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CASE REPORT

Pipeline embolization device for the treatment of a traumatic intracranial aneurysm in a child

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Abstract

Introduction Traumatic intracranial aneurysms in children are rare and may occur as the result of closed or penetrating head trauma. Their natural history seems to be more aggressive. Most traumatic aneurysms have complex shape, tending to have a large neck or even a fusiform morphology.

Case report We present a case of a traumatic carotid artery aneurysm in a 9-year-old girl that was successfully treated with pipeline embolization device.

Discussion Due to its dissecting nature, wall friability and lack of a substantial neck can make surgical clipping and selective coiling difficult and risky. Although endovascular parent artery occlusion is the best approach in the acute phase, in some situations it is not possible or very risky. In such scenario the use of flow diverter devices would be an alternative approach. Additionally, we discuss the potential advantages and risks of flow diverter deployment inside a developing vessel.

Keywords Aneurysm · Child · Embolization · Flow diverter · Trauma

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Introduction

Intracranial aneurysms are rare in childhood, with the prevalence reported to range from 0.5 to 5% [1–5]. Aneurysms in this population exhibit features that differ significantly from those in adults [2, 4, 6]. There is a higher incidence of unusual anatomic locations and male predominance and a higher incidence of uncommon etiologies, such as infection, dissection, and trauma [1–5].

Traumatic aneurysms are uncommon and constitute less than 1% of all intracranial aneurysms in large series [5]. They may occur as the result of closed or penetrating head trauma [7]. Although there has been a significant shift from microsurgical treatment towards endovascular management of cerebral aneurysms due to better outcomes and lower rates of procedural complications, traumatic pediatric aneurysms are very distinct lesions [2, 4, 5]. Therefore, one cannot assume that all treatment strategies used in adults are immediately applicable to a younger population [8, 9].

Once traumatic aneurysm wall does not contain the normal layers of an arterial wall, their natural history seems to be more aggressive and their treatment imposes specific challenges [5, 10]. While dealing with broad neck and complex aneurysms, the assistance of adjunctive techniques, such as balloons, stents, and flow diverters is mandatory to make endovascular treatment possible [8].

Literature information about the use of stents and flow diverter devices in children is extremely scarce [2, 8, 9]. Vessel response to growth in the presence of an endoluminal device is not known [8, 11]. Additionally, the use of antiplatelets in this population in order to prevent thrombogenic complications is not defined [8, 11].

We present a case of a traumatic carotid artery aneurysm that was successfully treated with pipeline embolization device. To our knowledge, this is the first report of a child harboring a traumatic carotid artery aneurysm treated with a flow diverter device.

Case report

A 9-year-old girl was admitted to the emergency department with a history of a car accident and polytrauma. Her development had been normal, and she had no history of other diseases. She presented with splenic trauma, right superior limb fracture, and severe head trauma. She was intubated, and computed tomography (CT) scan demonstrated left frontal lobe contusion, left parietal lobe contusion, and left orbit fracture, involving the optic channel and superior orbital fissure. No vascular lesion or intracranial bleeding was identified (Fig. 1). Brain lesions were medically treated. She was submitted to splenectomy and osteosynthesis of right radius. She was discharged after 20 days with grade 4 right hemiparesis, left eye amaurosis, and left third nerve palsy. Control CT scan showed no major complications.

After 30 days, in order to evaluate left optic and oculomotor nerve lesions, a magnetic resonance was performed. It revealed an aneurysm of the left supraclinoid internal carotid artery. We decided to perform a cerebral angiogram. A 5F sheath was inserted into the right femoral artery, and angiography was performed with a 5F vertebral catheter. The cerebral angiogram demonstrated a 17-mm aneurysm of the communicating segment of the left internal carotid artery, with a large neck, just proximal to the anterior choroid artery origin. Endovascular treatment was planned.

We considered that optimal endovascular treatment should occlude the aneurysm and decrease mass effect. Trapping of internal carotid artery, even keeping the carotid tip patent and thus flow to middle cerebral artery territory via anterior communicating artery, was excluded because it would lead to ischemia due to anterior choroid artery occlusion, which was very close to the aneurysm neck. Simple coiling and balloon-assisted coiling were not possible because of the very large neck. Additionally, it would increase the mass effect and the chance of recanalization would not be negligible.

Despite scarce information in literature, it was decided to treat the aneurysm with a flow diverter device to promote aneurysm occlusion. Since the patient would require aspirin plus clopidogrel, and because of the traumatic nature of the aneurysm, it was decided to place a small amount of coils, fearing early hemorrhagic complications associated to aneurysm rupture. These coils would promote faster aneurysm occlusion without significantly increasing mass effect. It was chosen to begin clopidogrel 1 mg/kg and aspirin 4 mg/kg 7 days prior to endovascular treatment.

