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The Burden of Ventriculoperitoneal Shunt Complications: A Quest for Standardization

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Background: Ventriculoperitoneal shunt (VPS) placement is the main treatment for hydrocephalus, but infection and malfunction remain important concerns, particularly where standardized insertion protocols are limited. This study describes VPS-related complications after implementation of a standardized perioperative protocol in two Nigerian tertiary hospitals.

Methods: We conducted a prospective descriptive cohort study from December 1, 2023, to October 31, 2025. Consecutive patients with hydrocephalus requiring VPS were enrolled. The protocol included morning scheduling with neonatal priority, povidone-iodine skin preparation, prophylactic antibiotics, double gloving, minimal shunt handling, delayed shunt opening, and limited skin contact. Sociodemographic, clinical, radiologic, operative, and outcome data were analyzed descriptively. Early complications were defined as events occurring within 6 months after surgery.

Results: Ninety VPS procedures were performed in 87 patients; two were lost to follow-up. Median age was 4 years (IQR, 1–16; range, 0.08–43), and 62.1% were male. Non-communicating hydrocephalus was most common (64.4%), mainly due to congenital aqueductal stenosis. Overall complication rate was 3.33% (n=3), including two proximal obstructions and one transanal protrusion. The latter occurred in a premature, malnourished neonate who developed meningitis and died after revision, corresponding to an infection rate of 1.11% per procedure. Median hospital stay was 5 days (IQR, 4–6), and median follow-up was 4 months (range, 1–19).

Conclusions: A standardized VPS insertion protocol was associated with low complication and infection rates. However, causal inference is limited by the descriptive design and bundled intervention. Comparative studies with longer follow-up are needed.

Keywords: standardized protocol; preterm; severe malnutrition; transanal protrusion; infection

INTRODUCTION

entriculoperitoneal shunt (VPS) placement is a ubiquitous neurosurgical procedure for treating hydrocephalus, yet it is not without significant complications, including infections and malfunction [1]. Shunt infections, which occur in approximately 8-10% of cases, are a major contributor to morbidity and mortality. The risk factors for shunt infection include prematurity, previous shunt infection, intraoperative use of neuroendoscopy, and CSF leak [2,3]. The microbiological profile of shunt infections is characterized by a predominance of *Acinetobacter* species, *Pseudomonas* species, and coagulase-negative *Staphylococcus* [4].

Despite advances in neurosurgical techniques and technology, shunt infections remain a pervasive problem. Various strategies have been employed to mitigate this risk, including the use of intraventricular antibiotics, Antibiotic-Impregnated Shunt (AIS) catheters, and povidone-iodine skin preparation [5–12]. However, infection rates and their adverse complications after VPS for hydrocephalus remain high.

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Other complications include shunt obstruction (proximal or distal), disconnection, migration, fracture, organ or intestinal perforation, and intestinal obstruction [13,14], and, in rare cases, shunt protrusion (namely transurethral, transanal, and, in very bizarre scenarios, transoral shunt extrusion) [15–17].

We sought to evaluate VPS complication rates and risk factors after instituting a standardized protocol, to generate a standard protocol for all patients with hydrocephalus fit for VPS insertion. Specifically, our objectives were to describe the incidence of VPS-associated complications and the clinical characteristics observed in patients with complications, and develop an evidence-based protocol for VPS insertion to minimize complications and improve patient outcomes.

MATERIALS AND METHODS

This 23-month two-center, prospective, descriptive cohort study was conducted at the neurosurgical units of Modibbo Adama University Teaching Hospital, Yola, and Benue State University Teaching Hospital, Makurdi, Nigeria, from December 1st, 2023, to October 31st, 2025.

Study Population and Sampling

The study population consisted of patients with hydrocephalus who underwent ventriculoperitoneal shunt (VPS) surgery during the study period. Consecutive non-exhaustive sampling was used to recruit participants.

Inclusion and Exclusion Criteria

The study included patients with hydrocephalus requiring ventriculoperitoneal (VP) shunt surgery, regardless of age. Exclusion criteria encompassed patients with hydrocephalus treated via alternative methods, those with preexisting infections, and those who declined VP shunt placement.

