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Literature Review

Acute Complications of Pre-Resection CSF Diversion in Posterior Fossa Tumors with Hydrocephalus

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Abstract

Study background and significance: Posterior fossa tumors are a common pathology worldwide and often present with obstructive hydrocephalus. In the year 2021 CSF diversion for acute hydrocephalus from brain tumors was the most common performed emergency procedure in Tikur Anbessa hospital. It is a clinical dilemma choosing the mode of management for the hydrocephalus as it could be a lifesaving procedure but with a risk of unfortunate and devastating outcome.

Objective: The aim of the study will be to evaluate the acute complications that occur with CSF diversion procedures that are done for obstructive hydrocephalus in the presence of posterior fossa mass before tumor resection.

Method: It will be prospective observational study conducted at Tikur anbessa specialized hospital, which will be held from March 2021 up to October 2022. The research will involve all patients who have undergone CSF diversion procedure for obstructive hydrocephalus from posterior fossa tumors prior to tumor resection and patients will be followed for the first 48 hours post operatively. Patient's presentation, nature of the posterior fossa tumor on imaging, post-operative clinical status and post op imaging will be taken to account.

Result: In the study time frame of 18 months there were 89 patients who came with acute obstructive hydrocephalus from posterior fossa of which all underwent CSF diversion procedure before tumor resection. 52.8% were pediatrics and 47.2% where adults. The most common tumor location was vermian (31.5%) followed by cerebellar hemisphere (29.2%), 4th ventricular (25.8%) and the rest 9% account for cranial nerve and extra axial location. The largest tumor was 9.8cm but the median was 5.1cm. Based on the size they were categorized in to 3 groups, 71.9% were tumor size 4-6cm, 22.5% had a tumor size of >6cm and there were 5.6% with tumor size <4cm. Of the CSF diversion procedures performed 93.3% were VPS, EVD and ETV account for 3.4% each. All were followed for 48 hours post op and 8 patients had clinical deterioration after CSF diversion was done, and all patients with clinical deterioration underwent urgent non -contrast CT scan. They were found to have upward herniation, intra-tumoral bleeding, intraventricular hemorrhage or a combination of these findings. Of the 8 patients that deteriorated 5 died without successful resuscitation. The rest 3 improved and underwent definitive surgery. The risk for postoperative deterioration was 8.9% and 48-hour mortality was 5.6%. Variables were chosen to check association with the outcome (post-operative deterioration). Variables tested include age of the patient, tumor size and tumor location, all did not have statistically significant relationship with outcome (post-operative deterioration and 48-hour mortality). The association between the type of intervention and outcome could not be checked as there were not enough samples representing ETV/EVD performed, and majority (93.3%) were VPS.

Conclusion: Through our research we tried to investigate the causes of acute deterioration after CSF diversion done for obstructive hydrocephalus from posterior fossa tumors by assessing the tumor size, location the type of intervention. Through our research we were not able to find any association from investigated factors and post-operative deterioration. Because of our limitation (the low number of sample size and not having enough number of ETV and EVD in the study population) we recommend further research is needed to have more information in this problem.

***Keywords:** Posterior fossa tumors; obstructive hydrocephalus; Up ward herniation.*

Abbreviations

CSF: Cerebrospinal fluid; CPA: Cerebello pontine angle; CT: Computed tomography; ETV: Endoscopic third ventriculostomy; EVD: External ventricular drain; ICP: Intracranial pressure; IVH: Intraventricular hemorrhage; TASH: Tikur anbessa specialized hospital; MRI: Magnetic resonance imaging; VPS: Ventriculoperitoneal shunt.

Literature Review

Brain tumors are one of the most common neoplasms which account from major morbidity and mortality worldwide. Posterior fossa tumors are predominantly seen in the pediatrics age group which can involve the cerebellum, the fourth ventricle and the brainstem. Posterior fossa tumors are a common pathology in our institution with, most common tumor being vestibular schwannoma followed by meningioma and epidermoid cyst in adults. [14] One may consider that the patient with hydrocephalus complicating a primary brain tumor has two distinctly different diseases: a neoplasm, and hydrocephalus [1]

Because of the anatomy of the posterior fossa hydrocephalus tends to be common. Hydrocephalus remains one of the most common presentation features of posterior fossa brain tumors. It occurs in 72% of patients with posterior fossa tumors [4] and more than 60% of patients are thought to have hydrocephalus at time of diagnosis of posterior fossa brain tumor is made. [4] Hydrocephalus is thought to arise from obstruction of cerebrospinal fluid (CSF) in patients with posterior fossa tumors at the level of the cerebral aqueduct or the fourth ventricle. 85% of cerebellar and 4th ventricular, and 32% of brainstem tumors tend to have hydrocephalus. [16].