A bilateral femoral approach was obtained to allow simultaneously navigation of two microcatheters (jail technique). Under general anesthesia and anticoagulation, a 5F guiding catheter (Stryker Neurovascular, CA, USA) was placed into the left common carotid artery to coaxially navigate an Excelsior SL10 microcatheter (Stryker Neurovascular, CA, USA) and place it inside the aneurysm sac. Angiography showed that aneurysm size increased to 30 mm, compared with diagnostic angiogram performed 7 days before.

A triaxial system was used to achieve good support for pipeline embolization device (PED) navigation: a long 6F introducer (Terumo, Tokyo, Japan) was placed within the cervical portion of the left internal carotid artery, a 6F guiding catheter (Neuron, Penumbra, Alameda, CA, USA) was then

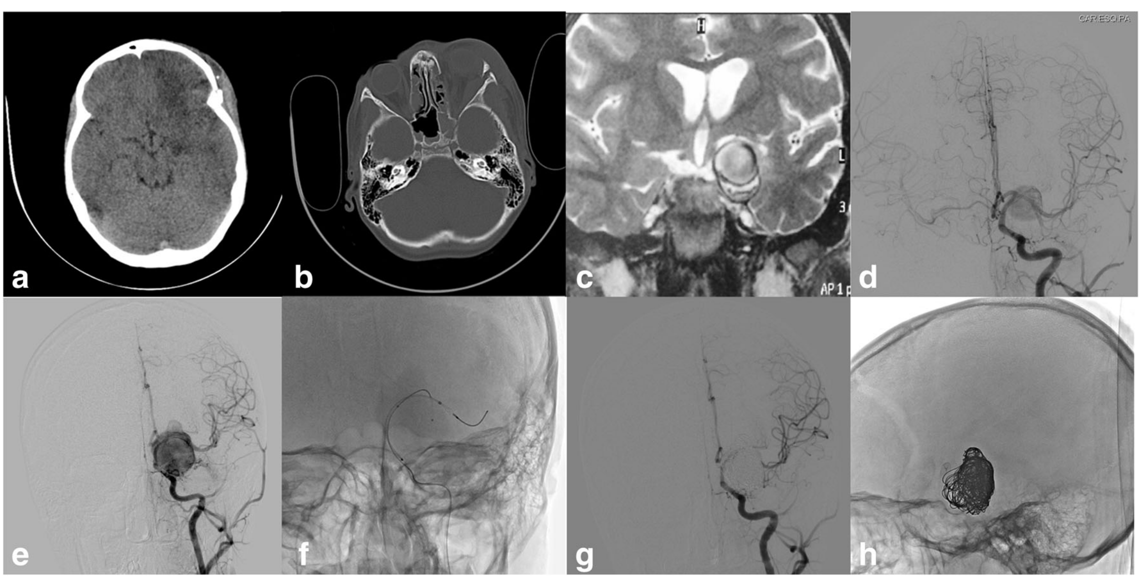

Fig. 1 **a**, **b** CT scan 15 days after trauma demonstrates left frontal contusion and orbital fracture but no vascular anomaly. **c** MRI 30 days after trauma shows an aneurysm of the left supraclinoid internal carotid artery. **d** Angiogram demonstrates a 17-mm aneurysm of the communicating segment of the left internal carotid artery. **e** Angiogram reveals an aneurysm size increase (7 days after diagnostic angiography). **f** Deployment of pipeline embolization device from left M1 to carotid artery with a jailed microcatheter. **g** Final angiogram shows total aneurysm occlusion. **h** Cast of coils

navigated into the left petrous internal carotid artery, and finally, the delivery microcatheter (Marksman, Covidien, USA) was navigated distally to the aneurysm neck toward the left M1 segment for subsequent deployment of the flow diverter. A PED 3.0 × 20 mm was first deployed covering the aneurysm neck, from the left M1 segment to the left ophthalmic segment. Despite marked contrast stagnation inside the sac, a small number of coils (Target, Stryker Neurovascular, Fremont, CA, USA) were inserted promoting total aneurysm occlusion.

The child had an uneventful recovery. Control after 6 months demonstrated persistence of total occlusion. She has very mild right side hemiparesis and left eye amaurosis. Left oculomotor nerve palsy improved partially.

Discussion

Intracranial aneurysms in the pediatric population are uncommon and often complex [2, 4]. Thus, there is limited experience with these lesions, and most published series are small [1, 3]. Moreover, unusual etiologies, like trauma, tend to be more frequent [7]. Reported locations are the vertebral, internal carotid, anterior cerebral, and middle cerebral arteries [3, 5]. These intracranial arteries are more vulnerable to injuries when they travel adjacent to skull fractures or even normal structures like the falx, tentorial edge, or sphenoid wing [5].

Disruption of internal elastic lamina is a characteristic histopathological feature of saccular intracranial aneurysms. On the other hand, in traumatic aneurysms, there is disruption across the intima, internal elastic lamina, and media layers of the arterial wall, with or without an intact adventitia [7]. When the intima is also fragmented, hematoma in the surrounding tissue prevents blood extravasation [5].

