Beth Israel Deaconess Medical Center
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SUMMER/FALL 2016

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NEUROVASCULAR NEWS

The Brain Aneurysm Institute

Multidisciplinary Care of Patients with Hemorrhagic and Ischemic Stroke

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Brainstem cavernous malformations

Christopher S. Ogilvy, MD, Rouzbeh Motiei-Langroudi, MD, Deidre Buckley, NP, Ajith J. Thomas, MD

Cavernous malformations are vascular lesions that can occur in the cerebral hemispheres, cerebellum, brainstem, spinal cord, and on cranial nerves. In gross appearance, the lesions have a blackberry-like appearance due to the composition of multiple bubble-like structures called caverns. Each cavern is filled with blood and lined with endothelium (Figure 1).

Cavernous malformations are estimated to occur in approximately one out of every 500-600 people, or approximately 0.2% of the general population. While presentation of cavernous malformations can occur in children, individuals often demonstrate their first symptoms in their 20-30s. It is thought that more than 30% of patients with cavernous malformations will eventually develop symptoms. For at least 20% of those with cavernous malformations, the lesions are hereditary in nature. These patients often have multiple cavernous malformations and also there are other close family members with the lesion.

Symptoms from cavernous malformations are typically due to small repeated hemorrhages. Overall, there is a 1-2% risk of hemorrhage per year. The risk doubles after the first episode of hemorrhage. When located in the cerebral hemispheres, cavernous malformations can also cause seizures, which are thought to be a result of scarring within the brain tissue surrounding the lesion. The scarring results from repeated hemorrhages and hemosiderin staining. When lesions occur in the brainstem and spinal cord, repeated symptoms of weakness, numbness, or focal cranial nerve abnormalities occur. This course mimics demyelinating diseases because patients improve between hemorrhagic events.

Brainstem cavernous malformations have been diagnosed with increased frequency as a result of better neuroimaging. The lesions are nicely demonstrated on MRI studies. Approximately 25% of cavernous malformations occur in the brainstem.

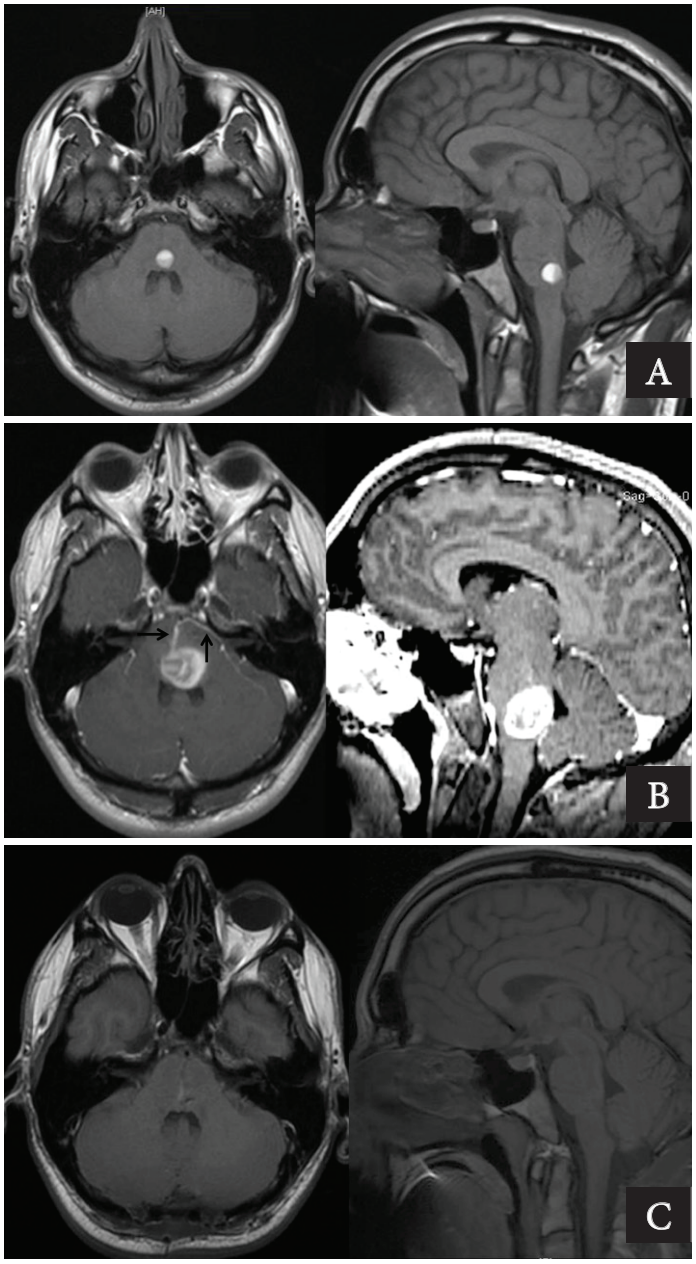
Cavernous malformations in the brainstem cause difficulties to both the affected individual and the treating physician. Even small amounts of hemorrhage can cause neurologic deficits

