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Original Article

The Development of Postoperative Hydrocephalus following Midline Posterior Cranial Fossa Tumors with Hydrocephalus Surgery with Preoperative Ventriculoperitoneal (V-P) shunt in Pediatric Patients

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Abstract

Background: *Posterior cranial fossa tumors are the most common tumors in children and constitute about two-thirds of pediatric brain tumors. Such pediatric patient presents with symptoms and signs of raised intracranial pressure. All pediatric patients were diagnosed with midline posterior cranial fossa tumors with hydrocephalus. The ventriculoperitoneal shunt was done before definitive surgery for all patients. Definitive surgery was done later on. These patients were followed up to the 7th postoperative day following definitive surgery. We assessed the development of postoperative hydrocephalus.*

Objectives: *The objective of the study was to assess the development of postoperative hydrocephalus of midline posterior cranial fossa tumors with hydrocephalus after definitive surgery following ventriculoperitoneal (V-P) shunt in pediatric patients.*

Methods: *This cross-sectional experimental study was conducted in the Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University, and the Department of Pediatrics Neurosurgery, National Institute of Neurosciences & Hospital, Dhaka from March 2018 to September 2019. A total of 43 pediatric patients were included in this study. All pediatric patients were diagnosed with midline posterior cranial fossa tumors with hydrocephalus. The ventriculoperitoneal shunt was done before definitive surgery. Later on, definitive surgery was performed. Follow-up of these patients was done up to the 7th postoperative day. The development of postoperative hydrocephalus was observed. Data were processed and then analyzed. Demographic data were expressed in numbers and percentages. The development of postoperative hydrocephalus was expressed in number and percentage. Logistic regression was done to predict the relationship between the dependent variable (development of hydrocephalus) and independent variables (age, sex, and the extent of tumor removal). The odds ratio (OR) was calculated by using the Chi-square test. The chi-square test gave a Wald statistic by observing at the 95% CI of the odds ratio. Statistical significance was set to p-value <0.05.*

Results: *A total of 43 pediatric patients were included in the study from March 2018 to September 2019. In the study, the maximum patients were in the age group 11-15 years. The mean age of the patients was 8.25 years ± 4.14. The male-to-female ratio was 1.26:1. The study showed preoperative clinical features which includes headache 40 (93%), vomiting 37 (86%), visual disturbance 24 (55.8%), altered level of consciousness 3 (7.0%), gait disturbance 30 (69.8%), swallowing disturbance 9 (20.9%), papilledema 38 (88.4%), lower cranial nerves palsy 8 (18.6%). Among them, 25 patients developed postoperative complications after definitive surgery.*

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Development of postoperative hydrocephalus was found in 2 (4.65%) patients. Logistic regression was found to be statistically non-significant in this study.

Conclusion: *The development of postoperative hydrocephalus of midline posterior cranial fossa tumors with hydrocephalus after definitive surgery following ventriculoperitoneal (V-P) shunt in pediatric patients was not the major complication among others.*

Key Words: *Midline posterior cranial fossa tumor, Hydrocephalus, Ventriculoperitoneal shunt (V-P shunt).*

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Introduction:

Posterior cranial fossa tumors are the most common tumors in children (Johnson et al. 2014). Posterior cranial fossa tumors constitute about two-thirds of pediatric brain tumors. Due to the anatomic relationships of these tumors to cerebrospinal fluid (CSF) drainage pathways, hydrocephalus is common, occurring in 71–90% of children with posterior cranial fossa tumors (Sainte-Rose et al. 2001). Hydrocephalus after tumor resection occurs in 10–36% of cases. (Lam et al. 2015).

There are many studies on the management of hydrocephalus in children with posterior cranial fossa tumors but no consensus regarding optimal hydrocephalus management is present (Due-Tonnessen and Helseth 2007). There are two opposing strategies for addressing preoperative hydrocephalus in children with posterior cranial fossa tumors. Traditionally, routine preoperative CSF diversion has been advocated followed by tumor resection (El-Gaidi, El-Nasr, and Eissa 2015). On the other hand, recent recommendations support directly addressing the obstructing posterior cranial fossa tumors with primary resection at the earliest opportunity (Matsumoto et al. 2006). Pre-resection ventriculoperitoneal (VP) shunt placement, or less often ETV, followed by tumor excision after 1 or 2 weeks is the most common approach (El-Gaidi, El-Nasr, and Eissa 2015). The potential advantages of this strategy include the following: Preoperatively, after relieving the manifestations of acute hydrocephalus, there is a remarkable improvement in the general condition of the child, which allows definitive tumor resection to be performed in a planned, elective manner that is more convenient for an overburdened hospital with a long operative waiting list due to limited resources (El-Gaidi, El-Nasr, and Eissa 2015).

