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Incidence and predictors of permanent cerebro-spinal fluid diversion in patient undergoing posterior fossa tumor surgery: multicenter prospective cohort study

A thesis for partial fulfillment of graduate course in Neurosurgery specialty, Addis Ababa University, College of Health Sciences

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Abstract

Background: Posterior fossa tumors are frequently cause hydrocephalus, which can be obstructive or communicating. After tumor removal, only some patients require permanent Cerebro-Spinal Fluid (CSF) diversion, and the best approach to managing hydrocephalus in these cases remains debated. While some advocate for initial CSF diversion, others favor early tumor resection. In low-income settings with high patient volumes, early tumor resection is often challenging

Objective: This study aimed to assess the incidence and predictors of permanent CSF diversion following posterior fossa tumor resection among patients at BLH, MCM, and ALERT Hospitals from August 1, 2023, to September 30, 2024.

Methodology: A hospital-based, multicenter prospective cohort study was conducted from August 1, 2023, to September 31, 2024, to examine the incidence and predictors of permanent CSF diversion following posterior fossa tumor resection at BLH, MCM, and ALERT Hospitals. Data were collected from patients, attendants, surgical notes, biopsy reports, electronic records, and pre- and post-op imaging. Patients were followed in person and by phone at 1st, 3rd, and 6th months post-op. A structured questionnaire and checklist were used for data collection, and data were entered into SPSS-30 for cleaning and analysis, with demographic, radiographic, perioperative, and postoperative variables analyzed using univariate and multivariate models.

Result: This study included 52 patients, equally divided by gender, with 76.9% being adults (>18 years). Follow-up was completed for all patients at one month, 48 patients at three months, and 37 patients at six months. The overall incidence of postoperative hydrocephalus requiring permanent CSF diversion was 13%, occurring in 15% of adults and 8.3% of pediatric patients. The most common symptoms were headache (98%), nausea/vomiting (48.1%), and blurred vision (52%). Irritability was the only variable significantly associated with permanent CSF diversion (P = 0.028). Most patients had symptoms for 2-6 months before presentation. Tumors were most frequently located in the cerebellopontine angle (44.2%), with 55.8% being extra-parenchymal. The majority of tumors (53.8%) measured 3-5 cm, and 40.4% exceeded 5 cm. Preoperative hydrocephalus was present in 72.6% of patients, with 36.5% having mild and 13.5% severe hydrocephalus based on Evans Index; 44% had periventricular CSF capping on imaging. Gross Total Resection (GTR) was achieved in 77% of cases, Near Total Resection (NTR) in 7.7%, and Subtotal Resection (STR) in 15.4%. EVDs were used in 71.2% of cases, with 94.6% placed intraoperatively, stayed in place for 5-10 days in 56.8% of cases. Postoperative complications occurred in 36.5% of patients, with CSF leaks (11.5%) being the most common, followed by pseudomeningocele and ventriculitis (7.7% each), IVH (5.9%), and tumor bed hemorrhage (3.8%). Meningioma (26.9%) was the most frequent tumor type, followed by schwannoma (21.2%), medulloblastoma (17.3%), low-grade astrocytoma (15.4%), and ependymoma (5.8%).

Conclusion: The overall incidence of postoperative permanent CSF diversion is 13%, with 15% in adults and 8.3% in pediatric patients. Irritability was the only variable significantly associated with the need for postoperative permanent CSF diversion. To strengthen these findings and develop a risk prediction model for identifying high-risk patients in low-income countries, further large-scale prospective cohort studies are recommended.

Acknowledgment

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Abbreviations and Acronyms

BLH	Black Lion Hospital
CPPRH	Canadian Preoperative Prediction Rule for Hydrocephalus
mCPPRH	Modified Canadian Preoperative Prediction Rule For Hydrocephalus
CSF	Cerebrospinal Fluid
CT	Computed Tomography
EI	Evans Ration
ETB	Ethiopian Birr
ETV	Endoscopic Third Ventriculostomy
EVD	External Ventricular Drainage
FOHR	Frontal to Occipital Horn Ratio
GTR	Gross Total Resection
HCP	Hydrocephalus
ICP	Intracranial Pressure
ICU	Intensive Care Unit
IRB	Institutional Review Board
iPFT	Intra Axial Posterior Fossa Tumor
ePFT	Extra Axial Posterior Fossa Tumor
ITH	Intra Tumoral Hemorrhage
IVH	Intraventricular Hemorrhage
MCM	Myungsung Christian Medical
MRI	Magnetic Resonance Imaging
NTR	Near Total Resection
PFTs	Posterior Fossa Tumors
STR	Subtotal Resection
TASH	Tikur Anbessa Specialized Hospital
TEF	Trans Ependymal Flow
UTH	Upward Trans Tentorial Herniation
VPS	Ventriculoperitoneal Shunt

1.Introduction

1.1 Background

Brain tumors located in the posterior fossa represent a grave category of human illnesses due to their critical positioning, often resulting in brainstem compression, hydrocephalus, and subsequent herniation leading to fatality. The prevalence of posterior fossa tumors is notably higher in children, constituting 54–70% of all pediatric brain tumors compared to 15–20% in adults. These tumors occur more in males than females [1].

Due to their anatomical proximity to cerebrospinal fluid (CSF) drainage pathways, posterior fossa tumors(PFTs) frequently manifest as hydrocephalus (HCP), presenting both obstructive and communicating forms[2,3]. Prior studies indicates a rate of HCP after PFT surgery to be 2% to 7% and up to 40% in adult and pediatric patients, respectively [1,2,4–7].

According to prior studies risk factors for persistent or new onset HCP are: young age, greater preoperative hydrocephalus, Incomplete resection of tumor, Histopathologic type such as ependymoma and medulloblastoma, brain stem compression, and CSF capping, large tumors, midline located tumors, High Evans index (EI), and fronto-occipital horn ratio (FOHR), on preoperative imaging, post operative Intraventricular hemorrhage, Post OP Ventriculitis or Meningitis [5,7–15].

The optimal management strategy for hydrocephalus in posterior fossa tumor patients is a subject of debate. Some advocate for preoperative placement of Ventriculoperitoneal Shunt (VPS) or External Ventricular Drainage (EVD) before definitive surgery, while others propose semi-emergent tumor removal, asserting that not all patients with posterior fossa tumors necessitate postoperative CSF diversion[1,15].

Preoperative CSF diversion may associated with number of risks such as: seeding of the peritoneum with malignant tumor cells e.g. with medulloblastoma, shunts infection, migration, malfunction or occlusion prior to the definitive surgery, delay definitive treatment, and the total number of hospital days may be increased, upward trans tentorial herniation may occur if there is excessively rapid CSF drainage [3,15–18].

1.2 Statement of problem

Posterior cranial fossa tumours commonly lead to hydrocephalus as first symptomatic presentation in up to 90% of pediatric patients and 21.4% of adults. Hydrocephalus is one of the most common complications after posterior fossa surgery in about 2.1% of adult patients and 10–40% of pediatric patients. However, optimal management of hydrocephalus due to PFT remains main controversy within neurosurgical community. Some authors advocate preoperative CSF diversion procedures such as VPS insertion and Endoscopic Third Ventriculostomy (ETV) while others recommend initial treatment by steroid following by early tumor removal as semi-emergent bases [1,3–5,7,8,18].

However, treating all patient with hydrocephalus due to posterior fossa tumors by preoperative permanent CSF diversion potentially exposes about 70% of pediatric patients and >90% adult patients to unnecessary procedure which are linked to several complications including: supratentorial intracranial hematomas, shunt associated complications, such as malfunction, shunt migration,infection,viscous perforation, Pseudocyst, long-term shunt dependence, metastases into the peritoneal cavity or vascular system ,intratumoral hemorrhage (ITH) and upward trans tentorial herniation [3,4,14,16–18].In other hand, in low-income country where patient load is high, intensive care unit(ICU) is not adequate usually early surgery is not possible and early preoperative CSF diversion may be an option [18,19].

In general, identifying and careful selection of patients who are at high risk of developing HCP after PFTs resection may avoid unnecessary risky procedures, readmission, complications that prolong hospitalization and worsen outcome. Data on incidence and predictors for occurrence of hydrocephalus requiring permanent CSF diversion after PFT surgery is lacking in our setting. In addition, there is no a risk prediction model used for identification of high-risk patients who may require CSF diversion due to persistent or new onset hydrocephalus, particularly in our setting so far. In this study, we described the incidence of preoperative, post operative HCP after posterior fossa tumors resection. We also analyzed the predictors of HCP after resection of PFTs in different groups of patients so that we tried to address the main limitations of our setup.

2.Literature Review

Hydrocephalus linked to posterior fossa tumors poses a prevalent neurosurgical challenge. Children exhibit a higher incidence of hydrocephalus associated with these tumors at presentation (70-90%) compared to adults (10-21%). This distinction persists post-resection, with rates ranging from 20-40% in children and 1.2-6.9% in adults[4,8,9,14,15,19–22]. The nature of hydrocephalus in posterior fossa tumors can be obstructive or communicative. Tumors within the fourth ventricle obstruct ventricular outlets, while cerebellar hemisphere tumors distort the ventricle, causing obstructive hydrocephalus. Choroid plexus papilloma and leptomeningeal carcinomatosis induce hypersecretion of CSF, resulting in communicative hydrocephalus[16,17,19]. Although the tumor itself can causes symptoms and signs of increased intracranial pressure (ICP), the complicating secondary hydrocephalus is often responsible for the increased ICP [16].