by compression or destruction of cranial nerve nuclei or motor and sensory fiber tracks that travel through the brainstem. The neural structures that traverse the brainstem control basic involuntary functions such as respiration, heartbeat regulation, gag reflex, body temperature, and pain and heat sensation. In addition, voluntary functions including limb and eye movements, swallowing, facial muscular control, walking, and speech can be affected.

Once a lesion is detected in the brainstem, it can be followed conservatively with a "watch and wait" approach. This consists of routine, periodic MRI studies to monitor the changes in the lesion as well as clinical follow-up of patient. If new clinical symptoms develop, an MRI study is often performed to visualize any changes, including new areas of hemorrhage.

Given the advancements in minimally invasive surgical techniques, a greater number of cavernous malformations are amenable to surgical resection today. However, the potential for significant functional deficits from surgery is still significant. Surgical removal may be considered in several situations. If the lesion abuts the surface of the brainstem, surgical resection may be undertaken. Repeated hemorrhages (two or more events) in the case of a surgically accessible lesion have been considered as another indication for surgery. Small repeated hemorrhages could cause cavernous malformation enlargement to the point where pressure on surrounding brain tissue causes symptoms. In these cases, decompression through surgery is often indicated. The hemorrhage rate for cavernous malformations in the brainstem in one study was estimated to be as high as 30% per person per year. Extracapsular hemorrhages (i.e. the hemorrhage goes beyond the boundaries of the cavernous malformation) and deteriorating neurologic deficits are two other indications for surgery in brain stem lesions.

Figure 1A shows the brain MRIs in an otherwise healthy 29-year-old gentleman who experienced double vision. This worsened over the course of two weeks and follow-up imaging demonstrated enlargement of the lesion. The patient was followed clinically and hemorrhaged on two separate occasions over the course of a month to the point where he became unable to ambulate. In the repeat MRI, the lesion was quite large (figure 1B). Surgical resection was undertaken through a suboccipital craniotomy, achieving total resection of the lesion without complications (figure 1C). The patient made a gradual recovery over six months and returned to his full level of work in construction, only needing to wear prism glasses for mild diplopia.



▲ **Figure 1**

A: The first MRI shows a cavernous malformation in pons (a part of brainstem) with hemorrhage.

B: The MRI with contrast on the day of surgery showed acute hemorrhage and enlargement of the lesion. The axial image (left) also shows a concomitant venous anomaly (arrows).

C: MRI three months after surgery shows complete resection of the lesion.

Stereotactic radiosurgery has also been used to treat cavernous malformations. For lesions in the brainstem, however, it is felt to be associated with relatively high morbidity rates. Unlike radiotherapy for arteriovenous malformations (AVMs), stereotactic radiosurgery does not result in obliteration of the cavernous malformation. Therefore, radiosurgery for the treatment of brainstem cavernous malformations remains controversial.

Many patients are evaluated at the Beth Israel Deaconess Medical Center (BIDMC) Brain Aneurysm Institute with the diagnosis of brainstem cavernous malformations. While we have a large experience performing surgery on such lesions, it is often best in many patients to opt for continued observation. In fact, many more patients are being followed than are ever operated upon. The decision to proceed to surgery depends on a multitude of factors including patient age, number of hemorrhages, neurologic deficit, occupation, and general medical health.

Venous anomalies are small collections of veins that merge to form one larger vein and often occur in association with cavernous malformations in the brainstem (arrows in figure 1B). These veins drain normal brain tissue and great attempts are made to leave them unaltered when removing an adjacent cavernous malformation with surgery.

