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Intracranial Perishunt Catheter Fluid Collections with Edema, a Sign of Shunt Malfunction: Correlation of CT/MRI and Nuclear Medicine Findings

H.A. Kale, A. Muthukrishnan, S.V. Hegde, and V. Agarwal

ABSTRACT

SUMMARY: Fluid collections with edema along the intracranial tract of ventriculoperitoneal shunt catheters in adults are rare and are more frequently seen in children. The imaging appearance of these fluid collections is frequently confusing and presents a diagnostic dilemma. We present 6 cases of adult patients noted to have collections with edema along the tract of ventriculoperitoneal shunt catheters. To our knowledge, there are no previous studies correlating the CT/MR imaging findings with nuclear medicine scans in this entity. We hypothesized that when seen in adults, the imaging findings of a CSF-like fluid collection around the intracranial ventriculoperitoneal shunt catheter on CT/MR imaging may suggest areas of CSF accumulation with interstitial edema. It is important to recognize this rare ventriculoperitoneal shunt complication in adults to prevent misdiagnosis of an abscess or cystic tumor.

ABBREVIATIONS: NM = nuclear medicine; VP = ventriculoperitoneal

Ventriculoperitoneal (VP) shunt catheters are placed for drainage of CSF for a wide variety of etiologies, such as hydrocephalus and idiopathic intracranial hypertension (pseudotumor cerebri). Fluid collections along the tract of an intracranial VP shunt catheter with edema are rarely seen in adults¹⁻⁵ and more frequently seen in children.⁶⁻¹⁰ VP shunt catheters may be complicated by blockage, kinking, or fracture of the catheter; overdrainage; infection; and malposition. Some of these complications can be treated by merely changing the shunt settings. In other situations, the catheters may have to be removed and replaced either along the same tract or at a new site.^{11,12} Shunt malfunction is a serious complication, and the most frequent reason for shunt revision. The rate of shunt failure after 1 year has been reported to be up to 30%, with 50% of shunts requiring some form of revision within 6 years of placement.^{13,14} The basic components of a CSF shunt include a proximal catheter, reservoir, valve, and distal catheter.^{1,11} In adults, distal catheter obstruction is more common. In children, proximal cath-

eter obstruction is more frequent and commonly occurs early after an operation.

Initial evaluation of shunt malfunction is with a shunt series and CT or MR imaging of the head and, if necessary, the abdomen/pelvis. Typically, VP shunt catheter malfunction results in inadequate drainage of CSF and is seen on imaging as an increase in ventricular size. VP shunt nuclear scintigraphy is usually performed to evaluate the patency and function of a VP shunt system. The patient is typically placed in a supine position, and the patient's scalp overlying the shunt reservoir/valve is prepared with iodine and draped. The neurosurgeon then injects a small volume, about 0.5 mL, of the radiotracer into the shunt reservoir/valve while manually applying pressure to the valve on the overlying skin to demonstrate reflux of tracer activity into the ventricles. Indium-111 disodium pentetate (¹¹¹In] DTPA) is the preferred radioactive tracer of choice, though technetium Tc99m DTPA has also been used in some institutions. Sequential spot planar imaging of the head, neck, chest, and abdomen is acquired in multiple projections with a gamma camera. The radiotracer flow through the proximal and distal portion of the catheter tubing is imaged immediately after injection and at 15-minute intervals.

When there is absent or substantially delayed tracer migration from the ventricular system into the abdomen, a diagnosis of shunt malfunction should be inferred. Pericatheter cyst with edema around VP shunt catheters are rare in adults. In our review of the literature, there were only 5 case reports in adults with pericatheter cyst and edema associated with VP shunt catheters. The purpose of our study was to illustrate the benefit of combin-

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ing the utility of anatomic CT/MR imaging with functional nuclear medicine (NM) information in arriving at a correct diagnosis of shunt malfunction.

