Frequency of Complications after Paediatric Ventriculoperitoneal Shunt Surgery for Management of Hydrocephalus: An Observational Cohort Study

Ahtesham Khizar[1,2], Hammad Mehtab[1], Soha Zahid[3], Pradhumna Kumar Yadav[1,4], Bushra Tariq Ali[1], Madeha Amjad[1]

[1]Pakistan Institute of Medical Sciences, Islamabad, Pakistan; [2]Punjab Institute of Neurosciences, Lahore, Pakistan
[3]Jinnah Medical and Dental College, Karachi, Pakistan; [4]National Trauma Center, Kathmandu, Nepal

Date of submission: 13th February 2023 Date of Acceptance: 28th September 2023 Date of publication: 15th October 2023

Abstract

Introduction: There are frequent complications after paediatric ventriculoperitoneal shunt surgery for management of hydrocephalus.

Materials and methods: An Observational Cohort Study was conducted from 19th March, 2020 to 18th September, 2021 at Pakistan Institute of Medical Sciences, Islamabad, Pakistan. Total 150 patients of both genders, aged between 1-18 years diagnosed with hydrocephalus were selected. Shunted patients operated for other pathologies of brain and spine and those with more than 3 shunt revisions were excluded. Based on the clinical findings and investigations, a final diagnosis was made and the treatment in individual cases was planned accordingly. Post-operatively all the patients were followed up till 6 months and any complication which occurred was documented.

Results: Age range in this study was from 1 to 18 years with mean age of 7.50 ± 4.22 years. Majority of the patients 74.0% were between 1 to 10 years of age. Out of these 150 patients, 85 (56.67%) were males and 65 (43.33%) were females with male to female ratio of 1.3:1. Shunt blockade was seen in 36 (24.0%), Shunt malfunction in 21 (14.0%), Shunt infection in 48 (32.0%) and Shunt migration in 23 (15.33%) patients.

Conclusion: This study concluded that ventriculoperitoneal shunt in children with hydrocephalus is not free of complications and should be monitored and managed properly to reduce the complications.

Key words: Hydrocephalus, Shunt Infection, Malfunction, Blockage, Migration.

Introduction

Hydrocephalus is a common paediatric brain disorder and ventriculoperitoneal (VP) shunts are one of the treatments for it. Hydrocephalus is an excessive accumulation of cerebrospinal fluid (CSF) within the brain, caused by an imbalance between the CSF production, flow or absorption. Increase in CSF volume causes enlargement of ventricles, thinning of cortical mantle and elevation of intracranial pressure (ICP). Mostly pressure builds up proximal to an obstruction, leading to ventricular dilatation and raised ICP. To prevent neurological deterioration associated with raised ICP, CSF diversion is required which is done by VP shunt systems.[1-3] VP shunt consists of 4 components; 1) a ventricular catheter, 2) a 1-way valve, 3) a reservoir and 4) a distal catheter. Different pressure shunt valves control unidirectional CSF flow by opening at a fixed pressure differential across the valve. So, the shunt valves are designed as low, medium and high pressure valves. Most neurosurgeons place medium pressure valve shunts.[4-6] The proximal catheter is inserted in the occipital or frontal horn of the lateral ventricle and the 1-way valve and reservoir run behind the ipsilateral ear. The distal portion is tunnelled down through the neck and chest wall and ends in the peritoneal cavity. Other sites for distal end are pleural cavity, atrium and gallbladder. However, peritoneal cavity is the preferred site, as it is associated with less complications.[7]

Access this article online
Website: https://www.nepjol.info/index.php/NJN
DOI: https://doi.org/10.3126/njn.v20i3.52498
HOW TO CITE
Khizar A, Mehtab H, Zahid S, Yadav PK, Ali BT, Amjad M. Frequency of Complications after Paediatric Ventriculoperitoneal Shunt Surgery for Management of Hydrocephalus: An Observational Cohort Study. NJNS. 2023;20(3):3-9.

