



# Ventriculoperitoneal Shunt Complications: A Four-Year Retrospective Study At St. Peter's Specialized Hospital, Addis Ababa, Ethiopia, 2016 -2020.

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**Abstract:** The risk in performing a shunt operation is low, the complications, such as mechanical malfunctions, over drainage and infection are commonly encountered at St. Peter's Specialized Hospital. However, limited studies are known exploring the determinants of ventriculoperitoneal shunt complications in developing countries. Thus, this study identified predictors of ventriculoperitoneal shunt (VPS) complications among patients who underwent VPS insertion at St. Peter's Specialized Hospital, Addis Ababa, Ethiopia. A retrospective cross-sectional study was carried out on patients diagnosed with hydrocephalus and have undergone VPS insertion from 2016-2020 at St. Peter's Specialized Hospital and were on follow up for at least 6 months postoperatively were included. Data was collected from medical records and in person/telephone interviews using a structured questionnaire. Overall 250 patients were included in this study. Among these 42% were female and about 73% of the patients had communicating hydrocephalus. The overall prevalence of complication was identified as 26.4% and complications related to proximal and distal catheter was 24% and 75.7% respectively. Out of these 22.7% and 57.7% had Ventriculitis and shunt infection respectively. Moreover, the determinants for complications were identified as; low CSF glucose and large head circumference before VPS insertion. Further follow up studies were suggested to strengthen the study.

**Key words:** Ventriculoperitoneal shunt, ventriculoperitoneal shunt complications, ventriculoperitoneal shunt infection, ventriculoperitoneal shunt malfunction, HCP

## INTRODUCTION

Hydrocephalus is a common pediatric disorder in which there is an increase in cerebrospinal fluid (CSF) volume, which in turn causes enlargement of the cerebral ventricles, thinning of the cerebral mantle and elevation of the intracranial pressure. This disorder is caused by an imbalance between production and absorption of CSF or obstruction in the CSF circulation. (Rajendra K. Ghritlaharey, 2012) It can be a manifestation of many congenital and acquired disorders of the brain (Mark S. Greenberg, 2016). In the developed world, the incidence of congenital hydrocephalus has been estimated to be about 0.5 cases per 1000 live births and the overall incidence of neonatal hydrocephalus is estimated to be about 3 to 5 cases per 1000 live births. The annual incidence of infant hydrocephalus in sub-Saharan Africa is unknown. Using developed world estimates for neonatal hydrocephalus incidence suggests 700 new congenital hydrocephalus cases and 4200 to 7000 new infant hydrocephalus cases per year in Uganda. In comparing Uganda with more developed countries, one might expect a similar or greater birth incidence of congenital hydrocephalus, but the non-congenital etiologies of acquired infant hydrocephalus would be expected to differ, with post hemorrhagic hydrocephalus of prematurity being common in more economically developed countries and post infectious hydrocephalus being more common in developing nations such as Uganda. (Benjamin C. Warf and the East African Neurosurgical research collaboration, 2010)

In Ethiopia, the etiology and incidence rates of hydrocephalus can be assumed to correspond to what has been reported from other East African countries. (Tsegazeab Laeke, 2017) Hydrocephalus in children can be acquired or congenital. It is categorized under 'congenital' if the HCP or its underlying cause is present at birth. If the child's HCP didn't manifest or a cause is not noted at birth the HCP is considered 'acquired'. (H.Richard Winn, 2017)

The insertion of ventriculoperitoneal (VP) shunts has been the mainstay of treatment. (Rajendra K. Ghritlaharey, 2012). Other shunting techniques for the management of hydrocephalus are endoscopic third ventriculostomy, ventriculoatrial (VA) shunt and lumboperitoneal (LP) shunt. (Joachim M. K. Oertel, 2009; Yad R. Yadav, 2010). The major disadvantage of VPS is the fact that it constitutes a foreign body and prone to complications such as mechanical blockage, shunt infection, shunt migration, and rarely shunt protrusion. (Villemure, 2007) , hence, under the best of circumstances, about half of shunts fail within a year or two of placement, the majority eventually fail at least once, and there is a continued lifetime risk of failure. (R.Hamdan, 2019).

