Stent-Assisted Coiling Treatment of Pediatric Traumatic Pseudoaneurysm Resulting from Tumor Surgery

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Key Words

Endovascular coiling • Stent placement • Traumatic pseudoaneurysm

Abstract

Background: Traumatic intracranial pseudoaneurysms in children are typically the result of blunt or penetrating head injury. There are isolated reports of pseudoaneurysm as the result of intracranial aneurysm surgery in both adults and children. Treatment of these lesions, both surgically and endovascularly, can be complicated due to the known variability of arterial wall thickness in traumatic pseudoaneurysms. **Case Report:** We describe a child who underwent successful craniopharyngioma resection following staged surgical procedures. Follow-up imaging 8 months after the operation demonstrated an enlarging pseudoaneurysm of the left supraclinoid carotid artery. The lesion was successfully treated with stenting of the vessel and coil placement between the stent and the aneurysmal segment of the artery. Follow-up angiographic imaging 6 months later revealed complete

obliteration of the aneurysm and normalization of the carotid artery lumen. **Conclusion:** To our knowledge, this is the first report of a pseudoaneurysm secondary to a surgical intervention in childhood that was treated with stent-assisted coiling. This strategy of vascular reconstruction is increasingly used in adults and appears safe to implement in the pediatric population. However, the long-term outcomes and the value of using an antiplatelet regimen in this young population are still to be determined.

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Traumatic intracranial pseudoaneurysm is a known potential complication of head injury. Because of the rarity of congenital intracranial aneurysms in childhood, the pediatric population has a disproportionate representation of traumatic pseudoaneurysms, accounting for up to one third of all aneurysms encountered in children [1–3]. Although the majority of these aneurysms occur as a result of blunt or penetrating trauma, there are reports of pseudoaneurysms that have resulted from intracranial

Fig. 1. T₂-weighted axial MR images (**a**, sagittal; **b**, coronal; **c**, axial) at the time of initial presentation of the patient described. The carotid arteries appear normal in caliber and adhere to the tumor (**b**, **c**; arrows). The tumor extends well into the third ventricle on sagittal (**a**; arrow) imaging. Sagittal T₁ (**d**), coronal T₂ (**e**), and axial T₂ (**f**) images show an immediate postoperative view with gross total resection of the lesion. The carotid arteries appear normal in diameter (**e**, **f**; arrows).

surgery in both pediatric and adult patients [4–7]. Whether iatrogenic or traumatic, treatment of pseudoaneurysms can often prove difficult because the entire vessel can be involved with the lesion, resulting in a fusiform dilatation of the vessel; therefore, treatment may involve vessel occlusion, vessel segment replacement, vessel reconstruction with clipping, or occlusion with an extracranial-to-intracranial bypass procedure [8–10]. Sutton [11] reported an update on a series of 11 patients who underwent surgery for craniopharyngiomas and chiasmatic gliomas that developed fusiform dilatation of the carotid

artery. One patient developed headaches and likely hemorrhage and had a poor outcome from microsurgical treatment of this lesion. Therefore, it was recommended that surgical exploration be reserved for symptomatic patients and observation for asymptomatic patients. As endovascular techniques have evolved, treatment of pseudoaneurysms has been reported with endovascular reconstruction utilizing intravascular stents, direct coiling, or a combination of stents and coils, or liquid embolic agents [5, 12–20].

Fig. 2. T₂ axial imaging demonstrates immediate preoperative (a) and postoperative (b) views with gross total resection of the lesion. The left carotid artery appears normal in diameter (arrows). T₂-weighted axial imaging obtained 8 months after surgery shows enlargement of the left carotid artery (c; arrow).

