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Endovascular retrieval of a broken distal ventriculoatrial shunt catheter within the heart: illustrative case

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BACKGROUND Displacement of a distal catheter of a ventriculoatrial (VA) shunt is a rare complication and can lead to a challenging extraction requiring endovascular retrieval of the distal catheter.

OBSERVATIONS The authors describe a patient in whom the distal catheter of the VA shunt had become displaced and traveled through the tricuspid valve into the right ventricular outflow tract.

LESSONS In this case report, the authors present a multidisciplinary approach to retrieving a displaced distal catheter from a VA shunt.

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KEYWORDS ventriculoatrial; shunt; endovascular retrieval

Although the majority of cerebrospinal fluid (CSF) shunts are ventriculoperitoneal (VP) shunts, ventriculoatrial (VA) shunts are often a second-line option when the peritoneum is unsuitable for shunt placement.[1,2] To optimize performance, VA shunt catheters should be positioned with the distal tip in the middle of the right atrium.[3]

In cases of failure or infection, shunt systems on occasion necessitate externalization. Distal breakage of VA shunt catheters is rare. We report a case of distal VA shunt malfunction in which the distal catheter broke and migrated farther into the right heart. This posed a unique treatment challenge.

Illustrative Case

The patient was a 12-year-old female who had been born prematurely at 25 weeks of gestation and who had a history of developmental delay and spasticity from grade 3 intraventricular hemorrhage and subsequent acquired hydrocephalus. She had a VP shunt placed shortly after birth with over 20 revisions during her lifetime, most recently in spring 2019, when her VP shunt was converted to a VA shunt. She presented on the day of admission with a 1-week history of poor feeding and fatigue.

Computed tomography showed slightly enlarged ventricular size, and the shunt series radiography revealed a disconnected distal atrial catheter (Fig. 1). Radiography of the skull showed complete detachment of the distal catheter at the distal end of the valve (Fig. 2). A transthoracic echocardiogram revealed that part of the embolized catheter had penetrated through the tricuspid valve toward the right ventricular outflow tract, with the distal tip just proximal to the pulmonary valve. Given the long length of the embolized catheter, risks of interference with tricuspid valve function, additional nidus for infection, source of dysrhythmia, and potential for further migration with obstruction to pulmonary blood flow, the decision was made to remove the catheter before shunt revision. Treatment options were discussed, including open cardiac surgery and interventional methods to retrieve the broken catheter. Members of the interventional cardiology team were consulted for attempted endovascular retrieval of the migrated distal catheter.

Endovascular Retrieval

The patient was brought to the cardiac catheterization laboratory and placed under general anesthesia. Using a modified Seldinger technique and ultrasound guidance, a 12-French, 55-cm-long Flexor Raabe sheath (Cook Medical) was inserted into the right femoral

ABBREVIATIONS CSF = cerebrospinal fluid; VA = ventriculoatrial; VP = ventriculoperitoneal.

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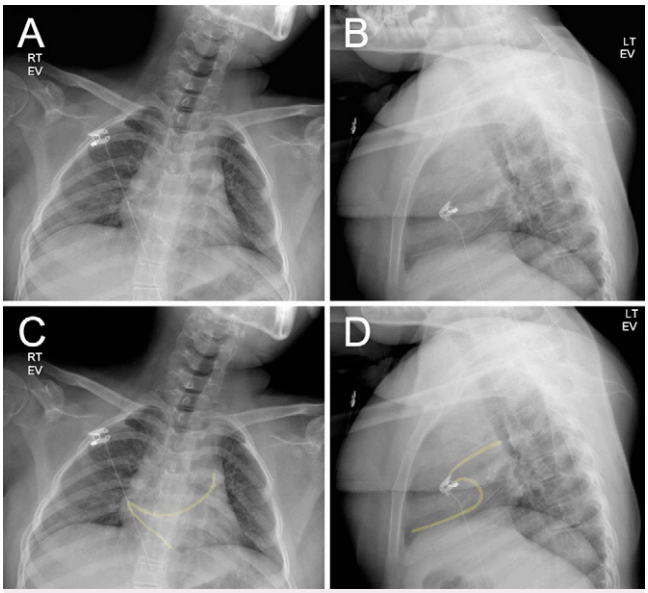

