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# Surgical management and outcomes of childhood hydrocephalus in a resource-challenged setting in Northeast Nigeria

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**Background:** Hydrocephalus is the most common neurosurgical presentation among pediatric patients in our center. The specificity of children with this condition justifies special care by a team comprising of pediatric neurosurgeons, anesthesiologist and nurses. A ventriculoperitoneal shunt is the surgical treatment we offer these patients, as facilities for other treatment options are unavailable. This study aimed to determine the outcomes of surgical management of childhood hydrocephalus in our center.

**Patients and methods:** A retrospective observational study that recruited all pediatric patients aged 16 years and below who had surgical intervention for hydrocephalus in our facility from January 2019 to December 2021. Data was analyzed using simple descriptive statistics.

**Results:** A total of 73 pediatric patients with hydrocephalus were recruited. The majority (53.4%) were males with a male-to-female ratio of 1.1:1. Most of the patients (53.4%) had acquired hydrocephalus and had ventriculoperitoneal shunt (93.2%) as surgical intervention. Nineteen point two percent (14 patients) had postoperative complications. Proximal shunt obstruction (6.9%); followed by surgical site infection (5.5%) were the most common and occurred commonly in those operated during infancy period. Mortality was higher in patients that had external ventricular drain (EVD). Overall mortality was 5.5%.

**Conclusion:** Acquired hydrocephalus is the most common type of hydrocephalus in children in our center. Ventriculoperitoneal shunt remains the surgical treatment employed with favorable outcomes despite limitations.

Keywords: Childhood, Hydrocephalus, Ventriculoperitoneal shunt, Outcomes, Resource-challenged

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## INTRODUCTION

Hydrocephalus is an abnormal accumulation of cerebrospinal fluid within the brain's ventricles [1]. It is the most common neurosurgical condition in children, with multitudes of causes, which could be congenital or acquired [2]. Left untreated in children is associated with high morbidity and mortality [3]. Despite the growing burden of neurosurgical conditions, there remains a global shortage of neurosurgeons, especially in low-resource settings [4,5], let alone pediatric neurosurgeons. Pediatric neurosurgery is a sub-specialty of neurosurgery dedicated to the care of children with central and peripheral nervous system pathologies from the fetal period to adolescence [6]. The specificity of children with these pathologies justifies specific care [7]. Sub-specialization is given less emphasis in our setting, probably due to lack of centers and facilities for such training. This is further compounded by lack of an established sponsorship program by the government. As such, interested fellows pay out of pocket to further specialize outside the country, which accounted for low number of pediatric neurosurgeons in our nation. Consequently, pediatric neurosurgical care is unavailable to the majority of patients in settings like ours, and the gap between capacity and need for such services remains wide [8,9].

The most common neurosurgical presentation in African children is hydrocephalus, however, inadequately recognized as an important cause of morbidity and mortality [10]. Managing a child with hydrocephalus is quite distressing in developing nations due to lack of sufficient centers trained and equipped to treat this condition, ignorance, superstitious beliefs, poverty, and low health insurance coverage especially for rural dwellers [10,11]. In Nigeria, most of the neurosurgeons practice in the major cities, and are more concentrated in the southern and western regions of the country, leaving the northern part of



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the country with a low number of neurosurgeons due to relatively lower human capital development [12]. As such, rural dwellers had to travel a long distance to have access to neurosurgical care. These result in delayed intervention leading to increased morbidity and possible mortality. Collaborations with centers outside Nigeria have improved the management of hydrocephalus in other parts of the country [13]. However, such collaborations are yet to reach the northern parts to a significant extent.

