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COLLEGE OF HEALTH SCIENCES

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DEPARTMENT OF RADIOLOGY AND RADIOTHERAPY

SPECTRUM OF PAEDIATRIC POSTERIOR CRANIAL FOSSA TUMORS AT THREE SELECTED HOSPITALS IN UGANDA

BY

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DECLARATION

I, **Lochoro Flavio**, declare that this dissertation is my own and has never been submitted for any academic award of Makerere University or any other institution of higher education.

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DEDICATION

This work is dedicated to my family and the friends who have been my side and supported me throughout my academic journey.

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LIST OF ACRONYMS

%	Percent
AT/RT	Atypical teratoid/Rhabdoid tumour
BG	Brainstem Glioma
CI	Confidence Interval
CNS	Central Nervous System
CT	Computer Tomography
df	degrees of freedom
DV	Dependent Variable
DWI	Diffusion Weighted Imaging
HTN	Hypertension
IQR	Interquartile Range
IRB	Institutional Review Board
IV	Independent Variables
JPA	Juvenile Pilocytic Astrocytoma
LMICs	Low to Middle-Income Countries
MB	Medulloblastoma
MRI	Magnetic Resonance Imaging
PCFT	Posterior Cranial Fossa Tumors
REC	Research and Ethics Committee
SOMREC	School of Medicine Research and Ethics Committee
$\chi 2$	Chi – square
UCI	Uganda Cancer Institute

OPERATION DEFINITIONS

Posterior fossa: The infra-tentorial cranial space containing cerebellum, brainstem and 4th ventricle in between.

Tumor: An abnormal tissue growth

Pediatric: By Ugandan laws is anyone less than 18 years of age.

Head CT: A computer tomography examination extending from vertex to cervical vertebrae 1 (C1).

Multi-slice CT scanner: A four and above slice scanner.

ABSTRACT

Pediatric primary brain tumors are the second most common types of childhood cancers, following hematologic malignancies. They constitute the most prevalent solid tumors in children, making up approximately 40–50% of all pediatric tumors. To date, there is limited published institutional or multi-institutional data regarding the profile of pediatric posterior cranial fossa brain tumors, in Sub-Saharan Africa, especially in Uganda. this study aimed to describe the clinical presentation and cranial computer tomography scan findings in children with posterior cranial fossa at three selected hospitals in Uganda.

This retrospective cross-sectional hospital-based study analyzed pediatric patients' records and cranial CT images from the past 7 years (2015 – 2022) at three selected hospitals. It focused on patients aged 0 to 18 years with a histological diagnosis. Data was collected, entered into Redcap through double entry, cleaned, and analyzed using STATA 15.1. Age was presented as mean ± standard deviation or median (interquartile range), while sex and types of posterior cranial fossa tumors were presented as proportions.

The study included patients with a median age of 7 years [IQR: 4 – 11 years], with a majority being female (60.6%). The most common intracranial tumor types were Juvenile Pilocytic Astrocytoma (JPA) at 29.4%, followed by medulloblastoma at 26.5%, and Brain/pontine glioma at 25.4%. Clinical presentations included ataxia (50%) in hemicerebellar syndrome and hemiparesis (29.4%) in focal brain stem compression. Increased intracranial pressure was commonly associated with headache (55.9%) and vomiting (47.1%). The location of posterior fossa tumors (PCF) had significant associations with histological diagnosis: midline ($\chi2 = 66.9291$, $p = 0.000$), other brain structures ($\chi2 = 30$, $p = 0.026$), and left side ($\chi2 = 16$, $p = 0.004$). Significant differences ($\chi2 = 38.71$, $p = 0.000$) were found among histological tumor types and density-heterogeneity-contrast, as well as contrast enhancement patterns ($\chi2 = 27.48$, $p = 0.000$) and hydrocephalus ($\chi2 = 23$, $p = 0.000$) with histological tumor diagnoses. However, there was no significant association ($\chi2 = 6.5704$, $p = 0.160$) among different histological tumor types and calcifications. Furthermore, a significant statistical difference ($\chi2 = 14.59$, $p = 0.007$) was observed among various diagnosed histological tumors in relation to mass effect-parenchymal edema. However, there was a statistically insignificant difference ($\chi2 = 10.043$, $p = 0.283$) in the location of posterior fossa tumors in the brain among different diagnosed histological tumor types.

In conclusion, the location of posterior fossa tumors (PCF) is significantly related to histological diagnosis: midline, other brain structures, and left side. Significant differences were found in tumor characteristics, including density, contrast enhancement patterns, and hydrocephalus. However, no significant association was found with calcifications. Importantly, mass effect-parenchymal edema significantly varied among histological tumor types, but the location of posterior fossa tumors did not. Therefore, clinical presentations and radiological findings can assist in profiling posterior fossa tumors in pediatric patients.

CHAPTER ONE: INTRODUCTION

1.0 Introduction

Brain tumor is one of the most devastating forms of human illness, especially when occurring in the posterior fossa and involving the brainstem. Cushing was the first to report a large series of posterior fossa tumors [1]. He published information about 61 patients with cerebellar medulloblastoma (MB) with mostly fatal outcome. Since then outcomes have improved because of advances in the discovery of anesthesia, asepsis, neurological localization, and technique of tumor removal and the crucial role of imaging in the initial workup, management, and post-treatment follow-up of primary pediatric posterior fossa tumors [2].

Tumors in the posterior fossa are considered some of the most critical brain lesions. This is primarily due to the limited space within the posterior fossa, as well as the potential involvement of vital brainstem nuclei. The posterior fossa is situated between the tentorium cerebelli above and the foramen magnum below. Anteriorly the clivus, anterolaterally the petrous ridge of the temporal bones, laterally the mastoid part of the temporal bones, and posterior-inferiorly the occipital bone forms the bony landmarks of the posterior fossa. The cerebellum, the pons, and the medulla are situated within it [3].

These tumors may present across all pediatric age groups, including infants, children, adolescents, and young adults, with the majority of cases presenting in the first decade of life. Clinical presentations vary, based upon the type of tumor, location, and patient age; however, the most common presenting symptoms include headaches, nausea and vomiting, and gait abnormalities [4]. In infants and very young children, obstructive hydrocephalus results in macrocephaly with bulging fontanelle [5]. Brainstem tumors commonly have symptoms associated with involved tracts and cranial nerves. Therefore, some patients should undergo operation on an emergency basis, especially if they present with acute symptoms of brainstem involvement or herniation.

1.1 Background of the study

Primary brain tumors are a varied group of benign and malignant tumors originating from the brain parenchyma and its surrounding tissues. They are one of the most debilitating disease forms causing human suffering especially when they occur in the posterior cranial fossa as well as brainstem (due to presence of vital nuclei therein). They are thus regarded as some of the most important CNS tumors. Posterior fossa tumors may be intra-axial or extra–axial, but intra–

axial tumors are common in children. These tumors may be primary or secondary [6-8]. It is reported that primary CNS tumors are second to only leukemia among the most common neoplasms diagnosed in childhood, and are the most common solid tumors in childhood, with an estimated incidence of 2–3.5 per 100,00 [9] [10].

Primary brain tumors are the leading cause of death from solid tumors in childhood [11, 12]. In children PCF tumors are the more common than supra–tetorial CNS tumors, accounting for 54–70% compared to 15–20% seen among adults [13]. Examples of common posterior fossa tumors in children are medulloblastoma (MB), Juvenile Pilocytic Astrocytoma (JPA), ependymoma, and Brainstem Glioma (BG). Less commonly, other types such as atypical teratoid/rhabdoid tumor (ATRT), dermoids, hemangioblastomas, meningiomas are seen. Typically, review of presenting complaints and physical examination leads to list of differential diagnoses to include a posterior fossa mass prompting imaging to make the diagnosis.

The clinical presentation of a child with posterior fossa mass is dependent on the anatomical location, histologic type and the presence or absence of hydrocephalus [14]. The posterior fossa is only one tenth of the intracranial volume and contains structures that are responsible for vital functions. Patients with posterior fossa tumors may present with signs and symptoms of raised intracranial pressure or compression of cerebellum, brain stem and cranial nerves. Such patients mostly present with cerebellar symptoms, multiple cranial nerve palsies, headaches, vomiting, blindness due to raised intracranial pressures, ataxia and long tract signs such as motor weakness [13],[15]. These clinical symptoms prompt neuroimaging (CT scan and MRI of the brain). Magnetic resonant imaging (MRI) is the investigation of choice in patients with posterior fossa lesions [16-18].

Location, characterization, and extension pattern of the tumor as well as other imaging findings provide a reliable prediction of tumor type. Although MRI is considered the imaging modality of choice in neuroimaging for evaluation of posterior fossa tumors [19], cranial CT scans are more commonly available and currently are an essential tool for neuroimaging, especially for initial diagnosis of patients with posterior cranial fossa tumors in our setting [20]. Treatment options for posterior fossa tumors are surgical excision, paliative shunting for hydrocephalus, and or chemo/radiotherapy. However, posterior fossa surgery involves greater morbidity, mortality and variety of complications [21]. The final diagnosis is confirmed with the histopathology report when lesions are biopsied or resected [22-24]

To date, there is limited published institutional or multi-institutional data regarding the profile of pediatric posterior cranial fossa brain tumors, in Sub-Saharan Africa, especially in Uganda. The epidemiology, clinico-pathologic and radiologic profiles of these brain tumors, remain obscure. The paucity of this information is associated with delayed timely diagnosis and precise intervention that is critical to the overall management and survival of children with posterior cranial fossa tumors [25]. Therefore, understanding the clinico-radiologic features of posterior cranial fossa tumors is of utmost significance in infratentorial tumor management and improved survival outcomes in Uganda and loco-regionally.

1.2 Problem Statement

Pediatric primary brain tumors are the second most common types of childhood cancers, following hematologic malignancies. They constitute the most prevalent solid tumors in children, making up approximately 40–50% of all pediatric tumors. The incidence of these tumors varies, ranging from 1 to 3 cases per 100,000 in different studies[26]. In childhood primary Central Nervous System (CNS) tumors, those located in the posterior cranial fossa account for more than 50% [27]. These tumors are the leading cause of cancer-related deaths in pediatric patients and pose significant treatment challenges, particularly in regions with limited resources, such as Sub-Saharan Africa, including Uganda. The epidemiology of posterior cranial fossa tumors in Uganda remains obscure, with the available data showing in homogeneous results arising from single and isolated hospital experiences that reported either specific histologic types or intracranial tumors in general. However, little is known about posterior cranial fossa tumors with the majority of them likely misdiagnosed, presenting late, lost to follow–up or poorly managed and inevitably resulting in the poor survival outcomes seen. The poor survival outcomes coupled with high morbidity and disability has led to a disproportionate burden of cancer mortality among these patients, with less than one–third of likely to survive at least 5 years after diagnosis except Juvenile pilocytic astrocytoma (JPA), which has a favorable prognosis. The lack of data profiling posterior cranial fossa tumors including their clinical presentation, brain CT scan findings and management outcomes warrants a multi-institutional study to map the spectrum of pediatric posterior cranial fossa tumors in Uganda, which is the aim of this study.

