- Subtotal (%)	12/77 (15.6)	10/23 (43.5)	
- Biopsy (%)	4/77 (5.2)	0/23 (0)	
Post-op EVD	40/72 (55.6)	14/22(63.6)	0.502
Post-op EVD duration (days)	1.91± 3.63	3.95 ± 6.17	0.063
Major complication (%)	25/77 (32.5)	9/23 (39.1)	0.554
- Pseudomeningocele (%)	8/77 (10.4)	1/23 (4.3)	0.68
- Meningitis (%)	6/77 (7.8)	2/23 (8.7)	1
- CSF leakage from wound (%)	0/77 (0)	1/23 (4.3)	0.23
CPPRH score	2.56 ± 1.4)	3.25 ± 1.67	0.228
-High risk CPPRH (%)	2/36 (5.6%)	1/8 (12.5)	0.461
Modified CPPRH score	3 ± 2.04	2.93 ± 2.15	0.911
-High risk mCPPRH (%)	11/61 (18)	2/15 (13.3)	1

Table 3 Provide a result of the variables analyzed and their associated significance values.

	Relative risk for VP shunt	95% CI	P–valve
Male	0.69	0.27–1.78	0.45
Age (yr)	0.99	0.9–1.1	0.98
Papilledema	0.75	0.16–3.49	0.71
Ventricular characteristics			
Transependymal edema	2.12	0.43–10.48	0.36
Hydrocephalus	1.13	0.22–5.85	0.89
Degree of hydrocephalus (none)			
– Mild	1.18	0.19–7.32	0.86
– Moderate	1.25	0.2–7.75	0.81
– Marked	0.9	0.13–6.46	0.92
Tumor characteristics			
Tumor location			
– Midline	1.1	0.36–3.38	0.87
Metastasis (total)	1.97	0.68–5.68	0.21
–Cerebral metastasis	7.24	0.63–83.76	0.11
Pathological diagnosis (other)			
– Ependymoma	2.08	0.28–15.77	0.48
– Medulloblastoma	0.63	0.11–3.7	0.61
– Pilocytic astrocytoma	0.5	0.06–3.9	0.51
– Dorsally exophytic brainstem glioma	0	0	0.99
– Glioblastoma multiforme	0.83	0.08–8.24	0.88
– Diffuse intrinsic pontine glioma	0.83	0.05–13.63	0.89
Surgery characteristics			
Preoperative EVD	1.33	0.37–4.71	0.66
Degree of resection (as compared to gross total resection)			
– Near–total	0.84	0.25–2.87	0.78
– Subtotal	**3.65**	**1.17–11.37**	**0.03***
– Biopsy	0	0	0.99
Postoperative EVD	0.71	0.27–1.91	0.5
Complication	1.33	0.51–3.5	0.55
– Meningitis	1.13	0.21–6.0	0.89
– Pseudomeningocele	0.39	0.05–3.31	0.39
CPPRH score	1.42	0.8–2.51	0.23
– High–risk CPPRH	2.43	0.19–30.63	0.49
mCPPRH score	0.98	0.75–1.3	0.91
– High–risk mCPPRH	0.7	0.14–3.55	0.67

(24%), and nausea/vomiting (18%). An average duration of symptom was 2.6 months. There were 76 patients with the data of preoperative ventricular size and preoperative hydrocephalus was present in 65 (85.5%) patients. Preoperative papilledema was present in 38 of 53 (71.7%) patients whose data was available. Postoperative VP shunt was required in 23 (23%) patients. Details of overall patient data are shown in Table 1. There *is* no *difference* of patient characteristics between the non-VP shunt group and the VP shunt group as shown in Table 2. Among various risk factors, only below near-total tumor removal was significant risk for postoperative VP shunt (RR 3.65, 95% CI 1.17-11.37; P= 0.03). Predicting models (CPPRH & mCPPRH) were not correlated with the need for postoperative VP shunt (Table 3).

Degree of resection had a trend to be statistically significant (P = 0.065). and for each cohort are shown in Table 2.

Discussion

Postoperative shunt procedure is not uncommon following posterior fossa tumor surgery in children. Bognar et al. reported postoperative shunt and third ventriculostomy in 15.5% of children with posterior fossa tumors resection.[6] Lee et al. found 40% of children with medulloblastoma required permanent shunts after tumor resection.[8] Postoperative VP shunt was required in 23% of children in our study keeping with previous reports. To the best of our knowledge, this is the first study of prevalence of postoperative shunt after posterior fossa tumor resection in children in Thailand.

Among various parameters analyzed in our study, only the subtotal resection was found to correlate with the need for postoperative VP shunt (Table 3). This suggest that greater than 10% residual tumor is more likely to obstruct normal CSF pathway than the more aggressive tumor removal. Kumar et al demonstrated that gross total resection was correlated with lower rate of shunt placement.[10] Bognar et al. also found a trend toward fewer shunt placements in complete resection as compared to partial resection although the result did not reach statistical significance.[6] Higher CPPRH or mCPPRH score is not a significant risk of postoperative VP shunt. Previous publications regarding risk factors for postoperative shunting procedures in pediatric posterior fossa tumor show discordant results (Table 4).

Table 4 Previous publications on risk factors for postoperative CSF diversion procedure

	Age	Preoperative Hydrocephalus	Tumor location	Extent of resection	EVD†	Complication	Pathological diagnosis
Culley et al.[7]	Yes	No	Yes	No	No	Yes	No
Bognar et al.[6]	Yes	No	No	No*	Yes	No	Yes
Dias et al.[11]	No	No	No	Yes	N/A	N/A	No
Gnanalingham et al.[12]	No	No	No	Yes	Yes	No	No
Lee et al.[8]	Yes	Yes	No	Yes	No	No	N/A
Kumar et al.[10]	Yes	N/A	N/A	Yes	No	No	Yes
Present study	No	No	No	Yes	No	No	No

†EVD=External ventricular drainage, * Trending without statistical significance, N/A = data not available

To the best of authors' knowledge, this is the first study of risk factor for the need of postoperative VP shunt after posterior fossa tumor resection in children in Thailand.

Study limitation

There are several limitations related to our results. First, this is a retrospective study with heterogenous characteristics of the patients. Second, assessment of surgical resection was based on surgeons' impression in operative note. Third, there were significant number of incomplete data on some parameter particularly papilledema and preoperative hydrocephalus.

Conclusion

Prevalence of postoperative shunt was 23%. Below near-total tumor resection was significant risk factor for postoperative CSF diversion.

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