Moreover, postoperative elevations of intracranial pressure (ICP) are reduced with a lower incidence of pseudo meningocele formation and CSF leakage and hence shortened hospital stay (Bhatia, Tahir, and Chandler 2009).

Ventriculoperitoneal shunting may decrease operative mortality by affording time to perform diagnostic tests, prepare the patient, and schedule a major neurosurgical procedure electively. Reduction in intracranial pressure also permits safer resection (Bhawani 2012).

Several complications have been associated with CSF diversion including supratentorial intracranial hematomas (e.g. extradural, subdural, intracerebral, and intraventricular hemorrhage). Many shunt-associated complications such as malfunction, infection, multiple abdominal complications, long-term shunt dependence, and infratentorial complications e.g. intertumoral hemorrhage and upward trans-tentorial herniation (El-Gaidi, El-Nasr, and Eissa 2015).

Several case reports have been published describing the serious infratentorial complications that may occur as a result of pre-resection CSF diversion, either by ventricular shunting or ETV in patients with posterior cranial fossa tumors. Therefore, the actual incidence of such complications is unknown (Elgamal, Richards, and Patel 2006).

The rationale of the study:

Patients with posterior cranial fossa tumors usually present with features of raised intracranial pressure (ICP). Usually, imaging shows obstructive hydrocephalus in most cases. Posterior cranial fossa tumors with hydrocephalus are treated in two ways either by doing preoperative CSF diversion and then definitive surgery for tumor removal or tumor removal without doing CSF diversion. The advantages and disadvantages regarding preoperative CSF diversion or without CSF diversion have been reported in the literature. So, we had planned to conduct a study to determine the outcome of midline posterior cranial fossa tumor surgery with preoperative ventriculo-peritoneal (V-P) shunt.

The objective:

The objectives of the study were to assess the development of postoperative hydrocephalus of midline posterior cranial fossa tumors with hydrocephalus after definitive surgery following ventriculoperitoneal (V-P) shunt in pediatric patients.

Materials and methods:

Study design: A cross-sectional experimental study.

Study place: Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University, Shahbag, Dhaka and Department of Pediatric Neurosurgery, National Institute of Neurosciences and Hospital, Sher-E-Bangla Nagar, Dhaka

Study duration: March 2018 to August 2019 (18 months).

Study population: The patients with posterior fossa tumors with obstructive hydrocephalus who were admitted to hospitals and underwent surgery. Total number of patients were 43.

Selection Criteria:

Inclusion criteria:

All the patients within 18 years and both sexes with the diagnosis of posterior cranial fossa tumors causing hydrocephalus.

Exclusion Criteria:

1. Patient with previous surgery for posterior fossa tumors.
2. Patient with a previous history of irradiation for posterior fossa tumors.
3. Patient with posterior fossa tumors without hydrocephalus.
4. Patients who were not interested to be included in this study.

Study procedure:

1. A detailed history of the patient was taken in the data collection sheet.
2. From the immediate postoperative period up to the 7th postoperative day follow-up was continued.
3. In the postoperative period all the patients were evaluated clinically for evaluation of features of raised ICP.
4. For radiological evaluation
   I. Preoperative CT scan of brain
   II. CT scan after V-P shunt and definitive surgery
5. All data was recorded in a data collection sheet

Clinical procedure:

The patient with posterior cranial fossa tumors causing hydrocephalus admitted under the Neurosurgery ward at BSMMU and NINS&H was included after primary screening with inclusion and exclusion criteria from the period of March 2018 to August 2019. This study was a cross-sectional experimental study. Data collection sheets were used to collect the necessary information. The patient was selected from those patients who underwent preoperative CSF diversion before definitive surgery. Here we used medium pressure Chhabra V-P shunt. The surgeon decided on which patient V-P shunt was done. The history of the patient along with demographic data was recorded. A preoperatively thorough neurological examination was done and findings of preoperative and postoperative clinical features for raised ICP, CT scan, and MRI of the brain were recorded. Informed written consent was taken from each participant and guardian before data collection. We assessed the patient concerning the development of postoperative hydrocephalus within the 7th postoperative day after definitive surgery.