Address for correspondence:
Ahtesham Khizar, MBBS, FCPS (Neurosurgery)
Consultant Neurosurgeon & Senior Registrar
Department of Neurosurgery
Punjab Institute of Neurosciences, Lahore, Pakistan
E-mail: arwain.6n2@gmail.com
Tel: +923228095862

ISSN: 1813-1948 (Print), 1813-1956 (Online)

CSF shunt systems increase life expectancy in paediatric patients with hydrocephalus. Consequently, children with shunts require lifelong follow-up, especially in the light of incidence of failure over the period of time. The probability of the occurrence of shunt failure is 70% at 10 years after the initial shunt insertion. 30% risk of failure during 1st year and 2% to 5% risk per year thereafter.[8,9]

Shunt system malfunction is due to three main factors; 1) Mechanical failure, 2) Infection and 3) Over drainage or under drainage i.e, function failure. Proximal obstruction is the most frequent cause of mechanical shunt failure. Other causes include; obstruction of the distal catheter, formation of peritoneal pseudocyst,[5,12] fracture of shunt,[4] disconnection of shunt, migration of shunt,[8-10] skin necrosis overlying the shunt.[11]

Munam et al. (2014) conducted a study on pattern of complications and ventriculoperitoneal shunt due to hydrocephalus and reported the complications which were obstruction of shunt (52.5%), infection (25%), and exposure of shunt (10%).[13] Khan et al. (2015) reported that complication of shunt revision was 14.1%, shunt blockade 11.0%, shunt infection 3.5%, shunt migration 0.9%, and CSF ascites 0.9%.[14] Pan et al. (2018) reported the complications of shunt revision as 27%, shunt blockade 45.94%, shunt infection 16.21%, shunt migration 10.81%, and shunt malfunction due to abdominal pseudocyst 10.81%.[15] Pal et al. (2017) observed that complication of shunt revision was 21.2%, shunt blockade 7.6%, shunt migration 5.05%, shunt infection 4.5%, and shunt malfunction due to other causes 8.6%.[16]

This study is important in the aspect that it will create a base for future research. By comparing the results of our study with both local and international studies it will show any drawback in our set up in terms of sterilisation and technique of insertion. This will be a step towards better care for patients. As we lack facilities so the burden of disease may be more in Pakistan hence, the study is designed to determine complications after paediatric ventriculoperitoneal shunt surgery so that facilities for early detection and management may be introduced. This will help in reducing the burden of mortality and morbidity associated with complications of ventriculoperitoneal shunt surgery. Knowledge of the magnitude of this problem will enable the doctors to anticipate with patients to identify and treat these complications which have serious social impact on a patient's quality of life.

Materials and Methods:

An Observational Cohort Study was conducted from 19th March, 2020 to 18th September, 2021 at Pakistan Institute of Medical Sciences, Islamabad, Pakistan. Sample size of 150 cases was calculated by WHO Sample Size Calculator with 95% Confidence level and 5% Margin of error while taking expected frequency of complication of shunt blockade to be 10.8% (least among all complications) in patients with ventriculoperitoneal shunt surgery. Sampling technique used was non-probability consecutive sampling.

Inclusion Criteria:

- Patients of both genders aged between 1-18 years diagnosed with hydrocephalus.
- Patients diagnosed in the last 6 months period were included.
- Patients whose parents signed written informed consent to participate in the study.

Exclusion Criteria:

- Patients having age above 18 years, no final diagnosis of shunt complication and incomplete patient records.
- Shunted patients operated for other pathologies of the brain and spine without shunt related problems were excluded from the study.
- Those patients with more than 3 shunt revisions.

Data Collection Procedure: After approval from the ethical review committee of the hospital, 150 patients who presented from the outpatient and through emergency in the department of Neurosurgery at Pakistan Institute of Medical Sciences, Islamabad, Pakistan and who fulfilled the above criteria were counselled and explained the details of the study. Written informed consent and detailed history was taken from each patient's parents. All patients after the admission underwent a complete clinical assessment including a detailed history and examination with particular emphasis on the neurological examination. The investigations performed in all the patients were complete blood count (CBC), urine detail report, erythrocyte sedimentation rate (ESR), CSF analysis, X-ray chest, serum electrolytes, and brain computed tomography (CT) scan. Specific investigations such as CSF culture & sensitivity, blood culture, urine culture & sensitivity, pus culture & sensitivity, ultrasound of abdomen, X-ray shunt series, and magnetic resonance imaging (MRI) of the brain were also performed where needed. On the basis of the clinical findings and investigations a final diagnosis was made and treatment in individual cases was planned accordingly. In case of infection, shunt was removed and external ventriculostomy done plus proceeded with appropriate antibiotic administration. New shunt was inserted after CSF became sterile. In case of malfunctioning shunt, shunt was explored and revision of the affected component done. In case of peritonitis shunt was exteriorized and appropriate antibiotics were started. Either shunt converted into ventriculoatrial shunt or re-implantation of new shunt done on clearance of CSF. Post-

operatively all the patients were followed up till 6 months and any complication which occurred was documented. Patients' demographic details like age, gender and type of complication were recorded into the attached proforma. All the lab investigations were acquired from within the hospital to minimize bias. Confounding variables had been controlled by exclusion.