1.3 Objectives of the study

1.3.1 General objective

To describe the spectrum of common posterior cranial fossa tumors among children presenting for care at the three selected hospitals in Uganda.

1.3.2 Specific objectives

The following specific objectives guided the study;

i) To describe the distribution of clinical and demographic findings of children with posterior cranial fossa brain tumors presented at the three selected hospitals (two government aided and one private non – for – profit) in Uganda.
ii) To describe the distribution of radiologic findings of cranial CT examinations done among children with posterior cranial fossa brain tumors presented at the three selected hospitals in Uganda.
iii) To describe the relationship between cranial CT findings and the histological classification of common posterior cranial fossa tumors in children with posterior cranial fossa brain tumors presenting at the three selected hospitals in Uganda.

1.4 Research Questions and Hypotheses

The following research questions and hypotheses were developed to aid in the attainment of the study objectives.

1.4.1 Research Questions

i) What are the clinico-demographic findings of children with posterior cranial fossa brain tumors presented at the three selected hospitals in Uganda?
ii) What are the radiologic findings of cranial CT examinations among this population?
iii) What is the relationship between cranial CT findings and the histological classification of tumors in the study group?

1.4.2 Research Hypotheses

i) Clinic-demographic features do not affect the final histological classification of common posterior cranial fossa tumors among children with posterior cranial fossa brain tumors.

ii) Cranial CT findings do not influence the histological classification of common posterior cranial fossa tumors.

1.5 Significance of the study

The results from this study will provide information on the presentation, radiologic pattern, operation outcomes and predictors of outcome among children with posterior fossa tumors loco–regionally and thus be used for advocacy for improved investigation and management. The study will provide future scholars with information to carry out further research in brain tumors information about the prevalence and predictors of survival of children with posterior cranial fossa tumors in Uganda.

1.6 Justification of the study

Despite the increasing incidence of posterior cranial fossa tumors [28], in Uganda, most patients have poor outcomes. This is attributable to among many factors: delayed or missed diagnosis, advanced disease at presentation, late referral, nosocomial infections, treatment delays chemo– and radiotherapy as well as lack of support psycho–socio services. Notably, there is no local study thus far that has been conducted and published to profile these tumors in order to orient clinicians on presenting complaints, radiologic findings on brain CT scan and potential treatment outcomes following management. This study will aid in timely diagnosis, early referral as well as combined multispecialty case management necessary for improved management outcomes and a reduction in the mortality and morbidity currently associated with posterior cranial fossa tumors. In addition, results obtained from this study will enable pediatric oncologists, radiologists and neurosurgeons set up a standard posterior cranial fossa database as well as management and follow–up protocols for pediatric patients with posterior cranial fossa tumors at Mulago NRH, UCI and Cure Children's Hospital.

1.7 Conceptual Frame Work

The conceptual framework in figure 1 below postulates that histological diagnosis of patients with posterior fossa tumors can be made using the patient's social demographic characteristics, clinical presentation, and brain CT findings. Clinical presentations vary, based upon the type of tumor, location, and patient age; however, the most common presenting symptoms include; hemi-cerebellar syndrome (ataxia, nystagmus and dysmetria), focal brain stem compression (ocular palsies, diplopia and hemiparesis), intracranial HTN (headache, vomiting, strabismus, blurring of vision, meningismus, hydrocephalus, macrocephally, dizziness, convulsions, delayed or retarded milestones. Whereas brain CT findings such as mass location (midline

posterior fossa mass), density–heterogenisity, parenchymal oedema, pressure effect, obstruction–hydrocephallus, calcifications, solid/cystic or both, and enhancement. Finally, socio–demographic characteristics (moderating factors) such as age category, gender, address, family history, and time between onset of symptoms and clinic presentation are postulated to be factors that influence a good prognosis of histological diagnosis of children with posterior cranial fossa tumor.

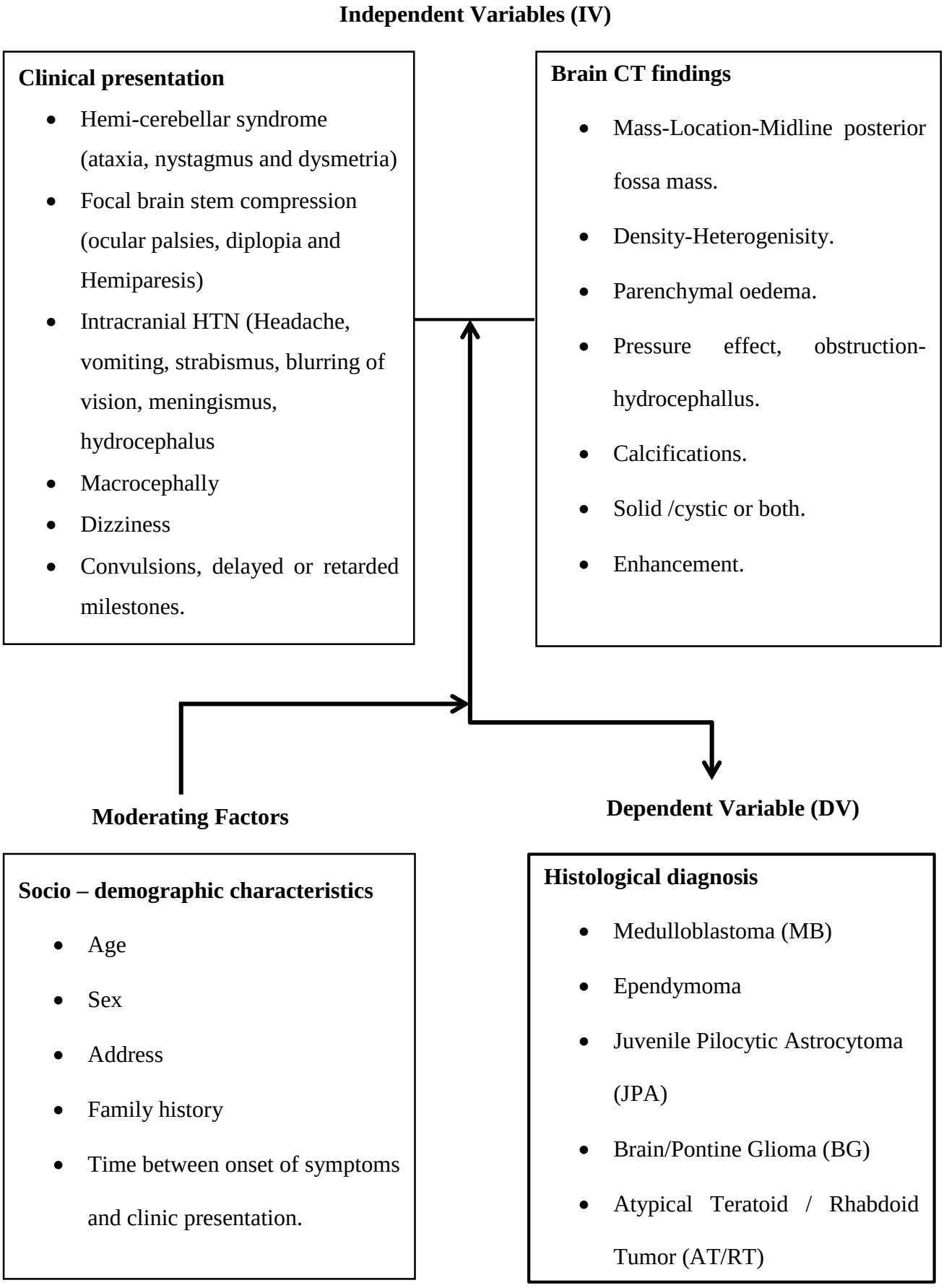


Figure 1: Conceptual framework showing associated factors with posterior cranial fossa tumors among children with posterior cranial fossa brain tumors.

CHAPTER TWO: LITERATURE REVIEW

2.1 Definition

Cancer is a disease condition in which abnormal cells divide uncontrollably with potential to spread to surrounding and distant body tissues. Primary CNS, CNS cancers are those cancers that originate from brain and spinal cord. Posterior cranial fossa tumors are an example of primary CNS cancers. These cancers pose long term physical, psychosocial and economic challenges to these children, their caregivers and caretakers [29-31].

2.2 Prevalence of pediatric posterior fossa tumors

Central Nervous System tumors are the most common solid cancers among pediatric patients with an average annual age-adjusted incidence rate of 5.57 per 100,000 population and account for the second most common cause of cancer-related deaths in childhood [32, 33]. PCF tumors account for approximately 45–60% of all pediatric brain tumors [34], most of these are diagnosed between ages 3 and 11years [34]. The prevalence of these tumors appears to be influenced by location i.e. most high grade gliomas arise from the pons compared to medulloblastoma and juvenile pilocytic astrocytoma that arise more commonly from the cerebellum [34]. Medulloblastoma accounts for majority of PFTs (30-40%), followed by Juvenile Pilocytic Astrocytoma (25–35%) brainstem gliomas (20–15%), Ependymoma (10–15%) and ATRT is the least common accounting for less than 1–2% [34].

According to a study by Wanyoike et. al. (2017) in Kenyatta National Referral Hospital, of the 37 children treated with PCF tumors, 99% were female. This study also concluded that posterior fossa tumors were more common among females than males. The study also revealed that, the most common PCF tumor was medulloblastoma, and the second most common histological diagnosis was JPA, accounting for 30% of the diagnoses. [35].

Moawia Mohammed Ali Elhassan et. al. (2017) in a retrospective review of 31 children with Posterior cranial fossa tumors at the National Cancer Institute of Sudan, the most common tumors seen were brainstem gliomas (48%) followed by medulloblastomas that accounted for 36% of the histological diagnoses. In these series, females were majority (51%) compared to 49% males [36].

A similar retrospective study by Kwasi et. al. (2014) at the Neurosurgical Unit of the Kenyatta National Referral and Teaching Hospital, 54 patients with posterior fossa were seen. 18 had

medulloblastoma 90% of whom were female. The other common tumor was JPA accounting for 30% of all cases [37].

2.3 Clinical presentation of posterior fossa cranial tumors

There are varied signs and symptoms seen in children with posterior fossa cranial tumors. These depend on site of tumor, its biological behavior and as well as rate of growth. Symptoms such as headache, nausea, vomiting, restlessness and poor feeding have been attributed to increased intracranial pressure in the setting of hydrocephalus [38]. Macrocephaly and bulging of anterior fontanelle have been reported among infants with raised intracranial pressure associated with hydrocephalus.

2.3.1 Signs and symptoms of posterior fossa cranial tumors

Symptoms occur very early with posterior fossa tumors because of their limited space. It may include drowsiness, headache, imbalance, ataxia, seizures, and symptoms associated with raised intracranial pressure like nausea, vomiting, and blurring of vision [39]. Symptoms from posterior fossa tumors also occur when the tumor damages local structures, such as the cranial nerves, or compresses the brain stem. Symptoms of cranial nerve damage include dilated pupils, facial muscle weakness, hearing loss, loss of taste, paresthesia, and vision problems [40]. Due to narrow confinement at the base of the skull, complete removal of posterior fossa tumors has certain difficulties. Therefore, accurate segmentation of posterior fossa tumors is necessary [39]. For the examination of intracranial tumors, MRI is the gold-standard imaging modality. Conventional and contrast-enhanced imaging helps us in identifying the size, shape, site, cellularity, intratumoral hemorrhage, calcification, and extension of the tumor. Compression of the surrounding vital structures and peritumoral edema can also be identified; however, it’s difficult to tell about the nature of the tumor [41].