Follow up:

All pediatric patients were diagnosed with midline posterior cranial fossa tumors with hydrocephalus. The ventriculoperitoneal shunt was done before definitive surgery. Later on, definitive surgery was performed. Follow-up of these patients was done up to the 7th postoperative day.

Results:

Table-I

Distribution of age of the study subjects (n=43)

Age (years)	Frequency (n)	Percentage (%)
≤5	14	32.6
6 – 10	12	27.9
11 – 15	17	39.5
Total	43	100
Mean ± SD	8.25±4.14 (1.6-15)	

The distribution of age of the study subjects is shown in Table I. The age of the patients was 1.6 years to 15 years. The mean age was found to be 8.25 years ± 4.14 SD. The peak age incidence was in the 11 to 15 years age group.

Table-II

Distribution of gender of the study subjects (n=43)

Gender	Frequency (n)	Percentage (%)
Male	24	55.8
Female	19	44.2
Total	43	100

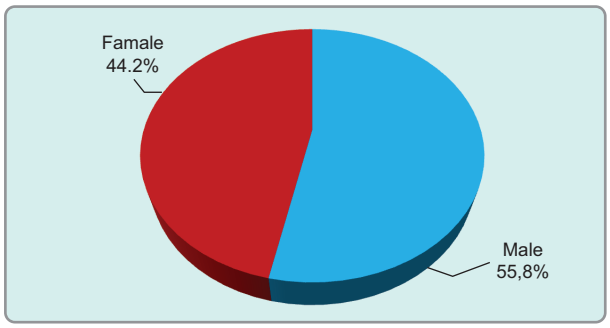

Figure 1:

A total of 43 patients were included with 24 (55.8%) males and 21 (44.2%) females. The male-to-female ratio was 1.26:1

Table-III

Distribution of the study subjects according to clinical features (n=43)

Clinical features	Frequency (n)	Percentage (%)
Headache	40	93.0
Vomiting	37	86.0
Visual dysfunction	24	55.8
Gait disturbance	30	69.8
Swallowing difficulties	9	20.9
Altered level of consciousness	3	7.0
Cranial nerve palsy	8	18.6
Papilloedema	38	88.4

Table III shows the preoperative clinical features of the study subjects. Headache 40 (93.0%), vomiting 37 (86%), visual disturbance 24 (55.8%), gait disturbance 30 (69.8%), swallowing disturbance 9 (20.9%), altered level of consciousness 3 (7.0%), cranial nerve palsy 8 (18.6%) and papilloedema 38 (88.4%).

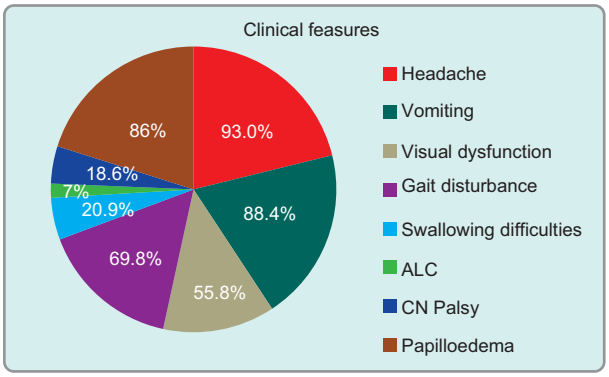

Figure 2:

Table-IV

Distribution of the study subjects according to CT scan of brain after definitive surgery (n=43)

	Frequency (n)	Percentage (%)
Gross total removal	37	86.0
Near total removal	2	4.7
Subtotal removal	4	9.3
Total	43	100

Table IV shows the distribution of the study subjects according to a CT scan of the brain after definitive