Data Analysis Procedure: All the collected data was entered and analysed through SPSS version 28. Numerical variables; age and duration of complications were presented by mean ±SD. Categorical variables i.e, gender and type of complication (shunt infection, shunt malfunction, shunt blockade and shunt migration) were presented by frequency and percentage. Data was stratified for age, gender and type of complications to address effect modifiers. Post-stratification chi-square test was applied taking P≤0.05 as significant.

Results

Age range in this study was from 1 to 18 years with mean age of 7.50 ± 4.22 years. Majority of the patients 74.0% were between 1 to 10 years of age as shown in Table-I. Out of these 150 patients, 85 (56.67%) were males and 65 (43.33%) were females with male to female ratio of 1.31:1 as shown in Figure-I. Mean duration of disease in our study was 3.87 ± 2.37 months as shown in Table-II. The ventriculoperitoneal shunt complications are shown in Table-III. Shunt blockade was seen in 36 (24.0%), shunt malfunction in 21 (14.0%), shunt infection in 48 (32.0%) and shunt migration in 23 (15.33%) patients. Stratification of complications with respect to age and gender is shown in Table-IV & V respectively. Table-VI has shown the stratification of complications with respect to duration of disease.

Table I: Distribution of patients according to Age (n=150).

Age (years)	No. of patients	Percentage (%)
1-10	111	74.0
11-18	39	26.0
Total	**150**	**100**

Mean ± SD = 7.50 ± 4.22 years

Table II: Distribution of patients according to duration of disease (n=150).

Duration	Frequency	Percentage (%)
≤3 months	86	51.33
>4-6 months	64	42-67

Mean ± SD = 3.87 ± 2.37 years

Table III: Frequency of complications after paediatric ventriculoperitoneal shunt surgery for management of hydrocephalus.

Complications	Frequency (%)	
	Yes	No
Shunt Infection	36 (24.0%)	114 (76%)
Shunt Malfunction	21 (14.0%)	129 (86%)
Shunt Blockade	48 (32.0%)	102 (68%)
Shunt Migration	23 (15.33%)	122 (84.67%)

Table IV: Stratification of complications with respect to age.

Complications		1-10 years (n=111)	11-18 years (n=39)	P-value
Shunt Infection	Yes	30	06	0.143
	No	81	33	
Shunt Malfunction	Yes	18	05	0.805
	No	95	34	
Shunt Blockade	Yes	37	11	0.555
	No	74	28	
Shunt Migration	Yes	11	06	0.992
	No	an	33	

Table V: Stratification of complications with respect to gender.

Complications		Male (n=85)	Female (n=65)	P-value
Shunt Infection	Yes	19	17	
	No	66	48	0.589
Shunt Malfunction	Yes	09	12	
	No	76	53	0.168
Shunt Blockade	Yes	30	18	
	No	55	47	0.323
Shunt Migration	Yes	14	09	
	No	71	56	0.658

Table VI: Stratification of complications with respect to duration of disease.

Complications		≤3 months (n=86)	4-6 months (n=64)	P-value
Shunt Infection	Yes	19	17	
	No	67	47	0.526
Shunt Malfunction	Yes	09	12	
	No	77	52	0.148
Shunt Blockade	Yes	30	18	
	No	56	46	0.380
Shunt Migration	Yes	14	09	
	No	72	55	0.709

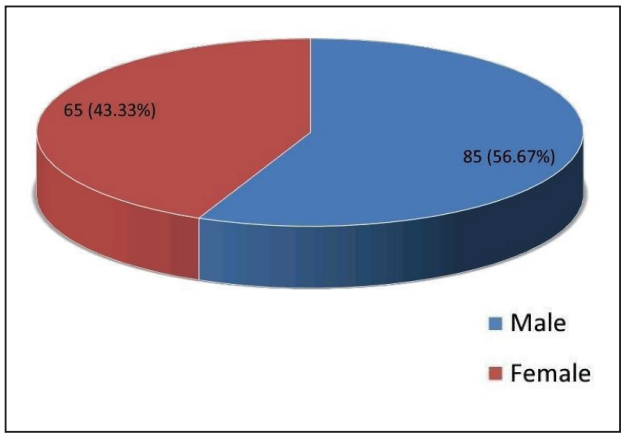

Figure I: Distribution of patients according to gender (n=150).