In pediatric patients, risk factors for postoperative hydrocephalus include: young age, greater preoperative hydrocephalus, incomplete tumor resection, ependymoma, medulloblastoma (especially within the fourth ventricle), brain stem compression, and CSF capping, midline location, large tumors, and certain histopathologies. Astrocytoma is a negative predictor for hydrocephalus development [5,7,9–11,13–15].Preoperative imaging parameters such as Evans index and front occipital horn ratio correlate with postoperative shunt requirements. Children subjected to intraoperative External Ventricular Drain (EVD) display a higher shunt insertion rate at 39.6%, contrasting with the 16.7% rate observed in those without EVD. Notably, patients experiencing postoperative meningitis and pseudo meningocele face a significantly elevated risk of requiring a shunt, as indicated by various studies[5,8,12]. However, other research suggests that CSF leakage and the placement of preoperative external ventricular drain or Rickham reservoir, does not show a significant association with the subsequent need for a shunt[10].

For adults, pilocytic astrocytoma and preoperative hydrocephalus are significant risk factors for postoperative hydrocephalus [9]. Variables such as intra-axial tumor location, larger tumor size, Trans-ependymal flow (TEF) on preoperative imaging, and postoperative complications influence the need for ventriculoperitoneal shunt (VPS). Postoperative complications that heighten the risk of postoperative hydrocephalus (HCP) include factors such as intraventricular hemorrhage (IVH), reoperation, incomplete tumor resection, and specific histopathologic results like choroid plexus papilloma (30%), ependymoma (23.8%), low-grade glioma (23.5%), and medulloblastoma (20%).

Contrarily, preoperative placement of an External Ventricular Drain (EVD) and the duration of EVD weaning do not exhibit a significant impact. Notably, in patients with extra-axial tumors, a stronger association is observed between preoperative tumor size and the necessity for VPS, as highlighted in certain studies[2,22].

The management of hydrocephalus associated with a surgically resectable posterior fossa tumor is a subject of ongoing debate [5,6,17,22]. Traditionally, there has been an inclination towards routine preoperative cerebrospinal fluid (CSF) diversion followed by tumor resection. Initially, ventricular shunts were introduced in the early 1960s, later followed by alternatives like External Ventricular Drainage (EVD), subcutaneous ventricular catheter reservoir, and more recently, endoscopic third ventriculostomy (ETV) to mitigate shunt-associated complications. The most common approach, observed in certain centers, involves placing a ventriculoperitoneal shunt before tumor resection or, less frequently, opting for endoscopic third ventriculostomy (ETV). Tumor removal typically follows after 1 or 2 weeks. Although most of these patients won't necessitate permanent cerebrospinal fluid (CSF) diversion, those who do often encounter a more complicated postoperative course, facing well-recognized issues linked to these procedure-related devices [17,19,20] In contrast, recent recommendations favor a direct approach, emphasizing primary resection of the obstructing posterior fossa tumor at the earliest opportunity [10,22]. Management of pre-resection hydrocephalus may involve steroid use following by early tumor removal. Preoperative CSF diversion is reserved for specific cases dictated by the patient's clinical needs[17,19].

Indications for postoperative shunt insertion includes: persistent symptomatic hydrocephalus, CSF leak, postoperative meningitis, and pseudomeningocele formation that does not resolve with conservative management through serial lumbar punctures and/or lumbar drain. Additionally, shunt insertion may be warranted for tumor recurrence and EVD-weaning failure[2,5,10].The majority (85%) of shunts are typically inserted within 2-6 weeks postoperatively. However, a late requirement is observed in a subset (18%) of patients, occurring between 2-83 months following tumor excision. Within this group, hydrocephalus in 12% of cases is associated with local tumor recurrence [5,7,10].

In numerous centers, especially those in low-income countries dealing with high patient loads and constraints on early surgery, the management strategies for post-resection hydrocephalus involve commonly pre-resection CSF diversion through either endoscopic third ventriculostomy or

ventriculoperitoneal shunts. It's crucial for surgeons to aware the variable failure rates and time-to-failure associated with both endoscopic third ventriculostomy and CSF shunts in posterior fossa tumors, influencing decision-making in patient management [19,20]. While some studies suggest that prophylactic treatment with internal CSF diversion during initial tumor resection reduces the risk of post-resection hydrocephalus from 26.8% to 6%, adopting this approach for all patients with posterior fossa tumors could potentially subject over 70% of patients to an unnecessary procedure with significant risks. Balancing the benefits and risks is essential in determining the most appropriate course of action for individual cases[1,4,17,21].

Preoperative cerebrospinal fluid (CSF) diversion has been linked with various complications, including supratentorial intracranial hematomas (e.g., extradural, subdural, intracerebral, and intraventricular hemorrhage), numerous shunt-related issues such as malfunction, migration, infection, multiple abdominal complications (viscous perforation, Pseudocyst), long-term shunt dependence, and metastases into the peritoneal cavity or vascular system. Infratentorial complications, such as infratentorial hematoma (ITH) and upward trans tentorial herniation (UTH), are also reported[3,9,14,16–18,22]. Notably, these complications are more commonly observed after ventriculoperitoneal (VP) shunt procedures than ETV[14].On the other hand, occlusive hydrocephalus might be spontaneously resolved after PFL surgery, which implies rather to a conservative management .

Several authors have reported notable success in improving the overall condition of patients after shunting procedures, leading to the disappearance or improvement of symptoms such as somnolence, headache, vomiting, loss of appetite, and double vision[21]. Additionally, there are several advantages to using a shunting device before the definitive craniotomy:

1. **Compensating for Increased Intracranial Pressure (ICP):** Inserting a shunt allows for the compensation of elevated ICP, providing adequate time for stabilization of intracranial contents, particularly cerebral blood flow, and reducing cerebral edema secondary to hydrocephalus[21].
2. **Surgical Field Facilitation**: The operative field becomes slack, facilitating the approach to the tumor and eliminating the need for hypertonic solutions, steroids, ventricular cannulation, or continuous spinal drainage during surgery[16,21].

3. **Smooth Postoperative Course**: Preoperative shunting increases the likelihood of a smooth postoperative course, contributing to better overall outcomes [16].
4. **Reduced Incidence of Complications**: The use of preoperative shunting has been associated with a decreased incidence of postoperative pseudomeningocele formation and CSF leakage, resulting in shortened hospital stays[8].

Utilizing perioperative external ventricular drainage during and after the removal of posterior fossa tumors causing hydrocephalus presents an effective alternative to the preoperative placement of an indwelling shunt. This approach helps avoid issues related to shunt dysfunction, tumor seeding, and upward herniation. Perioperative EVD is beneficial for intraoperative intracranial pressure (ICP) monitoring and drainage of blood and debris-laden CSF, enhancing the safety of the postoperative period and potentially reducing the incidence of aseptic meningitis and the need for postoperative shunting. A common complication of perioperative EVD is infection, occurring in approximately 10% of cases [14,22]. However, the risk of EVD infection can be reduced by using antibiotic pre-treated catheters, as suggested by some studies [8,13].

The endoscopic third ventriculostomy procedure stands as a viable alternative to the permanent shunt placement in cases where hydrocephalus develops following posterior fossa surgery. It may also obviate the need for shunt replacement in cases of shunt malfunction. Moreover, in patients where cerebrospinal fluid (CSF) has caused tumor spread at presentation, ETV allows for chemotherapy administration before tumor excision by effectively controlling hydrocephalus[17]. The success rate of ETVs varies between 71% and over 90% over durations exceeding 9 years[16,17]. . Although ETV failure tends to occur earlier than ventriculoperitoneal shunt (VPS) failure, the long-term treatment durability may be higher for ETV, with a median time to failure of 0.82 months for ETV and 4.7 months for VPS[22]. While the overall complication rate of ETV is reported at 9%, which is lower than associated complications with ventriculoperitoneal shunts, severe complications such as intratumoral hemorrhage, upward herniation, and death have been reported in approximately 1% of cases after ETV. Consequently, pre-resection ETVs remain a subject of controversy[16,17,19]. On the other hand, post-resection ETVs have demonstrated effectiveness in cases of external ventricular drain weaning failure, serving as an alternative to shunt placement [9,16,17,19].

Riva-Cambrin et al. developed a predictive score, the Canadian Preoperative Prediction Rule for Hydrocephalus (CPPRH), based on a large Toronto cohort (n = 331), aimed at identifying pediatric patients at high risk of requiring treatment for persistent hydrocephalus after posterior fossa tumor resection. This scoring system comprises five components: age < 2 years (score of 3), papilledema (score of 1), moderate to severe hydrocephalus (score of 2), cerebral metastases (score of 3), and specific estimated tumor pathologies (medulloblastoma, ependymoma, dorsally exophytic brainstem glioma) (score of 1). The score ranges between 0 and 10, with patients scoring ≥ 5 considered high risk. The sum of the score provides the probability of hydrocephalus at 6 months post-resection[5,9,21] In the modified version (mCPPRH), papilledema is replaced by radiological evidence of Trans-ependymal flow (TEF)[22]. However, according to a retrospective Cort study, the implementation of the mCPPRH score failed to reliably predict which children would require permanent cerebrospinal fluid (CSF) diversion following posterior fossa tumor resection. As a result, clinical judgment remains the primary determinant in choosing perioperative hydrocephalus treatment[12].