Worldwide, complication rates range widely, from 1% to 40%, with shunt infections being the most frequent cause of failure (Esther Gathura M.B.B.S., 2010) .Studies from developed countries have over the years reported an incidence of shunt infection varying from 0% to 27% per procedure (Tsegazeab Laeke, 2017). Shunt obstruction was reported in approximately 13.4% of patients (6.7% proximal obstruction by debris and 6.7% distal obstruction by

pseudo cyst) (R.Hamdan, 2019). Hamada and Abou Zeid found that misdirection of proximal catheter was found in two (7.1%) patients of their shunt malfunction series (Abou-Zeid, 2015). Shunt disconnection and fracture accounted for 15% of shunt malfunctions and that occipitally placed shunts had a higher tendency to dislocate than frontally placed shunts (Aldrich & Harmann , 1990).However, Ali R.Hamdan found that there was an advantage of anteriorly placed VP shunts over posteriorly placed shunts in terms of malfunction and infection. He also noted that complications tend to occur more with occipitoparietal than with frontal VP shunts. In more details, incidence of complications with occipito parietal VP shunt was 10.4% and with frontal type was 6%. Abdominal complications are not rare, intra-abdominal pseudocyst was reported in two (6.66%) patients and extra peritoneal catheter in one (3.33%) patients (R.Hamdan, 2019).

Many of the shunt complications need shunt revisions, i.e., 12.5 to 36% of the cases and many of them require multiple revisions (Ashraf Ahmed, 2009; Raj Kumar, 2005). For example, a study done in India from 2006-2010, of the of 236 VP shunts performed Forty (16.94%), 28 (70%) boys and 12 (30%) girls developed shunt complications in follow-up period and needed 48 shunt revisions (Rajendra K. Ghritlaharey, 2012).

There are many possible contributing factors for shunt failure. Among these factors some are: timing of shunt placement, duration of surgery, preoperative antibiotics, and surgical method for placement of the distal catheter, type of shunt, reason for shunt placement, previous shunt history, associated spinal dysraphism, number of early revisions, and concurrent infections (H.Richard Winn, 2017).For example, A Norwegian study showed that the incidence of infections significantly correlated with age, type of operation, and etiology of hydrocephalus, with infections being common during the first 6 months of life, after primary shunt insertions rather than revisions, and in children with meningomyelocele (MMC)-related hydrocephalus. Among other possible factors that are related to shunt infections are poor condition of the skin, presence of intercurrent infection at the time of surgery, prolonged operation time, as well as the education and experience of the neurosurgeon. (Enge P. Ø.r, 2003)

However, In Ethiopia limited studies were documented exploring the determinants of ventriculoperitoneal shunt complications. So, the real burden of HCP and shunt complications in our country remains unknown. Therefore, this study aimed at identifying the determinants of ventriculoperitoneal shunt complication amid patients who underwent VPS insertion at St. Peter's specialized Hospital, Addis Ababa, Ethiopia. The findings of this study will provide baseline data for the hospital and future prospective studies and serve as a teaching material for residents and neurosurgical societies.

## METHODS AND MATERIALS

The study was conducted at St. Peter's specialized Hospital which is one of the largest hospitals in Ethiopia affiliated with St. Paul's hospital millennium Medical college (SPHMMC). A chart review of all patients who underwent VP shunt insertion at St. Peter's Specialized Hospital between January 2016 - December 2020. Patient Medical charts, operative reports, imaging studies, and clinical follow-up evaluations were reviewed for all patients who underwent VP shunt surgery for clinical and/or radiographic evidence of hydrocephalus and further data was also collected by telephone interview using patients' mother tongue. Information on each patient, including age, sex, residency, etiology of hydrocephalus, type of hydrocephalus, date of shunt placement, duration of surgery and anesthesia, head circumference, weight for age, shunt malfunction or failure was collected from patient records and was analyzed. All patients with clinical and/or radiographic (US, CT or MRI) evidence of HCP for whom VPS was inserted were included while those who have had VPS inserted elsewhere, patients with missing charts, those who disappeared from follow up were excluded and Patients who underwent first VPS insertion elsewhere and revision done at St. Peter's Specialized Hospital were also excluded from the study.