The optimal management of patients with posterior fossa tumors with hydrocephalus remains to be an area of controversy. The options of management include, external ventricular drain (EVD), endoscopic third ventriculostomy (ETV), or ventriculoperitoneal shunt (VPS) before definitive surgery or differ CSF diversion procedure and doing tumor resection. The decision remains a topic of debate and complex with multiple factors affecting choice of management. This remains difficult as there is no class-I evidence to guide management in these patients.

With regards to the mode of management and which is superior over the others several studies have to assess different methods management and outcome. A study done in Kings College Hospital, United Kingdom tried to assess the role of pre-resection ETV in posterior fossa tumors and found that 87% had significant clinical improvement and only 8% complication rate with infection and bleeding. [2]

When it comes to choosing a method of CSF diversion procedure each has its own benefits and drawbacks. Although, theoretically, VP shunt is better than EVD by providing guarded decompression of ventricles, EVD has its own merits as the CSF output can be carefully monitored and externally controlled in the inpatient setting. In addition, the CSF diversion with an EVD can be turned off more rapidly than with a VP shunt in the event of symptomatic upward herniation. Furthermore, an EVD can potentially be removed after definitive treatment avoiding a permanent indwelling system. Similarly, ETV is helpful by avoiding the need of a permanent shunt, with the disadvantage being the loss of control of CSF diversion. [3]

Inserting VPS for the management of obstructive hydrocephalus with posterior fossa tumor is a common method used to stabilize patients prior to definitive craniotomy. In a study that tried to evaluate the complication rate of patients with posterior fossa tumors with hydrocephalus (total number of patients 345) which tried to compare shunted (165 patients) from non-shunted group, the mortality rate was 10% in the shunted group which was higher than the non-shunted group and 9 patients developed hematoma after shunting of which 2 of them died. When comparing incidence of post-operative CSF leak and pseudo-meningocele formation, it was more common in the nonshunted group. [8] Investigators also tried to assess whether predictors can be detected as which group of patients are likely to require CSF diversion from persistent hydrocephalus after tumor resection, significant correlation was identified with ependymoma followed by medulloblastoma and patients younger than 3 years of age are likely to require shunting. [13]

EVD is also another option of temporary method of CSF diversion before patient can receive definitive management for posterior fossa tumor. In a retrospective review involving 25 patients who underwent emergency EVD insertion for posterior fossa tumor with hydrocephalus, radiographic and clinical worsening was observed in 2 patients, the rest 44% remained clinically the same, 48% showed clinical improvement. [7]

ETV can be used as a mode of managing obstructive hydrocephalus, with regards to hydrocephalus related to posterior fossa mass, it has been shown to be successful with >50% of clinical and radiologic improvement with 35% failure rate and subsequent requirement of another method of CSF diversion, mostly in the form of VPS. [10] In the management with CPA tumors associated with obstructive hydrocephalus, 63% managed to be shunt free and had no complication post craniotomy. [12]

In a review that compared VPS and ETV for the management of obstructive hydrocephalus in pediatric patients, 25 patients underwent ETV and 31 patients underwent VPS, at 5 year follow up there was 26% ETV failure rate versus 42% shunt failure rate. [9]

Researches have tried to investigate the superior mode of management for patient with obstructive hydrocephalus with posterior fossa mass, in a paper that compared ETV and VPS, in patients who received pre resection ETV there was 6.2% complicated with bleeding and 3.1% post-operative CSF leak, while in patients who received VPS there was 9% risk of shunt infection and 4.7% ventriculitis, mortality was higher in VPS with 4.7% versus 0% with ETV plus lower incidence of procedure failure rate 6.2% for ETV and 38% for VPS. [11]

Many have debated that immediate tumor removal may normalize CSF dynamics as well as control ICP and doing CSF diversion before the primary surgery comes with early risks of intratumoral bleeding and upward herniation, as well as late complications like infection and potential seeding of the tumor via the diversion route. [15]