Study Procedures

A standardized protocol was implemented to minimize infections and other complications associated with VPS insertion [12,18]. The protocol included:

1. Timing of Surgery: Shunt procedures were performed in the morning, prioritizing neonates and infants. No surgery was performed after a dirty procedure.
2. Preoperative Preparation: Patients were shaved with surgical blades on the operating table, and the chest, abdomen, and scalp were thoroughly washed with warm water and 10% povidone-iodine surgical scrub.
3. Skin Preparation: Two 10% povidone-iodine solution skin scrubs were performed before draping, followed by a third skin wash after draping. Plastic adhesive draping was not used.
4. Intraoperative Antisepsis: Intermittent application of 10% povidone-iodine solution was performed every 10-15 minutes to maintain skin moisture and reduce bacterial colonization.
5. Prophylactic Antibiotics: A prophylactic antibiotic was administered at the induction of anesthesia.
6. Surgical Technique: Efforts were made to limit the number of incisions to two (abdominal and scalp). Double gloving and changing gloves before handling shunt hardware were performed.
7. Shunt Handling and Insertion: Shunt opening was delayed until immediately before insertion. Meticulous and minimal shunt handling was performed, and the abdominal catheter was wrapped in a sterile towel to avoid skin contact.
8. Catheter Placement and Anchoring: The ventricular catheter was placed into the ventricle, and the abdominal catheter was implanted into the peritoneal cavity. The catheters were anchored to the pericranium with a 3/0 silk suture.
9. Postoperative Care: Antibiotics were continued until day three after shunt insertion. The sterile dressing was removed on day three, and patients were typically discharged on days 2-4 post-shunt insertion.
10. Wound Care: Pressure on the shunt was avoided, and dressings were changed daily until suture removal.

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Data Collection and Analysis

Data were collected on sociodemographic variables, clinical profile, radiological profile, and operative profile. Data were entered into an Excel spreadsheet and analyzed using STATA 15 statistical software. Categorical variables were expressed as frequencies and proportions. In contrast, continuous variables were presented as means and standard deviations, medians (and interquartile ranges), or frequencies and percentages after categorization using the median, employing descriptive statistics.

This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies.

We defined VPS complications as malfunctions or adverse events following the surgical insertion of a device to treat hydrocephalus. These include shunt infection, sepsis, shunt migration, disconnection, fracture, intestinal or organ perforation and protrusion, obstruction that leads to underdrainage and raised intracranial pressure, and over drainage that could lead to slit ventricle and subdural collection. Complications manifesting in less than 6 months post-VPS insertion are termed early complications, while those presenting more than 6 months post insertion are late complications [19,20]. Parents were educated on all the features of complications to look out for and to present or call promptly upon notice of any complication.

RESULTS

This study comprised 90 VPS procedures performed on 87 patients, with three patients (3.33%- two were due to proximal obstruction and one due to transanal protrusion) who had repeat interventions (Figure 1). Two patients were lost to follow-up. The median age of the overall cohort was 4 years (IQR: 1–16 years; range: 0.08–43 years). Among patients under 5 years (n=32), the median age was 1 year (IQR: 0.5–3 years; range: 0.08–4.9 years). Among patients aged 5 years and older (n=55), the median age was 32 years (IQR: 21–43 years)

