Original Article

Management of Ventriculoperitoneal Shunt Complications in Children: A Review of 34 Cases

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Abstract

Objectives: The primary objective of this study was to analyse the demographics of the children who presented with ventriculoperitoneal shunt (VPS) complications. The secondary objectives were to review the clinical characteristics, surgical procedures performed for the management of VPS complications and the final outcome. **Materials and Methods:** This is a single-institution observational study that included children below 12 years of age who required VPS revisions during the study period. **Results:** During the study period of 10 years, *n* = 336 VPS catheters were implanted for the treatment of hydrocephalus in children. Forty (11.90%) children developed various VPS complications and required VPS revisions in the follow-up period. A total of *n* = 30 (8.92%) children (*n* = 21 boys and *n* = 9 girls) were selected/recruited for the present study, and they required *n* = 34 revision procedures. The mean interval from VPS insertion to the diagnosis of the complication was 7.29 months. VPS complications that required revisions occurred in the following order of frequency: (1) VPS catheter, cerebrospinal fluid (CSF) or shunt tract infection *n* = 8 (2.38%); (2) malfunction of distal VPS catheter *n* = 7 (2.08%); (3) coiling of distal VPS catheter at abdominal area *n* = 6 (1.78%); (4) extrusion of VPS catheter *n* = 5 (1.48%); (5) CSF leak from abdominal wound site/umbilicus *n* = 4 (1.19%); (6) malfunction of ventricular catheter *n* = 3 (0.89%) and (7) CSF pseudocyst peritoneal cavity *n* = 1 (0.29%). Surgical procedures were performed for the treatment of abovementioned complications in the following order of frequency: (1) revision of distal VPS catheter *n* = 14 (4.16%), (2) removal of entire VPS catheter ± external ventricular drainage (EVD) *n* = 7 (2.08%), (3) distal VPS catheter converted as EVD *n* = 6 (1.78%), (4) revision of proximal VPS catheter *n* = 3 (0.89%), (5) revision of entire VPS catheter *n* = 3 (0.89%) and (6) CSF pseudocyst excision *n* = 1 (0.29%). This study also documented *n* = 2 (6.6%) deaths during the post-operative period. **Conclusion:** VPS insertion done for the treatment of hydrocephalus in infants and children was associated with various complications. Seventy per cent of the complications occurred within the first 6 months after the VPS insertion. Two-thirds of the complications were related to the distal VPS catheter.

Keywords: Children, complication, hydrocephalus, infants, ventriculoperitoneal shunt, ventriculoperitoneal shunt revision

Introduction

Ventriculoperitoneal shunt (VPS) insertion is one of the most frequently performed, and is well accepted surgical procedure for the management of hydrocephalus.[1-3] Various complications are known and occur after VPS insertions. Many of the VPS-related complications required VPS revisions.[1,2,4-7] Complications relating to the distal VPS catheter are more frequently reported.[7] Children are more prone to the development of VPS complications.[8] The majority of the VPS revision procedures were required during the 1st year after the VPS insertion.[5,9,10] The present study is a retrospective, observational study that included *n* = 30 children who developed complications after the VPS insertion and they required VPS revisions, with a brief review of the literature.

Materials and Methods

This is a single-institution study in children below the age of 12 years and included children who required VPS revisions during the study period. This study was conducted for a period of 10 years from 1 January 2011 to 31 December 2020, and it

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was conducted at the author's department of paediatric surgery. Most of the VPS insertion and VPS revision procedures were carried out/performed by consultant paediatric surgeons with a clinical experience of more than 15 years to 30 years. VPS insertions done in children during the above period were followed till 30 April 2021. Case records of all the children who required VPS revisions for VPS complications were reviewed in detail for the desired information. The variables/details extracted from the case records were demographic details, indication for primary VPS insertion, VPS complication, the interval from the VPS insertion to the diagnosis of complication, clinical characteristics and surgical procedures performed for the management of VPS complications, post-operative complication and the final outcome.

Children who presented and required VPS revision for the trans-anal and trans-oral extrusion of distal VPS catheter during the study period were not included in the present study. Nine children presented with the trans-anal extrusion of the distal VPS catheter; they were treated by the author during the study period and were excluded from the present study to avoid duplicate submission/publication. One of the children presented with the trans-oral extrusion of the distal VPS catheter and was treated by the author during the study period. This case was also excluded from the present study to avoid duplicate publication, as the same has been published earlier as a case report. VPS insertions done prior to 1 January 2011, but children who required VPS revisions during the study period were also excluded from the present study. Institutional ethical committee approval was obtained for waiver of the consent and exemption from review because of the retrospective nature of the present study.

