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Ventriculoperitoneal Shunt Failure Due to Distal Peritoneal Catheter Kinking

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Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Patient: Female, 30-year-old
Final Diagnosis: Shunt vitium
Symptoms: Headache
Medication: —
Clinical Procedure: —
Specialty: Neurosurgery

Objective: Unusual or unexpected effect of treatment

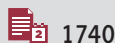
Background: Hydrocephalus is a common condition associated with high morbidity and mortality rates. Despite advancements in shunt systems and valve designs, complications associated with ventriculoperitoneal (VP) shunts are steadily recognized and reported in the literature. Here, we present an unusual case of VP shunt failure due to catheter kinking at the site of the slits in the distal peritoneal catheter.

Case Report: A 30-year-old woman with type I Chiari malformation, prior suboccipital craniectomy, and shunted hydrocephalus with prior revisions presented with 2 months of progressive, low-pressure headaches. Shunt series X-rays demonstrated kinking of the distal peritoneal catheter. A computed tomography (CT) scan showed interval enlargement of her ventricles concerning for shunt failure, which prompted return to the operating room. During shunt revision, her valve was nonfunctioning with loss of resistance and her distal catheter was kinked at the most proximal peritoneal slit. Postoperative shunt series X-rays demonstrated an intact shunt system without kinking or discontinuity and a CT of her head showed interval decrease in the caliber of her ventricles.

Conclusions: Distal peritoneal catheter kinking at the site of slits is an unusual complication of VP shunts and should be considered. Surgeons should add this possibility to the differential diagnosis of shunt malfunction when an imaging irregularity is identified in the peritoneal catheter.

Keywords: Chiari Malformation Type I with Syringomyelia • Hydrocephalus • Ventriculoperitoneal Shunt

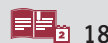
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Background

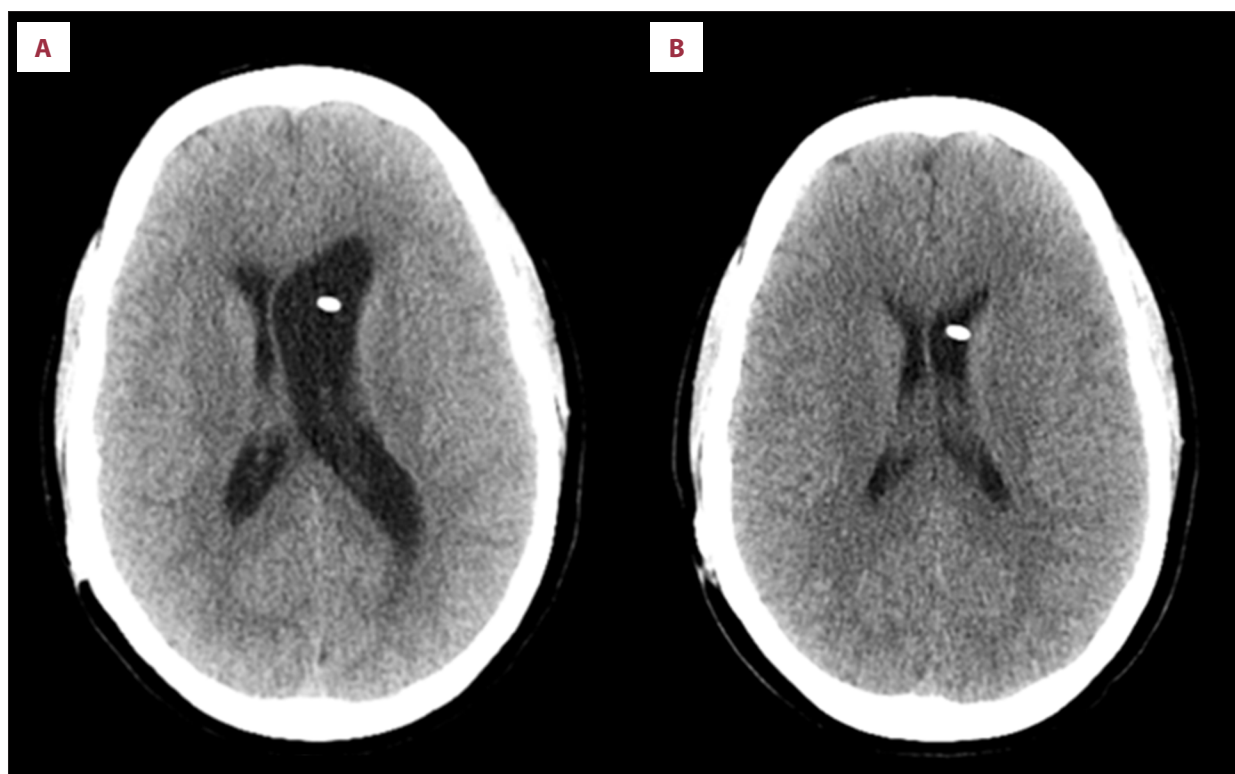
Hydrocephalus results from distortion of the normal cerebrospinal fluid (CSF) dynamics, leading to its accumulation and ventricular dilatation [1]. It is a relatively common condition with a prevalence of 85 per 100 000 people in the United States and an estimated 69 000-related annual hospital discharges [2,3]. The mainstay management of hydrocephalus is shunting with the goal of reducing intracranial pressures by diverting CSF to another compartment, most commonly into the peritoneal space [4]. Other commonly used options include the pleural space and the right atrium. However, despite its high efficacy and low adverse effects profile, CSF shunting imposes a heavy burden on healthcare systems, as up to 80% of patients will require at least 1 revision during their lifetime, with an estimated \$1 billion spent on VP shunt-related procedures annually [5-7].