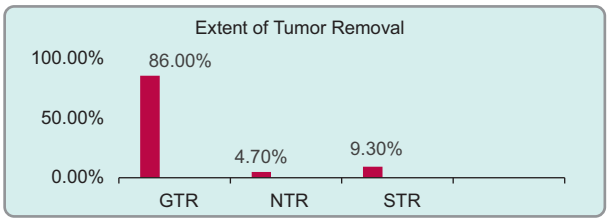

Figure 3:

Table-V

Outcome of the study subjects according to postoperative follow-up (n=43)

Postoperative Outcome	Complication		No Complication	
	Frequency (n= 25)	Percentage (58.14%)	Frequency (n= 18)	Percentage (41.86%)
Development of hydrocephalus	2	4.65	41	95.35
CSF leakage	3	7.0	40	93.0
Pseudo meningocele	9	20.9	34	79.1
Wound infection	9	20.9	34	79.1
Meningitis	17	39.5	26	60.5

surgery. Total number of study subjects was 43. Gross total removal of the tumor was done 37 (86%), near total removal 2 (4.7%), and Subtotal removal 4 (9.3%).

Note: The patient may have multiple complications.

Table V shows the outcome of the study subjects according to postoperative complications. Total number of patients was 43. Among them, 25 patients developed postoperative complications and 18 patients did not develop any complications. Development of postoperative hydrocephalus was 2 (4.65%), CSF leak was found in 3 (7.0%) patients, pseudo meningocele was found in 9 (20.9%) patients, wound infection was found in 9 (20.9%) patients and meningitis was found in 17 (39.5%) patients with preoperative shunt.

Note: The patient may have multiple complications.

Table VI shows the outcome of the study subjects according to the extent of tumor removal during postoperative follow-up. Total number of patients was 43. Among them, 25 patients developed postoperative complications. Development of postoperative hydrocephalus was 2 (4.65%), CSF leak was found in 3 (6.98%) in gross total removal of the tumor and others were nil. Pseudo meningocele was found in 7 (16.28%) and 2 (4.65%) patients in gross total and near total removal of tumor respectively. Wound infection was found in 6 (13.95%), 2 (4,65%), and 1 (2.33%) patients in gross total, near total, and subtotal removal of tumor respectively. and meningitis was found in 14 (32.56%), 2 (4.65%), and 1 (2.33%) patients in gross total, near total, and subtotal removal of tumor respectively with the preoperative shunt.

Table VI shows a Logistic regression of development of hydrocephalus with age, gender (male), near total and subtotal removal of tumor.

The odds of developing hydrocephalus following midline posterior fossa tumor surgery with preoperative V-P shunt for males is 6.225 more than that of females. Age (6-10) with a p-value of 0.514 and age (11-15) with a p-value of 0.929 have odds value of 0.448 and 0.885 respectively which signify that ages (11-15) are more likely to develop hydrocephalus considering any surgery. Thus male patients aged (11-15) have 5.509 times of developing hydrocephalus than in patients aged (6-10) with odds of 2.778. A patient who underwent near total removal has no odds than with subtotal removal where the odds is 0.285 indicating the development of hydrocephalus in the latter group. None of the variables has a significant relationship

Table VI

Outcome of the study subjects according to the extent of tumor removal during postoperative follow-up (n=43)

Outcome	Gross total removal		Near total removal		Subtotal removal	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%
Development of hydrocephalus	2	4.65	0	00	0	00
CSF leakage	3	6.98	0	00	0	00
Pseudo meningocele	7	16.28	2	4.65	0	00
Wound infection	6	13.95	2	4.65	1	2.33
Meningitis	14	32.56	2	4.65	1	2.33

Table-VII

Logistic regression of development of hydrocephalus

	Parameter Estimate	p-value	OR	95% CI for OR	
				Lower	Upper
Age (6 – 10)	-0.803	0.514	0.448	0.040	4.989
Age (11 – 15)	-0.122	0.929	0.885	0.061	12.929
Gender (Male)	1.829	0.157	6.225	0.493	78.555
Near total removal	-19.084	0.999	0.000	0.000	.
Subtotal removal	-1.255	1.000	0.285	0.000	.

OR=Odds ratio, CI=Confidence interval, p= Probability
A chi-square test was done to measure the level of significance.

with the development of hydrocephalus in patients with posterior fossa tumors and the model assumes that age, sex, and removal of posterior fossa tumors act independently on the development of hydrocephalus.

