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Ventriculoperitoneal shunt complications needing shunt revision in children: A review of 5 years of experience with 48 revisions

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ABSTRACT

Background: The aim of this study was to review the management of ventriculoperitoneal (VP) shunt complications in children. **Patients and Methods:** During the last 5 years (January 1, 2006 to December 31, 2010), 236 VP shunt operations were performed in children under 12 years of age; of these, 40 (16.94%) developed shunt complications and those who underwent VP shunt revisions were studied. **Results:** This 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), cerebrospinal fluid (CSF) leak from abdominal wound (4), shunt system failure (2), ventricular end/shunt displacement (2), CSF pseudocysts 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. Surgical procedures done during shunt revisions in order of frequency were revision of peritoneal part of shunt (27, 56.25%), revision of entire shunt system (6, 12.5%), extra ventricular drainage and delayed re-shunt (5, 10.41%), shunt removal and delayed re-shunt (5, 10.41%), opposite side shunting (2, 4.16%), cysts excision and revision of peritoneal catheter (2, 4.16%) and revision of ventricular catheter (1, 2.08%). The mortalities following VP shunt operations were 44 (18.64%) and following shunt revisions were 4 (10%). **Conclusions:** VP shunt done for hydrocephalus in children is not only prone for complications and need for revision surgery but also associated with considerable mortality.

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Key words: Hydrocephalus, shunt revision, ventriculoperitoneal shunt, ventriculoperitoneal shunt complications

INTRODUCTION

Hydrocephalus is a common paediatric 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.[1,2] Ventriculoperitoneal (VP) shunt is amongst the most frequently performed operations in the management of hydrocephalus.[3,4] Other shunting techniques for the management of hydrocephalus are endoscopic third ventriculostomy, ventriculoatrial (VA) shunt and lumboperitoneal (LP) shunt.[3,5-8] Although the risk in performing a shunt operation is low, the complications related to shunts are many and reported to occur in 24 to 47% of the cases, of which abdominal complications are reported in 25% of VP shunt operations. Many of the shunt complications need shunt revisions, i.e., 12.5 to 36% of the cases and many of them require multiple revisions.[9-11] We are reporting our experience with 48 VP shunt revisions in 40 children during last 5 years with a brief review of literature.

MATERIALS AND METHODS

This is a prospective, single institution study in children aged below 12 years, who underwent VP shunt revisions for various VP shunt complications. It was conducted in the department of paediatric surgery over a period of five years from January 2006 to December 2010. Two hundred and thirty six VP shunt operations were performed for hydrocephalus in children below 12 years of age during the study period [Table 1].

Forty of 236 who developed shunt complications and needed 48 shunt revisions in the follow-up period were included in this study. The follow-up period ranging from 3 months to 5 years after VP shunt operations. Demographics relating shunt revisions are given in Table 2. Complications occurring following VP shunt operations in order of frequency are peritoneal end malfunction (7.62%, *n*=18), shunt/shunt tract infection (2.96%, *n*=7), extrusion of peritoneal catheter through anus (2.11%, *n*=5) [Figure 1a and b], ventricular end malfunction (1.69%, *n*=4), CSF leak from abdominal wound (1.69%, *n*=4), shunt system malfunction (0.84%, *n*=2), ventricular end/shunt displacement (0.84%, *n*=2), CSF pseudocysts peritoneal cavity (0.84%, *n*=2) [Figure 2], extrusion of peritoneal catheter from neck wound (0.42%, *n*=1) [Figure 3], extrusion of peritoneal catheter from chest (0.42%, *n*=1) [Figure 4], extrusion of peritoneal catheter from abdominal scar (0.42%, *n*=1) [Figure 5] and extrusion of peritoneal catheter through umbilicus (0.42%, *n*=1) [Figure 6]. We used simple mathematical/statistical calculations for obtaining percentage. *P* values also obtained as and

Table 1: Ventriculoperitoneal shunt operations done in children (*n*=236) and post-operative deaths (*n*=44)