Discussion

Cerebral shunts are primarily used to manage hydrocephalus, a condition in which a buildup of excess CSF accumulates in the ventricles of the brain. The use of cerebral shunts to manage hydrocephalus dates back to the mid-20th century.[17] Left untreated, hydrocephalus can lead to increases in intracranial pressure, cerebral edema, and ultimately herniation of brain tissue. Various types of cerebral shunts are available, and they are classified by name, according to where the distal end of the shunt catheter routes CSF, or by valve type.[18] Examples of different types of shunts include; ventriculoatrial, ventriculopleural, and ventriculoperitoneal. Ventriculoperitoneal shunts route excess CSF from the ventricles into the peritoneal space.[19] Complications resulting from the VP shunt placement are common, particularly early after placement. Following VP shunt placement, the 1-year shunt failure rate is approximately 40%, and the 2-year shunt failure rate has been reported to be as high as 50%.[18] Complications include; intraventricular haemorrhage, obstruction, overdrainage of CSF, and infection. Among these complications, infection is one of the most serious, often requiring prompt management. The incidence of VP shunt infections in adults is between 1.6% and 16.7%.[17-23] Such a wide range of infection rates are due in part to varying definitions of shunt infections and patient demographics reported throughout the literature. Presently, no guideline recommendations are available for the diagnosis of a CSF shunt infection; however, standardized approaches have recently been proposed.[24] The highest rate of shunt infection occurs early after shunt placement or revision (e.g. within 1 month); therefore, mostly contamination with microorganisms is thought to occur intraoperatively.[23,25] The infection rate increases with the number of surgical revisions.[19]

In our study, shunt blockade was seen in 36 (24.0%), shunt malfunction in 21 (14.0%), shunt infection in 48 (32.0%) and shunt migration in 23 (15.33%) patients. Munam et al. (2014) conducted a study on pattern of

complications and ventriculoperitoneal shunt due to hydrocephalus and reported the complications which were obstruction of shunt (52.5%), Infection (25%), and exposure of shunt (10%).[15] Khan et al. (2015) reported that complication of shunt revision was 14.1%, shunt blockade 11.0%, shunt infection 3.5%, shunt migration 0.9%, and CSF ascites 0.9%.[16] A prospective study included 40 (28 boys and 12 girls) children and required 48 shunt revisions. Complications following VP shunts that required shunt revisions were peritoneal catheter/peritoneal end malfunction (18), shunt/shunt tract infections (7), extrusion of peritoneal catheter through anus (5), ventricular catheter malfunction (4), CSF leak from abdominal wound (4), shunt system failure (2), ventricular end/shunt displacement (2), CSF pseudocysts in peritoneal cavity (2), extrusion of peritoneal catheter from neck, chest, abdominal scar and through umbilicus, one each. Four-fifth of these shunt complications occurred within 6 months of previous surgery.[26] The main complications observed by Kinasha ADA et al.[42] were shunt blockage in 32.0%, shunt disconnection in 10.7%, shunt infection in 24.6% and shunt extrusion in 12.3% patients. In another study,[13] the most common complication was obstruction of shunt (52.5%), Infection (25%), and exposure of shunt (10%). Panda SS et al.[27] has shown in his study that malfunctioning and shunt obstruction were the most common problems faced by a neurosurgeon after VP shunt. Lee et al.[28] found shunt blockage in 12.2% of their series of 246 shunt procedures in Seoul, Korea. Their infection rate was 4.1%. Vanaclocha et al.[29] have observed shunt malfunction in infected shunts and some of which were clinically undetectable. They argue that the incidence of shunt infection might be higher than generally reported and that negative cultures of CSF taps do not exclude shunt infection in malfunctioning shunts. Peacock et al.[30] found shunt blockage to be 20% in their series of 440 children. Aldrich et al.[31] found that disconnection accounted for 15% of their shunt malfunctions and that occipitally placed shunts had a higher tendency to dislocate than frontally placed shunts. However, in a report of a prospective randomized study Bierbauer et al.[32] found no advantage of anteriorly placed shunts over posteriorly placed shunts in terms of shunt malfunction or infection. Lazareff et al.[33] reported a 44% prevalence of shunt blockage in 244 children followed up over a period of up to 6 years post initial insertion. The peak danger period for blockage is in the first year after insertion, with rates as high as 20% recorded in some series.[34] Annual rates of shunt blockage have been estimated by Rekate to be approximately 5%.[35] The overall prevalence of distal catheter blockage due to pseudocyst formation is varied from less than 1-4.5%.[36-38]