Our center pioneered neurosurgical services in northeast Nigeria and is located in Maiduguri, the capital of Borno state; one of the six states that constitute northeast Nigeria. The state has a total population of 6,111,500 (2022) and shares borders with Niger Republic, Cameroon, and Chad. At present, the state has 3 general neurosurgeons all practicing in our center, addressing the growing burden of neurosurgical conditions of the state and other neighboring African countries. This translates to a ratio of one neurosurgeon to 2,037,166.7 population, which is grossly inadequate. Pediatric neurosurgical cases are also treated by the general neurosurgeons as the region has no pediatric neurosurgeon. Anesthetic complications of pediatric patients are numerous, ranging from difficult intubation to bronchospasm among others [14], more so in patients with hydrocephalus where the enlarged head may further compromise smooth intubation. Our facility has no trained pediatric neuroanesthesiologist, and so all cases of childhood hydrocephalus are anesthetized by general anesthesiologists. Despite these challenges, no study was done to determine the outcome of ventriculoperitoneal shunt in children with hydrocephalus in our center. This study aimed to determine the outcomes of surgical management of childhood hydrocephalus in our center, as this may serve as an audit and an avenue for future treatment quality improvement.

## MATERIALS AND METHODS

This was a retrospective study that recruited all pediatric patients aged 16 years and below who had surgical intervention for hydrocephalus over three years, from January 2019 to December 2021, at the University of Maiduguri Teaching Hospital (UMTH), Borno state, Nigeria. We employed the use of nonantibiotic impregnated Chabra shunt, as it's cheap and relatively available in other parts of Nigeria. In order to minimize risk of shunt infection, we immersed it in diluted gentamicin solution before insertion, and also reduce the number of staffs in the suite to the barest minimum. The procedure was done under general anaesthesia and endotracheal intubation. Intravenous ceftriaxone was given at induction of anesthesia. Accesses into the lateral ventricle and peritoneal cavity were gained via right keen's point and right supraumblical incision respectively after cleaning with chlorhexidine and povidone iodine, and draping of the surgical field. A twist drill craniostomy was made at the Keen's point, dura was cauterized and incised in a cruciate fashion using size 11 blade. The ventricular catheter was inserted blindly into the right lateral ventricle, as the armamentarium needed to guide precise placement are not available in our facility. It was initially directed perpendicular to the cranium at craniostomy site until a gib was felt, then directed toward the medial canthus of the ipsilateral orbit to ensure tip placement in the frontal horn devoid of choroid plexus. Distal end of ventricular catheter was connected to the shunt valve using a connector and maintained in place with silk 2/0 suture. In those with turbid or persistent hemorrhagic CSF, ventricular catheter was exteriorized as EVD and connected to a urine bag held on to a drip stand at 10cm from patient's external auditory meatus. A tunneller was used for the placement of the peritoneal catheter, distal end of which was advanced into the peritoneal cavity toward the pelvis. Wounds were closed in layers. Post operatively, patients were nursed in a general pediatric surgical ward, and then discharged home on postoperative day 7 in the absence of complications.

Extracted for all the Patients were data on demography, aetiology of hydrocephalus, surgical treatment offered, and one-year postoperative outcomes obtained from their case files and operation register. Data was analyzed using a statistical package for social sciences version 26. A chi-square test was done to test the relationship between the age group of the patients and the occurrence of postoperative complications, as well as type of hydrocephalus and mortality. A survival analysis was conducted to compare the hospital stay (in days) between the patients that had ventriculoperitoneal shunt and external ventricular drain (figure 1). P-value was set at 0.05.