2.3.1.1 Ataxia and Hypotonia

Ataxia refers to a disturbance in the smooth performance of voluntary motor acts due to the absence of cerebellar inhibitory and modulation influences on skilled movements originating in the cerebral motor cortex [42]. The limbs, trunk or gait are usually affected presenting acutely, or in an episodic or progressive fashion. Ataxia also includes abnormalities of voluntary control of movement such as asnergia (lack of synergy) of various muscle components in performing more complex movements so that the movements are broken into isolated successive parts. It also includes dysmetra (defined as abnormal excursions in movement), dysdiadochokinesia (impaired performance of rapidly alternating movements) and

past pointing. Additionally, patients with cerebellar disease often have a wide–based stance and a gait characterized by staggering and impaired tandem walking [43]. Truncal ataxia, which is a sign of ataxia characterized by instability of the trunk, and titubation, a type of essential tremor, which is a nervous system disorder that causes uncontrollable, rhythmic shaking. These suggest midline cerebellar tumors such as MB, ependymoma and vermian astrocytomas. It is manifested by a tendency to fall frequently and widely based gait. Hemicerebellar on the other hand involves limb ataxia, nystagmus and dysmetria [44]. Lateral cerebellar tumors in childhood have been shown to paradoxically present with truncal ataxia despite the fact that bulk of the tumor being hemispherical rather than vermian in terms of location. This has been attributed to the influence of hydrocephalus producing a truncal form of ataxia characterized by a wide-based gait associated with impaired of tandem walking. However, in the absence of intracranial hypertension, truncal ataxia combined with spasticity is suggestive of intrinsic vermian rather than cerebellar tumor [44].

2.3.1.2 Rapid alternating movements

To evaluate rapid alternating movements, the patient is asked to touch their index fingertips in front of the examiner with their eyes closed. Dysmetria-abnormal range of motion and direction can be detected. For better precision, the patient may be asked to touch the tip of their nose and then the examiner's index finger-also known as the finger-nose test to test even for the mildest form of incoordination, terminal intentional tremor and dysmetria [44].

2.3.1.3 Tremor

This is a non-rhythmic movement of the trunk of extremities that may occur at rest or during action. It is a major feature of cerebellar disease usually occurring in action and maximal at the end of range movement i.e. terminal intentional tremor [44].

2.3.1.4 The Reflex Signs

Cerebellar tumors usually present with hypo-reflexia, often of the lower limbs. Symptoms such as hyperactive reflexes, Babinski sign or spasticity are symptoms that maybe suggestive of brainstem compression by cerebellar tumor or direct brainstem invasion by cerebellar tumor [44].

2.3.1.5 Cerebellar Mutism

Although commonly reported as a post-operative complication following resection of posterior fossa tumors, this symptom ranging from altered speech production, muteness and emotional

lability can occur preoperatively as well. In one case reported of a 7-year old with cerebellar mutism due to JPA arising from the quadrigeminal plate [45].

2.3.1.6 Abducens nerve palsy

The paired Abducens nucleus is located in the dorsal lower portion of the pons, separated from the floor of the fourth ventricle by the genu of the facial nerve aka facila colliculus. Lesions of the Abducens nucleus that occur early in life can cause Mobius syndrome or Duane's retraction syndrome whose common presentation includes a horizontal gaze disturbance, facial diplegia. This syndrome has been reported in patients with Pontine Glioma [46]. Abducens nuclear lesions produce a conjugate horizontal gaze palsy toward the side of the lesion, often associated with other neurologic signs of injury of the pons (usually ipsilateral peripheral CNVII palsy) [46].

2.3.2 Symptoms associated with posterior cranial fossa tumors

2.3.2.1 Headache

This is the most common symptom in patients with posterior cranial fossa tumors. In the study by Kameda-Smith, M., et al. (2013) among children with posterior cranial fossa, headache was reported among 63.6% of patients [47]. In children between 0 – 13 years, it presents as irritability and difficulty to be handled. It is insidious, intermittent, and severe in the morning and following a nap because of the raised intracranial pressure from recumbence and hypoventilation during sleep. Other associated complaints include neck pain, stiffness or head tilt suggestive of tonsillar herniation into the foramen magnum.

2.3.2.2 Nausea and vomiting

This is an equally common presentation in children with posterior cranial fossa tumors. In the same study by Kameda-Smith, M., et al. (2013), nausea and vomiting was reported to occur among 75.8% of children with posterior cranial fossa tumors [47]. It has been attributed to raised intracranial pressure or irritation of the vagal nuclei in the medulla oblongata or area postrena of the fourth ventricle. Projectile vomiting has been reported as well and may be associated with relief of headache, especially in the morning.

2.3.2.3 Lethargy

Loss of normal childhood energy and vomiting maybe the only symptoms of raised intracranial pressure. Young children may not complain of headache or diplopia. Lethargy is a relatively common symptom as it was present among 28.8% of children in one study [47].

2.3.2.4 Hydrocephalus and macrocephaly

Children with posterior cranial fossa tumors commonly present with shorter duration of these symptoms than Supratentorial tumors due to early obstruction of CSF pathways [25]. The most common presentation therefore are signs of raised intracranial pressure and hydrocephalus [48, 49]. In the study by Kameda-Smith, M., et al. (2013), 80.3% children with these tumors presented with radiological evidence of hydrocephalus in the initial cranial CT scan [47].

The open cranial sutures allow for increased volume caused by tumor, hydrocephalus or a combination of both. Associated findings such as nystagmus, sun–downing and malalignment of the eyes can be seen. Less specific symptoms like vomiting, lethargy, irritability and poor feeding, in one study, were more common than focal neurologic deficits. This has been attributed to the relative immaturity of the neonatal brain [49]. In the study by Işık and Özek (2015) among newborns with congenital intrinsic brainstem tumor signs and symptoms included, increased head circumference, hyper-reflexia, hypotonia, stridor, drooling of saliva, abnormal gag reflex, nystagmus, dysconjugate eye movements and facial palsy [50].

2.4 Cranial CT imaging features of paediatric cranial fossa tumors

2.4.1 Medulloblastoma

Head CT scan (contrasted and non-contrasted) is often employed as first line imaging tool in the emergency department largely because it's more available and quicker than MRI. Three quarters of medulloblastoma arise from the cerebellar vermis and tend to protrude into the 4^{th} ventricle. Cyst formation/necrosis is sometimes observed in older patients. Effacement of the 4^{th} ventricle and ventricular dilation due to obstructive hydrocephalus are often seen. Avid contrast enhancement is present in 90% cases with calcification seen in 10-20% cases [51-53].

2.4.2 Cerebellar Juvenile Pilocytic Astrocytoma (JPA)

These tumors tend to be located around the 3^{rd} and 4^{th} ventricles. CT- scan evaluation often reveals a hypo-isodense oval well demarcated and smoothly marginated cystic tumor with a solid, avidly enhancing nodular component. Generally, a large cystic component is present. The cystic component is hypodense and the solid nodular component is isodense compared to surrounding brain parenchyma before contrast. On administration of contrast, there is avid enhancement of the solid nodule and occasionally the walls of the cyst; enhancement of the cyst wall suggests but is not diagnostic of the presence of tumor cells within the cyst wall lining. Adjacent parenchymal edema may occur but is less common due to the indolent nature

of JPAs. A less common appearance is solid peripheral enhancement with central necrosis. Larger masses result in compression and obstruction of the fourth ventricle with associated hydrocephalus [54-57].

2.4.3 Ependymoma

At the time of clinical presentation, infratentorial ependymoma usually fills and distend the 4th ventricle resulting in hydrocephalus and symptoms of raised intracranial pressure such as nausea and vomiting in majority cases. Head CT findings suggestive of infratentorial ependymoma include fourth ventricular lateral recess heterogeneous (with areas of necrosis, cystic change and hemorrhage) mass that may extend through the foramina of Luschka and Magendi hence the term comparing it to toothpaste. This is a characteristic feature identifiable on both CT and MRI [57-59].

2.4.4 Brain/Pontine Glioma

On CT scan , this presents as a diffuse, infiltrative heterogeneous mass expanding the pons, often affecting more than 50-75% the cross-sectional area.[60]. It may distort the 4th ventricle, resulting in a degree of hydrocephalus. There is heterogeneous enhancement of the solid components following contrast administration; enhancement characteristics vary during treatment. Cystic or necrotic components are not uncommon with higher grade lesions [61].

2.4.5 Atypical Teratoid Rhomboid Tumor (ATRT)

Although it may arise anywhere within the CNS, the majority (2/3) arise from the posterior cranial fossa compartment. According to the study by Lee et al.(2009), of ATRT in children, results showed that, of the 17 lesions seen in 16 patients, 11 tumors (6 vermis, 3 brainstem, and 2 CPA) were infratentorial (65%) and 6 tumors (35%) were Supratentorial (3 frontal lobe,1 temporal lobe) one Parieto-occipital lobe and one lateral ventricle location) [62].

On cranial CT/MR imaging, ATRT appears as a poorly enhancing ill-defined posterior fossa midline mass causing obliteration of the 4th ventricle with resultant acute obstructive hydrocephalus. According to one case report of a child with ATRT of the posterior cranial fossa by Rahmat et al. (2008), typical imaging findings revealed included; multiple prominent cystic/necrotic areas associated with an inhomogeneous contrast-enhanced solid component [63]. These findings were consistent with documented imaging findings of ATRT in available literature [64, 65].

There are significant similarities between the imaging features seen in medulloblastoma and ATRT. One such feature synonymous with both ATRT and MB is hyper attenuation on unenhanced CT, (in addition to areas of necrosis, cyst formation and hemorrhage) that reflects the high nuclear/cytoplasmic ration seen on Immunohistochemistry. However, one distinguishing feature of ATRT is a distinct and unusual pattern of a wavy band-like enhancement surrounding a central hypo density reported by Warmuth-Metz et al. (2008) seen in 12/32 (38%) of children with ATRT in whom contrast medium was administered [66].

CHAPTER THREE: METHODOLOGY

3.1 Study Design

The study was a retrospective hospital-based descriptive crossectional study involving review of pediatric patients' medical files and radiology findings of cranial Computed Tomographic (CT) scan images done within the last 5 years (2015–2021) in three selected hospitals (two government aided and one private non-profit) in Uganda.

3.2 Study Setting

The study was conducted at three hospitals in Uganda, namely, Cure International hospital in Mbale, Uganda Cancer Institute – Mulago, and Mulago National Referral Hospital – Mulago. Cure Hospital is located in the central business district of Mbale, Mbale district approximately 221 km from Kampala. It is a specialized neurosurgery children's hospital owned and administered by CURE International. Opened in 2000, the hospital serves more than 7,000 outpatients, performing more than 1,000 operations per year.