Results

During the study period, $n = 336$ VPS catheters were implanted for the treatment of hydrocephalus in children, and consisted of boys $n = 200$ (59.52%) and girls $n = 136$ (40.47%). During the above period, $n = 241$ (71.72%) VPS catheters were implanted for congenital hydrocephalus during infancy, $n = 23$ (6.84%) VPS catheters were implanted for congenital hydrocephalus after infancy to 12 years of age and $n = 72$ (21.42%) VPS catheters were implanted for hydrocephalus secondary to tubercular meningitis (TBM) during 0–12 years of age. During the follow-up period, $n = 40$ (11.90%) children developed various VPS complications and required VPS revisions. Ten children (trans-anal extrusion $n = 9$ and trans-oral extrusion $n = 1$) were excluded from the present study. A total of $n = 30$ (8.92%) children required $n = 34$ VPS revisions, were recruited for the present study and included $n = 21$ (70%) boys and $n = 9$ (30%) girls. Twenty-six of them required VPS revision once while the remaining four children required VPS revisions twice.

Indications for initial VPS insertion amongst the above $n = 30$ children were (1) congenital hydrocephalus detected during infancy $n = 21$, 70%; (2) congenital hydrocephalus detected after infancy to 12 years of age $n = 2$, 6.66% and (3) hydrocephalus secondary to TBM detected during 0–12 years

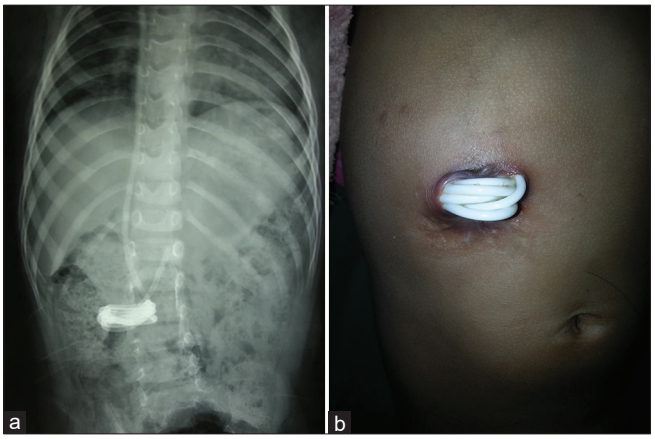


Figure 1: (a) Skiagram of abdomen (case 29) showing coiling of the distal VPS catheter at abdominal area, (b) Operative photograph (case 29) showing coiling of the distal VPS catheter at abdominal area, VPS: Ventriculoperitoneal shunt



Figure 2: Clinical photograph showing extrusion of distal VPS catheter through the healed abdominal scar, VPS: Ventriculoperitoneal shunt



Figure 3: Clinical photograph (case 22) showing extrusion of ventricular catheter through the scalp area

Table 1: Demographic details of children who presented with ventriculoperitoneal shunt complications and required ventriculoperitoneal shunt revisions (n=30)