Discussion:

Hydrocephalus is most commonly seen in children with posterior cranial fossa tumors, occurring in 71-90% of pediatric patients; approximately 10-40% demonstrate persistent hydrocephalus after posterior fossa tumor resection (Meenakshisundaram and Dhandapani 2018). Hydrocephalus is often the cause of the presenting signs and symptoms in patients with posterior cranial fossa tumors. The perioperative management of hydrocephalus associated with posterior cranial fossa tumors in children continues to be problematic. Pre-resection hydrocephalus can be managed either with an initial CSF diversion procedure such as ETV, VP shunting, or EVD followed by resection or by directly addressing the obstructing posterior fossa tumor with primary resection at the earliest opportunity (El-Gaidi, El-Nasr, and Eissa 2015).

Intracranial hypertension occurs markedly in most of the posterior fossa tumors. Volume parameters and the cerebrospinal fluid distribution can change after the removal of the tumor. The management of the tumor is the most important with the aim to normalize intracranial pressure (ICP). After tumor surgery, intracranial pressure can further rise as a result of cerebellar swelling, occlusion of cerebrospinal fluid flow, or bleeding in the tumor bed. The indications for ventricular drainage and shunting as preliminary treatment are still a matter of discussion (Islam et. al 2011).

This study was conducted in the Department of Neurosurgery, BSMMU, Dhaka from March 2018 to August 2019 to find out the outcome of midline posterior fossa tumor surgery with preoperative ventriculoperitoneal (V-P) shunt.

The purpose of this study was to determine the outcome of midline posterior fossa tumor surgery with a preoperative ventriculoperitoneal (V-P) shunt. For this, 43 patients were included in this study.

Due-Tonnessen et al. (2007) found that a significant number of patients were aged between 0.2 and 19.7 years and the mean age at presentation was 7.3 years. Riva-Cambrinet et al. (2008) described a significant correlation between age under 2 years at surgery and postoperative shunting.

According to de Oliveira et al. (2008), the patient's ages ranged from 3 months to 18 years and patients requiring shunts were younger (mean age, 7.4 years) than those who did not require shunt placement (mean age of 10 years).

Gopalakrishnan et al. (2012) found the ages ranged from 1.5 to 18 years and the mean age was 8 years at the time of diagnosis.

Helmbold et al. (2019) found that a significant number of patients were between ages 0.4–20.8 years (mean, 8.5; median, 8.2). 15 of the 70 patients (21.4%) required shunt placement over the post-operative course. Patients in the shunt group (n = 15; mean, 5.4; median, 3.0) were younger than those in the non-shunt group (n = 55; mean, 9.3; median, 9.0). An age < 3 years at surgery was significantly associated with postoperative shunt placement.

We have found that (Table I) maximum patients were in the age group 1 to 5 years and 11 to 15 years. The mean age of the patients was 8.25 years ± 4.14 SD.

Wanyoike (2004) found that 19 patients were female and 13 were male in all age groups. The sex distribution of patients matched with other studies conducted at the neurosurgical unit of Kenyatta National Hospital and found that 24 were females and 13 were males even though most of the literature pointed toward male predominance (de Oliveira et al. 2008). Habib (2014) found in his study that 29 (69%) were males and 13 (31%) were females, with a male-to-female ratio of 2.2:1.

Our study (Table II) shows that a total of 43 patients were included with 24 (55.8%) Males and 19 (44.2%) females. The male-to-female ratio was 1.26:1.

Goel (1993) in his study showed that the total number of patients was 62, among them headaches were present in 59 patients, vomiting in 55, and ataxia (truncal and limb) in 51 patients. Patients with severe hydrocephalus caused by posterior fossa lesions were characterized by headache, nausea, vomiting, diplopia, ventricular collapse, intracranial hypertension, papilledema, and somnolence which was also mentioned by Arriada et al. (2004). According to de Oliveira et al. (2008), preoperative clinical features were headaches 89%, cerebellar ataxia 61%, papilledema 41%, vomiting 77% and also found some typical signs and symptoms in patients namely headaches (89%), ataxia (61%), papilledema (41%), vomiting (77%), cranial nerve palsy (28%), motor deficits (11%), full

anterior fontanelle in infants, and torticollis (27%). Bhatia and his colleagues in 2009 mentioned that headache, vomiting, lethargy, papilledema, and upward gaze paresis were the most common preoperative hydrocephalic symptoms and signs. Habib (2014) found in the pediatric group, headache was the most common presentation in 75.7% of patients, followed by vomiting 51.5% and 45.5% with papilledema, diminution of vision and diplopia was noted in 15.1% and 12.1%, respectively. One patient was blind upon presentation.

