Percutaneously inserted ventriculoureteral shunt as a salvage treatment in pediatric hydrocephalus: a technical note

Ulrika Sandvik (ulrika.sandvik@ki.se)
Karolinska Institute
Jiri Bartek jr
Karolinska Institute
Erik Edström
Karolinska Institute
Mattias Jönsson
Karolinska University Hospital
Jakob Stenman
Karolinska Institute

Research Article

Keywords: Hydrocephalus, ventriculo-ureteral shunt, pediatric

Posted Date: July 28th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1781052/v1

Abstract

Background: Hydrocephalus is a challenge for pediatric neurosurgeons. When the abdominal cavity and heart fail as diversion sites for cerebrospinal fluid (CSF), many of the otherwise used alternative diversion sites are not feasible due to the smaller physical body size of children and infants. Using the urinary system as a site of diversion has been described in adults primarily.

Objective: To describe a minimally invasive procedure to percutaneously access the ureter for placement of a distal catheter in the treatment of pediatric hydrocephalus

Methods: A percutaneous ultrasound-assisted technique, was used to access the renal pelvis for catheter placement into the distal ureter.

Results: Fifteen months after the surgery the child has a stable neurological condition and adequately managed hydrocephalus.

Conclusion: The urinary tract should be considered a viable option for CSF diversion in complex pediatric hydrocephalus. A multidisciplinary approach consisting of interventional radiologists, urologists and neurosurgeons should be involved in the evaluation of potential candidates.

Introduction

Complex hydrocephalus is a challenge among prematurely born children with posthemorrhagic hydrocephalus. More than 80 % of shunt patients require revision and more than half of the hydrocephalic patients are subjected to more than four surgeries [1]. The standard method of diverting cerebrospinal fluid (CSF) into the abdominal cavity is not always feasible. Sometimes peritoneal resorptive insufficiency arises making other sites of diversion necessary. Current literature describes up to 36 sites of diversion varying from the mastoid bone to the pleura and the fallopian tubes[1]. Finding a site of diversion in a pediatric patient is challenging due to the small size of the patient and often high drainage volumes. The ventriculo-ureteral (VU) shunt is rarely used by the neurosurgical community and not many cases have been reported. Most of the reported cases are adult individuals and a percutaneous technique has rarely been used. In this paper, we describe a complex pediatric case that was successfully managed by the use of a percutaneously inserted VU shunt.

Case Description

The patient is a premature boy, born in gestation week 26+2 with a birth weight of 1068 grams. He was treated in neonatal intensive care and suffered from both necrotizing enterocolitis, as well as grade IV intraventricular haemorrhage and posthemorrhagic hydrocephalus. His abdominal condition required two laparotomies with intestinal resections, while his posthemorrhagic condition included 32 shunt procedures/revisions (Table I). He initially underwent implantation of a ventriculoperitoneal (VP) shunt, that due to infection and peritoneal malabsorption was replaced with a ventriculoatrial (VA) shunt. Due to

atrial catheter malfunction, a VP shunt was reimplanted. However, also this VP shunt had to be replaced with another VA shunt, secondary to problems with malabsorption and the development of a CSF cyst that caused right-sided hydronephrosis. Unfortunately, extensive central venous thrombosis with subsequent vena cava syndrome eventually required the removal of the second VA shunt. A pleural shunt was now being considered, but due to the large drainage volumes, this was abandoned. The urinary bladder was also considered, but due to episodes of documented non-symptomatic bacteriuria during the past year, this was believed to be a risky endeavour. Finally, a VU shunt remained a viable option, and while acknowledging the risks of urinary tract infections as well as the risk of the shunt becoming a nidus for the formation of urinary calculi, the VU shunt was deemed the best option for this patient.

The parents have consented to the publication of the case.

Preoperative work-up

An MRI of the brain was performed to rule out hematoma, subdural collections or new adhesions. Due to a left-sided posthemorrhagic ventricular dilatation, this side was chosen for the proximal catheter. CSF cultures were performed and found negative. Repeated urinary cultures showed no signs of bacteriuria. Persistent hydronephrosis was ruled out by ultrasound. Abdominal MRI showed that both kidneys were normal in size with adequate parenchymal thickness. The right ureter was found to be slightly wider than the left. A review of a previous CT scan showed a right-sided ureteric dilatation, sufficient to harbour the distal catheter. A voiding cystourethrography (VCUG) was performed to rule out vesicoureteral reflux while the bladder volume was estimated to be approximately 150 ml. A high-pressure bladder was considered unlikely, as there were no signs of bladder trabeculation or diverticulae on VCUG and both ultrasound and MRI showed a thin-walled bladder of normal size. Cystometry was not performed.