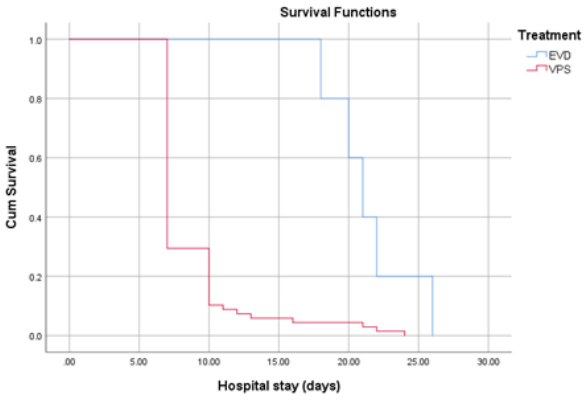


**Figure 1** – Kaplan-Meier survival curve



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## RESULTS

Seventy-three (73) pediatric patients with hydrocephalus aged 16 years and below were recruited during the study period. Males were 39 (53.4%), and females 34(46.6%). The majority (64.4%) were > one month to 1 year at presentation. Nine (12.3%) patients presented during the neonatal period, and only 1(1.4%) patient was above 12years of age (table 1). The mean age at presentation was 1.9 year ± 3.23 SD. Most patients had acquired hydrocephalus (53.4%); 39.7% (29 patients) were post meningitic, 4.1% (3 patients) following head trauma and 9.6% (7 patients) were due to brain tumor, commonly posterior fossa tumor (pilocytic astrocytoma). Congenital type constitutes 46.6% (34 patients); 27.4% (20 patients) due to Aqueductal stenosis, 16.5% (12 patients) and 2.7% (2 patients) due to Chiari II and Dandy-Walker malformations, respectively (figure 2 and 3). The most common co-existing congenital abnormality was myelomeningocele (19.2%), followed by umbilical hernia (5.5%). Ventriculoperitoneal shunt (93.2%) was the most performed surgical intervention in our study, followed by external ventricular drain (6.8%) insertion. None of the patients had endoscopic third ventriculostomy (ETV) (table 2).The mean duration of postoperative hospital stay was 9.45 days ± 4.73 days. Eighteen (24.7%) patients had complications that included shunt obstruction, surgical site infections, and shunt hardware infections as shown in table 3. Postoperative complications were common among patients operated during infancy with co-existing myelomeningocele (p = 0.000).

**Table 1:** Demographic characteristics of patients

| Variables | Number | Percentage (%) |
|---|---|---|
| **Gender** | | |
| Males | 39 | 53.4 |
| Females | 34 | 46.6 |
| **Total** | 73 | **100 (%)** |
| **Age** | | |
| ≤ 1 month | 9 | 12.3 |
| > 1 month – 1year | 47 | 64.4 |
| > 1 year -6 years | 6 | 8.2 |
| > 6 years-12years | 10 | 13.7 |
| >12 years- 16 years | 1 | 1.4 |
| **Total** | 73 | **100 (%)** |

**Table 2:** Surgical treatments

| Variables | Number | Percentage (%) |
|---|---|---|
| **Surgical options** | | |
| Ventriculoperitoneal (VP) Shunt | 68 | 93.2 |
| External ventricular drain (EVD) | 5 | 6.8 |
| Endoscopic third ventriculostomy (ETV) | 0 | 0.0 |
| Others | 0 | 0.0 |
| **Total** | 73 | **100%** |

**Table 3:** Postoperative complications among different age groups

| Variables | COMPLICATIONS | | | | | | P-value |
|---|---|---|---|---|---|---|---|
| | Distal shunt obstruction | Proximal shunt obstruction | Shunt infection | Surgical Site Infection (SSI) | Death | No complications | |
| **Age** | | | | | | | |
| <1year | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 9(100.0%) | |
| >12years - 16years | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 1(100.0%) | |
| >1month - 1year | 0(0.0%) | 5(10.0%) | 3(6.0%) | 4(8.0%) | 3(6.0%) | 35(70.0%) | 0.512 |
| >1year - 6years | 1(16.7%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 5(83.3%) | |
| >6years - 12years | 1(8.1%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 1(8.1%) | 9(81.8%) | |