Most of the patients presented with cerebellar signs (89.2%), headaches with vomiting were the most common symptoms (70.3%), and multiple cranial nerve palsies were seen in 56.8% of patients (Kalyani et al. 2014). Cranial nerve morbidity was also commonly encountered with posterior cranial fossa surgery. Deficit usually occurs as a result of nerve retraction, direct injury during operation, or compromise of the blood supply. It was occurred in 3 (10%) patients in the form of bulbar palsy. Depending on the location of the lesions and the surgical approaches, the post-operative cranial nerve dysfunction may involve CN III to XII. Injuries to lower CNs IX, X, XI, and XII occur infrequently after posterior fossa surgery on large tumors that distort the nerves and displace them inferiorly against the occipital bone (Hamadan et al. 2018).

This study (Table III) shows the preoperative clinical features of the patients. Headache 40 (93%), vomiting 37 (86%), visual disturbance 24 (55.8%), altered level of consciousness 3 (7.0%), gait disturbance 30 (69.8%), swallowing disturbance 9 (20.9%). Headache was present in all patients. Maximum patients had vomiting. Clinical examination of the patients revealed the following: according to fundoscopy findings, 38 patients (88.4%) had papilledema at the time of presentation, and 8 (18.6%) patients had lower cranial nerve palsy at the time of presentation. Preoperative clinical features of our study patient have more or less similarity with the studies above.

In our study, (Table V) shows the outcome of patients according to postoperative complications. Total number of patients were 43. Among them, 25 patients developed postoperative complications and 18 patients did not develop any complications. Development of postoperative hydrocephalus was 2 (4.65%), CSF leak was found in 3 (7%) patients, pseudo meningocele was found in 9 (20.9%) patients, wound infection was found in 9 (20.9%) patients, and meningitis was found in 17 (39.5%) patients in the preoperative shunt.

Table VI shows the outcome of the study subjects according to the extent of tumor removal during postoperative follow-up. Total number of patients was 43. Among them, 25 patients developed postoperative complications. Development of postoperative hydrocephalus was found in 2 (4.65%), CSF leak was found in 3 (6.98%) patients in gross total removal of tumor and others were nil. Pseudo-meningocele was found in 7 (16.28%) and 2 (4.65%) patients in gross total and near total removal of tumor respectively. Wound infection was found in 6 (13.95%), 2 (4,65%), and 1 (2.33%) patients in gross total, near total, and subtotal removal of tumor respectively. and meningitis was found in 14 (32.56%), 2 (4.65%), and 1 (2.33%) patients in gross total, near total, and subtotal removal of tumor respectively with the preoperative shunt.

Prusseit and his colleagues 2009 reviewed studies in patients with V-P shunt infections such as fever (96%), shunt malfunction (50%), local tenderness (25%), vomiting (0%), meningism (21%) and abdominal pain (36%) (Prusseit et al. 2009) V-P shunt group suffered added shunt related complications including shunt blockage that was absent in without shunt group.

El Molla and Hamza (2016) found in their study that failure of the V-P shunt was 5 (50%), infection 3 (30%), pseudo meningocele 3 (30%), CSF leak 2 (20%), upward herniation 1 (10%), subdural collection 2 (20%) and mortality 1 (10%) among 10 patients with pre resection V-P shunt and 12 patients of direct tumor surgery, 5 (41.6%) showed recurrence of hydrocephalus within two weeks and all were treated with V-P shunt, pseudo meningocele was 3 (25%) and mortality was 2 (16.7%) patients.