Year	Age at complication	Age VPS insertion	Sex	Indication for VPS insertion	Complication	Interval	Surgical procedures executed	Revision	Remark
2011	7 months	6 months	Male	Cong hydroc	Shunt tract/CSF infection	1 month	Removal of entire VPS catheter + EVD Delayed re-VPS insertion	First	Well
2012	8 months	7 months	Male	Cong hydroc	Malfunction of ventricular catheter	1 month	Revision of ventricular catheter	First	Death
2012	12 months	2 months	Male	Cong hydroc	Malfunction of ventricular catheter	8 months	Revision of ventricular catheter	First	-
					Shunt catheter extrusion (scalp)	2 months	Removal of entire VPS catheter + EVD Delayed re-VPS insertion	Second	Death
2013	8 years	7 years	Male	TBM hydroc	CSF pseudocyst peritoneal cavity	7 months	Cyst excision, adhesiolysis and relocation of distal VPS catheter	First	Well
2013	5 months	3 months	Female	Cong hydroc	CSF leak abdominal/chest	2 months	Removal of entire VPS catheter+EVD Delayed re-VPS insertion	First	Well
2013	10 months	9 months	Male	Cong hydroc	Malfunction distal catheter	1 month	Revision of distal VPS catheter	First	Well
2013	9 months	8 months	Male	Cong hydroc	Shunt tract infection	1 month	Removal of entire VPS catheter + EVD Delayed re-VPS insertion	First	Well
2013	12 months	9 months	Male	Cong hydroc	Shunt catheter extrusion (neck)	3 months	Removal of entire VPS catheter + EVD Delayed re-VPS insertion	First	Well
2014	36 months	30 months	Male	TBM hydroc	Shunt catheter extrusion (abdomen)	5 months	Revision of distal VPS catheter	First	Well
					CSF leak (abdomen)	1 month	Revision of distal VPS catheter	Second	Well
2014	24 months	10 months	Female	Cong hydroc with MMC	Malfunction distal catheter	14 months	Removal of entire VPS catheter Immediate re-VPS insertion	First	Well
2014	8 years	7.6 years	Female	Cong hydroc	Shunt tract infection	5 months	Revision of distal VPS catheter	First	Well
2014	5 months	2 months	Male	Cong hydroc	Malfunction distal catheter	3 months	Revision of distal VPS catheter	First	Well
2014	12 years	11.6 years	Male	TBM hydroc	Malfunction distal catheter	5 months	Revision of distal VPS catheter	First	Well
2015	6 months	4 months	Male	Cong hydroc	Malfunction distal catheter (intestinal adhesion)	2 months	Adhesiolysis and relocation of distal VPS catheter	First	Well
2015	4 months	2 months	Female	Cong hydroc	Shunt tract infection	2 months	Distal VPS catheter as EVD Revision of distal VPS catheter	First	Well
2016	5 years	58 months	Male	Cong hydroc	Coiling of distal catheter (abdomen)	2 months	Revision of distal VPS catheter	First	Well
2016	8 months	3 months	Male	Cong hydroc with MMC	Malfunction of ventricular catheter	5 months	Removal of entire VPS catheter Immediate re-VPS insertion	First	Well
2016	5 years	24 months	Male	TBM hydroc	Shunt tract infection	36 months	Distal VPS catheter as EVD Delayed revision of distal catheter	First	Well
2016	12 months	7 months	Female	Cong hydroc	Coiling and kinking of distal catheter (abdomen)	5 months	Revision of distal VPS catheter	First	Well
2016	12 months	4 months	Female	Cong hydroc	Shunt tract infection	8 months	Distal VPS catheter as EVD Delayed revision of distal catheter	First	Well

Contd...

Table 1: Contd...

Year	Age at complication	Age VPS insertion	Sex	Indication for VPS insertion	Complication	Interval	Surgical procedures executed	Revision	Remark
2016	7 months	1 month	Male	Cong hydroc	Malfunction of distal catheter	5 months	Removal of entire VPS catheter Immediate re-VPS insertion	First	Well
2017	8 months	3 months	Male	Cong hydroc	Shunt catheter extrusion (scalp)	4 months	Revision of ventricular catheter	First	Well
					Shunt catheter extrusion (neck)	1 month	Distal VPS catheter as EVD Delayed re-VPS insertion	Second	Well
2017	12 months	11 months	Male	Cong hydroc	Coiling distal catheter (abdomen)	1 month	Revision of distal VPS catheter	First	Well
2017	17 months	3 months	Male	Cong hydroc with MMC	Shunt tract infection	6 months	Removal of entire VPS catheter+EVD Delayed re-VPS insertion	First	Well
2017	36 months	3 months	Male	Cong hydroc with MMC	CSF leak (abdomen)	15 months	Revision of distal VPS catheter	First	Well
					Coiling of distal catheter (abdomen)	18 months	Distal VPS catheter as EVD Delayed revision distal catheter	Second	Well
2017	4 years	3.6 years	Male	TBM hydroc	Malfunction of distal catheter	4 months	Removal of entire VPS catheter+EVD Delayed re-VPS insertion	First	Well
2017	34 months	18 months	Female	TBM hydroc	CSF discharge through umbilicus	16 months	Relocation of distal VPS catheter	First	Well
2018	36 months	18 months	Female	TBM hydroc	Coiling of distal catheter (abdomen)	17 months	Revision of distal VPS catheter	First	Well
2019	4 years	3 months	Male	Cong hydroc with MMC	Coiling of distal catheter (abdomen)	36 months	Revision of distal VPS catheter	First	Well
2020	18 months	12 months	Female	Cong hydroc with MMC	Shunt tract infection	6 months	Distal VPS catheter as EVD Delayed revision of distal catheter	First	Well

Cong: Congenital, CSF: Cerebrospinal fluid, EVD: External ventricular drainage, Hydroc: Hydrocephalus, MMC: Myelomeningocele, TBM: Tubercular meningitis, VPS: Ventriculoperitoneal shunt