Case Series

The institutional Radiology Information System and PACS were used to retrospectively identify patients who presented with perishunt catheter collections on either CT or MR imaging who subsequently underwent evaluation with [¹¹¹In] DTPA examinations. Patients who had pericatheter hemor-

rhage on immediate postoperative examinations were excluded. Likewise, patients who did not have NM examinations were also excluded. The study was fully Health Insurance Portability and Accountability Act–compliant and was approved by the local institutional review board. We retrospectively evaluated the CT/MR imaging and [¹¹¹In] DTPA NM findings in 6 patients with peri-VP shunt catheter collections who presented to our institution through a search of our Radiology Information System and PACS.

In our group of patients, all 6 had an abnormal NM findings with delayed or absent detection of tracer in the proximal or proximal and distal limbs of the VP shunt catheter. Of these patients, 5 were treated surgically with shunt removal and replacement. The sixth patient was initially clinically stable and subsequently lost to follow-up. There was a near-complete resolution of the cyst after shunt replacement in all operated patients (Table).

Patient demographics

Total No. of patients	6
Age range (yr); sex (M:F)	24–46; 4:2
Indication for shunt placement (No.)	
Pseudotumor cerebri	4
Chiari I malformation	1
Postoperative pseudomeningocele	1
Presenting symptoms prior to shunt replacement (No.)	
Headache	5
Abdominal pain	1
Time to development of cyst after surgery	16 days to 5 years
Site of shunt catheter obstruction (No.)	
Proximal	3
Proximal and distal	3

Case 1. A 38-year-old woman with pseudotumor cerebri presented with new onset of headaches after placement of a VP shunt catheter. The duration between her initial catheter placement and clinical presentation was 12 months. CT performed at presentation showed edema and a fluid collection along the tract of the right-frontal-approach catheter (Fig 1A). An NM study showed no evidence of distal VP shunt obstruction with free tracer transit

into the peritoneal cavity (Fig 1B, -C).

However, there was focal accumulation of tracer activity on both early and delayed images in the right frontal fluid collection seen on the most recent head CT, suggesting an area of CSF accumulation. The patient was clinically stable with some improvement in symptoms. No shunt revision was performed. The patient was subsequently lost to follow-up.

Case 2. A 43-year-old man status post subependymoma resection with a postoperative pseudomeningocele treated with VP shunt placement presented with posterior headaches. The duration between catheter placement and presentation was 45 months. CT and MR imaging showed a right frontal fluid collection along the shunt catheter tract (Fig 2A). An NM study showed no evidence of radiotracer transit through the shunt tubing into the peritoneal cavity, suggesting a distal obstruction (Fig 2B). Also, focal tracer intracranial activity was noted corresponding to the area of the right frontal hypoattenuation seen on the head CT, suggesting a proximal obstruction. The patient subsequently underwent shunt revision. Immediate follow-up CT showed a decreased size of the collection and resolution of the cyst at 1 year.