At the BIDMC Brain Aneurysm Institute, a team of physicians and nurses meets regularly to review the clinical status and imaging of patients with brainstem cavernous malformations. By getting to know the patient's clinical course over long intervals of time, sometimes several years, the decision for continued observation or surgical intervention can be made. ■

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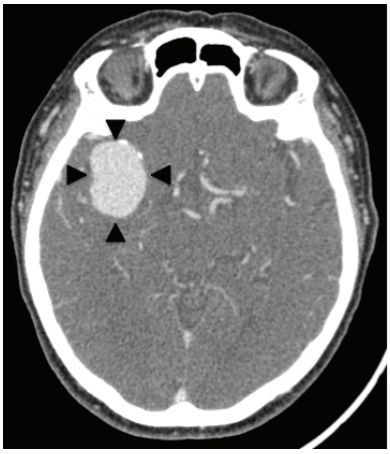
Combined surgical and endovascular treatment of a giant middle cerebral artery (MCA) aneurysm

Christopher S. Ogilvy, MD, Rouzbeh Motiei-Langroudi, MD, Ajith J. Thomas, MD

Here we present a 66-year-old woman with headaches and episodes of memory loss. She had an otherwise normal neurologic examination. Her CT angiogram demonstrated a giant right MCA aneurysm (figure 1). The proximal and distal MCA branches were involved in the aneurysm sac (figure 2).

Based on the anatomy of the aneurysm and the parent artery, a single approach (either open surgical or endovascular) was felt to be high risk. Therefore, we decided to take a two-stage combined surgical (bypass the aneurysm) and endovascular (coiling of the aneurysm) approach.

In the first stage, we performed a craniotomy and took a long segment of saphenous vein to perform a bypass.

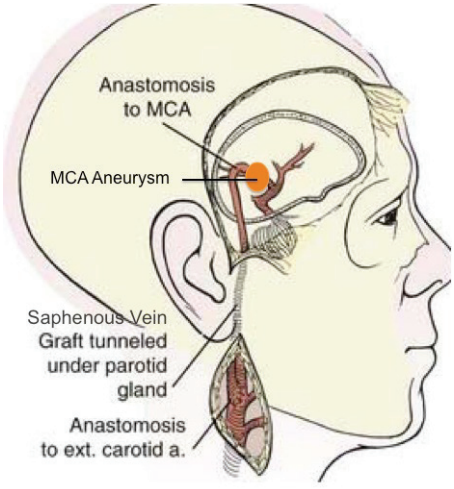


◀ **Figure 1:** CTA shows a giant right MCA fusiform aneurysm (arrowheads).

The vein was sutured to the external carotid artery (ECA) above the common carotid artery bifurcation in the neck, tunneled subcutaneously, and the distal end was grafted to the superior division of distal MCA branch (figures 2,3). Doing this, the superior distal MCA and branches were fed by the ECA through the graft (and not by the proximal MCA). We placed a clip on the MCA branch as it exited from the aneurysm. Figure 4 shows a schematic illustration of the ECA-to-MCA graft bypass procedure.

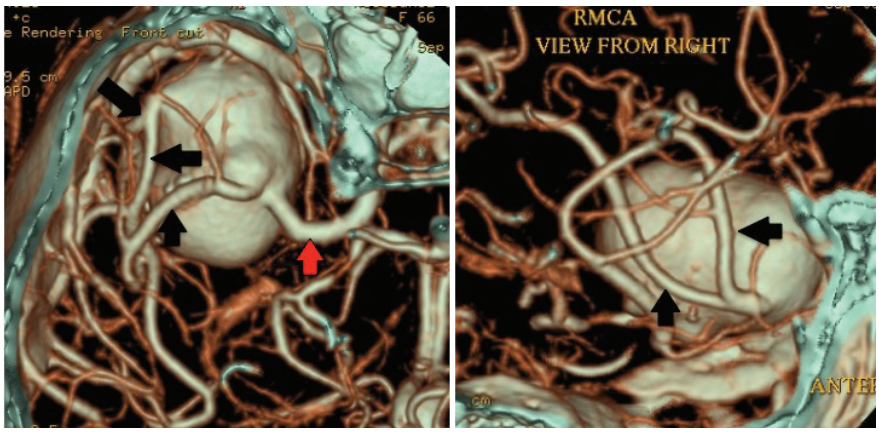
A second stage was performed three weeks later using an endovascular approach. Using femoral artery access, we were able to place a microcatheter in the aneurysm and occlude the dome with endovascular coils. Both surgical and endovascular procedures were uneventful and the patient tolerated both procedures well without any complications.