Pan et al. (2018) reported the complications of shunt revision 27%, shunt blockade 45.94%, shunt infection 16.21%, shunt migration 10.81%, and shunt malfunction due to abdominal pseudocyst 10.81%.[15] Pal et al. (2017) observed that complication of shunt revision was 21.2%, shunt blockade 7.6%, shunt migration 5.05%, shunt infection 4.5%, and shunt malfunction due to other causes 8.6%.[16] In a study on 60 patients undergoing VP shunt procedure, fourteen patients (23.3%) developed complications during the follow up period of two months. Five patients (8.3%) had shunt block, ventricular end in three patients and peritoneal end in two. Two patients (3.3%) had overdrainage with symptomatic subdural hematoma needing evacuation and temporary occlusion of the shunt tube. Five patients (8.3%) developed clinical shunt infection.[39] In a descriptive study conducted at Lady Reading hospital, Peshawar, shunt obstruction was found in 9.3% patients, shunt infection in 8.1% cases and shunt extrusion in 2.3% patients.[40] In a study,[41] a total of 278 shunt revisions occurred in 87 patients because of various causes such as obstruction, infection, overdrainage, mechanical, and other shunt complications. Obstruction caused a total of 141 shunt revisions in 68 patients (64.8%). Infection caused a total of 33 revisions in 22 patients (21%). Proximal shunt complications caused a total of 87 shunt revisions in 54 patients (51.4%). Shunt system replacement resulted in 73 total shunt revisions in 49 patients (46.7%). Other shunt complications resulted in a total of 73 shunt revisions in 48 patients (45.7%). Other complications of the shunt include shunt disconnection, shunt catheter leakage/breakage, shunt extrusion, shunt catheter migration, and shunt catheter protrusion.

Conclusion

This study concluded that ventriculoperitoneal shunt in children with hydrocephalus is not free of complications and should be monitored and managed properly to reduce the complications. We recommend that close follow up of shunted patients is essential for early detection of complications and a lot of stress should be paid on the counselling of the patient's guardians regarding ventriculoperitoneal shunt complications and their timely revision.

List of Abbreviations: CSF: Cerebrospinal fluid, VP: Ventriculoperitoneal, ICP: Intracranial pressure, CT: Computed Tomography, MRI: Magnetic Resonance Imaging.

Acknowledgements: Not applicable.
Funding: No funding was required for this work.
Disclosures: Authors have nothing to disclose.
Conflicts of Interest: Authors report no conflict of interest.