### *Study variables*

*Dependent variables:* Hospital based VPS complications

*Independent Variables:* Age, Gender, Type of HCP, Cause of HCP, Presence of associated MMC, HC at the time of surgery, Duration of procedure, Clinical investigations and Duration of per operation hospital stay.

### *Investigations and physical examinations*

A complete blood count (CBC) and a ventricular tap was routinely carried out for CSF WBC count, red blood cell count, glucose, protein and gram stain analysis prior to VPS insertion. CSF cultures were also obtained for all patients who presented with signs and symptoms of shunt malfunction. Weight for age, core body temperature and head circumference were also routinely done.

### *Type of hydrocephalus*

Based on specific details of the patient history, ultrasonography, and/or CT scan reports, the type and cause of the hydrocephalus was postulated. Type of hydrocephalus was classified as communicative and obstructive type and etiology was classified as post MMC repair, Chiari II, DWM/V, aqueductal stenosis, posterior fossa mass, IVH, congenital and post infectious.

### *Shunt Complications*

Shunt complications were classified as either proximal catheter related or distal catheter related. Proximal catheter related complications were further subclassified as ventriculitis and collection of CSF around the reservoir while distal catheter related complications were subclassified as shunt infection, shunt disconnections, CSF collection around the tube. A diagnosis of ventriculitis was made if there was contamination of CSF or shunt tip with bacteria while shunt infection was considered when positive Gram stains or cultures were obtained from CSF. Additional features included high-grade fever ( $> 38^{\circ}$ ), symptoms of shunt malfunction, and abdominal pain or distention. In the absence of positive cultures or Gram stains, a CSF WBC count greater than 50 cells/ml in the presence of positive CSF culture or presence of high-grade fever, altered level of consciousness and meningismus was considered diagnostic.

### **STATISTICAL ANALYSIS**

Data analysis was performed using SPSS version 20.0.a descriptive statistics such as frequency distribution, mean, standard deviation and percentages were calculated. Continuous variables were presented as mean and SD and categorical variables were presented as percentages and frequency. Finally, the result was described using texts and tables and statistical significance was set at  $p < 0.05$ .

### **ETHICAL CONSIDERATION**

Ethical approval and permission for the research was granted by review boards of SPHMMC and St. Peter's Specialized Hospital. Patient confidentiality was kept by not mentioning the name of the subjects. The authors declare that all the methods included in the study are in accordance with the declaration of Helsinki.

### **RESULTS**

#### *Socio-demographic factors*

From the 250 patients included in the study, 105 (42%) were female while the rest 145 (48%) were male. All of the patients were in the pediatric age group. Two hundred and two (80.0 %) were less than 1 year of age while the median age is 5 months and 12 days. Around half of the patients, 131 (52.4%) were from Oromia and 57 (22.8 %) were from Addis Ababa. [Table 1]

Table 1: Frequency and percentage of socio-demographic factors in patients VPS was inserted for between 2016 and 2020 G.C at St. Peter's Specialized Hospital.

		Frequency	Percent
Sex	Female	105	42
	Male	145	58
Age	<1 yr	202	80.8
	1 – 10 yrs	42	16.8
	>10 yrs	6	2.4
Residency	Amhara	26	10.4
	Oromia	131	52.4
	Somalia	1	.4
	Benshangul	4	1.6
	SNNPR	28	11.2
	Harar	1	.4
	Dire Dawa	2	.8
	Addis Ababa	57	22.8

*Clinical features of patients for whom VPS was inserted in the study area*

Based on the clinical examination of the patients; over 97% of patients included in the study have had fever, irritability, vomiting and convulsion. Besides, the majority of the study participants 139(58.2%) had weight for age

within normal range based on WHO classification. Bulged fontanel 66.4% and head enlargement 81.2% were the predominant presenting symptoms. Besides, patients were either on prophylactic 87.2% or therapeutic 12.8% antibiotics before their surgery and 45% of the participants have had CSF glucose < 50 mg/dl. The average (SD) duration of surgery and anesthesia were 59.4 (34.1) and 85.8 (39.7) minutes respectively. Moreover, the study participants mainly 182(72.8%) had communicative HCP; mainly due to post MMC repair.