In this report, we describe a 5-year-old boy who underwent successful resection of a craniopharyngioma. Initial postoperative imaging revealed no vascular abnormalities. Subsequently, an asymmetric aneurysmal enlargement of the left supraclinoid carotid artery was noted to grow progressively to 4 mm at 3 months and then to 8 mm at 8 months. Although the child remained asymptomatic, the rapid, asymmetric enlargement of the lesion was concerning, and he was successfully treated with stenting of the vessel and coil placement between the stent and the aneurysmal segment of artery. Follow-up imaging 6 months after treatment revealed complete obliteration of the aneurysm and normalization of the carotid artery lumen.

Case Report

History and Examination

This patient initially presented at the age of 4 years with a 1-week history of persistent headache. At the time of admission, he was noted to have right facial weakness and right pronator drift. A cranial computed tomographic (CT) scan demonstrated a large, cystic suprasellar mass extending through the third ventricle into the right frontal horn with a mild amount of calcification in the periphery. Magnetic resonance (MR) imaging and MR angiography studies demonstrated a large suprasellar tumor with heterogeneous enhancement, consistent with a diagnosis of craniopharyngioma (fig. 1a–c, 2a). Obstructive hydrocephalus with enlarged lateral ventricles and transependymal flow of cerebrospinal fluid was also noted. A ventriculostomy was placed, and the patient subsequently underwent a right parasagittal cra-

niotomy with a transcallosal approach to the craniopharyngioma using frameless stereotactic navigation. A subtotal resection of the tumor was accomplished, leaving the tumor margins adjacent to the carotid artery and hypothalamic structures for a second surgery. The patient awoke from surgery with no new neurologic deficits. During the second-stage surgery 6 days later, a right pterional and orbitozygomatic craniotomy was performed that resulted in gross total resection of the tumor. Postoperative MR imaging and MR angiography demonstrated complete resection of the tumor and an apparent normal caliber of the carotid arteries bilaterally (fig. 1d–f, 2b). Follow-up MR imaging and MR angiography 3 months after surgery revealed a 4-mm fusiform enlargement of the left paraclinoid internal carotid artery. As suggested by Sutton [11], a decision was made to follow up conservatively given the absence of symptoms. Six months thereafter, 8 months after the initial surgery (when the patient was 5 years old), MR angiography demonstrated asymmetric enlargement of the aneurysm to 8 mm (fig. 2c). The patient remained intact from a neurologic standpoint after his initial surgery with resolution of his headaches. Given the asymmetric, progressive, and rapidly enlarging nature of the lesion, it was decided to proceed with angiography and balloon test occlusion followed by treatment of the diseased segment of the artery with stent-assisted coiling.

Intervention

Under general anesthesia, the patient was monitored with somatosensory evoked potential monitoring as well as electroencephalography (EEG). A cerebral angiogram demonstrated the left carotid pseudoaneurysm (fig. 3a, b) as well as an atretic right A1 segment that did not fill on angiography, even during temporary digital occlusion of the left carotid artery. A test occlusion of the left carotid artery was performed by placing a 5-french Envoy NPD catheter (Cordis, Warren, N.J., USA) in the prepetrous segment of the carotid artery and advancing a 4 × 7 mm Hyperform balloon (MicroTherapeutics, Irvine, Calif., USA) into the petrous

Fig. 3. Angiography confirmed the pseudoaneurysm in the supraclinoid segment of the carotid artery on the left side (**a**, oblique AP view; **b**, lateral view; arrows). Following stent deployment, two separate coils were placed in the aneurysmal sac between the stent and aneurysmal wall (**c–e**; arrows).

segment of the carotid artery. Test occlusion for 30 min with mean blood pressure lowered to 50 mm Hg demonstrated no change in the EEG recording or the somatosensory evoked responses. Given the atretic A1 segment, we felt that a vessel-sparing procedure should be undertaken if possible.

