

## Complications of Ventriculoperitoneal Shunts in Children with Pediatric Hydrocephalus a Local Study at Benha University Hospitals

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### Abstract

Ventriculoperitoneal shunting is the main way used for extra-thecal cerebrospinal fluid (CSF) diversion. Despite being the main corner stone of treating different types of hydrocephalus, VP shunts has unfortunately a lot of complications making surgeries to treat these complications much more than initial shunt insertions. Methods: It is a clinical retrospective observational study that was conducted on 221 patients with congenital hydrocephalus of both genders with age ranging from 0 to 18 yrs old who came with symptoms and signs of shunt complications and were primarily shunted at Benha university hospital between 2016 and 2019. A complete clinical assessment was done, history taking, a final diagnosis was made, and a treatment of individual patients was planned accordingly. Patients were followed up till the end of the study post-operatively. Data was analyzed using the SPSS (version 16.0). VP shunt was inserted for 221 patients. 113 (51.1%) patients had various forms of complications. Obstructive complications accounts for the most common complications as they happened in 48 (42.5%) of complicated patients followed by infective complications as they appeared in 27 (24%) patients. Conclusions: Despite .great revolution in the field of neurosurgery in the past 100 years and sincere efforts from neurosurgeons worldwide, shunt complications still common among shunted patients. Background Hydrocephalus is regarded as an imbalance in the formation and absorption of CSF to a sufficient magnitude producing accumulation of CSF fluid with in ventricular system of the brain leading to an elevation of intracranial pressure. Compensatory adjustments especially in very young subjects may occur that may reduce prevailing CSF pressure to normal range on count of functioning brain tissue [1]. Hydrocephalus is the second most common congenital brain malformation [2]. Congenital hydrocephalus is type of hydrocephalus that is present or its underlying cause at birth. majority of cases are attributed to aqueductal stenosis, chiari malformation, dandy walker malformation, arachnoid cyst. approximately 55% of all cases of congenital hydrocephalus are due to Primary aqueductal stenosis whereas aqueductal stenosis secondary to neoplasm, infection, or hemorrhage accounts for another 5% [4]. Till now, the standard treatment of hydrocephalus is ventriculoperitoneal shunt. The technique of using the peritoneal cavity for CSF absorption in ventriculoperitoneal shunting (VPS) was developed by Kausch in 1908 [3]. Although VPS insertion is the most common neurosurgical Procedure done worldwide, complication rates in Children are high ranging from 10% to 100% [11]. The advent of endoscopic third ventriculostomy has gained popularity due to the high complication and failure rates of ventriculoperitoneal shunt [12]. VP shunts are prone to a lot of complications such as mechanical blockage, shunt infection, shunt migration, and various abdominal complications [13].

### 1. Introduction

Congenital hydrocephalus is the type of hydrocephalus that is present or its underlying cause at birth. the majority of cases are attributed to aqueductal stenosis, chiari malformations, dandy walker malformations, arachnoid cysts especially (post. Fossa, suprasellar, interhemispheric) and holoprosencephaly. It occurs in infants in common association with myelomeningocele with most common complications of ventriculoperitoneal shunts occurring in these patients [31].

### 2. Methods

This is a retrospective observational study that was conducted at the Department of Neurosurgery, Benha University Hospitals for a period Of 3 years October 2016 to October 2019 including 221 patients with age less than 18 yrs old. An informed signed consent was taken from the parents and guardians of patients before enrolling them into the study after the approval of the ethical committee of the Faculty of medicine Benha university. patients with age less than 18 yrs old with congenital hydrocephalus were included in the study. all patients underwent complete clinical assessment with

thorough history taking of previous NICU admission and any previous shunt complications or other underlying morbidities. Routin labs were done for all patients with CRP, ESR, CSF analysis and C&S when needed. The investigation performed for all patients were ct scans, pelvi-abd. US, shuntogram. MRI brain, abdominal cts were done when needed. on basis of clinical assessment and radiology, lab done, final diagnosis was taken and any patient who had adverse effect due to vp shunt was defined as having a vp shunt complication and included in the study.