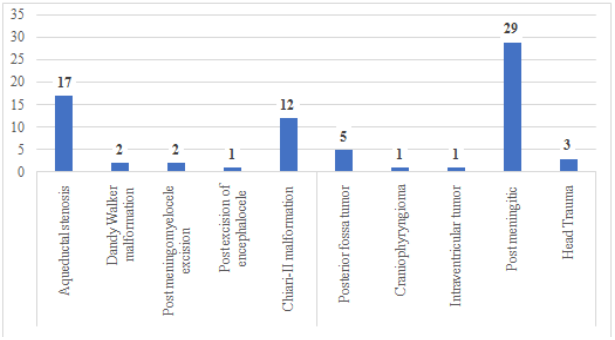


**Figure 2 –** Distribuition aetiology of hydrocephalus among the study participants



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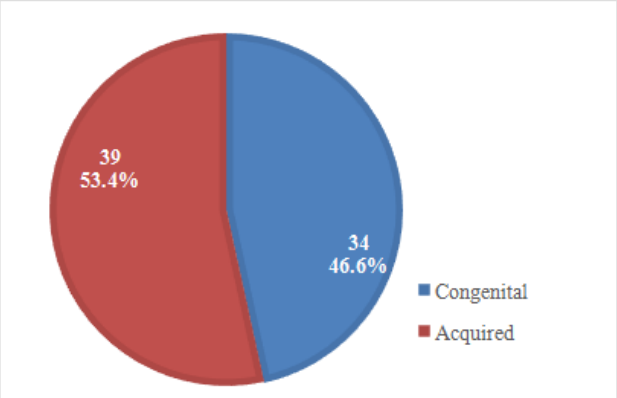


**Figure 3 –** Tyoes of hydrocephalus among study participants

The survival function, illustrated in the graph (fig. 1), shows a clear distinction in survival curves between the two treatment groups (VPS VS EVD). The table of means and medians for survival time (table 4) further proves that for EVD treatment, patients had an estimated mean survival time of 21.40 days (SE = 1.33, 95% CI [18.80, 24.00]), and the median survival time was 21.00 days (SE = 1.10, 95% CI [18.85, 23.15]). Patients that had VPS had a much shorter estimated mean survival time of 8.60 days (SE = 0.42, 95% CI [7.78, 9.43]), and the median survival time was 7.00 days. The median survival time for the VPS group could not be calculated beyond 7 days, as most of the patients were discharged beyond that time frame.

**Table 4:** Mean and median for survival time

| | Mean[a] | | | | Median | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 95% Confidence Interval | | | | 95% Confidence Interval | |
| Treatment | Estimate | Std. Error | Lower Bound | Upper Bound | Estimate | Std. Error | Lower Bound | Upper Bound |
| EVD | 21.400 | 1.327 | 18.800 | 24.000 | 21.000 | 1.095 | 18.853 | 23.147 |
| VPS | 8.603 | 0.422 | 7.776 | 9.430 | 7.000 | - | - | - |
| Overall | 9.479 | 0.553 | 8.395 | 10.564 | 7.000 | - | - | - |

a. Estimation is limited to the largest survival time if it is censored.

Overall mortality was 5.5%. There was no statistically significant association between type of hydrocephalus (congenital or acquired) and mortality (p= 0.374).

## DISCUSSION

Childhood hydrocephalus is more complicated, with significantly more developmental and cognitive morbidities when compared to adult hydrocephalus [3]. Morbidity and mortality is high [3], especially when surgical intervention is delayed.

Our study showed slight male preponderance, with a male-to-female ratio of 1.1:1, similar to the authors' findings in other parts of Nigeria [15,16]. It also agrees with the reports in other parts of the world [3,17]. However, Abebe et al. in Ethiopia reported female predominance in infants with congenital hydrocephalus [18], while Obanife et al. in northwestern Nigeria reported no sex predominance [19]. The disparity could be due to the variation in the overall birth ratio and ethnic difference [20,21]. Even though quite a number of patients (46.6%) had congenital hydrocephalus, only 9 (12.3%) patients presented during the neonatal period. The majority (64.4%) presented within >1 month–1 year of age, which agrees with the findings in the literature [15-17]. The late presentation could be attributed to poverty, ignorance, superstitious beliefs associated with childhood hydrocephalus, and lack of sufficient centers with neurosurgical expertise. As such, patients went through a long chain of referral before presenting to our facility.