Table 2: Clinical features of the patients included in the study

Variables(N=250)	Categories	Frequency	Percentage
Weight for Age of the patients	Under-weight	81	33.9
	Normal	139	58.2
	Overweight	19	7.9
Type of Hydrocephalus	Communicative	182	72.8
	Obstructive	68	27.2
Bulged Fontanel	Yes	166	66.4
	No	84	33.6
Head enlargement	Yes	203	81.2
	No	47	18.8
Cause of Hydrocephalus	Post MMC Repair	124	49.6
	Chiari II	40	16.0
	DWM/V	30	12.0

Aqueduct Stenosis	22	8.8
Posterior fossa mass	17	6.8
Either IVH or Congenital	2	0.8
Post Infectious	15	6.0

*Prevalence of Complications among patients who underwent VPS insertion in the study area*

The prevalence of complications among patients who underwent VPS insertion in the study area was identified to be 26.4 %. Based on the findings of this study proximal catheter related complications were seen in 16 (24 %) of patients who have developed complications and out of these, 15 (6.0 %) had ventriculitis. Whereas, 57 (86 %) of patients with complications had distal catheter related complications and from these, 38 (66 %) had shunt infection. [Table 3]

Table 3: Frequency and percentage of complications, proximal and distal catheter related complications in patients VPS was inserted for between 2016 and 2020 G.C at St. Peter's Specialized Hospital.

		Frequency	Percent
Complications	Yes	66	26.4
	No	184	73.6
Proximal catheter related complications	Ventriculitis	15	6.0
	Collection of CSF around the reservoir	1	0.4
Distal catheter related complications	Shunt infection	38	15.2
	Not documented	10	4.0
	Shunt disconnection	5	2.0



CSF collection around the tube	2	2.0
Extrusion through the anus	2	2.0

#### *Determinants of complications among patients who underwent VPS insertion*

On bivariate binary logistic regression, the presence of fever, high white blood cell count, CSF glucose, head circumference was significantly associated with the presence of complications. Patients who presented with fever were found to be 26.3 times at risk of developing complications (AOR 26.3(1.31-526.9)). Those patients who had CSF glucose between 0 and 50 mg/dl are 4.62 times more likely to complicate than those with CSF glucose above 50 mg/dl (AOR 4.62(1.356-15.7)). [Table 4] On the contrary, age, sex, WFA, duration of surgery, duration of anesthesia, type of HCP and being on antibiotics didn't have significant association with the development of post-operative complications.

Table 5: Bi-variable and multivariable logistic regression analysis of the determinant factors for complication after VP shunt insertion among study participants, in St Peter's specialized Hospital, Addis Ababa, Ethiopia, between 2016 and 2020 GC.

Variables	COR (95%CI)	AOR (95%CI)
Fever		
Yes	5.871(1.05-32.842)	26.308(1.313-526.9) **
No	1	1
Vomiting		
Yes	1.917(.788-4.667)	1.241(.121-12.76) *
NO	1	1

## WBC

0-6000	1	1
6000-14000	1.097(.344-3.493)	.37(.66-2.074) *
>14000	2.625(.717-9.6)	4.04(0.54-31.49) *

## CSF glucose

0-50	2.037(.843-4.92)	4.625(1.356-15.701) **
Above 50 mg/dl	1	1

## Head circumference

2 cm above 97th percentile	1.986(.926-4.261)	8.321(1.318-52.543) **
2 cm within 97th percentile	1.125(.34-3.749)	2.953(.250-34.935) *
Below 97th percentile	1	1

\*=p value >0.05, \*\*=p value <0.05

After controlling the likely confounders through a multivariate logistic regression model; CSF glucose and head circumference were significantly associated with the presence of complications. Thus, the prevalence of complications among patients who underwent VPS insertion at St. Peter's Specialized Hospital was explored as over 26%.