### 3. Statistical analysis

Data was recorded and analyzed using the Statistical Package of Social Sciences (SPSS) version 16. Descriptive statistics were presented as frequencies, percentages, means, and standard deviations.

### 4. Results

221 cases of congenital hydrocephalus who were operated up on in on Benha university hospitals. 113 patients had complications (51.1%) with 15 patients of them (6.6 %) came with more than one complication patients aged range 0.04 – 15 years and 52.2% of the

patients are between 0 – 2 years with mean age  $3.93 \pm 4.22$  and 55.8% of the patients are males.

That 61 (54%) of complicated patients presented with symptoms and signs of increased ICP ( increased HC , bulging ant. fontanelle, vomiting , headache, sleepiness, irritability, abducent palsy , DCL ). 20 (17.7) patients presented with symptoms and signs of inflammation ( fever , infected wound , pus discharge from wound, sloughed skin over reservoir, infected shunt track . 14 (12.4%) patients shunt failure was accidently discovered during regular follow up by physician like delayed filling resevoir , increase in HC that w , vomiting that was misdiagnosed by pediatricians as GE. 11 patients (9.8%) were presents by abdominal pain, abd. Swelling , signs of peritonitis like abd. Rigidity, garding , signs of intestinal obstruction ( vomiting , absolute constipation , abd. Distension).3

patients presented with fits 2 (1.8%) patients presented with shunt protrusion through anus . 2 (1.8%) patients presented with chronic psychomotor changes and bilateral lower limb spasticity. The documented complications were classified according their rate to:

Obstructive complications : happened in 48 (42.5%) patients with ventricular end obstruction as most complication encountered and happened in 35 (29.2%) patients and distal end obstruction in 13 (11.5%) patients.

Infective complication appeared in 27 (24%) patients , 17 patients (15%) had csf infections that was proved by csf analysis , 3 (2.6%) patients had scalp wound infection with skin slouphage over reservoir , 2 patients ( 1.7%) had brain abcess , 2 patients ( 1.7%) had ventriculitis , 1 ( 0.88 %) patient had subdural empyema.

**Table (1)** Demographic data, clinical presentations, frequencies, and classifications of complications of ventriculoperitoneal shunts.

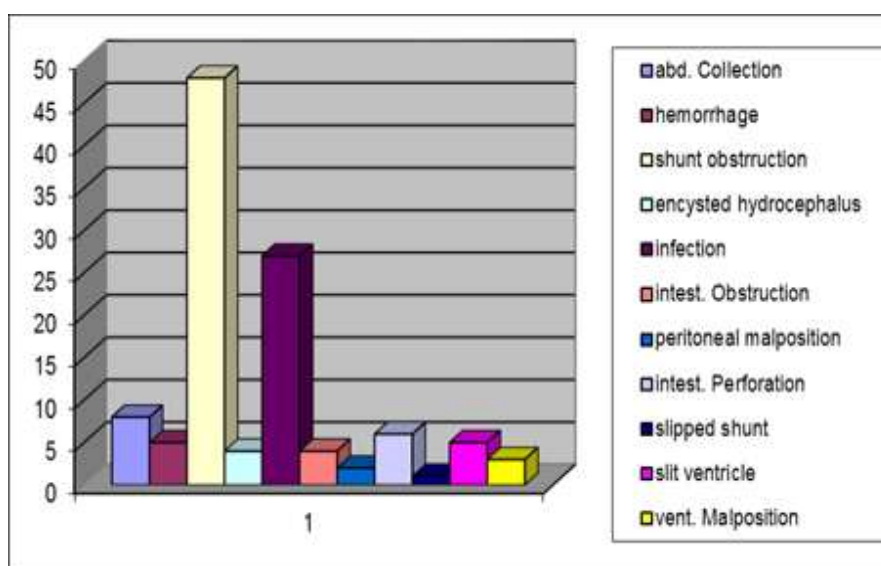
	No (113)	%
<b>Sex</b>		
Male	63	55.8
Female	50	44.2
Age mean $\pm$ SD (range)	47.14 $\pm$ 50.59 (0.5-180)	
<b>Clinical</b>		
Accidental	14	12.4
Acute abdomen	11	9.7
Raised ICP	66	58.5
Sh. Protrusion, anus	2	1.8
Signs of infections	20	17.7
<b>Complications</b>		
Abd collections		
Abd pseudocyst	4	3.5
CSF ascites	4	3.5
<b>Intracranial hge</b>		
IVH	1	0.9
Subdural he	4	3.5
<b>Shunt obstructions</b>		
Vent end obstruction	35	31.0
Distal end obstruction	13	11.5
<b>Shunt infection</b>	27	23.9
Encysted hydrocephalus	4	3.5
Intestinal obstruction	4	3.5
Intestinal perforation	6	5.3
Slipped shunt	3	2.7
Slit ventricle syn	5	4.4
Ventricular malposition	3	2.7
<b>Ttt</b>		
Abd exploration	4	3.5
End fenestration revision	4	3.5
Evacuation	3	2.7
Evacuation sh closure	1	0.9
EVD	23	20.4
Exterilization	3	2.7
Medical ttt	10	8.8
New shunt	11	9.7
Nothing	2	1.8
Revision	50	44.2
Shunt removal	2	1.8
<b>Prognosis</b>		
New complications	23	20.4
Improved	82	72.6
Death	8	7.1
1 <sup>st</sup> shunt mean $\pm$ SD (range)	19.07 $\pm$ 33.75 (0-180)	
<b>NICU</b>		
Yes	62	54.9
No	51	45.1