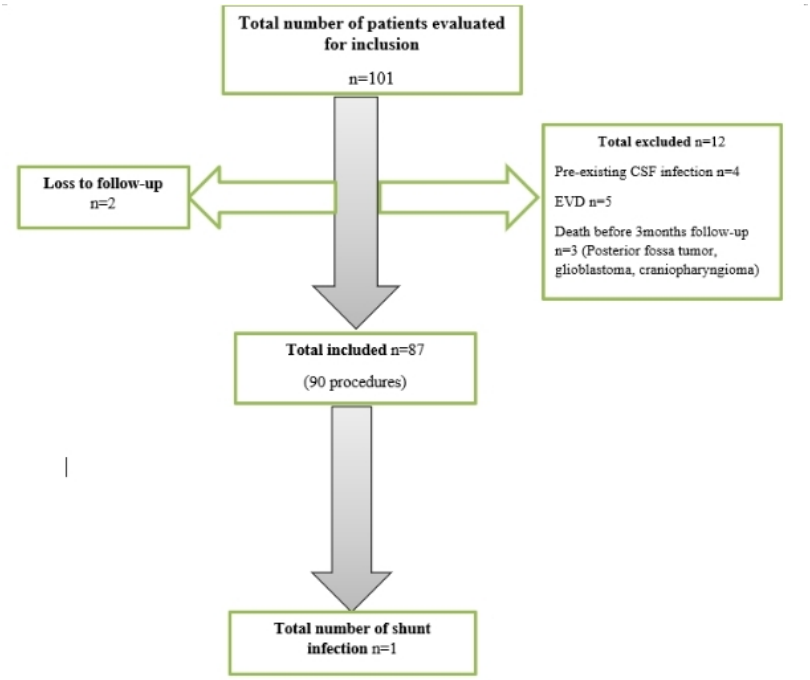

Figure 1. Flowchart of the patients included in the study

Patient Characteristics

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The sex distribution was 54 males and 33 females. Notably, 21.9% of patients under 5 years were born prematurely, and all participants were of African descent. The mean weight of patients under 5 years was 10.67 kg (SD, 3.30kg), while those over 5 years had a mean weight of 13.5 kg (SD, 3.4kg). Most patients under 5 years were breastfed (n=30, 93.75%). Diagnostic imaging modalities included CT scans (n=72, 82.76%), ultrasound (n=14, 16.09%), and combined CT/MRI (n=1, 1.15%). Non-communicating hydrocephalus was the predominant type (n=56, 64.37%), with congenital aqueductal stenosis being the primary etiology in both age groups (Table 1).

Table 1. Sociodemographic characteristics of the patients

Variable	n (%) or value
Age	
Overall cohort, median (IQR), years	4 (1–16)
Overall cohort, range, years	0.08–43
≤5 years, n (%)	32 (36.8)
Median (IQR), years	1 (0.5–3)
Range, years	0.08–4.9
>5 years, n (%)	55 (63.2)
Median (IQR), years	32 (21–43)
Sex	
Male, n (%)	54 (62.1)
Female, n (%)	33 (37.9)
Term of pregnancy (≤5 years)	
Preterm, n (%)	7 (21.9)
Race	
African, n (%)	87 (100)
Nutritional status — Weight-for-age (≤5 years)	
Mean weight (SD), kg	10.67 (3.30)
>+2 SD, n (%)	1 (3.1)
Normal, n (%)	25 (78.1)
<−2 SD, n (%)	6 (18.8)
Nutritional status — BMI (>5 years)	
Mean weight (SD), kg	13.5 (3.4)
Obese, n (%)	2 (3.7)
Overweight, n (%)	5 (9.3)
Normal, n (%)	40 (74.1)
Underweight, n (%)	7 (12.9)
Breastfeeding status (≤5 years)	
Breastfed, n (%)	30 (93.8)
Diagnostic imaging	
CT scan, n (%)	72 (82.8)
Ultrasound, n (%)	14 (16.1)
CT scan + MRI, n (%)	1 (1.1)
Type of hydrocephalus	
Non-communicating, n (%)	56 (64.4)

BMI, body mass index; CT, computed tomography; IQR, interquartile range; MRI, magnetic resonance imaging; SD, standard deviation.

Surgical Outcomes

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The median hospital stay was 5 days (IQR, 4-6 days). Chhabra shunts (Surgiwear, India) were used in 82 patients (91.1%), while Codman shunts were used in 8 patients (8.9%) (Table 2). Most surgeries were elective (n=82, 91.1%) and performed in the morning (n=84, 93.3%) by a single neurosurgeon. The mean number of personnel in the operating room was 8±2, and the median surgical duration was 60 minutes (IQR, 55-70 minutes). The median follow-up was 4months (1- 19months).

Table 2. Perioperative factors of the patients

Variable	n (%) or value
Total procedures, n	90
Shunt type	
Chhabra (Surgiwear, India), n (%)	82 (91.1)
Codman, n (%)	8 (8.9)
Surgery type	
Elective, n (%)	82 (91.1)
Emergency, n (%)	8 (8.9)
Timing of surgery	
Morning, n (%)	84 (93.3)
Afternoon, n (%)	6 (6.7)
Surgeon's experience	
Consultant level, n (%)	90 (100)
OR personnel, mean (SD)	8 (2)
Surgical duration, median (IQR), min	60 (55–70)
Number of procedures per patient	
First procedure, n (%)[a]	84 (96.6)
Second procedure (revision), n (%)[a]	3 (3.4)
Postoperative hospital stay, median (IQR), days	5 (4–6)
Follow-up, median (range), months	4 (1–19)
Patients lost to follow-up, n	2
Overall complications, n (%)	3 (3.33)
Proximal obstruction, n (%)	2 (2.22)
Transanal protrusion,[b] n (%)	1 (1.11)
Revision surgeries, n (%)	3 (3.33)
Infection rate, n (%)	1 (1.11)
Mortality, n (%)	1 (1.11)

[a] Three patients required a second procedure due to complications; no patient required a third procedure.

[b] The single case of transanal protrusion was complicated by secondary bacterial meningitis, resulting in death two weeks after revision surgery. This case constitutes the sole infectious event in the series.