The factors associated with the development of complications after VPS insertion were; CSF glucose (AOR:4.6 at 95% CI:1.36,15.7) and head circumference (AOR:8.3 at 95% CI: 1.32,52.54) in the study area. To be more precise; patients with low CSF glucose level(<50mg/dl) and enlarged head circumference (2 cm above 97th percentile) were more likely to develop complications after VPS insertion.

## DISCUSSION

This four-year retrospective study aimed at determining the frequency of ventriculoperitoneal shunt complications and the risk factors associated with developing these complications. According to the present study and previous studies done worldwide showed that among the various shunt complications, infection remains the most significant complication of VP shunt surgery in patients with hydrocephalus. (16) (19, 20, 21). However, the N.J.M. Mwang'ombe and T. Omulo study showed that Shunt block was the most common reason for shunt revision. (22) Similar to most studies, this study also found that infection is the most common complication in patients with VPS 38 (15.2 %) of the patients with VPS developed shunt infection while in 15(6%) ventriculitis was diagnosed as complication.

A study done in a hospital in Pakistan, shows that among the total number of 151 patients VPS was inserted for HCP, complications were encountered in 30 patients (19.87%) during the follow-up of 30 days. (24) Another study done on outcome analysis of VPS in pediatrics shows overall shunt complications of 35.76%. (26) Meanwhile, this study found that the prevalence of complications in patients with VPS was inserted at St. Peter's Specialized Hospital between 2016 and 2020 G.C was 26.4 %.

According to Bilal K. et al., the primary indications for the insertion of VP shunt were: congenital hydrocephalus in 70 (46.4%), post infectious hydrocephalus in 57 (37.7%), hydrocephalus due to tumor in 22 (14.6%), and post traumatic hydrocephalus in two (1.4%) patients. (Khan B, 2021 ) Another retrospective study done on indications for VPS showed that 24(40%) of the study population had congenital causes while the rest, 36 (60%) had acquired causes. (Ritvik D. Jaykar, 2017) on the contrary, the most common indication for VPS insertion according to this study was post mmc hydrocephalus seen in 124 (49.6 %) of the patients. Following it are, Chiari II malformation, Dandy Walker Malformation and Variant, and aqueductal stenosis with respective frequency and percentage of 40 (16 %), 30 (12 %), 22 (8.8%).

## CONCLUSIONS AND RECOMMENDATIONS

The prevalence of complications among patients who underwent VPS insertion was identified as 26.4% in the study area which is considered to be high as per the low risk of the procedure. Proximal catheter related complications were 24% among patients who developed complications; 22.7% had ventriculitis. Besides, 75.7% of patients with complications had distal catheter associated complications; 57.7% had shunt infection. Patients with low CSF glucose level(<50mg/dl) and enlarged head circumference (2 cm above 97th percentile) were more likely to present with complications after VPS insertion at St. Peter Specialized Hospital. Hence, intraoperative guidelines and protocols should be developed and followed strictly to reduce infection in the study setting. Moreover, public and health care provider education for the prompt recognition and referral of patients with HCP in its early phases as complications were significantly associated with head circumference. However, further prospective controlled studies are required to validate the observed associations among the risk factors and incidence of shunt complications in the study setting.

**LIMITATIONS OF THE STUDY;** A retrospective nature of the study.

**ACKNOWLEDGMENT;** Authors of all the publications used to write this research were recognized.

**DECLARATIONS;** This is an original work and lacks any competing interests.

**ABBREVIATIONS;** *HCP: Hydrocephalus; ICH: Intracerebral hematoma; ICU: Intensive care unit; IVH: Intraventricular hemorrhage; LP: Lumboperitoneal shunt; MMC: Meningomyelocele; VA: Ventriculoatrial shunt; VPS: Ventriculoperitoneal shunt; SPHMMC: St. Paul's Hospital Millennium Medical College; CSF: cerebrospinal fluid*

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