Ascending trans-tentorial herniation (upward herniation) is a life-threatening event where space occupying lesion in the posterior fossa cause superior displacement of superior part of the cerebellum through the tentorial notch. [4], new intra tumoral hemorrhage and effacement of quadrigeminal cistern on imaging have been used to assess herniation [15], this often leads to sudden clinical deterioration, with decreased level of conscious, respiratory deterioration [15] and often death. Displacement of the cerebellum through the tentorial incisura is more likely to occur when the mass originates near the incisura, when drainage of the lateral ventricles relieves obstructive hydrocephalus and reduces pressure above, and when the opening in the tentorium is large. [5] A study in Egypt tried to investigate posterior fossa complications after CSF diversion procedures done for posterior fossa tumors with hydrocephalus, 2.3% of patients deteriorated from pre-operative neurologic status. Except one patient all had clinical deterioration within 8 hours of the procedure. All had post op imaging that showed intratumoral hemorrhage and upward herniation. From this group of patients only 1 survived in vegetative state while the rest died. [6]

Ascending trans-tentorial herniation can be assessed using imaging which show flattening of quadrigeminal cistern, obliteration quadrigeminal cistern [15] and superior cerebellar cistern, spinning top appearance of midbrain from bilateral compression of posterior part of midbrain, infarction of posterior cerebellar artery and superior cerebellar artery and hydrocephalus form compression to the cerebral aqueduct. [17,18,19]

The incidence of upward trans-tentorial herniation is rare, 3% after ventriculoperitoneal shunt insertion and the most commonly attributed lesion is a cerebellar mass in 65% followed by lesions in the cerebello-pontine angle (CPA) 13%, pones 11% and the fourth ventricle. [5] Such complications are significantly associated with tumor size as well, with largest tumor diameter ≥ 4 cm having a higher risk. [6]

Method

Study population

All patients who underwent CSF diversion procedures (ETV/EVD/VPS) for acute obstructive hydrocephalus from posterior fossa tumors before tumor resection at Tikur Anbessa Hospital from April/2021 up to October/2021 and the participants where followed for the first 48hrs of post-op.

We evaluated for the incidence of post op morbidity and 48-hours mortality, we also looked for any associated variables that may be related to post op morbidity and 48-hours mortality.

Operative procedures

The decision to do CSF diversion procedure was not interfered with and it was the decision of the on-call neurosurgeon/attending but it was guided by the presentation of the participant, the physical finding and the imaging (MRI/CT).

From the pre-operative imaging (CT/MRI) information was gathered to be analyzed with patient outcome, these were the maximum diameter of the tumor (in centimeters) and they were grouped in to 3 < 4cm, 4-6cm and > 6cm, the anatomic location of the tumor (vermian, cerebellar hemisphere, extra-axial, cranial nerve and fourth ventricle). Choice of type of procedure (ETV/EVD/VPS) was not interfered it was the decision of the on-call neurosurgeon/attending, but generally were made by the patients' comorbidities, the physical finding and the favorable nature of the anatomy on imaging (CT/MRI).

The procedure was typically performed with the senior resident if it was either VPS or EVD, and in the presence/with the attendant if ETV was done.

In the post-operative period the patients were followed in the ICU/ward for the first 48 hours of post-operative period. Post-operative deterioration was labeled if the patient had worsening of symptoms or neurologic findings after the procedure.

All patients who had post-operative deterioration underwent emergency CT scan to check for complications for the deterioration. Control CT readings were done by radiologist to be labeled as upward herniation, intraventricular hemorrhage, intra-tumoral bleeding or a combination of findings.

Statistical analysis

Statistical calculations and data entry were made with SPSS for windows version 25. Data was described using numbers and percentages. Variables were tested for association with Chi-square test and p values were considered statistically significant if <0.05.

Results

A total of 89 patients were involved. Of which 47 were male and 42 were female, pediatrics (<14 years of age) contributed to 52.8%, while adults (≥14 years of age) made up 47.2% of patients.

The most common tumor location was 28 (31.5%) were vermian, followed by 26 (29.2%) cerebellar hemisphere. The rest were 23 (25.8%) fourth ventricle, 4 (4.5%) Cranial nerve, 5 (5.6%) brainstem, and 3 (3.4%) extra-axial. Table 1.1

The largest tumor size was 9.8cm and the smallest was 2.7cm with a median of 5.1cm. based on tumor size the patients were grouped in to 3. Tumor size <4 cm 5 (5.6%), 4-6cm 64 (71.9%) and >6cm 20 (22.5%), most fell between 4-6 cm. Table 1.2

All 89 patients underwent CSF diversion for acute obstructive hydrocephalus form posterior fossa tumors before tumor resection. VPS was done for 83 patients (93.3%), ETV done for 3 patients (3.4%) and EVD done for 3 patients (3.4%).