Surgical Technique

The child was positioned semi-prone with his right side slightly elevated. A radiologist experienced in ultrasound-assisted percutaneous nephrostomies (MJ) and a pediatric urologist (JS) were present for the implantation of the distal catheter. The renal pelvis was reached with a micropuncture technique (0.9 mm needle and 0.018inch guidewire) under ultrasound guidance and fluoroscopic control. Using the Seldinger technique and serial dilatation to 8 F, PTFE-coated stainless steel, 0.035 inch (0.89 mm) guidewire was placed via the ureter into the bladder (Figure 1) After a small skin incision, the distal shunt catheter was then placed 3 cm cranially to the ureteric orifice and the final position was verified with fluoroscopy (Figure 2). The shunt catheter was then tunnelled subcutaneously over the back, medially to the right scapula and connected to the shunt valve of a left-sided frontal ventricular catheter (inserted by neurosurgeons JB and US, Figure 3).

On postoperative day 2, the child developed new neurological symptoms and a CT of the abdominal cavity showed that the distal catheter had migrated 2 cm distally, close to the ureteric orifice where the ureter typically is slightly narrower. There is also the possibility of the tubing being clogged by blood. The

problem was resolved by shortening and flushing the distal catheter. The catheter was shortened by 2cm (neurosurgeon EE). After this revision, the recovery was uneventful.

Outcome

Follow-up at six months included urinary cultures and a low-dose CT to rule out the development of hydronephrosis or urinary calculi, as well as any possible formation of calcifications on the distal catheter. The patient remains on a daily dose of oral prophylactic antibiotics (trimethoprim-sulfamethoxazole). At the 15-month follow-up, there have been no urinary tract or CNS infections, and no further episodes of shunt dysfunction. A new MRI of the brain was performed one year postoperatively and showed expected ventricular size and adequate location of the proximal catheter No new abnormalities have emerged on radiological imaging, apart from those related to the pre-existing condition. There have not been any problems related to the maintenance of a normal electrolyte homeostasis and the patient has not required any form of fluid or electrolyte substitution. Neurological follow-up has consisted of out-patient appointments at the neurosurgical department, initially after four weeks and further every six months

Discussion

Diversion of CSF into the genitourinary system was suggested as early as 1925 when Heile proposed an ureterodural anastomosis by suturing the renal pelvis into the lumbar dura[2]. In 1949 Matson described using a polyethene tube for drainage into the ureter[3]. The idea of utilizing the urinary tract for CSF diversion relies on rapid elimination through micturition rather than absorption[1,4,5].

The urinary bladder has long been used as an alternative diversion site in the treatment of hydrocephalus. Development of the VU shunt was initially described as a procedure including nephrectomy and was later developed into a ventriculo-pyelo-ureterostomy, a ventriculorenal shunt, where the distal end of the shunt catheter was placed in the pyelocaliceal area[1,6]. Since the initial method of implanting a VU-shunt required removal of a kidney, this method never became widely adopted. Later, open surgical techniques sparing the kidney were described [7]. In the 1980s, Smith et al described a technique of low ureteral transection for distal catheter placement, combined with re-implantation of the ureter, thus avoiding a nephrectomy.[7] The introduction of percutaneous nephrostomy has opened up new possibilities for minimally invasive access to the ureters as a diversion site[8].

Only a few cases of VU shunts have been reported in the literature and several case reports describe adult patients where the size of the ureters is more favourable for this procedure [6,7,9-17]. One of the few long-term follow-ups, described good results in four patients, provided they had a low-pressure urinary bladder without urinary tract infections [16]. This study included a child, two teenagers and a 29-year-old man, both of them having an open surgical approach to the ureter. The study describes a five-year mean survival of the shunt, but all patients eventually needed a re-operation[16]. Complications such as shunt obstruction, infection (with and without associated urinary tract infection), migration or kinking of the tubing and