VP shunting has been utilized for more than 5 decades, and despite major advancements in valve designs and catheters, complications and malfunctions occur relatively often [8]. VP shunts are prone to problems such as infection, migration, occlusion, and pseudocyst formation, leading to shunt failure and hydrocephalus [4,5,8,9]. Here, we report an unusual case of VP shunt failure due to catheter kinking at the site of peritoneal catheter slits.

Case Report

We present the case of a 30-year-old woman with history of type I Chiari malformation, who underwent previous suboccipital craniectomy for decompression, and associated hydrocephalus treated with a Strata II programmable ventriculoperitoneal shunt (Medtronic, Dublin, Ireland) set at 1.0 with multiple prior revisions. She presented to the emergency room with 2 months of progressive headaches, worse in the sitting or standing position, suggestive of a low-pressure headache etiology. Her neurological examination was unremarkable, with no evidence of papilledema. Vital signs and laboratory work-up including complete blood count, erythrocyte sedimentation rate, and C-reactive protein were not concerning for infection.

A computed tomography (CT) scan of the head revealed interval enlargement of her ventricles compared to her most recent scan (Figure 1A, 1B). Together with her symptomatology, there was concern for shunt malfunction. Shunt series X-rays were obtained and demonstrated kinking of the peritoneal catheter (Figure 1C, 1D). Compared to prior shunt series X-rays obtained after her last revision 21 months prior, the kinking was new and suggestive of migration of her peritoneal catheter into a new conformation. In the period between her earlier shunt revision and current presentation, she underwent laparoscopic tubal ligation with necessary insufflation (Figure 1E, 1F).