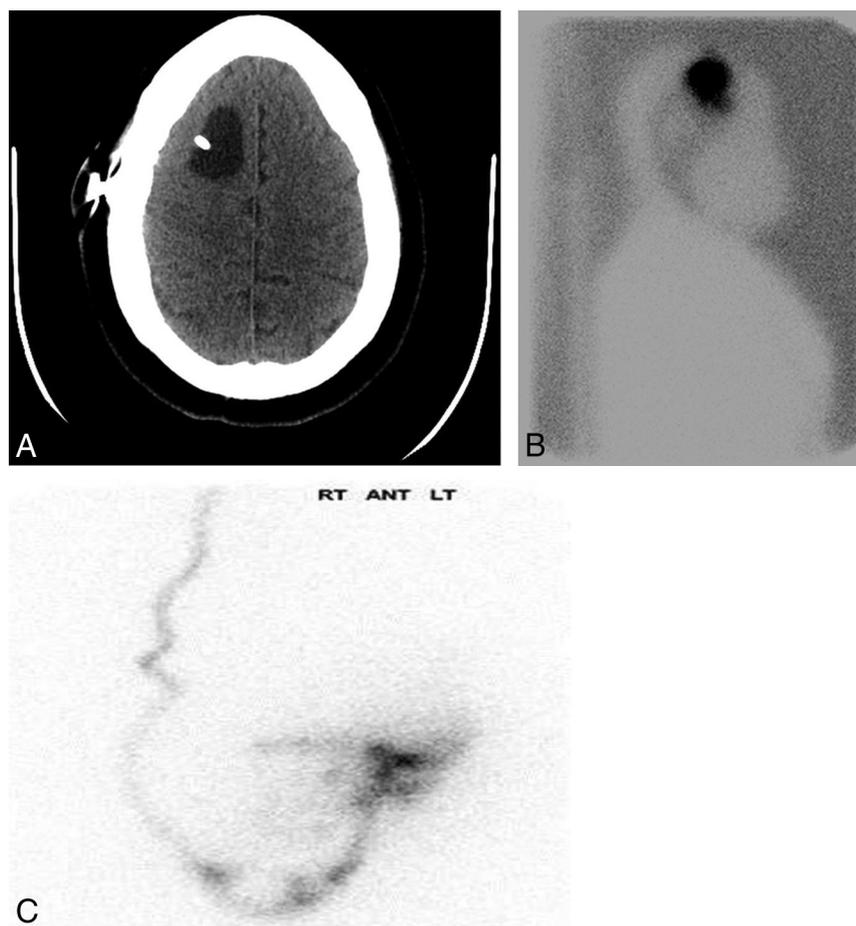


FIG 1. A, CT shows a fluid collection in the right frontal lobe along the tract of a VP shunt with surrounding edema. B, NM scan shows a focal accumulation of tracer in a right frontal cyst. C, NM scan shows normal transit of the radiotracer to the peritoneum.

Case 3. A 24-year-old woman with a history of pseudotumor cerebri was treated with VP shunt placement. She initially presented with abdominal pain and increased abdominal fluid. The interval between catheter placement and presentation was 60 months. CT of the head showed a fluid collection and edema along the right frontal shunt tract (Fig 3A). An NM study showed delayed passage of tracer distally into the peritoneum (Fig 3B). There was focal tracer accumulation within the right frontal region (Fig 3C), corresponding to the focal fluid collection on CT, suggesting an area of CSF accumulation. After initial conservative management, the shunt was ultimately revised.

Case 4. A 43-year-old woman with a history of Chiari I malformation with hydrocephalus treated with VP shunt placement presented with headaches. The duration between shunt placement and presentation was 3 months. CT and MR imaging showed fluid collection/edema along the left frontal shunt tract. An NM study showed free spillage of tracer into the peritoneal cavity; however, there was focal tracer retention within the left frontal region corresponding to the fluid collection on the CT of the head. The VP shunt catheter was subsequently revised.

Case 5. A 46-year-old woman with a history of pseudotumor cerebri had a shunt placed. Sixteen days after shunt placement, she presented with headaches. CT and MR imaging showed fluid collection/edema along the shunt tract. An NM study showed distal obstruction of the shunt with no evidence of tracer transit into the distal portions of the VP shunt tubing or peritoneum. In addition, there was focal intracranial accumulation of the tracer, with the right frontal region corresponding to the right frontal

fluid collection seen on the head CT, suggesting proximal obstruction. The VP shunt catheter was subsequently revised.

Case 6. A 36-year-old man with a history of pseudotumor cerebri had a shunt placed. Fifteen months after shunt placement, he presented with headaches, tinnitus, and blurred vision. CT and MR imaging showed fluid collection/edema along the shunt tract. An NM study showed no evidence of intracranial tracer movement through the distal portions of the shunt tubing into the peritoneum, consistent with a distal obstruction. Substantial tracer collection at the shunt reservoir, the site of the tracer administration, was also noted. On more delayed images, a small area of intracranial focal activity corresponded to the right frontal fluid collection seen on the head CT, suggesting additional proximal obstruction. The VP shunt catheter was subsequently revised.