Post operatively 81 patients (91%) had improvement/no deterioration from pre-operative clinical status and 8 patients (9%) deteriorated post operatively. From the deteriorated patients the most common timing of clinical decline was 5 patients (5.6%) <8hrs post op and 2(2.2%) patients deteriorated 8-24hrs post op, only 1 patient deteriorated >24hr post op.

All 8 patients who had clinical deterioration had CT scans done urgently. The findings are summarized in table 1.3.

Table 1.1: Location of Tumor.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Vermis	28	31.5	31.5	31.5
	cerebellar hemisphere	26	29.2	29.2	60.7
	fourth ventricle	23	25.8	25.8	86.5
	cranial nerve	4	4.5	4.5	91.0
	extra axial (meninges)	3	3.4	3.4	94.4
	brainstem	5	5.6	5.6	100.0
	Total	89	100.0	100.0	

Table 1.2: Largest tumor diameter Group.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<4cm	5	5.6	5.6	5.6
	4-6cm	64	71.9	71.9	77.5
	>6cm	20	22.5	22.5	100.0
	Total	89	100.0	100.0	

Table 1.3: Control CT findings of the deteriorated patients.

Case reference no.	Upward herniation	Intra-tumoral hemorrhage	Intra-ventricular hemorrhage
Case-74	+	-	-
Case-49	+	-	-
Case-83	+	+	+
Case-48	+	+	-
Case-17	+	+	-
Case-47	-	+	+
Case-9	+	+	+
Case 4	-	+	+

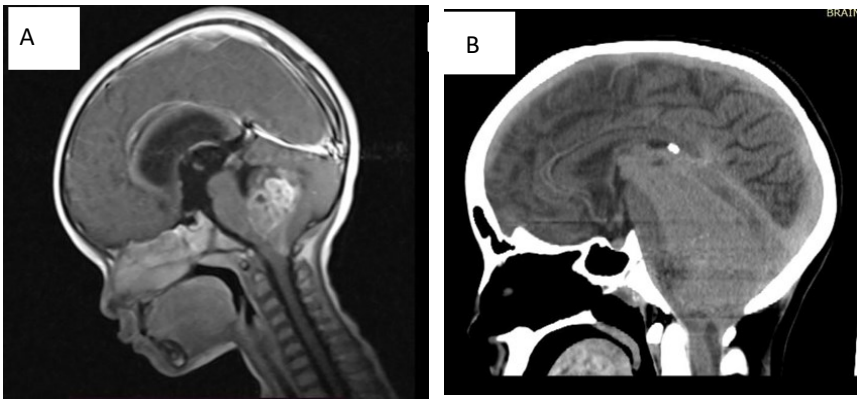

Figure 1.1: *A and B patient who deteriorated after ventriculoperitoneal shunt insertion with preoperative imaging (A) and control CT scan (B).*

From the patients who had clinical deterioration 5 patients died with initial resuscitation attempts failing. The 48 hours mortality rate was 5.6%, while 3 patients recovered and had definitive surgery.

Variables were checked with chi-square if they had statistically significant relationship with post-operative deterioration and 48-hours mortality. The tested variables included Age of the patient, tumor location and tumor size. The type of surgical intervention and post-operative deterioration could not be assessed as the number of VPS done significantly out number ETV/EVD procedures. Age group and post op deterioration had no association with P value of .565. Tumor location and post op deterioration had no association with P value of .631. Tumor size and post op deterioration had no association with a P value of .554. control CT scan findings and 48-hours mortality did not have association. Timing of post-op deterioration and 48-hours mortality had no association with P value of .293.

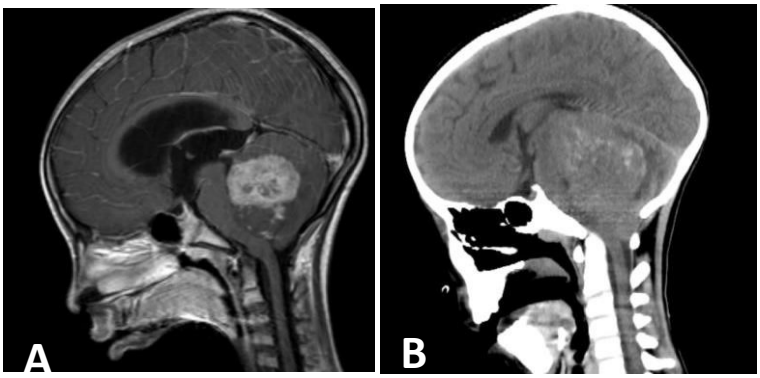

Figure 1.2: *A and B patient who deteriorated after ventriculoperitoneal shunt insertion with preoperative imaging (A) and control CT scan (B).*