IQR, interquartile range; OR, operating room; SD, standard deviation.

Complications

The overall complication rate was 3.33% (two were due to proximal obstruction and one due to transanal protrusion) and all had revision surgeries (Table 2). The single case of transanal protrusion was observed in a 4-week-old, premature, malnourished male neonate, who presented 10 weeks post-surgery (Figure 2). The shunt was successfully replaced, but the patient succumbed to bacterial meningitis 2 weeks later.

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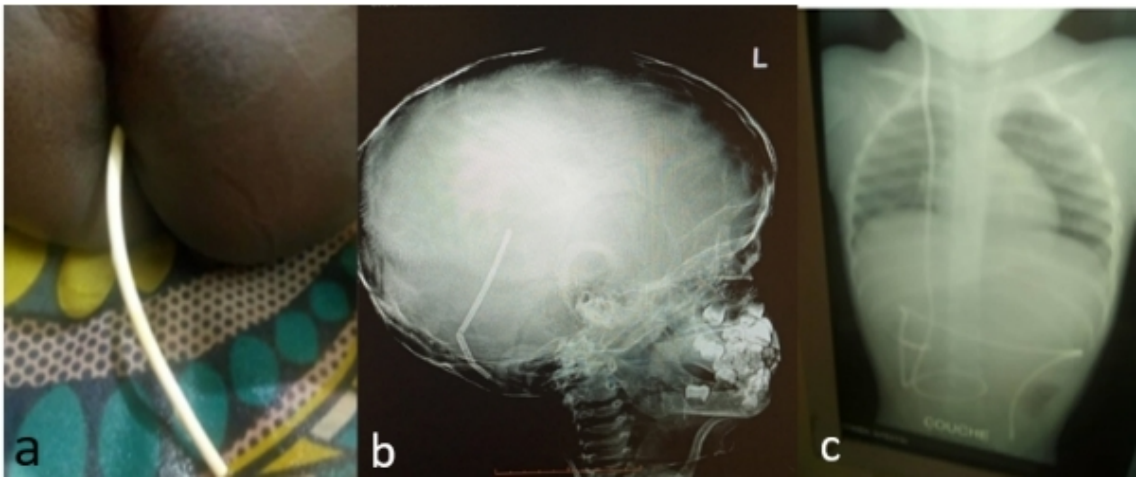

Figure 2. A four-week-old pretermed malnourished child with (a) Trans-anal protrusion, an X-ray of (b) an adequately placed ventricular catheter, and (c) ileocecal perforation and trans-intestinal migration of shunt hardware

DISCUSSION

Hydrocephalus is a significant neurosurgical problem in adults and children. VPS is the most common treatment for hydrocephalus. Among VPS complications, infection has the highest mortality rate, which makes it a significant problem for practitioners. Similarly, efforts have been made to decrease this mortality rate [12]. However, obstruction followed closely by infection is the most common complication of VPS, and bowel perforation is a rare complication occurring commonly in preterm infants and neonates [21].

Infection Rates and Prevention Strategy

The observed infection rate in this study was 1.11% per procedure. This was lower than the 2.8% prospectively reported by Kalangu et al., but higher than the 0.17% reported by Choux et al. [12,22]

In this cohort, the single infection occurred following anal protrusion of the distal catheter. Generally, shunt infections manifest within three months postoperatively and are associated with perioperative factors that include, but are not limited to, malnutrition, local or distant infection, poor handling of shunt hardware, excessive contact with skin, and uncontrolled operating theatre traffic. Accordingly, our protocol was designed to mitigate these known perioperative risk factors.

Key measures common across published protocols include minimizing handling of shunt components, delaying opening of the shunt until immediately before implantation, and avoiding direct contact between the shunt and the patient's skin. Additional measures vary among protocols [12,18].

One notable measure is limiting personnel and restricting traffic in the operating theatre, which can be difficult to implement in teaching hospitals. In the absence of intraoperative audiovisual aids, multiple students often observe shunt implantation procedures in rotation, which is contrary to recommendations in several protocols [23].

Controversies and Challenges

The continuous use of 10% povidone-iodine solution to prepare the patient's skin and its regular reapplication intraoperatively, in contrast to chlorhexidine alone, is another controversy with international norms. It has been proven that bacterial skin recolonization from the sweat glands occurs after about 30-45 minutes. Chlorhexidine has been proven to be a better skin antiseptic with a more durable action [18]. The continuous application of 10% povidone-iodine solution ensured that the peri-incisional skin of the operative sites remained moist to avoid the risk of skin microbial contamination. A low infection rate was still achieved using a 10% povidone-iodine solution combined with meticulous

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surgical technique rather than chlorhexidine alone. Therefore, a 10% povidone-iodine solution is a good alternative when chlorhexidine is unavailable.