One and a-half years after the treatment, cerebral angiography showed patency of the graft feeding the distal MCA branches. The aneurysm remained obliterated with no evidence of recurrence or regrowth (figure 5). This patient illustrates a successful combined surgical and endovascular approach to treat a giant fusiform cerebral artery aneurysm, which is hard to control by either treatment alone without significant complications. ■

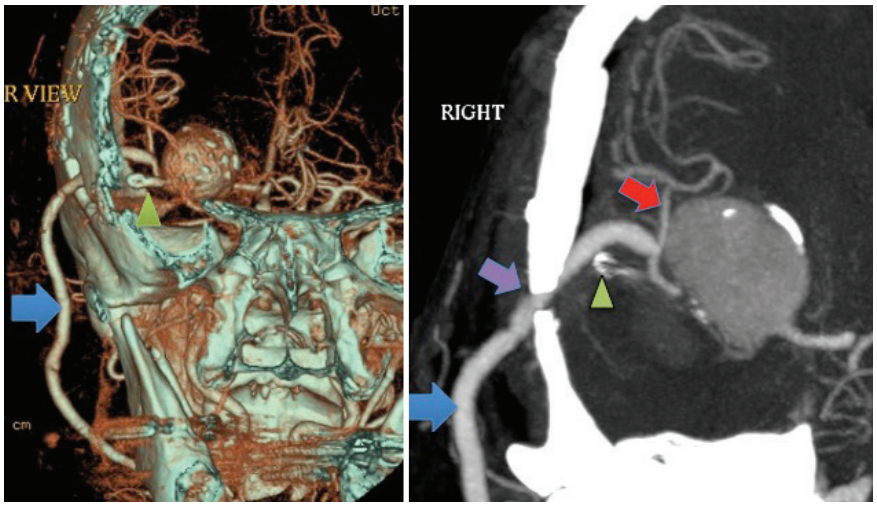


▲ **Figure 4:** A schematic illustration of ECA-to-MCA bypass with a saphenous vein graft.

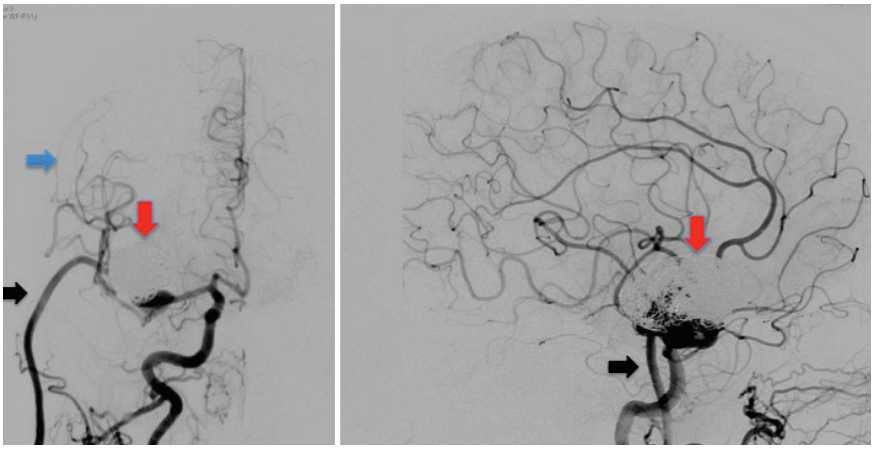
▼ **Figure 2:** CTA shows inferior (left) and lateral (right) views of the aneurysm. The parent MCA proximal to (red arrow) and branches distal to the aneurysm (black arrows) are partially involved in the aneurysm.



▼ **Figure 3:** A saphenous vein graft (blue arrow) is bypassed from ECA at the carotid bifurcation to superior division of distal MCA (red arrow). A clip was placed on the MCA branch as it exited the aneurysm (green arrowhead). After completion of the graft and closing the dura and bone flap, the bypass graft traverses through a craniotomy burr hole (purple arrow).



▼ **Figure 5:** The follow-up AP (left) and lateral (right) angiograms show patent bypass graft (black arrow) feeding the distal MCA territories (blue arrow). The aneurysm dome (red arrow) has been filled with endovascular coils.