For adult patients, the Frankfurt grading system, developed by Sae-Yeon Won and colleagues, serves as a predictive tool for postoperative cerebrospinal fluid (CSF) drainage requirement following the resection of posterior fossa tumors. The system categorizes tumors into intra-axial posterior fossa tumors (iPFTs) and extra-axial posterior fossa tumors (ePFTs). For iPFTs, the grading system comprises four components: preoperative hydrocephalus, periventricular CSF capping, patient positioning during surgery, and expected extent of resection. Each component is assigned 1 point, resulting in grades ranging from 0 to 4. In the case of ePFTs, the grading system includes three components: petroclival or midline location, perilesional edema, and preoperative hydrocephalus. Petroclival location and perilesional edema carry 2 points each, while the other component receives 1 point. The grading system for ePFTs ranges from 0 to 5 points. Patients with a score ≥ 3 points in both iPFTs and ePFTs should undergo prophylactic External Ventricular Drain (EVD) placement, as the risk of requiring postoperative CSF drainage surpasses 75%[23].

2.1 Conceptual framework

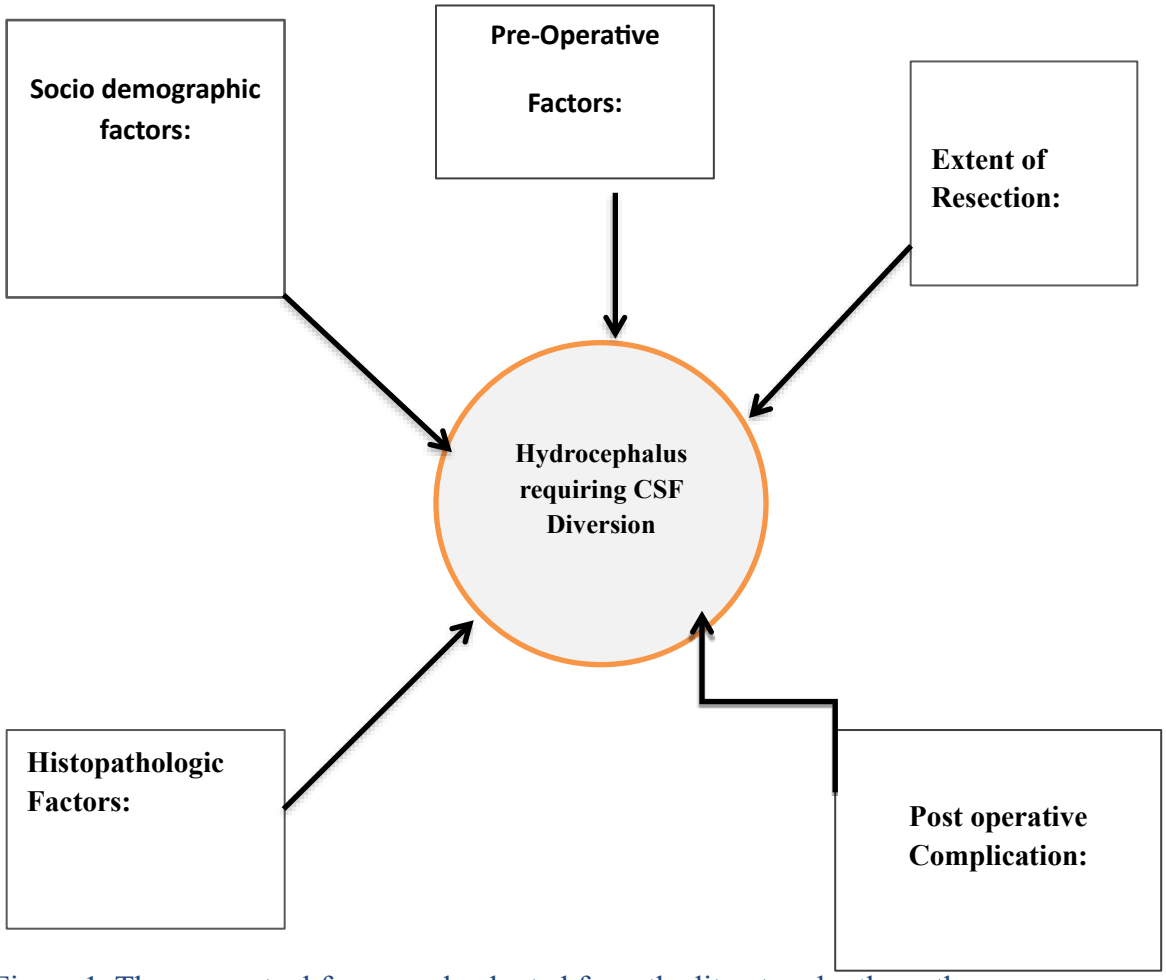


Figure 1. The conceptual framework adopted from the literature by the author.

3. Objectives

3.1 General objective

- To assess the incidence and predictors of permanent CSF diversion after posterior Fossa Tumour Removal

3.2 Specific objectives

- To assess the incidence of permanent CSF diversion following posterior fossa tumor surgery
- To identify common preoperative predictors of permanent CSF diversion after posterior fossa tumor surgery
- To evaluate common postoperative risk factors contributing to permanent CSF diversion following posterior fossa tumor removal.

4. Methods

4.1 Study design and Period

A hospital based 14 months prospective cohort study was conducted to find out incidence and risk factors of permanent CSF diversion among patient operated for posterior fossa tumours in three Addis Ababa Hospitals: TASH, MCM and ALERT Hospitals. Study was conducted from August 01, 2023 to September 30, 2024

4.2 Study Area

The study was conducted at three Addis Ababa Hospitals: TASH, MCM and ALERT hospitals which are Addis Ababa University (AAU) affiliated Neurosurgical teaching hospitals.

4.3 Source Population

All patients undergoing posterior Fossa tumors surgery in three of Addis Ababa University affiliate teaching hospitals: Black Lion Hospital (BLH), Mysung Christian Medical Hospital, ALERT Hospitals

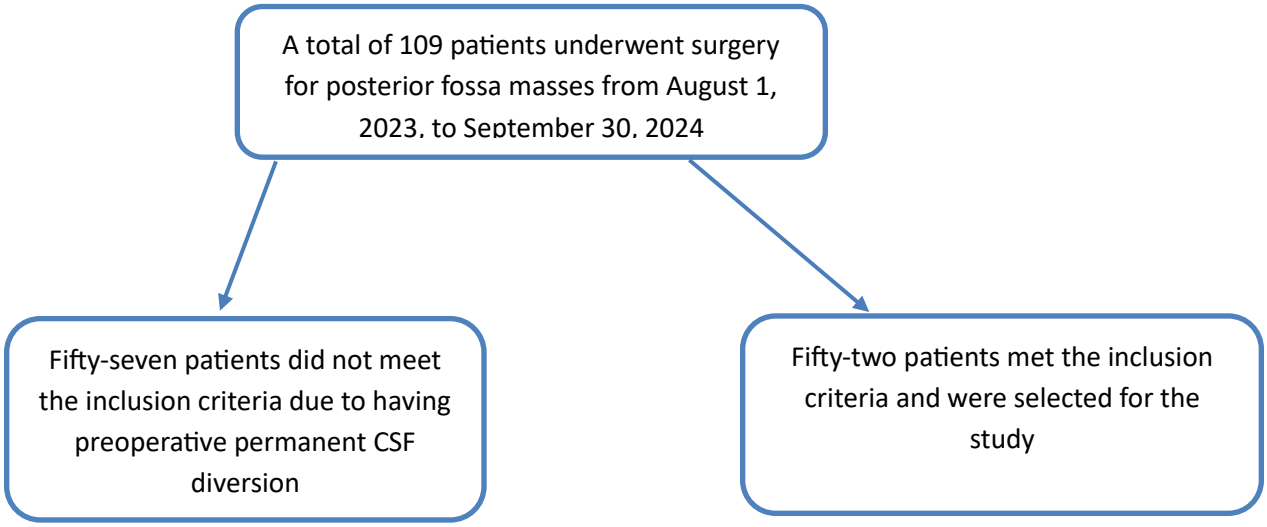
4.4 Study Population

All patients undergoing surgery for posterior fossa Tumors at three of Addis Ababa University affiliates teaching hospitals: BLH, MCM, ALERT Hospitals and fulfilling the inclusion criteria with in the study period

4.5 Sampling method

Non-probability convenience sampling technique was utilized

4.6 Sampling procedure



4.7 Eligibility criteria

4.7.1 Inclusion criteria

- All patients operated for PFT in the three of the study hospitals in the study time period and who are willing for study will be included in the study

4.7.2 Exclusion criteria

- Patients who are unwilling to participate in the study
- Patients who underwent pre-operatively CSF diversion (VPS Shunt or ETV)
- Patients who have no post operative and preoperative images

4.8 Study variables:

4.8.1 Independent variables:

- Age
- Sex
- Signs and Symptoms
- Duration of symptoms
- Size of the tumours
- Location of tumours
- Evans Index and FOHR
- Pre-Operative Trans ependymal CSF transduction
- Extent of resection
- Histopathology
- Post operative Complication
- Pre operative, intraoperative or postoperative EVD
- Pseudo meningocele
- Postoperative CSF leak

4.8.2 Dependent Variables:

- Permanent CSF diversion

4.9 Operational definitions

- **Adult age group**: person greater than 18 years of age[24].
- **Biopsy**: No reduction of tumour volume and administered for tissue-based diagnoses
- **Duration of surgery:** Time taken from skin incision up to skin closure
- **Evans Index:** Ratio of maximum width of the frontal horns of the lateral ventricle and the maximum internal diameter of the skull
- **Gross Total Resection**: Complete removal of contrast enhancing tumours
- **Near Total Resection**: Removal of >95% contrast enhancing tumour or <1cm3 residual contrast enhancing tumour
- **Patient status/Condition -**taken from follow note or description by patient or care giver as improved, same or died
- **Tumer Size-**Largest value after measured diameter from three dimension of tumor
- **New onset Hydrocephalus**: Hydrocephalus that happen after tumour operation
- **Paediatric age group**: Age from birth to 18 years[6]
- **Hydrocephalus**: diagnosed through clinical assessment and by measuring the Evans Index. The severity of hydrocephalus is classified based on the Evans Index as[22,25]: 1. Normal -EI<0.25 2. Borderline -EI 0.25-0.3 3. Mild -EI 0.3-0.34 4. Moderate EI-0.35-0.4 5. Severe EI>0.4
- **Subtotal Resection**: Removal of >80% contrast enhancing tumour or <5cm3 residual contrast enhancing tumour

4.10 Data collection tools and procedures

The data were collected directly from patients or attendants, operation note registry, Biopsy result report, Inpatient and outpatient laboratory report, patient's electronic record, patient's pre op and post op images, card and phone call. The patients were followed Personal and by phone on 1^{st} , 3^{rd} ,6^{th} post op months. The collection instrument was a structured questioner with a check list filled from data sources. The data was collected by Neurosurgical residents and principal investigator.

