Beth Israel Deaconess Medical Center
HARVARD MEDICAL SCHOOL TEACHING HOSPITAL

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NEUROVASCULAR NEWS

The Brain Aneurysm Institute

Multidisciplinary Care of Patients with Hemorrhagic and Ischemic Stroke

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"Angiogram Negative" Subarachnoid Hemorrhage

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Spontaneous subarachnoid hemorrhage (SAH) is an important cause of morbidity and mortality in neurosurgery. Intracranial aneurysm rupture is the most common cause, accounting for approximately 80% of cases[1, 2], which is usually diagnosed by digital subtraction angiography. However, in 15-20% of patients, no vascular source can be identified on angiography[1, 2], giving rise to the "non-aneurysmal" SAH entity. Various theories have been proposed to explain the mechanism of this type of hemorrhage, with the exact cause yet to be identified.

Depending on the hemorrhage patterns identified on initial brain computed tomography (CT) scan, non-aneurysmal SAH can be divided into two main categories: perimesencephalic (PM-SAH) and non-perimesencephalic hemorrhage (nPM-SAH). PM-SAH constitutes the majority of non-aneurysmal SAH, up to two-thirds in some studies[1]. As the name implies, it is characterized by collection of blood around the anterior part of the midbrain, without complete filling of the anterior interhemispheric fissure or extension into Sylvian fissure, and absence or presence of only small amounts of intraventricular hemorrhage (Figure 1a)[3].

Clinically, PM-SAH patients present similarly to aneurysmal SAH, with sudden onset of headache, nausea, neck stiffness, and photophobia with or without vomiting. However, symptoms tend to be less severe along with a more benign course and favorable outcomes as well. Extremely low risks of complications such as rebleeding, hydrocephalus, and vasospasm have been consistently demonstrated in the literature with PM-SAH[4], compared to either nPM-SAH or aneurysmal SAH, despite some case reports highlighting otherwise[5].

Ongoing technological advancements in radiological imaging have bolstered non-invasive modalities such as computed tomography angiography (CTA) and magnetic resonance angiography (MRA) as attractive alternatives to the invasive conventional angiography. However, being the modality of choice with the highest sensitivity; in our institution, patients with a history suggestive of SAH and a negative initial angiogram would most commonly undergo a second cerebral angiography within a week.

The goal of the repeated angiogram is to detect any potential source of bleeding that might have been missed

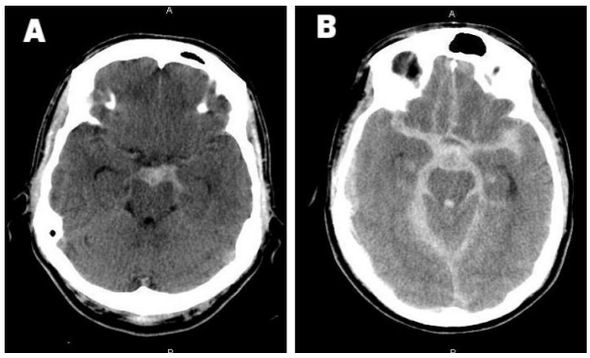

Figure 1:
A: Non-contrast head CT showing perimesencephalic distribution of subarachnoid hemorrhage

B: Non-contrast head CT showing diffuse distribution of subarachnoid hemorrhage involving the basal, suprasellar and sylvian cisterns and the interhemispheric fissure, which may suggest aneurysmal bleeding

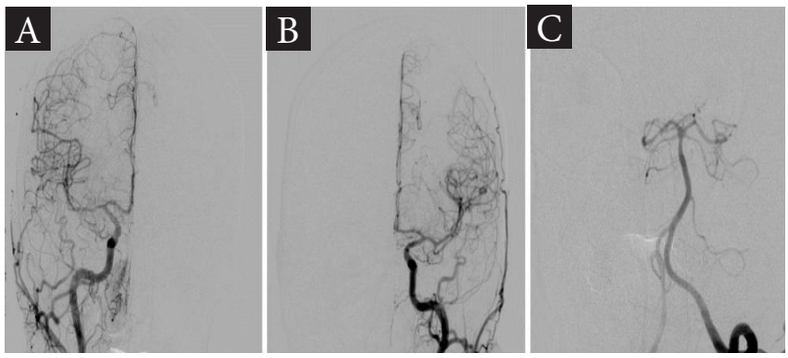

Figure 2: Cerebral angiography

A: Anterior view of right internal carotid artery injection

B: Anterior view of left internal carotid artery injection

C: Left vertebral artery injection; showing no identifiable aneurysms or any vascular anomalies

in the first procedure due to multiple reasons, including small aneurysm size, vasospasm, hematoma within the aneurysm, or small arteriovenous malformation (AVM). This is a commonly adopted approach across a wide range of the nation's hospitals but nevertheless, to date, there are no universal guidelines on diagnostic imaging following of these patients, and protocols tend to vary among institutions.