DISCUSSION

Our study of peri-VP shunt catheter fluid collections showed a CSF-like attenuation/signal within the collections with extensive surrounding edema on both CT and MR imaging without substantial ventricular dilation. On subsequent nuclear medicine studies, there was shunt obstruction noted in all the VP shunt catheters. These findings are important because the presence of a cystic mass with surrounding edema may lead to an incorrect suspicion of an abscess or cystic tumor.

Bianchi et al¹ reported a case of pericatheter cyst mimicking a cystic tumor. In their report, the patient had a VP shunt catheter placed for hydrocephalus associated with a myelomeningocele. The patient presented with a motor deficit. At the operation, discontinuity of the intraventricular portion of the catheter to the rest of the shunt was found. Amans and Dillon² reported a pericatheter cyst around a VP shunt catheter placed for communicating hydrocephalus. In the case reported by Vajramani and Fugleholm,³ the VP shunt catheter was placed for recurrent meningioma with symptomatic hydrocephalus.

Bianchi et al¹ and Amans and Dillon² demonstrated a proximally obstructed malfunctioning VP shunt catheter. Vajramani and Fugleholm³ hypothesized radiation-induced changes responsible for the cyst development rather than shunt malfunction.

In our series, the age range was 24–46 years. The collections were seen at an interval of 16 days to 60 months from the time of VP shunt catheter placement. All patients had postoperative CT or MR imaging, which did not reveal a collection. The patients

included 4 men and 2 women. All patients in our series demonstrated a fluid collection along the tract of the VP shunt catheter with surrounding edema on CT. There was proximal shunt obstruction in 4 patients and proximal and distal obstruction in 2 patients. The indication for shunt placement was a pseudotumor in 4 patients and Chiari malformation and postoperative pseudomeningocele in 1 each. The indication for repeat imaging was headache in 5 patients and abdominal pain in 1 patient. The shunt was replaced in 5 patients, and 1 patient was followed conserva-

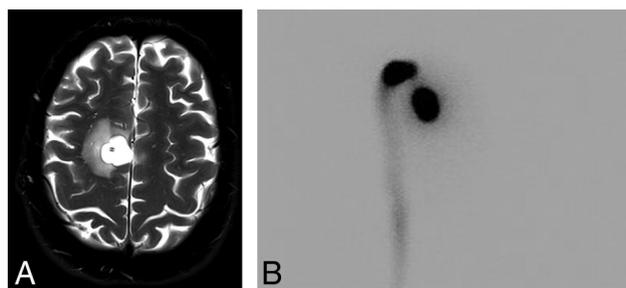


FIG 2. A, MR imaging shows a cyst in the right frontal region. B, NM scan shows focal accumulation of the tracer in a right frontal cyst.

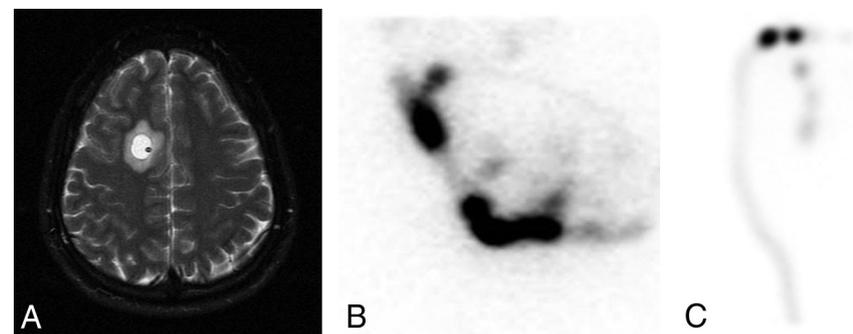


FIG 3. A, MR imaging shows a cyst in the right frontal region with surrounding edema. B, NM scan shows delayed passage of radiotracer to the peritoneum. C, NM scan shows focal accumulation of the tracer in a right frontal cyst.