4.11 Data quality control

Training was given to the data collectors on how to conduct the data collection. Data quality was managed by training and appropriate supervision of principal investigator. Overall supervision was made by the supervisor and principal investigator. And the collected data will be checked its completeness, clarity and accuracy. This quality checking was done daily after data collection and correction will be made. Data clean up, cross checking and double entry were done before analysis.

4.12 Data processing and analysis

The coded data containing demographic, pre op factors, preop imaging factors, post op factors and post op control imaging factors were exported into computer by using SPSS for analysis. Descriptive summary statistics were computed, and then a univariate and multivariate regression analysis was done from the variables.

4.13 Ethical considerations

Study participants were asked for their consent before asking for any information and informed consent was taken from every study participant. Confidentiality of the information were assured by omitting personal identifiers like names The data was analysed anonymously and data sets was kept confidential. Ethical approval were obtained from the Ethical Review Committee of Addis Ababa University.

4.14. Dissemination of the Results

The finding of this research will be shared to the neurosurgery unit so that it can serve as a baseline data to the attending neurosurgeons and fellow residents. This research finding will be submitted to journals for publication.

5.Result

5.1. Sociodemographic characteristics

In this study, 50% of the patients were male, resulting in a male-to-female ratio of 1:1. The majority of the patients were over 18 years old, with a mean age of 33.6 years and a standard deviation of 14.5. Additionally, more than half of the procedures were performed at TASH, as illustrated in the table below.

Table 1.The sociodemographic characteristics of the study patients

Variable	**CSF diversion**		**Total (%)**	**Chi-sqr p-value**
	yes (%)	**No (%)**		
Sex				0.685
Male	3(11.5)	23(88.5)	26(50)	
Female	4(15.4)	22(84.6)	26(50)	
Age in years				0.553
≤18	1(8.3)	11(91.7)	12(23.1)	
>18	6(15)	34(85)	40(76.9)	
Name of institution				
TASH			28(53.8)	
MCM			23(44.2)	
ALERT			1(1.9)	

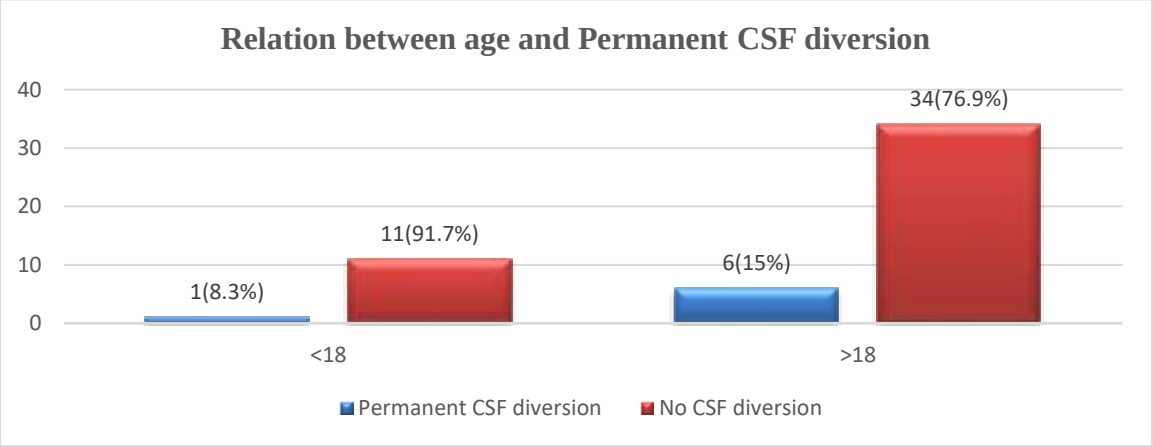


Figure 2. Bar chart showing relation between age and permanent CSF diversion

5.2 Clinical presentation of patients

Ninety-eight percent of the patients complained headaches, while 48.1% experienced nausea and vomiting. Nearly 52% had decreased or blurred vision. Two-thirds of the patients had balance issues, and one-third reported decreased hearing. Most patients presented after experiencing symptoms for 2 to 6 months.

Table 2. Clinical presentation

Variable	CSF diversion		Total (%)	Chi-sqr p-value
	yes(%)	No (%)		
Headache	7(13.7)	44(86.3)	51(98.1)	0.690
Nausea and vomiting	2(8)	23(92)	25(48.1)	0.267
Decreased or blurring of vision	4(14.8)	23(85.2)	27(51.9)	0.766
Change of mentation	2(33.3)	4(66.7)	6(11.5)	0.129
Difficulty of keeping balance	5(14.7)	29(85.3)	34(65.4)	0.719
Decreased hearing	3(18.8)	13(81.3)	16(30.8)	0.456
Extremities weakness	1(9.1)	10(90.9)	11(21.2)	0.632
Irritability	3(42.9)	4(57.1)	7(13.5)	0.014
Sphincter disfunction		1	1(1.9)	
Average duration of symptoms in months				0.838
<2month	1(16.7)	5(83.3)	6(11.5)	
2-6 month	3(16.7)	15(83.3)	18(34.6)	
6-12month	2(15.4)	11(84.6)	13(25)	
>12month	1(6.7)	14(93.3)	15(28.8)	

5.3 physical examination findings

Eighty-eight percent of the patients had a Glasgow Coma Scale (GCS) score of 15, and 98.1% exhibited reactive pupils. The most common physical findings included cranial palsies affecting cranial nerve 9 and 10 in 69% of the patients, while 57.7% displayed cerebellar signs positive, and 25% had deep tendon hyperreflexia.

Table 3. Physical examination finding

Variable	CSF diversion		Total (%)	Chi-sqr p-value
	yes(%)	No (%)		
GCS				0.129
<15	2(33.3)	4(66.7)	6(11.5)	
15	5(10.9)	41(89.1)	46(88.5)	
Pupillary reactivity				0.210
Yes	6(11.8)	45(88.2)	51(98.1)	
no	1(100)	0	1(1.9)	
Cranial nerve palsy				0.058
Yes	7(19.4)	29(80.6)	36(69.2)	
no	0	16(100)	16(30.8)	
Cerebellar sign				0.429
Yes	5(16.7)	25(83.3)	30(57.7)	
no	2(9.1)	20(90.9)	22(42.3)	
Deep tendon hyper reflexes				0.48.2)
Yes	1(7.7)	12(92.3)	13(25)	
no	6(15.4)	33(84.6)	39(75)	

5.4. Pre-Operative Imaging Finding

The majority of patients (57.7%) underwent both MRI and CT scans, while 42.3% had MRI only. Forty-two percent of patients had tumors located in the cerebellopontine angle, followed by 19.2% in the vermis and 19.2% in the cerebellar hemisphere. The study also found that 55.8% of participants had extra-parenchymal tumors, and Majority (53.8%) had tumors measuring 3-5 cm in their largest dimension. Most patients (36.5%) experienced mild ventriculomegaly, and 13.5% had severe hydrocephalus, as classified by the Evans Index. Additionally, 44% of the patients exhibited periventricular CSF capping.