Abd. Complication happened in 14 ( 12.3 %) patients , 6 ( 5.3 %) patients had intestinal perforation 4 ( 3.5 %) patients had Abd. Pseudocyst , 1 ( 0.9 %) patients had CSF ascites , 4 ( 3.5 %) patients had intestinal obstruction. Iatrogenic complication happened in 5 ( 4.4 %) patients , in 3 (2.6%) patients there was ventricular mal position that required re\_ revision , in 2 (1.8%) patients the distal end was extraperitoneal. 5- Intracranial hemorrhage happened in 5 ( 4.4 %) patients , 4 ( 3.5 %) patients had subdural hemorrhage , 1 (0.88 %) patient had intraventricular hemorrhage during ventricular end revision. 6-Slit ventricle syndrome happened in 5 ( 4.4 %) patients . while encysted hydrocephalus happened in 4 ( 4.4 %) patients. 7- Encysted hydrocephalus: happened in 4 patients(3.5%).

Shunt complications are more common in males 63(55.7%) compared to 50(44.3%) females. All

abdominal complications including pseudocyst , csf ascites , intestinal obstruction, intestinal perforation and distal end obstruction were common in male more than females ,14(12.4) compared to 2(1.8) in females. slit ventricle syndrome exclusively happened in female 5 (4.4%) cases compared to zero in males shunt infection were approximately equal in both female while intracranial hemorrhage exclusively happened in males. Encysted hydrocephalus was associated with least age mean(10 mon.) followed by intestinal obstruction (27) and abd. Collections(34) then shunt infections(35) then proximal end obstruction by mean age (38.9) followed by distal end(44.7) while other complications were associated with older patients.

62 (55 %) of studied cases were admitted at NICU during their infancy compared to 51(45%) were not admitted.



**Fig (1)** Complication rate



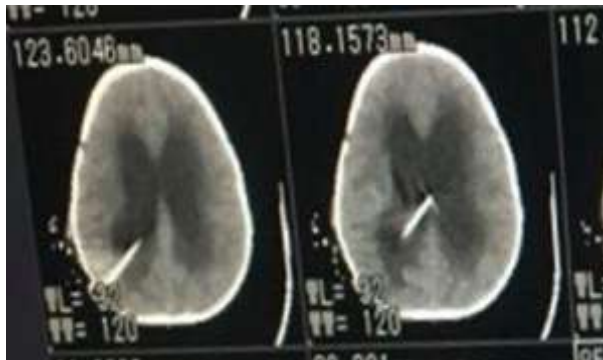
**Fig (2)** skin infection & sloughage over a burr hole shunt.