Some studies have evidenced this practice to be of low diagnostic value in PM-SAH, while having a high diagnostic yield in the nPM-SAH category[6], calling into question the necessity of aggressive diagnostic work up in the first group. In fact, some authors have gone further to recommend that CTA alone without additional follow up would be the most cost-effective strategy to manage PM-SAH patients[7]. They argue that the small margin of difference in sensitivity between angiography and modern-day CTA does not justify the angiography given the combination of its invasive procedural risk, associated costs, and the benign course of the PM-SAH. In contrast, the nPM-SAH is considered to be a highly aggressive disease with a higher risk of complications requiring more rigorous follow up (Figure 1b).

A less commonly encountered third subtype has been added to the non-aneurysmal SAH group, namely convexal SAH, in which the bleeding is mainly localized to the brain convexities without extension into the parenchyma. It has a wide range of etiologies, with overall good prognosis except in elderly patients[8].

Here at the BIDMC Brain Aneurysm Institute, decisions regarding patients' management are undertaken on a case-by-case basis after a multidisciplinary team discussion to adjudicate the optimal management strategy. We hereby present a case treated by our team.

Case Vignette:

A previously healthy 56-year-old male patient presented due to a sudden onset of severe suboccipital headache while playing soccer. The patient reported self-medication with ibuprofen, which helped decrease his pain significantly. He woke up the next day with a severe headache prompting him to go an outside hospital, where he underwent a non-contrast Head CT scan, showing SAH. He was given morphine for the pain and subsequently transferred to BIDMC for further care. On admission, neurological exam was unremarkable except for a mild headache. Initial CTA scan showed a perimesencephalic distribution of SAH (Figure 1a). He was admitted into the ICU for close observation, and started on nimodipine for vasospasm prophylaxis. A subsequent angiogram in the following day failed to uncover the source of the bleeding (Figure 2), and additional brain and spine MRI did not reveal any cause for the SAH. The patient remained neurologically stable throughout the hospital course, and a week later underwent a second angiogram, which again, did not show any vascular source for the bleeding. The patient was discharged home that day with no neurological deficits and in a good functional status (modified Ranking Scale = 0).

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Initial Experience in USA with Protective Transvenous Copernic RC Venous Remodeling Balloon for Embolization of Bilateral Transverse –Sigmoid Dural Arteriovenous Fistula

Alejandro Enriquez-Marulanda, MD, Abdulrahman Alturki, MBBS, MSc, FRCSC, Christopher S. Ogilvy, MD, Ajith J. Thomas, MD

Dural-Arterio-venous-fistulas (DAVFs) consists of anomalous connections between branches of dural arteries to dural venous sinuses, dural veins, meningeal veins or cortical veins[1]. These vascular lesions account for approximately 15% of arteriovenous malformations and most commonly involve the transverse and the sigmoid sinus[2]. DAVFs can be asymptomatic but also can be associated with either intracranial hemorrhage, venous hypertension and non-hemorrhagic neurologic deficits[1,2]. Currently, the mainstay of treatment for DAVF involves endovascular approaches, especially for high-grade lesions that are associated with higher risks of complications[1].

Previous approaches to endovascular treatment of DAVFs involved venous occlusive strategies such as coil embolization of the involved dural venous sinus. This deconstructive approach risks worsening venous hypertension due to inadequate cerebral venous drainage, particularly in the setting of inadequate contralateral venous sinus drainage[3,4] Transarterial embolization with preservation of the venous sinus has become the preferred approach due to the development of newer liquid embolic agents such as Onyx®. Two significant drawbacks with Onyx® are the possibility of arterial reflux alongside the delivery microcatheter and inadvertent venous penetration beyond the venous side of the fistula, even compromising the lumen of the venous sinuses[5].