Table 4. Characteristics of preoperative imaging findings

Variable	**CSF diversion**		**Variable (%)**	**Chi-sqr p-value**
	yes(%)	**No (%)**		
Anatomical location of tumor				0.824
Vermis	2(20)	8(80)	10(19.2)	
Cerebellar Hemisphere	1(10)	9(90)	10(19.2)	
Cerebellopontine Angle (CPA)	4(17.4)	19(82.6)	23(44.2)	
4th Ventricle	0	4(7.7)	4(7.7)	
Brain Stem	0	1(100)	1(1.9)	
Petroclival or clival	0	4(100)	4(7.7)	
Tumor category				0.370
Intraparenchymal	2(8.7)	21(91.3)	23(44.2)	
Extra parenchymal	5(17.2)	24(82.8)	29(55.8)	
Size of tumors in greatest dimension in centimeters				0.546
<3 cm	1(33.3)	2(66.7)	3(5.8)	
3-5 cm	3(10.7)	25(89.3)	28(53.8)	
>5 cm	3(14.3)	18(85.7)	21(40.4)	
Classification of hydrocephalus based on Evans Index				0.474
Normal	0	1(100)	1(1.9)	
Borderline	2(15.4)	11(84.6)	13(25)	
Mild hydrocephalus	3(15.8)	16(84.2)	19(36.5)	
Moderate Hydrocephalus	0	12(100)	12(23.1)	
severe hydrocephalus	2(28.6)	5(71.4)	7(13.5)	
Periventricular CSF capping				0.460
Yes	4(17.4)	19(82.6)	23(44.2)	
No	3(10.3)	26(89.7)	29(55.6)	

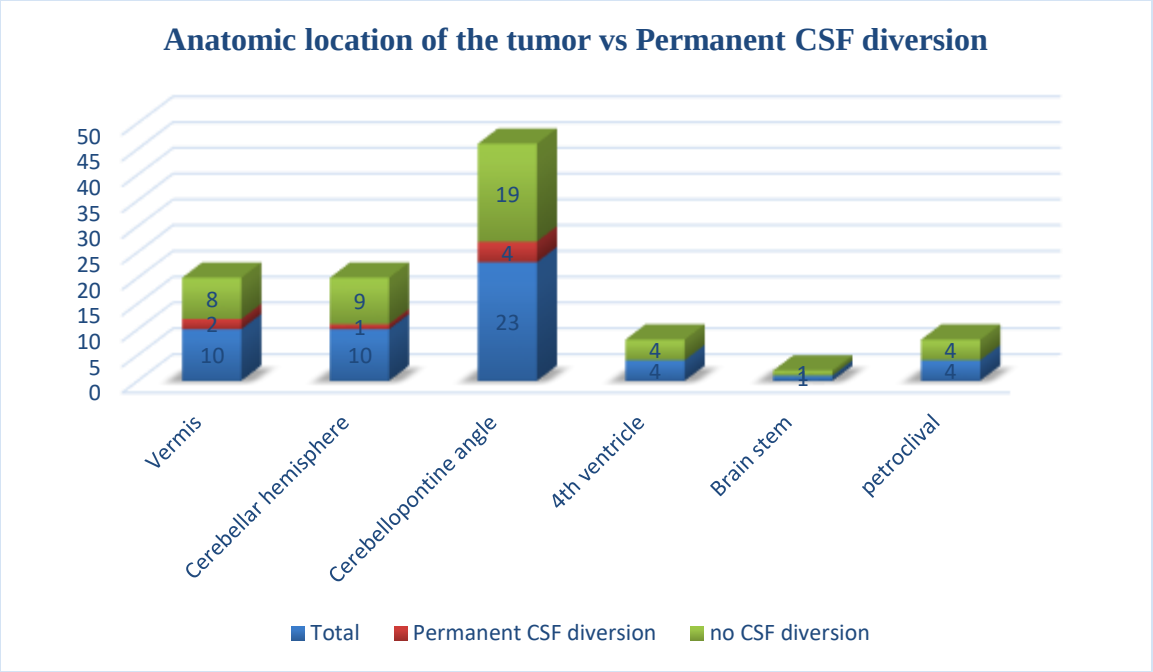


Figure 3. Bar chart illustrating the relationship between tumor anatomical location and permanent CSF diversion

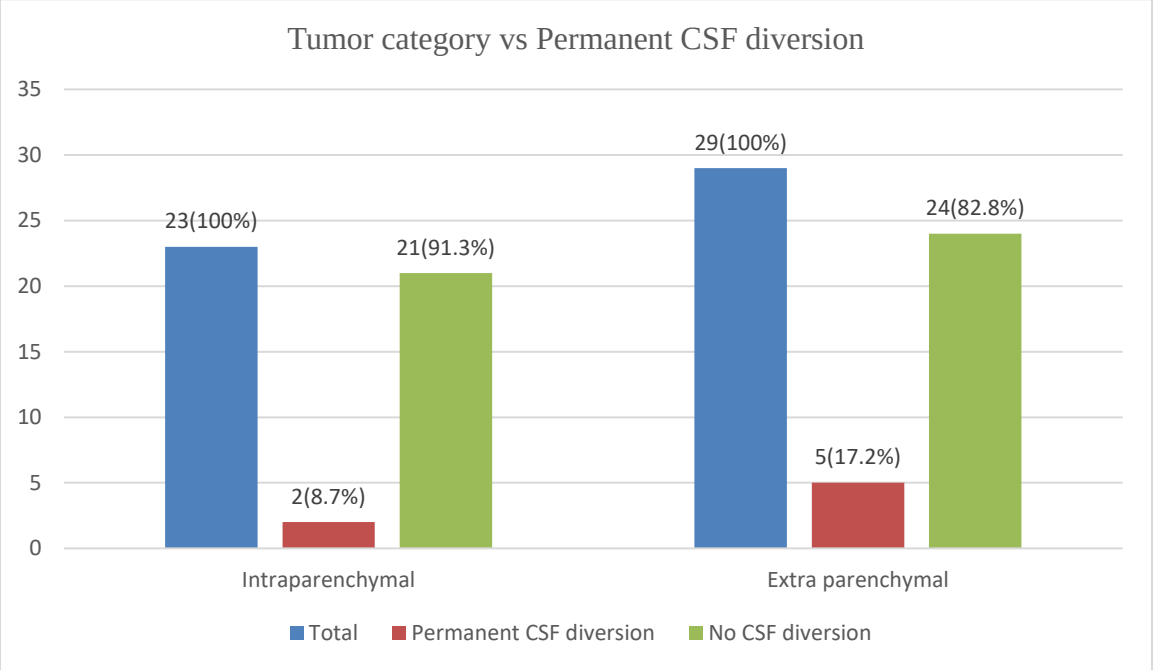


Figure 4. Bar chart depicting the relationship between tumor category and permanent CSF diversion.

5.5 Operation related characteristics of the independent Variable

Forty-six percent of patients were positioned on a park bench, while 38.5 % were positioned prone. EVD was inserted in 71.2 % of patients, with 94.6 % of these insertions performed intra-operatively. For the majority of cases, the EVD remained in place for 5-10 days (56.8 %). Gross Total Resection (GTR) was achieved in 77 % of cases, Near Total Resection (NTR) in 7.7 %, and Subtotal Resection (STR) in 15.4 %.

Table 5. Characteristics of variable related to the operation

Variable	**CSF diversion**		**Total (%)**	**Chi-sqr p-value**
	yes(%)	**No (%)**		
Surgical position				0.277
Prone	2(10)	18(90)	20(38.5)	
Park Bench	5(20.8)	19(79.2)	24(46.2)	
Supine with Lateral rotation	0	8(100)	8(15.4)	
Perioperative EVD use				0.070
Yes	7(18.9)	30(81.1)	37(71.2)	
No	0	15(100)	15(28.8)	
Time of EVD insertion				0.249
Pre-operative	1(50)	1(50)	2(5.4)	
Intra-operative	6(17.1)	29(82.9)	35(94.6)	
Mean duration of EVD Use in days				0.403
<5	3(33.3)	6(66.7)	9(24.3)	
5-10	2(9.5)	19(90.5)	21(56.8)	
11-15	1(33.3)	2(66.7)	3(8.1)	
>15	1(25)	3(75)	4(10.8)	
Extent of Resection				0.410
GTR	4(10)	36(90)	40(76.9)	
NTR	1(25)	3(75)	4(7.7)	
STR	2(25)	6(75)	8(15.4)	

5.6. Characteristics of post operative variable among study patients

In this study, 36.5 percent of patients experienced postoperative complications. The most common complication was a CSF leak (11.5 %), followed by pseudomeningocele and ventriculitis, each occurring in 7.7 5 % of cases, and postoperative IVH in 5.95 percent. In terms of tumor histopathology, meningioma was the most frequent diagnosis (26.9 5 %), followed by schwannoma (21.25 %), medulloblastoma (17.3 5 %), and low-grade astrocytoma (15.4%).

Table 6. Characteristics of post operative variable

Variable	Permanent CSF diversion		Total (%)	Chi-sqr p-value
	yes (%)	No (%)		
Post OP Complication				0.001
Tumor bed Hemorrhage	2(100)	0	2(3.8)	
Post OP IVH	1(33.3)	2(66.7)	3(5.89)	
Pseudo meningocele	0	4(100)	4(7.7)	
CSF Leak	0	6(100)	6(11.5)	
Ventriculitis/Meningitis	2(50)	2(50)	4(7.7)	
None	2(6.1)	31(93.9)	33(63.5)	
Tumor Histology				0.125
Medulloblastoma	2(22.2)	7(77.8)	9(17.3)	
Ependymoma	0	3(100)	3(5.8)	
Low Grade Astrocytoma	1(12.5)	7(87.5)	8(15.4)	
High Grade Astrocytoma	0	1(100)	1(1.9)	
Hemangioblastoma	0	1(100)	1(1.9)	
Schwannoma	2(18.2)	9(81.8)	11(21.2)	
Meningioma	2(14.3)	12(85.7)	14(26.9)	
Papilloma	0	1(100)	1(1.9)	
Cavernoma	0	1(100)	1(1.9)	
Epidermoid Cyst	0	2(100)	2(3.8)	
Others not specified	0	1(100)	1(1.9)	