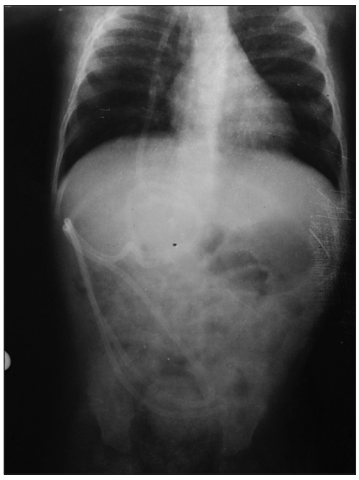


Figure 4: Skiagram of abdomen (case 19) showing kinking of the distal VPS catheter, VPS: Ventriculoperitoneal shunt

Table 2: Complication after ventriculoperitoneal shunt insertion in children (*n*=34)

Complication after VPS insertion (in order of frequency)	*n* (%)
VPS catheter/CSF/shunt tract infection	8 (2.38)
Malfunction of distal VPS catheter	7 (2.08)
Coiling of distal VPS catheter (abdomen area)	6 (1.78)
Extrusion of VPS catheter (scalp=2, neck=2 and abdomen=1)	5 (1.48)
CSF leak from abdominal wound site/umbilicus	4 (1.19)
Malfunction of proximal (ventricular) catheter	3 (0.89)
CSF pseudocyst peritoneal cavity	1 (0.29)

CSF: Cerebrospinal fluid, VPS: Ventriculoperitoneal shunt

Table 3: Surgical procedures executed for ventriculoperitoneal shunt complication in children (*n*=34)

Surgical procedures for VPS complication (in order of frequency)	*n* (%)
Revision of distal VPS catheter	14 (4.16)
Removal of entire VPS catheter±EVD	7 (2.08)
Distal VPS catheter converted as EVD	6 (1.78)
Revision of proximal VPS catheter	3 (0.89)
Removal and revision of entire VPS catheter	3 (0.89)
CSF pseudocyst excision	1 (0.29)

CSF: Cerebrospinal fluid, VPS: Ventriculoperitoneal shunt, EVD: External ventricular drainage

of age *n* = 7, 23.33%. The demographic details of *n* = 30 children who developed complication and required VPS revisions are detailed in Table 1.

The mean interval from VPS insertion to the detection of complication was 7.29 months and ranged from 1 month to 36 months. Seventy per cent of the complications were evident within the first 6 months after the VPS insertion. Various VPS complications that required VPS revisions in children are detailed in Table 2. Complications relating to the distal VPS catheter were observed/documented in two-thirds of the cases. Some of the causes of VPS catheter dysfunction were due to shunt catheter coiling beneath the abdominal skin [Figure 1a and b], shunt catheter extrusion through the healed abdominal wound site [Figure 2], shunt catheter extrusion through the scalp [Figure 3] and kinking of the distal VPS catheter [Figure 4]. Surgical procedures performed for the management of various VPS complications are detailed in Table 3. This study also documented the death of two (6.6%) children during the post-operative period. Both infants died after VPS revision procedures due to the poor pre-operative general condition.

Discussion

VPS placement is the mainstay for treating hydrocephalus.[1-3] Varieties of complications occur after the placement of a VPS catheter, and many of the complications require revision procedures.[1,2,4-7] The majority of the VPS-related complications occur early in the follow-up period, most frequently during the first 6 months to 12 months after the shunt placement.[5,7,9,10] VPS revision procedures are frequently required in paediatric cases and documented in one-third to as many as four-fifths of the cases, and some of them require VPS revisions more than once.[1,4-6,9-11]

VPS infection, cerebrospinal fluid (CSF) infection or shunt tract infection is one of the common reasons for VPS failure and is reported in as many as 15% of paediatric cases.[11,12] The present study revealed that *n* = 8 (2.38%) of the children developed shunt-related infections, and all of them had shunt tract infections in the form of redness of the shunt tract, pus collections or skin necrosis over the shunt tract. Amongst the above *n* = 8 cases, the interval from initial/previous shunt placement to the diagnosis of infection was 1–6 months for *n* = 6 of the cases. The treatment of most shunt infections or CSF infections requires removal of a VPS catheter, injectable antibiotics and delayed re-VPS insertion, including in the present study.[4,7,11,13,14]