Demography	Years					Total (%)	Deaths (%)
	2006	2007	2008	2009	2010		
Sex							
Male	34	23	35	32	29	153 (64.83)	34 (14.40)
Female	05	15	20	28	15	083 (35.16)	10 (04.23)
Diagnosis (age distribution)							
Infants congenital hydrocephalus	22	21	35	37	29	144 (61.01)	33 (13.98)
1-12 yrs congenital hydrocephalus	06	04	07	03	03	023 (09.74)	01 (00.42)
0-12 yrs TBM hydrocephalus	11	13	13	20	12	069 (29.23)	10 (04.23)
VP shunts done							
Total VP shunt done	39	38	55	60	44	236	44 (18.64)
Type of VP shunt used							
Low pressure shunt	10	26	43	43	34	156 (66.10)	32 (13.55)
Medium pressure shunt	29	12	12	17	10	080 (33.89)	12 (05.08)
Deaths							
Post-operative	10	08	03	13	10	044 (18.64)	44 (18.64)

VP shunt = Ventriculo peritoneal shunt, TBM = Tubercular meningitis

Table 2: Ventriculoperitoneal shunt revisions done in children (*n*-=48) and post-operative deaths (*n*=4)

Demography	Years					Total (%)	Deaths (%)
	2006	2007	2008	2009	2010		
Sex							
Male	6	1	9	3	9	28 (70)	3 (7.5)
Female	5	0	1	0	6	12 (30)	1 (2.5)
Primary diagnosis (VP shunt done earlier)							
Infants: Cong hydrocephalus	4	0	7	1	11	23 (57.5)	3 (7.5)
1-12 yrs: Cong hydrocephalus	1	0	0	0	1	2 (5.00)	0
0-12 yrs: TBM hydrocephalus	6	1	3	2	3	15 (37.5)	1 (2.5)
Type of shunt used during first shunting							
Low pressure shunt used	0	1	7	2	11	21 (52.5)	2 (5)
Medium pressure shunt used	11	0	3	1	4	19 (47.5)	2 (5)
Total no. of patients							
Male+female	11	1	10	3	15	40	4 (10)
Shunt revision done							
Total shunt revisions done	12	1	12	4	19	48	4
No. of revisions done							
Shunt revision once	10	1	8	2	12	33 (82.5)	3 (7.5)
Shunt revisions twice	1	0	2	1	2	6 (15)	1 (2.5)
Shunt revisions thrice	0	0	0	0	1	1 (2.5)	0
Deaths							
Post-operative deaths	1	0	1	0	2	4	4 (10)

VP shunt = Ventriculo peritoneal shunt, TBM = Tubercular meningitis



Figure 1a: Extrusion of peritoneal catheter through anus (clinical photograph)



Figure 1b: Extrusion of peritoneal catheter through anus (x-ray abdomen)

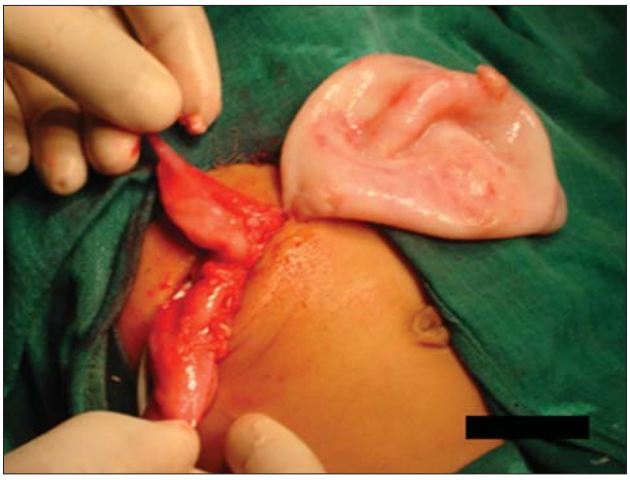


Figure 2: Cerebrospinal fluid pseudocysts peritoneal cavity (operative photograph)



Figure 3: Extrusion of peritoneal catheter from neck wound



Figure 4: Extrusion of peritoneal catheter from chest wound



Figure 5: Extrusion of peritoneal catheter from abdominal scar

when needed and added in the text. Diagnostic work up of patients included clinical history and examinations, plain X-ray of abdomen, Ultrasonography (USG) head/abdomen and pelvis, Computed tomography (CT) scan head/abdomen, etc. Details of clinical presentation, diagnosis, management, etc., of the above cases were reviewed.