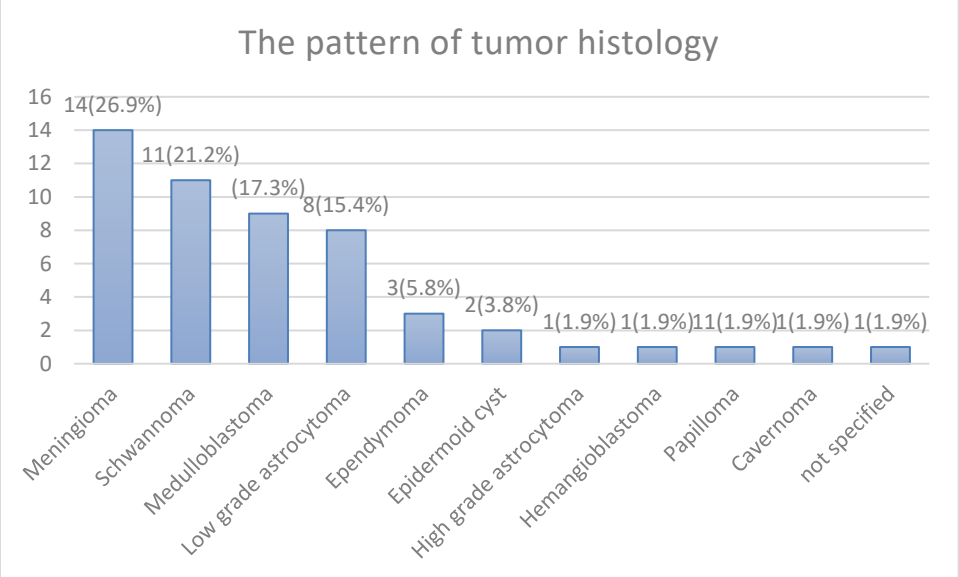


Figure 5. Bar chart depicting patterns of tumor histologic finding

5.7. Incidence of permanent CSF diversion among study patients

The overall incidence of postoperative hydrocephalus requiring permanent CSF diversion was 13 %. Among adult patients (>18 years), the incidence was 15 %, while in pediatric patients (≤18 years)

Table 7. Incidence of permanent CSF diversion among study patients

Age in years	Permanent CSF Diversion		Total
	Yes (%)	No (%)	N(%)
≤18	1(8.3)	11(91.7)	12(23.1)
>18	6(15)	34(85)	40(76.9)

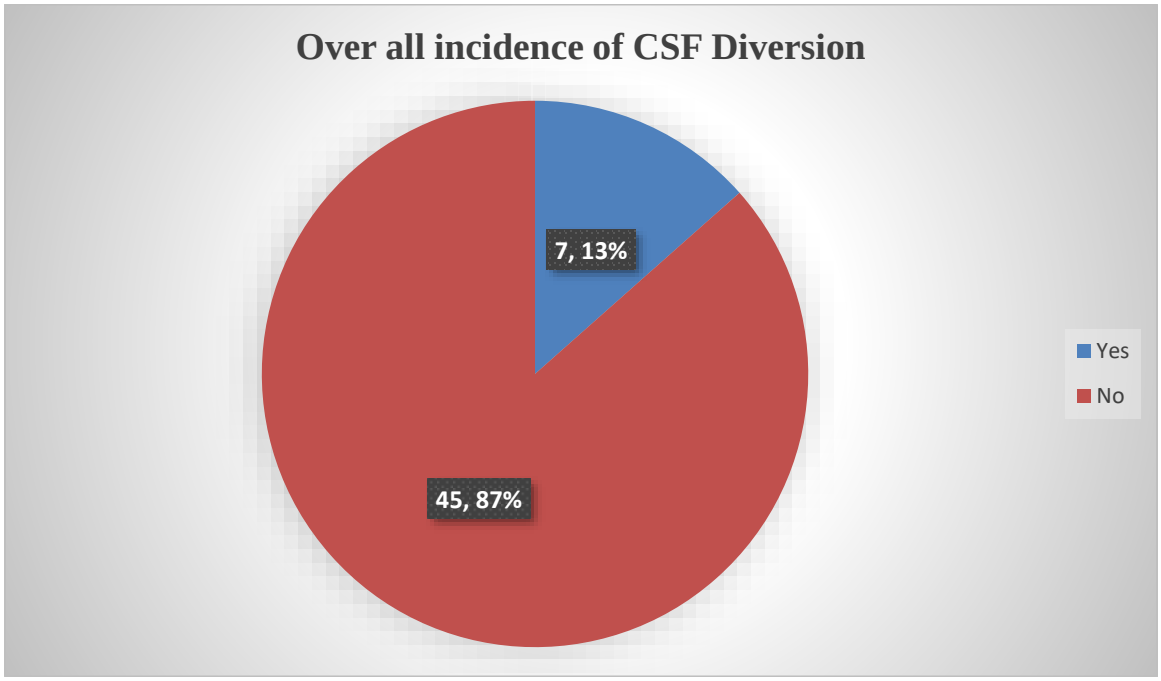


Figure 6. Pie chart showing overall incidence of permanent CSF diversion

5.8. Patients condition during each follow up

All patients (52) were followed up at one month, 48 patients at three months, and 37 patients at six months. Of the seven patients who required permanent CSF diversion, six (85.7%) had shunt placement within the first month, while one received a shunt after the first month postoperatively. Six patients (11.4%) passed away: two in the first month, one in the third month, and three during the six-month follow-up. Among the patients who received shunts, three died during follow-up.

Table 8.The patient's condition or status during each follow up

Variable	**Total (%)**
Permanent CSF diversion done within 1st month Post OP	
Yes	6(11.5)
no	46(88.5)
Patient condition /status at 1st month post OP	
Improved	44(84.6)
Same	6(11.5)
Died	2(3.8)
Permanent CSF diversion done at 3rd month post OP(n=48)	
yes	7(14.6)
No	41(85.4)
Patient condition /status at 3rd month post OP(n=48)	
Improved	42(87.5)
Same	2(4.2)
Worsen	1(2.1)
Died	3(6.3)
Permanent CSF diversion done at 6th month post OP(n=37)	
Yes	7(18.9)
No	30(81.1)
Patient condition /status at 6th month post OP(n=37)	
Improved	31(83.8)
Died	6(16.2)

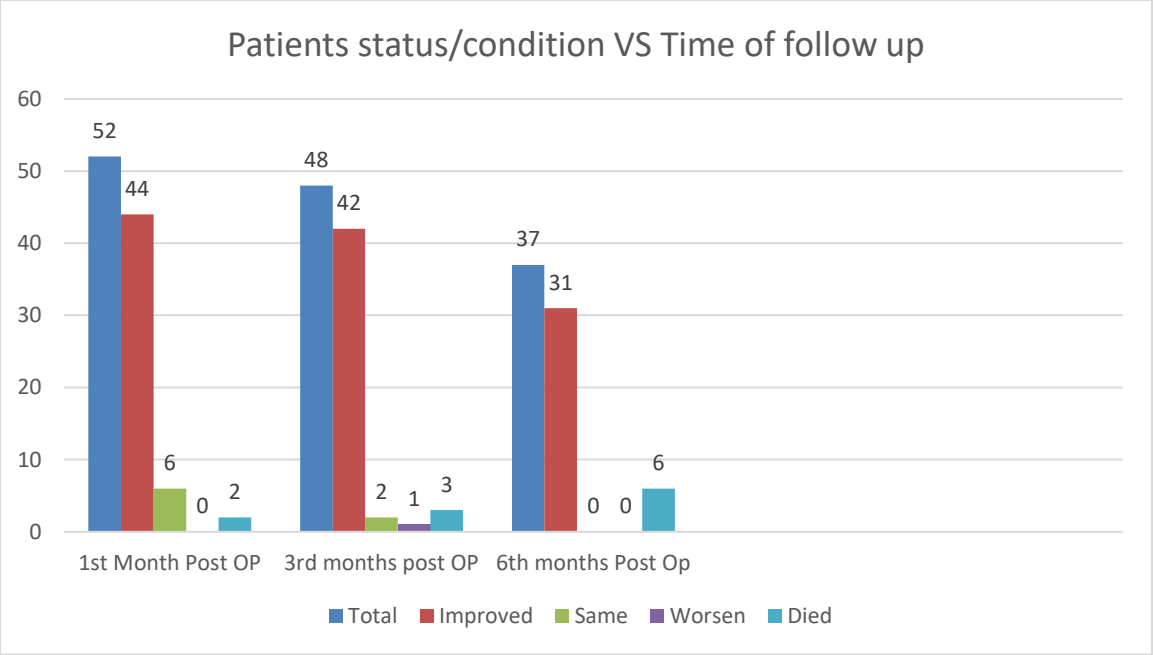


Figure 7. Histogram showing status of the patient during each follow up

Table 9. The relation between status/condition of the patients and permanent CSF diversion during each visit

Time of assessment	Status of the patient	CSF diversion	
		yes(%)	No (%)
Patient condition /status at 1st month post OP	Improved	3(6.8)	41(93.2)
	Same	2(33.3)	4(66.7)
	Died	2(100)	0
Patient condition /status at 3rd month post OP	Improved	4(8.3)	38(91.7)
	Same	0	2(50)
	Worsen	0	1(100)
	Died	2(66.7)	1(33.3)
Patient condition /status at 6^{th} month post OP	Improved	4(12.9)	27(87.1)
	Died	3(42.9)	3(42.9)

5.9. The mean value of the permanent CSF diversion using independent sample T-test

The mean age of patients who underwent permanent CSF diversion was 33.9 years (SD ±20.33), compared to 34.4 years (SD ±17.23) for those who did not require permanent CSF diversion. The mean duration of symptoms for patients with permanent CSF diversion was 9.0 months (SD ±8.00), while for those without it, the duration was 17.7 months (SD ±33.05). The mean size of the tumor in the greatest dimension was 4.9 centimeters for both groups, with an SD of ±1.98 for the permanent CSF diversion group and ±1.071 for the group without it. The mean Evans Index was 0.36 (SD ±0.08) for patients with permanent CSF diversion, compared to 0.34 (SD ±0.058) for those without. The mean duration of EVD use was 10.0 days (SD ±10.71) for the permanent CSF diversion group and 7.4 days (SD ±5.5) for the group without it, as shown in the table below. There was no statistically significant mean difference between the groups with and without permanent CSF diversion.