For further precision and avoidance of venous sinus compromise and sacrifice during embolization, the use of temporary balloon occlusion with the Copernic® RC balloon (BALT Extrusion, Montmorency, France) to protect the patency of dural sinuses from embolic agents migration has been described in a few publications outside the US[4,6]. This case is the first reported use of the Copernic® RC balloon in the United States under the "compassionate use" guidelines of the FDA.

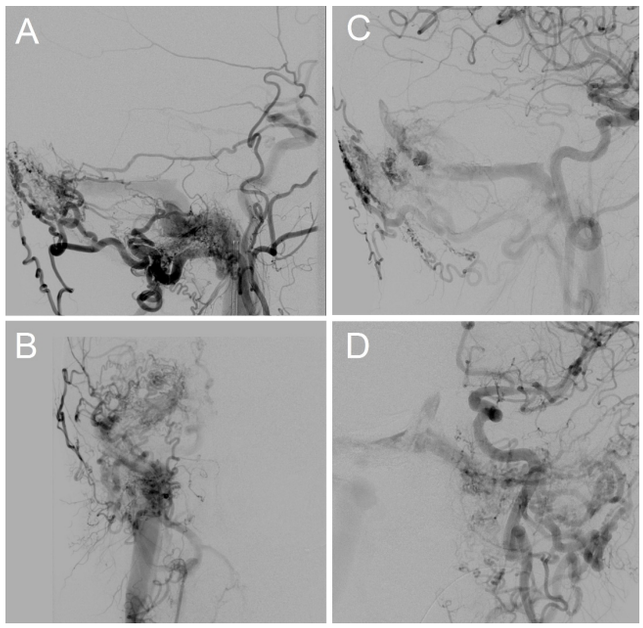

Figure 1: Preoperative angiography showing bilateral transverse-sigmoid dural arteriovenous fistula.

A: Right external carotid artery lateral

B: Right external carotid artery anteroposterior

C: Left external carotid artery lateral

D: Left external carotid artery anteroposterior

Case description:

A 64-year-old man presented with bilateral pulsatile tinnitus and visual decline. On exam, he was found to have bilateral papilledema. Radiologic evaluation consisting of an MRI and MRA of the brain and a diagnostic cerebral angiogram demonstrated a complex bilateral type 2 dural arteriovenous fistula (Figure 1).

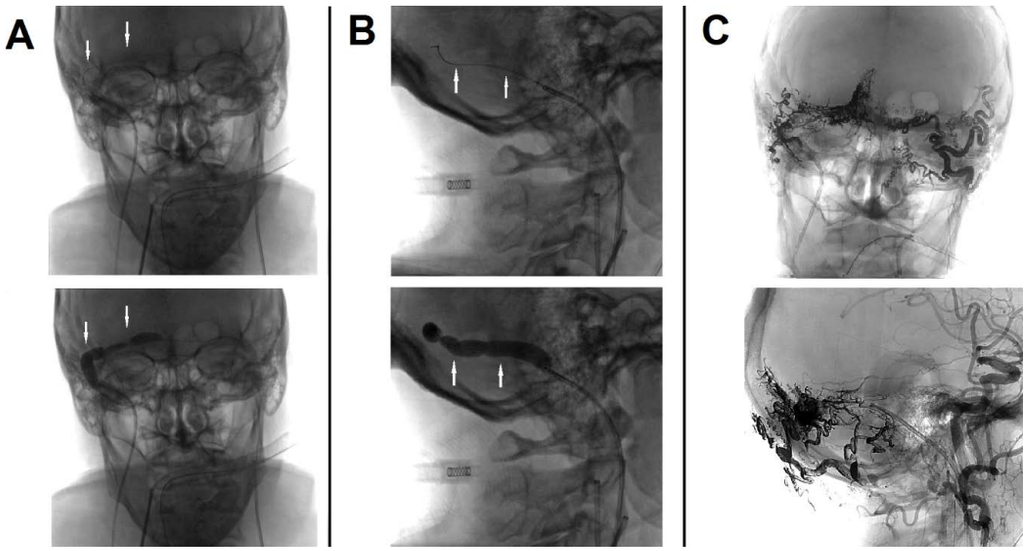

Figure 2: Procedure images that show the Copernic RC balloon inflated in the sinuses.

A: Antero posterior DSA shows deflated (upper image – white arrows) and inflated (lower image – white arrows) Copernic RC balloon in the right transverse and sigmoid sinus.