Figure 6: Extrusion of peritoneal catheter through umbilicus

RESULTS

Two hundred and thirty six VP shunt operations were performed for hydrocephalus in children below 12 years of age at the author's department of paediatric surgery during last 5 years. The details of age and sex distribution, diagnosis, type of shunt system used for shunting, etc., are given in Table 1. We are exclusively doing VP shunt operation for the treatment of hydrocephalus in children in our department of paediatric surgery. The average number of VP shunt operations done per year at the author's department of paediatric surgery was 47.2 shunts during 2006 to 2010. Forty (16.94%), 28 (70%) boys and 12 (30%) girls, of 236 VP shunts developed shunt complications in follow-up period and needed 48 shunt revisions. Demographics of age and sex distribution at previous operation, type of shunt system used earlier for shunting, revisions done, etc., are given in Table 2. VP shunt complications in order of frequency that required shunt revisions are given in Table 3. Four-fifth (n=38, 79.16%) shunt complications occurred within 6 months of previous surgery; of these, 28 (58.33%) were reported within 3 months of previous shunting. Shunt complications that occurred after 6 months to one year of previous VP shunt were 4 (8.33%) and after one year of shunting were 6 (12.5%). The average interval between VP shunt operation and shunt complications/revision was 5.11 months, ranging from one month to 4 years. However, we also encountered a shunt complication after 11 years of VP shunt (not included in study). The surgical procedures done during shunt revisions for various VP shunt complications in order of frequency are given in Table 4.

Table 3: Complications occurring (n-=48) following VP shunt operations (n=236) (Jan 01, 2006 - Dec 31, 2010)

Complications occurring following VP shunt operations ↓ (in order of frequency)	Number of cases (%)
Peritoneal end malfunction	18 (7.62)
Shunt/shunt tract infection	7 (2.96)
Extrusion of peritoneal catheter through anus	5 (2.11)
Ventricular end malfunction	4 (1.69)
CSF leak from abdominal wound	4 (1.69)
Shunt system malfunction	2 (0.84)
Ventricular end/shunt displacement	2 (0.84)
CSF pseudocysts peritoneal cavity	2 (0.84)
Extrusion of peritoneal catheter from neck wound	1 (0.42)
Extrusion of peritoneal catheterfrom chest wall	1 (0.42)
Extrusion of peritoneal catheter from abd wound	1 (0.42)
Extrusion of peritoneal catheter through umbilicus	1 (0.42)

Table 4: Surgical procedures done during shunt revisions (Jan 01, 2006 - Dec 31, 2010)

Surgical procedures done during shunt revisions	Number of cases (%)
Revision of peritoneal part of VP shunt done	27 (56.25)
Entire shunt system revision done	6 (12.5)
EVD and delayed re-shunt done	5 (10.41)
Shunt removal and delayed re-shunt done	5 (10.41)
CSF cysts excision and relocation of peritoneal part of shunt done	2 (4.16)
Opposite side shunt done	2 (4.16)
Revision of ventricular part of VP shunt done	1 (2.08)
Total shunt revisions done	48 (100)

EVD = Extra ventricular drainage of CSF

DISCUSSION

Prior to the late 19th century, treatment for "water on the brain" involved more observation than intervention. Hippocrates, 5th century B. C. (460–377 BC), Greek physician and surgeon, the father of medicine, is thought to be the first physician to attempt and document the treatment of hydrocephalus. The use of peritoneal cavity for CSF absorption in VP shunting was introduced in 1905 by Kausch; since then, VP shunt are amongst the most frequently performed operations in the management of hydrocephalus.[2] Other shunting techniques are endoscopic third ventriculostomy, VA shunts and LP shunts.[5-8] Endoscopic third ventriculostomy is more physiological and anatomical diversion pathway for CSF and at the same time, it obviates the need to place a foreign body such as ventricular shunt, thus avoiding shunt-related complications such as malfunction, infection, over-drainage, etc.[12] LP shunts are also being used for the treatment of communicating hydrocephalus not only in

adults, but also in children with good results.[8]