Table 10. The mean value of the independent and dependent variable using independent sample T-test

Variable	**Permanent CSF diversion**	**N**	**Mean and SD**	**P-value**	**95%CI of the difference**
Age	no	45	33.4±17.23	.835	-15.89, 12.88
	yes	7	34.9±20.33		
Average duration of symptoms in months	no	45	17.7±33.05	.495	-16.71, 34.08
	yes	7	19.0±8.00		
Size of tumors in greatest dimension in centimeters	no	45	4.9±1.071	.905	-1.94, 1.74
	yes	7	4.9±1.98		
Evans Index	no	45	0.34±0.058	.491	-.066, 0.032
	yes	7	0.36±0.08		
Frontal Occipital Horn Ratio	no	45	0.67±0.083	.256	-.110, 0.029
	yes	7	0.69±0.11		
Duration of surgery in minutes	no	45	356.7±107.13	.964	-85.88, 82.1
	yes	7	358.6±63.88		
Duration of EVD use in days	no	30	7.4±5.5	.359	-8.38, 3.12
	yes	7	10.0±10.71		

5.10. The determinant factors of permanent CSF diversion

5.10.1 The binary logistic regression of association between independent variable and permanent CSF diversion

Table 10 below indicates that all independent variables were assessed for their association with permanent CSF diversion. Variables with a p-value of less than 0.25 were then included in a multivariate analysis (Table 11) to identify potential confounding factors and confirm statistically significant variables.

Table 11. Univariate logistic regression analysis for independent variable of permanent CSF diversion

Variable	Permanent CSF diversion		p-value	COR with 95%CI
	Yes (%)	No (%)		
Sex				
Male	3(11.5)	23(88.5)	1	
Female	4(15.4)	22(84.6)	0.685	1.4(0.28, 6.95)
Age in years				
≤18	1(8.3)	11(91.7)	0.559	0.52(0.06, 4.76)
>18	6(15)	34(85)	1	
Nausea or vomiting				
Yes	2(8)	23(92)	1	
No	5(18.5)	22(81.5)	0.279	2.6(0.46, 14.90)
Decreased or blurring of vision				
Yes	4(14.8)	23(85.2)	0.767	1.3(0.26, 6.36)
No	3(12)	22(88)	1	
Change in mention				
Yes	2(33.3)	4(66.7)	0.153	4.1(0.59, 28.38)
No	5(10.9)	41(89.1)	1	
Difficulty of keeping balance				
Yes	5(14.7)	29(85.3)	0.719	1.4(0.24, 7.94)
No	2(11.1)	16(88.9)	1	
Decreased hearing				
Yes	3(18.7)	13(81.3)	0.461	1.8(0.36, 9.42)
No	4(11.1)	32(88.9)	1	
Extremities weakness				
Yes	1(9.9)	10(90.1)	0.636	0.58(0.06, 5.43)
No	6(14.6)	35(85.4)	1	
Irritability				
Yes	3(42.9)	4(57.1)	0.028	7.7(1.25, 47.2)
No	4(7.7)	48(92.3)	1	

Average duration of symptoms in months				
<2month	1(16.7)	5(83.3)	0.495	2.8(0.15, 53.71)
2-6 month	3(16.7)	15(83.3)	0.396	2.8(0.26, 30.18)
6-12month	2(15.4)	11(84.6)	0.469	2.5(0.20, 31.86)
>12month	1(6.7)	14(93.3)	1	
GCS				
<15	2(33.3)	4(66.7)	0.153	4.1(0.59, 28.38)
15	5(10.9)	41(89.1)	1	
Cerebellar sign				
Yes	5(16.7)	25(83.3)	0.235	2.0(0.35, 11.42)
no	2(9.1)	20(90.9)	1	
Deep tendon hyper reflexes				
Yes	1(7.7)	12(92.3)	0.491	0.46(0.05, 4.21)
no	6(15.4)	33(84.6)	1	
Tumor category				
Intraparenchymal	2(8.7)	21(91.3)	1	
Extra parenchymal	5(17.2)	24(82.8)	0.178	2.2(0.38, 12.48)
Size of tumors in greatest dimension in centimeters				
<3 cm	1(33.3)	2(66.7)	1	
3-5 cm	3(10.7)	25(89.3)	0.297	0.24(0.02, 3.51)
>5 cm	3(14.3)	18(85.7)	0.424	0.33(0.02, 4.93)
Periventricular CSF capping				
Yes	4(17.4)	19(82.6)	0.464	1.8(0.37, 9.12)
No	3(10.3)	26(89.7)	1	
Surgical position				
Prone	2(10)	18(90)	1	
Park Bench	5(20.8)	19(79.2)	0.338	2.4(0.41, 13.79)
Supine with Lateral rotation	0	8(100)	0.999	
Time of EVD insertion				
Pre-operative	1(50)	1(50)	0.288	4.8(0.26, 88.53)
Intra-operative	6(17.1)	29(82.9)	1	
Mean duration of EVD Use in days				
<5	3(33.3)	6(66.7)	1	
5-10	2(9.5)	19(90.5)	0.129	0.21(0.03, 1.57)
11-15	1(33.3)	2(66.7)	1.00	1(0.06, 15.99)
>15	1(25)	3(75)	0.765	0.67(0.05, 9.47)
Extent of Resection				
GTR	4(10)	36(90)	1	
NTR	1(25)	3(75)	0.387	3(0.25, 36.10)
STR	2(25)	6(75)	0.258	3(0.45, 20.15)

5.10.2. Univariate and multivariate logistic regression analysis of association between independent variables and permanent CSF diversion

To assess the association between independent variables and the need for permanent CSF diversion, odds ratios (OR) and 95% confidence intervals (CI) were calculated. All independent variables were initially analyzed using bivariate logistic regression, with those showing a p-value <0.25 subsequently included in a multivariate logistic regression model. As a result, irritability emerged as the only variable with a statistically significant association with permanent CSF diversion. Patients presenting with irritability had an 8.7-fold increased likelihood of requiring permanent CSF diversion compared to those without irritability (AOR=8.7, 95% CI=1.08, 70.1).

Table 12. Univariate and multivariate logistic regression analysis of independent variables and permanent CSF diversion

Variable	CSF diversion		p-value	COR with 95%CI	P-value	AOR with 95%CI
	yes	no				
Change of mentation						
Yes	2	4	0.153	4.1(0.59, 28.38)	0.222	4.3(0.42, 43.79)
no	5	41	1		1	
Irritability						
Yes	5	2	0.028	7.7(1.25, 47.2)	0.042	8.7(1.08, 70.1)
No	6	43	1		1	
GCS						
<15	2	4	0.153	4.1(0.59, 28.38)	0.324	2.4(0.25, 12.56)
15	5	41	1		1	
Cerebellar sign						
Yes	5	25	0.235	2.0(0.35, 11.42)	0.585	1.7(0.25, 11.71)
no	2	20	1		1	
Tumor category						
Intraparenchymal	2	21	1		1	
Extra parenchymal	5	24	0.178	2.2(0.38, 12.48)	0.178	5.0(0.48, 52.25)

6.Discussion

Hydrocephalus associated with posterior fossa tumors presents a common neurosurgical challenge, and there is ongoing debate on whether to perform a preoperative permanent CSF diversion or proceed directly with definitive tumor resection. This study was conducted to determine the incidence of postoperative hydrocephalus requiring permanent CSF diversion in both pediatric and adult patients with posterior fossa tumors. Additionally, it aimed to identify predictors of postoperative hydrocephalus necessitating permanent CSF diversion. Our study included 52 patients, with an equal gender distribution of 50% male, yielding a male-to-female ratio of 1:1. All 52 patients had a one-month follow-up, 48 were followed for three months, and 37 were followed for six months. Most patients were adults (over 18 years). The overall incidence of postoperative hydrocephalus requiring permanent CSF diversion was 13%, with an incidence of 15% among adult patients, which comparable with previous studies[24], and 8.3% in pediatric patients, which is lower than reported in prior series[6]. This discrepancy may be attributed to the small sample size in our study.

The most common symptom reported was headache (98%), followed by nausea or vomiting (48.1%), and decreased or blurred vision (52%). Two-thirds of the patients experienced balance issues, and one-third reported reduced hearing, consistent with previous literature[5,6]. Symptoms were analyzed using chi-square, univariate, and bivariate analysis, revealing that only irritability was significantly associated with the need for permanent CSF diversion (P value = 0.028). Most patients presented after experiencing symptoms for 2 to 6 months. Our study found no association between symptom duration and the need for permanent CSF diversion; however, other studies suggest that patients presenting within 3 months are more likely to require permanent CSF diversion[6].

The majority of patients (57.7%) underwent both MRI and CT scans, while 42.3% had MRI alone. The most common tumor location was the cerebellopontine angle (44.2%), followed by the vermis and cerebellar hemisphere, each accounting for 19.2%; the fourth ventricle (7.7%); the Petro clival or clival region (7.7%); and the brain stem (1.9%). Previous studies suggest that tumors located in the fourth ventricle and midline are more likely to be associated with the need for permanent CSF diversion[6]; however, our study did not find a significant association. The study also found that

55.8% of tumors were extra-parenchymal, which contrasts with findings in previous studies[24]. Our study did not show a statistically significant association between tumor type and the need for permanent CSF diversion, though other research indicates that patients with intra-axial tumors are more likely to require permanent CSF diversion[23]. Most tumors (53.8%) measured 3-5 cm in their largest dimension, while 40.4% exceeded 5 cm. Our study did not find a statistically significant association between tumor size and the need for postoperative permanent CSF diversion. The relationship between tumor size and permanent CSF diversion varies across studies; some have found a significant association, while others have not[6,24].