References

1. Hussain MA, Mahmood K. Complications of Ventriculopeitoneal Shunts in Paediatric Patients with Hydrocephalus. Ann Punjab Med Coll. 2015;9(1):1-4. doi:10.29054/apmc/2015.336
2. Agarwal N, Shukla RM, Agarwal D, Gupta K, Luthra R, Gupta J, Jain S. Pediatric ventriculoperitoneal shunts and their complications: an analysis. J India Asso Pediatr Surg. 2017;22(3):155. doi:10.4103/0971-9261.207624
3. Paff M, Alexandru-Abrams D, Muhonen M, Loudon W. Ventriculoperitoneal shunt complications: A review. Interdisciplin Neurosurg. 2018;13:66-70. doi:10.1016/j.inat.2018.04.004
4. Erol FS, Ozturk S, Akgun B, Kaplan M. Ventriculoperitoneal shunt malfunction caused by fractures and disconnections over 10 years of follow-up. Childs Nerv Syst. 2017;33(3):475-8. doi:10.1007/s00381-017-3342-0
5. Hamid R, Baba AA, Bhat NA, Mufti G, Mir YA, Sajad W. Post ventriculoperitoneal shunt abdominal pseudocyst: challenges posed in management. Asian J Neurosurg. 2017;12(1):13. doi:10.4103/1793-5482.145539
6. Gatto LA, Mathias R, Tuma R, Abdalla R, de Aguiar PH. Rare complication of ventriculoperitoneal shunt: Catheter protrusion to subcutaneous tissue–Case report. Surg Neurol Int. 2016;7(44):S1142. doi:10.4103/2152-7806.196926
7. Sher I, Gambhir S, Pinto S, Mujic A, Peters-Willke J, Hunn A. Spontaneous peritoneal catheter knot formation: A rare cause of ventriculoperitoneal shunt malfunction. J Clin Neurosci. 2017;38:67-8. doi:10.1016/j.jocn.2016.12.031
8. Guthe SP, Pravin S, Darade P, Velho V. Silent migration of ventriculoperitoneal shunt per anus in a child: Management and review of literature. Asian J Neurosurg. 2018;13(2):446. doi:10.4103/1793-5482.228559
9. Jorgensen J, Williams C, Sarang-Sieminski A. Hydrocephalus and ventriculoperitoneal shunts: modes of failure and opportunities for improvement. Crit Rev Biomed Engin. 2016;44(1-2):273-277. doi:10.1615/CritRevBiomedEng.2016017149
10. Singh S, Pant N, Kumar P, Pandey A, Khan TR, Gupta A, Rawat J. Migration of ventriculoperitoneal shunt into a hernia sac: An unusual complication of ventriculoperitoneal 2016;51(3):154-7. shunt surgery in children. Pediatri Neurosurg. doi:10.1159/000442179
11. Nguyen TA, Cohen PR. Scalp necrosis overlying a ventriculoperitoneal shunt: a case report and literature review. Dermatol Online J. 2015;21(10):221-225. PMID: 26632796
12. Pahwa S, Sherwani P, Anand R. CSF pseudocyst: An unusual cause of abdominal distension in a child. Tropic Doc. 2014;44(2):112-113. doi:10.1177/0049475513519442
13. Munam A, Vashdev RA. Pattern of Complications and Presenting Features in Patients Implanted Ventriculoperitoneal Shunt due to Hydrocephalus. J Liaquat Uni Med Health Sci. 2014;13(2):57.
14. Khan F, Rehman A, Shamim MS, Bari ME. Factors affecting ventriculoperitoneal shunt survival in adult patients. Surg Neurol Int. 2015;6(3):323-327. doi:10.4103/2152-7806.151388
15. Pan P. Outcome analysis of ventriculoperitoneal shunts surgery in pediatric hydrocephalus. J Pediatr Neurosci. 2018;13(2):176-178. doi:10.4103/jpn.JPN_29_18
16. Pal SS, Dubey S. A study of VP shunts in management of hydrocephalus. Int Surg J. 2017;4(5):1697-701. doi:10.18203/2349-2902.isj20171623
17. Nulsen FE, Spitz EB. Treatment of hydrocephalus by direct shunt from ventricle to jugular vein. Surg Forum. 1951:399–403. PMID: 14931257
18. Drake JM, Kestle JRW, Tuli S. CSF shunts 50 years on past, present and future . Child's Nerv Syst. 2000;16:800–804. doi:10.1007/s003810000351
19. Korinek AM, Fulla-Oller L, Boch AL, Golmard JL, Hadiji B, Puybasset L. Morbidity of ventricular cerebrospinal fluid shunt surgery in adults: an 8-year study. Neurosurgery. 2011;68:985–95. doi:10.1227/NEU.0b013e318208f360
20. McClelland S III, Hall WA. Postoperative central nervous system infection: incidence and associated factors in 2111 neurosurgical procedures. Clin Infect Dis. 2007;45:55–9. doi:10.1086/518580
21. Wang KW, Chang WN, Shih TY. Infection of cerebrospinal fluid shunts: causative pathogens, clinical features, and outcomes. Jpn J Infect Dis. 2004;57:44–8. PMID: 15118207
22. Puca A, Anile C, Maira G, Rossi G. Cerebrospinal fluid shunting for hydrocephalus in the adult: factors related to shunt revision. Neurosurgery. 1991;29:822–26. doi:10.1097/00006123-199112000-00003
23. Borgbjerg BM, Gjerris F, Albeck MJ, Borgesen SE. Risk of infection after cerebrospinal fluid shunt: an analysis of 884 first-time shunts. Acta Neurochir (Wien). 1995;136:1–7. doi:10.1007/BF01411427
24. Overturf GD. Defining bacterial meningitis and other infections of the central nervous system. Pediatr Crit Care Med. 2005;6 (suppl):S14–S18. 81. doi:10.1097/01.PCC.0000161933.42822.86