Malfunction of the distal VPS catheter is also an important VPS complication and one of the major causes of the VPS revisions. The present review documented that *n* = 7 children presented with distal VPS catheter malfunctions and required revision of their distal VPS catheter. Various studies also reported that the malfunctions of the distal VPS catheter were also frequently documented.[4,7,11,15]

Coiling of the distal VPS catheter beneath the abdominal skin was also a cause of distal VPS catheter obstruction and malfunction in the present study, and it was documented in *n* = 6 of the cases. The mean interval from VPS insertion to the detection of the complication was 13.16 months and ranged from 1 month to 36 months. Five of them were successfully treated with the revision of the distal VPS catheter, while one of the children required an external ventricular drainage (EVD) and delayed revision of the distal VPS catheter.

Extrusions of the VPS catheter or part of the VPS catheter from various body parts other than extrusion through the natural orifices have also been reported in the literature. Extrusion

of the VPS catheter may occur at any place from the scalp to the abdominal old healed scar or any healthy area unrelated to the VPS catheter tract.[7,16-21] Five children of the present study presented with extrusion of VPS catheter or part of VPS catheter from various body parts (scalp = 2, neck = 2 and abdomen = 1). The mean interval from the VPS insertion to the diagnosis of complication was 3 months and ranged from 1 to 5 months. Two of them were managed by the removal of the entire VPS catheter with EVD and delayed re-VPS insertions. One of the children was managed with the revision of a distal VPS catheter and another child was managed with the revision of a ventricular catheter. In one of the children, the distal VPS catheter was converted as EVD, and later on, delayed re-VPS insertion was done.

The literature has also reported leakage of CSF from the old healed abdominal scar or healthy area and through the umbilicus after the VPS insertion.[7,21-23] Four such cases were documented in the present study, three had CSF leakage from the old healed abdominal wound site, while another one presented with the CSF leakage through the umbilicus. The mean interval from VPS insertion to the diagnosis of complication was 8.5 months and ranged from 1 to 16 months. Three of them were managed with the revision of the distal VPS catheter and another one of the children required the removal of the entire VPS catheter, an EVD and followed by the delayed re-VPS insertion.

Malfunction of proximal/ventricular VPS catheter is due to the migration of the shunt catheter or blockage of the holes of the ventricular catheter.[7,24-26] Three children were diagnosed with the malfunction of a ventricular catheter in the present study and managed with the revisions of the ventricular catheters in two, and one of the children required removal of the entire VPS catheter and immediate re-VPS insertion.

Hydrocephalus is the most frequently observed complication of the TBM, and it occurs more frequently in children than adults. Hydrocephalus secondary to TBM is most frequently treated by the insertion of a VPS catheter. VPS insertion done for the management of such a type of hydrocephalus is also associated with complications, and it ranged from 10% to 44% of the cases.[27-29] In the present study, in n = 72 (21.42%) children, VPS catheter was inserted for the treatment of hydrocephalus secondary to TBM. A total of n = 7 (9.72%) children from this group constituted 23.33% of the children recruited for the present study, developed complications and required shunt revisions in the follow-up period.

In general, the causes of VPS complication are technical failure, CSF/shunt tract/shunt system infection, mechanical failures and patient factors. Multiple factors are responsible for the causation of VPS complications, either alone or contributory to each other. The incidence of VPS complications varies from study to study, and it depends upon the age, the indication of VPS insertion, shunt system implanted, number of the cases included in the study and others. The incidence of VPS complications is directly associated with the indication for VPS insertion, age of the patient, type of shunt system used, the technique for VPS implantation, CSF character, patients' general condition, associated other anomalies/illness and others.[30-32] In the present study, most of the VPS insertion/revision procedures were performed by consultant paediatric surgeons with clinical experience of over 15–30 years. Second, the insertion of the peritoneal catheter was done by open technique and under direct vision. The chances of the technical error/technical failure are less likely factors for some of the VPS complications reported in the present report but cannot be completely ruled out.

The present study also documented the death of two (6.66%) children after the VPS revision procedures. Both infants initially received their VPS catheter for treatment of congenital hydrocephalus. One of the children died after the first shunt revision procedure, while the second child died after the second VPS revision procedure. Both children died due to the pre-operative poor general condition and poor central nervous system status.

VPS insertion done for treatment of hydrocephalus in children was prone to complications. A total of 12% of children in the present study developed various VPS complications and required VPS revisions in the follow-up period. Seventy per cent of the VPS-related complications occurred within the first 6 months of the VPS insertion. Two-thirds of complications were related to the distal VPS catheter.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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