B: Lateral DSA shows deflated (upper image – white arrows) and inflated (lower image – white arrows) Copernic RC balloon in the right transverse and sigmoid sinus.

C: Onyx® cast post-embolization lateral

Surgical strategy consisted of transarterial Onyx® embolization with venous sinus balloon-assisted protection technique since both transverse sinus and sagittal sinus was involved in drainage of the fistula. Following IRB approval, we obtained "compassionate use" FDA approval of the Copernic® RC balloon for one time use to repair this DAVF.

The Copernic® RC 10x80mm balloon was positioned in the right transverse-sigmoid sinus across the torcula into the left transverse sinus. The balloon was inflated during embolization to protect the right transverse sigmoid venous sinus system and torcula (Figure 2) during Onyx embolization. In the second stage, the Copernic® RC balloon was positioned in the left sigmoid-transverse system through the right internal jugular vein due to difficult left sided venous access to the dural sinuses. The balloon was again inflated to protect the left transverse sigmoid venous sinus system and torcula during embolization of the left occipital artery feeding vessels.

Complete obliteration of the left DAVF was achieved and patency of the left transverse and sigmoid sinuses was preserved. Patency of the right transverse and sigmoid sinus was also conserved post-procedure. The patient recovered overnight without signs of neurologic deficit and was again released on postoperative day one.

At three months follow-up there was an improvement of hearing and visual symptoms without evidence of papilledema on physical exam.

Conclusions:

Transvenous and transarterial balloon-assisted transarterial Onyx® embolization is becoming a useful treatment alternative in selected cases of DAVFs. Previous reports in Asia and Europe with venous remodeling balloons are encouraging. We report the first known experience with this device in USA. The device performed as expected and there were no complications attributable to the device. Additionally, it provided a valuable adjunct to improve the safety and efficacy of transarterial embolization.

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Spinal Cord Cavernous Malformations

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Cavernous malformations (CMs) are vascular lesions that can occur throughout the nervous system. When they present in the spinal cord, there are a number of factors to consider regarding treatment. Histologically, these lesions consist of irregular dilated vessels with closely apposed, blood-filled spaces lined by a single layer of endothelium, resembling a cavern[1]. CMs prevalence ranges from 0.4 to 0.6%[2], represent 5-12% of all spinal lesions and 9% of patients have a family history of this condition[3]. The average age at presentation is 42 years-old[3]. Due to its low prevalence, medical literature from this condition is mostly from retrospective surgical series and systematic reviews.

Symptoms are typically caused by hemorrhage from the fragile vessels which produces mass effect and compression. Small repeated hemorrhages may occur giving rise to recurrent symptoms with resolution of symptoms between hemorrhages, which can mimic demyelinating disease[3]. The annual hemorrhagic incidence of cavernous malformations reported in the literature ranges between 1.4 to 6.8%[4].

Three different modes of presentation of spinal cord lesions have been described depending on the size of the lesion and the presence of hemorrhage. 1) Acute presentation with neurological deficit. 2) Recurrent episodes of neurological deficits with varying degrees of recovery 3) Progressive neurological decline[3].

CMs are a potential cause of significant morbidity due to the development of focal motor or sensory neurologic deficits depending on the location within the spinal cord. Other symptoms reported are bladder or bowel disturbances and respiratory distress when the cervical cord segment is involved[3]. The most common location is in the thoracic segment of the spinal cord (57%), followed by the cervical segment (38%) and lumbar segment (4%)[3]. Concomitant brain lesions can be found as well in up to 27% of cases[3]. Therefore, brain magnetic resonance imaging is warranted in these patients.

Spinal CMs diagnosis can be challenging. The best diagnostic test for detecting these lesions is a whole spine Magnetic Resonance Imaging (MRI). The lesions are better observed in T2-Weighted sequences as mixed signal intensity lesions with a hypointense rim that suggest hemorrhage[3].

Patients with spinal cord cavernous malformation can be followed conservatively or managed with surgical excision of the lesion. Careful selection of surgical candidates is paramount, as the resection is the only definitive treatment for symptomatic and surgically accessible intramedullary spinal cord CMs. The risk of the natural history of the lesion must be carefully weighed against the potential for surgical morbidity by manipulation of this eloquent tissue.

