Flow diversion of a recurrent, iatrogenic basilar tip aneurysm in a pediatric patient: case report

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Endoscopic third ventriculostomy (ETV) is a common treatment for noncommunicating hydrocephalus. Although rare, vascular injury and traumatic pseudoaneurysm development during ETV have been reported. The authors present the case of a 13-year-old boy who underwent repeat ETV (rETV) for shunt and ETV failure, and who suffered an intraoperative subarachnoid hemorrhage due to iatrogenic injury to the basilar tip, with subsequent development of a pseudoaneurysm. Despite initial primary coil embolization, the aneurysm recurred and was definitively treated with flow diversion. In this report, the authors review complication rates associated with ETV and rETV as well as the emerging use of flow diversion and its applications in vessel reconstruction within the pediatric population.

<https://thejns.org/doi/abs/10.3171/2017.7.PEDS17235>

KEY WORDS endoscopic third ventriculostomy; basilar tip pseudoaneurysm; vascular disorders; hydrocephalus

ENDOSCOPIC third ventriculostomy (ETV) is a common treatment strategy for noncommunicating hydrocephalus. Although rare, vascular injury and traumatic pseudoaneurysm development during ETV has been reported. We present the case of a 13-year-old boy who underwent repeat ETV (rETV) for shunt and ETV failure, and who suffered an intraoperative subarachnoid hemorrhage (SAH) due to iatrogenic injury to the basilar tip, with subsequent development of a pseudoaneurysm.

Case Report

History and Examination

A 13-year-old boy who had undergone an ETV and ventriculoperitoneal shunting for hydrocephalus secondary to intraventricular hemorrhage (IVH) of prematurity presented to our emergency department with persistent headaches. Magnetic resonance imaging of the brain demonstrated enlarged lateral and third ventricles and closure of the prior ETV fenestration site, consistent with shunt and ETV failure. Preoperative thin-cut T2-weighted constructive interference in steady state (CISS) MRI demonstrated navigability through the right lateral ventricle,

through the floor of the third ventricle, into the prepontine cistern, without evidence of frank arachnoid adhesions to the basilar artery (BA) (Fig. 1).

Operation

Given the patient's age, treatment of hydrocephalus with rETV was chosen given its potential long-term durability and lower potential complication rate. Under stereotactic guidance, a rigid endoscope was advanced into the right lateral ventricle, through the foramen of Monro, and into the third ventricle. The prior ETV fenestration site was identified as a translucent membrane between the mammillary bodies and median eminence, and was refenestrated with forceps until CSF flow was observed through the fenestration. As the balloon catheter was being prepared for introduction, arterial bleeding was observed from the fenestration site. The origin of the bleeding could not be visualized. The site was irrigated for 30 minutes until hemostasis was achieved; however, because of the amount of bleeding encountered, an external ventricular drain was placed, and the procedure was terminated.

A CT angiographic study conducted within the intraoperative CT suite demonstrated a 2-mm basilar tip pseudo-

ABBREVIATIONS BA = basilar artery; CISS = constructive interference in steady state; ETV = endoscopic third ventriculostomy; IVH = intraventricular hemorrhage; PCA = posterior cerebral artery; PCoA = posterior communicating artery; rETV = repeat ETV; SAH = subarachnoid hemorrhage.

SUBMITTED May 4, 2017. **ACCEPTED** July 17, 2017.

INCLUDE WHEN CITING Published online October 13, 2017; DOI: 10.3171/2017.7.PEDS17235.

FIG. 1. Sagittal (A) and coronal (B) slices of preoperative T2-weighted CISS MRI demonstrating navigability through the right lateral ventricle and through the floor of the third ventricle into the prepontine cistern.

aneurysm, SAH, and IVH (Fig. 2A). The patient was emergently brought to the endovascular suite, where a diagnostic angiogram redemonstrated the 2×2.2 -mm basilar tip aneurysm (Fig. 2B). Embolization was then performed with 3 Penumbra SMART coils placed within the dome of the aneurysm, with satisfactory modified Raymond-Roy Class IIIb closure (Fig. 3). The patient awoke without neurological deficit and was monitored for vasospasm. His shunt was reinternalized on postoperative Day 14.

Postoperative Course

Follow-up angiography conducted on postoperative Day 17 demonstrated aneurysm regrowth to a size of 2.7×5.4 mm, with evidence of coil compaction at the superior left dome (Fig. 4). Given these findings, a flow diversion treatment strategy was chosen as definitive therapy. While in the endovascular suite, the patient received a loading dose of 325 mg aspirin and 30 mg prasugrel. The pseudoaneurysm was re-coiled with 2 Penumbra SMART coils and 1 Axium Prime coil. Afterward, a 3 mm $\times$ 12-mm Pipeline Flex embolization device was introduced and placed from the left P₁ posterior cerebral artery (PCA) to the BA (Fig. 5). The patient was uneventfully extubated and discharged the following day. Follow-up angiography

FIG. 2. A: Axial CT angiogram obtained immediately after the aborted ETV demonstrating a 3-mm basilar tip pseudoaneurysm. B: Left vertebral artery angiogram demonstrating a 3-mm basilar tip pseudoaneurysm.

FIG. 3. Anteroposterior (A) and lateral (B) left vertebral artery angiograms demonstrating successful closure of the basilar pseudoaneurysm with 3 extra-soft 1.5 mm $\times$ 2-cm Penumbra SMART coils.

conducted 1 month later demonstrated complete obliteration of the aneurysm and complete filling of the right PCA from the right posterior communicating artery (PCoA). These findings were again demonstrated at the 7-month follow-up (Fig. 6), at which time his prasugrel was discontinued.