Opened in 1967, UCI is a public medical facility under the Ministry of Health, with focus on research, training, consultation, prevention and cancer treatment. UCI has a bed capacity of more than 80 beds. It attends to an average of about 200 patients daily. The facility is located along Upper Mulago Hill Road, on Mulago Hill, in the Kawempe- Division of Kampala, about 4.5 kilometers North-East of the central business district of Kampala. UCI is a specialized cancer treatment Center with various units/departments including the pediatric oncology unit.

The pediatric oncology unit runs outpatient clinic from Monday to Friday, receives, and treats an average of 25 pediatric cancer patients every day. The pediatric oncology unit has 35-bed admission capacity and has treated 550 new pediatric cancer patients in 2017 and 582 new pediatric cancer patients in 2018. Children with or suspected to have posterior fossa tumors seen at pediatric oncology unit of UCI are referred from Mulago Hospital pediatric surgery department, other Government and private health facilities, such as Cure Hospital. Posterior fossa tumor patients are managed and followed–up in conjunction with Mulago national referral hospital neurosurgery department. They undergo surgery at UCI.

3.3 Study Population

The study was conducted among pediatric patients (0 – 18 years) with a histological diagnosis of a posterior fossa tumor who received care at the three selected hospitals.

3.4 Eligibility Criteria

3.4.1 Inclusion Criteria

- All patients below 18 years with a histological diagnosis of a posterior fossa tumor.
- Must have been enrolled at one of the three selected hospitals in Uganda and a medical record containing histological diagnosis results, CT results and clinical presentation information.

3.4.2 Exclusion Criteria

- Patients with inconclusive histological reports.

3.5 Target Population

Children with posterior fossa tumors in Uganda attending care at one of the three selected hospitals in Uganda.

3.5.1 Accessible Population

All children who had a histological diagnosis of posterior cranial fossa brain tumors and were managed at the three selected hospitals in Uganda between 2015 and 2020.

3.6 Study Period

The research was conducted between August 2015 and June 2022.

3.7 Sample Size Determination and Selection

3.7.1 Sample Size Determination

The study sample size was estimated using the Cochran's sample size formula [67] for categorical data shown below;

$$\boldsymbol{n = \frac{Z^2_{\alpha/2} \times (p)(q)}{e^2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \boldsymbol{eqn.\ 1}$$

Where;

$n =$ Required sample size;

$Z_{\alpha/2} =$ value for selected alpha level of .025 in each tail = 1.96 (the alpha level of 0.05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error).

$(p)(q) =$ estimated variance = 0.044, for posterior fossa (infrateritorial) tumors comprise between 54% and 70% of childhood brain tumors compared to 15%–20% in the adult population [68].

$e =$ acceptable margin of error = 0.05 for the proportion of children that present with posterior fossa (infrateritorial) tumors.

Therefore, the computation for the required sample size, *n* is as follows;

$$\boldsymbol{n} = \frac{1.96^2 \times .0.044}{0.05^2} = 67.61216 \cong \mathbf{68}\ children \ldots eqn.2$$

3.7.2 Selection Procedure

The researcher employed a stratified sampling technique, in this technique all the expected patients are included in the sample basing on the hospital form which the study selected. The above sample size obtained is the distributed to the selected hospitals by the formula shown below;

$$n_i = \frac{N_i}{N} * n$$

$where,$

$n_i -$ Total number of patients from a given selected hospital.

$N_i -$ Total number of patients from the different selected hospitals

$N -$ Total number of patients from all the three selected hospitals

$n -$ The predetermined sample size.

Table 1: Distribution of the sample size into the different selected hospitals

Selected Hospitals	**(N_i)**	**Calculation** $n_i = \frac{N_i}{N} * n$	**(n_i)**
Government Hospital 1	48	$= \frac{48}{145} * 68$	22
Government Hospital 2	22	$= \frac{22}{145} * 68$	10
Private Non-Profit Hospital	73	$= \frac{73}{145} * 68$	36
TOTAL	**145**		**68**

Source: Primary data 2023

3.7.3 Sampling procedure

A sample of 145 numbers was generated using Microsoft excel. This was applied to the sampling frame of the pediatric patients managed at the selected three hospitals in Uganda among children with posterior fossa tumor cases. Those who did not meet the inclusion criteria, were not chosen and the next random number were selected not until the sample size of 145 patients was met.

3.8 Data Collection Methods

The research team identified study patients in the three selected hospitals (two government aided and one private non-profit). The patients' files (or records) containing the socio-demographic characteristics of the patients, clinical presentation, and brain CT scan findings were reviewed from these hospital data archives for the study period. The research team reviewed the patient images and medical records for research purposes.

Following approval of the proposal by Institution Review Board (IRB), following its 159 convention of 21/12/2021, the investigator set out to the three selected hospitals managing patients with posterior cranial fossa brain tumors to obtain permission to access archived patient records. Two data clerks were identified, the medical files were retrieved and de-identified cranial CT images of the eligible patients were compiled. The research team then captured the clinical presentation and examination findings into the data collection tool and together with the radiologists, reviewed the cranial CT scan and captured the required findings.

3.9 Study Tool

A data collection form (see **appendix III**) was developed to capture the relevant information from the selected patient files obtained from the hospital archives. The form included segments covering demographic information, clinical manifestation, imaging-based lesion description, and a histopathology report. The cranial CT scan was captured in the form to clarify the radiological aspects of posterior fossa tumors in pediatric patients.

3.10 Quality Assurance and Control

All the data extraction was done by the principal investigator with help of well-trained research assistants. The study was conducted with close monitoring of the research supervisors and radiologists. The CT scans images used in the study were of good quality for both non–contrast and contrasted studies as assessed by the imaging technologists and attending radiologists. Data was collected after training on the study questionnaire and before conducting the study. Supervision by attending radiologists was done to ensure compliance throughout the study. During data collection, data collection tools were reviewed at the end of each session so that corrections were made in addition to checking for completeness.

3.11 Data Management and Analysis

Data from files of the participants was double-checked before being entered into Redcap using double entry method; data was cleaned and exported as Stata file. Data collected was entered into an electronic database using redcap by double entry method; de-identification carried out and coded then entered into a statistical package. The cleaned data was imported into STATA 15.1 for analysis. Continuous variables like age, were summarized as mean ± standard deviation or median (IQR). While categorical variables like sex were summarized in proportions and tables or graphs. A p – value of ≤ 0.05 was considered significant. Chi-square (χ^2) analyses with the Fisher's exact tests were performed to establish the associationbetween variables since all the variables of interest were categorical in nature and cell counts were mostly < 30 counts.

3.12 Ethical Considerations

Anonymity was maintained by using codes or initials instead of patient names. Permission to conduct the study was sought from the Department of Radiology – Makerere University College of Health Sciences. Ethical approval to carry out the study was obtained from the School of Medicine Research and Ethics Committee, SOMREC. Administrative clearance as well as permission to access patient files/ records was obtained from Mulago NRH, Cure

Children's Hospital and UCI administration through their respective research and ethics committees. The IRB was provided with updates to ensure no deviations from the protocol in addition to provision of the finished work. A waiver of consent was requested and subsequently reviewed for approval by the REC. During the study, the data extraction form bore study numbers instead of individual names for purposes of confidentiality. No individual identities will be used in any reports or publications resulting from the study.

3.13 Dissemination of Results

The findings from this study may be published in a medical journal. The researchers will publish results of the study in accordance with the respective journal or manuscript guidelines along with Makerere University guidelines. The findings from this study will also be presented to the Department of Radiology and Radiotherapy, College of Health Sciences Makerere University which will keep archives for free access in both soft and hard copies for current and future students and staff in case of use as reference study material. In addition, records of the study findings will be uploaded on Makerere University Main Library Repository for access by University stakeholders and affiliated institutions.

CHAPTER FOUR: RESULTS AND PRESENTATION OF FINDINGS

4.0 Introduction

The purpose of the study was to describe the spectrum of common posterior cerebral fossa tumors in children presenting for care in three Ugandan hospitals. It specifically described the clinico-demographic findings of children with posterior cranial fossa brain tumors; the radiologic findings of cranial CT examinations performed among children with posterior cranial fossa brain tumors; and the associations between clinico-demographic, cranial CT findings, and histology in children with posterior fossa tumors presented in three selected Ugandan hospitals (two government-aided and one private non-profit). The results are presented based on the study objectives as follows;

4.1 Socio-demographic findings of children with posterior cranial fossa brain tumors

Sex distribution of patients

Figure 1 below shows that majority of the patients presenting with PCF tumors in this study were female (60.6% [48.1 – 71.9]).

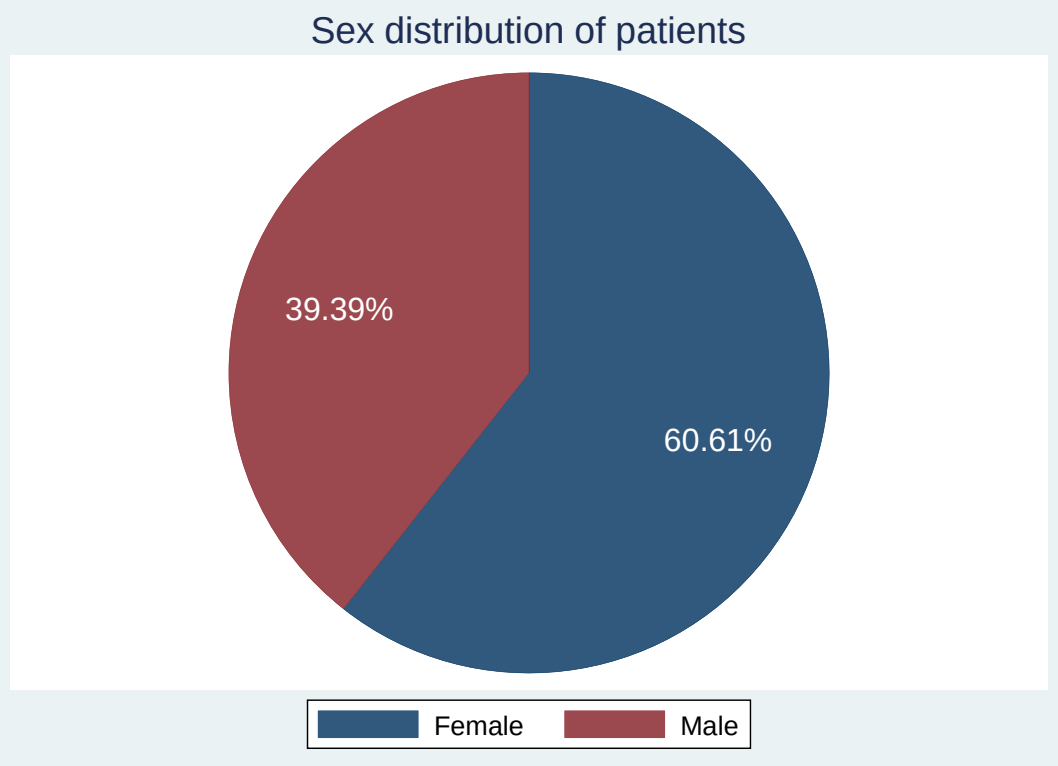


Figure 2: Sex distribution of study patients

Age in years of patients

The study also reveals that the median age of the study patients was 7 years with an interquartile range (4 – 11 years) as presented in figure 2 below. The age distribution is skewed to the right.