FIG. 1. Anteroposterior (**A**) and lateral (**B**) shunt series radiographs revealing the distal catheter within the heart. The catheter is highlighted in the same anteroposterior (**C**) and lateral (**D**) radiographs.

vein. Through the sheath, Amplatz Goose Neck (Medtronic) and EN Snare (Merit Medical) snare catheters were used in an attempt to snare the VA shunt catheter in the right atrium and right ventricle. However, this effort was unsuccessful due to the large radius of curvature of the catheter within the right atrium. Attempts to capture the catheter within the body of the right ventricle were not considered due to the high risk of entrapment of tricuspid valve chordae, which would result in leaflet avulsion and subsequent regurgitation. Therefore, an Arrow wedge catheter (Teleflex) with a small inflated balloon at the tip was used to hook the midportion of the embolized catheter and drag it into the inferior vena cava. The catheter end was then captured with a 15-mm Amplatz Goose Neck snare, transferred through the long sheath, and removed from the body (Figs. 2 and 3). A Perclose ProGlide (Abbott Medical) device was used to achieve hemostasis after the 12-French sheath was removed.

Surgery

After removal of the distal catheter from the heart, the patient was taken immediately to the operating room for distal VA shunt revision. An incision was made above the right occipital valve. A small portion of the distal catheter was noted to be attached at the distal end of the valve, with a securing suture still in place. The distal end of this retained catheter was broken just beyond the plastic outlet connector of the valve. CSF was flowing freely and briskly from the distal end of the valve. The remaining broken catheter was removed. With the assistance of the general surgery team, a new distal atrial catheter was placed under fluoroscopic guidance. Contrast dye was injected through the distal catheter to confirm placement within the middle portion of the right atrium.

Discussion

Observations

CSF shunts are commonly used by a neurosurgical team to provide lifesaving treatment for hydrocephalus. Despite being in use for many decades, shunts are still prone to failure, with reported rates of failure within 2 years of placement as high as 50% in pediatric patients.[4]

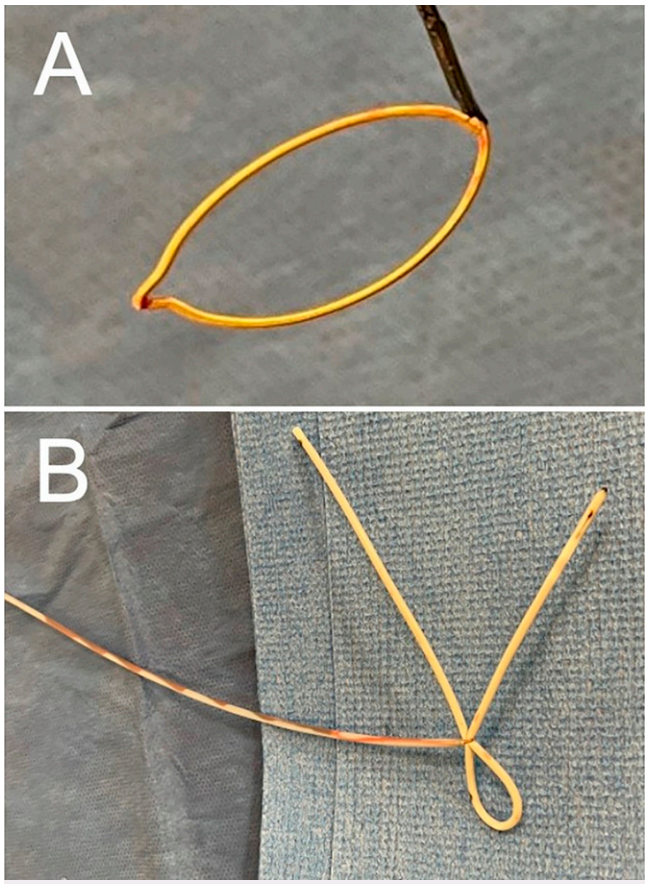

FIG. 2. A: Amplatz Goose Neck 15-mm snare used to retrieve the broken catheter. **B:** Retrieved distal catheter within the snare.