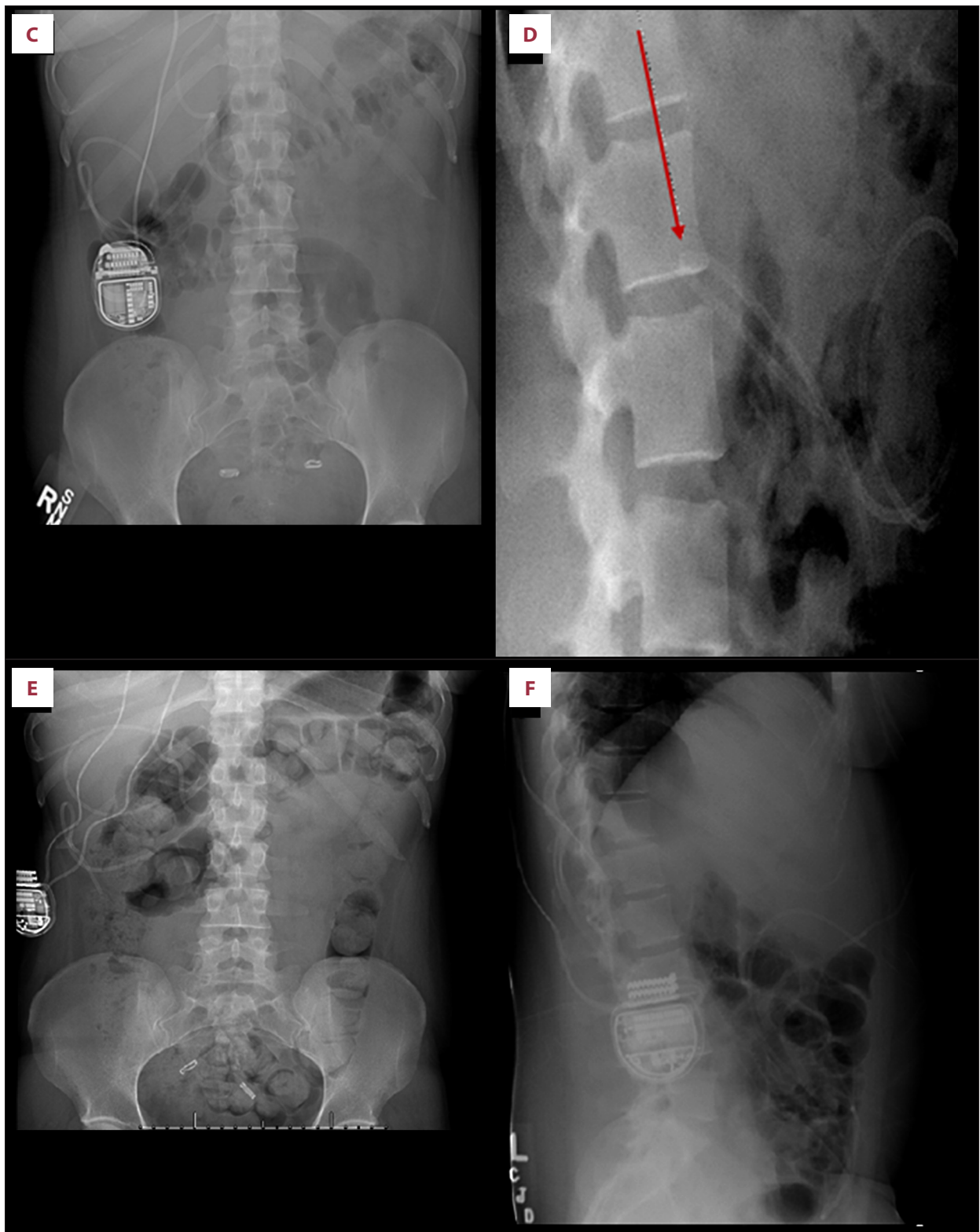


Figure 1. Axial computed tomography (CT) scan depicting enlarged ventricles. (A) compared to prior CT scan (B) concerning for shunt failure. Anteroposterior (C) and lateral (D) shunt series X-rays demonstrating kinking of the distal peritoneal catheter (arrow) compared to postoperative anteroposterior (E) and lateral (F) shunt series X-rays following laparoscopic tubal ligation, without evidence of kinking at that time.