Medical or conservative management represents only 8.9% of cases compared to 91.1 % that were surgically managed. Shunt revision was done in 50(44.2%) of cases and was done in cases of mechanical obstruction , EVD was done in 23 (20.4%) of cases and

done in majority of cases of infection and cases of intraventricular hemorrhage , new shunt insertion was done in 11(9.7%) of cases and this was done in cases of slipped shunt and ventricular end obstruction that were revised many times or shunt was working but the patient

still has the signs of increase intracranial pressure , shunt exterilization was carried on in 3(2.7%) of cases and done in cases of abd. Failure. Endoscopic fenestration and shunt revision in the same session was done in

4(3.5%) cases and represent all cases of encysted hydrocephalus. abd. exploration was done in 4 (3.5%) of cases and represent cases of abd. Obstruction while shunt removal and follow up was done in 2(1.8%) of cases.



**Fig (3)** proximal vp shunt obstruction resulting in dilated ventricles.



**Fig (4)** a- faecal distal shunt contamination.



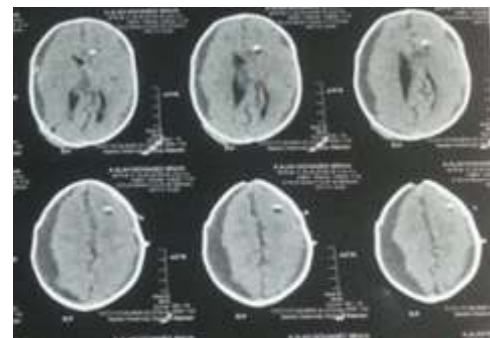
**Fig (5)** CSF leak around the shunt reservoir

82(72.2%) improved and discharged , 23 (20.4%) patients had another complication , 8 (7%) unfortunately died. New complications included Iatrogenic complications (fig.6)which happened in 10(8.8%) of cases in form of extraperitoneal shunt mal position that happened in 3(2.7) of cases, ventricular malposition happened in 3 (2.7) of cases with thalamic insertion in one case casing side weakness and completely extraventricular in the other 2 cases that required revision, slippage of the ventricular end during shunt

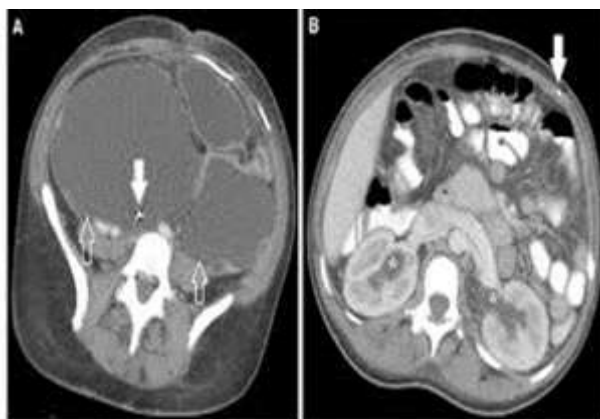
revision or new shunt insertion observed in 3(2.7) that required new shunt insertion, tight burse knot around distal end shunt encountered in 1(0.9) case causing distal end obstruction that required another revision. infection: happened in 8(7%) of cases, CNS infections happened in 6(5.3) while peritonitis happened in 2(1.7%) of cases. fits appeared for the first time in 2 (1.8%) of patient after surgery or during admission. Csf leak (fig.5), intestinal obstruction , IVH were encountered once for each.



**Fig (6)** Ventricular catheter malposition



**Fig (7)** ct scan showing subdural hge



**Fig (8)** ct abdomen showing abd. Pseudocyst.

outcome of management strategies was better in patients without comorbidities compared to patients with comorbidities other than hydrocephalus. New complications were encountered in 11(22.4%) of patients with comorbidities compared to 12(18.8%) of patients without comorbidities.