In the present case, the child had a high-energy head trauma. CT at discharge showed no aneurysm. Although this is not the best method to diagnose aneurysms, an aneurysm with 17-mm of diameter would be identified. Additionally, comparing the angiography at diagnosis with the angiography of the intervention day (7 days of interval), the aneurysm increased in size. This finding is very characteristic of a traumatic lesion.

Traumatic aneurysms in child pose two different problems. First, the treatment of an intracranial aneurysm in the scenario of head and systemic trauma is challenging, especially when dealing with low-weighing child [5]. Additionally, most traumatic aneurysms have complex shape, tending to have a large neck or even a fusiform morphology, with no well-defined neck at all [1, 5, 7]. Thus, selective occlusion of this type of aneurysm is often impossible, either with surgical or endovascular treatment [6, 7, 10].

Traumatic intracranial aneurysms have a high rate of rupture, and they tend to keep growing, as in the reported case [5, 6, 10]. Therefore, they need to be detected early and treated aggressively. Unfortunately, due to its dissecting nature, wall friability and lack of a substantial neck can make surgical clipping difficult and even risky [5, 7, 9, 12–14].

Bell et al. [13] reported a series of 64 craniocervical vascular injuries. Twenty-four aneurysms were treated endovascularly. The parent artery was preserved in 12 cases (50%). On the other hand, 13 aneurysms were treated surgically. Four of 13 surgical cases resulted in preservation of the parent artery (30.8%). Therefore, in most cases, it was not possible to selectively clip the aneurysm neck.

Additionally, Alawi et al. [15] reported a series of 1120 children submitted to aneurysm treatment. Overall in-hospital mortality was higher in the surgical clipping group compared with the coil embolization group (6.09 vs 1.65%, respectively).

On the other hand, recanalization after coiling alone is almost certain [8]. Therefore, deconstructive modalities of treatment like trapping or parent vessel occlusion, performed either surgically or endovascularly, have predominated for managing those lesions [2, 7, 10]. We consider endovascular treatment as an excellent alternative [5, 9]. A minimally invasive approach that avoids craniotomy, brain retraction, and surgical vessel manipulation is always desired, especially in multiple trauma patients [5].

Although endovascular parent artery occlusion is the best approach in the acute phase, in some situations, it is not possible or very risky [5, 7]. The lack of collateral blood circulation and the presence of perforating vessels in the involved segment make selective treatment mandatory [1, 7, 10].

In such scenario, the use of flow diverter devices would be theoretically the most adequate choice [9]. Besides keeping the parent artery patent, it leads to neointimal formation and provides endoluminal matrix for endothelial growth and vessel remodeling [2, 9, 10, 12]. To date, no recurrence has been reported after documented obliteration of an aneurysm treated with flow diverters [2]. However, while dealing with an aneurysm with a high rate of bleeding and rebleeding, immediate occlusion rates are quite low [9]. Thus, in order to prevent early bleeding, association of coils is strongly recommended.

While the use of intracranial stents and flow diverters is widely studied in adult population, there is scarce information about its employ in children. There are only few reports, especially about flow diverters [2, 8, 9, 12]. An important issue to have into account is the growth of the arteries. Arat et al. measured intracranial vessels of adults and children after performing DSA and found that the ICA and ACA reach almost their full diameter by the age of 4 years, and MCA has an approximately adult diameter at the 6 months of life [8].

Additionally, the ideal antiplatelet therapy and dose for children undergoing neurovascular procedures are unknown. They are based exclusively on adult and or cardiologic data [8, 11]. Moreover, antithrombotic therapy in the setting of trauma may be problematic.

To our knowledge, the first case of a child (13-year-old) treated successfully with a flow diverter has been published in 2009 [14]. A basilar trunk aneurysm was treated with seven serially placed, telescoping pipeline embolization devices [14].

In 2016, additionally to three new reported cases of pediatric aneurysms, Vargas have found 11 previously reported children treated with flow diverter device [9]. Most aneurysms were incidental or presented with mass effect. Locations included the basilar artery and the cavernous internal carotid artery more frequently. Many of them were classified as dissecting or vasculopathic, with a fusiform morphology. Both SILK and PED were used, with a high rate of multiple overlapping devices. No complications related to the treatment were mentioned [9].

Flow diverters for the management of pediatric traumatic aneurysms seem to be a safe and an effective option. This treatment has some advantages: (1) it avoids craniotomy, (2) it keeps the parent vessel patent, (3) it have high rates of total occlusion, and (4) no recurrence. However, some potential disadvantages are (1) the use of dual antiplatelet therapy in the setting of trauma and the (2) need for coil association in order to promote immediate occlusion, which increases costs. Furthermore, it should be avoided in very young children because of lack of data about the behavior of the endoluminal device inside a developing vessel.

Conclusion

Trapping continues to be the best approach in the acute phase of a ruptured traumatic aneurysm; but sometimes, when there is lack of collateral blood circulation and or presence of perforating vessels in the involved segment, flow diverters should be considered.

A greater number of cases with long-term follow-up and comparative studies are necessary to allow drawing conclusions about the safety and superiority of this technique.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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