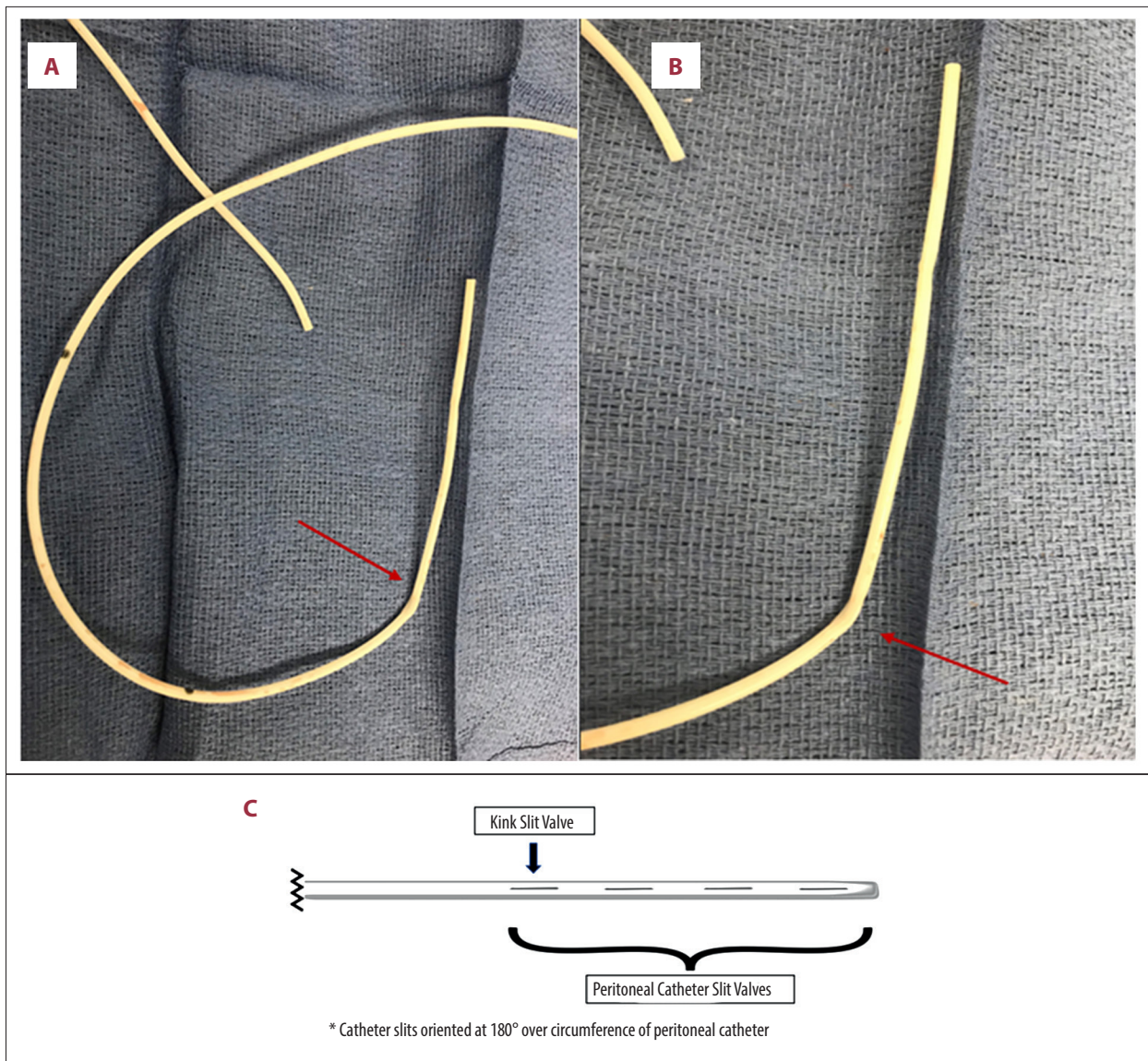


Figure 2. Intraoperative images (A, B) demonstrating kinking of the distal catheter at the site of the distal peritoneal slit valves (arrow). Illustration (C) depicting the location of the catheter kink in relation to the distal peritoneal slit valves.

The patient was taken to the operating room for shunt exploration, interrogation, and revision. Following general anesthesia, the patient's head, neck, chest, and abdomen were prepped and draped in the standard sterile fashion. After opening the right frontal cranial incision, the proximal catheter was explored by exposing the Rickham reservoir (separate from the Strata valve), and disconnecting the proximal catheter from the reservoir, CSF egress with robust flow under high pressure was noted from the proximal catheter confirming proximal patency. CSF was sent for routine laboratory analysis, which did not indicate any evidence of infection. Next, the valve and distal catheter were explored in isolation. Given the presence of an end-to-end connector from a prior revision at the releasing incision posterior to her right ear, the valve and peritoneal

catheter were able to be interrogated in isolation. We exposed the valve and then connected a manometer filled with normal saline. Using this, we interrogated the flow through the valve and found it to be nonfunctional with no resistance to flow and complete emptying of the manometer through the valve. Ordinarily, we would expect resistance (residual saline in the manometer) proportional to the shunt setting. We then turned our attention to the distal peritoneal catheter. Conversely, interrogation of the peritoneal catheter using the manometer revealed high resistance to flow with residual saline in the manometer, concerning for distal partial obstruction. Therefore, a decision was made to replace the whole system except the ventricular catheter. Upon removal of the peritoneal catheter from the abdominal cavity, kinking was noted at the site of the