Acquired hydrocephalus (53.4%) was more common in our study. The most common aetiology was post-meningitic (39.7%), probably due to increased incidence of neonatal infection/ poorly treated childhood central nervous system infection in sub-Saharan Africa [22]. This is followed by posterior fossa tumor (9.6%), precisely pilocytic astrocytoma. Our findings were similar to those of other authors [3,18,23]. However, Yusuf et al. reported congenital hydrocephalus as the most common type of hydrocephalus in infants, probably because only patients <12 months of age were considered in that study [15], as opposed to ≤16 years in our study. In developed countries, post-hemorrhagic hydrocephalus is the most frequent cause of neonatal hydrocephalus [24]. We managed such cases nonoperatively with serial transfontanelle ultrasound scan monitoring to assess for the resolution of bleeding. The nonsurgical treatment excluded them from this study. Our treatment modality agrees with that of Singh et al. [3]. Aqueductal stenosis (27.4%) was the most common aetiology for congenital hydrocephalus, followed by Chiari II malformation (16.5%) and Dandy-Walker malformations (2.7%). Our finding was similar to that of Abebe et al. [18], however, contrary to that of Yusuf et al., who reported Chiari II malformation in infants with lumbosacral myelomeningocele [15]. It was also contrary to the findings of Kulkarni et al., who reported intraventricular hemorrhage as the most common, followed by aqueductal stenosis [25]. The most common co-existing congenital abnormality was myelomeningocele (19.2%), in keeping with Yusuf et al. and Obanife et al. findings [15,19].

Computed tomography (CT) and magnetic resonance imaging (MRI) are the gold-standard imaging modalities for evaluating pediatric hydrocephalus [3]. In our series, we reserved CT/MRI for suspected tumoral or post-traumatic hydrocephalus as the majority of our patients couldn't afford CT/MRI and surgery concomitantly. This limitation is due to the lack of national health insurance scheme coverage for all citizens, especially those in the informal sector and rural

dwellers [26]. As such, hospital bills are settled out of the individual's pocket.

In this study, sixty-eight (93.2%) patients had ventriculoperitoneal (VP) shunt insertion. In 5 (6.8%) patients with purulent CSF, the ventricular catheter was exteriorized and connected to a urine bag, as the appropriate EVD set is not readily available in our facility. Two out of these patients died following over drainage. The remaining three patients had antibiotic therapy, and EVD was removed after seven days. A serial ventricular tap was commenced, and subsequently, all had VP shunt insertion following three consecutive negative CSF microscopy, culture, and sensitivity. Evidence regarding the comparative effectiveness of different types of shunt is lacking [27], and so the choice of shunt catheter depends on the economic condition of the patient and surgeons' preferences [3]. We use the Chabra shunt device in our center, which is relatively cheap and readily available.