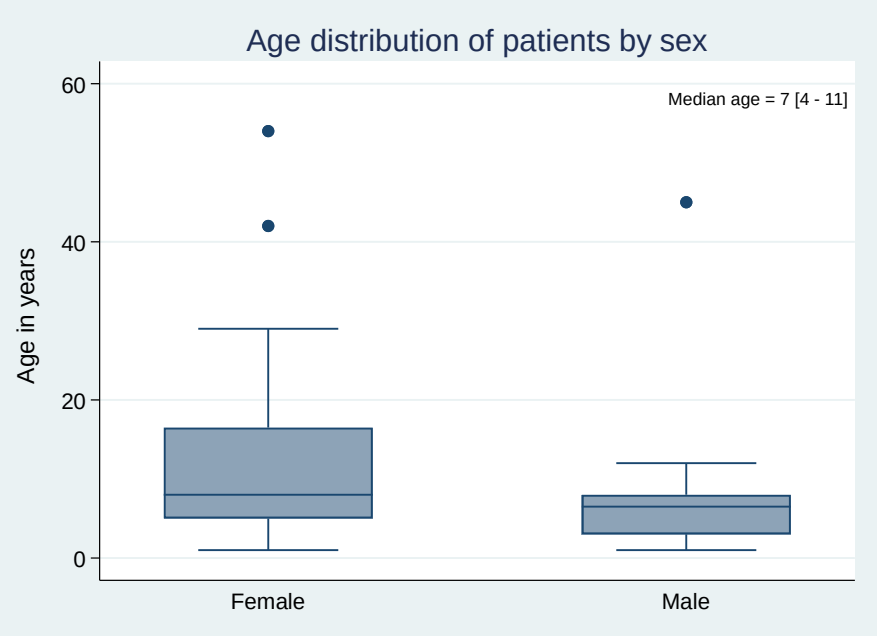


Figure 3: Age in years of patients

Family history of any Cancer

Figure 4 below shows that, 98.5% of the study patients reported having no history of any cancer whereas 1.5% reported having no family history of any cancer.

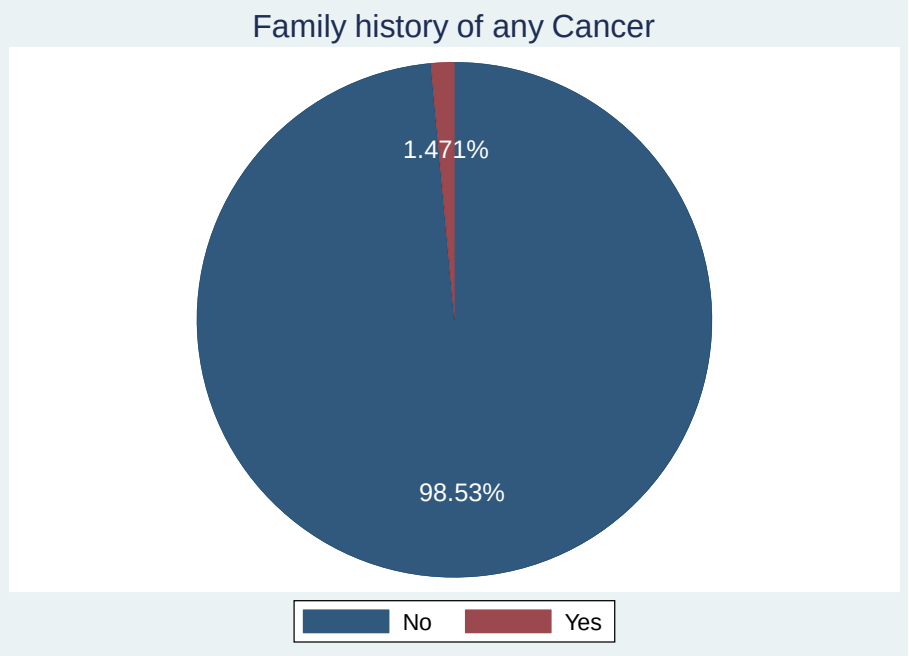


Figure 4: Family history of any cancer

4.2 Clinico-demographic findings of children with posterior cranial fossa brain tumors

The study was obliged to describe the clinico-demographic findings and these are presented in Table 2 and 3 below;

Table 2: Clinic presentations among children with PCF tumors

Clinical presentations	Frequency, *n*	Percentage, *%*
Hydrocephalus		
No	24	36.4
Yes	42	63.6
Meningismus		
No	66	97.1
Yes	2	2.9
Macrocephally		
No	46	68.7
Yes	21	31.3
Dizziness		
No	43	67.2
Yes	25	32.8

Table 2 above shows some of the reported clinical presentations among children with PCF tumors. The table reveals that 63.6% of the children with PCF presented with hydrocephalus, 31.3% with macrocephaly, and 32.8% with dizziness. Whereas Table 3 shows that ataxia was the most common hemicerebellar syndrome reported (51.5%) followed by other forms of hemicerebellar syndrome (28.8%) like drooling saliva, motor impairment, brisk reflexes, convulsions, regression childhood milestones, lower limb weakness and failure to walk, staggering gait, deconjugate gaze, reduced quality and quantity of speech, aphasia, and dysarthria.

Among the focal brain stem compression signs and symptoms, the commonest was hemiparesis (40.4%) followed by other forms of focal brain stem compressions such as convulsions, drooling saliva, paraplegia, seizures, childhood milestone regression, difficulty in swallowing, and lower limb weakness. For those that presented with increased intracranial hypertension, the commonest complaint was headache (44.3%), followed by vomiting (36.4%) whereas the least reported intracranial hypertension sign was meningismus (2.9%). Other symptoms in this

cluster (9.1%) include convulsions, difficulty breathing, fever, irritability and failure to feed well.

Table 3: Signs and symptoms of PCF tumors among children presented.

Signs and symptoms	Responses		Percent of Cases, %
Hemicerebellar syndrome [a]	**Frequency, n**	**Percent, %**	
Ataxia	34	51.5%	66.7%
Nystagmus	4	6.1%	7.8%
Dysmetria	9	13.6%	17.6%
Other, specify	19	28.8%	37.3%
Total	**66**	**100.0%**	**129.4%**
Focal brain stem compression [a]			
Ocular palsies	9	19.1%	25.7%
Diplopia	6	12.8%	17.1%
Hemiparesis	19	40.4%	54.3%
Other, specify	13	27.7%	37.1%
Total	**47**	**100.0%**	**134.3%**
Intracranial hypertension [a]			
Headache	39	44.3%	70.9%
Vomiting	32	36.4%	58.2%
Blurring of Vision	7	8.0%	12.7%
Meningismus	2	2.3%	3.6%
Other (specify)	8	9.1%	14.5%
Total	**88**	**100.0%**	**160.0%**

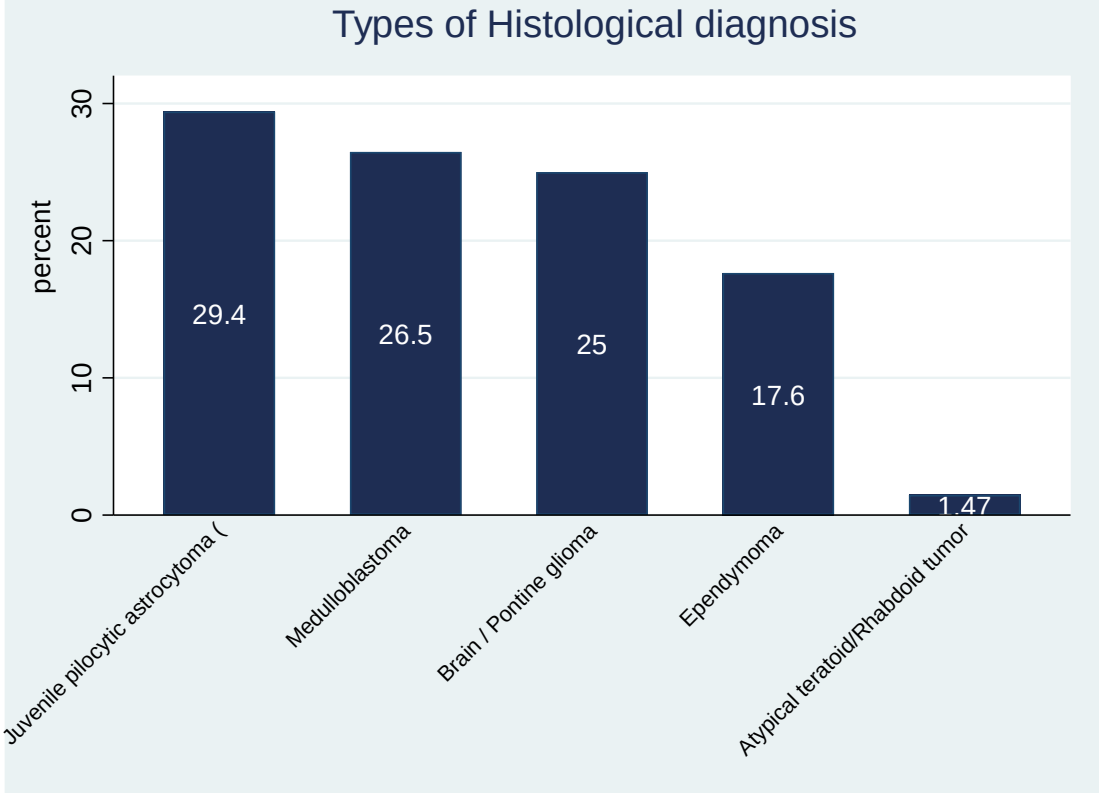
a. Dichotomy group tabulated at value 1

b. % of cases – the times in percentage a response has been selected

Types of histological diagnosis

The study revealed that the commonest tumor was Juvenile Pilocytic Astrocytoma (JPA) at 29.4%, followed by medulloblastoma at 26.5%, then by Brain/pontine glioma at 25.4%, followed by ependymoma at 17.6%, and AT/RT at only 1.47% as shown figure 5.

Figure 5: The different types of posterior cranial fossa tumors



4.3 Radiologic findings of cranial CT examinations performed among children with posterior cranial fossa brain tumors

The study was set to describe the radiologic findings of cranial CT examinations performed among children with posterior cranial fossa brain tumors and these are presented in table 3 below;

Table 4: Radiologic findings of cranial CT examinations performed among children presenting to the three selected hospitals.