Timing of Surgery and Breastfeeding

Most procedures in this cohort were performed in the morning, with only 6.7% done in the afternoon. This pattern aligns with prior observations that operating theatre sterility may be higher earlier in the day, and that physiologic factors such as sweating are reduced in the morning [24].

Most patients were under five years of age and were breastfed. Breastfeeding has been previously associated with lower infection risk in infancy, potentially due to immunologic benefits within the first six months of life. While our descriptive data do not permit causal inference, the high proportion of breastfed infants observed here is consistent with the literature. Encouraging breastfeeding in this population remains important for general immune support [25].

The standardized protocol specified a postoperative hospital stay of 4 to 6 days. Shorter hospital stays have been noted to reduce exposure to nosocomial pathogens that may contribute to shunt infection. In this cohort, the median length of stay was 5 days, which is compatible with that observation [26].

Several non-measured factors may also be relevant to the low observed infection rate. These include routine education provided to parents and caregivers regarding shunt care, and close postoperative follow-up maintained by the principal investigator with patients' families. Such measures may promote vigilance for early signs of infection following shunt implantation.

Complications and Outcomes

Overall, complications requiring revision surgery occurred in 3 of 87 patients (3.4%). These included two cases of proximal obstruction and one case of trans-anal shunt protrusion, which was followed by meningitis in that patient. Consistent with the single infection noted earlier, this case of meningitis occurred secondary to the anal protrusion of the distal catheter.

Proximal obstruction may result from blockage by blood clots, choroid plexus, tumor particles, or brain parenchyma, as observed in our cases [19]. Trans-anal protrusion of ventriculoperitoneal shunts is rare, with approximately 68 cases reported in the literature [15]. Although the exact pathomechanism remains incompletely understood, factors implicated in bowel perforation during ventriculoperitoneal shunt placement include the use of trocars, the stiff end of the abdominal catheter, prolonged bowel irritation by the catheter, and silicone-induced tissue reaction [15]. Prematurity and malnutrition may predispose to bowel perforation, as was noted in our patient with trans-anal protrusion [16]. The proposed mechanism for subsequent anal extrusion is intestinal peristalsis acting on the catheter tip once it enters the bowel lumen. Because a fibrous track often forms around the catheter at the perforation site, patients rarely present with overt peritonitis. However, they remain at risk for intracranial infection, which can be fatal if not promptly recognized and treated, as occurred in the index case. Other series have reported infection, obstruction, and shunt malfunction as the most common complications following ventriculoperitoneal shunt placement [13–16].

CONCLUSION

This 23-month prospective descriptive cohort study of 87 patients undergoing VPS insertion in two Nigerian tertiary hospitals found a low overall complication rate of 3.33% per procedure and an infection rate of 1.11% per procedure following implementation of a standardized perioperative protocol. The protocol included morning surgery, povidone-iodine skin preparation, prophylactic antibiotics, double gloving, glove change before shunt handling, minimal catheter manipulation, delayed shunt opening, limited skin contact, and structured postoperative wound care.

All complications occurred in children. The most severe complication was transanal protrusion of the distal catheter in a premature, malnourished neonate, followed by fatal bacterial meningitis. This case suggests that prematurity, malnutrition, bowel perforation, and distal catheter extrusion may be associated with severe adverse outcomes.

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Because this was a descriptive study using bundled interventions, no causal relationship can be established between individual protocol components and the observed low complication rate. Nevertheless, the findings suggest that a structured VPS insertion protocol is feasible in resource-limited settings and may be associated with favorable short-term outcomes. Larger comparative studies with longer follow-up are needed to determine which protocol components are most effective, assess cost-effectiveness, and evaluate generalizability across other low- and middle-income settings.

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DISCLOSURES

ETHICAL APPROVAL

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the local Ethics Modibbo Adama University Teaching Hospital, Yola (HREC/24/322).

CONSENT TO PARTICIPATE

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

CONFLICT OF INTEREST

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper

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ARTIFICIAL INTELLIGENCE

No artificial intelligence assistance was employed in the preparation of this manuscript.

CONTRIBUTIONS

- **Emmanuel Garba Sunday**: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing
- **Eno-Abasi Garba Sunday:** Conceptualization, Validation, Visualization, Writing – original draft, Writing – review & editing

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