This prospective study included 236 children and they were 153 (64.83%) boys and 83 (35.16%) girls. One hundred and sixty seven (70.76%) VP shunt operations were done for congenital hydrocephalus; of these, 144 (61.01%) were infants and 23 (9.74%) were 1 to 12 years of age. During above period, 69 (29.23%) VP shunt operations have also been done for hydrocephalus secondary to Tubercular meningitis (TBM) in infants and children below 12 years. Other reports also had similar pattern of patients, i.e., having higher number of VP shunt operations done for congenital hydrocephalus and during infancy followed by surgery for hydrocephalus due to TBM.[4,9,11,13]

Although the risk in performing shunt operation is low, the complications related to shunts are many, with a reported incidence of 24 to 47%, of which abdominal complications are reported to occur in 25% of VP shunt. Shunt infection remains a frequent and potentially fatal complication of CSF diversion with reported incidence of 5 to 15% and approximately 70% of shunt infections manifest within 2 months after shunt insertion.[3,9,11] We observed 20 (8.47%) of 236 shunt-related infections in the form of shunt infection/shunt tract infection and meningitis, during initial VP shunting (n=13) and in follow-up period (n=7). Thirteen (5.5%) of them died due to above complications in immediate post-operative period, following initial shunting and 7 (2.96%) needed shunt revision in follow-up period. The organisms identified were *E. coil,* Proteus, *Staphylococcus aureus*, *Klebsiella*, etc. The treatment protocol observed in 13 patients who died due to shunt infection/shunt tract infection and meningitis were i/v antibiotics and other supportive measures in all the cases and shunt system removal and extra ventricular drainage (EVD) of CSF in few of them. In seven patients who needed shunt revisions due to shunt infection/shunt tract infection and meningitis in follow-up period, the treatment protocol observed were (a) EVD and delayed re-shunt in n=3, (b) entire shunt system removal and delayed re-shunt in n=2 and (c) entire shunt system removal and opposite side (left) shunting in n=2.

Shunt revisions are required for shunt-related complications following VP shunt operations and reported to occur in about 12 to 36% cases, and up to 18% may require multiple revisions.[9,10] Shunt obstruction is one of the frequently observed complications following VP shunt operations and needed revisions in up to 14% of the cases.[9,11,13] One of the study reported 53.8% of shunt obstructions and another study reported 78% revision following shunt complications.[14,15] We observed various shunt complications that needed revisions in 40 (16.94%) patients among 236 VP shunt done during the study period. Thirty three (82.5%) children in the present study required shunt revision only once, six (15%) required twice and one (2.5%) required shunt revisions thrice in follow-up period. In four-fifth (n=38, 79.16%) of children, shunt revisions were needed within 6 months of previous surgery; of these, 28 (58.33%) were needed within 3 months.

Visceral perforation is an unusual but serious complication of VP shunt and bowel is the most commonly involved site for perforation and is reported to occur in 0.1 to 0.7% of cases with reported mortality of up to 15%. The occurrence of a viscous perforation by the abdominal portion of a VP shunt is often a prolonged clinical phenomenon which usually does not lead to acute peritonitis.[16-18] Rarely, acute viscous perforation may also occur and may present as peritonitis; this is the exception rather than the rule.[16-18] There are many options for the management of patients who presented with protrusion/extrusion of catheter through anus viz. (1) Mini laparotomy and revision of peritoneal part of shunt, (2) formal exploratory laparotomy and repair of bowel perforation in selected cases having peritonitis, (3) shunt removal and external ventricular drainage, antibiotics, followed by VP shunt or VA shunt, ventriculostomy and (4) colonoscopic removal of shunt and transanal repair of colon has also been reported.[4,16-20] We observed 2.11% (n=5) VP shunt catheter extrusion/protrusion through anus in our present study. All cases presented as extrusion of peritoneal part of VP shunt catheter through anus without features of peritonitis or meningitis. Three of them earlier had VP shunt operation for hydrocephalus secondary to TBM and two for congenital hydrocephalus during infancy. The average interval between shunt operations to per rectal extrusion was 9.4 months with a range from 2 to 20 months. All of them were managed by mini laparotomy with revision of peritoneal part of shunt alone. None of the above patients needed or underwent formal exploration to identify the site of entry of the catheter in the bowel, neither any one developed peritonitis following shunt revisions.