metabolic complications were described[16]. Many failures have been described to be due to calcification of the distal catheter, which is a known complication of ureteral stenting[9]. There is also the theoretical risk for retrograde reflux of urine into CSF spaces, although this has not been described in any cases[12]. A high-pressure bladder should be ruled out before considering a VU shunt. It also seems that patients with VU shunts might be prone to symptomatic electrolyte imbalance in situations of dehydration or gastroenteritis[3,12]. Other potential long-term problems in addition to calcifications include biofilm formation on the shunt and erosion of the ureteral wall due to the catheter[12,18]. Percutaneous insertion, with similar techniques as the one we used, has previously been described by Pillai et al and Subramanian et al, where two adults with postinfectious and posttraumatic hydrocephalus were successfully treated [8,12]. To the best of our knowledge, this is the first description of the percutaneous insertion of a VU shunt in a child.

Conclusion

We have demonstrated the successful use of a percutaneously inserted VU-shunt in a 4-year-old child. The ureters have a high capacity for distension and can accommodate shunts with a larger diameter than those typically recommended for ureteric stenting in children. VU-shunting can thus provide an alternative for salvage CSF drainage even in relatively small children. A multidisciplinary team consisting of neurosurgeons, urologists and interventional radiologists is essential in evaluating suitable candidates.

Declarations

Funding and disclosures: none

Ethics approval and consent to participate: The parents have consented to the publication of the case and the case description including follow-up is approved by the local ethics board (2018/1873-31).
Consent for publication: The parents have consented to the publication
Availability of data and materials: Not applicable
Competing interests: none
Funding: none
Authors' contributions: Ulrika Sandvik, Jiri Bartek Jr, Erik Edström, Jakob Stenman and Mattias Jönsson conducted the surgery. The manuscript writing was performed by Ulrika Sandvik, and revision, as well as litterature search, were performed by all the authors.
Acknowledgements: none

Abbreviations

CSF (cerebrospinal fluid), VU shunt (ventrikulo-ureteral shunt), VP shunt (ventriuloperitoneal shunt), VCUG (voiding cystourethrography), F (French scale)

References

1. Morosanu CO, Filip GA, Nicolae L, Florian IS. From the heart to the bladder-particularities of ventricular shunt topography and the current status of cerebrospinal fluid diversion sites. *Neurosurg Rev*. Jun 2020;43(3):847-860. doi:10.1007/s10143-018-1033-2
2. Heile B. Anastomosis between ureter and spinal dura to drain congenital hydrocephalus. . *Zbl Chir,* . 1925;52: :2229.
3. Matson DD. A New Operation for the Treatment of Communicating Hydrocephalus: Report of a Case Secondary to Generalized Meningitis. *Journal of Neurosurgery*. 01 Jan. 1949 1949;6(3):238-247. doi:10.3171/jns.1949.6.3.0238
4. Negrete HO, Lavelle JP, Berg J, Lewis SA, Zeidel ML. Permeability properties of the intact mammalian bladder epithelium. *Am J Physiol*. Oct 1996;271(4 Pt 2):F886-94. doi:10.1152/ajprenal.1996.271.4.F886
5. Ames CD, Jane JA, Jr., Jane JA, Sr., Campbell FG, Howards SS. A novel technique for ventriculovesical shunting of congenital hydrocephalus. *J Urol*. Apr 2001;165(4):1169-71.
6. Behrendt H, Nau HE. [Ventriculo-renal shunt in the therapy of hydrocephalus]. *Urologe A*. Nov 1987;26(6):331-3. Ventrikulo-renaler Shunt zur Therapie des Hydrocephalus.
7. Smith JA, Jr., Lee RE, Middleton RG. Ventriculoureteral shunt for hydrocephalus without nephrectomy. *J Urol*. Feb 1980;123(2):224-6. doi:10.1016/s0022-5347(17)55868-1
8. Subramaniam V, Ganapathy S, Paruchuri S. Ventriculo-ureteric shunts, the last resort in complicated shunt patients. *Interdisciplinary Neurosurgery*. 2020/12/01/ 2020;22:100805. doi:https://doi.org/10.1016/j.inat.2020.100805
9. Lescure V, Descazeaud A, Caire F, Salle H. The ventriculo-ureteral shunt: An underused, valuable neurosurgical approach. *Neurochirurgie*. Nov 2021;67(6):640-642. doi:10.1016/j.neuchi.2020.12.007
10. Attai K, Kursh E, Persky L, Nulsen F. Bilateral Ureteroileostomy in Children with Ventriculo-Peritoneal Shunt. *The Journal of Urology*. 1972/09/01/ 1972;108(3):474-476. doi:https://doi.org/10.1016/S0022-5347(17)60778-X
11. Maggi G, Ambrosio A, Profeta G. Value of the ventriculo ureteral shunt after the failure of other shunts for hydrocephalus (case report). *J Neurosurg Sci*. 1974 Jan-Mar 1974;18(1):12-15.
12. Pillai A, Mathew G, Nachimuthu S, Kalavampara SV. Ventriculo-ureteral shunt insertion using percutaneous nephrostomy: a novel minimally invasive option in a patient with chronic hydrocephalus complicated by multiple distal ventriculoperitoneal shunt failures. *Journal of Neurosurgery JNS*. 01 Aug. 2017 2017;127(2):255-259. doi:10.3171/2016.8.Jns16342
13. Pittman T, Steinhardt G, Weberf T. Ventriculo-ureteral shunt without nephrectomy. *British Journal of Neurosurgery*. 1992/01/01 1992;6(3):261-263. doi:10.3109/02688699209002936
14. Sarkar H KA. Ventriculo-ureteric shunt surgery: Thou shalt not be forgotten of me!
15. . *Neurol India* 2013;61:448-50.