33(67.3%) of patients with comorbidities were discharged after initial complication management compared to 49(76.6%) of patients without comorbidities. unfortunately 5 (10.2%) patients with comorbidities died compared to 3(4.7%) of patients without comorbidities.



**Fig (8)** a- shunt protrusion through anus , b- shuntogram showing shunt prolapse through anus

## 5. Discussion

Cerebrospinal fluid (CSF) diversion procedures are among the most common neurosurgical interventions performed worldwide . there are hundreds of thousands of vp shunts placed worldwide every year . in the united states, approximately 36000 vps operations are done every year, Nearly half of shunt-related procedures, however, are revisions of previous insertions. Despite their necessity and ubiquitous usage, it is well established that shunts are prone to various complications that may occur throughout the patient's lifetime. one can easily agree with R.I.Mclaurin who wrote" the history for evolution of ventricular shunting is largely a history of efforts to prevent the complication of shunting" [23].

there is misconception between terms like shunt failure , shunt malfunction and shunt complication ,, shunt failure is not well defined in the literature but the most accepted view is that incapability of accomplishing an appropriate control of hydrocephalus that will end in

shunt revision ,removal or replacement . failure may be related to mechanical malfunction , infection or over or underdrainage. the term complication refers to any adverse effect that interferes with the expected success of procedure and these complication may or maynot end in shunt revision or removal . these complication may derive from problems related to the shunt, the patient or the surgery itself. These complications may be early during the first year after shunt insertion and they are due to infection and iatrogenic complication like hemorrhage , misplacement of catheter. Late shunt dysfunction is due to proximal or distal mechanical obstruction or shortening [16].

incidence of VP shunt complications was reported by most studies to be slightly higher in males than females [18], which was consistent with the current study as males represent 56% Among 113 of complicated patients. Shunt complications are common in children and associated with younger ages at first shunt insertion. This is consistent with Abdul Munam et al who

conducted their study on 40 VP shunt complicated patients where children represented 85% [19]

in current study The rate of complications was 51% with 17% of complicated patients came with one more than one complication that required more than surgical intervention. Mortality rate was 7.1%. 67% of complications happened in the first year after vp shunt insertion, 21% happened in second year , 14.5% happened in the years following first shunt. lower complication rate was observed by Alexander et al who documented a lower incidence of complication rate in a 4 year study at one of califorinia hydrocephalus centers over 17035 patients from 2005 to 2012 as the rate of complications was 33.4% . 63.7% of those complications happened in first year , 17% happened on the second year and 7.4% happened after that . mortality rate was 2.7%. through their study results , they suggested that there has been no significant improvement in the rate of vps complications over the last several decades as a study of the same center from 1970 to 1988 reported a vps complication rate of 28.7% . 15 years later , another study from 1990 to 2000 reported a complication rate of 29% [22].

A higher complication rate was observed by Nortarianni et al who reported higher incidence rate on their study of 253 pediatric patients with congenital hydrocephalus as they found that complication rate was 78% while death rate was 1.6% over a 3 year period study [23].

In current study , obstructive complications : happened in 48 (42%) , Infective complications appeared in 27 (23.9%) patients, Abd. Complications happened in 14 ( 12.3 %) patients, Iatrogenic complications happened in 5 ( 4.4 %) patients, Intracranial hemorrhage happened in 5 ( 4.4 %) patients, Slit ventricle syndrome happened in 5 ( 4.4 %) patients, Encysted hydrocephalus happened in 4 ( 3.5%) patients. That was inconsistent with Ali R. Hamdan found that most encountered complication was exposure of reservoir (13.3%) followed by Iatrogenic complications inform of malplaced ventricular catheter that happened in 10% of patients followed by extraperitoneal shunt placement (6.6%), proximal shunt obstruction was (6.6%) which is not consistent with our study [22].