Most patients (72.6%) had hydrocephalus on preoperative imaging (EI > 0.3), with 36.5% presenting with mild hydrocephalus (EI = 0.3-0.34) and 13.5% with severe hydrocephalus (EI > 0.4). The reported incidence of preoperative hydrocephalus varies across the literature[2,5,6,24]. Our study did not find a significant relationship between the severity of preoperative hydrocephalus, as measured by the Evans Index, and the need for permanent CSF diversion, although some studies suggest that patients with a higher Evans Index(EI>0.34) are more likely to require a postoperative shunt[6,22,23]. Among those with preoperative hydrocephalus, 44% showed periventricular CSF capping on imaging. Our study found no association between periventricular CSF capping and the need for postoperative permanent CSF diversion, and previous studies on this association have shown inconsistent results[10,22–24].

Gross Total Resection (GTR) was achieved in 77% of cases, Near Total Resection (NTR) in 7.7%, and Subtotal Resection (STR) in 15.4%. Our study found no statistically significant association between the extent of resection and the requirement for permanent CSF diversion, a relationship that varies across different studies[2,5,6,10,23,24]. Regarding patient positioning, 46% were positioned in the park bench position, and 38.5% in the prone position. While some studies have found a significant association between the semi-sitting position and permanent CSF diversion, others have not[2,10,23], and none of our patients were positioned semi-sitting. External Ventricular Drains (EVDs) were placed in 71.2% of patients, with 94.6% of these placed intraoperatively. In the majority of cases (56.8%), the EVD remained in place for 5-10 days. Although previous studies suggest that perioperative EVD use and extended EVD duration are linked to a higher likelihood of permanent CSF diversion[6,8,24], our study did not find this association.

In this study, 36.5% of patients developed postoperative complications, a rate slightly higher than reported in previous studies[24]. The most common complication was a CSF leak (11.5%), followed by pseudo meningocele and ventriculitis, each in 7.7% of cases, postoperative IVH in 5.9%, and tumor bed hemorrhage in 3.8%. Our study did not find any specific postoperative complications significantly associated with the need for permanent CSF diversion. However, previous literature has shown significant associations between postoperative complications such as IVH, tumor bed hemorrhage, ventriculitis/meningitis and the requirement for permanent CSF diversion[2,5,6,8,24].

In terms of tumor histopathology, meningioma was the most frequent diagnosis (26.9%), followed by schwannoma (21.2%), medulloblastoma (17.3%), low-grade astrocytoma (15.4%), and ependymoma (5.8%), with other tumor types making up less than 15%. Prior studies indicate that meningioma and schwannoma are the most common histologic diagnoses in adults[2,5,23,24], while low-grade astrocytoma, medulloblastoma, and ependymoma are more frequent in pediatric patients[22,26]. Our findings align with former pattern, likely because the majority of our patients were adults. Although some studies have found a statistically significant association between histologic types like medulloblastoma and ependymoma and the need for permanent CSF diversion[6,10], our study did not confirm this association.

7.Conclusion

This is prospective study aimed to determine the incidence and predictors of postoperative hydrocephalus requiring permanent CSF diversion after posterior fossa tumors (PFTs) resection. We analyzed both pre- and postoperative variables that could impact the likelihood of needing permanent CSF diversion. Our results show an overall incidence of 13%, with a 15% incidence in adult patients and 8.3% in pediatric patients. Notably, we found a statistically significant association between irritability at presentation and the need for postoperative permanent CSF diversion. To strengthen these findings and develop a risk prediction model for identifying high-risk patients in low-income countries, further large-scale prospective cohort studies are recommended.

8. Limitations of the study

This study was conducted on a small sample size and did not include a broad range of both adult and pediatric patients, which may limit the generalizability and applicability of our findings across all age groups, as well as affect the statistical power of our results. A larger sample size with a more diverse patient demographic would be necessary to confirm these findings and enhance their robustness. Additionally, standard EVD weaning protocols were not consistently practiced due to concerns over EVD infection. Furthermore, some patients with postoperative hydrocephalus passed away while still on EVD, before their need for subsequent CSF diversion could be fully established.

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10.Annexes

10.1 Questionnaire

1. Sociodemographic Data	**2. Symptoms Increased ICP at Presentation (Yes or No)**
1.1 Card no_____ 1.2 sex _____ 1.3 age_____ 1.4 Address_____ 1.5 phone no_____ 1.6 Hospital A) TASH _____ B) MCM _____C.ALERT Hospital	2.1. Headache - 2.2. Nausea or vomiting- 2.3. Decreased (Burring) Vision- 2.4. Decreased Mentation- 2.5. Extremity weakness- 2.6. Abnormal body movement - 2.7. Irritability- 2.8. Increased head size - 2.9. Sphincter dysfunction- 2.10-Other Specify- **2.11. Average duration of symptoms –**

3.Physical Finding	**4. Imaging**
3.1. GCS- 3.2. Pupillary reaction; Reactive ___ Nonreactive___ 3.3. Cranial Nerve Palsy Yes___ No___ if yes specify Cranial nerve involved ___ 3.4. Hyper reflexes Yes___ No__ 3.5.Other Specify-	4.1 Modality of Diagnosis CT- MRI- Both- 4.2 Location of Tumour A. Medline (Vermian) B. Lateral (Cerebellar Hemispheric) C. Cerebellopontine Angle D. 4th Ventricular E. Brain Stem F. Extra-Axial G. Intra-Axial G-Other Specify- 4.3 size of Tumour in Greatest Dimension in Centimetres- 4.4. Evans Index- 4.5. FOHR- 4.6. Trans ependymal transduction (Flow) of CSF? Yes No

5.**Operative Status**

5.1. Date of surgery-

5. 2. Duration of surgery-

5.3. Position: a. Prone b. Park bench c. Sitting d. Other Specify-

5.4. Did EVD Placed? Yes No If yes a. pre-Operative b. Intra-Operative c. post-Operative

5.5. Extent of Resection from post OP images a. GTR b.NTR (Size of remained tumour diameter in cm) c. STR (Size of remained tumour diameter in cm) d. Biopsy (Size of remained tumour diameter in cm)

6. Postop status

6.1. If EVD was inserted duration of EVD before removal –

6.2. Did the patient have post OP ICH? If yes, volume of ICH-

6.3. Did patient develop post Op complication? a. Yes b. No

6.4. If question 6.3 yes, what type complication the patient developed? A. Post OP IVH B. Pseudo meningocele c.CSF leak d. ventriculitis/Meningitis

6.5. **What is histopathology diagnosis?** A. Medulloblastoma B. Ependymoma C. Low Grade Astrocytoma D.High Grade Astrocytoma E.Metasteses F.Hemangioblastoma G.Shwannoma H.Meningioma I. Other Specify-

7.**Patient Condition on one month post op**

7.1. Do the patient has **symptoms Increased ICP (yes or No):** a.Headache - b,Nausea or vomiting-c,Decreased (Burring) Vision- d,Decreased Mentation- e.Abnormal body movement - f.Irritability-g.Increased head size - h,Sphincter dysfunction-

7.2. Did the patient require permanent CSF diversion? Yes - No-
7.3. If question 7.2 yes, how long after craniotomy? -
7.4. If question no 7.2 yes, what is indication of CSF Diversion? a. Persistent Hydrocephalus b.New onset hydrocephalus c. Pseudo meningocele d.CSF Leak e. hydrocephalus 2ry to tumor recurrence
7.5. Patient Out come at 1 month's post OP **A.** Improved B. Same C. Worsened D. Dead

7.6. If patient died, what is cause of death?

8.Patient Condition at 3rd month Post Op

8.1. Do the patient has **symptoms Increased ICP (yes or No):** a.Headache - b,Nausea or vomiting-c,Decreased (Burring) Vision- d,Decreased Mentation- e.Abnormal body movement - f.Irritability-g.Increased head size - h,Sphincter dysfunction-

8.2. Did the patient required permanent CSF diversion? Yes - No-
8.3. If question 8.2 yes, how long after craniotomy? -
8.4. If question no 8.2 yes, what is indication of CSF Diversion? a. Persistent Hydrocephalus b.New onset hydrocephalus c. Pseudo meningocele d.CSF Leak e. hydrocephalus 2ry to tumor recurrence
8.5. Patient Out come at 3rd month's post OP **A.** Improved B. Same C. Worsened D. Dead

8.6. If patient died, what is cause of death?
9.Patient Condition at 6rd month Post Op

9.1. Do the patient has **symptoms Increased ICP (yes or No):** a.Headache - b,Nausea or vomiting-c,Decreased (Burring) Vision- d,Decreased Mentation- e.Abnormal body movement - f.Irritability-g.Increased head size - h,Sphincter dysfunction-

9.2. Did the patient required permanent CSF diversion? Yes - No-
9.3. If question 9.2 yes, how long after craniotomy? -
9.4. If question no 9.2 yes, what is indication of CSF Diversion? a. Persistent Hydrocephalus b.New onset hydrocephalus c. Pseudo meningocele d.CSF Leak e. hydrocephalus 2ry to tumor recurrence
9.5. Patient Out come at 6rd month's post OP **A.** Improved B. Same C. Worsened D. Dead

9.6. If patient died, what is cause of death?