Patient treatment should be based on patients' symptomatology and lesion location in the spinal cord (deep vs superficial), as well as patient's age and medical co-morbidities[3]. In patients with superficial lesions and with symptoms, surgical resection should be recommended due to the accessibility of the lesion. In patients with deep lesions and progressive neurological symptoms, surgery may transiently worsen the clinical symptoms but obviates the neurological deterioration. In patients with transient or minimal symptoms and with deep lesions, clinical and radiographic observation should be considered, as the risk of surgical morbidity outweighs the benefits of microsurgical resection.

At the BIDMC Brain Aneurysm Institute, we meet weekly with a multidisciplinary team to discuss the decision-making involved in the management of spinal CMs. Here we present a case handled by our team.

Case Vignette:

A previously healthy 44-year-old female patient consulted us due to a sudden onset of numbness, paresthesia and decreased sensation in her lower limbs. These symptoms were predominantly below the knees, primarily on the left. Neurological exam revealed decreased sensation to vibration and light touch in her lower extremities, primarily in the left limb. Impaired proprioception was present in her left large toe and intact in the other extremities. Full strength with 2+ reflexes was observed in all extremities, with mild gait impairments. A cervical spine MRI revealed an exophytic lesion in the posterior aspect of the cervical spinal cord at the C5-C6 level (Figure 1) with mixed signal intensity that measured 7 (AP) X 7 (TV) X 14 (SI) mm. This lesion was surrounded by low-intensity signal rim of hemosiderin. These findings suggested a diagnosis of a cervical cavernous malformation with hemorrhage. Based on the accessibility of the lesion and the clinical presentation of the patient, the BIDMC Brain Aneurysm Institute Group recommended

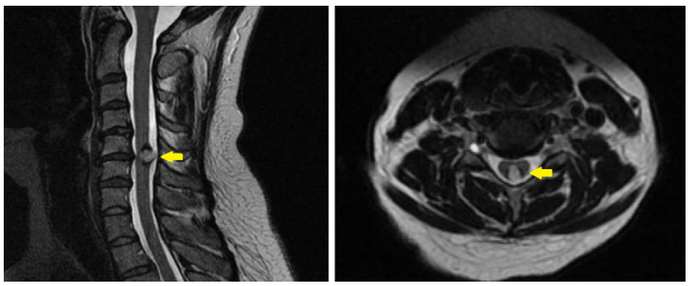

Figure 1: Sagittal (left image) and Axial (right image) T2-weighted MRI showing a exophytic mixed signal intensity lesion in the posterior aspect of the C5-C6 spinal cord segment (yellow arrow), with a surrounding hypointense rim of hemosiderin suggesting a cavernous malformation.

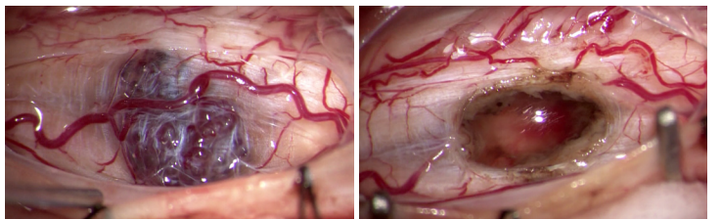

Figure 2: Intraoperative image of the C5-C6 segment spinal cord cavernous malformation before (left) and after (right) microsurgical resection.

microsurgical resection of the spinal cavernous malformation via a midline cervical C5-C6 posterior approach with neurophysiological monitoring (motor-evoked potentials and somatosensory-evoked potentials recording). The lesion was resected completely without any complication during the surgery (Figure 2). After surgery, the patient had transient worsening of her posterior column function which improved over two weeks. She ambulated well and was discharged home on postoperative day five with a good functional status and a McCormick Scale=1.

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Initial Experience with PulseRider® Device in the Treatment of Basilar Tip Aneurysms

Luis C. Ascanio, MD, Abdulrahman Y. Alturki, MBBS, MSc, FRCSC, Christopher S. Ogilvy, MD, Ajith J. Thomas, MD

The PulseRider® is a device designed to treat an aneurysm arising at bifurcations preserving the integrity of the branches and providing support at the aneurysmal neck during coiling[1]. The different flow dynamics in these aneurysms make them harder to treat endovascularly, usually requiring an adjunctive stent during the coiling[1,2].