We deployed a 4.5 × 22 mm Enterprise stent (Codman and Shurtleff, Raynham, Mass., USA) in the carotid artery from a level just below the carotid bifurcation to a segment of the carotid artery proximally at the level of the distal cavernous internal carotid artery. With the stent deployed, we proceeded to coil the pseudoaneurysm by advancing an LPES 45-degree angle microcatheter (Codman and Shurtleff, Inc.) between the tines of the stent into the pseudoaneurysm. Two separate coils were deployed: a 5 mm × 12 cm Cashmere Complex 14 Cerecyte coil (Micrus Endovascular, San Jose, Calif., USA) and a 3 mm × 8 cm Hypersoft Microplex 10 helical coil (MicroVention Inc., Aliso Viejo, Calif., USA). With this construct in position, we had what appeared to be excellent filling of the left carotid artery with obliteration of the asymmetric dome and only minimal residual stasis within the pseudoaneurysm (fig. 3c–e). The patient tolerated the procedure well and had no new neurologic deficit following emergence from anesthesia. He was placed on clopidogrel (75 mg by mouth on a daily basis) and aspirin (5 mg/kg by mouth on a daily basis) 1 week prior to treatment and was maintained on this regimen after the procedure for a total of 3 months. A gadolinium-enhanced MR angiogram obtained at 3 months revealed no filling of the aneurysm and good flow proximal and distal to the stent. Clopidogrel was discontinued, although aspirin was continued. An angiogram at 6 months revealed complete obliteration of the aneurysm

and restoration of normal luminal patency of the left carotid artery (fig. 4a, b). The child remained completely asymptomatic after treatment and throughout the follow-up period (now 1 year). To evaluate the patency of the stent and ensure complete aneurysm obliteration, we plan to obtain follow-up gadolinium-enhanced MR angiograms in the future.

Discussion

Traumatic pseudoaneurysms are typically the result of penetrating or blunt head injury. In this context, the term pseudoaneurysm is often hard to define as the dilatation seen in the artery may represent a partial thickness tear in the artery wall with thinning of the wall and protrusion of the remaining layers of arterial wall anatomy. There are situations in which the pseudoaneurysm represents a hematoma surrounding a vessel tear. In this situation, there is no true arterial wall around the area of enlargement seen on a conventional arteriogram or a CT angiogram. Instead, blood is flowing out of the artery and through a hematoma cavity and then back into the distal artery. In the patient we describe, the mechanism of pseudoaneurysm formation is much more likely that of a partial arterial injury with resultant thinning of the wall and

Fig. 4. Six-month follow-up angiographic images showing the coil mass and the stent with a patent lumen. The aneurysmal sac is obliterated, and there is no evidence of in-stent thrombosis (**a**, oblique AP view; **b**, lateral view).

subsequent bulging to form the asymmetric pseudoaneurysm we observed.

Pseudoaneurysms are a known complication of intracranial tumor surgery. Dunn et al. [4] report a traumatic pericallosal artery as a result of transcallosal resection of a hypothalamic pilocytic astrocytoma. Traumatic pseudoaneurysms have also been described following transsphenoidal surgery and spine surgery, causing carotid artery injury and vertebral artery injury, respectively [5]. Interestingly, fusiform dilatations have been described in the carotid artery following surgery for childhood craniopharyngiomas [6, 21]. In the description by Sutton et al. [6], 9 of 31 (29%) patients were found to have fusiform dilatation of the supraclinoid carotid artery either at the time of surgery for tumor recurrence (1 patient) or on follow-up CT imaging performed 6–18 months after surgery (8 patients). Those authors did not treat any of the observed dilatations and reported no incidence of hemorrhage at a mean follow-up of 3.7 years after diagnosis. Sutton [11] also reported on 11 children who developed fusiform dilatation of the carotid artery following resection of craniopharyngiomas and hypothalamic tumors. Only one child in this group suffered a subsequent hemorrhage during a follow-up period of 5–11 years. According to Levy et al. [22], aneurysms of traumatic origin exhibit a greater propensity for intraoperative rupture than congenital lesions because of the presence of dense arachnoid adhesions. Because these aneurysms are mostly pseudoaneurysms, clipping of the aneurysm without sacrifice of the parent artery may not be possible [23]. Therefore, surgical treatment is associated with significant morbidity and a reported mortality of 18–29% [24].