Hamdan et al. (2018) described regarding the postoperative complications, 6 (20%) patients were complicated with postoperative hydrocephalus, secondary to cerebellar edema and/or fourth ventricular hematoma and treated surgically by ventriculoperitoneal shunt, 4 (13.33%) patients were presented with postoperative CSF leak, 3 (10%) patients had bulbar palsy, death was recorded in 2 (6.66%) patients, 1 (3.33%) patient was presented with wound infection, and 1 (3.33%) patient was presented with cerebellar mutism. Table VI shows the Logistic regression of the development of hydrocephalus following midline posterior fossa tumor surgery with preoperative V-P shunt for males was

6.225 more than that of females. Ages (6-10) with a p-value of 0.514 and age (11-15) with a p-value of 0.929 have odds values of 0.448 and 0.885 respectively which signify that ages (11-15) are more likely to develop hydrocephalus considering any surgery. Thus male patients aged (11-15) have 5.509 times of developing hydrocephalus than in patients aged (6-10) with odds of 2.778. The patient who underwent near total removal has no odds than with subtotal removal where the odds is 0.285 indicating the development of hydrocephalus in the latter group. None of the variables has a significant relationship with the development of hydrocephalus in patients with posterior fossa tumors and the model assumes that age, sex, and removal of posterior fossa tumors act independently on the development of hydrocephalus. Logistic regression was statistically non-significant.

Stein et al. (1972) described a higher incidence of postoperative hydrocephalus following total removal than after subtotal removal of childhood cerebellar astrocytoma. The authors reasoned that total removal created a larger tumor bed followed by an intense CSF reaction resulting in hydrocephalus.

Morelli et al. (2005) found in their study that tumor removal can restore CSF circulation, and obstructive hydrocephalus persists or progresses postoperatively in approximately 15 to 30% of cases in which patients need postoperative treatment. Authors of many studies have suggested that young age and incomplete tumor resection could be related to a higher incidence of persistent hydrocephalus.

de Oliveira et al. (2008) described that chronic arachnoiditis after posterior fossa surgery, leading to adhesions, may have been responsible for the higher rate of shunt requirements.

Gopalakrishnan et al. (2012) found that the extent of tumor removal was determined according to the opinion of the surgeon and the postoperative imaging. 'Gross total excision' included patients in whom no tumor was visible following resection. 'Near total removal' included patients with only a very small tumor residual following resection as evident on MR imaging. 'Subtotal removal' included patients with significant tumor residual volume. Concerning the extent of tumor excision, it was apparent that the incidence of CSF diversion was higher when a less than gross total resection, that is, near-total or subtotal resection was achieved (36.3%) than in cases of macroscopically complete excision (28.7%) but this result did not achieve any statistical significance. Regarding gender 17 (56.5%) patients were males and 13 (43.5%) patients were females.

Helmbold et al. (2019) found in their study that within the shunt group, gross total resection was achieved in 9 (60%) and subtotal resection in 6/15 patients (40%). There was no significance found between postoperative shunt placement and gross total tumor resection according to the postoperative neuroradiological report.

Conclusions:

The development of postoperative hydrocephalus of midline posterior cranial fossa tumors with hydrocephalus after definitive surgery following ventriculoperitoneal (V-P) shunt in pediatric patients was not the major complication among others.

Limitation of the study:

1. The study was conducted with a very small sample size.
2. The study was conducted within a short time. So, the patients were not followed up for a longer duration.
3. The study would be diverse and convenient if it could be done in a multicenter and over a prolonged period to include more study subjects.
4. The outcome of benign and malignant tumors is not always similar as well as different age groups may have different results.
5. Surgical procedures were performed by different surgeons at different hospitals and the extent of tumor removal varied which could have an impact on postoperative outcome.
6. We conducted this study in a tertiary-level hospital with a high facility for patients, So, it is difficult to understand the percentage of posterior fossa tumors in the community from this data. It would be possible if we had the opportunity to collect data from secondary Hospitals where neurosurgical treatment facilities are available.

Recommendations:

1. Further study should be carried out incorporating a larger number of patients for a better conclusion.
2. The study should be done for a longer period for a better result.

3. A single expert operating surgeon should be included to perform this procedure to reduce the risk of complications related to surgery.
4. Young children with a midline posterior fossa tumor with preoperative hydrocephalus should be considered V-P shunt before definitive surgery.
5. A life-saving operation should be performed in case of acute hydrocephalus.

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