Common reasons for shunt failure include obstruction, infection, mechanical shunt failure, and overdrainage. Although most CSF shunts are VP shunts, VA shunts are often a second-line option when the peritoneum is unsuitable for shunt placement.[1,2] If elective lengthening procedures are not considered failures, the rate of failure for VA shunts is similar to that of VP shunts.[2] VA shunts require placement of the distal catheter into the intravascular space, which carries a unique set of risks. Deep positioning of the catheter has a risk of causing arrhythmias or thrombus formation that may lead to shunt obstruction or embolization into the pulmonary artery.[5,6] The distal catheter is ideally positioned in the middle portion of the right atrium. As children grow taller, the distal catheter naturally gets pulled out of the right atrium, and 66% of patients may require repositioning with normal growth.[7] Somatic growth can also lead to tension on the catheters, and breaks can occur in areas of greater mobility such as the neck.[8] In the present case report, a VA shunt had broken 1 year after the most recent revision.

Intravascular foreign bodies can cause serious complications, and retrieval should be attempted when safely possible. Although patients may be asymptomatic at first, there are serious adverse events associated with unretrieved foreign bodies.[9] Embolization of a distal VA shunt catheter can result in migration of the catheter within the right atrium, right ventricle, or, rarely, the pulmonary arteries, where obstruction can result in death.[3,10] In managing a detached shunt catheter, there are main two considerations: (1) The shunt must be reestablished if the patient is shunt dependent due to hydrocephalus, and (2) the detached catheter should

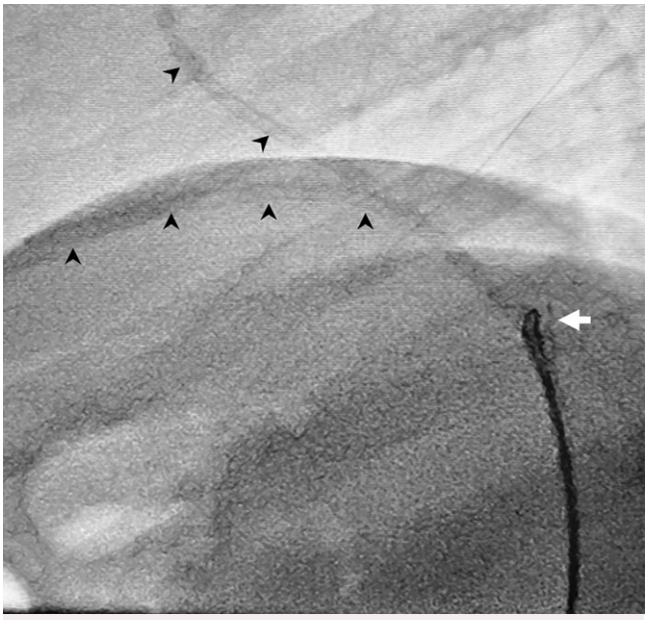

FIG. 3. Anterior-posterior radiographic view of the chest with the distal catheter (*black arrowheads*) captured by the snare (*white arrow*).

be retrieved if possible to prevent further embolism, thrombus formation, or arrhythmia.[10] In rare cases, a foreign body may adhere to the myocardium, and the risks of retrieval may be greater than those associated with leaving the catheter in place.

Lessons

Foreign body retrieval poses unique challenges and risks, including the possibility of vascular injury or further migration of the foreign body. A multidisciplinary team should be recruited because endovascular cases may need to be converted to open procedures. Retrieval of a distal VA shunt catheter can be performed using open thoracotomy, which is highly invasive, or using a transvenous endovascular approach. Endovascular retrieval of VA shunt catheters in the heart was reported as early as the 1970s.[11–14] Various tools and techniques are available for retrieval, including loop-snare devices, forceps, hooked catheters, and balloon catheters.[15] Most case reports describe use of a snare, which can be introduced through the internal jugular or femoral vein.[3,13,16] Endovascular techniques have also been used to reposition distal VA shunt catheters that are in suboptimal positions.[17,18] In this patient, a broken distal shunt catheter was safely removed using an endovascular technique before proceeding to surgery for replacement of the distal catheter. Although distal shunt catheter breakage in the heart is a rare clinical situation, we present a multidisciplinary treatment approach that should be considered in this type of scenario.

Conclusions

Distal VA catheter detachment is a rare complication of VA shunts. An embolized catheter within the right heart has a risk of further complications and should be removed if safely possible. Endovascular retrieval of a broken shunt catheter in the heart via snare is an effective treatment option.