Radiologic findings of cranial CT examinations	Frequency, *n*	Percentage, *%*
Number of lesions		
1	66	97.1
2	2	2.9
Location of the posterior fossa tumor		
Midline		
Cerebellar	16	23.5
4^{th} ventricle	14	20.6
Cerebellar vermis	10	14.7
Others	15	22.1
Left		
Cerebellar	3	4.4
Cerebellar vermis	1	1.5
Others	4	5.9
Right		
Cerebellar	3	4.4
Other	2	3.0
Density – Heerogenisity – Contrast		
Hypodense	22	32.8
Hyperdense	24	35.8
Isodense	8	11.9
Heterodense	13	19.4
Contrast Enhancement Pattern		
Non-enhancing	10	15.4
Enhancing	55	84.6
If enhancing		
Mild	41	77.4
Avid	2	3.8
Hetero	10	18.9
Mass Effect – Parechymanl edema		
No	14	21.2
Yes	52	78.8
Hydrocephallus		
No	19	27.9
Yes	49	72.1
Calcifications		
No	44	68.8
Yes	20	31.2

Table 4 summarizes the radiologic features of cranial CT scans. The majority of patients (97.1%) had one lesion, and 2.9% had two lesions. Most lesions (82.3%) were midline, with 17.7% on the left or right. Pre-contrast density showed 35.8% hyperdense, 32.8% hypodense, and 11.9% iso-dense tumors. Contrast enhancement revealed 84.6% enhancing and 15.4% non-enhancing lesions.

Among enhancing lesions, 77.3% showed moderate enhancement, 18.9% heterogeneous enhancements, and 3.8% avid enhancement. Parenchymal edema was seen in 78.8% of lesions, while 21.2% had no mass effect. Hydrocephalus features were observed in 72.1%, mainly obstructive type. The rest (27.9%) did not show hydrocephalus.

Furthermore, intracranial calcifications were common on plain film radiographs and CT scans of the skull. Among patients examined for calcifications, 68.8% had none, and 31.2% had physiologic calcifications. These calcifications vary in prevalence from 1% in young people to 20% in the elderly [69]. Intracranial calcifications can be found in the brain parenchyma or vasculature and are usually benign. However, they can also indicate more serious conditions like tumors, infections, or vascular issues, especially if they have a scattered pattern [70].

4.4 Associations between clinico-demographic findings and histology in children with posterior fossa tumors

The study sought to ascertain whether there exists a relation between clinico-demographic findings and histology in children with posterior fossa tumors. Chi-square analyses with the Fisher's exact test results are presented in table 4 below;

Table 5: Chi-square (χ^2) table showing the relationship between the demographics, clinic findings and histology in children with posterior fossa tumors

Variables	Medulloblastoma *freq. (%)*	Ependymoma *freq. (%)*	Juvenile Pilocytic Astrocytoma (JPA) *freq. (%)*	Brain/pontine glioma *freq. (%)*	Atypical teratoid/ Rhabdoid tumor *freq. (%)*	Total *freq. (%)*	$\chi^2(df)$, p – value
Gender							
Female	9 (52.94)	7 (63.64)	16 (80.00)	8 (47.06)	0 (0.00)	40 (60.61)	6.4567 (4),
Male	8 (47.06)	4 (36.36)	4 (20.00)	9 (52.94)	1 (100.00)	26 (39.39)	0.136
Age category							
< 1 year	0 (0.00)	2 (16.67)	0 (0.00)	0 (0.00)	0 (0.00)	2 (2.94)	11.8000 (8),
2 - 12 years	14 (77.78)	8 (66.67)	14 (70.00)	15 (88.24)	1 (100.00)	52 (76.47)	0.334
> 13 years	4 (22.22)	2 (16.67)	6 (30.00)	2 (11.76)	0 (0.00)	14 (20.59)	
Macrocephally							
No	12 (66.67)	7 (63.64)	13 (65.00)	14 (82.35)	0 (0.00)	46 (68.66)	3.9586 (4),
Yes	6 (33.33)	4 (36.36)	7 (35.00)	3 (17.65)	1 (100.00)	21 (31.34)	0.427
dizziness							
No	10 (58.82)	10 (90.91)	13 (72.22)	10 (58.82)	0 (0.00)	43 (67.19)	6.1412 (4),
Yes	7 (41.18)	1 (9.09)	5 (27.78)	7 (41.18)	1 (100.00)	21 (32.81)	0.175

Gender of patients

The results in Table 4 show that chi-square analyses with Fisher's exact test did not reveal statistically significant differences among the various histological tumor diagnoses (Medulloblastoma, Ependymoma, Juvenile Pilocytic Astrocytoma (JPA), Brain/pontine glioma, and Atypical teratoid/Rhabdoid tumor (AT/RT)) and gender, with $\chi 2 = 6.4567$, df = 4, and a Fisher's exact test *p* – value of 0.136. This suggests that the data does not support the presence of an association between gender and histological diagnosis.

Age category of patients

Chi-square analyses, including Fisher's exact test (Table 4), revealed no statistically significant difference among various histological tumor diagnoses (Medulloblastoma, Ependymoma, Juvenile Pilocytic Astrocytoma (JPA), Brain/pontine glioma, and Atypical teratoid/Rhabdoid tumor (AT/RT)) and patients' age groups, with $\chi 2 = 11.8000$, df = 8, and a Fisher's exact test *p* – value of 0.334. This indicates that the data does not support an association between patients' age groups and histological diagnoses.

Dizziness

Study chi-square analyses with the fisher's exact test indicated in table 4 above demonstrate a statistically insignificant difference within the different diagnosed histological tumours (Medulloblastoma, Ependymoma, Juvenile Pilocytic Astrocytoma (JPA), Brain/pontine glioma, and Atypical teratoid/Rhabdoid tumour (AT/RT)) and vertigo or dizziness induced by many pathologies of the posterior fossa, $\chi 2 = 6.1412$, *df* = 4, fisher's exact test *p* – value of 0.175. This implies that the data does not provide evidence of association between vertigo or dizziness and histological diagnosis.

Macrocephaly

The Chi-square analysis in Table 4 above, using Fisher's exact test, reveals no significant difference among various diagnosed histological tumors (Medulloblastoma, Ependymoma, Juvenile Pilocytic Astrocytoma (JPA), Brain/pontine glioma, and Atypical teratoid/Rhabdoid tumor (AT/RT)) and macrocephaly ($\chi 2 = 3.9586$, df = 4, Fisher's exact test p-value = 0.427). This suggests that there is no evidence of an association between macrocephaly and histological diagnosis. Macrocephaly or an enlarged head is an easily recognizable and common phenotypic feature of achondroplasia [71, 72]. The etiology of the head enlargement is of concern,

particularly in achondroplastic children under 2 years of age with delayed motor development. Earlier studies suggested that hydrocephalus was the cause of the head enlargement. Other studies have suggested that the enlarged head was due to a large brain (megalencephaly) and that the ventricles were normal or only mildly dilated [73].

4.5 Relationship between cranial CT findings and histology in children with posterior fossa tumors

The study sought to ascertain whether there exists a relationship between radiologic cranial CT scan findings and histology in children with posterior fossa tumors. Chi-square analyses with the Fisher's exact test results are presented in table 5 below;

Table 6: Chi-square (χ^2) table showing the relationship between cranial CT findings and histology in children with posterior fossa tumors

Variables	Medulloblastoma *freq. (%)*	Ependymoma *freq. (%)*	Juvenile Pilocytic Astrocytoma (JPA) *freq. (%)*	Brain/pontine glioma *freq. (%)*	Atypical teratoid/ Rhabdoid tumour *freq. (%)*	Total *freq. (%)*	$\chi^2(df)$, *p* – value
structure if the location is Midline							
Cerebellar	5 (31.25)	2 (18.18)	8 (50.00)	0 (0.00)	1 (100.00)	16 (29.09)	
4th ventricle	2 (12.50)	9 (81.82)	3 (18.75)	0 (0.00)	0 (0.00)	0 (0.00)	66.9291 (12),
Cerebellar vermis	8 (50.00)	0 (0.00)	2 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0.000***
Other, specify	1 (6.25)	0 (0.00)	3 (18.75)	11 (100.00)	0 (0.00)	15 (27.27)	
Other structure if the location is Midline							
Midbrain	0 (0.00)	0 (0.00)	0 (0.00)	1 (9.09)	0 (0.00)	1 (6.67)	
Midbrain, Pons	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	1 (6.67)	
Pons	0 (0.00)	0 (0.00)	0 (0.00)	8 (72.73)	0 (0.00)	8 (53.33)	30.0000 (12),
Pons, Medulla	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	1 (6.67)	0.026*
Roof of fourth vent	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (6.67)	
foramen magnum	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	1 (6.67)	
structure if the location is left							
Cerebellar	0 (0.00)	0 (0.00)	3 (100.00)	0 (0.00)	0 (0.00)	3 (37.50)	

Variables	Medulloblastoma *freq. (%)*	Ependymoma *freq. (%)*	Juvenile Pilocytic Astrocytoma (JPA) *freq. (%)*	Brain/pontine glioma *freq. (%)*	Atypical teratoid/ Rhabdoid tumour *freq. (%)*	Total *freq. (%)*	$\chi^2(df)$, *p* – value
Cerebellar vermis	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (12.50)	16.0000 (4),
Other, specify	0 (0.00)	0 (0.00)	0 (0.00)	4 (100.00)	0 (0.00)	4 (50.00)	0.004**
Density-Heerogenisity-contrast							
Hypodense	2 (11.11)	0 (0.00)	9 (47.37)	11 (64.71)	0 (0.00)	22 (32.84)	
Hyperdense	13 (72.22)	4 (33.33)	4 (21.05)	3 (17.65)	0 (0.00)	24 (35.82)	38.7140 (12),
Isodense	1 (5.56)	2 (16.67)	2 (10.53)	2 (11.76)	1 (100.00)	8 (11.94)	0.000***
Heterodense	2 (11.11)	6 (50.00)	4 (21.05)	1 (5.88)	0 (0.00)	13 (19.40)	
Contrast enhancement pattern							
Non-enhancing	0 (0.00)	0 (0.00)	1 (5.26)	9 (56.25)	0 (0.00)	10 (15.38)	27.4753 (4),
Enhancing	18 (100.00)	11 (100.00)	18 (94.74)	7 (43.75)	1 (100.00)	55 (84.62)	0.000***
If enhancing							
Mild	14 (77.78)	8 (72.73)	13 (81.25)	6 (85.71)	0 (0.00)	41 (77.36)	
Avid	1 (5.56)	0 (0.00)	1 (6.25)	0 (0.00)	0 (0.00)	2 (3.77)	6.3960 (8), 0.625
Hetero	3 (16.67)	3 (27.27)	2 (12.50)	1 (14.29)	1 (100.00)	10 (18.87)	
Hydrocephalus							
No	2 (11.11)	0 (0.00)	5 (25.00)	12 (70.59)	0 (0.00)	19 (27.94)	