tively because this patient was subsequently asymptomatic. The time between the cyst being reported and shunt revision was <1 month in 3 patients and >1 year in 2 patients. The ventricular size was nondilated in 5 patients and mildly dilated in 1 patient. In our series, one of the patients is asymptomatic and continues to show persistence of the collection and surrounding edema on a follow-up examination. We believe this finding may represent early partial or complete obstruction of the catheter, which, if followed, will ultimately result in shunt failure.

Four of the 6 patients had VP shunt catheters placed for refractory increased intracranial pressure (pseudotumor). VP shunt catheter placement is an established surgical treatment for refractory increased intracranial pressure.^{15,16} Previously, its use was thought to be increasing.¹⁷

VP shunt catheters are the main treatment option available for hydrocephalus due to various causes. Shunt malfunction is a serious problem. The initial diagnostic evaluation for VP shunt malfunction is CT or MR imaging and a plain film evaluation for shunt integrity. The typical CT/MR imaging findings in shunt malfunction include hydrocephalus, fracture, migration, and overdrainage with slit-like ventricles and extra-axial fluid collections. Pericatheter cyst and edema around VP shunt catheters are rare, with a few case reports mostly described in children.

Most of the patent well-functioning VP shunt systems demonstrate good ventricular reflux of the tracer activity. Also, the entire portion of the shunt system will be visualized with uninterrupted passage of the tracer into the distal portions of the shunt tubing, with free spilling of the tracer into the peritoneal cavity (the pleural cavity in case of a ventriculopleural shunt) within the first 15 minutes of the injection of the radiotracer. Delayed or no clearance of the radioactivity through the distal portions of the shunt tubing, in general, is useful in confirming and localizing distal obstruction. However, in case of proximal obstruction of the ventricular portion of the tubing, the absence of ventricular reflux is considered a more reliable imaging finding.

Collections with edema around VP shunt catheters are uncommon in adults. Although these findings may be confused with infection or tumor, shunt malfunction should be considered. The exact etiology of pericatheter collections is unclear. Findings may represent accumulation of CSF in the brain parenchyma as a result of differential pressure between the intraventricular CSF and brain parenchyma. This finding would explain the higher incidence in children, with the softer more pliable pediatric brains being more amenable to yielding to pressure. This would also explain the relatively younger adult patients in our series (24–46 years). Edema around the VP shunt tract is probably a precursor or an associated finding. Other proposed mechanisms have been CSF leak into the pericatheter space/fibrous tunnel, slit ventricle syndrome, and subependymal dislocation of holes of the catheter.¹

In the series of cases presented here, all patients demonstrated absence of radiotracer reflux into the ventricles. Also, there was focal accumulation of radiotracer corresponding to the loculated fluid collection as seen on head CT or MR images. Some patients also had good passage of the radiotracer through the distal portions of the tubing, which should not be mistaken for a well-functioning shunt system, especially in the absence of ventricular reflux and the presence of an intracranial loculated collection of radiotracer activity.

Combining the benefits of the anatomic imaging (CT/MR imaging) and functional information (NM study) can help make the diagnosis of shunt malfunction, especially related to proximal obstruction; however, management remains controversial.

A limitation of this case series is the low number of cases; however, given the relative frequency with which VP shunt catheters are placed, though rare, this entity is probably underdiagnosed.

CONCLUSIONS

Pericatheter fluid collection with edema along the tract of the VP shunt catheter is an uncommon finding in adults. When present on CT and/or MR imaging, the findings should raise concern for catheter malfunction and prompt further NM evaluation.

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