Endovascular embolization of cerebral arteriovenous malformations

Raghav Gupta, Nimer Adeeb, MD, Ajith J. Thomas, MD, Christopher S. Ogilvy, MD

Cerebral arteriovenous malformations (AVMs) are direct, abnormal connections between arteries and veins of the brain, without connecting capillary beds. They are estimated to affect 18 out of every 100,000 adults, and typically present in the 3rd, 4th, and 5th decades of life (1). The lesions are characterized by the presence of a nidus, or radiographically evident 'tangle' of thin blood vessels. These high flow and high pressure 'shunts' can induce venous hypertension and damage to the arterial and venous endothelial cells, leading to intracranial hemorrhage, stroke, and in severe cases, death. The annual risk of rupture of these lesions is believed to be between 2% and 4%, though patient age and AVM location are believed to play an important role as well, with elderly patients and deeper lesion location associated with poorer outcomes (2). The timely diagnosis and treatment of AVMs, therefore, is essential.

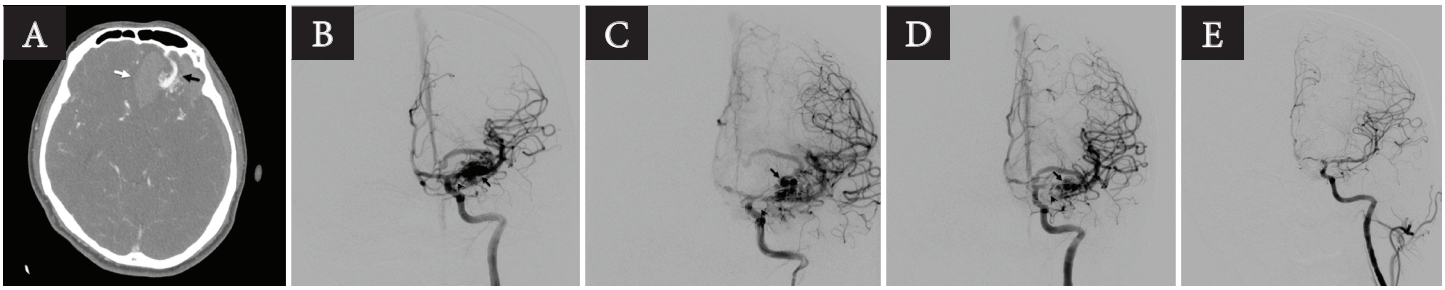
Patients typically present with seizures, headaches, or hemorrhage with acute onset of neurological deficits. Magnetic resonance (MR) and computed tomography (CT) imaging are used to evaluate the extent of hemorrhage (if present) as well as to assess the anatomy and relationship of the lesion to surrounding normal neural structures. Digital subtraction angiography (DSA), which involves injection of a contrast agent into a blood vessel and subsequent visualization of the vasculature with X-rays, is considered the gold standard for detecting these lesions and obtaining details on arterial and venous anatomies. At the BIDMC Brain Aneurysm Institute, we also make use of functional MRI (fMRI) to detail the location of the AVM for estimation of risk of treatment.

The decision to treat an AVM is complex and is guided by a number of factors including: patient age, patient presentation, lesion characteristics, previous patient health history, and risk of hemorrhage. While aggressive management of AVMs is feasible in younger patients, medical management of elderly patients is often preferred. Advances in endovascular technologies over the past few decades, however, have expanded the number of treatment options available for management of AVMs in all patients. Embolization, for example, has emerged as an alternative and an adjunct to microsurgical resection (removal) and radiosurgery. Developed initially in 1968, embolization involves the delivery of liquid embolic (adhesive) agents, such as Onyx (ethylene-vinyl alcohol copolymer), via a combination of catheters fed through the femoral artery in the groin, into the arterial pedicles feeding the AVM. The patient is kept under either a general or local anesthetic during this period and fluoroscopic guidance is used to assess the extent to which the nidus is obliterated following injection of the embolic material. A follow-up cerebral angiogram is performed to reassess blood flow within the AVM nidus (figure 1).