Variables	Medulloblastoma *freq. (%)*	Ependymoma *freq. (%)*	Juvenile Pilocytic Astrocytoma (JPA) *freq. (%)*	Brain/pontine glioma *freq. (%)*	Atypical teratoid/ Rhabdoid tumour *freq. (%)*	Total *freq. (%)*	$\chi^2(df)$, *p* – value
Yes	16 (88.89)	12 (100.00)	15 (75.00)	5 (29.41)	1 (100.00)	49 (72.06)	23.0156 (4), 0.000***
Calcifications							
No	12 (70.59)	5 (45.45)	13 (72.22)	14 (82.35)	0 (0.00)	44 (68.75)	6.5704 (4), 0.160
Yes	5 (29.41)	6 (54.55)	5 (27.78)	3 (17.65)	1 (100.00)	20 (31.25)	
Mass effect – parechymanloedema							
No	3 (16.67)	1 (9.09)	1 (5.26)	9 (52.94)	0 (0.00)	14 (21.21)	14.5911 (4), 0.007**
Yes	15 (83.33)	10 (90.91)	18 (94.74)	8 (47.06)	1 (100.00)	52 (78.79)	
Location							
Midline	16 (88.89)	12 (100.00)	16 (80.00)	11 (64.71)	1 (100.00)	56 (82.35)	10.043 (8), 0.283
Left	1 (5.56)	0 (0.00)	5 (25.00)	4 (23.53)	0 (0.00)	10 (14.71)	
Right	0 (0.00)	0 (0.00)	2 (10.00)	3 (17.65)	0 (0.00)	5 (7.35)	

Note: **, **, *** – significant levels at 5% ($p < 0.05$)*

Brain structure involving posterior fossa tumour is located in the midline

Table 5 below reveals significant statistical differences in histological tumor diagnoses (Medulloblastoma, Ependymoma, JPA, Brain/pontine glioma, and AT/RT) located in the midline of the posterior fossa. Chi-square and Fisher's exact tests confirmed this difference ($\chi 2$ = 66.9291, df = 12, p = 0.000). These findings suggest a strong association between tumor location and histological diagnosis. Notably, 29.09% of tumors were in the cerebellum, while 27.27% were found in other brain locations like the midbrain, pons, and root of the 4th ventricle.

Other brain structures whose posterior fossa tumour is located in the midline

The results in Table 5 show a significant difference, $\chi 2 = 30.0000$, df = 12, p = 0.026, between various histological tumor types (Medulloblastoma, Ependymoma, Juvenile Pilocytic Astrocytoma (JPA), Brain/pontine glioma, and Atypical teratoid/Rhabdoid tumor (AT/RT)) and midline posterior fossa tumors. This suggests an association between tumor location and histological diagnosis. Moreover, 53.33% of these tumors were found in the pons.

Brain structure whose posterior fossa tumour is located on the left

Table 5 reveals significant differences in histological tumor diagnoses (Medulloblastoma, Ependymoma, Juvenile Pilocytic Astrocytoma, Brain/pontine glioma, and Atypical teratoid/Rhabdoid tumor) based on their location within the brain's posterior fossa. Chi-square and Fisher's exact tests confirm this association ($\chi 2 = 16.0000$, df = 4, Fisher’s exact test p-value = 0.004). Notably, 50.00% of these tumors developed in other brain regions, followed by 37.5% in the cerebellum and 12.5% in the cerebellar vermis. These findings underscore a strong link between tumor location and histological diagnosis.

Pre-contrast Density

The structure's heterogeneity refers to dissimilar elements appearing irregular or varied. For instance, a dermoid cyst exhibits varied attenuation on CT scans. Table 5 shows significant differences in chi-square and Fisher's exact test results ($\chi 2 = 38.7140$, df = 12, p = 0.000) among histological tumor types (Medulloblastoma, Ependymoma, JPA, Brain/pontine glioma, and AT/RT) and density-heterogeneity-contrast. These results support an association between density-heterogeneity-contrast and histological diagnosis. Regarding pre-contrast density in CT scans, 35.82% were hyperdense, 32.84% hypodense, and 11.94% iso-dense.

Contrast enhancement pattern

The brain's pial surface shows leptomeningeal enhancement, filling sulci and cisterns, often described as "gyriform" or "serpentine" [74]. Table 5 reveals a significant association ($\chi 2$ = 27.4753, df = 4, p = 0.000, Fisher's exact test) between diagnosed histological tumors (Medulloblastoma, Ependymoma, JPA, Brain/pontine glioma, AT/RT) and contrast enhancement patterns. Specifically, 84.62% exhibited enhancing patterns resembling Medulloblastoma and JPA (>80%), while 15.38% displayed non-enhancing patterns seen in other posterior fossa tumors.

Hydrocephalus

Hydrocephalus is the accumulation of cerebrospinal fluid in the brain's ventricular system, resulting from disruptions in its normal circulation. This disruption can stem from excessive CSF production, inadequate absorption, or blockages caused by factors like brain tumors. The data in Table 5 reveals a significant association between hydrocephalus and histological tumor diagnoses, as demonstrated by statistical tests ($\chi 2$ = 23.0156, df = 4, Fisher's exact test p-value of 0.000). Notably, a substantial proportion (72.06%) of patients with hydrocephalus were diagnosed with medulloblastoma (88.89%), ependymoma (100.0%), or Juvenile Pilocytic Astrocytoma (JPA) (75.0%). This suggests a strong association between hydrocephalus and specific tumor types.

Calcifications

The common intraventricular tumors prone to calcification include ependymomas, choroid plexus tumors, central neurocytoma, meningiomas, and metastasis. Ependymomas often exhibit calcifications, appearing as dots or masses. Statistical analyses, including chi-square and Fisher's exact test ($\chi 2$ = 6.5704, df = 4, Fisher's exact test p-value = 0.160), did not reveal a significant difference among various histological tumor diagnoses (Medulloblastoma, Ependymoma, Juvenile Pilocytic Astrocytoma (JPA), Brain/pontine glioma, and Atypical teratoid/Rhabdoid tumor (AT/RT)) concerning the presence of calcifications. This suggests insufficient evidence to establish an association between calcification occurrence and histological diagnosis, as the majority (68.75%) of patients without calcifications were diagnosed with medulloblastoma, 70.59% with Juvenile Pilocytic Astrocytoma (JPA), and 82.35% with Brain/pontine glioma.

Mass effect-parechymanloedema

The results in Table 4 reveal a significant statistical difference ($\chi 2 = 14.5911$, df = 4, Fisher's exact test p-value = 0.007) among various diagnosed histological tumors, including Medulloblastoma, Ependymoma, Juvenile Pilocytic Astrocytoma (JPA), Brain/pontine glioma, and Atypical teratoid/Rhabdoid tumor (AT/RT), in relation to mass effect-parenchymal edema. This condition leads to an abnormal accumulation of fluid within the cerebral parenchyma, resulting in increased brain volume and elevated intracranial pressure (ICP) due to the rigid skull enclosure [75]. These findings suggest a strong association between mass effect-parenchymal edema and histological diagnosis, with the majority (78.79%) of examined patients displaying this effect.

Location of posterior fossa tumor

Study chi-square analyses with the fisher's exact test indicated in table 4 above demonstrate a statistically insignificant difference within the different diagnosed histological tumours (Medulloblastoma, Ependymoma, Juvenile Pilocytic Astrocytoma (JPA), Brain/pontine glioma, and Atypical teratoid/Rhabdoid tumour (AT/RT)) and the location of posterior fossa tumors, $\chi 2 = 10.043$, $df = 8$, fisher's exact test p – value of 0.283. This implies that the data does not provide evidence of association between location and histological diagnosis.

CHAPTER FIVE: DISCUSSION OF FINDINGS

5.0 Introduction

The part that follows offers the current study findings while also acknowledging the findings of other researchers. These have been discussed in light of the study objectives, which are as follows:

5.1 Socio-demographic findings

Morbidity and mortality caused by the malignant tumors is becoming an increasingly serious problem all over the world, in developing countries, the prevalence rate of pediatric tumors has been reported from 4.38% to 12.6% while in developed countries, the prevalence rate of childhood tumors is 2% [76]. In the present study, the youngest child was that with ATRT at the age of 2 years. Majority of our patients in the review were aged less than 10 years. These results are consistent with this finding from studies by [4, 77]. The study was dominated by female patients (60.6%) reported otherwise in the works of [4, 78, 79] who reported a slight male predominance. There is no reason to explain this, however, female predominance maybe due to the overall high number of females seen which is a common social demographic finding. Other studies have also reported female predominance without any identifiable risk factor.

5.2 Prevalence of the posterior fossa tumors

Regarding prevalence of the posterior fossa tumors, the present study reported Juvenile Pilocytic Astrocytoma (JPA) as the most common intracranial tumor at 29.4%, followed by medulloblastoma (MB) at 26.5%, then by Brain/pontine glioma at 25.4%. This is concordant with the findings by [80] who reported MB as the commonest intracranial tumor at 36% followed by cerebellar astrocytoma at 28%, brainstem glioma at 9%, and ependymoma at 4%. Relating to Clinico-demographic findings, headache was the most prevalent symptom at 55.9% with a frequency of 38 patients, this was closely followed by vomiting at 47.1%. This finding is similar to that by [80] who also reported that headache is the most common symptom in most series, occurring in 80 – 92% cases followed by vomiting and gait disturbances.

5.3 Clinico-demographic findings

Association between location of tumor and histological diagnosis, in the present study, majority of the tumors seen were located in the midline (88.6%), most of which arose from the cerebellar vermis accounting for 23.5% and most of these (23.9%) were MB. This finding is consistent with those by [52] who reported that MB was diagnosed most among children. Furthermore, the other clinico-demographic finding was density and histological diagnosis, basing on

literature search, MB are commonly seen as hyperdense mass arising from the vermis with a central cystic/necrotic centre [81].

5.4 Radiologic findings of cranial CT examinations

In the present study, majority of MB were hyperdense on non – contrast enhanced cranial CT scans. This finding was similar to one in a study on MB in children comparing CT scan and MRI findings in children that revealed that a combination of high density on CT and low signal on T1W images is highly suggestive of MB [52]. In addition, hyper attenuation on non – enhanced CT study has been reported as the most reliable imaging feature for distinguishing MB from JPA [82]. The present study also suggests about half (50.00%) of the ependymomas were heterodense. This is consistent with existing reports that most ependymomas appear heterogeneous with arears of necrosis, calcification, cystic change and hemorrhage. On the other hand, majority (47.37%) of the Juvenile Pilocytic Astrocytoma (JPA) cases were hypodense. This is due to large cystic component. In this present retrospective review of JPA 37 cases, results showed that all tumors on CT scan examinations were hypo or isodense with micro or macro cysts and strong contrast enhancement and these findings are consisted with the works by [54]. Regarding brainstem/pontine glioma, majority (64.71%) of these were hypodense. In one study, diffuse hypodense lesions involving the whole brainstem constituted 41.2% lesions in children and were either iso-hypodense to normal brain tissue. In this series, tumors were homogenous, however, due to necrosis or hemorrhage, increased density was also seen and confirmed at surgery. In the present study, the only case of Atypical teratoid/Rhabdoid tumour (AT/RT) seen was isodense to surrounding brain parenchyma. Data from literature review suggests that imaging features of ATRT are nonspecific, ranging from iso-to hyperdense with some heterogenic findings reported. In one retrospective review of 11 children seen with ATRT, 6 of which were located in the posterior cranial fossa, 64% showed a hyperdense solid component [65]. In another review of 20 cases, almost all cases revealed heterogeneous density and enhancement with peripheral cystic components. Correlation with histopathology concluded that density of ATRT on CT is nonspecific [83].