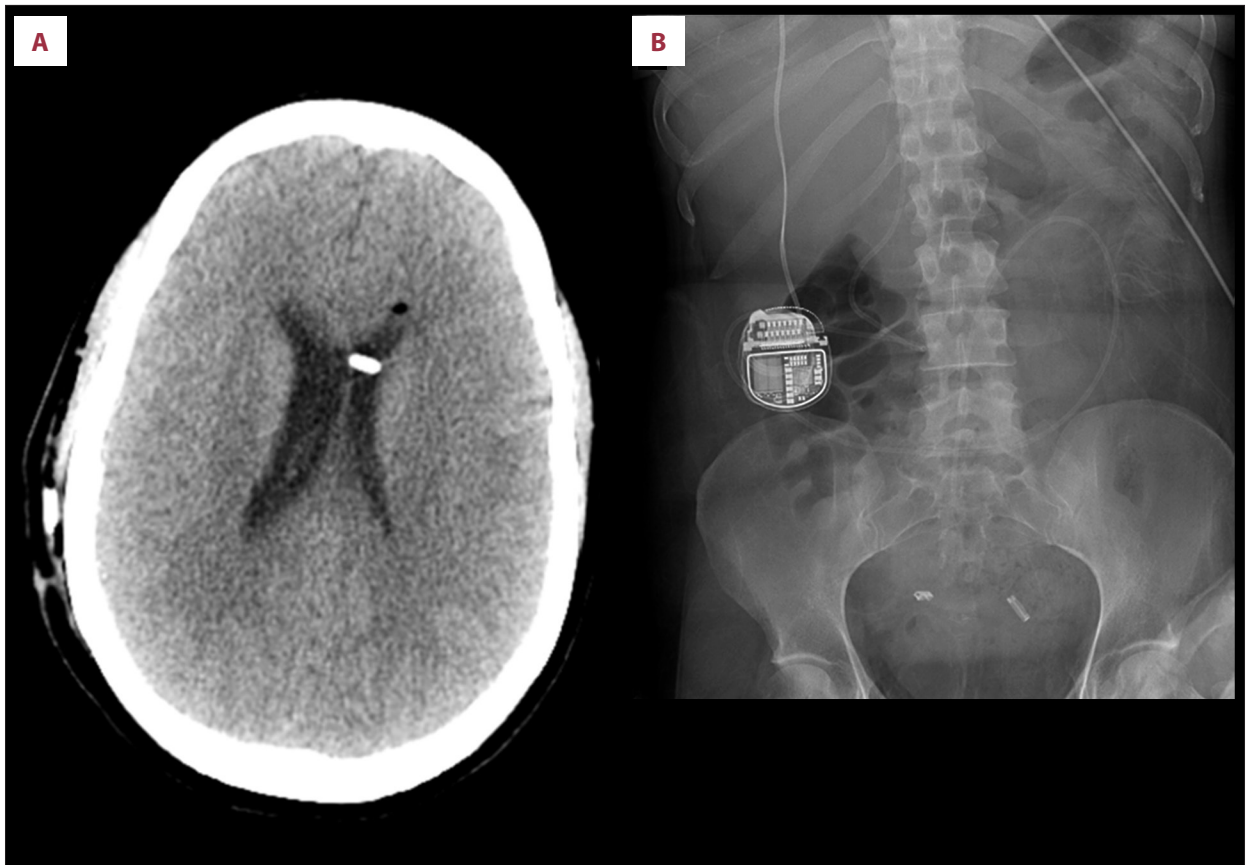


Figure 3. Axial postoperative computed tomography (CT) scan depicting interval decrease in the size of the ventricles (A). Shunt series X-rays demonstrating intact shunt system with no kinking or discontinuity (B).

most proximal draining slit valve (Figure 2A-2C). To confirm that this kinking was the site of obstruction, the distal catheter was again interrogated outside the body and very little flow was seen extruding only from that most proximal peritoneal slit valve, which was the site of kinking. The valve and distal peritoneal catheter were replaced with general surgery assistance and spontaneous flow of CSF was noted distally. The incisions were closed in the standard fashion.

Postoperatively, the patient reported improvement in her headaches. Shunt series X-rays were normal and a CT scan showed interval decrease in the size of her ventricles (Figure 3A, 3B). She was discharged home on postoperative day 1. On her last follow-up appointment, 9 months after surgery, the patient was doing well with complete resolution of her headaches and no other neurological concerns.

Discussion

Hydrocephalus is a common condition resulting from distorted CSF dynamics, and various surgical techniques have been employed, with ventriculoperitoneal shunting being most

common [1,4,9-12]. Herein, we report an unusual case of peritoneal catheter kinking specifically at the site of the most proximal draining slit valve, leading to ventriculoperitoneal shunt malfunction. While catheter malposition of the proximal and/or distal catheter is a reported cause of ventriculoperitoneal shunt failure, kinking at the distal-most end where the slit valves are found is unusual. Thus, kinking of the distal catheter is a rare form of shunt failure.