Lee & et al reported shunt blockage in 12.2% of 246 shunt procedures in Seoul, Korea, and their infection rate was 4.1%. Shunt infection was found together with blockage in most instances in their series indicating that shunt malfunction could have been caused by infection in these patients .Peacock and Currer found shunt blockage to be 20% in their series of 440 patients . Mwan'gombe and Omulo reported an infection rate of 24.6% among children operated for non-tumor hydrocephalus. Mwachaka et al found that rate of obstruction was 53% , migration of shunt tube was 22.5% , infection rate was 19.7% while subdural hemorrhage was 4%. 26].

Dickerman et al studied 117 shunt revisions performed at their institution to see if placement of the proximal catheter within the anterior horn of the lateral

ventricle, farthest from the choroid plexus would be associated with a lower rate of shunt malfunction at six months . While this association was not found, they did find the lowest rate of shunt malfunction to occur among patients with NPH . These authors theorized that because the patients with NPH had large ventricles, the proximal catheters were less likely to become obstructed with choroid plexus [27].

in current study , Infective complications was the second common cause of shunt malfunction as it appeared in 27 (23.9%) patients and mostly associated with prolonged NICU admission , low weight at insertion, poor general condition , patients with myeloimeningocele , peritonitis, history of blood sepsis. The most common isolated organisms were staph. Epidermis , staph aureus , streptococci followed by E.coli , pseudomonas which were responsible for higher morbidity and mortality rate. CNS infection in our study was treated by antibiotics alone without shunt removal which failed 100% , shunt extirpation and shunt removal and EVD insertion. reported by multiple studies, include young age , postoperative CSF leak , glove holes during shunt handling ,African American race , public insurance , previous shunt infections and etiology of intraventricular hemorrhage . The population reported to be at highest risk for shunt infections are premature neonates in whom the immune system is not fully developed .[28]. The majority of shunt infections occur within the first few weeks to several months after VPS placement, although late shunt infections are observed as well . While early shunt infections are often due to inoculation during shunt insertion, late infections have been traced to instances of peritonitis, abdominal pseudocyst, bowel perforation and hematogenous inoculation [29].

In current study, abd. Complications were 6 ( 5.3 %) patients had intestinal perforation 4 ( 3.5 %) patients had Abd. Pseudocyst , 1 ( 0.9 %) patients had CSF ascites. Dabdoub et al. found pseudocyst recurrence to happen in 19.8% of children and 24.2% of adults, with the lowest odds of recurrence in children in whom the distal catheter was repositioned into a non-peritoneal space. Thus, creation of ventriculopleural and ventriculoatrial shunts is often performed during revision, although repositioning within the peritoneal space may also be successful . One group has found that placement of the catheter in a retro-hepatic position is effectively avoids pseudocyst recurrence. Perforation of the bowel by catheter tubing is a rare complication of VPS placement that is estimated to occur with a rate of between 0.1 and 0.7% [22]

higher rates have been reported by Ghritlaharey & et al and the most common reported presentation is protrusion of the tip of the distal catheter through the anus . Often, there is no sign of meningitis as indicated by normal CSF cell counts , and<25% of patients present with signs of peritonitis. the majority of cases of bowel perforation by the distal catheter occur in children . This may be due to infants having a relatively thin bowel wall,



especially in children with myelomeningocele in whom innervation of the bowel wall may be insufficient [25].

In current study Intracranial hemorrhage happened in 5 ( 4.4 %) patients, Slit ventricle syndrome happened in 5 ( 4.4 %) patients and was medically treated. Faulhauer and Schmitz reported incidence of 4% of subdural collections in a series of 400 shunted patients only 30% of them required surgical evacuation with shunt occlusion to occlude subdural space. The incidence of the SVS is variable among different studies. The Shunt Design Trial demonstrated SVS in only one case out of the 344 patients included to the study (follow-up 1.0– 5.5 years, median 3 years [20].

## 6. Conclusions

Despite keen efforts from neurosurgeons worldwide to reduce vp shunt complication, complications are common among paediatric patients. Obstructive complications are the most common complications followed by shunt infections. Complications are more common to occur during first year following initial shunt insertion and more associated with . younger patients , male gender, NICU admission.

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