Overall, the natural history of this cohort of iatrogenic lesions appears poorly defined, and the course of action in the face of progressive enlargement of an asymmetric aneurysmal lesion remains unclear, especially in the pediatric population. In adults, such progressive enlargement (from 0 mm after surgery to 4 mm at 3 months and then 8 mm at 8 months) would be considered a harbinger of a particularly aggressive and high-rupture-risk lesion. In the patient we report, it was precisely this rate of asymmetric growth that resulted in a change in course from radiographic follow-up to consideration of intervention. An increasing number of reports describe the use of endovascular techniques to treat traumatic pseudoaneurysms [5, 12, 13, 15–19]. In most of these reports, the lesions treated are either spontaneous dissections with pseudoaneurysm or traumatic lesions caused by penetrating or blunt head injury. In the report by Lempert et al. [5], there were three pseudoaneurysms caused by transsphenoidal surgery and one that was observed in the vertebral artery after a cervical disectomy. To date, three strategies were described for the use of endovascular techniques to treat traumatic pseudoaneurysms. The lesion can be treated with coils alone if it is a more saccular pseudoaneurysm. This approach carries a higher potential risk of rupture, because a pseudoaneurysm has a wall that is unpredictable in its ability to contain the coil mass [5, 12]. Alternatively, techniques utilizing stent-supported coil embolization have been described to treat fusiform and wide-necked pseudoaneurysms [18]. Finally, stent therapy alone was described by Fiorella et al. [13] in the treatment of 10 patients with ‘uncoilable’ intracranial pseudoaneurysms. The patient we describe tolerated

balloon test occlusion of the internal carotid artery with the mean blood pressure lowered on the basis of somatosensory evoked potential monitoring as well as EEG recording. He had an atretic A1 segment on the right side that was not well visualized on angiography. Given this feature and because the patient was 5 years of age, we felt that a vessel-sparing maneuver should be primarily attempted. Consideration was given to the possibility of extracranial-to-intracranial bypass with vessel occlusion proximal to the diseased segment of artery. We felt that the risk of another intracranial surgery could be avoided if an endovascular strategy could be utilized safely. We therefore decided to proceed with a strategy of stent deployment and coil deposition between the stent and the wall of the diseased vessel. Although this strategy required prolonged dual antiplatelet therapy (3 months), we felt this was superior to the possibility of vessel sacrifice, given the patient's young age. In a pediatric population, aspirin should be used with extreme caution given its known – albeit rare (fortunately) – association with Reye's syndrome, which can be life-threatening [25]. Therefore, when surgical treatment options are explained to the patient and family, any long-term medication regimens that are required should also be discussed in detail, including the potential associated risks.

This is, to our knowledge, the first report of stent-assisted coil embolization of a likely postsurgical iatrogenic carotid artery pseudoaneurysm. This treatment was successful, with follow-up imaging demonstrating complete obliteration of the pseudoaneurysm and normalization of the carotid artery lumen. It should be re-emphasized that the vast majority of these postoperative lesions have a benign natural history and require only radiographic surveillance. However, for the very small subset that continues to asymmetrically enlarge, treatment options remain complex. Stent-assisted coiling may allow for vessel preservation and avoidance of a reoperation for an extracranial-intracranial high-flow bypass, which in the pediatric population is not considered a low-risk endeavor [26].

The case described in this report highlights the importance of follow-up imaging not only with MR imaging but also with MR angiography studies after significant intracranial surgery. Specifically, attention should be paid to the intracranial vasculature for any lesion that is dissected free from large intracranial vessels. In the small cohort of pediatric patients that needs to have consideration for aneurysm treatment, stent-assisted coil embolization may be a viable option.

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¹ Boston Scientific's neurovascular business has been acquired by Stryker.

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