Enhancement pattern

With respect to medulloblastoma (MB), literature review suggests a prominent contrast enhancement has been reported in over 90% cases. In the present study, mild enhancement was seen in 77.8% cases confirmed with MB. Enhancement is one typical characteristic of medulloblastoma. Also, regarding Juvenile Pilocytic Astrocytoma (JPA), literature search, reveals that these tumors have been described as a large cystic lesion with an enhancing mural

nodule, seen on cranial CT as strong enhancement with frequent demonstration of micro-or macro cysts. The data obtained from our study suggests a similar finding. Whereas for ependymoma, reviewed data suggests that posterior fossa ependymoma demonstrates heterogeneous enhancement [84]. This has been attributed to the composition of these tumors, consisting of areas of necrosis, calcifications, hemorrhage. The present study also revealed similar findings that the heterogeneous appearance on the CT scan and thus heterogeneous enhancement is shown by the heterogeneous enhancement seen in all cases of ependymoma reviewed. About Atypical teratoid/Rhabdoid tumour (AT/RT), reviewed literature suggests that these tumors may demonstrate heterogeneous enhancement although they are often described as isodense to grey matter [65, 83]. Findings from these works are quite similar to those in the present study which reported the only case of ATRT exhibited a heterogeneous enhancement.

Mass Effect

The present study identifies a significant association between perilesional edema and histological diagnosis for all posterior fossa tumors reviewed.

Hydrocephalus

Data suggests that posterior cranial fossa tumors commonly cause hydrocephalus which is associated with raised intracranial pressure, usually requiring pre-operative CSF diversion [85]. The findings in the present study are similar to theirs that there was a significant association between features of hydrocephalus and histological diagnosis of posterior fossa tumor reviewed.

Calcifications

Data suggests calcifications as an uncommon finding in most posterior fossa tumors in children [54, 86, 87]. For medulloblastoma, this feature has been described among atypical finding. Other atypical findings in medulloblastoma include a cystic/necrotic component, hemorrhage, a lack of contrast enhancement and an eccentric location. In the present study, tumour calcifications were reported in only 31.2% cases with majority (54.5%) being described in ependymoma.

5.5 Study Limitations

Basing on histological diagnosis alone may lead one to miss out on some cases of posterior cranial tumors without histologic diagnosis altering the reported prevalence. Also, histopathological correlation of the imaging findings was not done as some of the patients were

referred to higher centers especially those that attended the private non-profit hospital and the rest were lost to follow-up. While the majority of patients reported no family history of cancer, this information might be subject to recall bias. Moreover, the study does not delve into the potential genetic predispositions that could be relevant in pediatric tumor cases. The study primarily focuses on diagnostic aspects, but it lacks information on treatment outcomes and their impact on patients' long-term well-being. This information is crucial for a comprehensive understanding of pediatric brain tumor management.

CHAPTER SIX: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

This study was aimed at describing the spectrum of posterior fossa tumors and in addition, profiling their clinical presentation, cranial CT scan findings at the three selected hospitals in Uganda.

6.1 Summary of findings

This high frequency of pediatric tumors in developing countries could be attributed to the increased percentage (39% of total population) of children in the overall population [88]. Posterior fossa tumours are the most frequent primary solid neoplasm in the paediatric age group. Brainstem compression, cranial nerve involvement and hydrocephalus occur in most of the posterior fossa neoplasm. Intracranial tumors constitute about one third of all pediatric malignant neoplastic lesions. In the present study, the median age of the study patients was 7 years [IQR: 4 – 11 years] exhibiting that posterior cranial fossa tumors cases are more prevalent in children than in adolescents. Also, a majority (60.6%) of the patients in this study were female with a female to male ratio of 1.5:1, and again 98.5% of the study patients reported to have no family history of any cancer.

Regarding prevalence of the posterior fossa tumors, the most common intracranial tumor was Juvenile Pilocytic Astrocytoma (JPA) at 29.4%, followed by medulloblastoma at 26.5%, then by Brain/pontine glioma at 25.4%. In relation to clinico-demographic findings of patients, the study revealed that the most common clinical presentation reported under the hemicerebellar syndrome was ataxia (50%), whereas among the focal brain stem compression signs and symptoms, the commonest was hemiparesis (29.4%). Also, for those presenting with increased intracranial pressure, the commonest complaint was headache (55.9%) and vomiting (47.1%), and also, up to 63.6% of the participants came in with hydrocephalus, 31.3% with macrocephaly, and 32.8% with dizziness. With regards to radiologic findings of cranial CT examinations, the majority of patients (97.1%) had one lesion, majority (82.3%) of the CT scans showed that the tumors were located in the midline, whereas the rest were either on the left or right side of the brain.

Regarding density – heterogeneity – contrast, most of the patients (35.8%) showed hyperdense abnormalities, followed by 32.8% of patients who showed hypodense (less dense) abnormalities, in terms of contrast enhancement pattern, majority (84.6%) presented an

enhanced pattern among whom 77.3% had moderate enhancement patterns. Regarding the mass effect, majority (78.8%) reported to have developed it, 72.1% were found to have developed hydrocephalus, and lastly on intracranial calcifications, majority (68.8%) did not have this developed in their brains.

At bi-variate level of analysis, chi-square tests were carried out to establish relationship between clinico-demographics and histological diagnosis, as well as radiologic findings of cranial CT examinations and histological diagnosis. The study revealed a statistically significant relationship between mass effect – parenchymal oedema and histological diagnosis, whereas the rest of the clinico-demographic findings revealed a statistically insignificant relationship. For radiologic findings of cranial CT examinations, a statistically significant association was revealed among brain structure whose posterior fossa tumour is located in the midline, the other brain structures whose posterior fossa tumour is located in the midline, the brain structure whose posterior fossa tumour is located on the left, the density-heterogeneity-contrast, the contrast enhancement pattern, the reported occurrence of hydrocephalus and histological diagnosis, whereas the reported occurrence of calcifications exhibited an insignificant relationship with histological diagnosis.

6.2 Conclusion

This study aimed to describe the spectrum of pediatric posterior fossa tumors as well as their clinical and radiological findings at three tertiary hospitals in Uganda. This study found medulloblastoma, juvenile pilocytic astrocytoma, ependymoma and atypical teraotoid/ rhabdoid tumor, ATRT. Unlike most reports that suggest medulloblastoma and ATRT as the most and least common posterior fossa tumor respectively, the present study results suggest that juvenile pilocytic astrocytoma is most common among the spectrum of tumors studied. However, it also reaffirmed that ATRT is least common posterior fossa tumor seen among children. In our review as well, headache was the most prevalent symptom accounting for 55.9% with a frequency of 38 children. This study therefore reaffirms the finding from reports that headache is the most common symptom among children with these tumors. Majority of imaging findings on cranial CT had a significant relationship with histological diagnosis of posterior cranial fossa tumors. This therefore, implies the importance of cranial CT scans in the work-up of these patients, especially in low-resource settings like ours where MRI studies are few and not affordable.

In conclusion, this study examined pediatric patients with a median age of 7 years, primarily females (60.6%). The most common intracranial tumors were Juvenile Pilocytic Astrocytoma

(JPA), medulloblastoma, and Brain/pontine glioma. Clinical presentations included ataxia and hemiparesis, with increased intracranial pressure often manifesting as headaches and vomiting. The location of posterior fossa tumors had significant associations with histological diagnosis, specifically in the midline, other brain structures, and the left side. Additionally, significant differences were noted in various aspects of tumor characteristics, including density, contrast enhancement patterns, and the presence of hydrocephalus. However, no significant association was found with calcifications. Importantly, there was a significant statistical difference in the presence of mass effect-parenchymal edema among different histological tumor types, while the location of posterior fossa tumors did not significantly vary between diagnoses.

6.3 Recommendations

The study recommends that Cranial CT scans should be part of imaging work up for diagnosis of children with neurological symptoms suspected for posterior cranial fossa tumor. A longer study period of PCFTs series is recommended in order to create a pediatric PCFT registry in Uganda.

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APPENDICES

Appendix I: Budget

ITEM	QUANTITY	UNIT COST	TOTAL (ug.shs)
Research Assistants	6	@ 30,000/day	2,520,000/=
Disposable face mask	2 boxes	36, 865/=	73,730/=
Hand sanitizer ½ gallon jug	4	73,915/=	295,660/=
Printing proposal	39 pages x 30 copies	100Ush/page	117,000/=
Printing questionnaire	8 pages x 360 copies	100 Ush/page	288,000/=
Printing report	100 pages x 3 copies	100Ush/page	300,000/=
Printing final thesis	100 pages x 5 copies	100Ush/page	500,000/=
Internet (Airtel)	9 GB x 3 months	50,000/=	150,000/=
Box file	5	@ 12000/=	60,000/=
Pens	1 box	12,000/=	12,000/=
Note books	6	5,000/=	30,000/=
Stickers	360	20,000/=	20,000/=
Training research assistants	4	50,000/=	200,000/=
Dissemination	5	20,000/=	100,000/=Ush
Transport	14 days		2,500,000/=Ush
Feeding/refreshment		1,000,000/=	1,000,000/=Ush
Miscellaneous		500,000/=	500,000/=Ush
Total			**15,000,000/=Ush**

Appendix II: Time Frame

Activity	May – December 2021	January 2022	February-2022	March-May. 2022	June 2022	July-August 2022	September-2022
Proposal development							
Proposal review							
Proposal approval							
Data collection							
Data analysis and reporting							
Development of the draft report							
Review of draft report							
Submission of report for external examination							
Defence of report							

Appendix III: Data Collection Form

PART A: DEMOGRAPHIC CHARACTERISTICS

1. Patient initials…….
2. Age……
3. Sex……
4. Address……
5. Family history of cancer: …….

PART B: THE CLINICAL PRESENTATION

Tick where applicable:

1. Hemi-cerebellar syndrome
   (i) Ataxia [ ]
   (ii) nystagmus [ ]
   (iii) dysmetria [ ]
2. Focal brain stem compression symptoms and signs
   (i) Ocular palsies [ ]
   (ii) Diplopia [ ]
   (iii) Hemiparesis [ ]
3. Intracranial HTN
   (i) Headache [ ]
   (ii) Vomiting [ ]
   (iii) Strabismus [ ]
   (iv) Blurring of Visio [ ]
   (v) Meningismus [ ]
4. Hydrocephalus [ ]
5. Macrocephally [ ]
6. Dizziness [ ]

PART C: Radiologic findings of cranial CT examinations of children with posterior fossa brain tumors at UCI, Mulago NRH, and CURE hospital.

6. Cranial CT examination features

Mass-Location-Midline posterior fossa mass

……

……

Density-Heterogenisity-contrast enhancement

……

……

Effect on surrounding structures -Mass effect-Parenchymal oedema

……

……

Pressure effect, obstruction-hydrocephallus

……

……

Calcifications

……

……

Solitary or Multiple

……

……

Histological diagnosis

……

……

END