25. Ragel BT, Browd SR, Schmidt RH. Surgical shunt infection: significant reduction when using intraventricular and systemic antibiotic agents. J Neurosurg. 2006;105:242–47. doi:10.3171/jns.2006.105.2.242
26. Ghritlaharey RK, Budhwani KS, Shrivastava DK, Srivastava J. Ventriculoperitoneal shunt complications needing shunt revision in children: a review of 5 years of experience with 48 revisions. Afr J Paediatr Surg. 2012;9(1):32-9. doi:10.4103/0189-6725.93300
27. Panda SS, Singh A, Bajpai M, Sharma N. Shunt in scrotum: unusual complication in operated cases of hydrocephalus. BMJ Case Rep 2013 Nov 6;2013. pii: bcr2013201854. doi: 10.1136/bcr-2013-201854.
28. Lee JY, Wang KC, Cho BK. Functioning periods and complications of 246 cerebrospinal fluid shunting procedures in 208 children. J Korean Med Sci. 1995 Aug;10(4):275-80. doi:10.3346/jkms.1995.10.4.275
29. Vanachola V, Zais-Sapena N, Leiva J. Shunt malfunction in relation to shunt infection. Acta Neurochir (Wien). 1996;138(7):829-34. doi:10.1007/BF01411261
30. Peacock WJ, Currer TH. Hydrocephalus in childhood. A study of 440 cases. S Afr Med J. 1984 Sep 1;66(9):323-4. PMID: 6474296
31. Aldrich EF, Harmann P. Disconnection as a cause of ventriculoperitoneal shunt malfunction in multicomponent shunt systems. Pediatr Neurosurg 1990 91;16(6):309-11 82. doi:10.1159/000120549
32. Bierbrauer KS, Storrs BB, McLone DG, Tomita T, Dauser R. A prospective, randomisd study of shunt function and infections as a function of shunt placement. Pediatr Neurosurg. 1990-91;16(6):287-91. doi:10.1159/000120544
33. Lazareff JA, Peacock W, Holly L, Ver Halen J, Wong A, Olmstead C. Multiple shunt failures: an analysis of relevant factors. Child Nerv Syst 1998;14:271–5. doi:10.1007/s003810050223
34. Peacock WJ, Currer TH. Hydrocephalus in childhood: a study of 440 cases. S Afr Med J 1984;66:323–4. PMID: 6474296
35. Rekate HI. Shunt revision: complications and their prevention. Pediatr Neurosurg 1991-92;17:155–62. doi:10.1159/000120587
36. Rainov N, Schobess A, Heidecke V, Burkert W. Abdominal CSF pseudocysts in patients with ventriculo-peritoneal shunts. Report of fourteen cases and review of the literature. Acta Neurochir (Wien) 1994;127:73–8. doi:10.1007/BF01808551
37. Sharma AK, Pandey AK, Diyora BD, Mamidanna R, Sayal PP, Ingale HA. Abdominal CSF pseudocyst in a patient with ventriculoperitoneal shunt. Indian J Surg. 2004;66:360–3.
38. Oh A, Wildbrett P, Golub R, Yu LM, Goodrich J, Lee T. Laparascopic repositioning of a ventriculoperitoneal catheter tip for a sterile abdominal cerebrospinal fluid pseudocyst. Surg Endosc. 2001;15:518. doi:10.1007/s004640000162
39. Karmacharya BG, Kumar P. A study on Complications of ventriculoperitoneal shunts surgery in Bir Hospital, Kathmandu, Nepal. Nepal J Med Sci. 2012;1(2):119-22.
40. Ali M, Khan A, Khan H, Khwanzada K. Short-term complications of ventriculoperitoeal shunt in children suffering from hydrocephalus. J Pediatr Neurol. 2009;7(2):165-69. doi:10.3233/JPN-2009-0290
41. Reddy GK, Bollam P, Caldito G, Guthikonda P, Nanda A. Ventriculoperitoneal Shunt Surgery Outcome in Adult Transition Patients With Pediatric-Onset Hydrocephalus. Neurosurg. 2012;70:380–389. doi:10.1227/NEU.0b013e318231d551
42. Kinasha AD, Kahamba JF, Semali IT. Complications of ventriculoperitoneal shunts in children in Dar es Salaam. East and Central African Journal of Surgery. 2005;10(2):55-9.