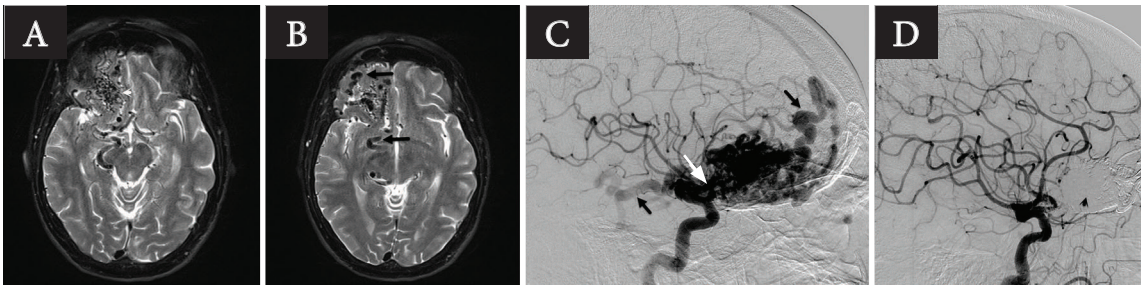
Approximately 20% of AVMs can be completely obliterated following embolization (3). As such, the procedure has been performed, historically, on larger AVMs with the intent of reducing their size prior to open surgical treatment (figure 2). The Spetzler-Martin grading scale (4), first proposed in 1986, found that larger size, deep venous drainage, and eloquent cortex location, are important predictors of complications following microsurgical resection. In cases where resection would otherwise be contraindicated, or in cases in which the lesions incorporate the aforementioned characteristics, embolization may be beneficial. At the BIDMC Brain Aneurysm Institute, embolization is performed with a curative intent, though surgical resection and radiosurgery may be scheduled following incomplete obliteration of complex lesions.

Morbidity (4.6%) and mortality (2.3%) rates associated with embolization in the literature are extremely low (5). Our team recently submitted a report to the *Journal of Neurointerventional Surgery* in which we found no embolization-related mortalities across a six-year period during which these procedures were performed. The incidence of major complications was found to be 3.6%. Despite these low observed complication rates, our team of neurosurgeons, neurologists, and neuroradiologists at the Brain Aneurysm Institute continuously work to

enhance the safety profile of embolization procedures. Recently, we have adopted the use of triaxial (guide catheter + distal access catheter + microcatheter) catheter systems, which replace previous coaxial (guide catheter + microcatheter) systems, and detachable tip microcatheters. We believe that the addition of an intermediate catheter will enable greater microcatheter control within tortuous anatomies, curbing the incidence of vessel perforation and procedure-related hemorrhage. We have also begun to use detachable tip microcatheters to prevent catheter entrapment within the Onyx mold. ■



▲ **Figure 1:** A 54-year-old Asian male presented unresponsive with a left intraparenchymal hemorrhage. (A) A CTA performed at the hospital indicated a large hematoma (white arrow) and AVM with its associated draining vein (black arrow). An AP angiogram confirmed a (B) left frontal AVM (black arrow). The patient underwent two staged, successive embolization procedures (C & D) resulting in step-wise reduction in the size of the nidus along with visible expansion of the Onyx cast (black arrows). Surgical resection was then performed, and (E) an AP angiogram performed at follow-up indicated complete obliteration of the lesion.



▲ **Figure 2:** A 63-year-old Caucasian female presented for an elective, curative Onyx embolization of her right frontal AVM. (A) An axial T2-weighted MR of the head indicated flow voids consistent with this diagnosis (white arrowhead) and demonstrated the lesion's (B) associated draining vein (black arrow). (C) A pre-operative lateral angiogram indicated a nidus measuring 3 cm X 2 cm X 2 cm with a visible feeding arterial pedicle (white arrow) and draining veins (black arrows). (D) A cerebral angiogram performed shortly following her procedure demonstrated complete obliteration of the nidus with a visible Onyx cast (black arrowhead).

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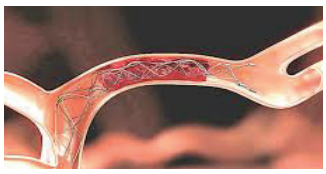

Help Make September National Brain Aneurysm Awareness Month

In April 2016, the U.S. Senate passed a resolution (SR 438) to make September National Brain Aneurysm Awareness Month. The resolution will come before the House of Representatives (HR 667) soon and needs your support.

Contact your representatives in Congress to thank them for their support of SR 438 and encourage the passage of HR 667. The Brain Aneurysm Foundation hopes to get the support of Vice President Joe Biden, a brain aneurysm survivor, for this resolution. Direct your letter to the Vice President at: ***bafound.rallycongress.com.***

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