Non-enteric viscous perforation has also been sporadically reported in literature and includes urinary bladder, vagina, gall bladder, stomach, scrotum, liver, uterus, urethra, etc. VP shunt catheter protrusion has also been reported through umbilicus, gastrostomy wound, healed neck wound, knee, mouth, abdominal wound, etc.[16,18,21-30] Migration of peritoneal catheter

of VP shunt into the pulmonary artery and heart has also been reported.[31,32] We also encountered extrusion of the peritoneal part of the VP shunt catheter, one each from healed neck wound, chest wall, healed abdominal wound and through umbilicus. Extrusion of peritoneal catheter from healed neck wound was observed 17 months following VP shunt operation for congenital hydrocephalus. The entire shunt system was removed and delayed re-shunt was done. An extrusion of peritoneal catheter from the chest was noticed 2 years following VP shunt operation for hydrocephalus due to TBM and was managed by removal of entire shunt and opposite side shunting. Extrusion of peritoneal catheter from healed abdominal wound and through umbilicus were observed 2 and 3 months, respectively, following VP shunt operation for hydrocephalus due to TBM and congenital hydrocephalus and were managed successfully by revision of peritoneal part of the shunt.

CSF pseudocysts in peritoneal cavity is an uncommon albeit well-described complication of VP shunt malfunctions with a reported incidence of <1 to 4.5% of VP shunt operations. Predisposing factors for CSF pseudocysts formation are low-grade shunt infection, chronic inflammation, multiple shunt revisions, increased CSF protein content, peritoneal adhesions, mal-absorption of CSF secondary to subclinical peritonitis, silicon allergy, etc. Ultrasonography and CT scan of the abdomen and pelvis are excellent imaging modalities for diagnosis of CSF pseudocysts.[33-35] The treatment options for the CSF pseudocysts peritoneal cavity are excision of the cysts and relocation of the shunt and can be done either through formal laparotomy or laparoscopically. Other options are exploratory laparotomy/laparoscopic removal of shunt/shunt externalization, with or without cyst excision and conversion of VP shunt to VA shunt or third ventriculostomy.[33,35-37] We observed two cases (0.84%) of CSF pseudocysts in peritoneal cavity following VP shunt operations (one for hydrocephalus due to TBM and another for congenital hydrocephalus). Both presented with progressive abdominal distention and malfunction of the peritoneal part of the shunt. The interval of this complication from shunt insertion was 1 and 7 months, respectively. Both were managed by formal exploratory laparotomy, excision of the cysts and relocation of the peritoneal catheter. There were four (1.69%) cases of CSF leak from abdominal wound following VP shunting and all were managed successfully by revision of the peritoneal part of shunt.

In present study, 40 (28 boys and 12 girls) children needed 48 shunt revisions in follow-up period. Thirty three (82.5%) of them needed VP shunt revision once, six (15%) required twice and one (2.5%) required thrice shunt revisions in follow-up period. Twenty three (57.5%) of them earlier had VP shunt operation for congenital hydrocephalus during infancy, 15 (37.5%) for hydrocephalus following TBM and another two (5%) for congenital hydrocephalus after infancy. Shunt revisions were needed almost equally for both low pressure and medium pressure shunts, i.e., 21 and 19. Most frequently performed operation was revision of peritoneal part of shunt and was done in (n=27) 56.25%, followed by revision of entire shunt system in (n=6) 12.5%, EVD and delayed re-shunting in (n=5) 10.41%, shunt removal and delayed re-shunting in (n=5) 10.41%, opposite side shunting in (n=2) 4.16%, CSF pseudocysts excision and revision of peritoneal part of shunt in (n=2) 4.16% and (n=1) 2.08% required revision of ventricular catheter.