The PulseRider® is a nitinol self-expanding device composed of a lower portion that resembles a saddle, which sits on the parent vessel; and an upper portion that resembles a letter "T" or "Y", in which each arm sits on the bifurcated vessels, providing a scaffold that prevents the vessels from closing. Each portion has radiopaque markers to allow identification during placement. Its' structure allows deployment and catheterization through its struts[1-3]. (Figure 1).

One of its' advantages is that most of the metallic component of the device is located in the portion that blocks the aneurysm neck, giving the device a low metal-to-artery ratio compared to other devices. This means that the risk of jailing adjacent arteries is very low[1]. Also, reducing the metal contact surface to the intima may potentially decrease the thrombogenic risk seen in stents, thereby reducing the length of time Clopidogrel and Aspirin prophylaxis is needed[2]. However, future studies are needed to support these hypotheses. Another advantage is that its flexibility allows the device to be repositioned before detachment. Currently, Y-stenting techniques have shown long-term and effective aneurysmal occlusion overtime, but the procedure is more difficult, more expensive and carries a higher risk of complications[1,2].

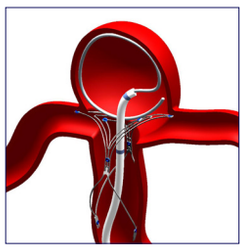

Figure 1: Representation of a PulseRider® assisted coiling of a wide-neck basilar tip aneurysm. The device has several radiopaque markers (blue dots) that provide guidance during the procedure. Image provided and reproduced with authorization of Pulsar Vascular.

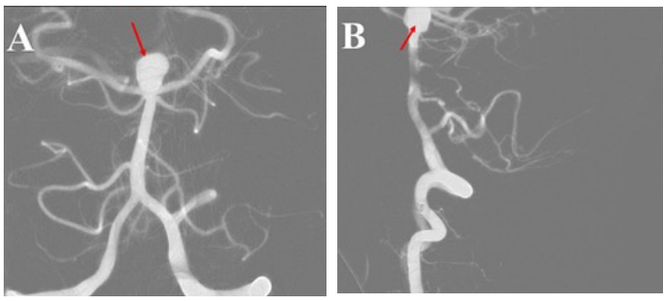

Figure 2: Preoperative angiogram shows a 10-mm basilar tip aneurysm in AP **(A)** and Lateral **(B)** projections.

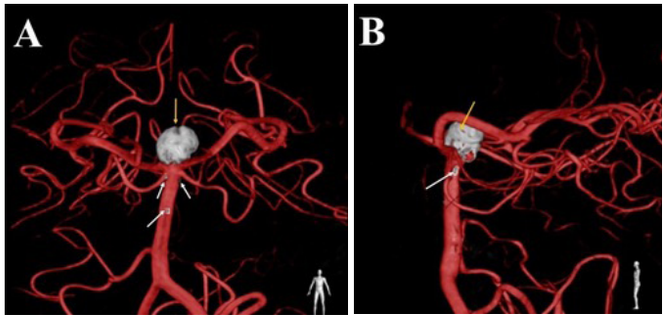

Figure 4: Postoperative tri-dimensional reconstruction angiogram showing the PulseRider® radiopaque markers (white arrows) in AP **(A)** and Lateral **(B)** projections.

The Adjunctive Neurovascular Support of Wide-neck aneurysm Embolization and Reconstruction (ANSWER) study is the only clinical trial available that investigated the use of the PulseRider® and enrolled 34 patients in 10 different centers in the United States[4]. Their results showed no mortality associated with the procedure and 94.1% of patients had a good functional outcome at 6-months follow-up. Angiographically, 52.9% of aneurysms occluded completely at day 0 and an additional 22.1% occluded completely after a year follow-up. Incomplete occlusion remained around 25% from day zero to up to a year follow-up. Intraprocedural complications were 8.8% and post-procedural complications were mostly transient neurological deficit that resolved.

The BIDMC Institutional Review Board (IRB) recently approved the use of PulseRider®. Here we present the first case treated by the Neurosurgery team at The BIDMC Brain Aneurysm Institute.

Case Vignette:

A 72-year old female was referred to The Brain Aneurysm Institute after an incidental finding of a 10-mm basilar tip aneurysm. Her past medical history is positive for depression, anxiety, hypertension, diabetes, hypercholesterolemia and chronic kidney disease.