Discussion

In the study time frame of 18 months there were 89 patients who came with acute obstructive hydrocephalus from posterior fossa of which all underwent CSF diversion procedure before tumor resection. 52.8% were pediatrics and 47.2% where adults. The most common tumor location was vermian (31.5%) followed by cerebellar hemisphere (29.2%), 4th ventricular (25.8%) and the rest 9% account for cranial nerve and extra axial location. The largest tumor was 9.8cm but the median was 5.1cm. Based on the size they were categorized in to 3 groups, 71.9% were tumor size 4-6cm, 22.5% had a tumor size of >6cm and there were 5.6% with tumor size <4cm. Of the CSF diversion procedures performed 93.3% were VPS, EVD and ETV account for 3.4% each. All were followed for 48 hours post op and 8 patients had clinical deterioration after CSF diversion was done, and all patients with clinical deterioration underwent urgent non-contrast CT scan. They were found to have upward herniation, intra-tumoral bleeding, intraventricular hemorrhage or a combination of these findings. Of the 8 patients that deteriorated 5 died without successful resuscitation. The rest 3 improved and underwent definitive surgery. The risk for postoperative deterioration was 8.9% and 48-hour mortality was 5.6%. Variables were chosen to check association with the outcome (post-operative deterioration). Variables tested include age of the patient, tumor size and tumor location, all did not have statistically significant relationship with outcome (post-operative deterioration and 48-hour mortality). The association between the type of intervention and outcome could not be checked as there were not enough samples representing ETV/EVD performed and majority (93.3%) were VPS.

Because of the anatomy of the posterior fossa hydrocephalus is a common manifestation of posterior fossa tumors, 60% will already have hydrocephalus at the time of presentation. [4] Although it is a common presenting pattern the optimal management of hydrocephalus with posterior fossa tumor is still a controversial topic and it can include CSF diversion before tumor resection in the form of ETV/EVD/VPS or doing the definitive surgery from the outset [5] A rare but feared complication is upward herniation +/- intra tumoral bleeding which leads to sudden clinical deterioration and often death. [15] A study in Egypt tried to evaluate the rate of posterior fossa complication after CSF diversion done for acute obstructive hydrocephalus from posterior fossa tumor and the risk of deterioration was 2.3% [6]. Which is less than our findings of 8.9%. But the Egyptian study had a larger sample size of 301 patients but they were all pediatrics (did not include adult patients). [6] the other suggestion made was tumors ≥4cm and close to the incisura may be at higher risk of deterioration and should be managed with medical treatment (steroids and diuretics). [6] But from our investigation we tested association between postoperative deterioration with both tumor location and size but both did not show statistically significant associations. The study from children's memorial hospital, Chicago conducted from 1967 to 1979, out of 143 patients had shunt insertion before craniotomy for the definitive management of their posterior fossa tumor and they found the risk for upward herniation to be 3%. [1] Although in our study we did not compare the outcome of different interventions, the retrospective case series from Kings and St. Thomas medical school, London showed that ETV is a safe procedure as a management tool for acute hydrocephalus before tumor resection, the series evolved 59 patients for whom ETV was done for acute obstructive hydrocephalus from posterior fossa tumors before definitive surgery they encountered 2 patients with meningitis and only 1 patient with bleeding. [2] the risk of EVD for the management of acute obstructive hydrocephalus from posterior fossa tumors was evaluated in a retrospective study done from 2007 to 2014 by Sherri A. Braksick, on his observation out of the 25 patients for whom EVD was inserted there was radiologic evidence of upward herniation in 22 (85%) out of 25 patients and radiologic and clinical worsening was seen in 2 patients. [7]

Although the mentioned numbers for deterioration and mortality are low, it was found to be high in our research, and it difficult to predict deterioration after CSF diversion procedure based on preoperative presentation, imaging findings and the type of intervention performed for the hydrocephalus. Further research needs to be done to have a solid conclusion in this controversial issue.

Conclusion

Through our research we tried to investigate the causes of acute deterioration after CSF diversion done for obstructive hydrocephalus from posterior fossa tumors by assessing the tumor size, location the type of intervention. Through our research we were not able to find any association from investigated factors and post-operative deterioration. Because of our limitation (the low number of sample size and not having enough number of ETV and EVD in the study population) we recommend further research is needed to have more information in this problem.

Conflict of Interest

None.

Source of funding

None.

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