We are exclusively using Chhabra "slit n spring" valve and a regular reservoir medium-/low-pressure hydrocephalus shunt system (G Surgiwear Limited, Shahjahanpur, Uttar Pradesh, India) as a routine irrespective of the causes of hydrocephalus or the age of patient. According to the manufacturer, the medium pressure shunt would open at 7–12 cm of H_2O and low-pressure shunt at 2–5 cm of H_2O.[13] The length of peritoneal/distal catheter is 75 cm. We are using full length of distal catheter during shunting. We used a small, supra-umbilical, right transverse, rectus splitting incision for insertion of the peritoneal catheter under direct vision to prevent injury to bowel. One prospective study was conducted to compare the low *vs* medium pressure shunts for congenital hydrocephalus and they found that low-pressure shunt had higher flow rates and can cause marked negative intracranial pressure, especially in erect.[13] Two studies on hydrocephalus were conducted by Korinth *et al.*, in neonates and infants using programmable, Hakim valve VP shunts. They initially used low pressure setting and re-adjusted it after wound healing, during VP shunt operations. They concluded that an initial, temporary, over drainage, may contribute to further lowering the incidence of non-infectious complications like wound break down, CSF fistula or subcutaneous accumulation of CSF, without side effects.[38,39]

We are using low-/medium-pressure shunt system and the rationale for using medium- *vs* low-pressure shunt is based on author's belief and their experience. Author one (corresponding author) has been, exclusively, using medium-pressure shunt system for VP shunting, for more than 15 years and it is based on the results of

authors previous study, (used medium pressure shunt system) in 398 VP shunts in children under 12 years, with 8.29% mortality.[4] Author second and third, both are using low-pressure shunt system in majority of cases during last five years and believe that use of low-pressure valve temporally leads to excess CSF drainage and do not attribute to mortality. Author four is a trainee resident in the department of paediatric surgery, and worked as per the instruction of consultants. We implanted low-pressure shunt in 156 (66.10%) and medium-pressure shunt in 80 (33.89%) during present series, irrespective of the age and the causes of hydrocephalus. We frequently observed excess CSF drainage in peritoneal cavity, deterioration of central nervous system status (low intracranial pressure syndrome) and more deaths with low-pressure shunt system.

The mortality reported in various series following VP shunt operations varies from 0 to 8.2% and following VP shunt revisions up to 15%.[4,10,15] We observed 18.64% (44 of 236) deaths following VP shunt operations and 10% (4 of 40) deaths following shunt revisions. The causes of deaths following initial VP shunt surgery in order of frequency were (a) excess CSF drainage/over drainage in $n=19$ (8.05%), (b) shunt infection/shunt tract infection/meningitis in $n=13$ (5.5%) and (c) poor general condition/gross hydrocephalus in $n=12$ (5.08%). Eight (18.18%) of 44 deaths were neonates/infants who underwent VP shunt insertion and meningomyelocele excision at the same sitting. Twenty seven (61.36%) deaths occurred within 1 to 7 days following VP shunting, $n=11$ (25%) deaths occurred within 8 to 15 days and remaining $n=6$ (13.63%) deaths occurred within 16 to 30 days, following shunt insertion. We noticed significantly more deaths following VP shunt surgery done during infancy for congenital hydrocephalus than operated for the same after infancy, i.e., 13.98% and 0.42%, respectively ($P<0.01$). This higher mortality in infants can be attributed to more frequent use of low-pressure shunt system and operations during early infancy. Deaths during infancy for congenital hydrocephalus were also more than deaths for hydrocephalus following TBM, 13.98% and 4.23%, respectively ($P<0.01$). There were 33 deaths during infancy, out of which 28 (84.84%) occurred in patients <6 months of age and 15 (45.45%) occurred in patients <3 months of age. Deaths were more in patients implanted with low-pressure shunt than patients implanted with medium-pressure shunt system, i.e., 13.55% and 5.08%, respectively ($P<0.05$). We also encountered four (10%) deaths amongst 40 children, who required 48 shunt revisions in follow up. Three of them had earlier VP shunts during infancy for congenital hydrocephalus and another one had VP shunt for TBM hydrocephalus. Two of them died due to meningitis following shunt revisions. One had poor general condition and died following shunt revision, and another one died due to anaesthesia complication during shunt revision.

CONCLUSION

VP shunt operations done for hydrocephalus in children are not only prone for complications and need for shunt revisions in follow-up period, but are also associated with considerable mortality. A strict follow up is a must during first 6 months after the shunt surgery as majority of complications are being reported within this period. Preferably, a medium-pressure shunt system is advisable for the VP shunt operation in children.

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