16. Hetet J-F, Hamel O, Rigaud J, et al. Ventriculo-ureteric shunt without associated nephrectomy for the treatment of hydrocephalus. *Progres en Urologie: Journal de L'association Francaise D'urologie et de la Societe Francaise D'urologie*. 2004;14(3):390-3; discussion 393.
17. Irby PB, 3rd, Wolf JS, Jr., Schaeffer CS, Stoller ML. Long-term follow-up of ventriculoureteral shunts for treatment of hydrocephalus. *Urology*. Aug 1993;42(2):193-7. doi:10.1016/0090-4295(93)90646-r
18. Ohaegbulam C, Peters C, Goumnerova L. Multiple successful revisions of a ventriculoureteral shunt without nephrectomy for the treatment of hydrocephalus: case report. *Neurosurgery*. 2004;55(4):E1027-E1031.
19. Tunney MM, Keane PF, Jones DS, Gorman SP. Comparative assessment of ureteral stent biomaterial encrustation. *Biomaterials*. Aug 1996;17(15):1541-6. doi:10.1016/0142-9612(96)89780-8

Figures

Figure 1

Ultrasound-guided percutaneous insertion of the distal catheter

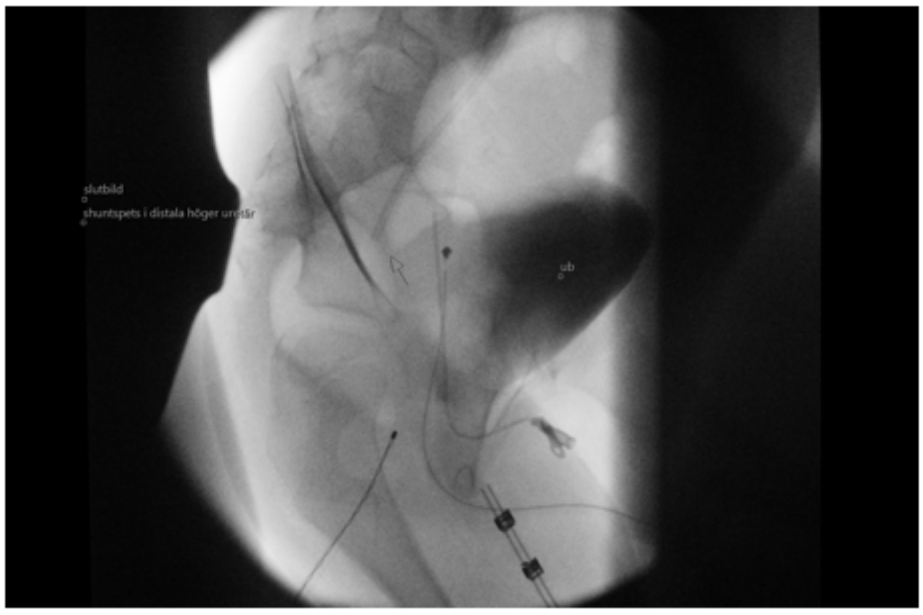

Figure 2

Intraoperative imaging of the distal catheter

Figure 3

Tunneling of the shunt dorsally and connection to the valve.