Discussion

At long-term follow-up, the success rate of ETV in children has been reported at 50%–70%.^{7,8} Many underlying causes of ETV failure, such as inadequate ostomy diameter, arachnoid scarring, ostomy occlusion by a membrane, and development of a second membrane between the third ventricle and the cisterns have been described.^{4,9,11} Repeat ETV is considered a safe option for ETV failure, with rates of successful treatment ranging from 50% to 89%.⁹

Intraoperative and postoperative complications of ETV include bleeding; forniceal, hypothalamic, or thalamic injury; meningitis; CSF leak; and new neurological deficit.^{3,8} In a prospectively collected data set from the Hydrocephalus Clinical Research Network, the rates of moderate to severe intraoperative bleeding and major arterial injury were reported to be 6.0% and 0.3%, respectively.⁸ Basilar artery rupture was identified in 5 (0.21%) of 2344 cases in a large, heterogeneous review.³ Although data regarding specific complications in rETV are sparse, no cases of bleeding or aneurysm development in rETV have been reported.¹¹

To our knowledge, 3 cases of BA aneurysms have been reported as complications of ETV.^{5,10,12} Horowitz et al. re-

FIG. 4. Anteroposterior (A) and lateral (B) left vertebral angiograms demonstrating gross recurrence and enlargement of aneurysm.

FIG. 5. Left ventricular angiograms demonstrating coiling of the aneurysm (A) and diminished flow through the right PCA (B).

ported the discovery of a 6- to 7-mm saccular aneurysm of the upper BA trunk in a 30-month-old child after third ventricular fenestration with a Bugby wire and low coagulating current.⁵ Because of the presence of a fetal left PCoA and large right PCoA, the authors elected to embolize the aneurysm and the BA directly above and below the aneurysm with Guglielmi detachable coils. Rezende et al. reported the discovery of a 2-mm upper basilar trunk aneurysm in a 4-year-old child following removal of a Fogarty balloon catheter from a fenestration created with a Bugby wire.¹² The authors elected to treat this aneurysm with coil embolization alone. In both of these cases, the aneurysm was completely obliterated on follow-up imaging. McLaughlin et al. reported the delayed discovery of a 6-mm basilar apex aneurysm in a 3-year-old child 35 days after the original ETV, during which brisk intraoperative bleeding was encountered following the passage of the endoscope through the fenestration to assess CSF flow.¹⁰ Although the postoperative CT scan demonstrated SAH and IVH, subsequent angiography did not demonstrate an aneurysm. Follow-up interval angiography demonstrated a basilar tip pseudoaneurysm and the patient underwent open surgical clipping. Finally, Abtin et al. reported the development of a 3-mm pseudoaneurysm of the P₁ segment of the right PCA following fenestration of the third ventricle floor with an endoscope that resulted in brisk arterial bleeding.¹ The pseudoaneurysm was subsequently clipped following a pterional craniotomy and, following recurrence 1 month later, clipped again.

Our case highlights an unstable pseudoaneurysm that was treated successfully with coil embolization and subsequent flow diversion. Flow-diverting devices, which offer treatment for aneurysms that may not be amenable to other endovascular interventions, are a relatively novel addition to the armamentarium of aneurysm occlusion devices. The use of a flow-diverting device to treat this pseudoaneurysm in particular demonstrates the reconstructive capabilities of this technology for treating injured vessels. Although the pediatric experience with these devices is limited, no recurrence of an aneurysm treated with flow diversion has been reported in the adult literature.¹³ Unfortunately these devices currently require the use of dual antiplatelet agents and are used with hesitancy in acutely ruptured lesions.¹⁴ Furthermore, flow-diverting devices risk development of in-stent thrombosis and loss of branch vessels. This has been specifically noted within the poste-

FIG. 6. A: Left vertebral angiogram demonstrating resolution of the lesion with expected loss of flow in the right P₁ segment of the PCA. B: Right internal carotid artery unsubtracted angiogram demonstrating collateral perfusion of the right PCA filling via the right PCoA.

rior circulation.^{2,6} Yet, as in this case, in circumstances in which treatment options are limited, the risk of conservative management may outweigh the risk of flow diversion.

Conclusions

Development of a BA aneurysm is a rare but serious consequence of ETV in pediatric patients. We report the case of a 13-year-old patient who developed an aneurysm of the basilar tip following rETV for hydrocephalus. The aneurysm recurred despite initial coil embolization and was definitively treated with flow diversion. To our knowledge, this is the first report of a basilar aneurysm developing during rETV and of an iatrogenic BA aneurysm being successfully treated with a flow diverter. Further research will be necessary to identify the frequency and etiologies of complications associated with rETV and to determine the durability of treatment of pediatric aneurysms with flow-diverting devices.

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Disclosures

Dr. Patel reports being a consultant for Medtronic and Penumbra.

Author Contributions

Conception and design: Patel, Koch, Grannan, Stapleton, Butler. Acquisition of data: Patel, Sastry, Koch, Butler. Analysis and interpretation of data: Sastry, Koch. Drafting the article: Sastry, Koch, Grannan. Critically revising the article: Koch, Grannan. Reviewed submitted version of manuscript: Sastry, Koch, Stapleton, Butler. Statistical analysis: Grannan, Stapleton. Administrative/technical/material support: Patel.

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