A Magnetic Resonance Angiogram (MRA) revealed a wide-neck 10 x 10 mm basilar tip aneurysm. After

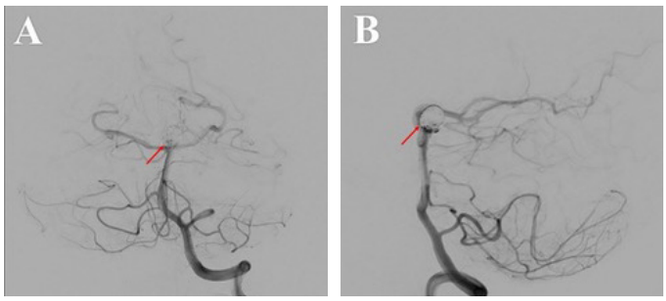

Figure 3: Postoperative angiogram in shows complete aneurysmal obliteration in AP **(A)** and Lateral **(B)** projections after PulseRider® assisted coiling.

discussing the risks and benefits, the Brain Aneurysm Institute clinicians considered this patient an excellent candidate for PulseRider® assisted coiling. After consent was obtained, the patient was scheduled for an elective procedure. Two weeks before the procedure, the patient was started on Aspirin 325mg daily and Clopidogrel 75mg daily.

Procedure:

Under general anesthesia, the basilar artery was catheterized endovascularly through the right femoral artery. Once the aneurysm was identified (Figure 2), a 2.7-3.5mm Pulse Rider was mounted and advanced slowly and carefully until it was deployed inside the aneurysm at the neck but not detached. Then, a MICRUSFRAME® micro coil of 6mm x 26cm was used as a framing coil until it was fully deployed inside the aneurysm. Before final detachment, an angio run was done confirming patency of the vertebrobasilar system (Figure 3). Subsequently, more coils were deployed until complete obliteration was achieved. After the deployment of the last coil, the microcatheter was pulled out and the PulseRider® was detached and the microcatheter was removed. Final AP and lateral views were obtained which confirmed the patency of all involved arteries and a satisfactory obliteration of the aneurysm (Figure 4). At the conclusion of the procedure, there was no evidence of thromboembolic complication and the patient was at her neurologic baseline.

The post-procedure course was uneventful and the patient was doing well at the 4-week follow-up office appointment with the neurosurgeon.

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News and Events

BIDMC Brain Aneuysm Institute joins the Brain Aneurysm Foundation in these upcoming events:

BRAIN ANEURYSM FOUNDATION CHAMPION AWARDS

Friday, March 30, 2018
5:30 – 7:30 p.m.
UMASS Club
1 Beacon St, 32nd Floor, Boston, MA 02108

Ajith Thomas, MD – Recipient of our Physician Champion Award

7TH ANNUAL ADVOCACY DAY ON CAPITOL HILL

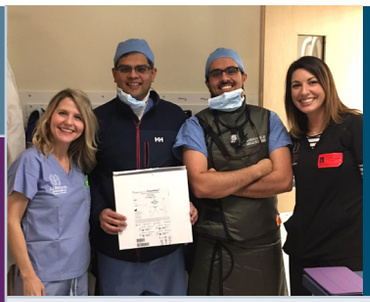
This is an opportunity to inform our Congress and Senate members about brain aneurysms in order to increase awareness of and research for brain aneurysms.

Tuesday, March 20, 2018
9:00 a.m.
Capitol Hill, First St SE, Washington, DC

17TH ANNUAL ARTERIAL CHALLENGE AT FENWAY

Sunday, April 22, 2018
8:00 a.m.
Fenway Park, 4 Yawkey Way, Boston, MA 02215

For more information:
Brain Aneurysm Foundation | 888-272-4602 | *office@bafound.org*



BIDMC Brain Aneurysm Institute Uses New PulseRider® Technology

Save the Date

Ischemic and Hemorrhagic Update: Current Practices and Future Directions

FRIDAY, MAY 7, 2018
Omni Parker House
60 School Street, Boston, MA 02108

Course Directors:
Christopher S. Ogilvy, MD, Magdy Selim, MD, PhD, *and* Ajith J. Thomas, MD

This is a unique course focused on recent advances in the field of neurovascular disease including up-to-date theories of carotid disease, cerebral hemorrhage, and brain aneurysms. Topics covered will include assessment, management, and specific issues of carotid disease, cerebral hemorrhage, and brain aneurysms.

CME credit awarded.

For information about registration, contact Deidre Buckley, NP, at *dabuckle@bidmc.harvard.edu.*