Our overall complication rate was 24.7%, this is within the range of 1 to 40% reported in the literature [28,29]. It was higher than the complication rate of 19.8% reported by Khan et al. [30], though this rate was recorded at a one-month follow-up rather than one year in our study. Our complication rate was slightly lower than the 25.8% reported by Javeed et al. [31], probably due to a larger sample size of 1030 patients as opposed to 73 patients in our series. The most common complication in this study was proximal shunt obstruction (6.9%), followed by surgical site infection (SSI) (5.5%). Cannulating the lateral ventricle blindly may account for why proximal shunt obstruction was the most common complication in our series. Our finding was similar to that of Singh et al. [3], but contrary to that of Yusuf et al. and Dakurah et al., who reported infection as the commonest complication [15,32], probably because congenital hydrocephalus associated with myelomeningocele was more prevalent in their studies, and open neural tube defect is a known risk factor for shunt infection [1]. Two out of the four patients with SSI developed necrosis of the overlying skin and shunt device exposure . Shunt removal, antibiotic, serial ventricular taps, and VP shunt managed such patients. Three (4.1%) patients had shunt hardware infection similar to Singh et al. finding [3]. One of these patients died, while the remaining were managed as in patients with SSI and shunt exposure. Postoperative complications were more common among those operated on during infancy. However, there was no statistically significant association between age group and the type of complication experienced by the patients (p=0.512). This also implies that the occurrence of complications does not significantly differ across the different age groups. Our overall mortality was 5.5%, like the 4.59% reported by Dakurah et al. [32] but lower than the 10.6% reported by Javeed et al. [31]. There was no statistically significant association between the type of hydrocephalus (congenital or acquired) and mortality (p=0.374).

Those who had EVD, SSI, or shunt infection had a longer duration of hospital stay. The mean duration of postoperative hospital stay was 9.45 days ± 4.73 days. Patients that were treated with EVD had significantly longer hospital stays compared to those that had VPS, as evidenced by both the survival curves and the significant difference in survival times between the two groups. The steep decline in the VPS group indicates that patients in this group experienced events (such as discharge or other relevant outcomes) much sooner than those in the EVD group. This analysis showed that EVD prolonged hospital stay relative to VPS, as demonstrated by the significantly different survival distributions.

Ventriculoperitoneal shunt surgery is the predominant mode of therapy for hydrocephalus but plagued with significant shunt failures requiring shunt revisions [33]. Other shunting procedures, though with higher complication rates than VPS, which can be employed when the peritoneum is not ideal for VPS, include ventriculoatrial and ventriculopleural shunts. Treatment of hydrocephalus by shunting procedure is associated with variable outcomes, depending on the setting in which the procedure is performed [32]. Results from some parts of sub-Saharan Africa were not good when compared to developed nations due to various reasons which include poor health infrastructure, low socioeconomic profile of the population, and late recognition or nonrecognition of morbidity by health professionals [32]. Endoscopic third ventriculostomy is another surgical option that has been found to have fewer complications than VPS, especially when employed in patients with noncommunicating hydrocephalus due to aqueductal stenosis who are greater than one month of age and had no previous VPS [34]. It has been found to be the most effective in developing nations, as it requires less revision and continued care appointments for patients with childhood hydrocephalus [29], even though the facilities and expertise are lacking in most centers.

The retrospective and single-center nature of our study, small sample size, and short follow-up duration were some of our limitations. We suggest a prospective multicenter study with a larger sample size and longer follow-up duration.

## CONCLUSION

Ventriculoperitoneal shunt is our center's most widely employed surgical intervention for children with hydrocephalus. Generally, the outcome is good despite some challenges. International collaborations, provision of an appropriate external ventricular drain set, endoscopic third ventriculostomy facilities and training of personnel, as well as National health insurance cover for all citizens, including

rural dwellers, may revolutionize the surgical treatment and outcome of childhood hydrocephalus in our center.

## DISCLOSURES

### *Ethical approval*

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the local Ethics Committee, number:OHRP-IRB-FWA 00013572 UMTH/REC/24/05

### *Consent to participate*

The patients gave consent to use their information and images for research purposes. *Consent for publication*

The patient gave consent to use his information and images for publication.

### *Conflict of interest*

The authors declare no conflicts of interest with respect to the content, authorship, and/or publication of this article.

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## CONTRIBUTIONS

-**Usman Daibu**: Conceptualization, Data curation, Formal Analysis, Methodology, Validation, Writing – original draft, Writing – review & editing
-**Babagana Usman**: Conceptualization, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing
-**Babagana Mohammed**: Methodology, Supervision, Validation, Writing – review & editing
**-Samuel Wabada:** Methodology, Supervision, Validation, Writing – review & editing

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