Low-pressure headaches in the setting of shunt malfunction are not an expected finding. After testing shunt components in isolation, the valve was determined to be malfunctioning and over-draining; conversely, the peritoneal catheter was partially occluded. Together, these features potentially offset each other and likely delayed both radiographic and clinical evidence of shunt malfunction. While the distal catheter kinking in isolation would likely not create low-pressure symptoms, low-pressure headaches may be partially attributed to the nonfunctional valve and lack of antisiphon function. Second, the patient's last revision was approximately 21 months prior, with a postoperative shunt series demonstrating the absence of a catheter kink. However, another laparoscopic surgery in the interim may have led to migration of the catheter and/or kinking,

which may have led to partial obstruction component of the malfunction. However, without interim imaging it is not possible to say this definitively, raising the possibility of spontaneous kinking. The possibility of peritoneal catheter expulsion into the abdominal wall and subsequent kinking following laparoscopic tubal ligation and insufflation cannot be entirely excluded.

Despite advancements in VP shunt systems and valve designs, shunt failure and complications requiring shunt revision are often encountered. The literature demonstrates that 40% of shunted pediatric patients and 29% of shunted adult patients will have shunt failure in the first year after surgery and up to 81% of patients will undergo at least 1 shunt revision in their lifetime [5,6]. VP shunt failure can result from various etiologies, including infection, obstruction, shunt migration, and pseudocyst formation [4,5,8,9]. The possibility of a hardware manufacturing defect contributing to distal catheter kinking remains a possibility in our case, as does migration during a prior laparoscopic surgery. Muzumdar and colleagues [10] reported an interesting case of transient VP shunt malfunction and enlarged ventricles secondary to chronic constipation in a 16-year-old boy with shunt-dependent hydrocephalus. The authors found evidence of distal peritoneal catheter kinking on shunt series X-rays. After performing an aggressive bowel regimen, the patient's symptoms improved, and his ventricular caliber decreased with distal peritoneal catheter kink straightening. However, our patient did not have evidence of constipation and the distal peritoneal catheter kinking was fixed as seen in **Figure 2A-2C**.

Wetzel et al [11] compared the survival and failure trends of shunts with distal slit valves to standard shunt systems among 232 patients with shunted hydrocephalus. Interestingly, they noted a higher rate of distal shunt failure in patients with distal slit valves shunts compared to conventional valve shunts (33.9% vs 13.8%). The authors attributed the increased rate of distal catheter occlusion in the distal slit valves group to omental blockage of the slit valves during valve opening and closure. Additionally, general surgery assistance during VP shunts is important and is routinely employed in our center. Multiple reports in the literature show that general surgery assistance is associated with shorter operative time and costs, and lower failure rates [13,14].

Cozzens et al [15] analyzed their 11-year records of shunt malfunction and found that 12.1% of shunt malfunctions were related to distal shunt obstruction. Contrary to the common causes of distal shunt obstruction (eg, catheter malposition,

catheter disconnections, catheter migration, and pseudocyst formation), the authors reported that 77.5% of their distal shunt occlusion were related to distal slit catheter occlusion with debris or omentum. The authors concluded that the presence of side slits in the distal peritoneal catheters is associated with a higher incidence of distal shunt obstruction and malfunction. Similarly, Del Bigio and colleagues [16] found that graphite coating of distal catheter slits to prevent adhesion increases inflammation and incidence of distal catheter obstruction among 30 explored cases (22 patients and 8 autopsies) and recommended against its use. Our report and the above-described ones raise the question of the risk/benefit balance of distal catheter slits. However, interestingly, none of the above-mentioned literature identified specific kinking of the distal slits. The findings from this case suggest that kinking of the distal slits should also be considered during evaluation of distal slit valve shunts for failure. Other design improvements may result from not having the catheter slits 1800 from each other, which increases the likelihood of such kinks. If slits are to be part of the design, a different configuration may reduce the likelihood of obstructive kinking.

Shunt failure is associated with increased morbidity and mortality rates due to resulting hydrocephalus [17,18]. Thus, early and timely recognition and intervention is essential to prevent undesirable sequelae. We report this case for neurosurgeons to add this unusual possibility to the differential diagnosis of shunt malfunction.

Conclusions

VP shunt failure due to distal peritoneal catheter kinking at the site of slits is an unusual complication that should be considered. Surgeons should add this possibility to the differential diagnosis of shunt malfunction when an imaging irregularity is identified in the peritoneal catheter.

Department and Institution Where Work Was Done

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Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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