References

1. Aschoff A, Kremer P, Hashemi B, Kunze S. The scientific history of hydrocephalus and its treatment. *Neurosurg Rev.* 1999;22(2-3):67–95.
2. Rymarczuk GN, Keating RF, Coughlin DJ, et al. A comparison of ventriculoperitoneal and ventriculoatrial shunts in a population of 544 consecutive pediatric patients. *Neurosurgery.* 2020;87(1):80–85.
3. James CA, McFarland DR, Wormuth CJ, Teo CM. Snare retrieval of migrated ventriculoatrial shunt. *Pediatr Radiol.* 1997;27(4):330–332.
4. Hanak BW, Bonow RH, Harris CA, Browd SR. Cerebrospinal fluid shunting complications in children. *Pediatr Neurosurg.* 2017; 52(6):381–400.
5. Ladouceur D, Giroux M. Echocardiographic detection of intracardiac thrombi complicating ventriculo-atrial shunt. Report of two cases. *Pediatr Neurosurg.* 1994;20(1):68–72.
6. Natarajan A, Mazhar S. Right heart complications of ventriculoatrial shunt. *Eur Heart J.* 2011;32(17):2134.
7. Vernet O, Campiche R, de Tribolet N. Long-term results after ventriculoatrial shunting in children. *Childs Nerv Syst.* 1993;9(5):253–255.
8. Goeser CD, McLeary MS, Young LW. Diagnostic imaging of ventriculoperitoneal shunt malfunctions and complications. *Radiographics.* 1998;18(3):635–651.
9. Carroll MI, Ahanchi SS, Kim JH, Panneton JM. Endovascular foreign body retrieval. *J Vasc Surg.* 2013;57(2):459–463.
10. Mori T, Arisawa M, Fukuoka M, Tamura K, Kurisaka M, Mori K. Management of a broken atrial catheter migrated into the heart: a rare complication of ventriculoatrial shunt – case report. *Neurol Med Chir (Tokyo).* 1993;33(10):713–715.
11. Akune J, Oda H, Kitamura T, Suzuki M, Hoshino M. Successful treatment of a foreign body in the heart (a migrating catheter) in ventriculo-atrial shunt. Article in Japanese. *Kyobu Geka.* 1972;25(2):132–137.
12. Gopal VV, Peethambaran AK. Rare sequelae following ventriculoatrial shunt: case report and review of literature. *Asian J Neurosurg.* 2016;11(2):173.
13. Magrassi L, Mezzini G, Moramarco LP, et al. Minimally invasive procedure for removal of infected ventriculoatrial shunts. *Acta Neurochir (Wien).* 2021;163(2):455–462.
14. Tatsumi T, Howland WJ. Retrieval of a ventriculoatrial shunt catheter from the heart by a venous catheterization technique. Technical note. *J Neurosurg.* 1970;32(5):593–596.
15. Koseoglu K, Parildar M, Oran I, Memis A. Retrieval of intravascular foreign bodies with goose neck snare. *Eur J Radiol.* 2004;49(3): 281–285.
16. Thirkateh P, Riaz A, Tate MC, Stein S, Resnick SA. Combined cut down and endovascular retrieval of orphaned ventriculoatrial shunt with stenting of chronic superior vena cava occlusion. *Pediatr Radiol.* 2021;51(8):1531–1534.
17. Rao AJ, Teton Z, Rodriguez V, Tieu BH, Raslan AM. Distal ventriculoatrial shunt revision in adult myelomeningocele patient performed via endovascular transvenous approach. *World Neurosurg.* 2019;121:24–27.
18. Xu B, Chotai S, Yang K, et al. Endovascular intervention for repositioning the distal catheter of ventriculo-atrial shunt. *Neurointervention.* 2012;7(2):109–112.

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Magge, Xu. Acquisition of data: Magge, Xu. Analysis and interpretation of data: Magge, Xu. Drafting the article: Magge, Xu, Morchi. Critically revising the article: all authors. Reviewed submitted version of manuscript: Magge, Xu, Morchi. Approved the final

version of the manuscript on behalf of all authors: Magge. Statistical analysis: Magge, Xu. Administrative/technical/material support: Xu. Study supervision: Magge, Xu.

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